DRAFT ONONDAGA LAKE CAPPING, DREDGING AND HABITAT INTERMEDIATE DESIGN

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LIST OF ACRONYMS

AMP	Ambient Monitoring Program
ARARs	Applicable or Relevant and Appropriate Requirements
BMPs	best management practices
BSQV	bioaccumulation-based sediment quality value
CPOI	chemical parameters of interest
CPP	Citizen Participation Plan
CQAP	Construction Quality Assurance Plan
DSC	Dredging Supply Company
ESD	Explanation of Significant Differences
foc	fraction of organic carbon
FS	Feasibility Study
GPS	global positioning system
IDS	Initial Design Submittal
ILWD	in-lake waste deposit
IRM	Interim Remedial Measure
koc	organic carbon partitioning coefficient
Metro	Onondaga County Metropolitan Wastewater Plant
MNR	monitored natural recovery
MSL	mean sea level
NAPL	non-aqueous-phase liquid
NAVD	North American Vertical Datum
ng/L	Nanograms per liter
NPL	National Priorities List
NTU	Nephelometric turbidity units
NYSCC	New York State Canal Corporation
NYSDEC	New York State Department of Conservation
NYSDOT	New York State Department of Transportation
OCDWEP	Onondaga County Department of Water Environment Protection
OM&M	operation, maintenance, and monitoring
OU-2	Operable Unit 2
PDI	Pre-Design Investigation
PEC	Probably effects concentration

PECQ	PEC quotient
PRG	preliminary remedial goal
QA/QC	quality assurance and quality control
RI	Remedial Investigation
RAO	Remedial Action Objective
ROD	Recorded of Decision
SAV	submerged aquatic vegetation
SCA	sediment consolidation area
SECs	sediment effects concentrations
SMU	sediment management units
SOW	Statement of Work
SVOCs	semi-volatile organic compounds
TSS	total suspended solids
VOCs	volatile organic compounds
WBB/HB	Wastebed B/Harbor Brook
USEPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

The development of the Draft Capping, Dredging, and Habitat Intermediate Design submittal is Honeywell's next step toward achieving the goals of the Record of Decision (ROD) and the community's vision for a restored Onondaga Lake. The lake remediation plan, which was selected by the New York State Department of Environmental Conservation (NYSDEC) and the U.S. Environmental Protection Agency (USEPA), calls for a combination of dredging and capping. These methods are proven environmental cleanup methods that address contamination in water and lake sediment. This document provides information on the design for remedial areas, sediment cap, habitat restoration and enhancement, areas and depths of sediment to be dredged, and dredging and capping methods.

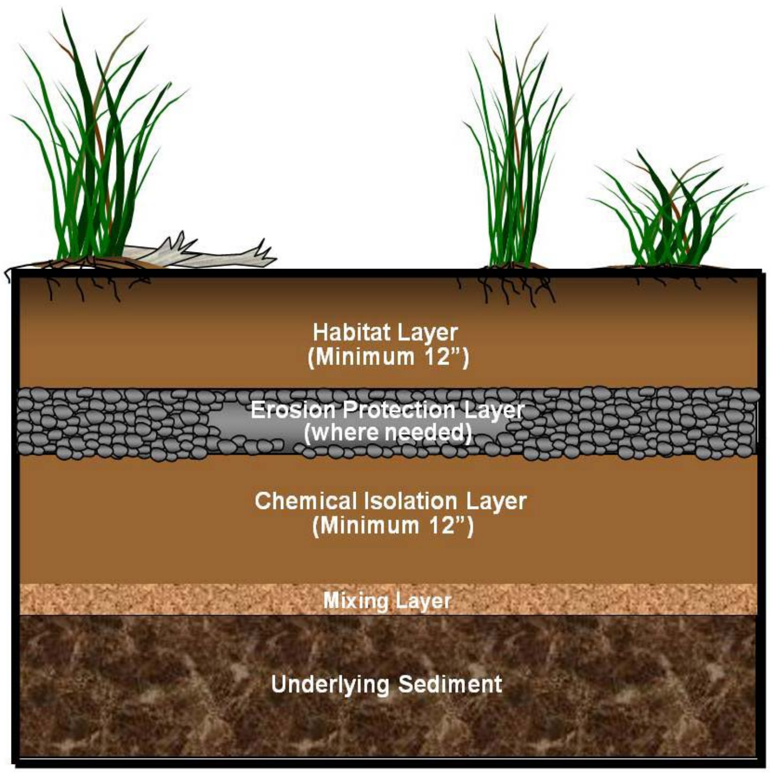
Honeywell's design team consists of more than 100 local engineers and scientists working with nationally recognized experts from various universities, research institutions, and specialty engineering firms, and with input from community stakeholders. The design generated through this collaboration is effective and meets the objectives for remediation and long-term protection of health and the environment outlined in the ROD.

Restoring diverse, functioning and sustainable habitats to the remediated areas of Onondaga Lake is one of the top priorities of this remedial program. Therefore, habitat considerations are at the forefront of the various design evaluations for the lake and have been fully integrated into this document. Habitat considerations are a major factor in developing the habitat layer and the total thickness of the cap. The cap will provide a suitable habitat layer for plants, animals, and fish to use without impacting the chemical isolation layer. The cap will also provide long-term chemical and physical isolation of underlying material from the lake and will resist erosive forces such as wind/wave-generated currents, tributary and other inflows, and ice.

Capping, Dredging, and Habitat Restoration

Detailed technical evaluations demonstrate that capping will be effective in Onondaga Lake. Sediment caps are a proven technology and have been implemented at numerous sediment remediation sites, including the Fox River in Wisconsin, the St. Louis River Interlake Duluth Tar site in Minnesota, and Commencement Bay in Washington.

The caps for Onondaga Lake will include the following layers: habitat layer, erosion protection layer, buffer layer (integrated into the habitat layer), chemical isolation layer, as well as an allowance for mixing of the bottom of the chemical isolation layer with underlying sediment. The different layers will provide long-term protection of human health and the environment, and will ensure that goals are met for habitat restoration, erosion protection and chemical isolation. The layers are depicted in the graphic below.



General Schematic of Sediment Cap

The design team performed detailed evaluations to ensure each layer meets the remedial goals and is designed to withstand expected conditions in the lake. The evaluations include the following:

- Extensive laboratory bench-scale analysis
- State-of-the-science numerical and computer modeling designed to conservatively predict long-term effectiveness
- Evaluation of capping successes and lessons learned at other remediation sites
- Evaluation of post-remediation habitat considerations
- Continuous consultation with national and local experts

The total thickness of the cap includes the habitat layer, erosion layer, and chemical isolation layer, as well as the mixing layer. As part of the habitat restoration goal, areas will be developed near the mouth of Ninemile Creek where floating aquatic plants (such as lily-pads) will thrive. The required depth for a floating aquatic plant is 1 ft. to 3 ft. Sufficient dredging will be completed in this area such that the post capping water depth will be between 1 ft. and 3 ft. Because dredging depths are based on these types of considerations, dredging designs are presented after the goals and designs for the cap and habitat restoration are developed.

Dredging is a major component of the lake remedy. To achieve removal goals specified in the ROD, dredging will be implemented in an area of the lake known as the in-lake waste deposit

(ILWD). In addition to the ILWD dredging, elevation-based dredging will be conducted in other portions of the lake to allow for the subsequent placement of the sediment cap, and will result in post remedy water depths based on habitat considerations. The water depths and habitat restoration concepts were developed in the Draft Habitat Plan to achieve optimum conditions throughout the dredging and capping areas in the lake.

Community Participation

Community input remains a vital component of Honeywell's design for the restoration of Onondaga Lake. Honeywell is committed to working with community leaders, interested stakeholders, and citizens to include input, recommendations, comments and perspectives into the design process. Community members have the opportunity to participate in the design, construction, and post-construction periods as detailed in the NYSDEC's Citizens Participation Plan (CPP) (NYSDEC 2009). Feedback received through the community participation process has already been incorporated into design-level decisions in several areas of the remedial design.

SECTION 1

BACKGROUND AND DESIGN PROCESS OVERVIEW

This Onondaga Lake Capping, Dredging and Habitat Intermediate Design Report has been prepared on behalf of Honeywell and advances the conceptual-design presented in the Initial Design Submittal (IDS). This report describes the components of the Onondaga Lake remediation pertaining to the sediment cap, sediment dredging, and habitat restoration and enhancement. Restoring diverse, functioning and sustainable habitats to the remediated areas of Onondaga Lake is one of the top priorities of this remedial program. Therefore, habitat considerations are at the forefront of the various design evaluations for the lake and have been fully integrated into this document. Regulatory and community input and review will continue through the design process, and public feedback will be obtained on this design and addressed during further development and finalization of the remedial design.

The lake bottom is on the New York State Registry of Inactive Hazardous Waste Sites and is part of the Onondaga Lake National Priorities List (NPL) Site. Honeywell entered into a Consent Decree (United States District Court, Northern District of New York, 2007) (89-CV-815) with the NYSDEC to implement the selected remedy for Onondaga Lake as outlined in the ROD issued on July 1, 2005. The following documents are appended to the Consent Decree: ROD, Explanation of Significant Differences (ESD), Statement of Work (SOW), and Environmental Easement.

The design information presented here is based on extensive information and data gathered during six years of design-related investigations, as well as data collected as part of the Remedial Investigation (RI) (TAMS, 2002). These investigations have included collection and analysis of thousands of samples, numerous bench studies, and completion of many field evaluations and data collection activities.

1.1 ONONDAGA LAKE DESCRIPTION

Onondaga Lake is a 4.6 square mile (3,000 acre) lake located in Central New York State immediately northwest of the City of Syracuse (Figure 1.1). The lake is approximately 4.5 miles long and 1 mile wide, with an average water depth of 36 ft.

Ninemile Creek and Onondaga Creek are the two largest tributaries to Onondaga Lake (Figure 1.1). 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. 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, contributes a significant portion of the water entering the lake.

As part of the remedial alternative development and evaluation process during the Feasibility Study (FS) (Parsons, 2004), the lake bottom was divided into eight sediment management units (SMUs) based on water depth, source of water entering the lake, and physical, ecological, and chemical characteristics (NYSDEC and USEPA, 2005). SMUs 1 through 7 are located in the littoral zone (less than 30 ft. water depth) of the lake where most aquatic vegetation and aquatic life reside, while SMU 8 consists of sediment in the profundal zone (deeper than 30 ft.) (Figure 1.2).

1.2 REMEDIATION OBJECTIVES AND GOALS

A key objective of all remedial activities is to ensure protection of onsite workers, the surrounding community, and the environment from potential risks associated with the completion of the remedy. The ROD also provides more specific objectives, called Remedial Action Objectives (RAOs), as listed below.

- ROA 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.
- ROA 3: To eliminate or reduce, to the extent practicable, releases of mercury from profundal (SMU 8) 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 chemical parameters of interest (CPOIs).

Of these, RAOs 2, 4, and 5 pertain to the dredging and capping activities described in this report.

As part of the FS process, USEPA guidance requires the establishment of preliminary remedial goals (PRGs) that can be used to select appropriate remediation technologies and to develop remedial alternatives within the FS. The PRGs represent the primary goals of the remedial efforts. To achieve the RAOs stated above, three PRGs were developed to address the three primary affected media within the lake: sediment, biological tissue, and surface water. PRGs for Onondaga Lake, as per the ROD (NYSDEC and USEPA, 2005, p. 35), are listed below.

- PRG 1: Achieve applicable and appropriate sediment effects 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 USEPA'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 addresses RAOs 2 and 4. PRG 2 addresses RAO 4. PRG 3 addresses RAO 5.

1.3 REMEDY OF RECORD

The ROD for the lake bottom presents the remedy selected by NYSDEC and USEPA for addressing the RAOs and PRGs presented in Section 1.2 above. The SOW, presented as Appendix C of the Consent Decree, further describes design-related elements for the implementation of the remedy, such as the development of dredging areas and volume; isolation cap areas, models and components; approach for addressing the profundal zone (SMU 8); management of dredged sediments; water treatment system; and the design and construction schedule.

Major components of the selected remedy relevant to the dredging and capping activities in the littoral zone, which is the focus of this report, are set forth in the ROD and SOW and are summarized as follows (United States District Court, 2007 – appendices to the Consent Decree):

- Dredging of as much as an estimated 2,653,000 CY of contaminated sediment/waste from the littoral zone in SMUs 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 re-establish the littoral zone habitat. Most of the dredging will be performed in the ILWD (which largely exists in SMU 1) and in SMU 2.
- Dredging, as needed, of an additional 3.3 ft. in the ILWD to remove materials within areas of hot spots (to improve cap effectiveness) and additional dredging, as needed, to ensure stability of the cap.
- Placement of an isolation cap over an estimated 425 acres of SMUs 1 through 7.
- Completion of a comprehensive lakewide habitat restoration plan.
- Habitat reestablishment will be performed consistent with the lakewide habitat restoration plan in areas of dredging/capping.
- Implementation of institutional controls including the notification of appropriate governmental 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.

Honeywell will certify to NYSDEC that the institutional controls are in place and that Honeywell is conducting remedy-related OM&M consistent with the approved OM&M plan.

The NYSDEC and USEPA issued an ESD as Appendix B of the Consent Decree to specify a modification to the selected remedy documented in the ROD. Based on investigation data and a stability evaluation, there was significantly less NAPL-impacted material beneath the lake in

SMU 2 than was assumed during the FS and ROD, and removing this material could result in instability of the adjacent shoreline. Therefore, the alignment of the Willis/Semet Interim Remedial Measure (IRM) Barrier Wall (Willis portion) was moved offshore immediately beyond the farthest extent of pooled NAPLs within the lake in lieu of dredging of this material. NAPL recovery wells will also be installed on the landward side of the new barrier wall, and upland areas along Waste Beds 1-8 will be converted to new aquatic habitat to mitigate the loss of lake surface area resulting from placement of the barrier wall offshore.

1.4 DESIGN PROCESS OVERVIEW

Detailed technical evaluations completed during the FS demonstrated that capping in conjunction with dredging would be effective and would be the best approach to meet the remedial goals. Following completion of the FS and after the ROD was issued, extensive design-related investigation activities were initiated to supplement the data collected during the RI and provide the data necessary to allow design of the remedy. Design–related investigations related to capping and dredging design have included:

- Bench-scale tests to evaluate cap performance and generate data pertaining to design of the chemical isolation layer
- Geophysical surveys to map the lake bottom and identify debris and in-lake utilities that will be addressed as part of the remediation
- Sediment sampling for chemical and geotechnical analyses to determine the remediation areas and dredge depth
- *In situ* geotechnical testing of sediments to provide data related to design of the cap and dredging operations
- Porewater sampling and analysis to generate data pertaining to design of the chemical isolation layer

These activities to date have resulted in more than 12,000 samples collected from over 1500 discrete locations, to support design of the selected remedy. Honeywell presented the results of these investigations in data summary reports and submitted them to the NYSDEC. These reports are available in the public document repositories listed in the Citizen Participation Plan.

The design related to capping, dredging, and habitat was developed using the design-related investigation summarized above. The design overview that follows is provided to put the capping, dredging, and habitat components of the project into context with the rest of the remedy.

The primary elements of the selected remedy as documented in the ROD, and as described above, include:

- sediment removal (dredging) and transport to the sediment consolidation area (SCA)
- onsite management of dredged material at the SCA
- sediment capping (isolation and thin-layer)
- water treatment system

- nitrate addition or oxygenation of the hypolimnion
- monitored natural recovery (MNR)
- habitat restoration and enhancement
- institutional controls
- long-term operation, maintenance, and monitoring

For most of these elements, design-related investigations, engineering assessments, and evaluation reports were completed in advance of the preparation of this report to assess specific elements of the remedy, advance design decisions, and to obtain concurrence with NYSDEC and USEPA on critical path components.

Due to interaction between the various remedial elements, and varying design schedule considerations with specific design components, it was necessary to separate the design into several distinct submittals. Separating the design into different components allows for accelerated design submittals for critical path activities (e.g., SCA and water treatment), helps the agency review process by staggering the submission of large documents, and facilitates the schedule for starting and completing the remedial action consistent with the Consent Decree. Future design submittals and their associated submittal schedules have been developed and presented in each of the IDS reports.

The content of the four IDS Reports is as follows:

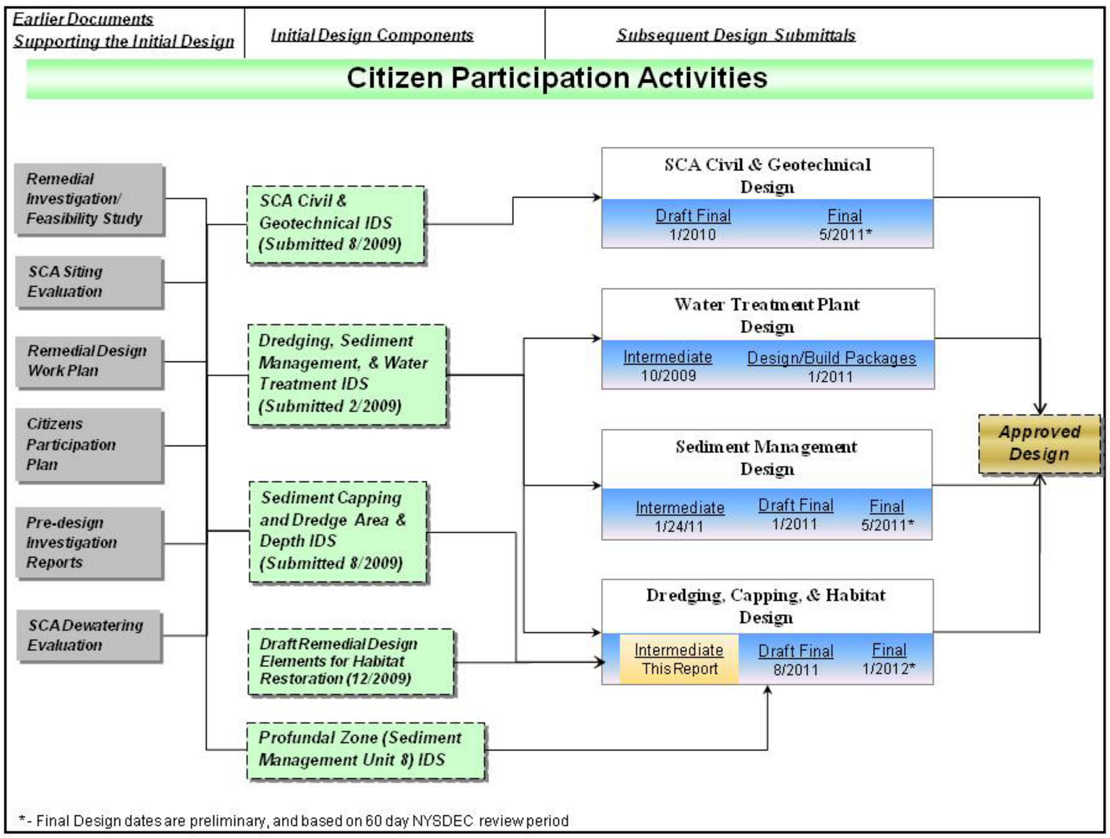
- The *Dredging, Sediment Management, and Water Treatment IDS* provides conceptual design-level information pertaining to operational components of the remedy including the dredging, transportation, and dewatering of impacted lake sediments, and treatment of construction water generated during the process. This IDS was submitted to the NYSDEC in February 2009 and is available in the public repositories. NYSDEC's comment letter is also included with the report in the public repositories.
- The *SCA Civil & Geotechnical IDS* includes the civil and geotechnical design elements (*e.g.*, liner system) required for construction of the SCA. This IDS was submitted to the NYSDEC in August 2009 and is available in the public repositories. NYSDEC's comment letter is also included with the report in the public repositories.
- The *Sediment Cap and Dredge Area, Depth and Volume IDS* includes the conceptual level design for the sediment cap components of the remedy. This submittal also includes the integration of conceptual level design details pertaining to habitat restoration and also provides estimates of dredging volumes and removal areas and depths. This IDS was submitted to the NYSDEC in December 2009 and is available in the public repositories. NYSDEC's comment letter is also included with the report in the public repositories.
- The *Profundal Zone (Sediment Management Unit 8) IDS* focuses on the deep water areas of the lake, and provides conceptual design-level details pertaining to thin-layer capping (including locations, extent, materials, and sequencing), nitrate addition and/or oxygenation for the purposes of inhibiting the formation of methylmercury within the lake, and the approach to MNR in specific areas of the lake. This IDS was

submitted to the NYSDEC in November 2010 and will be available in the public repositories.

Following the initial phase of the design, separate design tracks were established, with each track ultimately constituting a portion of the overall Onondaga Lake Design. These design tracks include:

- SCA Civil & Geotechnical Design
- Water Treatment Plant (WTP) Design
- Sediment Management Design
- Dredging, Capping, & Habitat Design (Including SMU 8)

The graphic below depicts the overall Onondaga Lake Design process, how project documents submitted to date serve as the basis for the various design tracks, and presents the plan for the submittal of the remaining design components.



Onondaga Lake Design Process

1.5 INTERMEDIATE DESIGN ORGANIZATION

This Intermediate Design report is organized into ten sections and multiple appendices. A summary of each section is provided below.

- Section 1: Site Description and Design Process Overview – Presents background information, site description, remedial goals for the site, and a summary of the remedial action.
- Section 2: Community Protection and General Project Requirements – Highlights Honeywell's community participation efforts and presents general requirements applicable to many aspects of the project, including federal, state, and local requirements, ordinances and regulations applicable to the design.
- Section 3: Remediation Areas – Provides an updated basis for the division of the littoral zone into distinct remediation areas, which include capping and/or dredging. The boundaries of these remediation areas are based on the data collected during the pre-design investigation.
- Section 4: Capping and Habitat Restoration – Presents the technical evaluations and design for the sediment cap and the details related to habitat restoration in the remediation areas.
- Section 5: Dredging – Presents the design plans for the dredging areas, depths and volumes for each remediation area and the details pertaining to dredging methods.
- Section 6: In-Lake Debris, Cultural Resources and Utility Management – Presents the characterization and management approach for debris, cultural resources and utilities within capping and dredging areas.
- Section 7: Management of Ambient Water Quality During Dredging and Capping – Presents an overview of the ambient water quality goals and related management and monitoring approach to be implemented during construction.
- Section 8: Construction Sequencing and Schedule - Presents a preliminary analysis of the sequencing of dredging and capping operations in various remediation areas of the lake.
- Section 9: Post Cap Monitoring and Maintenance – Presents summary-level plans for post-construction maintenance and monitoring of the sediment cap.
- Section 10: References – Lists the references used to prepare this report.

SECTION 2

COMMUNITY PARTICIPATION, COMMUNITY HEALTH AND SAFETY, AND GENERAL PROJECT REQUIREMENTS

The health and safety of members of the community and consideration of community input are of paramount importance in designing the lake remedy. Section 2.1 of the *Dredging, Sediment Management, and Water Treatment IDS (*Parsons, 2009a) and the *Sediment Consolidation Area Civil and Geotechnical IDS* (Parsons, 2009b) provide detailed discussions of community considerations and project requirements relevant to those aspects of the Onondaga Lake remedy. The *Onondaga Lake Citizen Participation Plan* (CPP) (NYSDEC, 2009) provides details regarding community involvement for the entire Onondaga Lake Bottom Subsite remedial program. Community considerations and project requirements that pertain specifically to the sediment capping and habitat aspects of the remedy are discussed in the subsections below.

2.1 COMMUNITY PARTICIPATION AND HEALTH AND SAFETY

Honeywell is continuing a Community Outreach Program designed to ensure transparency of the design process, incorporate community ideas and feedback, and to maintain awareness of remedial progress and milestones. This outreach was designed in recognition of the importance of the lake as a natural resource to the surrounding area, and the level of community interest in the progress of the Onondaga Lake remediation. This section discusses the importance of community feedback and some of the design aspects that have been modified based on feedback received to date, and outlines future plans and design components which will help ensure the health and safety of the surrounding community while remedial activities are ongoing.

2.1.1 Community Participation

The NYSDEC and Honeywell are required and committed to informing and involving the public during the remedial design and construction phases of the Onondaga Lake project. Public interest in the cleanup and restoration remains high. The CPP provides a formal, yet flexible plan for communication with the public during the remediation of the Onondaga Lake bottom.

Feedback received through the community participation process has already had a significant influence on design-level decisions in several areas of the remedial design. Pertaining to the activities described in this report, community interest and feedback have primarily focused on the restoration and end-use components of the remedial design. Significant effort has been spent to develop a lakewide plan for the incorporation of habitat restoration. These plans are presented in the draft *Onondaga Lake Remedial Design Elements for Habitat Restoration* (Parsons, 2010). Community members and interest groups such as the Audubon Society, Ducks Unlimited, Citizens Campaign for the Environment, Salt City Bassmasters, New York Wildfowlers, Onondaga County Federation of Sportsmen, Sierra Club, Izaak Walton League of America, and NYSDEC have provided important input to ensure that the vision for post-remediation Onondaga Lake fits with the goals of the community, and that the recreational opportunities facilitated by the remedial design are aligned to maximize the benefit to the surrounding community.

Continued involvement of the community is a critical component to the successful restoration of Onondaga Lake. Opportunities for further community participation have been summarized in the CPP and are incorporated into the design process.

2.1.2 Community Health and Safety

As part of the remedial design process, the design team will continue to work with the community to develop various performance criteria and work plans specifically designed to ensure that the health and safety of the surrounding community and environment is maintained throughout the execution of the remedy. The performance criteria developed will be approved by the NYSDEC prior to any remedial action taking place in the lake. An Onondaga Lake Remedial Operations Community Health and Safety Plan will be prepared as part of the final design which will provide details pertaining to the following:

- Site Security
- Air Quality Management and Monitoring
- Traffic Management
- Navigational Protection
- Noise Abatement
- Spill Prevention

In addition, the Community Health and Safety Plan will include contingency plans to prevent potential hazards to the public posed by remedial activities.

