Honeywell

Onondaga Lake

Remedial Design Elements for Habitat Restoration

December 2009

DRAFT

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List of Acronyms

AMP	Ambient Monitoring Program
ASLF	Atlantic States Legal Foundation
BAF	biological aerated filter system
BSQV	bioaccumulation-based sediment value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSO	combined sewer overflow
DNAPL	dense non-aqueous phase liquid
DSA	Dredge Spoils Area
EE/CA	Engineering Evaluation/Cost Analysis
ESD	explanation of significant differences
FEMA	Federal Emergency Management Association
FS	feasibility study
HRFS	high rate flocculated settling system
IBA	Important Bird Area
ILWD	in-lake waste deposit
IRM	Interim Remedial Measure
LCP	Linden Chemical and Plastics
MNR	monitored natural recovery
NAPL	non-aqueous phase liquid
NPL	National Priorities List
NWI	National Wetlands Inventory
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OCDWEP	Onondaga County Department of Water Environmental Protection
OEI	Onondaga Environmental Institute
OLMC	Onondaga Lake Management Conference
OLP	Onondaga Lake Partnership
OM&M	operations, maintenance & monitoring

List of Acronyms (cont.)

ROD	Record of Decision
SMU	sediment management unit
SOW	statement of work
SUNY ESF	State University of New York College of Environmental Science and Forestry
TES	Terrestrial Environmental Specialists
TWG	Technical Work Group
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USSCS	United States Soil Conservation Service
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
YOY	young-of-year

Executive Summary

Onondaga Lake
Syracuse, New York

Honeywell continues the progress toward achieving the community's vision of a restored Onondaga Lake with the development of this draft *Remedial Design Elements for Habitat Restoration* (Habitat Plan). The development of this plan, which is referenced in the *Remedial Design Work Plan* for Onondaga Lake, marks an important milestone in the continued revitalization of the lake. Habitat restoration goals and concepts will serve as a guide for future designs for the lake remediation.

Habitat is the physical and biological surroundings that comprise the natural environment of an organism. It is the area where plants and animals normally live, grow, feed, reproduce, and otherwise exist for any portion of their life cycle. These surroundings provide organisms or communities of organisms the necessary elements for life, such as space, food, water, and shelter. The restoration of habitat is an integral component of the overall remedy for Onondaga Lake and, in fact, is one of the most significant elements in the design for the dredging and/or capping activities specified for the lake.

Habitat considerations presented in this plan are at the forefront of the restoration designs for Onondaga Lake, and habitat restoration will continue to play a key role as the remedial activities are advanced. A sustainable habitat that allows for public access has been, and will continue to be, an integral part of the approach for restoring Onondaga Lake.

Largemouth Bass are a popular game fish in Onondaga Lake.

This Habitat Plan presents the conceptual habitat restoration and enhancement designs for Onondaga Lake in those portions of the lake where remediation activities will be conducted. Wherever possible, this design respects the natural processes and conditions to create suitable habitat for various species of plants, mammals, fish, benthic macroinvertebrates (bottom-dwelling organisms such as crayfish), birds, reptiles, and amphibians, while allowing for public access in and around the lake. Creating sustainable habitats while allowing for public access for recreation requires balance and this plan was developed with consideration for the complexities of these relationships in an effort to address the many needs of this unique resource.

Goals for Habitat Restoration in Onondaga Lake

Three overarching goals drive habitat restoration:

1) Maintain or improve the quality and diversity of habitat in the lake;

2) Discourage the establishment of invasive species; and

3) Promote public access and use and minimize future maintenance.

These goals focus on those areas, species, or processes (such as the function of the shallow water zone) that have been altered over time due to industrialization along the shoreline, and areas where physical changes will occur as a result of the remediation program.

AGENCY REPRESENTATIVES

NYSDEC

Honeywell TEAM

State University of New York College of Environmental Science and Forestry

Local and national experts prepared this Draft Habitat Plan. Community input will continue to be sought from the Onondaga Nation and local interest groups.

Key benefits that result from this conceptual design include:

- integrating a diverse habitat design with considerations for public access;
- providing deep water nearshore for improved fishing access;
- increasing the size, diversity and function of shoreline wetlands and connectivity with the lake;
- creating conditions suitable for a variety of native and culturally significant species;
- discouraging the establishment of invasive species;
- promoting pike spawning in adjacent wetland areas;
- providing suitable conditions for transient cold water fish (e.g. brown trout) and other game fish (e.g. bass); and
- establishing habitats that are currently lacking in the lake (e.g. floating aquatic plants).

The Habitat Plan was developed by Honeywell with extensive input from members of the Habitat Technical Work Group (TWG) with input from multiple organizations that use the lake on a regular basis. This group was comprised of representatives from the New York State Department of Environmental Conservation (NYSDEC) Bureau of Remediation; NYSDEC Division of Fish, Wildlife and Marine Resources; United States Environmental Protection Agency (USEPA); United States Fish and Wildlife Service (USFWS); and Honeywell and its team from the State University of New York College of Environmental Science and Forestry (SUNY ESF), Mississippi State University, Terrestrial Environmental Specialists (TES), AnchorQEA, O'Brien & Gere, and Parsons. This extensive team of local and national experts encompasses experience in the areas of wetland ecology, limnology, biology, restoration ecology, fisheries biology and sediment remediation. Input was also provided by the Onondaga Nation and local interest groups during the preparation of this plan.

The TWG reviewed information on the historical and current conditions of Onondaga Lake to identify habitat types and species for which *specific* restoration objectives could be developed to meet the goals. Specifically, the habitats and species identified, such as the northern pike, existed historically within the lake, but are currently lacking, or those that currently exist within the lake, but are degraded (such as wetlands dominated by *Phragmites*).

To address the overarching goals and more specific objectives of the Habitat Plan, the TWG identified *representative* species from groups of fish, plants, benthic macroinvertebrates (organisms in the sediment), mammals, amphibians, reptiles, and birds whose habitat requirements could be used to guide the development of the restoration designs.

Semi-Palmated Sandpiper is a representative species for shorebirds.

The representative species *represent* a larger group or guild of species that share similar habitat requirements. For instance, the semi-palmated sandpiper represents shorebirds that would share similar habitats and needs for survival.

Representative Species						
Fish	**Aquatic Plants**	**Benthic Macro-Invertebrates**	**Mammals**	**Amphibians**	**Reptiles**	**Birds**
Northern Pike	Submerged Vegetation	Mayfly	Muskrat	Spotted Salamander	Northern Water Snake	Mallard
Lake Sturgeon	Floating Vegetation/ Aquatic Beds	Caddisfly	Mink	Mudpuppy	Snapping Turtle	Common Goldeneye
Smallmouth Bass	Nonpersistent Emergent Vegetation	True Flies	Otter	Leopard Frog	Painted Turtle	Spotted Sandpiper and Semi-palmated Sandpiper
Largemouth Bass	Persistent Emergent Vegetation	Dragonfly/ Damselfly	Beaver	Wood Frog	Musk Turtle	Bank Swallow
Walleye	Salt Marsh Vegetation	Scud	Indiana Bat	Green Frog		Red-winged Black Bird
Pumpkinseed Sunfish	Unvegetated Shoreline/ Mudflats	Crayfish		Red Spotted Newt		Common Tern
Golden Shiner	Wet Meadow Wetland					Belted Kingfisher
Emerald Shiner	Forested/Scrub-Shrub Wetlands					Osprey
Brown Trout	Forested Scrub-Shrub Uplands					Great Blue Heron
	Open Field Uplands					Green Heron

The habitat requirements for each representative species were then characterized using available Habitat Suitability Index Models (developed by the USFWS), the current literature, professional experience, and judgment gained from field observations. The TWG identified habitat requirements for various life stages of each species for the following physical parameters: water depth, substrate type, wave energy, structure-vegetation cover, structure-woody debris, rooting/burrowing depth, and where appropriate, various water quality parameters. The list of representative species is presented in the table below.

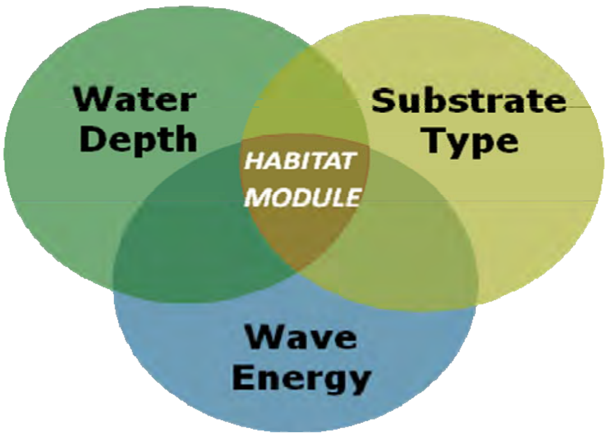
Designing the Habitat Plan

This wood frog represents other frogs that have the same habitat.

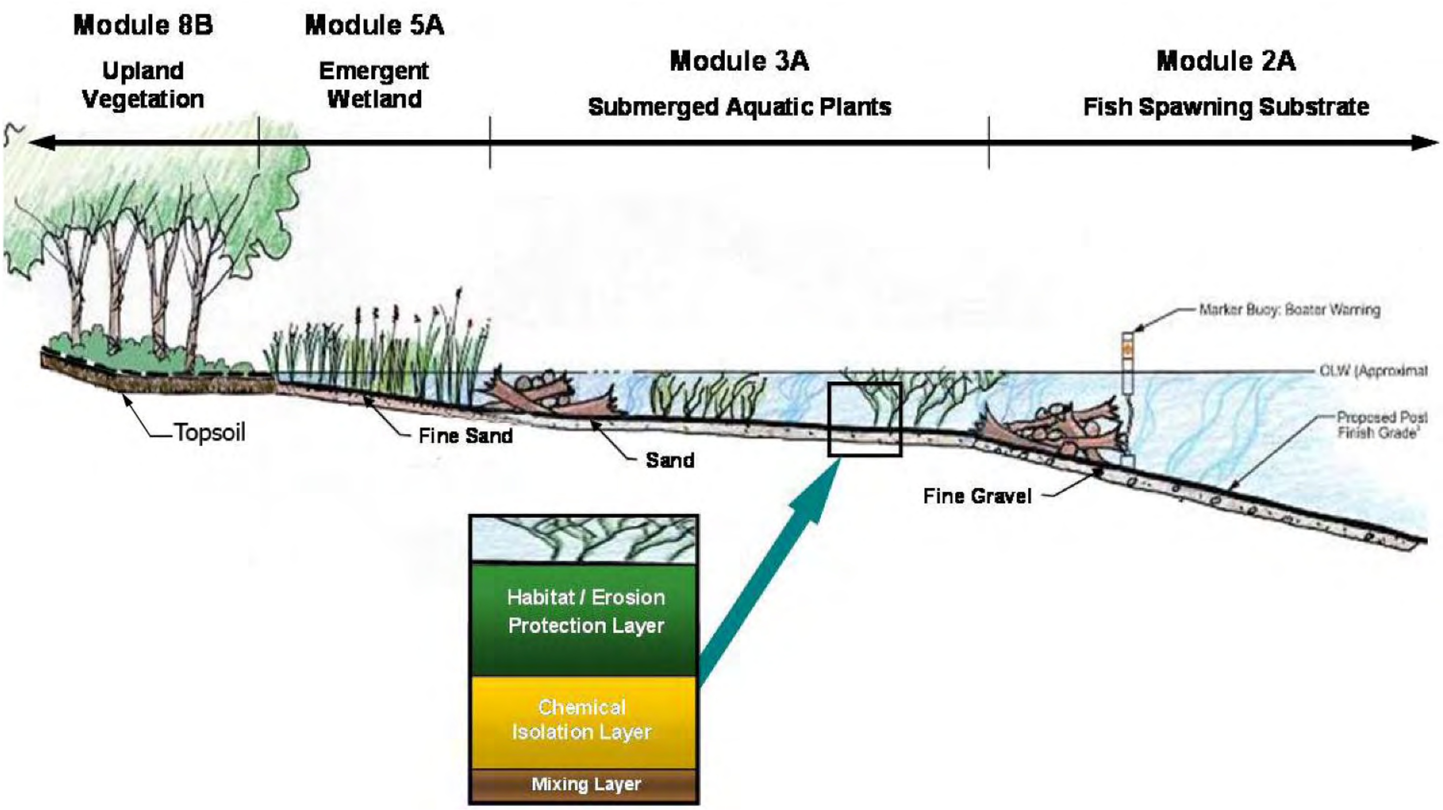
The TWG evaluated current habitat conditions, along with the selected or anticipated site remedies and interim remedial measures adjacent to the lake to identify the potential effects of remediation on existing habitats. Based on this evaluation, the TWG defined the boundary around the lake within which the conceptual habitat designs would be applied. This “red line” boundary was drawn to facilitate a holistic approach that integrates habitat restoration work *within* the lake with areas *adjacent* to the lake to provide habitat connectivity and transition areas.