2.2 GENERAL PROJECT DESIGN AND PERFORMANCE CRITERIA

General requirements applicable to the dredging and capping components of the remedial design are described below. Additional details on requirements pertaining to specific aspects of the remedy are provided in Sections 3 through 5.

2.2.1 Sustainability

Honeywell is committed to minimizing the carbon footprint of construction activities anticipated as part of the execution of the remedy. During the design phase, evaluations are being conducted to identify opportunities to incorporate sustainability concepts, including those presented in the *Clean and Green Policy* (USEPA, 2009) and the NYSDEC’s DER-31/Green Remediation program policy into all aspects of the Onondaga Lake remediation. To the extent practicable, use of renewable energy sources, utilization of locally produced/sourced materials and supplies, reduction/elimination of waste, efficient use of resources and energy, and other practices will be specified in the remedial design, and implemented during remedial construction.

2.2.2 Federal and State ARARs

Compliance with federal and state Applicable or Relevant and Appropriate Requirements (ARARs) will ensure that the existing resources are protected during operations and provide for overall protection of human health and the environment. A comprehensive list of chemical-specific, action-specific and location-specific ARARs is included in the ROD. Compliance with federal and state ARARs frequently involves formal permit application and approval processes. Details pertaining to these processes applicable to Onondaga Lake are outlined in the Consent Decree (United States District Court, 2007).

2.2.3 Health and Safety Requirements

The health and safety of site personnel, visitors and members of the public are considered the top priority on this project. Written safety plans will be developed for each phase of the remediation project. Project Safety Plans will be developed and updated as needed to address changing activities and site conditions. The health and safety record of all bidding contractors will be evaluated as part of the bidding process. Selected remedial contractors will be required to prepare Project Safety Plans, which will address potential safety issues associated with the specific tasks the contractor will be performing. Specific requirements, including audit procedures, employee drug and alcohol screening programs, and near-miss reporting protocols will also be specified within the safety plans.

2.2.4 Property and Site Access and Right-of-Way Entry

Several components of the remedy may require the use of non-Honeywell owned property. These activities could include construction laydown and cap material storage areas. Access agreements and necessary permits will be obtained in advance of the execution of the remedial activities. All remedial contractors whose scope requires use of these properties will be required to abide by the terms and conditions of the negotiated access agreements and permits.

SECTION 3

REMEDIATION AREAS

The littoral remediation area has been delineated based on extensive design-related investigations and covers over 400 acres . Design and performance criteria pertaining to establishment of remediation areas are discussed below, followed by a discussion of the design evaluation methods and results. A discussion of remedial areas adjacent to the lake that are included in the lake design is also provided below.

3.1 REMEDIATION AREA DESIGN AND PERFORMANCE CRITERIA

To facilitate achievement of the RAOs and PRGs detailed in Section 1.2 and ensure protection of human health and the environment, numeric sediment cleanup criteria were developed in the ROD. The cleanup criteria that must be met within the littoral area are the probable effects concentration (PEC) of 2.2 mg/kg for mercury and a mean PEC quotient (PECQ) of 1 for the 23 contaminants that showed significant contributions to toxicity on a lakewide basis. These 23 contaminants and the method for calculating the Mean PECQ are provided in Table 3.1. In addition, the ROD also states that “the selected remedy will also attain a 0.8 mg/kg 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.” This criteria is relevant only in determining the remedial scope in the profundal zone (SMU 8).

3.2 REMEDIATION AREA EVALUATION AND DESIGN

Onondaga Lake was divided into eight different SMUs during the FS and ROD process, based on water depth, sources of water entering the lake, and ecological and chemical risk drivers. SMUs 1 through 7 are located in the shallow (littoral) zone (less than 30 ft. water depth) of the lake where most aquatic vegetation and aquatic life reside, while SMU 8 consists of sediment in the deeper (profundal) zone (deeper than 30 ft). These SMUs were developed for remedial alternative development and evaluation purposes. Also, the ROD-specified remedy presented the required in-lake portions of the remedy on a SMU-specific basis. These SMU-specific ROD requirements will be met during remedy design. However, analysis of the data collected following the FS and ROD as part of four years of design-related investigation indicated that the SMU boundaries did not always accurately define the limits of the individual sub-areas of the lake. Therefore, the concept of remediation areas has been developed to facilitate the design process.

To more accurately reflect the current understanding of in-lake conditions, the littoral area remediation has been redefined into remediation areas (RA) A through F. Remediation areas and their relationship to SMU boundaries are shown in Figure 3.1. A summary description of these remediation areas is provided below.

- Remediation Area A - Mouth of Ninemile Creek. SMU 4 was originally delineated based on the sediment impacts resulting from the discharge of Ninemile Creek. Subsequent data indicated these impacts extended into adjacent SMUs 3 and 5.

Therefore, Remediation Area A includes SMU 4 and adjacent impacted areas in SMU 3 and SMU 5.

- Remediation Area B – SMU 3 was originally delineated based on the area impacted offshore of Wastebeds 1-8. This is consistent with the Remediation Area B designation. However, it excludes the portions of SMU 3 that are now included in Remediation Area A and Remediation Area C.
- Remediation Area C – This area is offshore of the New York State Department of Transportation (NYSDOT) Turn-around Area and the Willis/Semet IRM barrier wall, consistent with SMU 2. However, based on design-related investigation data, the area of contamination extends into adjacent SMU 3, which is included in Remediation Area C. Also, the ILWD was found to extend into SMU 2. The SMU 2 ILWD area is excluded from Remediation Area C.
- Remediation Area D – SMU 1 was originally delineated as the extent of ILWD in the littoral area. Based on design-related investigation data, the ILWD extends into SMU 2 and SMU 7. Remediation Area D includes the ILWD in SMUs 1, 2, and 7.
- Remediation Area E – This includes the southwestern end of the lake, inclusive of SMU 6 and SMU 7, except for the portion of the ILWD that extends into SMU 7. It also includes the contiguous remedial area that extends into adjacent SMU 5.
- Remediation Area F – This includes small areas of impacted sediment north of Remediation Area A and on the north-eastern shore within SMU 5.

The designation for SMU 8 has not been revised (i.e., profundal zone in water depths greater than 30 ft.).

Remediation area boundaries, as shown in Figures 3.2 through 3.4, were established using the extensive sediment database available from the RI and six phases of design-related investigations. The boundaries were drawn from point to point based on sampling locations where contaminant concentrations are below the sediment cleanup criteria (i.e., neither a mean PECQ of 1 nor a mercury concentration of 2.2 mg/kg) are not exceeded. This provides for a more conservative establishment of remediation boundaries than methods that rely on interpolation or kriging between sampling locations to estimate remediation boundaries, and ensures all sediments exceeding cleanup criteria will be addressed.

Remediation Area boundaries were drawn from point to point based on sampling locations where the sediment cleanup criteria were not exceeded at any depth from the shoreline out to a water depth of 20 ft. (6 meters). This conservative approach will prevent impacted subsurface sediments underlying sediments that do not exceed criteria from potentially being exposed in the future due to natural processes such as erosion.

Remediation area boundaries between 20 ft. (6 meters) and 30 ft. (9 meters) were drawn from point to point based on sampling locations where the sediment cleanup criteria were not exceeded in the top 1 ft. of sediment. Due to the depth of overlying water in these areas, existing sediments are stable even under a 100-year storm event in water depths from 20 ft. to 30 ft. (6 to 9 meters) in Remediation Area A, Remediation Area B, Remediation Area C, and Remediation Area F, and would be expected to see only minor disturbances in Remediation Area E, as documented in Appendix D. This demonstrates that deeper impacted sediments would not be exposed even under extreme events (e.g., 100-year storm). Therefore, determination of remediation area boundaries in these deep water areas is appropriate based on consideration of the top 1 ft. of sediment. These areas are also net depositional, as discussed in Section 4.1.6, therefore the thickness of clean surface sediments in these areas will increase over time.

As shown in Figure 3.3 and detailed in Appendix A, the remediation boundary addressed in this design report includes a small portion of SMU 8 directly adjacent to Remediation Area D. This Remediation Area D addendum cap area (approximately 5.6 acres) has elevated mean PECQ values; therefore, a chemical isolation cap rather than a thin-layer cap is appropriate for this area of SMU 8. Chemical isolation cap details are provided in Section 4.1. All other SMU 8 surface sediment mean PECQ values in the vicinity of Remediation Area D have a mean PECQ value less than 2, and therefore will be remediated with thin-layer capping and monitored natural recovery, consistent with other areas of SMU 8. Additional details pertaining to delineation of this addendum cap area are provided in Appendix A. Delineation of the SMU 8 areas subject to thin-layer capping are detailed in the SMU 8 IDS.

Remediation Area C includes the localized area around sample location S48. This sample location does not exceed remediation criteria, but showed a chironomid mortality greater than 50% during the RI. The remediation boundary around sample location S48 was based on surrounding sample locations that did not exceed remediation criteria, consistent with other remedial area delineation.

Appendix A provides documentation pertaining to development of these remediation area boundaries. Discussion on boundaries associated with capping versus dredging and capping is provided in Sections 4 and 5. The remediation area boundaries as well as the boundaries for capping areas and dredging areas shown in Figures 3.1 through 3.4 may be subject to minor revisions based on ongoing technical evaluations and additional limited sediment data collected in late 2010 that was not included in the design.

3.3 LAKE BATHYMETRY, WATER ELEVATIONS, AND SHORELINE DEFINITION

The remediation area boundaries extend to the lake shoreline. The water level used to define the shoreline and for the lake remediation design was 362.5 ft. (North American Vertical Datum [NAVD]88) in order to meet habitat objectives focused on plant communities in nearshore areas of the lake. This elevation of 362.5 ft. is the average lake level during the aquatic plant growing season. The average annual lake surface elevation is 362.8 ft. (NAVD88), which is slightly higher than the average lake surface elevation during the aquatic plant growing season.

A dam located approximately 15 miles downstream of the lake along the Oswego River in Phoenix, New York, controls the water level in the lake, but the lake level can change seasonally due to spring run-off and dry summers as well as daily due to weather events. Extreme events can raise the lake level to as high as 369 ft. above mean sea level [MSL] (highest recorded level was 369.77 ft. above MSL). Low lake levels are typically not lower than 1 ft. below average due to the dam system in the river (lowest recorded level was 361.59 ft. above MSL). High water events are relatively frequent, with the lake elevation above 366 ft. above MSL more than 180 days during the past 30 years (approximately 2% of days on record). 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.

Geophysical and bathymetric surveys of Onondaga Lake were performed by CR Environmental, Inc. to define lake bathymetry for design purposes as part of Honeywell's Phase I Pre-Design Investigations (PDI) (Parsons, 2005) as documented in *Onondaga Lake Phase I Pre-Design Investigation Geophysical Survey Report* (CR Environmental, 2007). Four types of surveys were conducted as part of the Phase I PDI: (1) bathymetric survey to identify the contours of the lake bottom ; (2) side-scan sonar to characterize debris, obstructions, and other surficial features of the lake bottom; (3) sub-bottom profiling to supplement the assessment subsurface stratigraphy; and (4) magnetometer data to identify fired debris (such as bricks) and obstructions containing iron within or on top of the lake sediments. A 1-ft. contour interval bathymetric map of Onondaga Lake was generated from the 2005 data set and is the basis for the design described in this report.

3.4 ADJACENT REMEDIATION AREAS INCLUDED IN DESIGN

The lake design includes portions of the designs for three areas along the shoreline that are being remediated in addition to the lake: the spits at the mouth of Ninemile Creek, the connected wetlands and shoreline stabilization at Wastebeds 1-8, and the Wastebed B/Harbor Brook (WBB/HB) Outboard Area (Figure 3.5). Due to similarities in remedial approaches and the connectivity with the adjacent lake dredging, capping and habitat designs, remediation of these areas will occur in conjunction with the remediation of the adjacent lake area. Integration is required to provide for appropriate transitions between the lake and adjacent remediation areas. Each of these areas is included in the Draft Habitat Plan and discussed in detail below.

3.4.1 Ninemile Creek Spits

Ninemile Creek flows into Onondaga Lake and was impacted by past industrial activities, as was its tributary Geddes Brook. The remedial approach for the lower portion of Ninemile Creek, referred to as Operable Unit 2 (OU-2), is documented in the 2009 Operable Unit 2 of the Geddes Brook/Ninemile Creek Site ROD (NYSDEC and USEPA, October 2009). The spits of land that extend into the lake at the mouth of Ninemile Creek were included as part of OU-2 (Figure 3.5), and were formed by deposition of sediments coming from Ninemile Creek. As documented in the OU-2 ROD, remediation of the spits includes sediment removal, placement of a cap/backfill material, and habitat restoration, consistent with the remediation of adjacent lake areas in Remediation Area A.

Remediation of the spits will be completed as an integral part of the lake remediation, and the therefore the design for this area is included in this submittal. The spits on both sides of the mouth of Ninemile Creek are delineated as emergent wetlands. The integrated design for this area includes removal of the complete area delineated as emergent wetland (approximately up to the shore tree line), construction of a chemical isolation cap similar to the lake chemical isolation cap and habitat restoration. The removal of the eastern spit terminates just prior to the start of the future shoreline groundwater collection system on the east side, and the scrub-shrub upland on the south. The western spit terminates along the deciduous forest wetland on the south border of the emergent wetland delineation. The removal approach for materials within the spits and material management strategy associated with removed material are under evaluation as part of the Ninemile Creek design.

3.4.2 Wastebeds 1-8

The Wastebeds 1-8 Site, a subsite of the Onondaga Lake Superfund site, is located along approximately 2.1 miles of Onondaga Lake's southwest shoreline and borders Ninemile Creek (Figure 3.5). The wastebeds consist largely of inorganic wastes resulting from the production of soda ash using the Solvay process. The Wastebeds 1-8 IRM will include the construction/ operation of a shoreline groundwater collection trench (O'Brien & Gere, 2010) to control shallow groundwater discharging to the lake from this area via a shoreline groundwater collection trench (O'Brien & Gere 2010). Dredging will be completed up to the shoreline to ensure adequate depth for placement of the cap and for habitat restoration as part of the Remediation Area B remedy. The removal will slope from the bottom of the dredge cut along the shoreline into the adjacent upland. The shoreline groundwater collection trench location will be documented in the Wastebeds 1-8 IRM design and will take into consideration this slope.

Remedial activities on Wastebeds 1-8 include construction of 2.3 acres of lake-connected wetlands in the vicinity of Remediation Area B to off-set the loss of lake surface area associated with the off-shore location of the Willis IRM barrier wall in Remediation Area C, as documented in the ESD discussed in Section 1.3. This will include removal of material above and below the water table, construction of an isolation cap, and habitat restoration. The removal area and depth and cap construction details for the connected wetlands are being developed as part of this design due to the similarities in design and the connectivity between the lake remediation and connected wetland construction. The material removal approach and associated material management strategy associated with the wetland construction are being developed as part of the IRM design.

The Wastebeds 1-8 IRM also includes a vegetative cover along the eastern shore and shore stabilization along the surf zone of Remediation Area A. These elements will be integrated with the shoreline stabilization along Remediation Area B required by the Onondaga Lake ROD to address erosion of Solvay waste material along the shoreline of Wastebeds 1-8. The lake design includes the shoreline treatment within the lake and extending up to an elevation of 365 ft. (NAVD88) in both Remediation Area A and Remediation Area B, due to the consistency of the stabilization and restoration approach from the lake shore up to this elevation.

3.4.3 Wastebed B/Harbor Brook Outboard Area

The Outboard Area is a 16-acre strip of land that lies between Onondaga Lake and the Wastebed B barrier wall alignment, and includes the mouth of Harbor Brook and areas of wetlands along the lake shoreline. The Outboard Area is part of the WBB/HB Site, which is subsite of the Onondaga Lake Superfund site. In order to maintain the overall schedule for remediation of Onondaga Lake, Honeywell has proposed to address remediation of the Outboard Area as an IRM. The comprehensive scope of this IRM is still under development and will be detailed in upcoming submittals specific to the Outboard Area.

Based on the wetland restoration concepts advanced as part of the Draft Habitat Plan (Parsons, 2009), it is anticipated that the remedy will include removal of material above and below the water table, construction of an isolation cap, and habitat restoration. Due to the similarities in design and the connectivity between the lake remediation and outboard area construction, the cap and habitat restoration details are being developed as part of this design. In addition, the minimum required sediment removal to allow cap construction and habitat restoration are developed as part of this design. The total removal volume, removal approach for materials above and below the water table, and material management approach associated with the Outboard Area are being developed as part of the ongoing IRM scoping activities.

SECTION 4

CAPPING AND HABITAT RESTORATION

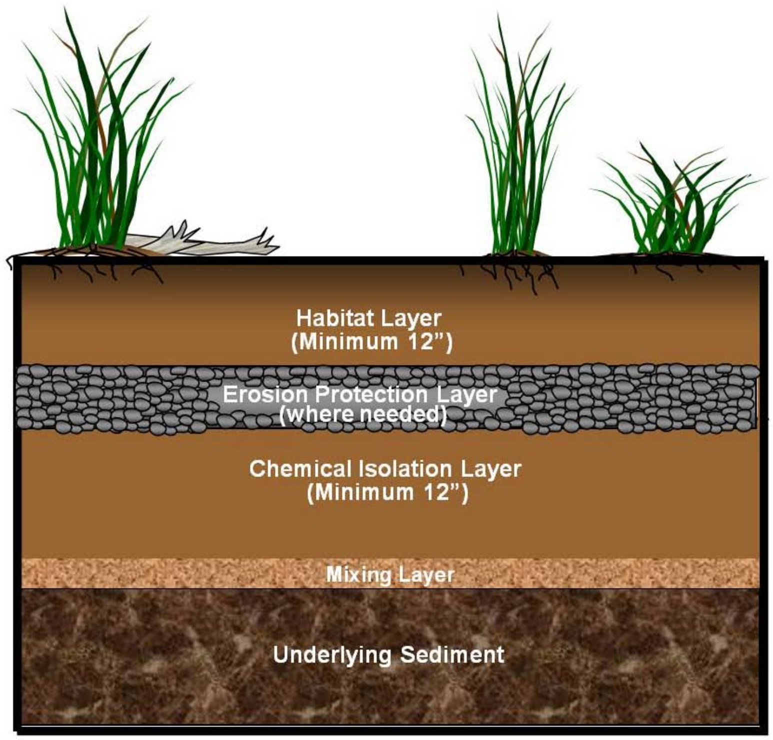
Restoring diverse, functioning and sustainable habitats to the remediated areas of Onondaga Lake is one of the top priorities of this remedial program. Therefore, habitat considerations are at the forefront of the various design evaluations for the lake and have been fully integrated into this document. Habitat considerations are a major factor in developing cap thicknesses. The cap will provide long-term chemical isolation of underlying impacted sediments. It will be resistant to erosive forces such as wind/wave-generated currents, tributary and other inflows, and ice. It will also provide a suitable habitat substrate that plants, animals, and fish can use without impacting the chemical isolation layer.

The depth of sediments requiring dredging in many parts of the lake is determined by the depth of water desired following construction and the thickness of the cap necessary to meet chemical isolation, erosion protection, and habitat objectives. Water depths following dredging and capping were developed in the Draft Habitat Plan to achieve optimum habitat conditions. For example, in areas near the mouth of Ninemile Creek, the habitat restoration goal includes development of areas where floating aquatic plants such as lily-pads will thrive. This type of habitat is currently absent from Onondaga Lake. The optimal water depth for floating aquatic plants is 1 ft. to 3 ft. Dredging to achieve a water depth of 7 ft. prior to placement of a 5 ft. thick cap (including a 2 ft. habitat layer) would result in a post-remediation water depth of 2 ft., which is ideal for floating aquatic plants. Because dredge depths are developed based on these types of considerations in many areas, the cap and habitat restoration goals and design are developed in this section prior to presentation of the dredging design in Section 5 even though dredging will be completed prior to capping as part of the construction sequence.

Detailed technical evaluations presented below demonstrate that capping will be effective in Onondaga Lake. Capping of subaqueous contaminated sediments is an accepted and proven long-term engineering option for managing dredged materials and for *in situ* remediation of contaminated sediments (USEPA, 1994, 2005; NRC, 1997, 2001; Palermo, Clausner, et al., 1998, Palermo, Maynord, et al., 1998), and is a significant component of the Onondaga Lake remedy. Sediment caps are a proven technology and have been implemented at numerous sediment remediation sites, including the Fox River in Wisconsin, the St. Louis River Interlake Duluth Tar site in Minnesota, Commencement Bay in Washington. Based on the cleanup objectives established for the lake, the functions for the cap include:

- Restoration and enhancement of aquatic habitat in the lake
- Physical isolation of the contaminated sediment from the aquatic environment
- Reduction or elimination of the flux of dissolved contamination into the upper layers of the cap such that cap performance criteria are not exceeded
- Stabilization of contaminated sediment, preventing resuspension and transport of contaminants to the profundal area and other areas of the lake

To ensure that these goals are met and that the cap provides long-term protection of human health and the environment, the cap will include specific layers dedicated to various purposes. These layers will include a habitat layer, an erosion protection layer, a buffer layer and a chemical isolation layer, as well as an allowance for mixing of the bottom of the chemical isolation layer with the underlying existing lake sediment, as shown in the schematic below. Minimum thicknesses for the habitat layer and chemical isolation layer shown below are based on ROD-specified minimums.



General Schematic of Sediment Cap

In addition to the layers shown above, a buffer or safety layer will be incorporated into the habitat layer or added to the chemical isolation layer, as required by the ROD. A detailed discussion of each cap layer and the basis for the layer thickness and substrate type is provided in Sections 4.1 through 4.3. Thicknesses and materials for these layers in each Remediation Area are shown in Figures 4.1 through 4.6.

Based on evaluations presented in these sections, the minimum habitat layer thickness will range from 1 ft. to 2 ft. depending on the water depth. The habitat layer material will range from sand to coarse gravel, consistent with the intended habitat for specific areas of the cap. The minimum erosion protection layer will range from 0.5 ft. to 1 ft. thick for various areas of the cap. The erosion protection layer material will range from sand to cobble-sized materials, consistent with the erosion protection requirements for specific areas of the cap (see Section 4.2 and Appendix D). In areas where the desired grain size of habitat layer material is consistent with the erosion protection layer material requirements, the layers will be combined since a single layer can function as both in such cases.

The chemical isolation layer will consist primarily of sand or gravely sand. Based on detailed modeling, the chemical isolation layer will be 1 ft. thick throughout the capped area. In certain areas, modeling indicates that a thinner cap would be effective; however the minimum cap thickness as specified by the ROD is 1 ft. In certain areas, amendments, including granular activated carbon and siderite will be added to the chemical isolation layer to ensure that the 1 ft. thick layer will be protective in the long term. GAC will provide an added level of protectiveness by improving sorption of contaminants within the isolation layer. Siderite, a naturally occurring mineral, will be added in areas where elevated pH in underlying sediments, such as the ILWD, could impede long-term microbial degradation of contaminants within the isolation layer. As described above, the chemical isolation layer placement will include an allowance for mixing of the bottom of the cap with the underlying existing lake sediment.

The modeling used to develop the design of the chemical isolation layer is conservative in that it does not include several factors that will significantly contribute to the long-term performance of the cap. Specific concepts and processes not incorporated into the model which will result in an even higher level of long-term chemical isolation than predicted by the model are summarized below. Additional modeling conservative assumptions are detailed in Appendix B. Future modeling revisions may be completed to incorporate some of these factors, such as long-term biological decay.

- Long-term anaerobic biodegradation of organic contaminants will occur within the chemical isolation layer and bottom of the habitat layer, lowering long-term contaminant concentrations and transport within the cap.
- Rapid aerobic biodegradation will occur within the upper portion of the habitat layer. This will result in lower contaminant concentrations at the surface of the cap, where essentially all benthic activity occurs.
- An allowance for placement of additional cap thickness beyond the design-specified minimum will be provided to the remediation contractor during construction to ensure that the minimum thickness is achieved everywhere. This material over-placement will result in increased contaminant sorption, biological decay, and amendment application, and will lower concentrations throughout the cap and extend its long-term performance.
- Additional activated carbon beyond the design-specified minimum will be incorporated into the chemical isolation layer to account for potential unequal mixing of the activated carbon with the sand.
- Additional material will be placed to account for mixing of the bottom of the cap with the underlying sediment (the mixing layer) which provides additional chemical isolation.
- The modeling includes porewater data from sediments with higher contaminant concentrations than will remain after dredging. The higher concentrations will be removed during dredging, including ILWD hot spot areas.

As listed above, the actual thickness of each cap layer constructed in the field will typically exceed the minimum required design thickness based on engineering analyses due to operational considerations of how the cap materials will be placed in the lake. The contract requirements will specify that the contractor will need to place a minimum thickness for each layer. To ensure that the minimum required cap thickness is obtained, the capping construction contract will allow for over-placement beyond the minimum target cap layer thickness. This over-placement allowance addresses the tolerances contractors can achieve given the water depths, bathymetry, currents, waves, capping equipment, and other factors. For each specific layer (e.g., chemical isolation, erosion protection, and habitat) the contract documents will specify the minimum thickness and the allowable amount of over-placement. The result will be that the final thickness of each layer will be equal to or more than the specified minimum thickness in each area, which will provide additional chemical isolation and habitat value. However, over-placement will be controlled during construction to prevent excessive cap material placement so that target water depths can be achieved for specified habitat objectives. Section 4.3.4 discusses how cap over-placement allowances and target habitat water depths were considered in the design of the dredge depths and areas.

There are several areas associated with design and construction of the cap where adaptive management concepts may be appropriate. Adaptive management refers to enhancements to project implementation based on lessons learned and from actual experience gained during the course of the project. These lessons learned can lead to revisions to the assumptions that were made during the course of the design, allowing the project construction schedule and final effectiveness to be optimized. Specific areas of the dredge and cap design and construction where adaptive management may be appropriate include over-dredge and cap material over-placement allowances, cap mixing layer thickness, water quality monitoring, debris removal, and project sequencing.