Once the areas for the habitat designs were identified, the TWG reviewed historic and current conditions to identify representative species and habitat considerations. The habitat requirements for the representative species were then used to identify important factors such as current and future land use, topography (land surface), bathymetry (lake bottom surface), hydrology, and soils/substrate needed to support the various life cycles of the representative species and habitats.

Following the identification of the habitat requirements for each representative species, the TWG developed a method to combine the representative species and their habitat requirements into habitat areas, or “modules,” which could be readily integrated with the remedial activities. The in-lake habitat modules are defined by three basic habitat parameters that serve as the basis for the habitat restoration design: water depth, substrate type, and energy. As shown in the figure below, a habitat module was developed where these three elements exist together, such as required for a particular representative species.



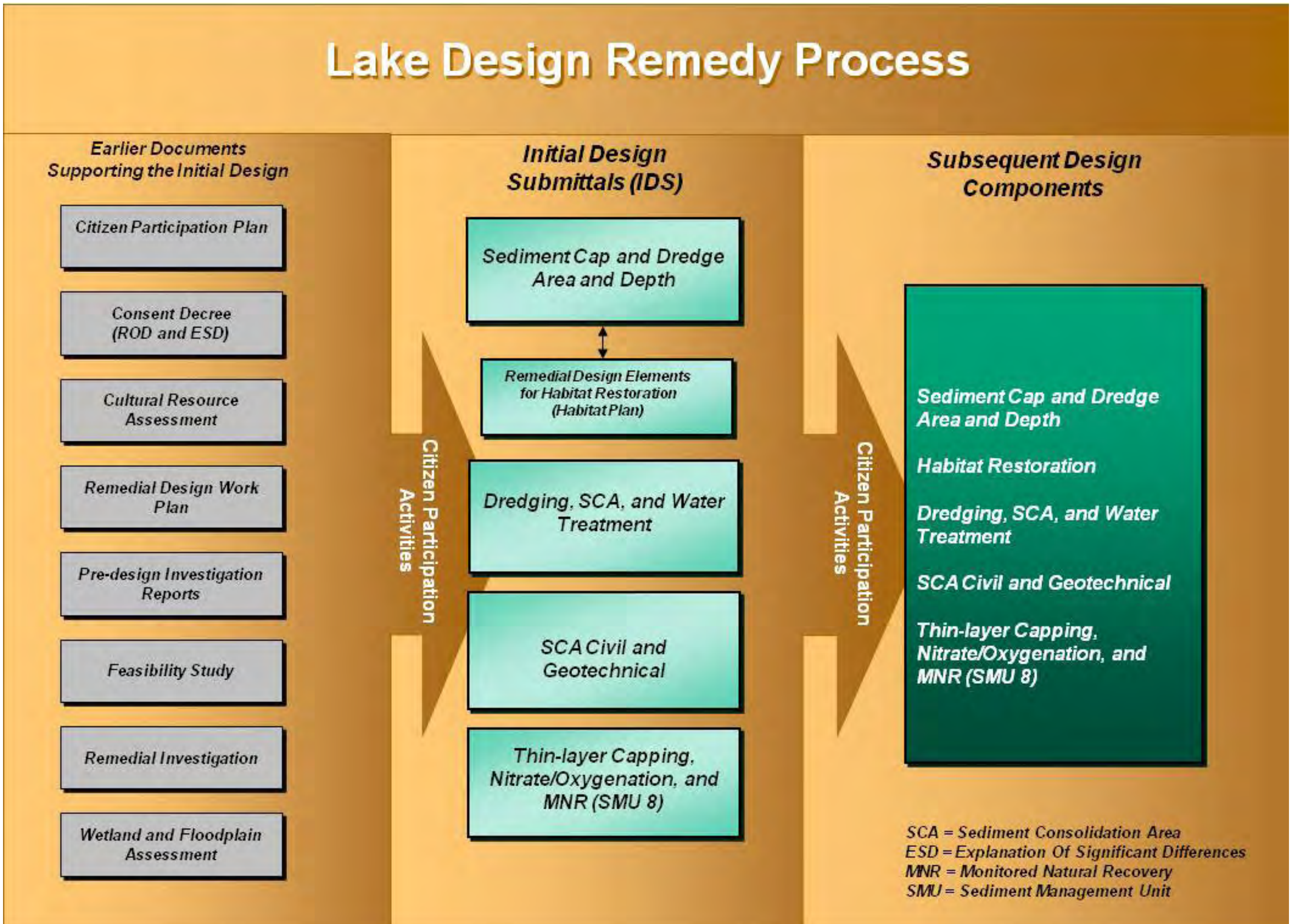
Using this method of analysis, the TWG developed seven in-lake modules, each with a specified water depth, energy, and substrate type to provide suitable habitat for the representative species. The modules are numbered starting from the deep waters of the lake to the shoreline areas addressed by this plan. Two additional upland modules were also developed based on elevation and the type of habitat cover in adjacent areas. A summary of each of the modules is included on Table ES-1. Each module has a different color, and those colors correspond to the figures illustrating the application of modules in the different remediation areas (Figures ES-1 through ES-5).



Each module provides suitable habitat for different species, and the combination of modules, applied throughout the areas of remediation, creates a diverse habitat for the group of representative species. Below is a diagram showing an example of how one module cross section may look when integrated with the cap design. In areas of the lake where dredging and/or capping will be conducted, the habitat goals and objectives noted above drive many of the design considerations. Included as part of these considerations is the goal of no net loss of lake surface area as specified in the ROD. Also, the water depth following restoration will be an important factor determining the habitat conditions that will be present in those areas. In order to achieve the desired water depth there are multiple considerations that are integral to the design. Several of those considerations include required thickness of the cap and habitat materials, erosion protection requirements, wind/wave energy, ice scour, dredging depth, slope stability, and substrate type. These considerations, which can vary depending on the type of remedy and the location in the lake, were then used as guiding assumptions in developing the habitat restoration designs based on the habitat modules.

How does this Plan fit within the Lake Remedy?

This Habitat Plan is just one of several documents that will be provided to the public for comment as part of the comprehensive remedial design process for Onondaga Lake. The Remedial Design Work Plan describes the four design components, each of which will be documented in separate initial design submittals, to address various elements of the remedy. The design for habitat restoration presented in this Habitat Plan will be integrated with the remedial design presented in the forthcoming *Sediment Capping and Dredge Area and Depth* Initial Design Submittal. The figure below illustrates how this Habitat Plan fits within the various submittals for the Onondaga Lake remedial design.



Citizen Participation input and outreach activities, as outlined in the Onondaga Lake Citizen Participation Plan, will be included throughout the remedial design process

A musk turtle basks on a shoreline log.

Public participation is a critical component of the overall lake remedy, and will continue throughout the entire schedule of design preparation and submittal. Over the past several years, the NYSDEC and Honeywell have solicited opinions and perspectives on this conceptual plan from local habitat conservation and environmental organizations such as Salt City Bassmasters, Izaak Walton League of America, Audubon Society, Ducks Unlimited, and Citizen's Campaign for the Environment.

NYSDEC and Honeywell are committed to continuing to work with community leaders, environmental groups, fishing and wildlife enthusiasts, interested stakeholders and citizens so their input, recommendations, comments, and perspectives can be thoroughly evaluated by the technical design team. As part of the NYSDEC Citizen Participation Plan, community members will have the opportunity to participate during the design, construction, and post-construction periods. Further details on citizen participation activities are outlined in NYSDEC's *Citizens Participation Plan* (NYSDEC, 2009).

History of Onondaga Lake

While Onondaga Lake is important to the present-day community, its significance began much earlier than the settling of what has become modern-day Syracuse.

Statement of Onondaga Nation[1]

Onondaga Lake is the spiritual, cultural and historic center of the Haudenosaunee Confederacy. Over one thousand years ago, the Peacemaker brought the Mohawk, Oneida, Onondaga, Cayuga, and Seneca Nations together on the shores of Onondaga Lake. At the lakeshore, these Nations accepted the message of peace, laid down their arms, and formed the Haudenosaunee Confederacy. The Confederacy was the first representative democracy in the West and inspired the founders of the United States.

Onondaga Lake is sacred to the Haudenosaunee. The Onondaga Nation has resided on the Lake and throughout its watershed since time immemorial, building homes and communities, fishing, hunting, trapping, collecting plants and medicine, planting agricultural crops, performing ceremonies with the natural world dependent on the Lake, and burying ancestors - the mothers, fathers and children of the Onondaga Nation. The Onondaga Nation views its relationship to this area as a place where they will forever come from and will return to; they will continue to work for the healing of the lake.

The Habitat Plan addresses needs for birds like the Virginia Rail — a culturally significant species.

[1] The Onondaga Nation requested that the following oral tradition be included in this Habitat Plan. The inclusion of the Onondaga Nation's oral tradition in this Habitat Plan is not intended as, and shall not constitute, an admission of any fact or law in any judicial or administrative proceeding.

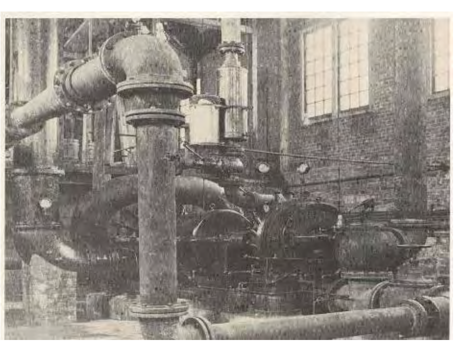
Jesuit missionaries from Quebec later established a mission on the shores of Onondaga Lake in 1656.(Ste Marie, 2006). Father LeMoyne learned of the salt springs from the Onondaga Nation, and the salt industry began operations in 1793. The industry thrived for over 100 years, and the extraction and processing of salt fostered the development of an extensive infrastructure in the region, including railroads and the Erie Canal system. The region lost its monopoly on salt production due to changing industrial demands for salt and the discovery of large sources of salt in other areas of the United States. However, despite the dwindling market for Syracuse salt, many different industries took advantage of the naturally occurring salt in this region for use in the manufacture of various chemicals and in chemical processes necessary for refining metal (Hohman, 2004).

Salt Works on the shores of Onondaga Lake.

The infrastructure initially developed for the salt industry later supported the establishment of a number of additional industries near Onondaga Lake, including soda ash and hydrogen peroxide manufacturing facilities; petroleum-product storage facilities; a fertilizer production plant; a steel foundry; a manufacturing plant for vehicle accessories; a pottery and china manufacturing plant; and industries including pharmaceuticals, air conditioning, general appliances, and electronics manufacturing.

By 1920, the region around Onondaga Lake was a national center of manufacturing for metal products, automobiles, typewriters, pottery, and other small machinery (de Laubenfels, 1977). By 1950, 139 industries used Onondaga Lake for waste disposal (Ferrante, 2005), often directly to the lake.

In addition to industrial development, the Onondaga Lake area experienced further residential and economic growth during the twentieth century. Paralleling the rise of development in the area, the population of Onondaga County rose from approximately 160,000 in 1900 to 458,336 in 2000 (US Census Bureau, 2002). Much of the population is, and has historically been, located in the Syracuse metropolitan area, which is located on the southeastern end of Onondaga Lake.