4.1 CHEMICAL ISOLATION LAYER

The chemical isolation layer will physically and chemically isolate aquatic plants, benthic organisms, animals and humans from the underlying sediment. Chemical isolation is achieved through placement of a clean cap material that inhibits contaminant migration for hundreds or even thousands of years. This long-term isolation is a result of contaminant sorption onto the cap material as well as contaminant degradation through biological processes within the chemical isolation layer. This section discusses design and performance criteria, the methods and results from bench testing, design evaluations, computer modeling, and the design of the chemical isolation layer.

4.1.1 Chemical Isolation Layer Design and Performance Criteria

Design and performance criteria for the chemical isolation layer based on ROD requirements and other project-specific considerations are listed below.

- Computer modeling will be used to determine the required thickness and composition of the chemical isolation layer such that concentrations of contaminants, which may migrate into the habitat layer, do not exceed cap performance criteria.
- As required by the ROD, the chemical isolation layer will be a minimum of 1 ft. thick.

- As required by the ROD, a buffer layer, or safety layer, equal to 50% of the thickness of the chemical isolation thickness will be added to the overall cap thickness. As part of the design, a decision will be made regarding what portion (if any) of the buffer layer may be considered part of the habitat restoration layer.
- The point of compliance, consistent with the ROD, is at the bottom of the habitat layer. The isolation layer will be designed to prevent unacceptable concentrations of contaminants throughout the habitat restoration layer.
- The performance criteria for the cap at the point of compliance and throughout the habitat layer will be the PEC for each of the contaminants that have been shown to exhibit acute toxicity on a lakewide basis (see Table 3.1), as well as the NYSDEC sediment screening criteria for benzene, toluene, and phenol.
- A thin-layer cap in lieu of the isolation cap may be appropriate based on design evaluations in some depositional portions of the littoral zone in water depths from 20 ft. to 30 ft. (6 to 9 meters) provided it can be demonstrated that it will be effective in meeting remedial goals.

The design team undertook extensive bench-scale evaluations, design analyses, and computer modeling to develop the chemical isolation layer design in accordance with these design criteria, the results of which are discussed below.

4.1.2 Chemical Isolation Layer Bench-Scale Evaluations

Tests were conducted to simulate site-specific conditions, evaluate *in situ* fate and transport processes, assess potential cap amendment performance for select areas of the lake, and provide information for the chemical fate and transport modeling (see Section 4.1.3). The design of the chemical isolation layer of the cap is supported by over six years of site-specific laboratory and bench-scale testing. Bench tests were designed and executed in consultation with and by leading researchers in the field of sediment cap design. Specifically, bench-scale experiments were conducted to evaluate:

- Biological degradation rates for use in cap modeling to determine the isolation layer thickness
- Whether significant gas is generated within lake sediments, and if so, whether it could result in contaminant migration through the cap
- Whether consolidation of underlying sediments resulting from cap placement could result in NAPL migration into the cap
- Contaminant partitioning onto cap material for use in cap modeling to determine the isolation layer thickness
- Effectiveness of sorption amendments (carbon, organoclay and peat) in minimizing contaminant migration through the cap
- Effectiveness of amendments for buffering pH in order to promote biological decay of contaminants within the cap

The following sections provide detail on each of these evaluations, including a summary of the results and a discussion on their application and relevance to the chemical isolation layer design. Complete reports and work plans referenced below are available in the Onondaga Lake public repositories, or will be available once they receive approval by NYSDEC.

4.1.2.1 Biological Degradation Bench Testing

Biological degradation of organic contaminants within the chemical isolation layer is an important contaminant fate process considered in the design of the chemical isolation layer. Over time, natural biological processes will degrade organic contaminants as they slowly migrate upwards into the cap and reduce contaminant concentrations throughout the isolation layer and the overlying habitat layer. Several stages of bench-scale experiments were conducted to evaluate the rate of biological decay anticipated to occur within the cap for key compounds present in lake sediments and porewater.

Rapid aerobic decay was consistently observed for all VOCs evaluated, as discussed below. Anaerobic decay was also documented for all VOCs in at least one of the bench-scale studies. However, given the inherent complexities in replicating long-term environmental processes in the relatively short-term investigation period, it is difficult to quantitatively measure anaerobic biological degradation rates for all of the VOCs. There is evidence from the testing described below and in the literature that over time anaerobic biological decay will occur in the isolation cap for all of the VOCs, including naphthalene. However, as a conservative assumption, the current model predictions do not quantitatively incorporate biological decay of any contaminants except phenol. Robust aerobic and anaerobic biological decay of phenol was observed consistently under a variety of conditions during multiple phases of PDI bench testing. Therefore, biological decay of phenol is considered in the modeling evaluation in areas that do not require a pH amendment. Future model revisions may incorporate biological decay for other contaminants.

The first stage of bench testing included batch slurry experiments as part of the Phase II PDI to qualitatively assess biological degradation (Parsons, 2006). Under these experiments, sealed vials of a mixture of lake sediment and water were sampled and analyzed over time for contaminant biological decay. The slurry experiments indicated that anaerobic biological decay of those organic compounds anticipated to drive the cap design can occur naturally in most areas of the lake (Parsons, 2009e). The slurry experiments also suggested that biological decay within the cap in Remediation Area D would likely not occur at significant rates without neutralization of the pH of porewater as it passes through the cap due to the high pH of the underlying ILWD.

Building on the results of the batch slurry experiments, column studies were executed during Phase III of the PDI (Parsons, 2007). The column studies simulated *in situ* cap conditions and provided a realistic representation of microbe density and contaminant fate and transport through a sand cap. A layer of Onondaga Lake sediment (approximately 6 in. thick) was placed at the bottom of each column, and layer of sand capping material was added over the top of the sediment layer. Water flow was introduced through each column and effluent water samples were collected and analyzed periodically from the top of the column above the sand cap layer. In general, the results of the Phase III PDI column tests were similar to those observed in the batch slurry experiments. Biological decay was observed in columns collected in Remediation Area E (SMU 6 and 7), while columns collected in Remediation Area D (ILWD) showed little to no biological activity (Parsons, 2009d).

Additional batch and column experiments were conducted to supplement the results of the Phase III PDI testing and evaluate variability in the experimental results. Column experiments were designed to collect additional information on biological decay rates in areas not impacted by elevated pH or where pH will be neutralized as part of the capping remedy (Parsons, 2008). In addition, a second set of batch slurry experiments was executed as part of the Phase V PDI (Parsons, 2008) to provide additional detail on biological degradation rates, mechanisms and geochemical processes. The results of the additional column studies demonstrated degradation of certain CPOIs over the time frame of the experiment. Results from extensive batch testing under a variety of conditions showed rapid aerobic degradation of all organic compounds and anaerobic degradation of phenol, toluene, and DCBs. Testing is ongoing; however, significant biological decay of the other CPOIs has not definitively been measured to date. Testing related to evaluation of potential impacts associated with pH indicated that biological decay was not impeded at a pH of 8.0, but may be impeded at a pH of 8.5 and higher.

4.1.2.2 Mercury Transport Bench Testing

The mercury partitioning coefficient is a key input parameter to the cap model evaluation. Isotherm experiments, as discussed in more detail in Section 4.1.2.5.1, were conducted to assess partitioning of mercury onto sand, activated carbon, peat and organoclay. Modeling of mercury partitioning is based on the results of these isotherm experiments. This is a very conservative approach to modeling mercury in the areas of the cap where siderite will be added to reduce pH. Results from leachate testing using site porewater and siderite conducted during PDI Phase IV (Appendix I) as well as batch testing conducted during PDI Phase VI (Parsons, 2010) (see Section 4.1.2.5.2) demonstrated near complete removal of mercury from porewater in the presence of siderite (presumably due to formation of stable precipitate that cannot be transported in the aqueous phase). This process has not been incorporated into the cap modeling, nor has the sorption of mercury onto activated carbon, which was documented as part of the Phase IV (Parsons, 2009e) and Phase VI PDI isotherm studies. Removal of mercury by siderite will be further documented by evaluating mercury concentrations during the Phase VI PDI column studies which are underway to further evaluate siderite performance with respect to pH neutralization and mercury transport.

Prior to disassembling the Remediation Area D (SMU 1) Phase III PDI biological decay columns described in Section 4.1.2.1, the flow rate of water was increased significantly (to generate the necessary volume for analysis) and effluent water samples were collected and analyzed for mercury. Samples were also collected along the cap profile and analyzed for mercury. These results indicated that there was no transport of mercury through the cap over the course of the experiment (Parsons, 2009d). Given the lack of mercury transport into the cap, it was not possible to determine a quantitative partitioning coefficient for mercury from these studies.

Mercury-specific column experiments were conducted during the Phase IV PDI (Parsons, 2008). The sediment sampling locations used to generate sediment for these tests were located in areas with elevated porewater mercury concentrations to allow for detectable concentrations during column studies; additionally these samples were also located in areas with high pH. The results from these column studies demonstrated low partitioning coefficients under the high pH conditions present. Reduced mercury partitioning would be expected at high pH. In areas where pH is currently elevated, the current design includes pH neutralization via siderite amendments in the cap, therefore these results were not used for cap modeling.

4.1.2.3 Gas Generation Bench Testing

Bench study results, as well as the technical team's experience at other capping sites, indicate that contaminant mobilization driven by gas generation will not occur at significant levels in Onondaga Lake. Gas generation experiments were designed during Phase II of the PDI to measure the gas generation potential of sediments underlying the cap and to assess the potential for gas to impact contaminant migration (Parsons, 2006). These experiments involved measuring gas generation and release in closed tubes filled with lake sediment. Based on the gas generation rates measured in the batch studies, potential contaminant transport was assessed through column experiments. In the gas column experiments, gas was introduced to a sediment layer at a rate consistent with the upper range of gas generation rates measured in the batch tests. Monitoring results did not detect significant contaminant migration as a result of gas generation. (Parsons, 2009c).

4.1.2.4 Settlement-Induced NAPL Migration Bench Testing

Bench test results indicate that NAPL migration will not result due to consolidation of Onondaga Lake sediments as a result of capping. Settlement-induced NAPL consolidation studies were conducted during Phase II of the PDI to assess the potential for increased mobility of NAPL in Onondaga Lake sediments due to the physical loading of a sediment cap (Parsons, 2006). These studies involved subjecting a series of sediment samples to loads equivalent to the range of potential loading anticipated from placement of a sediment cap. These studies were focused on samples from areas of known high contaminant concentration and where stained sediments potentially indicative of discontinuous "blebs" of NAPL were observed.

Neither the application of a load exceeding the maximum that would result from cap placement norr the resulting consolidation of the lake sediments resulted in NAPL release in any sample. The intermittent and weathered form of NAPL observed in the sample cores was not consistent with the type of NAPL that has a high potential for migration into the cap as settlement occurs.

4.1.2.5 Amendment Bench Testing

Following the biological decay bench testing conducted during the Phase II and Phase III PDI discussed in Section 4.1.2.1, it became evident that in areas where elevated levels of pH impact biological activity, cap amendments would likely be appropriate in order to meet the cap performance criteria specified in the ROD. Therefore, a series of bench testing was conducted to evaluate potential cap amendments. These studies focused on amendments that would increase the sorbtive capacity of the cap, as well as amendments that would neutralize the high pH within the cap resulting from elevated pH in the underlying sediment, as discussed below.

4.1.2.5.1 Isotherm Testing of Organoclay, Sand, Peat, and Activated Carbon

Isotherm testing was conducted during the Phase IV PDI on selected organic contaminants and mercury using representative porewater from Remediation Area D and Remediation Area E

(SMUs 1 and 6/7, respectively) to assess the contaminant sorbtive capacity of sand, activated carbon, organoclay and peat (Parsons, 2008). Based on the results of the isotherm experiments, subsequent modeling, and constructability considerations, activated carbon was selected as the most effective and appropriate cap amendment to improve contaminant sorption in areas where cap amendments will be incorporated (Parsons, 2009e).

Prior to full isotherm development, preliminary isotherms were conducted on four types of activated carbon to identify the best candidate to study in detail. The preliminary isotherm experiments were designed to obtain the necessary information for executing the full isotherm experiment. These experiments were also designed to identify the form of activated carbon most resistant to fouling by natural organic matter through a comparison of isotherm results in organic free water with those results obtained from SMU 1 porewater. The preliminary experiments identified Calgon Carbon Corporation Filtrasorb™ 400 (F400) 12 x 40 mesh as the optimal activated carbon to conduct full isotherm studies based on the sorption capacity measured as well as the fact that F400 carbon is a standard product subject to less variability than regenerated carbon. Regenerated carbon also performed well in the screening experiments, demonstrating effective sorption and resistance to organic fouling similar to the virgin F400 carbon (Parsons, 2009f), and may be considered for application as the design progresses.

Additional isotherm testing was conducted during the Phase VI PDI to validate the Phase IV PDI results and evaluate each isotherm point in triplicate to reduce variability in the initial testing (Parsons, 2010). Screening studies conducted during the Phase VI isotherm experiments indicated a potential influence of pH on activated carbon sorption for some compounds. As a result, a second round of isotherms was conducted at a neutral pH. Results from the adjusted pH isotherms were generally consistent with or more conservative (i.e., showed less sorption) than the Phase IV results, and employed higher levels of QA/QC; therefore, the Phase VI amended pH carbon isotherms were used in the cap modeling evaluation for all cap areas where a activated carbon amendment will be employed.

As part of the Phase III PDI column studies described under Section 4.1.2.1, two columns were also initiated using activated carbon. These columns have been running for a two to three year period at a flow rate equivalent to 279 cm/yr. which is approximately two orders of magnitude higher than will be present within the cap. Evidence of contaminant breakthrough has not been observed in the effluent to date.

4.1.2.5.2 pH Amendment Evaluation

Bench test results, in conjunction with constructability considerations, were used as the basis for selecting granular siderite as the preferred pH amendment. The pH amendment testing was completed during the Phase III PDI to evaluate methods to neutralize pH within the sediment cap in order to enhance biological decay in areas where pH is elevated in underlying sediments (Parsons, 2007). The amendments tested included three forms of siderite (powder, pelletized and granular), iron sulfate, aluminum sulfate, iron phosphate, aluminum phosphate, and peat. Batch testing was used to derive information on pH neutralization rates and endpoints for different application rates of the amendments tested (Parsons, 2009f). Granular siderite successfully lowered the pH and did not drop the pH below a circumneutral pH endpoint (between 6 and 8).

Geochemical modeling was conducted to assess the performance of siderite and to establish dosing rates. Appendix I provides additional detail on the cap pH modeling.

Two different leaching tests were also performed on siderite to evaluate potential impacts due to trace metals and other impurities possibly present in the material. As detailed in Appendix I, results from this testing confirm that there would be no adverse environmental impacts in the lake due to placement of siderite as part of an amended cap layer. Additionally, results from the leachate testing for mercury showed that addition of siderite resulted in a reduction of Mercury concentrations in porewater to levels below the reporting limit. The effects of siderite on mercury concentrations are being further evaluated as part of the Phase VI PDI.

Following the Phase III batch testing and cap pH modeling, additional column testing was initiated to provide information on potential porous media effects that need to be considered in up-scaling from bench scale to field scale. This testing is ongoing and results will be discussed in the draft final design report. Results may impact the mass application rate of siderite but are not expected to influence other aspects of the design.

4.1.3 Chemical Isolation Layer Design Evaluations

Design of the chemical isolation layer was based on site-specific data, laboratory bench-scale evaluations and computer models that simulate cap processes and evaluate long-term cap performance. Two design models, developed by experts in the field of sediment cap design, were employed to evaluate: 1) steady state; and 2) transient concentrations throughout the cap profile and to calculate concentrations within the habitat layer.

The steady-state model was used to predict concentrations that would exist after contaminants have travelled upwards into the cap and an equilibrium condition becomes established between advective and diffusive transport, biodegradation (where quantified), and exchange with the overlying water column. This model was used as a conservative screening tool to reduce the number of contaminants requiring detailed evaluation, and is described in detail in Appendix B. The transient model was used to predict time-varying concentrations within the cap system and was used to evaluate non-linear sorption processes, short-term impacts resulting from porewater expression from underlying sediment resulting from settlement, and long-term behavior for the amended cap areas.

These models have been published and discussed in peer reviewed literature (Lampert and Reible, 2009 and Palermo, Maynord, et al., 1998) and have been tested by Parsons and independent reviewers by benchmarking against other models. Appendix B provides additional detail on the models employed, modeling strategy, modeling framework and model results. Modeling results are summarized in Section 4.1.4. Isolation layer modeling was conducted in Remediation Area A, Remediation Area B, Remediation Area C, Remediation Area D, and Remediation Area E.

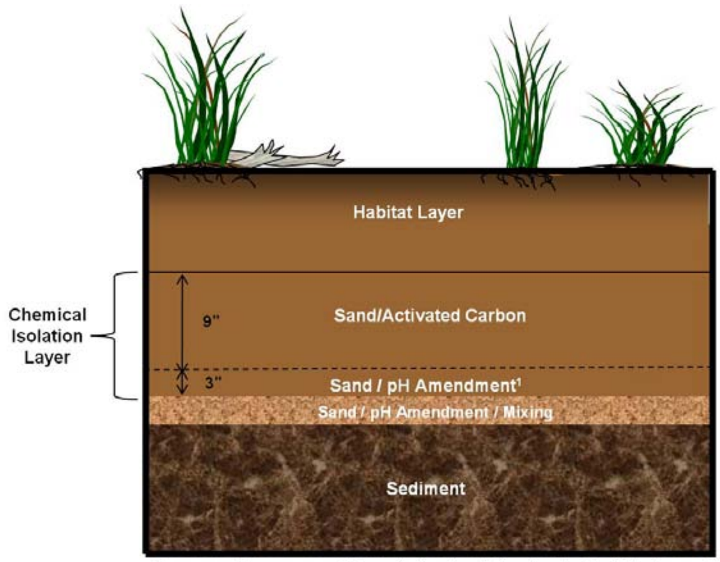
Site-specific data were used in the model to maximize the accuracy and reliability of the results. An extensive site-specific database for the most important model input parameters has been developed based on the RI and six years of PDI data and laboratory studies, which includes the analytical results from over 7,000 sediment samples and 5,500 porewater samples. Site-specific model input parameters include:

- Initial contaminant porewater concentration
- Fraction of organic carbon (foc) in the isolation layer and habitat layer
- Groundwater upwelling velocity;
- Organic carbon partitioning coefficient (Koc) for the isolation and habitat layers (as well as the underlying sediments)
- The phenol biological decay rate for the isolation layer

Site-specific data were also collected to evaluate the performance of cap amendments, including activated carbon sorption parameters and pH buffering capacity and rate of neutralization.

4.1.4 Chemical Isolation Layer Design

The chemical isolation layer will consist primarily of sand or gravely sand. Based on bench-scale testing summarized in Section 4.1.2, and cap modeling results presented in Appendix B, amendments will be incorporated into the cap in certain areas to ensure long-term effectiveness of the cap. These amendments will consist of siderite to neutralize elevated pH and promote long-term biological decay of key contaminants within the cap, and activated carbon to improve sorption of contaminants within the cap and provide an added level of protectiveness. A general schematic of an amended cap is shown below, followed by a discussion of the amendments and how they will function as part of the isolation layer in areas where they are required. In areas where amendments are not required to achieve long-term chemical isolation, the profile will be similar except that the chemical isolation layer will consist of a minimum of 12 in. of sand only.



1. In amended cap areas of Remediation Area E the chemical isolation layer will be 12" sand/carbon mix. Siderite will not be added to the cap as pH levels are at or close to neutral.

Example Schematic of an Amended Cap

The pH amendment will consist of siderite, which is a naturally occurring mineral (typically mined in rock form) that is used primarily as an iron supplement for livestock. It consists of approximately 77% iron carbonate, 12% quartz, 10% clay, and trace amounts of pyrite by weight. Prior to the application, the siderite will be crushed and screened to result in a grain size similar to sand. The siderite will be mixed with sand at the required dosage (with appropriate factor of safety to account for variability in field application) and placed in a pH amendment layer (part of the larger chemical isolation layer) with a minimum thickness of 0.5 ft. This will constitute the base layer of the amended cap, and will include the "mixing" layer of the cap. Mixing of the siderite with the underlying sediment will not impact the siderite's pH neutralization capacity. As porewater passes through the pH amendment layer, it will be neutralized to a pH of approximately 7, which will produce conditions that are amenable to long-term microbial activity and biological decay of key contaminants as they migrate through the overlying sand layer.

The areas where a pH amendment will be incorporated were determined based on the biological decay studies discussed in Section 4.1.2.1, which indicated that biological activity was not impaired at a pH of 8.0 but was potentially impaired at a pH of 8.5 or greater. Therefore, pH amendment will be incorporated into those areas of the carbon-amended cap where the underlying pH exceeds 8.0. Figures showing pH in underlying sediments for each remediation area are included in Appendix B. The required siderite application rate for Remediation Area D has been determined based on bench-testing and geochemical modeling, provided in Appendix I. The dosage of siderite in the other areas will be determined as part of the draft final design based on model area-specific geochemical modeling (similar to that performed in Appendix I for Remediation Area D) as well as considering the results of ongoing column studies discussed in Section 4.1.2.5.2.

As discussed above, it is anticipated that application of the pH amendment will facilitate biological decay of organic contaminants within the cap. As discussed in Section 4.1.2.1, there is evidence from the testing to date and in the literature that over time biological decay will occur in the isolation cap for all of the VOCs, including naphthalene. However, given the inherent complexities in replicating long-term environmental processes in the relatively short-term investigation period, it is difficult to quantify the biological degradation rate for all organic contaminants of concern currently evaluated with the cap model. Therefore, as a conservative assumption, the current model predictions do not incorporate biological decay for any of the CPOIs except phenol. Future modeling may include biological decay of other contaminants. Robust biological decay of phenol was observed consistently under a variety of conditions during multiple phases of PDI bench testing. Therefore, biological decay of phenol is considered in the modeling evaluation for areas of the cap that will not include an activated carbon amendment.

Activated carbon will be mixed with the sand used for construction of the chemical isolation layer to improve sorption of contaminants within the cap and ensure long-term effectiveness. Site-specific bench-scale testing of granular activated carbon and subsequent modeling has demonstrated that activated carbon will effectively adsorb the various dissolved organic contaminants for hundreds to thousands of years as described in detail in Appendix B. This will ensure that the cap is protective and achieves long-term compliance with cap performance criteria. The amended cap design is based on application of bulk activated carbon mixed with sand, which offers several advantages over use of a carbon mat (which was considered during the Initial Design phase), including the ability to adapt the activated carbon dosage based on area-specific requirements, improved construction schedule, and improved activated carbon performance in a diffusion-dominated scenario such as that present in the remediation areas of Onondaga Lake.

Results from the modeling based on site-specific conditions and incorporation of conservative assumptions, as listed in the introduction to Section 4 and detailed in Appendix B, are summarized in the table below. Remediation areas were subdivided as appropriate into modeling areas as discussed following the summary table.

Chemical Isolation Layer Design Summary

Remediation Cap Area	Model Area	Design Thickness (ft.)	Activated Carbon Amendment Dose (lb/ft.^{2})	pH Amendment Dose
A (77 acres)	A1	1	None	None
	A2	1	0.11	TBD[a]
B (16.1 acres)	B1/C1	1	0.5	TBD[a]
	B2	1	0.33	TBD[a]
C (18.9 acres)	C2	1	0.005	TBD[a]
	C3	1	0.07	TBD[a]
D (98.5 acres)	SMU2	1	0.04	1.0 lb/ft^2
	West	1	0.33	1.0 lb/ft^2

	Center	1	0.78	1.0 lb/ft^2
	East	1	0.22	1.0 lb/ft^2
E (173.8 acres)	E1	1	None	None
	E2	1	0.05	None
	E3	1	0.03	None
F (<1 acres)	F	1	None	None

a The required siderite application rate will be determined as part of the draft final design.

The basis for development of each of the modeling areas listed above and the chemical isolation layer design for each model area are discussed below. The modeling areas are delineated on Figures 4.1 through 4.5. Model areas were developed to ensure that the cap would be designed specific to conditions in an area based on key model input parameters such as groundwater upwelling velocity and contaminant porewater concentrations. Supporting information such as figures showing contaminant porewater distributions in each area are included in Appendix B. The isolation layer design required for each area is based on computer modeling for all 26 contaminants for which cap performance criteria were established, as detailed in Appendix B.

Remediation Area A: As listed in the summary table above and shown in Figure 4.1, Remediation Area A was segregated into Model Areas A1 and A2. Model Area A2 was delineated due to the presence of higher levels of VOCs, higher groundwater upwelling velocities, and elevated pH in this area, as compared to Model Area A1. Due to the VOC concentrations and pH, GAC and pH amendments will be included in the cap for Model Area A2.

The predominant VOC in Model Area A1 is phenol. Biodegradation of phenol has been incorporated into the modeling for this area based on the robust biodecay of phenol documented in the bench studies and no activated carbon amendment is required in this area. There are isolated areas in Model Area A1 where pH exceeds 8.0, as shown in the Appendix B figures. However, these are not co-located in areas where phenol is present; therefore no pH amendment is required in this area.

Remediation Area B: Remediation Area B is relatively small (4% of the total cap area), as shown in Figure 4.2. Remediation Area B was divided into Model Area B1 and Model Area B2 given the relative differences in groundwater velocities and contaminant distribution. The pH is elevated in both model areas, and pH and activated carbon amendments will be included in both Model Area B1 and B2. In Model Area B2 phenol is the primary VOC. In Model Area B1 multiple contaminants are present at levels that could drive the design. Given the similarities in groundwater velocities and contaminant distribution and concentration, Model Area B1 was combined with Model Area C1 (i.e., Model Area B1/C1 was treated as a single area for modeling purposes).

Remediation Area C: Remediation Area C is relatively small (approximately 5% of the total cap area), as shown in Figure 4.3. Remediation Area C was divided into Model Areas C1, C2 and C3. The pH is elevated in all three model areas, and pH and activated carbon amendments will be included throughout. As discussed above, Model Area C1 was combined with Model Area B1 given the similarities in contaminant nature and groundwater upwelling velocities. The distinction between Model Areas C2 and C3 results from the impact of the influence of the upland hydraulic containment system along the shoreline adjacent to Model Area C3. Model Area C3 also contains a wider distribution of contaminants that may drive the cap design, while Model Area C2 is primarily impacted by higher concentrations of phenol.

Remediation Area D: As shown in Figure 4.4, Remediation Area D is divided into four subareas based on differing levels of contamination, as discussed further in Appendix G. The pH is elevated throughout Remediation Area D, and pH and activated carbon amendments will be incorporated into the cap design in each subarea.

As shown in Figure 4.4, there is a relatively small area in SMU 8 adjacent to Remediation Area D where a chemical isolation cap will be constructed. The basis for delineation of this addendum cap area is provided in Section 3.2 and Appendix A. The design for this area is consistent with the cap design in the adjacent subareas of Remediation Area D. The carbon application rate in this area will be determined as part of the final design.

Remediation Area E: Remediation Area E was divided into three Model Areas E1, E2 and E3, as shown in Figure 4.5. The distinction between Model Areas in Remediation Area E was based on the distribution and relative concentrations of contaminants. The groundwater upwelling velocities across Remediation Area E are relatively uniform. Cap Model Area E2 was delineated due to the presence of higher levels of VOCs in sediment porewater as compared to those in Cap Model Area E1. Concentrations of most contaminants in Model Area E3 were consistent with levels in E1; however, the concentration of naphthalene was somewhat elevated in that area, warranting evaluation of E3 as a separate Model Area. Activated carbon amendments will be incorporated into Model Areas A2 and A3 based on the levels of organic contaminants present. The pH is neutral throughout Remediation Area E, therefore no pH amendment is required in this area.

Remediation Area F: Remediation Area F consists of two small areas totaling less than one acre. These areas were delineated based on sediment mercury concentrations that exceed the Mercury PEC. These areas are not close to shore; therefore, groundwater upwelling velocities are low. Mercury concentrations are much lower in these areas than in other areas where modeling indicates that a 1 ft. chemical isolation layer will be sufficient. Therefore, the chemical isolation layer thickness in this area will be a minimum of 1 ft. consistent with the ROD. The pH in these areas is not elevated, so no amendments are required.

Adjacent Areas: Cap modeling will be completed as part of the Draft Final Design for the caps in the adjacent wetlands that are being incorporated into the lake design.

Buffer Layer: As an additional level of conservatism, the ROD specifies that a 50 % buffer or safety layer will be included in the cap design, and that the decision will be made during design whether this buffer layer will be added to the chemical isolation layer or will be considered as part of the habitat layer. As detailed in Appendix B, the isolation layer thickness required to meet remediation goals for those contaminants that do not rely on activated carbon is less than 8 in. in all model areas. A 1-ft. isolation layer consistent with the minimum ROD requirements results in a safety factor greater than 50%. For those contaminants that rely on amendments to ensure long term effectiveness, increasing the cap thickness would not have a significant impact on protectiveness. For these contaminants, chemical isolation is primarily a function of amendment dosage, not cap thickness. In the amended cap areas, a highly sophisticated model (Appendix B), which significantly reduces uncertainty around model predictions, is being used in conjunction with a robust performance evaluation to predict cap performance. Additionally, as discussed in Section 4.1.3, numerous conservative assumptions have been built into the chemical isolation layer design, including assumptions related to model input and results as well as material placement during construction. Therefore, the buffer layer required by the ROD as a thickness equal to 50% of the chemical isolation layer thickness will be applied to the habitat layer in all areas.

4.1.5 Mixing Layer Allowance

The chemical isolation layer design will include an allowance for mixing of the bottom of the cap with the underlying existing lake sediment. Based on a review of mixing layer thicknesses measured at other recently completed capping sites (Table 4.2), a mixing layer thickness of 0.25 ft. (3 in.) was determined to be a conservative and appropriate estimate of constructed mixing layer depths. This assumption may be refined through adaptive management, with concurrence from NYSDEC, based on observations and measurements made during cap construction.

The sites evaluated varied with respect to cap construction, water depth, placement mechanism and substrate properties, resulting in a relatively heterogeneous cross section of site types. Overall, sediment mixing appears to be relatively minimal for all of the 22 sites which were reviewed. Of the eight sites where quantitative results were available, one reported a mixing depth of 4 in., while the remaining seven reported a mixing depth of 2 in. or less. For those sites where mixing depths were not reported, the qualitative information indicated minimal mixing was noted or that a clear cap/sediment boundary was identified.

The 0.25 ft. mixing allowance, combined with the range of over-placement allowance that is expected for all cap layers (estimated mean overplacement on the order of 0.5 ft. to 1 ft. in most cap areas, as shown in Table 4.1), significantly exceeds the 0.5 ft. that was assumed in the ROD to account for mixing and over-placement.

4.1.6 Modified Cap in Six to Nine Meter Water Depths

As specified in the ROD, a thin-layer cap may be appropriate in water depths from 20 ft. to 30 ft. (6 to 9 meters) provided it can be demonstrated that it will be effective in meeting remedial goals. A thin-layer cap typically refers to placement of approximately 0.5 ft. of sand or less to reduce contaminant levels in surface sediments, and is a significant component of the SMU 8 remedy. For evaluation of thin-layer capping in the 6 to 9 meter zone, a more robust thin-layer cap was developed. This will consist of a 0.25 ft. mixing layer, a minimum 0.5 ft. chemical isolation layer, and a 1 ft. minimum habitat layer, as shown in Figures 4.1 and 4.5. This cap is referred to here-in as a modified cap rather than a thin-layer cap to avoid confusion with the thin-layer cap which will be constructed in SMU 8.

A modified cap is appropriate in the 6 to 9 meter zone based on several considerations, including the results of chemical isolation layer modeling and the depositional nature of this area. Based on cap modeling, as detailed in Appendix B, 4 in. is sufficient thickness to achieve chemical isolation of all contaminants in the 6 to 9 meter zone in Model Areas A-1 and E-1, and chemical isolation of mercury in 6 to 9 meter zone in Model Areas E-2 and E-3. Long-term effectiveness of the cap with regard to organic contaminants in Model Areas E-2 and E-3 is a function of the GAC dose, which will be developed specifically for the 6 to 9 meter zone of these areas as part of the Final Design. Therefore, a 0.5 ft. chemical isolation layer will meet cap performance criteria and is appropriate for Model Areas A-1, E-1, E-2 and E-3. The appropriateness of a 0.5 ft chemical isolation layer in the 6 to 9 meter zone of other model areas may be evaluated as part of the Final Design.

The chemical isolation layer modeling in this area considers VOC and other contaminant porewater concentrations and groundwater upwelling velocities. Groundwater upwelling velocities in the 6 to 9 meter zone in Remediation Areas A and E is low, as documented in Appendix C. Concentrations of VOCs in porewater in these areas is very low, as documented in the figures included in Appendix B.

Although the effectiveness of the cap in the 6 to 9 meter zone does not depend on long-term sedimentation, the long-term depositional nature of this area will contribute to the long-term effectiveness of the cap in this area. Effler (1996) concluded that Onondaga Lake regions with depths in excess of 6 to 8 meters (20 to 26 ft.) represent the depositional basin of the Lake. A more detailed evaluation of sediment stability completed in Section 10 of Appendix D also concluded that the sediments in this zone are not subject to resuspension and that this area is net depositional.

4.2 EROSION PROTECTION LAYER

The erosion protection, or armor layer, will overlie and protect the chemical isolation layer from erosional processes including:

- Wind-generated waves (waves resulting from winds blowing across the lake)
- Ice scour (stresses induced from ice freezing to the bottom of the lake in shallow water)
- Tributary flows (high flows discharging into the lake resulting from the creeks and other discharges)
- Currents within the lake
- Vessel-related effects including propeller wash (high velocities resulting from the propellers on recreational and commercial boats operating on the lake) and vessel-generated waves (i.e., vessel wake)

Design and performance criteria and the methods and results from design evaluations pertaining to the erosion protection layer are discussed below and further detailed in Appendix D. Based on the evaluations detailed in Appendix D wind-generated waves present the greatest potential erosive forces and therefore dictate the erosion protection layer design. The erosion protection layer will be a minimum of 0.5 ft. thick. In some areas, the materials planned to construct the habitat and erosion protection materials are the same, resulting in a top cap layer in these areas of 1 ft. that functions as both the habitat and erosion protection layers. The erosion protection layer material will range from sand to cobble-sized particles, consistent with the erosion protection requirements for specific areas of the cap as detailed below. In areas where the habitat layer material is consistent with the erosion protection layer material requirements, the layers will be combined since a single layer can function as both in such cases.

4.2.1 Erosion Protection Layer Design and Performance Criteria

USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA 2005) states that:

> The design of the erosion protection features of an *in situ* cap (i.e., armor layers) should be based on the magnitude and probability of occurrence of relatively extreme erosive forces estimated at the capping site. Generally, *in situ* caps should be designed to withstand forces with a probability of 0.01 per year, for example, the 100-year storm.

Incremental increases in erosive forces due to events with a return frequency of greater than 100 years tend to be smaller (when compared to frequencies lower than 100); hence, such effects are expected to be localized, resulting in minor damage potential and an easier repair of any resulting disrupted areas. Thus, in accordance with USEPA guidance and precedents from similar projects, the 100-year extreme events were used in the armor layer design to ensure long-term effectiveness of the cap.

Based on ROD requirements and other project-specific considerations, design and performance criteria for the erosion protection layer are listed below:

- The erosion protection layer will be physically stable under conditions predicted to occur based on consideration of 100-year return-interval waves. The 100-year wave is the highest wave that would be expected to occur, on average, once every 100 years. The cap will also be stable from waves induced by vessel wake.
- The erosion protection layer, specifically the areas potentially impacted by influent from tributaries, will be physically stable under conditions predicted to occur during a 100-year flood flow event.
- The cap will be designed to prevent the chemical isolation layer from being disturbed by ice.
- The cap will be designed such that the chemical isolation layer will not be negatively impacted by erosive forces resulting from propeller scour.

Design analysis methods and results pertaining to development of the erosion protection layer design to meet these criteria are provided below.

4.2.2 Erosion Protection Layer Design Evaluations

The erosion protection layer is designed to provide long-term protection of the chemical isolation layer using methods developed by the USEPA and the USACE specifically for *in situ* caps. This includes the methods included in Armor Layer Design of Guidance for *In Situ* Subaqueous Capping of Contaminated Sediments (Maynord, 1998). The armor layer design presented herein involved evaluating the particle size (ranging from sand to cobbles) required to resist a range of erosive force expected on Onondaga Lake. Appendix D presents the details of the armor layer design evaluations.

Wind measurements from 1942 to 2009 were obtained from the Hancock International Airport (formerly Syracuse Municipal Airport) and used for the wind/wave analysis. Statistical analysis was performed on the data to estimate the 100-year wave height and duration. The wind-wave analysis was used to determine the depth of the surf zone, where breaking waves result in larger required grain-sized material for erosion protection. Once the height and duration of the 100-year event was derived, the particle grain size required to withstand the erosive forces inside and outside of the surf zone was calculated.

In addition to wind-generated waves, a tributary analysis was performed to evaluate the stable particle sizes under the 100-year flood flow for the armor layer of the cap. Velocity fields generated by the 100-year flows from Ninemile Creek and Onondaga Creek were modeled using a 2-dimensional hydrodynamic model. Particle sizes necessary to withstand the 100-year flood flow were computed for the 100-year flood flow from Ninemile Creek and Onondaga Creek as well as current velocities observed under typical conditions within the lake. An additional evaluation was performed to assess the potential simultaneous combination of erosive forces from wind-generated waves and high tributary flows.

As a vessel or boat moves through the water, the propeller produces an underwater jet of water. This turbulent jet is known as propeller wash (or propwash). If this jet reaches the bottom, it can contribute to resuspension or movement of bottom particles. Types and operating conditions of commercial and recreational vessels that use Onondaga Lake were obtained. Representative vessels were selected for this analysis and the resulting particle size necessary to withstand potential propeller wash erosion from those vessels was calculated.

Finally, an evaluation of the ice processes and the potential for ice erosion along shoreline caps was performed. The analysis involved a field reconnaissance, reviews of published literature on ice processes, observations of water temperature and ice formation at Onondaga Lake, and evaluation of data from other lakes. This evaluation was used to develop required design considerations for protection of the cap against ice scour.

4.2.3 Erosion Protection Layer Design

The erosion protection layer material will range from sand to coarse gravel, consistent with the erosion protection requirements for specific areas of the cap, as detailed in Table 4.3. Details pertaining to the grain size distribution corresponding to the grain size descriptions in the table are provided in Appendix D. As shown on Table 4.3, the minimum erosion protection layer thickness will range from 0.5 to 1 ft. for various areas of the cap. The design of the erosion protection layer is driven primarily by consideration of wind-generated waves. Analysis of vessel wake-induced waves concluded that wind-induced waves would be more of a significant potential impact to the armor layer.

The tributary analysis resulted in stable particle sizes of fine gravel for the portions of the cap near the discharge of both Ninemile Creek (Remediation Area A) and Onondaga Creek (Remediation Area E). The required particle sizes are less than or equal to the stable particles computed from the wind-wave results (see below). Ninemile Creek and Onondaga Creek are the two largest inflows to the lake. Evaluation of erosive forces from other tributaries and discharges to the lake, such as from stormwater and other outfalls, will be completed as part of future design efforts, but is not anticipated to result in significant design revisions. The assessment of typical current velocities measured in the lake (away from the influence of tributary flows) indicated a stable particle size of fine sand, which is less than or equal to the stable particles computed from the wind-wave results.

Based on a review of the types of vessels and operating procedures for these vessels in Onondaga Lake, there will be two types of vessel operations over the cap: 1) commercial and recreational vessels operating frequently in the New York State Canal Corporation (NYSCC) navigation channel to the Inner Harbor in Remediation Area E, and 2) recreational vessels operating in shallower water depths. The propeller wash analysis indicates that particle sizes in the coarse gravel range (1 in. to 2 in.) would be required for the armor layer in the NYSCC navigation channel. For the other areas of the cap, recreational vessels will likely operate infrequently and randomly. That is, these vessels will not start and stop or pass over the exact same location on a regular basis. Due to the limited area impacted by propeller wash from an individual vessel, significant movement of armor layer is not expected from propeller wash. In addition, in shallow water, a dedicated 1.5 ft. to 2 ft. thick habitat layer is planned above the armor and chemical isolation layers. Any potential disturbance to particles within the habitat layer of a localized area is expected to "self-level" soon after disturbance due to natural hydrodynamic conditions within the lake.

Ice freezing to the bottom of the lake is expected in shallow water at the shoreline of Onondaga Lake. In such cases, it is expected that the normal thickening of ice will encounter the bed and freezing will continue. It was determined that the freezing of ice to the lake bottom is typically limited to water depths of less than 1.5 ft. To protect the chemical isolation layer for the cap, the armor layer and chemical isolation layer will be placed below the ice freezing depth of 1.5 ft. Using a low lake water level of 362.0 ft. NAVD88, the ice freezing zone would be above 360.5 ft. The top of both the armor layer and chemical isolation layer will be placed below an elevation of 360.5 ft. to protect against ice scour. Effects associated with ice, if any, are expected to be localized and restricted to the habitat layer thickness.

Although not a true erosive force, a bearing capacity evaluation demonstrating that human wading in near shore areas will not exceed the cap bearing capacity is also presented in Appendix D. Bearing capacity pertaining to structure associated with habitat restoration will be completed as part of future evaluations following further identification of potential habitat structure requirements.

4.3 HABITAT DESIGN

The habitat restoration layer is a critical part of the overall habitat restoration program. It will be the upper-most layer of the cap and will provide the appropriate substrate to promote an active and diverse environment for a wide variety of species, allow for natural movement in the lake system, and exhibit micro-topography. The habitat layer thicknesses are based on an understanding of bioturbation, plant and animal biology (e.g., rooting and burrowing depth), professional experience of local and national experts, and a review of relevant scientific literature and technical guidance. Design and performance criteria and the methods and results from design evaluations pertaining to the habitat layer are discussed below and presented in more detail in Section 4 of the Draft Habitat Plan (Parsons, 2009f).

4.3.1 Habitat Layer Design and Performance Criteria

Based on the requirements specified in the ROD and other project-specific considerations, the design and performance criteria developed for the habitat layer are listed below:

- The specific habitat layer thickness and habitat layer substrate (i.e. grain size) will be consistent with the target habitat conditions developed as part of the Draft Habitat Plan.
- The habitat layer thickness will be determined based on consideration of plant rooting depth and animal burrowing and nesting depth species typical of central New York lake systems as well as human use.
- The habitat layer will be a minimum of 1 ft. thick in all remediation areas.

Design analysis methods and results pertaining to development of the habitat layer design are provided below.

4.3.2 Habitat Layer Design Evaluations

General habitat restoration goals are established within the Draft Habitat Plan. The first general restoration goal is to maintain or increase diversity of habitats, communities and species in all habitats by maintaining or improving the:

- Size, diversity, and function of wetlands
- Connectivity of the lake habitats with adjacent stream and upland habitats
- Ecological function of the littoral zone
- Ecological function of the shoreline habitat
- Habitat conditions of the profundal zone
- Conserve and/or create habitats for threatened and/or endangered or rare species

The second general restoration goal is to design conditions that discourage the establishment of invasive species (e.g., avoid creating conditions conducive for invasive species) to the extent practicable.

The third general restoration goal is to develop conditions that require minimal maintenance and minimal public use restrictions. Once implemented, the habitat restoration designs are intended to provide self-sustaining, functioning habitats that require little or no maintenance over the long term. In addition, the restored areas should be open and accessible to the public to the extent practicable within the constraints of the remedy.

In order to meet the general restoration goals, the Draft Habitat Plan describes more specific restoration objectives. To achieve the habitat-specific goals and objectives, the Draft Habitat Plan and the cap and dredge area and depth design were developed concurrently. Habitat layer thickness and substrate requirements have been developed within the Draft Habitat Plan and are summarized below.

4.3.3 Habitat Layer Design

Based on the evaluations summarized above and detailed within the Draft Habitat Plan, the following habitat layer thickness criteria have been developed:

- The habitat layer will be a minimum of 2 ft. thick in water depths from the shoreline to a water depth of 3 ft.
- The habitat layer will be a minimum of 1.5 ft. thick in water depths from 3 ft. to 7 ft.
- The habitat layer will be a minimum of 1 ft. thick in water depths from 7 ft. to 30 ft.
- The minimum habitat layer thickness requirements include the erosion protection layer.

The estimated mean and maximum habitat layer thicknesses are greater than the minimums specified above. This is due to the over-placement of habitat material during the installation of the habitat layer in order to ensure that the minimum thickness is achieved. Minimum cap layer thicknesses and estimated mean over-placements are listed in Table 4.1. Typical maximum over-placements are two times the mean over-placements listed.

These thickness requirements were developed consistent with habitat modules described in the Draft Habitat Plan. Habitat modules are areas with specific physical characteristics suitable for various representative species of fish, birds, plants, etc. In-lake habitat modules are defined by three basic habitat parameters: water depth, substrate type, and water energy. Habitat modules within the lake and the associated habitat layer material substrate are summarized below.

HABITAT MODULE SUMMARY

Module	Water Depth (ft.)	Substrate/Energy
1 - Deep water	20 to 30	Sand. Low to medium energy.
2A - Mid water depth	7 to 20	Sand/fine gravel. Low to medium energy.
2B - Mid water depth	7 to 20	Coarse gravel/cobble. High energy.
3A – Shallow water	2 to 7	Sand/fine gravel. Low energy.
3B – Shallow water	2 to 7	Sand/coarse gravel. High energy.
4A - Floating aquatics wetland	1 to 3	Organics/fines/sand. Very low energy.
5A - Non-persistent emergent wetland	0.5 to 2	Organics/fines/sand. Low energy.
5B - Shoreline shallows/limited emergent wetland	0.5 to 2	Gravel. High energy.
6A - Persistent emergent wetland or salt marsh	1 ft. above water to 1 ft. deep	Organics/fines/sand. Low energy.
6B - On shore to shallows/limited emergent wetland or salt marsh	1 ft. above water to 1 ft. deep	Coarse gravel/sand. High energy.

7A - Mudflats/unvegetated shoreline	0.7 ft. above water to 0.7 ft. deep	Fines/sand substrate gravel. High energy or fluctuating water levels.

The habitat layer substrate listed in Table 4.1 is consistent with the resulting post-capping habitat module goals for each area, as detailed in the Draft Habitat Plan. Post-construction plan views and cross-sections and the resulting habitat modules for each Remediation Area are shown on Figures 4.7 through 4.24. The dredging approach to achieve the target habitat modules and elevations in each area is discussed in Section 4.3.4, below.

In the majority of the cap areas, particularly in deeper water, the grain-size requirements for the erosion protection layer are consistent with the habitat layer objectives. In those areas, the habitat layer will consist of materials that meet the requirements for habitat and erosion protection, as shown in Table 4.1. In some shallower areas, the habitat layer substrate will be a finer grained material than what is required for erosion protection. In these areas, the erosion protection layer will be considered a part of the habitat layer in meeting the overall habitat layer thickness requirements, provided the substrate required based on habitat considerations is at least 12 in. thick, which is the condition in all areas.

4.3.4 Development of Dredge Depths to Achieve Habitat-Based Cap Elevations

The depth of sediments requiring dredging in Remediation Areas A, B, C, E, and portions of D were determined by the depth of water desired following capping and the thickness of the cap necessary to meet chemical isolation, erosion protection, and habitat objectives. Conceptual post-capping water depths and resulting habitat modules were developed in the Draft Habitat Plan to achieve optimum habitat conditions. Because dredge depths were developed based on these habitat-based cap elevations in most areas, the cap and habitat restoration goals and resulting dredge design were developed in this section prior to presentation of the comprehensive dredging design in Section 5. The capping and dredging design has accounted for each factor that may impact the final post-capping water depth such that habitat-based goals will be achieved. Specific considerations include over-dredging, cap material over-placement, and settlement of the underlying sediment due to the weight of the cap, as discussed below.

Habitat module-based target elevations will be met on an area-wide-average basis. Variation in water depth beyond the variances shown in Figures 4.7 through 4.24 may occur in localized areas, which will support the goal of microtopography on the lake bottom. Microtopography has been identified as a beneficial habitat feature. The post capping elevations and habitat module boundaries are also likely to shift over time after cap placement due to natural processes such as settlement and wind and wave activity. This process is consistent with how natural habitat systems function and will enhance the variability of the cap surface as would be expected in a natural system.

In order to achieve a minimum required thickness for a specific cap layer, some over-placement (additional thickness beyond the minimum required by the design) will likely occur based on typical construction tolerances achieved at other similar capping sites (see Table 4.1). Typical mean over-placements from these other capping sites range from 0.25 ft. for materials such as sand and fine gravel to 0.5 ft. for cobble-sized particles. In habitat modules that have a maximum water depth of 3 ft. or less (Modules 4, 5, and 6), tighter controls will be implemented on the dredging and capping operations due to the increased sensitivity associated with achieving target post-capping water depth ranges. These tighter controls will also apply to areas of Habitat Module 3 in Remediation Area E where the minimum post-capping water depth is 3 ft. due to navigational considerations. Based on constructability evaluations by the selected dredging and capping contractor (Sevenson Environmental), and their experience on other sites using similar equipment to that planned for Onondaga Lake (discussed in Section 4.5), the following cap material over-placement tolerances are expected to be achievable in the areas where tighter operational tolerances are warranted:

Cap Material	Mean Over-Placement (in.)	Maximum Over-placement (in.) in Shallow Habitat Modules
Sand	3	4
Fine Gravel	3	4
Coarse Gravel	4.5	6
Cobble	6	12

Based on these refined over-placement tolerances, and taking into consideration over-dredging that will likely result in order to achieve required minimum dredge cuts, the required minimum dredge cuts developed in Appendix F are based on total cap thicknesses inclusive of mean over-placements from Table 4.1 for each cap layer. This will provide sufficient water depth post-dredging to achieve the post-capping habitat modules, cap elevations, and anticipated elevation variances shown in Figures 4.7 through 4.24. Following placement of the chemical isolation and erosion protection layers to at least the minimum required thickness in Habitat Modules 4, 5, and 6, bathymetry will be measured. The thickness of the habitat layer placement will be increased in these areas, if necessary, and consistent with the adaptive management approach for habitat modules, in order to ensure the final surface of the habitat layer is within the target water depth range. However, based on the dredging and capping plans, placement of additional habitat material to achieve target cap elevations is not anticipated.

Constructability evaluations associated with the capping and dredging are ongoing, and may result in modifications during the final design to the habitat-based dredging plan developed above. In addition, adaptive management concepts will be applied to the capping and dredging program during construction. Adaptive management refers to enhancements to project implementation based on lessons learned and from actual experience gained during the course of the project. As construction proceeds, the construction tolerances will be closely monitored and the design or construction methods may be refined and optimized, as appropriate. For example, target dredge depths may be reduced if even tighter cap placement tolerances can be demonstrated during construction. Remediation Areas A and E represent the vast majority of the area where dredge depths are determined based on habitat-based elevation goals. As discussed in Section 8, remedial activities in these areas are not anticipated to begin until 2014, allowing ample time to revise the dredging depths in these areas based on initial construction performance in other areas.

The weight of the cap will result in some consolidation settlement over time of the underlying sediments, provided that the weight of sediment dredged prior to capping does not exceed the weight of the cap, as detailed in Appendix E. The magnitude and time-rate of this settlement has been predicted using state of the art models to estimate the implications of this parameter. Estimated settlements are included in the cross-sections shown in Figures 4.7 through 4.24.

As a result of the capping and dredging, bathymetry will be different from current conditions in order to achieve the target habitat goals. Changes in water depth from current conditions based on the conceptual design presented in the IDS are included in the Draft Habitat Plan. These figures will be updated in the Final Habitat Plan following, which will be submitted as part of the Final Design.