10 Million gallon pump erected in 1904 at the Onondaga Lake pump station.

Over 150 years of manufacturing, industrialization, and population growth altered the habitat and fisheries in Onondaga Lake and in the region. These changes also impacted the water level of the lake and had a significant impact on the diversity of habitat within the lake. For example, northern pike was a common fish predator in the region in the late 1800s and early 1900s; but lowering of the lake level for the construction of the Barge Canal system reduced the availability of wetland spawning habitats for this species, and the number of fish declined. The disposal of industrial wastes, including Solvay Waste, in and around the lake also decreased the overall lake surface area and resulted in the loss of historic wetlands. Based on a variety of resources, it is clearly documented that industrialization and community development altered the landscape, impacted lake levels, and degraded the lake's habitat. Today, industries and communities recognize the importance of the lake's future and are working to restore it.

Current Conditions of the Lake

Industrial and urban pollution, urbanization, and municipal waste have reduced the suitability of Onondaga Lake habitats for a variety of species. The cumulative effects of human-induced disturbances, such as tree clearing, agriculture, filling, dam construction, industrialization, and urbanization have reduced terrestrial, floodplain, and aquatic habitats and have altered species diversity and abundance.

Metro's upgrades have greatly improved the water quality in Onondaga Lake.

Onondaga County has conducted extensive upgrades to the Metro sewage treatment facility, and these changes have resulted in greatly improved water quality. One measure of this improvement is seen in the increase of aquatic plant species. Since 1991, the number of aquatic plant species in the lake has increased by almost 70%. The abundance of aquatic plants in the lake has also increased. The percent cover and biomass of aquatic plants were, on average, slightly more than three times greater in 2005 compared to 2000 (Ecologic *et al*., 2006).

Honeywell has begun cleaning up and restoring areas adjacent to the lake. The Linden Chemical and Plastic (LCP) Bridge Street site, one of two primary sources of mercury entering the lake, has been cleaned up and restored. Along the southern shore of the lake, a barrier wall and groundwater extraction system was installed to prevent contaminated groundwater from entering the lake. These activities are the first important steps in cleaning up and restoring the lake. There are still many issues to address, but recent investigations reveal that the lake is improving.

Restored wetland marsh at LCP Site

Effects of the Remedy on Existing Habitats

Much of the remediation program for the Onondaga Lake bottom is focused on reducing or eliminating the hazardous substances in the sediments that pose the risk of adverse effects to the organisms living in the sediments on the lake bottom. Organisms may experience adverse effects as acute (short-term) or chronic (long-term) toxicity directly from exposure to the contaminants in the sediments, or they can experience indirect exposure when contaminants enter into the food chain and affect organisms which feed on other contaminated species. Another area of focus for remedial efforts is the adjacent upland sites and shoreline areas. Addressing these sites will ensure that contaminants are not reintroduced to remediated areas in the lake, thus eliminating the process of acute toxicity in organisms. These key wetland and shoreline areas along the lake have been included in this Habitat Plan to ensure a holistic approach to the conceptual designs.

A portion of the Willis-Semet barrier wall is installed along the lakeshore.

The actual construction phase of the lake bottom remedy will have a short-term impact on existing habitats in remediation areas, but overall habitat conditions within remediation areas will be maintained or improved after the implementation of the designs presented in this Plan. The dredging and/or capping of areas within the lake, along with remedial activities at several upland areas adjacent to the site will also cause short term, temporary loss of habitat and displacement of some species. However, the restoration of these areas will result in improved habitat conditions throughout the areas of the lake that require remediation.

The Future of Onondaga Lake

Bald eagles have returned to Onondaga Lake.

The habitat designs described in this Plan were developed using many different criteria, including the integration of habitat needs for representative species with the requirements associated with the dredging and capping design specified in the Onondaga Lake Bottom Record of Decision, the physical conditions of the site, and the habitat goals and objectives. The holistic approach for integrating multiple remedial considerations from the related lake and shoreline areas will result in improved conditions for a wide variety of species in these areas.

Onondaga Lake continues to show progress toward becoming the thriving, dynamic, natural resource and community asset that it once was and this comprehensive plan for habitat restoration is another important step toward realizing that vision.

TABLE ES.1
HABITAT MODULE CHARACTERISTICS
ONONDAGA LAKE REMEDIAL DESIGN PROGRAM

HABITAT MODULE AREAS[(a) (b) (e)]	REPRESENTATIVE SPECIES/HABITAT						
	Fish	Plants	Benthic Macroinvertebrates[(c)]	Mammals	Reptiles and Amphibians	Birds	Minimum Habitat Layer Thickness[(d)]
1. Deep water (20-30 ft) (6-9 m) Sand substrate Low to medium energy Note: This module also generally applies to deeper water (profundal) areas. [(f)]	Transient cold water fish (brown trout), lake sturgeon, emerald shiner, bass, walleye and pumpkinseed	None	Amphipoda (Pontoporeia affinis), Annelida (Oligochaeta, Diptera (Chironomidae), Mollusca, and Annelida	None	None	Common goldeneye, mallard, osprey and bank swallow	1 ft. (30 cm) (Average of 1.25 ft.)
2A. Mid water depth (7-20 ft) (2-6 m) Sand/fine gravel substrate Low to medium energy	Lake sturgeon, transient cold water fish, bass, northern pike and pumpkinseed; additionally, walleye and bass if structure is present	Submerged aquatics in shallow portion	Diptera (Chironomidae) Annelida, Ephemeroptera, Odonata, and Mollusca; diptera if structure is present	Otter	None; mudpuppy if structure is present	Mallard, common tern, osprey and bank swallow	1 ft. (30 cm) (Average of 1.25 ft.)
2B. Mid water depth (7-20 ft) (2-6 m) Coarse gravel/cobble substrate High energy	Lake sturgeon, transient cold water fish, bass, smallmouth bass and pumpkinseed; additionally walleye if structure is present	Limited	Diptera (Chironomidae)	Otter	None; mudpuppy if structure is present	Mallard, common tern, osprey and bank swallow	1 ft. (30 cm) (Average of 1.25 ft.)
3A. Shallow water depth (2-7 ft) (0.5-2 m) Sand/fine gravel substrate Low energy	Largemouth bass, pumpkinseed, golden shiner and northern pike	Medium to dense submerged aquatic vegetation	Ephemeroptera, Trichoptera, Diptera, Odonata, Amphipoda, and Decapoda	Otter, mink, beaver; additionally muskrat if structure is present	Snapping turtle; additionally mudpuppy if structure is present	Mallard, belted kingfisher, osprey, great blue heron and bank swallow	1.5 ft. (45 cm) (Average of 2.0 ft.)
3B. Shallow water depth (2-7 ft) (0.5-2 m) Coarse gravel/cobble substrate High energy	Bass, pumpkinseed, golden shiner and northern pike	Sparse to medium submerged aquatic vegetation	Ephemeroptera, Trichoptera, Diptera, Odonata, Amphipoda, and Decapoda	Otter, mink, beaver, muskrat	Limited/none; mudpuppy and snapping turtle if structure is present	Mallard, belted kingfisher, great blue heron, common tern and bank swallow	1.5 ft. (45 cm) (Average of 2.0 ft.)