4.3.5 Habitat in Adjacent Remediation Areas Included in Design

As discussed in Section 3.4, this lake design submittal includes portions of the designs for three areas along the shoreline that are being remediated in addition to the lake: the spits at the mouth of Ninemile Creek, the connected wetlands and shoreline stabilization at Wastebeds 1-8, and the WWB/HB Outboard Area. The habitat design pertaining to each of these areas is discussed below. The cap designs for these adjacent areas have not been developed in detail. For purposes of habitat development and material removal volume development, the overall cap thickness in these areas is assumed to be consistent with the cap thickness for the in-lake area immediately adjacent to each area.

4.3.5.1 Ninemile Creek Spits

The spits on both sides of the Ninemile Creek outlet are delineated as emergent wetlands. The integrated design includes removal of the emergent wetland (approximately up to the shore tree line), and restoration of the area with an isolation cap constructed similar to the adjacent isolation cap in the lake, as shown in Figure 4.7. The post-remediation acerage of the spits and associated wetland will be the same as currently exists. The post-remediation water depth in the area of the recreated spits will be 1 ft. above water to 1 ft. deep and the area will be restored as Habitat Module 6A. The restoration approach for this area includes a broad, shallow shelf (Module 6A) to help reduce wave energy on the sensitive near shore environments in this remediation area and provides the only shallow water lower energy environment in the areas specified for remediation. The removal of the eastern spit will terminate just prior to the start of the shoreline groundwater collection trench on the east side, and the scrub-shrub upland on the south. The western spit terminates along the deciduous forest wetland on the south border of the emergent wetland delineation (Figure 4.7) The restoration of these spits includes several acres of emergent wetland providing diverse habitat similar to previous conditions. A shallow emergent transition (0 to 1 ft.) provides connectivity between lake and Ninemile Creek and protects floating aquatics.

4.3.5.2 Wastebeds 1-8

New mitigation wetlands will be constructed at the Wastebeds 1-8 site to offset the loss of 2.3 acres of open water due to the construction of the Willis IRM barrier wall, as documented in the ESD discussed in Section 1.3. The connected wetland will be a 2.3 acre freshwater marsh with varied habitat characteristics that will provide ecological value through floral and faunal diversity. The current design specifies a primary wetland pool protected from wave energy by a narrow landform approximately up to an elevation of 364 ft. (1.5 ft. above the typical growing season lake water level; Figure 4.10).The connected wetland will likely ranging elevations from 363 ft. to 359.5 ft., providing weltand community types consistent with Habitat Modules 4A, 5A, and 6A.

The connected wetland will provide open water intended for use by waterfowl, wading birds, amphibians, and reptiles that may forage on the small fish likely to inhabit the pool. The connected wetland will also provide shallow water saturated soil habitats allowing for a wide diversity of plant species and a broad range of niches, further facilitating plant diversity, wildlife use and aesthetic value. Overall, the connected wetland is intended to serve as a wildlife migration corridor between the lake and adjacent upland habitats at the Wastebeds 1-8 site.

The Wastebeds 1-8 Integrated RM also includes a vegetative cover along the eastern shore and shoreline stabilization along a portion of the surf zone of SMU 4. These elements will be integrated with the shoreline stabilization along SMU 3 required by the Onondaga Lake ROD to address erosion of Solvay waste material along the shoreline of Wastebeds 1-8. The lake design includes the shoreline treatment within the lake to elevation 360.0 ft. and extending up to an elevation of 365.0 ft. in both SMU 3 and SMU 4, due to the consistency of stabilization and restoration approach from the lake shore up to this elevation.

4.3.5.3 Wastebed B/Harbor Brook Outboard Area

Habitat restoration in the Outboard Area was designed to take better advantage of the seasonal inundation of emergent wetland areas along the shoreline and create habitat that is more suitable for northern pike reproduction. This design focuses on providing the appropriate water depths at the appropriate time of year (and concomitant water temperature) for northern pike spawning.

Water temperature is a key consideration for northern pike spawning. Research conducted by Dr. John Farrell of SUNY ESF at the St. Lawrence River Research Station indicates northern pike typically spawn in temperatures from 5 to 13^{o}C (Farrell, 2001 and Farrell et al., 1996). The period for spawning in this part of the Northeast (i.e., south of the St. Lawrence) is typically mid March to early April. The period of March 15th through April 7th has been selected as the anticipated time of year to support the current design evaluations in this area based on the input from Dr. Farrell and the recent lake conditions. Data from www.ourlake.org indicates mean epiliminion weekly water temperature just above 5^{o}C in late March 2010 with the yearly average epiliminion water temperature approximately 5^{o}C during early April. However, these data were collected in the middle of the lake and are not representative of shallow water conditions along the Wastebed B shoreline. The shallow near shore littoral zone habitat is likely warmer during this same period and likely will be following remedial activities.

To provide suitable conditions over a wide range of lake levels, the wetlands have been designed with a gradual slope from the areas adjacent to the barrier wall out to the Onondaga Lake shoreline. This design eliminates the need for spawning channels with specific depths, which could be prone to sedimentation, in favor of a self-designing system that will respond to natural changes in water level and patterns of sediment movement. Water levels during potential spawning season were evaluated using Onondaga Lake level data from the USGS Gauging Station at Liverpool, New York. The median, 10th percentile and 90th percentile values for Onondaga Lake water levels during this time period are shown in Figure 4.25. Because dam and lock procedures from plant operations on the Seneca River were modified in 1997, only data from the last 12 years were used for this analysis.

Based on the research and recommendations of Dr. Farrell and others, northern pike typically spawn in water depths of 12 in. to 18 in. (Casselman and Lewis 1996; Farrell et al., 2006). The design is based on providing 12 in. of water depth at the midpoint of the slope for the median water level of 363.3 ft. during the period of March 15th to April 7th for Onondaga Lake. Figure 4.26 presents a schematic cross section showing the various water levels, zones of vegetation, and slope of the wetland system outboard of the IRM Barrier Wall. The restored habitat surface begins at 363.3 ft. adjacent to the barrier walll and slopes to an elevation of 361.3 ft. at the Onondaga Lake shoreline. A key function of this sloped design will be the presence of submerged wetlands with 12 in. to 18 in. of water during the spawning season, even during high (364.5 ft. - 90th percentile) and low (362.7 ft. – 10th percentile) water level conditions. The 12 in. to 18 in. water depth range falls within the literature values noted above and has been recommended by Dr. Farrell. The reconfiguration of Harbor Brook would also allow for increased stream length and sinuosity, development of improved habitats suitable for a variety of species, and improved connectivity of wetlands with the lake habitats.

The type and density of vegetation within the wetland area also affect northern pike spawning. As the design is advanced during 2011, the planting of the wetlands will be addressed in more detail based on the direction of Dr. Don Leopold at SUNY ESF with input from Dr. Farrell. The design will include persistent herbaceous species that will have submerged stems during the March/April spawning period to provide a structural component to support northern pike spawning. A list of potential species was included as part of the Draft Habitat Plan and will be refined and discussed in more detail as part of the draft final design for this area. In addition, a wave break to reduce wind/wave energy on this wetland, along with other structural elements such as rock piles or large woody debris will also be evaluated for use in this wetland complex.

Due to the fluctuation of lake level throughout the year, there will be some portion of the Outboard Area that is just above lake level during average conditions. This area will serve as potential waterfowl nesting habitat during portions of the year. Due to the objective of pike spawning in this area, consideration for piscivorous birds such as cormorants will be considered as part of the draft final design. In addition, upland habitat modules (Modules 8A and 8B) will be restored to transition from the wetlands over the top of the final elevation of the barrier wall. Restoration of the areas on the landward side of the barrier wall will be addressed as part of the Wastebed B site.

The area of forested wetland (Habitat Module 9) for the on-shore area is designed to increase some wooded wetlands in the area, diversify the restored habitats, and provide additional leaf litter and connectivity to the Wastebed B site.

During periods of high lake water levels (at or over an elevation of 363.5 ft. [NAVD88]), the creation of shoreline wetlands will actually provide more lake water area, while providing for interspersed islands for waterfowl nesting. At these lake levels, the lake area will increase as the shoreline will actually be along the toe-of-slope from the barrier wall. Fringing wetlands are commonly flooded during seasonal high water events, increasing lake surface area.

As with other persistent emergent wetlands around the lake, the potential encroachment of Phragmites is a concern. For this reason, clean fill materials and an aggressive planting program of shade trees will be implemented along the shoreline edge of the wetlands. The shade trees will help to limit the spread of phragmites and provide additional leaf litter and organics along the edge of the wetland complex.

4.3.6 SMU 3 and SMU 5 Habitat Enhancement

The ROD identified two locations where habitat enhancement activities would be applied even though remediation activities are not required in these areas based on exceedance of cleanup criteria concentrations. The areas are along an estimated 1.5 miles (2.4 km) of SMU 3 shoreline, and over approximately 23 acres of lake bottom in SMU 5 to stabilize calcite deposits and oncolites and promote submerged aquatic plant growth. Both of these areas are summarized below with additional detail provided in the Draft Habitat Plan (Parsons, 2009f).

4.3.7 SMU 3 and SMU 4 (Shoreline Stabilization)

The shoreline stabilization in SMU 3 and 4 will be designed to reduce resuspension and turbidity along the shoreline. This stabilization will ultimately be integrated with the IRM for Wastebeds 1-8, which is still under development. Therefore, the shoreline stabilization described in this section is specific to the shallow water portion of SMU 3 and SMU 4 up to an elevation of approximately 365 ft. (NAVD88), which is close to the highest high water mark for Onondaga Lake (i.e., 95% of all recorded water surface elevations are at or below 365 ft. [NAVD88]). Stabilization measures for the shoreline areas above the 365 ft. (NAVD88) elevation will be developed as part of the Wastebeds 1-8 IRM design.

The results of the wind/wave analysis (Section 4.2) completed for Onondaga Lake were used to determine the extent of the surf zone and the size of stone needed to stabilize the substrate (Appendix D). The surf zone associated with the 10-year wind/wave event was selected as the basis of design for defining the treatment area, resulting in a treatment area which extends to a water depth of approximately 2.5 ft., resulting in a total treatment area of approximately 16.2 acres, as detailed in the Draft Habitat Plan (Parsons, 2009f).

The 10-year wind/wave event was used as the basis of design for determining the stable particle size in order to balance between stability and gravel size. Based on this analysis, medium sized graded gravel will be placed within the surf zone to stabilize the substrate and reduce resuspension. This material will be placed on top of a fabric layer to prevent sinking into the Solvay waste material and will be a minimum of 0.5 ft. thick in underwater portions along the entire SMU 3 and SMU 4 shoreline to a water depth of approximately 2.5 ft. Shoreline stabilization will not be required in areas where dredging and/or capping will be conducted.

The approach for stabilizing the calcite deposits above the waterline from 362.5 ft. to 365 ft. along the SMU 3 and SMU 4/Wastebeds 1-8 shoreline will use bioengineering techniques to the extent possible to minimize hardening of the shoreline and provide a transition between the

Wastebeds 1-8 and the lake. These bioengineering techniques may include the use of a live crib wall or live rock revetment, live fascines (woody vegetation bundles such as *Salix spp*.) and vegetative mattresses (brush material buried in trenches) that will be installed in a layer of topsoil and gravel. The majority of bioengineering techniques incorporate larger sized stone near the toe of the slope, which corresponds with the surf zone of SMU 3.

4.3.8 SMU 5 (Habitat Enhancement)

As described in the ROD, habitat enhancement was planned to occur over approximately 23 acres in Remediation Area F (SMU 5) to stabilize calcite deposits and oncolites and promote submerged aquatic plant growth (NYSDEC and USEPA, 2005). The approach described in the ROD was based on stabilizing the oncolitic sediments to allow plant colonization. The target of 23 acres was based on increasing the percent cover of the littoral zone to provide optimal habitat for the largemouth bass (Stuber et al. 1982). The information used in the ROD was based on 2000 plant surveys, which documented a total of 17.8 acres in Remediation Area F (SMU 5) (EcoLogic, 2001) within the optimal water depth for plants.

Since that time, the area covered by plants has increased significantly, largely due to water quality improvements associated with the upgrades to the Metro facility. Based on the most recent 2008 survey, there were approximately 314 acres of plants mapped in the lake and approximately 160 acres in Remediation Area F within the optimal water depth for. As such, there is significantly more acreage covered by aquatic plants than would have occurred resulted from implementation of the 23 acres of habitat enhancement. In fact, the majority of the treatment areas identified in the Onondaga Lake FS for habitat enhancement have been naturally colonized by aquatic plants. Therefore, the goals outlined in the ROD for habitat enhancement in this area have already been met.

4.4 CAP MATERIALS, SOURCES, TRANSPORT AND STAGING AREAS

Based on the evaluations in Sections 4.1 through 4.3 pertaining to the chemical isolation, erosion protection and habitat restoration layers, the cap areas, material types and cap material volumes have been estimated for each remediation area and are detailed in Table 4.4. Information pertaining to material specifications and sources, and how the materials will be transported and stored for the project are described below.

As discussed in Section 2.2.1, as part of its sustainability program, Honeywell is committed to minimizing the carbon footprint of construction activities anticipated as part of the execution of the remedy. To the extent practicable, use of locally produced/sourced materials and supplies, reduction/elimination of waste, efficient use of resources and energy, and other sustainable practices will be incorporated into cap material sourcing and transport.

4.4.1 Cap Material

Cap materials will be secured for the project based on the requirements of each individual layer in the cap construction. Specifications for each of the cap materials are under development and will be presented in the draft final design. Specifications will include both chemical and physical property requirements for each material type and will be coordinated with the modeling (chemical isolation), erosion protection and habitat based requirements. The earthen materials physical requirements will also be coordinated with available local material sources to ensure the material specifications take into account sustainability considerations for the procurement of the cap materials.

4.4.2 Material Sources

Materials required for the capping operations in the lake include aggregate materials (e.g., sand, gravel, rock, and wetland soils) as well as siderite and activated carbon that will be incorporated into the cap as amendments. A range of potential sources for the aggregate materials have been identified, and an initial source has been selected for the initial phase of the project. Other potential sources that meet the project needs continue to be evaluated. In general, material will be delivered to the site directly from the mines, quarry pits, and other material supply facilities. Multiple sources of some material may be required to meet the required cap quantities in the future.

Sources of aggregate materials required for the cap, including chemical isolation, erosion protection and habitat material, have been located local to the Syracuse area. The identified sand and gravel sources provide adequate reserves necessary for the project, and meet the materials requirements for the cap. An extensive investigation of the materials currently being performed in order to develop cap material specifications that minimize processing effort, meet the engineering requirements of the cap materials, and minimize the generation of by-product materials that do not have an identified use on this or other local projects.

Additional sources for potential cap materials are also being examined. Clean material dredged for marine navigation at other sites is being investigated and may be proposed for incorporation in the cap. Other construction and development projects that present a beneficial re-use opportunity are also currently being reviewed.

The pH amendment, siderite, is a mined mineral that will be crushed to sand-sized particles for use in the cap. The siderite used for pH bench studies was produced by a mine in Texas that encompasses over 200 acres and has the resources and capabilities to produce the required siderite for the entire Onondaga Lake project. Additional potential siderite mines, some active and some not active, are located throughout the United States and will continue to be evaluated as the project progresses.

Granular activated carbon will be incorporated into the cap for portions of the site to improve the performance of the chemical isolation layer. Carbon isotherm studies were performed to determine activated carbon sorption characteristics for site conditions using a coal based activated carbon from Calgon Carbon Corporation. Carbon can be supplied by bulk transport (truck or rail car). The activated carbon will be produced to the size and specifications required at the carbon activation facility. As the design is finalized, reactivated carbon or additional activated carbon vendors may be considered. Use of reactivated carbon or additional vendors would require additional isotherm studies to verify that the alternate products would perform equal to or better than the materials used in the evaluations to date.

4.4.3 Material Transport

Sustainability is a key consideration for transport of materials for the Onondaga Lake project. The following variables were considered in deciding the best methods for transport of the materials.

- Viability of the potiential material source
- Efficiency of production and delivery
- Minimizing handling and minimizing the area of impact both at the pit and required for stockpile at site for imported materials
- Distance to the Onondaga Lake project site

Onondaga Lake's proximity to major transport modes provides the project with inherent transportation advantages. The lake connects to the New York State Canal System, making barge transport of capping materials potentially viable. Rail lines of the Finger Lakes Railway run adjacent to the lake and connect to CSX, Norfolk, Southern and Geneva and other major rail carriers. The lake is also located adjacent to major vehicle transportation routes from both the east/west and north/south. Several modes of transport will be considered for eventual selection during final design, with the final selection of the transport mode being a function of the material sources for the various cap materials. Based on the current evaluation of capping material sources, trucking appears to be the best delivery option for aggregate materials (sand, gravel, and stone). Using materials local to the project and minimizing the required infrastructure lend to the trucking advantage. Barge delivery for aggregate materials is still under evaluation. Rail delivery is also being considered for both pH and activated carbon amendments for the cap.

Materials will be delivered "just in time," to the extent practical, to reduce the required stockpile area for materials and reduce double handling of the materials. Transport routes to the site will maximize major highways as shown in Figure 4.27. Routes 81, 90, 481, 690, and 695 will be used as potential transportation routes to the project. Entry and exit routes from the sites have been reviewed for safety and logistics and transport through residential areas has been minimized.

In support of Honeywell's sustainability goals, delivery trucks for all earthen materials will be equipped with 2007 or better engines or meet the diesel retrofit technology to reduce their carbon footprint. Biodiesel is being evaluated and may be used in delivery trucks and on-site equipment for further carbon footprint reduction.

4.4.4 Material Staging

To keep the capping of the lake on schedule, material stockpiles will be used to provide the material to the capping operations when needed. Strong daily coordination efforts between the material supplier and the capping operations will keep the supply of material delivered to the project as it is requested, while minimizing stockpiling of materials to the extent practicable.

Only the minimum amount of material necessary will be stockpiled on site. This will minimize the need to handle the materials, reduce the amount of maintenance necessary for large stockpiles, and will result in only a small footprint of stockpiled materials. A typical stockpile area for the southeastern shore is as depicted in Figure 4.28. There are other areas adjacent to the lake that may be considered as potential stockpile locations. Due to the existing projects that are scheduled to take place at many of these areas, coordination with each project site will be required. Potential adjacent stockpile sites include Wastebed B and the existing causeway staging area. Stockpile size and locations will be evaluated in more detail in future design submittals.

4.5 CAP MATERIAL PLACEMENT

This section provides an overview of the anticipated cap placement technologies and methods to be used in Onondaga Lake. Cap placement equipment was selected taking into consideration input from the selected cap construction contractor (Sevenson Environmental). This section also provides details on anticipated capping production rates and anticipated quality control procedures to assure appropriate cap placement.

Several methods have been used on previous projects to place granular capping materials and were considered for Onondaga Lake, including:

- Direct placement with a mechanical clamshell bucket
- Surface release from a barge, hopper, conveyor belt, or broadcast spreader
- Spreading with hydraulic pipeline and baffle box or plate
- Jetting off of a barge
- Submerged diffuser or tremie pipe
- Pneumatic placement in very shallow water or marsh areas

In selecting the most appropriate placement methods for Onondaga Lake, the selected capping construction contractor and design team considered numerous factors including, but not limited to:

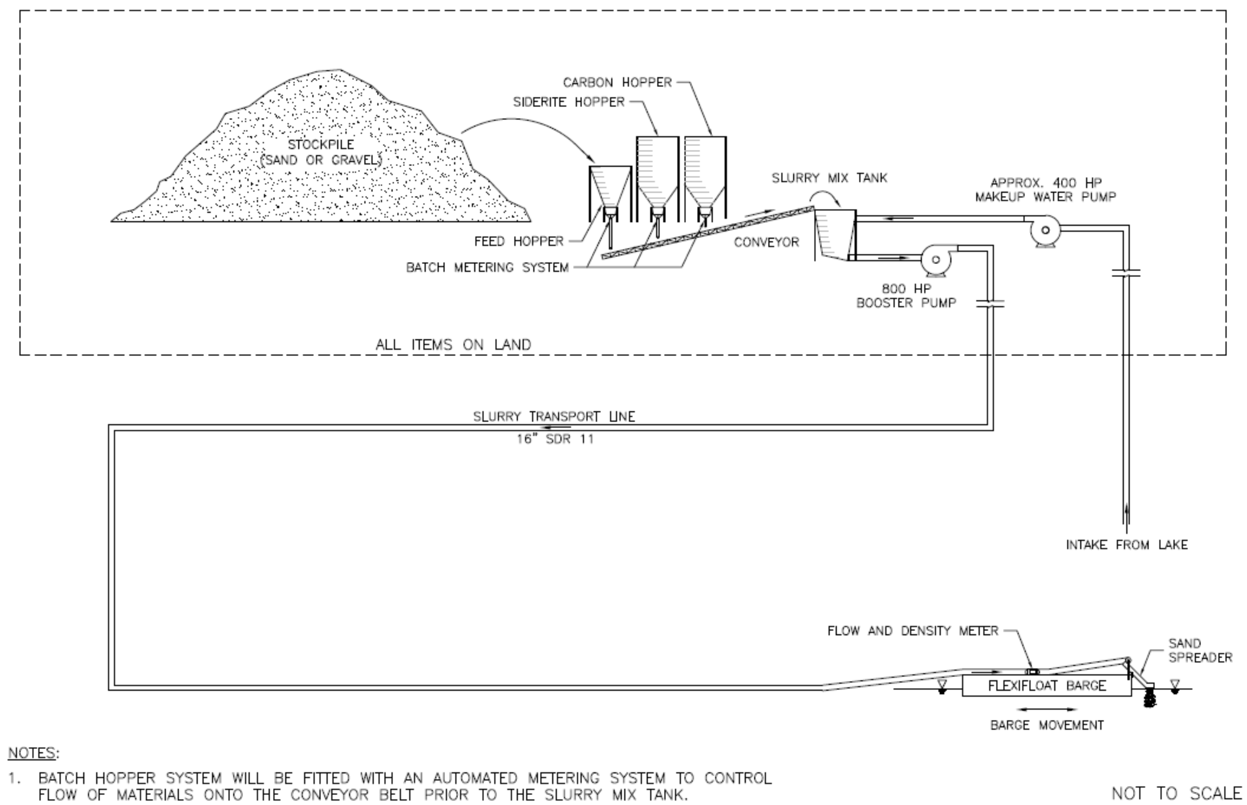
- Site conditions (e.g., water depth, water currents)
- Stability of existing sediment and the potential for resuspension during cap placement
- Method of material delivery to site (e.g., by barge, truck, rail, etc)
- Distance between material stockpile (if applicable) and placement location
- Site access limitations (e.g., shallow water, pilings, docks, etc.)
- Grain size and volume of material being placed
- Site-specific placement requirements (e.g., production rates, lift.-thicknesses, etc.)
- Availability of placement equipment (i.e., market factors)

Capping materials planned for placement as part of the Onondaga Lake caps will range from sand-sized to cobble-sized, depending on the layer (chemical isolation, erosion protection, and habitat). Based on the considerations listed above, a hydraulic spreading system has been selected for placement of sand-sized cap materials (including sand, siderite, and activated carbon) as well as small armor stone up to approximately 2 in. in diameter. The larger armor materials (e.g., coarse gravel and cobbles) cannot be efficiently transported or placed via hydraulic slurry or broadcast spreader, and the contractor anticipates using a mechanical bucket (clamshell or other) for placement. These methods of cap placement have been successfully used at numerous other capping sites. The following sections provide a summary of the anticipated means and methods of placement. Appendix J provides a detailed discussion of the cap placement equipment.

4.5.1 Hydraulic Spreader Placement

A specially-designed hydraulic spreading unit will be used for the placement of the majority of the capping materials, consisting primarily of sand-sized materials for the chemical isolation and habitat layers. The hydraulic spreader will also be used for placing erosion protection and habitat layer materials ranging up to gravel-sized (approximately 2-in. diameter). Cap amendments are currently anticipated to be mixed with the sand material and placed using the hydraulic spreader system. Similarly, if it is determined that habitat material with a specific organic carbon content is required in shallow cap areas, it would be placed using the hydraulic spreader system.

The hydraulic spreading system consists of a series of upland hopper bins that will feed capping materials from a stockpile to a slurry system that will entrain water for pumping. The slurry of capping materials will be pumped through a pipeline and a series of booster pumps to a spreader barge at the placement location. The spreader barge will be equipped with an energy diffuser to gently and evenly distribute the capping materials. The spreader barge will also be outfitted with electronic position tracking equipment and software so that the location of material placement can be tracked in real-time. Additional details of the hydraulic spreader system and electronic positioning system are provided in Appendix J. The schematic below presents the conceptual design of hydraulic spreading system.



Schematic of Hydraulic Cap Spreading System

Based on contractor experience with this type of capping equipment at other sites, the hydraulic slurry system will be capable of placing cap materials with a median particle size (D_{50}) up to approximately 1 in. (maximum particle size of approximately 2 in.). Larger diameter capping materials will be placed by mechanical equipment, as described below.

As discussed above, the hydraulic spreader system will be used to place the siderite and activated carbon cap amendments, which will be mixed with sand as part of the chemical isolation layer. This mixing of the sand/siderite or sand/activated carbon will likely be performed during the initial stages of the capping system (e.g., just after the upland hoppers) using a series of weight-metered conveyor belts to combine the correct ratio of sand and amendment. Additional design analyses will be performed to determine the most efficient/effective means of mixing the cap amendments with the chemical isolation materials.

The siderite planned for use as part of the amended cap will be granular (sand-sized particles) with a specific gravity of approximately 3.8 (greater than sand). The activated carbon will also be in granular form and will likely require a period of soaking prior to placement to remove entrained air so the material will settle more quickly through the water column. Although the siderite and activated carbon have specific gravities that differ from sand, they are expected to settle through the water column at approximately the same rate as sand when each is mixed with the sand. This settling has been demonstrated through preliminary bench-scale testing performed by the selected contractor and will be further evaluated during subsequent phases of bench testing and design to ensure uniform placement at the mix ratios required by the design.