Footnotes:
a. High, medium, and low energy designations were developed by Anchor-QEA in the Wind/Wave Analysis from the Capping and Dredge Area and Depth Technical Document (Parsons, 2009).
b. Selection of modules for specific areas around the lake will consider the presence/occurrence of invasive species.
c. Diversity of species for benthos will be evaluated during the next phase of design.
d. See representative species Tables 4.1 to 4.7 for substrate depth and minimum habitat size information for specific organisms.
e. Structure can be added to any module. Species that would benefit from structure have been noted on the table.
f. A habitat layer will not be required in areas of the Profundal zone that do not have an isolation cap.

TABLE ES.1 (Continued)
HABITAT MODULE CHARACTERISTICS
ONONDAGA LAKE REMEDIAL DESIGN PROGRAM

HABITAT MODULE AREAS[(a) (b) (e)]	REPRESENTATIVE SPECIES/HABITAT						
	Fish	Plants	Benthic Macroinvertebrates[(c)]	Mammals	Reptiles and Amphibians	Birds	Minimum Habitat Layer Thickness[(d)]
4A. Floating aquatics wetland (1-3 ft) (0.3-1 m) Organics/fines/sand substrate Very low energy	Northern pike and Pumpkinseed	Floating aquatics, some submerged aquatics in deeper portions, some nonpersistent emergents in shallower portion	Ephemeroptera, Trichoptera, Diptera, Odonata, Amphipoda, and Decapoda	Otter, mink, muskrat and beaver	Snapping turtle, painted turtle, musk turtle and water snake; additionally mudpuppy if structure is present	Mallard, belted kingfisher, great blue heron, common tern, green heron and bank swallow	2.0 ft. (60 cm) (Average of 2.5 ft.)
5A. Non-persistent emergent wetland (0.5-2 ft) (0.1-0.6 m) Organics/fines/sand substrate Low energy	Northern pike and pumpkinseed	Non-persistent emergent vegetation. Some persistent emergents in shallows.	Ephemeroptera, Trichoptera, Diptera, Odonata, Amphipoda, and Decapoda	Otter, mink, muskrat and beaver	Snapping turtle, painted turtle, musk turtle, water snake, red spotted newt, green frog and leopard frog; additionally mudpuppy if structure is present	Mallard, belted kingfisher, great blue heron, green heron, common tern and bank swallow	2.0 ft. (60 cm) (Average of 2.5 ft.)
5B. Shoreline shallows/limited emergent wetland (0.5-2 ft) (0.1-0.6 m) Gravel/cobble substrate High energy	Smallmouth bass; additionally walleye if structure is present	Limited/none	Limited numbers Trichoptera, Ephemeroptera; Trichoptera, Ephemeroptera and Decapoda if structure is present	Otter and mink	Limited/none; Turtle, water snake, and mudpuppy if structure is present	Mallard, belted kingfisher, great blue heron, green heron and bank swallow	2.0 ft. (60 cm) (Average of 2.5 ft.)

Footnotes:
a. High, medium, and low energy designations were developed by Anchor-QEA in the Wind/Wave Analysis from the Capping and Dredge Area and Depth Technical Document (Parsons, 2009).
b. Selection of modules for specific areas around the lake will consider the presence/occurrence of invasive species.
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	Fish	Plants	Benthic Macroinvertebrates[(c)]	Mammals	Reptiles and Amphibians	Birds	Minimum Habitat Layer Thickness[(d)]
6A. Persistent emergent wetland or salt marsh (1 ft above water to 1 ft deep) (0.3 m above water to 0.3 m deep) Organics/fines/sand substrate Low energy	Northern pike	Persistent emergent vegetation, salt marsh vegetation	Trichoptera, Diptera, Odonata and Decapoda; additionally Amphipoda if structure is present	Otter, mink, muskrat and beaver	Snapping turtle, painted turtle, musk turtle, water snake, red-spotted newt, leopard frog and green frog; additionally mudpuppy if structure is present	Mallard, spotted sandpiper, semi-palmated sandpiper, red-winged blackbird, great blue heron, green heron, common tern and bank swallow	2.0 ft. (60 cm) (Average of 2.5 ft.)
6B. On shore to shallows/limited emergent wetland or salt marsh (1 ft above water to 1 ft deep) (0.3 m above water to 0.3 m deep) Cobble/coarse gravel/sand High energy	Limited use	Limited/none	Trichoptera, Ephemeroptera and Decapoda	Otter and mink	Limited/none, snapping turtle	Mallard, spotted sandpiper, semi-palmated sandpiper, great blue heron, green heron and bank swallow	2.0 ft. (60 cm) (Average of 2.5 ft.)cm)
7A. Mudflats/unvegetated shoreline (0.7 ft above water to 0.7 ft deep) (0.2 m above water to 0.2 m deep) Fines/sand substrate or cobble/gravel High energy or fluctuating water levels	None	Limited/none	Limited-Annelida	Otter and mink	Snapping turtle	Mallard, spotted sandpiper, semi-palmated sandpiper, great blue heron and green heron	2.0 ft. (60 cm) (Average of 2.5 ft.)

Footnotes:

a. High, medium, and low energy designations were developed by Anchor-QEA in the Wind/Wave Analysis from the Capping and Dredge Area and Depth Technical Document (Parsons, 2009).
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e. Structure can be added to any module. Species that would benefit from structure have been noted on the table.
f. A habitat layer will not be required in areas of the Profundal zone that do not have an isolation cap.

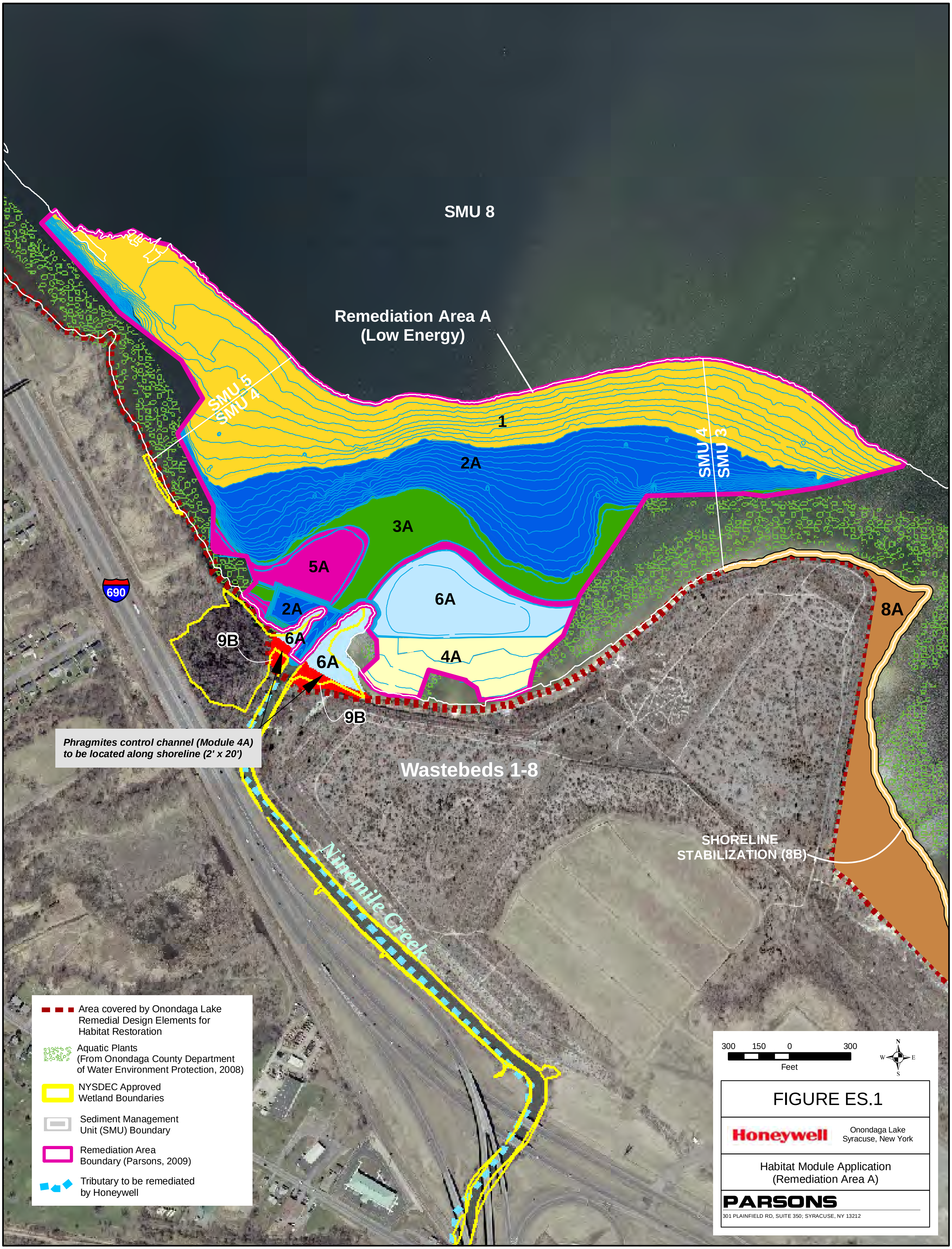
TABLE ES.1 (Continued)
HABITAT MODULE CHARACTERISTICS
ONONDAGA LAKE REMEDIAL DESIGN PROGRAM