4.5.2 Mechanical Bucket Placement

Certain areas of the lake will require an erosion protection layer of coarse gravel or larger, which cannot be placed using the hydraulic spreader system described above. Therefore, the contractor will place these larger materials using a mechanical excavator positioned on a barge. A clamshell or other type of bucket will be attached to the arm of the excavator, which will be outfitted with appropriate positioning equipment such that the position of the material placement can be tracked in real-time during construction. Appendix J provides additional details of the mechanical placement equipment and position tracking system anticipated for the project.

4.5.3 Capping Production Rate

Production rates for granular cap material will vary between mechanical and hydraulic placement methods as well as between the varying material types (sand versus gravel) and site conditions (water depth, size of contiguous capping area, proximity to staging areas, pumping distances, etc.). The contractor has sized the equipment to ensure that the overall project schedule for capping can be achieved within the required project schedule (see Section 8). Depending on the overall sequence and schedule of construction operations, multiple capping operations may be working simultaneously. This may include separate capping operations for different remediation areas (or multiple areas within a single remediation area) and/or separate operations for the different material types. Cap production rates for hydraulic and mechanical placement operations are provided in Appendix J and incorporated into the sequencing discussion in Section 8.

4.5.4 Cap Placement Performance Criteria and Quality Assurance/Control Measures

A series of cap placement performance criteria and quality control procedures will be implemented to ensure that cap materials will be placed to the thickness and extent required by the design in a controlled manner, thereby providing an environmentally protective cap. The following presents cap placement performance criteria, which may be enhanced or appended as the remedial design progresses.

- Cap thickness tolerances: The design provides the minimum, mean and maximum cap layer thicknesses and completed habitat layer elevations. The contractor will be required to place the cap within these tolerances in order to satisfy chemical isolation, erosion protection, and habitat thickness/elevation objectives. Compliance with minimum cap layer thicknesses will be verified during construction, as described below.
- Mixing: Capping material will be placed in a manner that minimizes disturbance of the underlying sediment or previously placed cap material. A maximum cap lift thickness (or differential cap height) of 12 in. will be placed to ensure cap stability on top of existing sediments. Refinements to the design-level recommendations may be made during construction through adaptive management based on the observations and results during and after cap placement.

- Cap disturbance: The contractor will develop and implement means to control construction activities so as to minimize to the extent possible any disturbance to previously placed cap material (such as from spuds, pipelines, anchors, etc.).
- Construction sequencing: Dredge and cap work will be sequenced such that they minimize recontamination of placed cap material (see Section 8).

In addition to the performance criteria discussed above, strict quality assurance and quality control (QA/QC) measurements will be performed throughout cap placement to ensure compliance with the criteria listed above and to verify that the cap materials have been placed to the thicknesses and lateral limits specified by the design and in accordance with the performance criteria (e.g., within specified construction tolerances). The Construction Quality Assurance Plan (CQAP), to be submitted under separate cover, will detail the multiple QA/QC procedures that will be implemented to ensure compliance with the placement criteria. The QA/QC methods to be implemented will include:

- Accurate material volume tracking: Each cap placement operation will be outfitted with equipment to monitor the quantity and rate of material being placed. Volumes of material placed within a known area will be used to compute theoretical cap thickness, which can be used to validate other thickness verification methods. This may include tracking of the number of excavator buckets loaded to the hopper of the hydraulic spreading system, weight-metered conveyor belts, or other appropriate techniques.
- Real-time tracking of horizontal position: Cap placement equipment will be outfitted with a positioning system that will accurately measure and track the position of the placement in real-time through the cap construction to verify that cap materials have been placed within the specific horizontal limits. This typically includes the use of global positioning system (GPS) sensors, inclinometers, tilt sensors, and/or other positioning equipment mounted directly on the placement equipment (e.g., the boom of a mechanical excavator). The positioning equipment will be connected to a computer software package specifically designed for tracking and logging the position and movement of the equipment. Appendix J provides additional details of the anticipated position tracking equipment.
- Post-cap placement samples: Post-placement cores or “catch pans” will be used to collect samples of the cap material placed. The collected samples will be used to verify the thickness and chemical composition of the placed cap materials (e.g., verifying that clean capping materials have been placed in accordance with the design). The sample collection and measurements described above may not be suitable for verifying the placement of large armor stone or in deep water portions of the lake. Therefore alternate means (e.g., geophysical surveys, as described below) may be required for verifying compliance with the design for these materials and areas. The CQAP (to be submitted under separate cover) provides additional details on the cap placement verification program.
- Geophysical surveys: Acoustical and/or manual bathymetric surveying, or other geophysical measurement approaches such as sub-bottom profiling, performed prior to and after cap placement can be used to evaluate the thickness of the placed cap. The

specific equipment to be used and accuracy of these surveys will be dependent on site conditions and may not be suitable for thickness verification in all areas of the lake.

4.6 CAPPING DATA GAPS

Input parameters pertaining to design of the chemical isolation, erosion protection and habitat layers are well defined based on six years of investigation activities. No data gaps have been identified related to design of the various cap layers. Ongoing or anticipated data collection activities associated with the cap design are limited to sediment samples related to minor refinements of the remedial area, as discussed in Appendix A, and the ongoing pH amendment column study discussed in Section 4.1.2. In addition, bench testing is anticipated to help refine the method for placement of bulk activated carbon as part of the amended cap construction.

SECTION 5

DREDGING AREA, DEPTH, AND VOLUMES

Dredging of contaminated sediments is a significant part of the overall Onondaga Lake remedy. The remedy for the lake as specified in the ROD includes dredging of as much as 2,653,000 CY. This was an estimate of the dredge volume required to achieve the ROD-specified goals based on RI data and FS-level evaluations conducted in 2004. Subsequent data collection and more detailed design evaluations between 2004 and 2010 have allowed for a more accurate estimate of the dredge volume required to meet the ROD-specified remedial goals, resulting in an estimated dredge volume of approximately 2,000,000 CY. Details pertaining to this dredge volume estimate are provided in Section 5.2.

Based on the evaluations presented in Section 5.2, the estimated dredge volume has increased in some SMUs and decreased in other SMUs compared to the ROD estimates. For example, the estimated dredge volume in SMU 2 decreased by approximately280,000 CY based on the ESD issued by the NYSDEC December of 2006 and other less-significant refinements.

Design and performance criteria and the methods and results from design evaluations pertaining to dredging, including detailed volume estimates, are discussed below.

5.1 DREDGING DESIGN AND PERFORMANCE CRITERIA

Design and performance criteria relative to dredging fall into two categories: ILWD dredging and dredging to achieve a habitat-based post-capping elevation. All dredged areas will subsequently be capped, therefore there will be no dredging completed to achieve numeric cleanup criteria. ILWD dredging will be to a specified elevation, but it is described separately in this design due to its significance to the overall dredging program. Based on ROD requirements and other project-specific considerations, design and performance criteria pertaining to dredging are listed below.

- ILWD dredging:
  - Dredging will be performed to remove sediments and/or wastes to an average depth of 6.6 ft. (2 meters) in SMU 1. Dredging of ILWD that extends into SMU 2 and SMU 7 will also average 6.6 ft. (2 meters) in each of these areas. The combined area of ILWD in SMUs 1, 2, and 7 is referred to as Remediation Area D.
  - In areas of the ILWD defined as hot spots, dredging will be performed to remove an additional 3.3 ft. (1 meter). Hot spots will be defined as those sediments and or wastes that contain contaminants above the criteria specified in the ROD, as listed below. As specified in the ROD, these criteria may be revised based on refined modeling during the design, using an assumed groundwater upwelling velocity of 6 cm/yr.
    - Benzene 208 mg/kg
    - Chlorobenzene 114 mg/kg

– Dichlorobenzenes	90 mg/kg
– Naphthalene	20,573 mg/kg
– Xylene	142 mg/kg
– Ethylbenzene	1655 mg/kg
– Toluene	2626 mg/kg
– Mercury	2924 mg/kg

  - Dredging of ILWD material will be performed if necessary to ensure the geotechnical stability of the isolation cap. The determination of geotechnical stability will consider both static and seismic stability of the ILWD. The determination of seismic stability will be based on an analysis of cap stability during an operating level event (i.e. a seismic event with a 50% chance of exceedance in 50 years [approximate 72 year recurrence interval]) and a contingency level event (i.e., a seismic event with a 10% chance of exceedance in 50 years [approximate 475 year recurrence interval]).

- Dredging to achieve a habitat-based post-capping elevation. Dredging will be performed as necessary to ensure that after the cap is placed there is no loss of lake surface area. In certain areas, dredging will also be performed to achieve a specific post-capping water depth based on habitat considerations. Dredging will be performed to a specified elevation in these areas based on the thickness of the cap and the desired post-capping water depth.

5.2 DREDGING DESIGN EVALUATIONS AND DESIGN

Discussion regarding design evaluations and the resulting design for dredge areas, depths and volumes for Remediation Areas A through F is presented below. Areas to be dredged are shown in Figures 3.2 and 3.3. Details pertaining to development of dredge areas, depths and volumes are presented in Appendix F. The estimated total dredge volume is approximately 2,000,000 CY, as listed in Table 5.1. Estimated dredge volumes for each remediation area are also included in Table 5.1.

The dredge plans presented in Appendix F were developed based on achieving a specified post-dredging water depth. In Remediation Areas A, B, C, E, and portions of D, these are minimum dredge depths that must be achieved in order to meet the specified habitat-based post-capping elevations. Detail on how the dredge depths were developed to achieve these habitat-based elevations is provided in Section 4.3.4

To achieve the minimum required dredge depths, some over-dredging will result. Over-dredge is an allowance provided to the contractor to account for equipment accuracy and assure that target (required) elevations are met. Typical over-dredging in past similar projects has averaged approximately 4 in. to 6 in. The dredge cuts developed in Appendix F do not include over-dredging. However, the total dredge volumes listed in Table 5.1 do include an average over-dredge of 0.5 ft. in Remediation Areas A, B, C and E, where elevation-based dredging will be completed to a minimum specified depth. During construction, over-dredging will be minimized to the extent practical through tight control of contractor operations and QA/QC.

The dredging elevation in water depths less than 3 ft. in Remediation Area D is also based on a minimum required elevation to achieve a target post-capping water depth; therefore, an estimated removal volume associated with over-dredging is included for this area. However, the overall dredge plan in the ILWD is based on the ROD-required removal volume equal to an average of 2 meters, not on a required elevation. Therefore, the removal in the remainder of the ILWD will be to the specified target elevation plus or minus 0.5 ft. such that the final removal volume achieves the ROD-specified goal of a volume equal to a 2-meter average removal, plus the volume of hot spots, as discussed in Section 5.2.4.

5.2.1 Remediation Area A

Dredging to a target elevation (i.e., elevation-based dredging) to achieve post-cap water bathymetry for designed habitat modules will be completed along the shoreline areas in Remediation Area A, as shown in Figures 4.8 and 4.9. Sufficient dredging will be completed up to the shoreline (surface elevation of 362.5) to ensure placement of the full-thickness cap all the way to the shoreline. As a result, the removal prism will extend inland of the shoreline in order to accommodate suitable dredge cut slopes. The shoreline groundwater collection trench east of Ninemile Creek, being designed as part of the Wastebeds 1-8 IRM, will be located a sufficient distance from the furthest inland extent of the dredge prism so that it is not impacted by the shoreline dredge cut sloping. The shoreline groundwater collection trench is being installed to reduce nearshore groundwater upwelling velocities, allowing the cap to be effective up to the shoreline.

Consistent with Onondaga Lake and Ninemile Creek decision documents, the outlet of Ninemile Creek will also be dredged and capped as part of the lake remedy. This is the area between the two narrow landforms (referred to as “spits”) that protrude into the lake at the mouth of Ninemile Creek. The dredging and capping will extend 300 ft. upstream from the tip of the western spit.

5.2.2 Remediation Area B

Dredging to a target elevation (i.e., elevation-based dredging) to achieve post-cap bathymetry for designed habitat modules will be completed along the shoreline areas in Remediation Area B, as shown in Figures 4.11 and 4.12. A shoreline groundwater collection trench is currently being designed for the shoreline of Wastebeds 1-8 as part of the IRM for that site. This will reduce nearshore groundwater upwelling velocities, allowing the cap to be effective up to the shoreline. Sufficient dredging will be completed up to the shoreline to ensure placement of the full-thickness cap all the way to the shoreline. As a result, the dredge prism will extend inland of the shoreline in order to accommodate suitable dredge cut slopes. The shoreline collection trench will be located a sufficient distance from the furthest inland extent of the dredge prism so that it is not impacted by the shoreline dredge cut sloping.

5.2.3 Remediation Area C

Dredging in a portion of the area adjacent to the east side of the NYSDOT turnaround area in Remediation Area C will be completed to a target elevation in order to increase the post-capping water depths from current conditions and facilitate future use of the NYSDOT turnaround area as a boat launch. The remainder of the dredging in Remediation Area C will be completed to a target elevation to achieve post-cap bathymetry for designed habitat modules, as shown in Figures 4.14 and 4.15.

Sufficient dredging will be completed up to the shoreline to ensure placement of the full-thickness cap all the way to the shoreline. As a result, the removal prism will extend inland of the shoreline in order to accommodate suitable dredge cut slopes. In a small section of shoreline, an existing utility line (force main operated by Onondaga County) would be potentially impacted due to this sloping; therefore, the shoreline dredging and capping plan has been modified in this area, as detailed in Appendix F.

The very steep slope along the middle portion of the NYSDOT turnaround area would make a cap placed in this area unstable. This slope is comprised primarily of slag placed in the lake through non-Honeywell industrial activities when this area was created rather than contaminated lake sediments. This small steep area will be covered with clean substrate consisting of large cobble to physically isolate the slag with no dredging prior to placement.

5.2.4 Remediation Area D

The ROD requires removal to an average depth of 6.6 ft. (2 meters) in SMU 1, which constitutes the majority of the ILWD area (Remediation Area D), plus up to an additional 3.3 ft. (1 meter) in areas defined as hot spots. This same removal approach is required in the portions of the ILWD that extend into SMUs 2 and 7. The ILWD dredging will include dredging of an estimated 1,056,000 CY to achieve the average removal goal of 6.6 ft. (2 meters) and dredging of an estimated 124,000 CY to address hot spots, resulting in a total estimated dredge volume of 1,180,000 CY. Details regarding the development of the dredge volumes are provided below.

A rigorous evaluation of the extensive ILWD sediment and porewater database was completed to develop the removal approach that optimizes contaminant mass removal and reduction of sediment and porewater contaminant concentrations underlying the cap, as detailed in Appendix G. Based on this evaluation, the ILWD was divided into four sub-areas based on chemical concentration and distribution, and optimal removal strategies were developed for each of these sub-areas, as shown in the plan view in Figure 5.1. Removal cross sections are provided in Figures 4.17 through 4.20. The primary removal strategy and basis for the removal strategy for each sub-area are summarized below and are detailed in Appendix F. Example contaminant versus depth plots that were used to identify contaminant distribution trends and the removal strategies listed below are provided in Figure 5.2.

- SMU 1/SMU 7 ILWD Eastern Area: Removal of the top 9.9 ft. (3 meters) in this area will remove the highest sediment and porewater concentrations of chlorobenzene and dichlorobenzene measured anywhere in the ILWD, and will lower the concentration in this area for numerous other contaminants in sediment and/or porewater.
- SMU 1 ILWD Center Area: Sufficient dredging will be completed to ensure that the post-capping bathymetry is consistent with current bathymetry in areas where the current water depth is 7 ft. or less. The amended cap thickness in this area will have a maximum thickness of 5.5 ft. (1.7 meters) assuming maximum over-placement of each layer. Therefore, the removal depth in this area will be approximately 5.5 ft. out to a water depth of 7 ft.

- SMU 1 ILWD Western Area: Contaminant concentrations were generally lower in this area and patterns of concentration versus depth were less defined. However, removal of the top 9.9 ft. (3 meters) in a portion of this area will reduce the concentrations of several contaminants in sediment and/or porewater, including toluene and total SVOCs.
- SMU 2 ILWD Area: Contaminant concentrations are significantly lower in this area than elsewhere within the ILWD. Therefore, habitat considerations were the primary consideration in developing the removal approach in this area. In general, the dredge removal was selected to increase water depth near shore to enhance future shoreline fishing opportunities.

As shown in Figure 5.1, there will be transition zones between the full removal depth and shoreline in some areas, and approaching the littoral area boundary based on habitat and other considerations. There are also transition zones between the removal areas.

Following development of the removal approach that results in an average removal of 6.6 ft. (2 meters), sediment data for the next 3.3 ft. (1 meter) down was evaluated to identify exceedances of the hot spot criteria listed in the ROD and the subsequent hot spot removal approach, as detailed in Appendix G. Hot spots are defined as those wastes/sediments that contain select contaminants (based on their presence at significantly elevated concentrations in the ILWD and/or the compounds to which the cap model is most sensitive) above threshold concentrations. Based on existing data, only chlorobenzene, dichlorobenzenes, and xylenes exceed their respective cap threshold values in the one meter interval immediately underlying the baseline dredge cut, although sporadic exceedances of hot spot criteria for other contaminants were observed in deeper sample intervals. The resulting hot spot removal areas A through G are shown on Figure 5.1. In limited areas, sediments may remain that exceed hot spot criteria following the 1-meter hot spot removal. The remedy will be protective and isolate these areas because the cap design incorporates porewater data inclusive of hot spot areas. This conservatively includes data from sediment that will be dredged.

Hot spot areas A through G shown on Figure 5.1 cover approximately 22 acres. The dredge areas around sampling points that exceeded hot spot criteria were developed based on interpolation with surrounding data points that did not exceed the hot spot criteria using conservative assumptions, as detailed in Appendix G. Based on these hot spot areas and a dredge cut side slope of 5 horizontal to 1 vertical (5H:1V), the estimated hot spot dredge volume is approximately 124,000 CY. All hot spot dredging will be based on existing data, no additional design-related or confirmatory sampling will be performed.

The detailed dredge prisms and associated design and contracting plan will be developed to ensure the volume-based goal corresponding to an average removal of 6.6 ft. (2 meters) is achieved (exclusive of hot spot dredging) on a SMU-specific basis. This results in dredge volumes in the ILWD in SMU 1, SMU 2, and SMU 7 as follows:

	Area (acres)	Volume (CY)
SMU 2 ILWD 2-meter average	7.1	75,400
SMU 1 ILWD 2-meter average	83.9	888,300
SMU 7 ILWD 2-meter average	7.5	92,400
Subtotal	98.5	1,056,000
Hot spot removal volume		124,000
Total (w/o over-dredging)		1,180,000

The SMU 7 ILWD dredge volume equates to greater than a 2 meter average removal in order to achieve the SMU 1/SMU 7 ILWD East removal goal listed above of 3 meters in the majority of this area.

Geotechnical stability evaluations were completed to evaluate seismic stability of the ILWD, as detailed in Appendix H. These stability evaluations concluded that the ILWD is stable following the removal described above and no additional removal is required to meet seismic stability goals listed in Section 5.1.

5.2.5 Remediation Area E

Dredging to a target elevation to achieve post-cap water bathymetry for designed habitat modules and navigational considerations will be completed along the shoreline areas in Remediation Area E, as shown in Figures 4.22 through 4.24. Sufficient dredging will be completed up to the shoreline in the northern portion of Remediation Area E to ensure placement of the full-thickness cap all the way to the shoreline. As a result, the removal prism will extend inland of the shoreline in order to accommodate suitable dredge cut slopes.

In the area south and immediately north of Onondaga Creek, three active CSX rail lines are located immediately adjacent to the shoreline. Geotechnical analysis indicates that dredging within approximately 150 ft. of the shoreline could result in an unacceptable factor of safety for the shoreline and rail line stability. Therefore, detailed dredging and capping prisms have not been developed for the area within 150 ft. from shoreline along this portion of Remediation Area E. An appropriate approach for this area that is environmentally protective and does not negatively impact the stability of the CSX rail lines will be developed as part of the draft final design. Table 5.1 includes a maximum estimated dredging volume from this area to ensure that the total dredge volume is not underestimated.

Nearshore contamination is relatively deep at the mouth of Onondaga Creek. The channel depth at the mouth of Onondaga Creek must be sufficient to accommodate commercial boat traffic that uses Onondaga Creek and the Inner Harbor. Therefore, the proposed approach in this area is to dredge to a sufficient depth to allow cap placement while maintaining minimum required navigational depths as provided by the NYSCC.

5.2.6 Remediation Area F

The area requiring remediation in Remediation Area F consists of two small areas totaling less than one acre. The water depth is sufficient in these areas such that dredging prior to capping is not required.

5.2.7 Removals in Adjacent Areas

The area and depth of material requiring removal for remediation of the Ninemile Creek spits was developed in Appendix F, resulting in an estimated removal volume without contingency of approximately 22,000 CY. The removal approach and management strategy for material removed from this area are being developed as part of the Ninemile Creek design. Therefore the volume of material removed from this area is not included in the dredge volumes in Table 5.1.

The area and depth of material requiring removal for construction of the connected wetland at Wastebeds 1-8 was developed in Appendix F, resulting in a removal volume without contingency of approximately 64,000 CY. The removal approach and management strategy for material removed from this area are being developed as part of the Wastebeds 1-8 IRM decision documentation. Therefore the volume of material removed from this area is not included in the dredge volumes in Table 5.1.

The minimum area and depth of material requiring removal in the Wastebed B Outboard Area in order to achieve the desired habitat was also developed in Appendix F, resulting in a minimum removal volume without contingency of approximately 196,000 CY. The final removal volume, as well as the removal approach and management strategy for the material removed from this area, are being developed as part of the Wastebed B IRM decision documentation. Therefore, the volume of material removed from this area is not included in the dredge volumes in Table 5.1.

5.3 DREDGING OPERATIONS AND EQUIPMENT

This section provides an overview of anticipated dredging equipment and operations, which have been developed taking into consideration input from the selected dredge contractor (Sevenson Environmental). This section also summarizes the anticipated dredging production rates, interaction with shoreline remediation, emissions monitoring and management, and quality control measures.

5.3.1 Dredging Equipment

The use of hydraulic dredging and transportation by pipeline was evaluated relative to other options (e.g., mechanical dredging) in the Feasibility Study (Parsons 2004). The FS concluded that hydraulic dredging was the most suitable method of sediment removal. Hydraulic dredging eliminates the truck traffic associated with transportation of mechanically dredged material and minimizes exposure of the dredged material to the air, thereby minimizing the odor and emissions generation potential.

In selecting the most appropriate dredging operation for Onondaga Lake, the selected contractor and design team considered numerous factors including, but not limited to physical site conditions, physical characteristics of the dredged material, dredged material transport requirements, sediment management and dewatering, and water treatment system capacity.

The dredging contractor will use several dredges, including dredges of different sizes operating individually and concurrently. The use of multiple dredges ensures the flexibility to operate in multiple areas simultaneously or in differing site conditions (water depth, cut thickness, etc.). This redundancy and optimization in operation will allow the contractor to maintain schedule and complete the dredging within four years. The dredging contractor will utilize three hydraulic dredges based on the range of site characteristics and the required production rates and schedule. A memo developed by Sevenson summarizes the selection of the hydraulic dredges and the anticipated production rates (see Appendix J). The three dredges selected are listed below.

- Dredging Supply Company (DSC) Marlin 7650D dredge with a 16-in. diameter discharge line and a 30 ft. spud carriage
- DSC Shark 75450D dredge with a 14-in. diameter discharge line and a 30 ft. spud carriage
- DSC Moray 2000D swinging ladder dredge with an 8-in. diameter discharge line

The proposed dredges will be used in various combinations depending on the thickness of the dredge cut, the type of material and location of dredging. The 16-in. dredge will be used as the primary production dredge, focusing on areas with thick dredge cuts for efficiency of operations. Due to the discharge flow requirements of the 16-in. dredge, it will operate individually. The 14-in. dredge can operate individually as a production dredge when needed, or used in combination with the 8-in. dredge. The 8-in. dredge does not generate enough discharge flow to the sediment transport system and therefore cannot be used individually unless significant makeup water is provided to meet minimum pipeline flow requirement. It will be utilized more as a specialty dredge in areas of shallow water or thin dredge cuts, which are more efficient for the smaller dredge. More details on the likely sequencing of dredge operations are discussed in Section 8.3.

5.3.2 Dredging Production Rate

Appendix J presents the estimated production rates for each of the three selected dredges operating in each of the remediation areas. The production rate estimates are based on the in-situ geotechnical data, dredge cut thickness, dredge characteristics (i.e. impeller diameter/ horsepower), swing speed, swing distance, time required to advance the dredge and handle anchors, pumping distances to the first available booster pump, and booster pump spacing along the proposed alignment. Average dredging production rates are developed in Appendix J for each Remediation Area based on these factors. The anticipated range of average production rates for each dredge is listed below.

- 16-in. Dredge: 178 to 351 CY/hr, depending on remediation area
- 14-in. Dredge: 159 to 224 CY/hr, depending on remediation area
- 8-in. Dredge: 22 to 38 CY/hr, depending on remediation area

The estimated combined production rate for the 14-in. dredge and the 8-in. dredge when operated simultaneously ranges from 183 to 262 CY/hr, depending on Remediation Area. Due to factors within the dredging/sediment transport/solids handling/water treatment system, a 75% up time is estimated for the system. These production rates are more than adequate to achieve the required dredge volume within four years, as discussed in sequencing (Section 8). Depending on the overall sequence and schedule of construction operations, multiple dredging operations may be working simultaneously. This may include concurrent dredging operations for different remediation areas (or areas within a remediation area) based on operation of the 14-in. dredge and 8-in. dredge.

The dredging, slurry transport, and the dewatering activities essentially form one integrated system. The dredges and resulting production rates described above have been incorporated into the design of the sediment management system, including piping, pump station and dewatering system designs, as detailed in the sediment management design documents.

5.3.3 Nearshore Dredging and Interaction with Shoreline Areas

Nearshore dredging involves the removal of dredged material within the dredge prism along the shoreline and is defined by access to the shoreline based on bathymetry and dredge draft. Dredging will be completed up to the shoreline so that the required thickness of the cap can be constructed up to the shoreline without losing any lake surface after the cap is placed. The removal will then slope into the shoreline at an assumed slope of 5H:1V, although this may be revised based on field observations, as detailed in Appendix F.

Tasks associated with nearshore dredging and shoreline sloping involve tree and bush removal, shoreline debris management, and submerged aquatic vegetation (SAV) management. SAV in near-shore dredge areas will be managed appropriately to ensure it does not negatively impact dredging and sediment management operations. The SAV has the potential to reduce the efficiency of the dredge cutter head during dredging due to entanglement of the roots or vegetation on the cutter head. This could result in a system shutdown due to the need to raise the cutter head to physically remove accumulated material. Another potential concern is the management and segregation of the SAV that would clear the cutter head(s), booster pumps, and ultimately be deposited on the particle size segregation screens prior to dewatering at the SCA. The SAV may block off or “blind” the screens, causing sediment and water flow blockages or restrictions at the SCA. This may also result in a reduction of flow to the system, or a system shutdown to remove the blockage. In addition, the organic SAV material that accumulates in the geotubes at the SCA may reduce the dewatering ability of the geotubes causing a reduction in allowable flow. For these reasons, the SAV in the lake will be managed to ensure that it does not impact the dredging and sediment management systems. Two potential ways to manage SAV are mechanical removal and chemical treatment. These two methods are currently being evaluated and will be addressed in future design submittals.

The anticipated approach for nearshore dredging involves hydraulically removing targeted material within the dredge prism up to the edge of the lake, with potential mechanical removal on the upland side along the shoreline. In Remediation Area C and Remediation Area E, on-shore material that is removed as part of the sloping requirements will be temporarily stockpiled on shore and then replaced as part of the shoreline restoration following cap placement. In areas where on-shore material that is removed is within the remedial boundary of an adjacent site, such as along the shoreline of Remediation Area A and Remediation Area B, removed material will be managed in kind with management of other material generated at that upland remediation site.

Nearshore dredging design will involve coordination/integration with other Honeywell upland remediation projects that are currently or will be implemented along the shoreline of the remediation areas. This includes remedial activities at Ninemile Creek, Wastebeds 1-8, Willis/Semet Barrier Wall, Tributary 5A, and Waste Bed B/Harbor Brook barrier wall. Integration of the lake remedial design and construction sequencing with these remedies is discussed in Sections 3.4 and 8.1. The scopes and schedules for upland remedial activities are being advanced as part of the remedial programs for the individual sites. As these programs are advanced and additional details become available, the information will be used to further define the approach for integrating these on-shore activities with the lake remediation in future lake-related design submittals.

5.4 DREDGING OPERATIONS QUALITY CONTROLS MEASURES

The quality control measures for dredging operations have been developed with consideration of the elevation based dredging methodology and requirements for dredging in the ILWD area. Dredging within the ILWD area Remediation Area D will be performed to remove sediments and/or wastes to an average depth of 6.6 ft. (2 meters) in SMU 1, SMU 2 and SMU 7. Quality control measures that will be implemented related to dredging include:

- Real-time horizontal & vertical position control – Each dredge will be outfitted with a positioning system that will track, in real-time, the position of the cutterhead. This typically includes the use of differential global positioning system (DGPS) sensors, inclinometers, tilt sensors, and/or other positioning equipment mounted directly on the arm of the dredge (e.g., the ladder of the hydraulic dredge). The positioning equipment will be connected to a computer software package specifically designed for tracking and logging the position and movement of the cutterhead while it is in operation. The horizontal datum for the site will be U.S. State Plane – New York Central Zone NAD83, U.S. Survey feet. The vertical datum for the site will be North American Vertical Datum 1988 (NAVD88), U.S. Survey feet. Appendix J provides additional details of the planned position control systems for the dredges.
- Dredged material quantity tracking – Each dredge will be outfitted with equipment to monitor the density and rate of material being removed (see Appendix J). Additional means to track quantities will include volume computations utilizing contractor progress surveys.
- Side slopes – Removal of sediment from the side slope beyond the limit of the dredge prism are designed at a 5H:1V vertical side slope, as depicted on the Drawings (Appendix F). Dredge prism side slopes may be defined upon further evaluation of geotechnical properties, as well as adaptive management of actual conditions in the field. The side slope will reduce material from sloughing into the dredge prism during or after construction. The actual side slope will be as steep as practical to reduce the impact of dredge operations on shoreline areas.

Quality control and quality assurance procedures, including pre, interim, and post dredging surveys and data collection, will be performed throughout the dredging operations. Detailed procedures will be provided in the Construction Quality Assurance Plan.

5.5 DREDGING DATA GAPS

Dredging areas and depths, as well as the properties of the materials to be dredged, are well defined based on data from the RI and six years of design-related investigations. No current dredging-related data gaps have been identified.

SECTION 6

IN-LAKE DEBRIS AND UTILITY MANAGEMENT

6.1 DEBRIS

This section provides the basis and considerations for accommodating debris encountered within the areas of Onondaga Lake to be dredged and/or capped.

6.1.1 Debris Design and Performance Criteria

The primary objective in debris management, as it pertains to dredging, is to remove or otherwise manage debris in place such that targeted sediment can be efficiently and effectively dredged and dewatered through the on-site processing system. Certain debris can be left in place, including large boulders and rocks that do not pose a contamination risk and provide beneficial habitat structure. Smaller debris can be effectively removed by the dredge, but other debris that could interfere with and/or damage the dredge, pipeline, or sediment processing equipment will be removed before dredging begins.

Within capping areas, debris will either be contained in place or removed to ensure that neither the ability to place the sediment cap, nor integrity and long-term effectiveness of the cap is impacted. Similar to debris management in dredge areas, it is feasible, and in some cases beneficial based on habitat considerations, to leave some of the debris in place, while other debris may require removal prior to capping. In general, it is anticipated that only limited, if any, debris removal in the capping areas will be required.

6.1.2 Debris Characterization

Debris refers to wood, concrete, plastics, glass, metal, cable, tires, rocks,pilings, and other objects located on the surface of or within lake-bottom sediment. The Phase I PDI geophysical survey work conducted during the fall of 2005 for Honeywell (CR Environmental, 2007), which included side-scan sonar and magnetometer surveysdetected debris and obstructions, referred to as contacts, as small as 1 ft. to 2 ft. located on or above the mudline. Magnetometer surveys detected contacts containing iron or items that have been fired (such as bricks) located either at or below the mudline. Unlike side-scan sonar data, the magnetometer data do not reveal information about size or depth of those materials. Because no one single survey technology is available to characterize size, shape, or depth of debris, or other obstructions submerged below the mudline, a combination of the two methods provides the most comprehensive view of debris on the lake bottom.

Figure 6.1 presents locations of debris identified during the Phase I PDI geophysical survey work. An extensive data set was generated during this investigation. To facilitate management of the data, only debris that was equal to or greater than 5 ft. in size in any one dimension was reported on Figure 6.1. In addition, several debris features which are known to exist based on field observations but were not detected during the 2005 survey, are depicted on Figure 6.1.

In preparation for remedial activities, additional surveys may be completed to update/refine the debris characterization completed during 2005. Additional information from potential future surveys will be evaluated, and incorporated into the debris management strategy. Despite the best efforts to identify debris in advance of the work, it is possible that some debris may be encountered during the conduct of the work that will require adaptive management in the field.

Onondaga Lake also contains some debris that may be of historical significance, including potential wrecks that may be considered underwater archeological resources. As described in Section 3.12 of the Sediment Management & Water Treatment IDS (Parsons, 2009a), a Phase 1B Underwater Archaeological Resource Work Plan for the lake bottom and a Phase 1B Archeological Work Plan that includes the shoreline and several of the upland sites have been prepared. Underwater and upland archeological field investigations were conducted in 2010. The results of these investigations will be documented in the Phase 1B Reconnaissance Survey Reports.

Underwater archeological resources identified during the cultural resources investigation will be addressed before starting any debris removal, dredging, or capping operations. Details pertaining to the management of archeological resources in dredge and cap areas will be further developed following finalization of this Phase 1B Reconnaissance Survey Report.

6.1.3 Debris Management in Dredge Areas

Based on experience at other dredging projects, proper debris management is critical to ensuring the efficiency of the dredging operation. Prior field experience also indicates that debris management is most efficiently undertaken in an adaptive management mode, in the field, in which the dredging contractor retains the flexibility to make real-time field decisions as to which debris to work around, versus which warrants removal (completely or partially). As such, the dredging contractor will have general discretion as to what debris will be removed prior to dredging, and which will be left in place. As all dredging areas will be subsequently capped, dredging-area debris removal decisions will also be required to comply with the requirements for debris management in capping areas, as outlined in Section 6.1.4.

Based on evaluation of the geophysical survey results and other field investigations conducted to date, it is anticipated that at least some of the dredge areas will require some amount of debris removal prior to dredging. However, a general effort to rake <u>all</u> sediments prior to dredging will likely not be necessary. For example, aerial photograph reconnaissance has revealed the presence of a large area of discarded tires near the discharge of Harbor Brook, within the dredge prism for Remediation Area E (Figure 6.1). As these tires would likely become entangled in the dredge cutterhead, they will be removed prior to dredging. In addition, several areas of the lake, particularly at the mouth of Onondaga Creek, old wooden pilings remain embedded in the sediment. Timber piles within the dredging areas will be pulled or cut at or below the final dredge depth.

6.1.4 Debris Management in Cap Areas

Debris management in cap areas will fall into two categories; management of debris in cap areas not requiring prior dredging (e.g., cap-only areas), and management of debris in dredge areas that will receive a post-dredge cap (e.g., dredge-and-cap areas). Debris within the dredge-and-cap areas may be removed before or during the dredging operations as described in Section 6.1.3. However, if the debris does not require removal to facilitate dredging and would otherwise not impact the construction or performance of the cap, it may be left in place, as discussed below.

In general, most debris present in the capping areas would not impact the construction or performance of the sediment cap. Due to the thickness of the cap being placed, most debris would simply be buried in place. This management strategy has been successfully implemented at other sediment capping projects recently completed, such as the Lower Fox River (WI). Debris removal in capping areas will be limited to those targets which will have been determined to significantly impact the constructability or effectiveness of the cap. Further evaluation will be conducted as part of the final design to assess which debris targets, if any, could adversely impact the cap. These debris targets will be identified in the draft final design.

6.1.5 Debris Removal and Management

Debris removal will likely be accomplished with barge-mounted cranes and/or excavators using various types of attachments such as grapples, clam shells, and rakes. Debris will be placed into/onto a barge, transported to shore, and moved to an onshore area for transportation to the SCA. Details pertaining to the on-land debris management is provided in the Sediment Management Draft Final Design.

6.2 UTILITY AND STRUCTURE MANAGEMENT

This section provides the basis and considerations for accommodating utilities and structures located within the areas of Onondaga Lake to be remediated through dredging and/or capping.

6.2.1 Utility and Structure Design and Performance Criteria

The primary goal in utility and structure management, as it pertains to dredging and capping, is to achieve the remedial objectives through incorporation, modifications to, or removal of those items as necessary to insure the integrity and long-term effectiveness of the cap.

6.2.2 Utility and Structure Characterization

Utilities and structures consist of active and inactive pipelines, culverts, outfalls, and water intake structures on the sediment surface or buried on the lake bottom. For purposes of this submittal, pilings are considered debris.

The primary sources of information on utilities and structures are historical records, and the Phase I PDI geophysical survey work conducted during the fall of 2005 for Honeywell (CR Environmental, 2007), which included side-scan sonar and magnetometer surveys. A list of utilities and supporting information (i.e., owner, material of construction, remediation area location, dimensions, and active status) is provided on Table 6.1. Figure 6.1 presents the approximate locations of these utilities and structures, as determined by the analysis of the geophysical surveys and available historical records.

6.2.2.1 Tributary 5A Outlet (Active)

A 60-in. diameter steel culvert with a headwall structure owned by Honeywell discharges flow from Tributary 5A to the lake. The structure, including outlet protection, extends approximately 40 ft. from the lake shore into the dredge prism. Field reconnaissance will be needed to verify the construction of the outlet protection, which will be completed as part of the final design. The invert of the outlet is at elevation 362.0 ft. (NAVD88). The integrity of this outfall will not be impacted during remediation and scour protection will be addressed.

6.2.2.2 Westside Pumping Station Outlet (Active)

A 42-in. diameter reinforced concrete culvert with unknown headwall details discharges flow from the Metro Westside Pump Station to the lake. The invert of the culvert at the shoreline is 362.6 ft.(NAVD88) and it is assumed it extends into the dredge prism. The integrity of this outfall will not be impacted during remediation and cap scour protection will be addressed as part of the Final Design.

6.2.2.3 NYDOT (I-690) Outfall (Active)

During construction of the Willis/Semet barrier wall, outfalls from stormwater drainage along I-690 were decommissioned. A new 24-in. diameter pipeline connected to a manhole (MH-3) replaced the stormwater system, and currently discharges at a penetration though the eastern end of the Semet Wall. The new outfall pipe is constructed of ductile steel and is encased in concrete where it penetrates the Semet barrier wall. The outfall extends approximately 20 ft. from the shore and terminates at invert elevation 361.5 ft. (NAVD88). A 10-ft. wide rock outlet protection apron consisting of filter fabric, Type F bedding and medium rip-rap extends approximately 7 ft. from the invert. This outfall is in-use and both it and the outlet protection will not be impacted during the dredging and capping operations.

Decommissioned outfalls (outfalls 040 and 041) that were demolished during construction of the Willis/Semet barrier wall were replaced by the MH-3 outfall. These were 18-in. diameter reinforced concrete pipes which were not removed from outboard of the barrier wall.

6.2.2.4 Metro Deepwater Outfall (Active)

A discharge pipeline from Metro extends from the shoreline through the south corner of Remediation Area E and into Remediation Area D. This discharge is not currently active, however the option to initiate use in the future must be considered, and the pipeline's integrity must remain intact.

The pipeline is referred to as Outfall 1 (Subaqueous Conduit) on the historical Metro design detail drawings. It is a 60-in. inner diameter pipe of reinforced concrete construction with 6-in. thick pipe walls for a total outer diameter of 72 in. The pipe consists of 20 ft. lengths clamp-bolted together and sealed.

According to design drawings for this outfall, approximately 1,350 ft. of the outfall lies within a channel that was dredged as part of the construction. The final 900 ft. length is supported with timber frames spaced every 20 ft. which are pile-supported to an unknown depth. The dispersion section has pipe support structures that are spaced every 4 ft. and is also underlain by a 20 ft. wide apron of rock protection.

Previous reports have discussed the potential presence of two Metro outfalls. However historical records and underwater photographs indicate one actual discharge pipeline (Outfall 1), discussed above. The second outfall was never constructed.

6.2.2.5 Metro Stormwater Drain (Active)

This is a 24-in. diameter reinforced concrete stormwater drain currently in use at the Metro facility. It extends approximately 82 ft. from the shoreline into the dredging and capping prism of Remediation Area E. No details on exact location or headwall construction are available. However the invert elevation is at 361.2 ft. (NAVD88) and the top is above the water surface. The integrity of this structure will not be impacted during remediation.

6.2.2.6 Metro Shoreline Outfall (Active)

This is a 96-in. diameter reinforced concrete sewerage effluent outfall which is currently in use at the Metro facility. It extends approximately 95 ft. from the shoreline into the dredging and capping area of Remediation Area E. No details on exact location or headwall construction are available. However the invert elevation is at 361.2 ft. (NAVD88) and the top is above the water surface. The integrity of this structure will not be impacted during remediation.

6.2.2.7 Remediation Area A Pipelines (Inactive)

Two cast-iron pipelines exist above the sediment surface within Remediation Area A. These were identified during the Phase I Pre-Design Investigation as clusters of magnetic anomalies. Side-scan contacts for the features could not be established, as the features are located in a shallow area where limited resolution of the side-scan sonar image is available. Aerial photographs and visual reconnaissance conducted during the Phase III PDI investigations revealed the pipelines’ characteristics and location above the lake bottom.

Historical information regarding these pipelines has not been identified. Both pipelines extend into the dredging and capping prisms in Remediation Area B.

6.2.2.8 Cooling Water Intakes (Solvay Process) (Inactive)

Two known utilities within Remediation Area D, an 84-in. and a 72-in. diameter cooling water intake line, were formerly owned by Solvay Process Company, and are now the property of Honeywell. The pipes are no longer in service.

The 84-in. diameter pipeline is constructed of corrugated iron and is supported by 9-ft. wide timber frames, with each frame supported by two timber piles driven to unknown depths. The supports are spaced at an average of 32 ft. along the length of the pipe. Historically, a trestle structure existed above the 84-in. pipeline for a distance of approximately 125 ft. from the current shoreline. The trestle platform has been removed; however, according to observations made during construction of the Willis/Semet IRM barrier wall, the supporting timber piles were cut off a few feet above the existing sediment surface. Details pertaining to further action needing to be taken on these cut-off timber piles will be determined as part of the final design.

The trestle platform terminated at a valve structure. According to local knowledge, this structure was not completely removed during decommissioning, therefore it is assumed that it still exists, either intact or as debris close to this location.

The 72-in. diameter pipeline is constructed of cast iron, and originally lay on the lake bottom. There are two elevation transitions within the dredging and/or capping prisms at which manholes exist.

As part of the Willis/Semet IRM barrier wall construction, the intake pipelines were plugged inboard and outboard of the barrier wall alignment. Additionally, portions of the pipes intersecting the barrier wall alignment were demolished to allow for installation of the sheet piling in this area. The demolished portions of the pipelines were not removed from outboard of the barrier wall.

6.2.2.9 Water Inlet Pipes (Allied Chemical) (Inactive)

Three water inlet pipes (42-, 30-, and 16-in. diameter) lie near the western boundary of Remediation Area D. The three pipelines were installed by Allied Chemical and are currently owned by Honeywell. The pipelines have been abandoned from service, but remain in place beneath the lake bottom. The three pipelines were detected by the magnetometer survey but were not identified during the side-scan sonar survey, indicating the three pipelines are buried.

Historical mapping indicates pipeline locations, however these alignments do not concur with the magnetometer survey results. Results from the magnetometer survey indicate that the 42-in. diameter pipeline extends 1230 ft., the 30-in. diameter pipeline extends 1145 ft. and the 16-in. diameter pipeline extends 890 ft. into the dredging prism and cap area.

During the Phase III PDI, drilling was consistently obstructed at two locations at a depth of 16 ft. to 18 ft. below the sediment surface in the vicinity of the expected location of the 30-in. diameter pipeline. These locations were at a distance of 25 ft. to 35 ft. from the shore and within the alignment of the barrier wall.

During the installation of the Willis/Semet IRM Barrier Wall, two of the intakes were intersected by the sheet pile driving operation, most likely the 30 in. and 42 in. As no removal of these pipelines was conducted, no verification of the sizing is available. However, it is assumed it was the 30-in. diameter pipe encountered approximately 17 ft. below the surface of the sediment, and the 42-in. diameter pipe encountered approximately 8 ft. below the surface of the sediment. The 16-in. diameter pipeline was not encountered during the installation of the barrier wall.

6.2.2.10 Diffuser Pipeline (Inactive)

An abandoned cooling water intake, previously owned by Allied Chemical and now owned by Honeywell, extends approximately 800 ft. into the lake, perpendicular from the shore. The 60-in. diameter pipeline of coal-tar lined steel construction originates from the East Flume pump house via a flowmeter. The pipeline terminates at a diffuser of similar construction, aligned perpendicular to the pipe itself, and 130-ft. in length.

The pipeline originally lay on the lake bottom, however it is currently under the sediment from the flow-meter to approximately 650 ft. offshore from the flow-meter. The remaining section of pipeline and diffuser daylight from the sediment, with the diffuser itself being pile supported on a structure of unknown detail.

6.2.2.11 Sun Oil Pipeline (Inactive)

This is an 8-in. diameter cast-iron pipe previously owned by Sun Oil. It has been abandoned, and Sunoco Logistics (the successor to Sun Oil and current owner of the pipeline) has verified the pipeline as having been cleaned prior to closure. An historical plan indicates the pipeline's alignment, however the alignment does not concur with the location established through magnetometer survey as part of the Phase I Pre-Design Investigation.

This pipeline was encountered during construction of the barrier wall along the south-east shoreline of the lake. During this construction, this portion of the pipeline was demolished to allow the barrier wall to be installed. Field observations during the demolition of that pipeline verified that the pipeline did not appear to contain any residual materials.

Based on historical drawings for the Metro outfalls, a section of this oil pipeline was deepened where its alignment interfered with construction of an outfall and storm drain at Metro. Details for this alteration establish invert elevations of 357.9 ft. (NAVD88) directly below the Metro structures and at 365.4 ft. (NAVD88) outside the alignment of the Metro structures. However, depths of this pipeline along its alignment are currently unknown. Further research and evaluation on this pipeline, including the existing alignment and elevations, will be completed as part of the final design.

Based on previous experience with decommissioning of sections of this pipeline, Sunoco Logistics would likely be responsible for the execution of any decommissioning, and further planning regarding, relocation, plugging or removal as necessary to facilitate the remediation.

6.2.2.12 Remediation Area D Linear Anomaly (Inactive)

Review of aerial photographs taken during the pre-design investigations, and field observations during the construction of the shoreline barrier walls, indicate the presence of a linear anomaly extending from the shoreline near the Upper East Flume, into the lake at an acute angle to shore. Based on observations, the anomaly appears to be a baffle wall, of wooden construction; however no previous records of such a structure have been identified. This structure penetrates the surface of the sediment, and is within the dredge prism for Remediation Area D. Further investigation will be conducted during the final design to assess the nature of this structure, and to determine how it will be addressed during the dredging and capping operations.

6.2.3 Utility and Structure Management

To the extent practicable, utilities and structures within the dredging and/or capping areas will be left in place and incorporated into the final cap. To accommodate these structures, it may be necessary to modify the cap grade, taking into consideration water depth and habitat criteria. Management strategies that may be considered for utilities and structures include:

- Leave active or inactive utilities and structures in place and install the cap up to and adjacent to these items
- Leave active or inactive utilities and structures in place and install the cap over these items taking into consideration potential cap enhancement details that may be necessary for cap stability and integrity (i.e., cap enhancement/erosion protection in high energy discharge on intake locations)
- Provide utility or structure modifications to preserve the intent and functionality of the active utility or structure (i.e., extend pipe discharge or intake locations with additional pipe lengths or add risers to structures so these elements daylight out beyond where the cap is placed)
- Remove those portions of inactive utilities and structures that will inhibit or jeopardize dredging operations and/or the long term integrity or performance of the cap
- Extract or cut timber piles at bottom of cap

Based on evaluations completed to-date, no utility removal is anticipated. Utilities that are in continuous or intermittent use may need to be protected during the dredging and capping operations. Some of these utilities are not owned by Honeywell; therefore, discussions with the utility owners will be required before any management steps are taken. In some instances, the utility owners themselves may need to take management steps for their utilities prior to initiation of dredging and/or capping.

Information obtained as part of the Phase I Pre-Design Investigation, through review of historical records, and as part of the Willis/Semet IRM barrier wall installation were used to define the alignment of three known utilities within the dredging and capping prisms. Details of the orientation of these three utilities, and details pertaining to how they will be incorporated into the dredging and capping prisms, are provided below. Design plans for the remaining utilities will be developed as part of the Draft Final Design.

6.2.3.1 Cooling Water Intakes (Solvay Process)

As presented in Figure 6.2, approximately 300 ft. of the 84-in. diameter intake line lies within or above the dredging or capping prisms, in water depths ranging from approximately 15 ft. to 25 ft. Approximately 250 ft. of the 72-in. diameter intake line lies within or above the dredging or capping prisms, in water depths ranging from approximately 17 ft. to 24 ft. The remaining lengths of both pipes fall below both the dredging and capping prisms.

To accommodate these pipelines, the dredging and capping prisms will be modified, to incorporate these structures into the final cap elevation. In the areas of these pipes, sediment will be dredged on top of, and next to the pipelines as close as can be reasonably completed by the dredging contractor. Following dredging, the cap will be placed, per the required thickness, in the vicinity of and over these pipelines. The existing water depths in the portions of pipe which fall within the dredging and capping prisms are sufficient to maintain draft requirements and habitat criteria. These modifications have not been incorporated into the dredge prisms presented in Appendix F, but will be incorporated into the final design.

6.2.3.2 Diffuser Pipeline

As presented in Figure 6.3, the entire portion of the pipeline which falls within the dredging area (approximately 750 ft.), lies within or above the dredge and cap prisms. Within the corresponding cap area along this pipeline, the pipe lies above the cap prism.

To accommodate this pipeline in the dredging area, the dredging and capping prisms will be modified, so as to incorporate these structures into the final cap elevation. Sediment will be dredged next to the pipeline, as close as to the pipeline as can be reasonably completed by the dredging contractor. Following dredging, the cap will be placed, per the required thickness in the vicinity of and over this pipeline. These modifications have not been incorporated into the dredge prisms presented in this design report, but will be incorporated into the Final design.

6.2.4 Remaining Utilities

As part of the final design process, a similar evaluation will be completed for the utilities and/or structures described above. These investigations will assess orientation with respect to the dredging and capping prisms, and define how the various utilities and/or structures can be incorporated into the existing prisms, or if the dredging and/or capping prisms will require modification.

SECTION 7

MANAGEMENT OF AMBIENT WATER QUALITY DURING DREDGING AND CAPPING

A comprehensive water quality management and monitoring program will be implemented to prevent potential unacceptable water quality impacts as a result of sediment disturbances during capping and dredging activities. This program will address suspension of impacted sediments as well as release of dissolved contaminants. Suspension controls, both physical (e.g., silt or turbidity curtains) and operational (e.g., minimize cutterhead rotation speed and other best management practices [BMPs]) have proven effective at numerous capping and dredging sites, and will be used to mitigate any potential impacts during Onondaga Lake remedial activities.

The method for managing ambient water quality impacts is presented in this section by describing the design and performance criteria, existing water quality and wave/lake current conditions, turbidity controls such as silt curtains that will be used, monitoring activities, and potential operations optimization activities. Additional details pertaining to these topics will be provided in the Water Quality Management and Monitoring Plan.

7.1 DESIGN AND PERFORMANCE CRITERIA

Water quality criteria for in-lake remedial construction activities will be established during final phases of the design and will incorporate the results from 2010 and 2011 water quality sampling activities. The development of water quality criteria will consider the existing ambient water quality of the lake and incorporate spatial (e.g., distance from dredging and capping operations) and temporal (e.g., 2-hour average) components. Water quality criteria will consist of two tiers: 1) criteria to be met at performance monitoring stations; and 2) criteria to be met at compliance monitoring stations. The intent of the performance monitoring stations is to monitor near-field water quality in the general vicinity of the construction area (outside of the silt curtains). Specific locations of the performance monitoring stations will be developed to identify and manage any dredging- or capping-related impacts, so that early warning is available to refine the dredging or capping process. Response to an exceedance at the early warning, performance monitoring station may include additional monitoring and operational improvements (see potential operations optimization activities in Section 7.6). Compliance monitoring stations will serve as the official compliance location for water quality and will be developed to assure environmental protection of the lake.

Water quality criteria will be developed such that an efficient and environmentally protective program can be implemented. Turbidity will be the primary criteria used to monitor the impacts of dredging and capping in real time. This will provide for rapid implementation of corrective actions, if warranted, to ensure water quality criteria are met at the compliance monitoring stations. A review of relevant environmental dredging projects indicates that water quality criteria typically ranging from 25 to 50 Nephelometric turbidity units (NTU) above background were proven to be protective and practical limits. These same programs had “performance” and “compliance” levels at distances ranging from 300 to 600 ft., typically outside the resuspension containment systems (i.e., silt curtains, in most cases). The criteria will also include chemical-specific numeric criteria which will be met at the compliance monitoring stations.

7.2 EXISTING WATER QUALITY CHARACTERIZATION

Water quality, particularly turbidity, within Onondaga Lake can vary significantly due to natural events such as rain storms, high winds, and other weather events. For example, the southeast portion of the lake in the area of Remediation Area E represents the predominantly leeward end of the lake, and as a result becomes turbid on windy and stormy days. On calm days, water clarity can be good in shallow areas. Additionally, tributaries to the lake (e.g., Onondaga Creek, Harbor Brook, and Ninemile Creek) and outfalls (e.g., Metro) can contribute to increased turbidity within the littoral regions of the lake, particularly after rain storm events. Each year, the OCDWEP collects and analyzes water quality samples from various areas of the lake on a quarterly basis and after select rain storm events. Parameters monitored in the littoral area of the lake include turbidity and temperature. Onondaga County provides annual updates of results for public consideration (OCDWEP 2007). A review of 2006 turbidity results in the littoral regions of the lake indicated the turbidity levels near Ninemile Creek increased from approximately five NTU to over 50 NTU during a rain storm. Similarly, 2002 turbidity results near the Metro outfall increased from approximately 10 NTU to over 40 NTU during a rain storm.

While dredging and capping are being conducted, water quality will be monitored to identify and minimize impacts created by the remedial activities. To develop the baseline range of water quality conditions within the lake for an accurate benchmark for comparison during remediation, data pertaining to various water quality parameters has been collected by Honeywell during the RI and as part of the on-going baseline monitoring program and by the OCDWEP as part of their Ambient Monitoring Program (AMP). These data along with additional baseline water quality data collected in 2010 and 2011 will be incorporated into a baseline water quality analysis as part of the Water Quality Management and Monitoring Plan.

7.3 WAVE/LAKE CURRENT CONDITIONS

With any water-based dredging or capping operation, a thorough understanding of wave heights and lake currents is required. Specific planning aspects such as dredging and capping sequencing (see Section 8) and turbidity controls deployment configurations can both be heavily influenced by these conditions (see Section 7.4).

Wave heights of half a foot have been measured in Remediation Area D (Owens et al., 2009). Additionally, annual wind-generated wave heights of approximately 1 ft. to 2 ft. were predicted to occur in the southern basin based on historic average wind speeds.

The circulation of the water within the lake is generated by wind speed and direction, tributary inflows, the outflow at the northern end of the lake, shoreline configuration, and stratification (Parsons, 2004). Currents at the water surface tend to move in the direction of the wind except close to shore, where currents move water parallel to the shoreline (Owens and Effler, 1996). General current velocity is greatest when winds are situated along the major axis of the lake basin (northwest to southeast, in a counter-clockwise direction). Although the current flow is complex and variable, the prevailing current direction is generally counter clockwise in response to prevailing westerly wind direction. Discrete current velocities were measured as part of the 2010 Baseline Water Quality Monitoring for Construction Program and additional current monitoring is proposed for 2011. This information will be taken into consideration during design of the silt curtains and development of the final Water Quality Management and Monitoring Plan.

7.4 TURBIDITY CONTROLS

7.4.1 Silt Curtains

Silt curtains are a proven method for limiting migration of suspended sediments that result from dredging and capping activities. Silt curtains will be used as turbidity control devices within each dredging work zone. Capping operations are inherently a low impact activity based on experience at numerous other capping sites, cap placement does not result in significant disturbance of contaminated sediments or release of significant contamination to the water column. Increases in turbidity that may occur during capping operations are a result of the placement of clean material. Therefore silt curtains will not be a component of typical capping operations on the lake.

Silt curtains are vertical, flexible structures that extend downward from the water surface to a specified water depth. They are typically constructed of filter fabrics or impervious polyethylene sheets combined with floatation and anchoring devices. Figure 7.1 shows a general schematic of a silt curtain system, and illustrates its primary components (including the boom system that provides sheen containment and flotation and the silt curtain).

The design of the turbidity controls will be developed to minimize potential impacts to the integrity of the system that may result from hydrodynamic conditions that exist within the lake. The orientation of the lake (northwest to southeast) provides a long fetch in the direction of prevailing winds, which has the capability to produce sizeable wind-generated waves in the southern basin, as discussed in Section 7.3. The detailed design for the silt curtains will take these and other factors into consideration and will be included in the final design.

During nearshore dredging activities, silt curtains may be deployed in a semicircle or “U” pattern. In the “U” configuration, the silt curtain encloses the dredging activities in a semicircular shape that is anchored to the shoreline at both ends. In general, within Onondaga Lake, large remediation areas will be enclosed with a “U” configuration in Remediation Area A, Remediation Area B, Remediation Area C, Remediation Area D, and Remediation Area E, avoiding inclusion of tributaries where possible. During dredging that is “detached” from the shoreline, silt curtains may be deployed in a circle or ellipse configuration that surrounds the dredging activities. The final configurations and requirements for silt curtain placement will be determined following development of the dredging and capping operations sequencing.

7.4.2 Best Management Practices (BMPs)

In addition to silt curtains, BMPs (i.e., operational and/or physical controls) will be employed to minimize construction related impacts. BMPs will be developed as part of the Final Design. Potential BMPs include:

- Dredging on slopes steeper than a set angle (e.g., steeper than 10 horizontal to 1 vertical) will begin, where feasible, at the highest elevation and work towards the lowest elevation. This will be modified as necessary to allow dredging from deeper water to shallow water where necessary to allow the dredge to approach the shallow shoreline areas.
- Sequencing of dredging and capping will be optimized (upcurrent to downcurrent, offshore to onshore, or with respect to number of lifts).
- Capping materials will generally be placed uniformly over the sediment surface, minimizing disturbance to the sediment or previously placed cap material.
- Capping materials will be placed from toe up to the top of the slope on slopes steeper than a set angle (e.g., steeper than 10 horizontal to 1 vertical).
- Location and material control equipment will be required to maximize controlled placement of cap material (see Section 4.5).

7.5 MONITORING PLAN

Monitoring will occur at both performance (near-field) and compliance (far-field) monitoring stations to ensure that the water quality control measures described above are successful in protecting ambient water quality. The intent of the performance monitoring stations will be to monitor near-field turbidity in the vicinity of the construction area (outside of turbidity control structures) to provide an early warning of potential water quality impacts. The compliance monitoring stations will serve as the official compliance locations for water quality, and will be used to assess and manage potential impacts to water quality associated with the remedial construction activities. Specific details (e.g., location and sampling frequency) pertaining to water quality monitoring during dredging and capping operations will be provided in the final Water Quality Management and Monitoring Plan.

7.6 OPERATIONS OPTIMIZATION

Water quality monitoring at the performance and compliance monitoring locations will validate the protectiveness of the turbidity controls. In the event the water quality monitoring criteria are exceeded, a series of response actions will be implemented including additional monitoring and inspection of silt curtains to identify the cause of the exceedance. Potential operations optimization activities that may be implemented include:

- Optimizing specific dredging or capping operations (e.g., ladder swing speed, cutter rotation speed, depth of cut, speed of advance of dredge, cap material placement rate)
- Limiting dredging and cap placement operations to calmer environmental/weather conditions (e.g., stopping dredging or placement when wave heights or wind speeds exceed a certain value)

- Limiting single-cut depths to approximately 80% of the cutterhead diameter
- Decreasing the cap lift thickness if turbidity exceedances are a result of resuspended sediment and not clean sand
- Installing additional turbidity controls to contain construction-related impacts

SECTION 8

CONSTRUCTION SEQUENCING

The goal for the lake remediation is to complete dredging in four years (beginning in 2012), and capping in five years (beginning 2012). A draft sequencing plan has been developed by the design team with input from the remediation contractor and is described in Section 8.3. The sequencing plan will be further developed in subsequent design submittals.

8.1 UPLAND REMEDIATION SEQUENCING CONSIDERATIONS

There are potential Honeywell and non-Honeywell sources of contamination to the lake, which are being addressed to help prevent the restored lake bottom from being recontaminated. In addition, the lake remedy design and implementation will take into consideration how remedial actions in adjacent nearshore areas, and actions associated with onshore support zones, will be integrated with remediation activities within the lake. For example, the in-lake shoreline remediation and habitat restoration activities will be integrated with remediation and habitat restoration activities within adjacent wetlands associated with the Ninemile Creek, Wastebeds 1-8, and WBB/HB, as discussed in Section 3.4.

As the scopes and schedules for upland remedial activities are finalized, the information will be used to further define the approach for integrating these onshore activities with the lake remediation in future lake-related design submittals. A discussion of sequencing and integration considerations for each remediation area is provided below.

Several of the upland sites subject to remediation activities are directly adjacent to those in the lake. The conceptual habitat restoration approach and integration of the onshore and in-lake remedies as it pertains to habitat restoration was developed in the Draft Habitat Plan. The overall objective of this effort is to develop and implement a habitat restoration plan for remedial actions associated with the Onondaga Lake Bottom remedy and with remedies and IRMs for adjacent Honeywell sites that provides ecological, recreational, and/or aesthetic benefits as well as complies with applicable state and federal laws and regulations, executive orders, and policies for floodplains, wetlands and surface waters.

8.1.1 Ninemile Creek (Remediation Area A)

Completing the Ninemile Creek remediation to the extent necessary to prevent recontamination will be required prior to remediation of Remediation Area A. The narrow landforms extending from the lakeshore out into the lake at the mouth of Ninemile Creek will be remediated as part of Remediation Area A, as discussed in Section 3.4. The current anticipated schedule for the completion of the Ninemile Creek remedy is 2013.

8.1.2 Wastebeds 1-8 (Remediation Areas B and C)

Remediation of Wastebeds 1-8 to the extent necessary to prevent recontamination will be required prior to remediation of the western portion of Remediation Area A, Remediation Area B and the northern portion of Remediation Area C. The scope for the Wastebeds 1-8 remedy includes installation of a shoreline groundwater collection trench to control of shallow groundwater discharging to the lake from the wastebed area, which requires completion prior to completion of remediation in adjacent lake areas. The groundwater collection trench for the Wastebeds 1-8 site is currently scheduled to be complete in 2013.

8.1.3 Barrier Wall and Tributary 5A (Remediation Area C)

Shoreline remedial activities adjacent to Remediation Area C are complete and include the Semet portion of the shoreline barrier wall installed in 2008, and the Tributary 5A remediation completed in 2010. Dredging and capping sequencing in this area will take into consideration the boat launch located in this area that is frequently used for small boats as well as shoreline fishing.

8.1.4 Outboard Area (Remediation Areas D and E)

Remediation of the Wastebed B/Harbor Brook Outboard Area, to the extent necessary to prevent recontamination, is necessary prior to remediation of Remediation Area D and Remediation Area E. The shoreline of the western third of Remediation Area D consists of the exposed sheet pile barrier wall installed in 2008 as part of the Willis/Semet IRM. Dredging design and implementation in this area will ensure dredging and capping operations and shoreline support activities do not subject the sheet pile wall to excessive stress and compromise structural integrity that could lead to potential damage and safety risks.

The remainder of the shoreline in Remediation Area D and the southern shoreline of Remediation Area E consists of the low-lying Outboard Area of the WBB/HB site. Remedial action in the area between the WBB/HB Willis/Semet IRM Barrier Wall and the lake is required, and will be performed concurrent with the Lake remediation effort, as discussed in Section 3. This includes removal of material and construction of an isolation cap similar to Remediation Area D.

8.2 DREDGE SEQUENCING

A significant goal in sequencing the dredging activities is to minimize the potential for recontamination of previously capped areas or areas outside the proposed cap area, resulting from deposition of contaminated sediment that may be resuspended as a result of dredging operations (referred to as “generated residuals”) or due to wind/wave action. Additional factors that will be considered in developing the detailed sequence for dredging activities are listed below.

- **Other nearshore remediation activities.** In-water work will be coordinated with work in adjacent remediation areas to avoid potential recontamination.
- **Seasonal construction window.** Depending on weather and freezing temperatures, it is estimated that dredging activities will occur from April 1 to November 15 of each year. Mobilization, demobilization, equipment maintenance, and general construction planning will occur, to the extent practicable, outside of these seasonal construction windows. The seasonal construction period may be extended based on the weather conditions at the start and end of each season.

- **Production "shake down" or "ramp up" periods.** It is anticipated that during the first year of dredging, the optimal dredging production rate (i.e., cubic yards per hour or dredge days) may not be realized while developing and optimizing the system-wide integration of debris removal, dredging, slurry transport, processing dredged material at the SCA and water treatment. Dredging production will gradually increase to the optimal production rate to complete dredging in four years. This period of less-than-optimal production rates is referred to as the "shake down" or "ramp up" period, and serves a similar function as a pilot test. Dredging production in years 2, 3, and 4 is expected to have a shorter ramp up period than year 1.
- **Lake circulation patterns.** General circulation patterns in Onondaga Lake are counter clockwise in response to prevailing westerly winds. Circulation of the water within the lake is generated by wind speed and direction, tributary inflows, the outflow at the northern end of the lake, shoreline configuration, and stratification (Parsons, 2004). In the littoral areas where dredging will be performed, currents will generally move in the directions of the wind and waves. Therefore, resuspended dredged material will move parallel to the shore (long-shore transport) as well as in onshore/offshore direction (cross-shore transport). Dredging and subsequent capping will be phased to generally proceed in an up-current to down-current direction to minimize the potential recontamination. Winds and wind-generated waves within Onondaga Lake will likely be the primary transport mechanism in the remediation areas during dredging activities rather than the overall circulation pattern.
- **Dredge slopes.** In areas where targeted dredge slopes are greater than a given angle (e.g., 10 horizontal:1 vertical [10H:1V]), dredging will generally be performed in a top to bottom of slope direction to minimize potential suspended sediment or sloughed sediment transported down slope. However, in some cases there may be a need to dredge upslope into a remediation area due to shallow water depths that limit dredge access/mobility.
- **Production rate.** Dredging production rates will vary based on equipment, thickness of cut and material characteristics. For additional information and descriptions on dredging production, refer to Section 5.3 and Appendix J - Dredging and Capping Equipment Selection and Production Rates. In addition, the number and location of dredges will affect the overall production rate and therefore sequencing. One or multiple dredges can work in exclusive areas, advancing sediment removal to final dredge grade elevations. An option for multiple dredges is to have the 14-in. dredge perform production dredging, focusing on areas of relatively thick dredge cuts thereby optimizing the efficiency, and the 8-in. dredge following behind the large dredge to perform dredging better suited to low production and finer dredge control. The 14-in. and 16-in. dredges cannot operate simultaneously due to transport and water treatment flow limitations.
- **Dredge area and volume.** Table 5.1 presents a summary of the anticipated dredge volumes and areas for each remediation area. The sequence and schedule for dredging considers the amount of area that can be completed in a given year based on a production rate and dredge volume for each deposit.

Based on these considerations, dredging will likely be performed in a generally counter-clockwise direction, beginning in Remediation Area C and proceeding through Remediation Area D and Remediation Area E. Dredging of Remediation Area A will be scheduled as soon as Ninemile Creek remediation is complete (2013). Remediation Area A requires a relatively low volume of sediment dredging, but will make available a large area for cap construction. When the remediation in Ninemile Creek is complete, the dredge(s) will stop at a logical point of the counter clockwise dredge progression within Remediation Area D and Remediation Area E and proceed to Remediation Area A. Dredging of Remediation Area B can begin after the remediation in Wastebeds 1-8 IRM is complete (2013), and will follow Remediation Area A dredging. Dredging in Remediation Area A and Remediation Area B represents a low risk of recontamination to other remediation areas, primarily due to the large distance between these and other remediation areas.

The preliminary dredge sequence is provided in Figure 8.1 and lists the anticipated dredge sequence, area, and potential dredge volume per year. Also depicted in Figure 8.1 are the adjacent remediation sites, with estimated year of completion, that require completion before lake dredging in the adjacent remediation area can begin. The dredge sequencing in Figure 8.1 is based the following assumptions:

- 132 dredge days per year. This assumes 32 weeks of dredging 6 days per week, less 60 days of operation due to discharge limitations at Metro.
- 70% operational uptime over 22 operational hours per day
- Use of the 16” dredge for 60 to 65% of the time, with the 14” dredge operating the remainder of the time.

8.3 CAP SEQUENCING

Depending on the overall sequence of dredging operations, multiple capping operations may be working simultaneously. This may include separate capping operations for different remediation areas and/or separate operations for the different material types (e.g., chemical isolation, erosion protection, or habitat material). General factors for developing guidelines for sequencing of cap operations include:

- **Other nearshore remediation activities (see Section 8.1).** In-water work will be coordinated with work in adjacent remediation areas to avoid potential recontamination.
- **Seasonal construction window.** Depending on weather and freezing temperatures it is estimated that capping construction activities will occur from April 1 to November 15 of each year. Mobilization, demobilization, equipment maintenance, and general construction planning (e.g., material stockpiling, etc.) will occur to the extent practicable outside of these seasonal construction windows. The seasonal construction period may be extended based on the weather conditions at the start and end of each season.
- **Coordination with dredging.** Capping operations will generally follow dredging operations in a similar pattern and sequence. Cap operations will be separated from dredge operations by an appropriate distance to avoid recontamination of the cap due

to dredging operations. A turbidity curtain will be maintained around all dredge operations to minimize the potential for resuspended sediment to be transported outside of the dredge area and settle within areas previously capped or actively being capped.

- **Production rate.** Capping production rates will vary based on equipment, thickness of cap and material type. For additional information and descriptions on capping production, see Section 4.5 and Appendix J of this document.
- **Capping slopes.** In areas where slopes to be capped are greater than a given angle (e.g., 10 horizontal:1 vertical [10H:1V]), capping operations will generally place material from the bottom of a slope up to the top of slope to minimize the loss of material during placement. This sequence of slope capping has been successfully completed on other projects. In some shallow areas, capping from the top of slope down to the bottom of slope will be necessary in order to maintain draft for the cap placement equipment.
- **Interim residual cap.** In areas where dredging has been completed, but the final cap cannot be completed within the same construction season, an interim residual cap layer may be placed within portions of the dredge area to manage potential residual sediments if they present a risk of recontaminating remediated areas. An assessment of site conditions that warrant placement of an interim residual cap will be completed as part of future design-related submittals. When placed, the interim cap will be considered to contribute to the full cap design to be placed in the following years (e.g., the interim residual cap may function as the “mixing” zone of the overall cap design).
- **Cap area and volume.** Table 4.4 presents a summary of the currently anticipated cap areas and volumes for each Remediation Area. The sequence for capping will consider the progress of the prior dredging as well as the amount of area that can be capped in a given year based on the capping production rate and cap thickness of each area.

Based on the considerations listed above, capping in a remediation area will follow dredging and will likely be performed in a general counter-clockwise direction, beginning in Remediation Area C and proceeding through Remediation Area D and Remediation Area E. Capping of Remediation Area A and Remediation Area B will follow the dredging of those respective remediation areas.

Figure 8.2 provides the preliminary cap sequence and lists the anticipated cap sequence, area and volume per year. Due to the amount of area available for capping in year one and year two (2012 and 2013), a single cap operation is anticipated. Starting in year three (2014) it is anticipated that multiple cap operations will be required and operated simultaneously in order to meet the overall project schedule. The cap sequencing shown in Figure 8.2 is based on an annual 32 weeks of capping 6 days per week. The production rates provided in Appendix J account for downtime associated with moving anchors, safe cable winching speed, maintenance, shift changes, weather delays, fueling and material logistics based on contractor experience at similar sites. Sequence operations consist of 6 days per week, 24 hours per day with 80% estimated operational uptime and weighted average rates for the sand and gravel volumes and anticipated production rates.

SECTION 9

POST CONSTRUCTION CAP MONITORING AND MAINTENANCE

The cap will be designed to provide a high level of long-term protection and to be resistant to disruption by forces such as erosion due to wind generated waves. Post-construction monitoring and maintenance of the capped areas will be performed to verify that the overall integrity of the cap is maintained so that it remains physically stable (i.e., does not erode) and chemically protective over time. The conceptual cap monitoring and maintenance plan outlined below provides a high-level overview of monitoring and maintenance activities to be implemented. A discussion of potential institutional controls is also provided below. Details pertaining to cap monitoring and maintenance will be provided in the Cap Monitoring and Maintenance Plan.

9.1 POST CONSTRUCTION CAP MONITORING PLAN

Long-term monitoring of the caps will include physical monitoring to verify stability and sampling of the caps to verify their chemical integrity, as detailed below.

Physical Monitoring

Physical monitoring will involve verifying that the armor layer and underlying chemical isolation layer are stable and intact using bathymetric surveys and/or other physical or geophysical methods. The cap integrity will be monitored routinely and following wind/wave, tributary inflow or seismic events that exceed a threshold design magnitude, consistent with USEPA (2005) recommendations. The frequency of routine monitoring will be greater initially after construction (e.g., multiple monitoring events within the first 5 to 10 years), and reduced over time once the monitoring is able to establish a consistent pattern of cap performance. Details of the monitoring methods, frequencies, and procedures and response actions will be developed based on joint discussions with NYSDEC and will be presented in the Cap Maintenance and Monitoring Plan.

Chemical Monitoring

Chemical monitoring will involve measuring chemical concentrations within the habitat and chemical isolation layers to verify that contaminants are not moving through the cap at rates and concentrations that exceed specified remedy success metrics. As described in the ROD,

> 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 [Probable Effects Concentration] PEC of any of the [Chemicals Potentially of Interest] CPOIs that have been shown to exhibit acute toxicity on a lake-wide 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.

Therefore, samples will be collected for chemical analysis from the bottom 6 in. of the habitat layer. In addition, to serve as an early indicator of any chemical migration which exceeds predictions and therefore may indicate future potential exceedances, samples will be collected for chemical analysis from the top 6 in. of the chemical isolation layer. Details of the chemical monitoring methods, frequencies, procedures, and response actions will be developed based on joint discussions with NYSDEC and will be presented in the Cap Maintenance and Monitoring Plan.

9.2 POST-CONSTRUCTION CAP MAINTENANCE PLAN

In the unlikely event that the monitoring plan discussed above identifies areas where the cap may not be performing consistent with expectations, follow-on assessments and/or response actions will be implemented. Follow-on assessments/actions may include additional investigation to further evaluate potential deficiencies, continued monitoring and assessment of overall remedy effectiveness over time, and replacement of cap materials. Cap monitoring and maintenance actions will be detailed in the Cap Maintenance and Monitoring Plan.

The plan will include criteria for when a follow-on assessment or response action is required based on physical and chemical monitoring and the appropriate type of response action. For example, if bathymetric or other surveys from either the routine or event-based surveys show evidence of disruption of the armor layer, then a typical response would include an additional assessment of the affected cap areas, potentially including underwater video surveying and/or core sampling. If cap erosion is confirmed by additional assessment such that the performance of the chemical isolation layer is compromised, then response actions may be applied. Possible response actions after the cause of erosion is determined could include:

- Place additional armor or otherwise repair the cap within the identified area of erosion (e.g., reestablish cap thickness) if the performance standards are no longer being met.
- Enact managerial or institutional controls to help control any further cap erosion if it is being caused by activities such as boat traffic or stormwater discharges.

Potential response actions will also be developed based on the results of the long-term chemical monitoring. Details of the cap maintenance response actions will be developed based on joint discussions with NYSDEC and will be presented in the Cap Maintenance and Monitoring Plan.

9.3 INSTITUTIONAL CONTROLS

As described in Section 4.2, the cap armor layer has been designed to protect the chemical isolation layer from recreational vessel operations and from commercial vessel traffic in the NYSCC navigation channel. Therefore, the only institutional control envisioned to promote the long-term integrity of caps is to prevent disturbance of the caps by dredging or other in-water construction activities. It is anticipated that “No Dredge Areas” will be established over the capping areas by the NYSDEC and NYSCC to prevent removal of the capping materials. These restrictions would also include anchoring of commercial vessels and certain in-water development activities, such as setting utility or cable corridors. The restrictions can be marked by the NYSCC on the NOAA Navigation Chart for Onondaga Lake (currently included as Chart

Number 14786 for the Small-Craft. Book Chart for the New York State Barge Canal System). The New York State Office of Parks, Recreation and Historic Preservation currently maintains navigation buoys in Onondaga Lake to warn boaters of hazards in water less than 4 ft. in depth and beyond 100 ft. from shore. The “No Dredge Areas” could also be identified on figures submitted to the public and appropriate websites pertaining to the lake.

SECTION 10

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TABLES

FIGURES