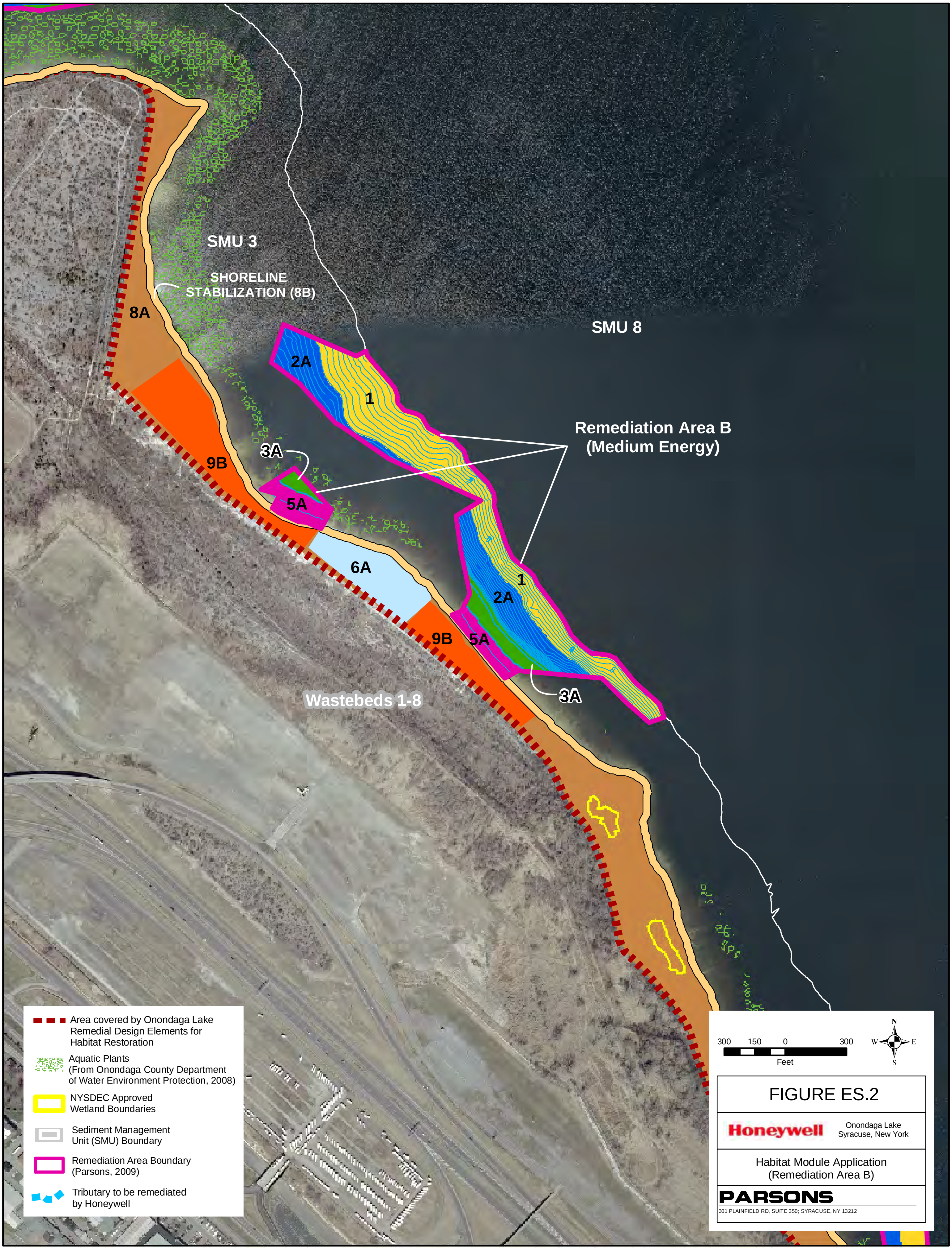
HABITAT MODULE AREAS[(a) (b) (e)]	REPRESENTATIVE SPECIES/HABITAT						
	Fish	Plants	Benthic Macroinvertebrates[(c)]	Mammals	Reptiles and Amphibians	Birds	Minimum Habitat Layer Thickness[(d)]
8A. Shoreline uplands/riparian Topsoil substrate	None	Successional fields	None	Otter and mink	Leopard frog	Mallard, great blue heron, green heron and red-winged blackbird	1.5 ft. (45 cm) (Average of 2.0 ft.)
8B. Shoreline uplands/riparian Topsoil substrate	None	Scrub-shrub or forested	None	Otter, mink, beaver and Indiana bat	Leopard frog and water snake	Mallard and green heron	1.5 ft. (45 cm) (Average of 2.0 ft.)
9A. Inland wetlands not associated with the lake (saturated soils to pooled water that may be temporary) Topsoil substrate	None	Wet meadow and persistent emergent wetland species, primarily herbaceous	Limited numbers/species, Annelida and Mollusca	Muskrat and mink	Leopard frog, red spotted newt, water snake and green frog	Red-winged blackbird, green heron, great blue heron, spotted sandpiper and bank swallow	2.0 ft. (60 cm) (Average of 2.5
9B. Inland wetlands not associated with the lake (saturated soils to pooled water that may be temporary) Topsoil substrate	None	Forested wetland and scrub-shrub wetland species	Limited numbers/species, Annelida and Mollusca	Mink and beaver	Spotted salamander and wood frog	Red-winged black bird and green heron	2.0 ft. (60 cm) (Average of 2.5

SPECIAL FEATURES/CONSIDERATIONS

Endangered aquatic plants (*Potamogeton strictifolius, Najas guadalupensis* var. muenscheri, or Najas *guadalupensis* var. olivacea)	Potential for these species where submerged aquatic vegetation is targeted. These would most likely fall under Module 3A.
Northern Pike Spawning Wetlands	Provide spawning habitat for northern pike.

Footnotes:
a. High, medium, and low energy designations were developed by Anchor-QEA in the Wind/Wave Analysis from the Capping and Dredge Area and Depth Technical Document (Parsons, 2009).
b. Selection of modules for specific areas around the lake will consider the presence/occurrence of invasive species.
c. Diversity of species for benthos will be evaluated during the next phase of design.
d. See representative species Tables 4.1 to 4.7 for substrate depth and minimum habitat size information for specific organisms.
e. Structure can be added to any module. Species that would benefit from structure have been noted on the table.
f. A habitat layer will not be required in areas of the Profundal zone that do not have an isolation cap.


SMU 8
Remediation Area A
(Low Energy)
SMU 5
SMU 4
SMU 4
SMU 3
1
2A
3A
5A
6A
2A
6A
6A
4A
9B
9B
8A
690
Phragmites control channel (Module 4A)
to be located along shoreline (2' x 20')
Wastebeds 1-8
SHORELINE
STABILIZATION (8B)
Ninemile Creek
Area covered by Onondaga Lake
Remedial Design Elements for
Habitat Restoration
Aquatic Plants
(From Onondaga County Department
of Water Environment Protection, 2008)
NYSDEC Approved
Wetland Boundaries
Sediment Management
Unit (SMU) Boundary
Remediation Area
Boundary (Parsons, 2009)
Tributary to be remediated
by Honeywell
300 150 0 300
Feet
N
W
E
S
FIGURE ES.1
Honeywell
Onondaga Lake
Syracuse, New York
Habitat Module Application
(Remediation Area A)
PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



SMU 3
SHORELINE STABILIZATION (8B)
8A
SMU 8
2A
1
Remediation Area B (Medium Energy)
3A
9B
5A
6A
2A
1
9B
5A
3A
Wastebeds 1-8
Area covered by Onondaga Lake Remedial Design Elements for Habitat Restoration
Aquatic Plants (From Onondaga County Department of Water Environment Protection, 2008)
NYSDEC Approved Wetland Boundaries
Sediment Management Unit (SMU) Boundary
Remediation Area Boundary (Parsons, 2009)
Tributary to be remediated by Honeywell
300 150 0 300
Feet
N
W
E
S
FIGURE ES.2
Honeywell
Onondaga Lake
Syracuse, New York
Habitat Module Application
(Remediation Area B)
PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

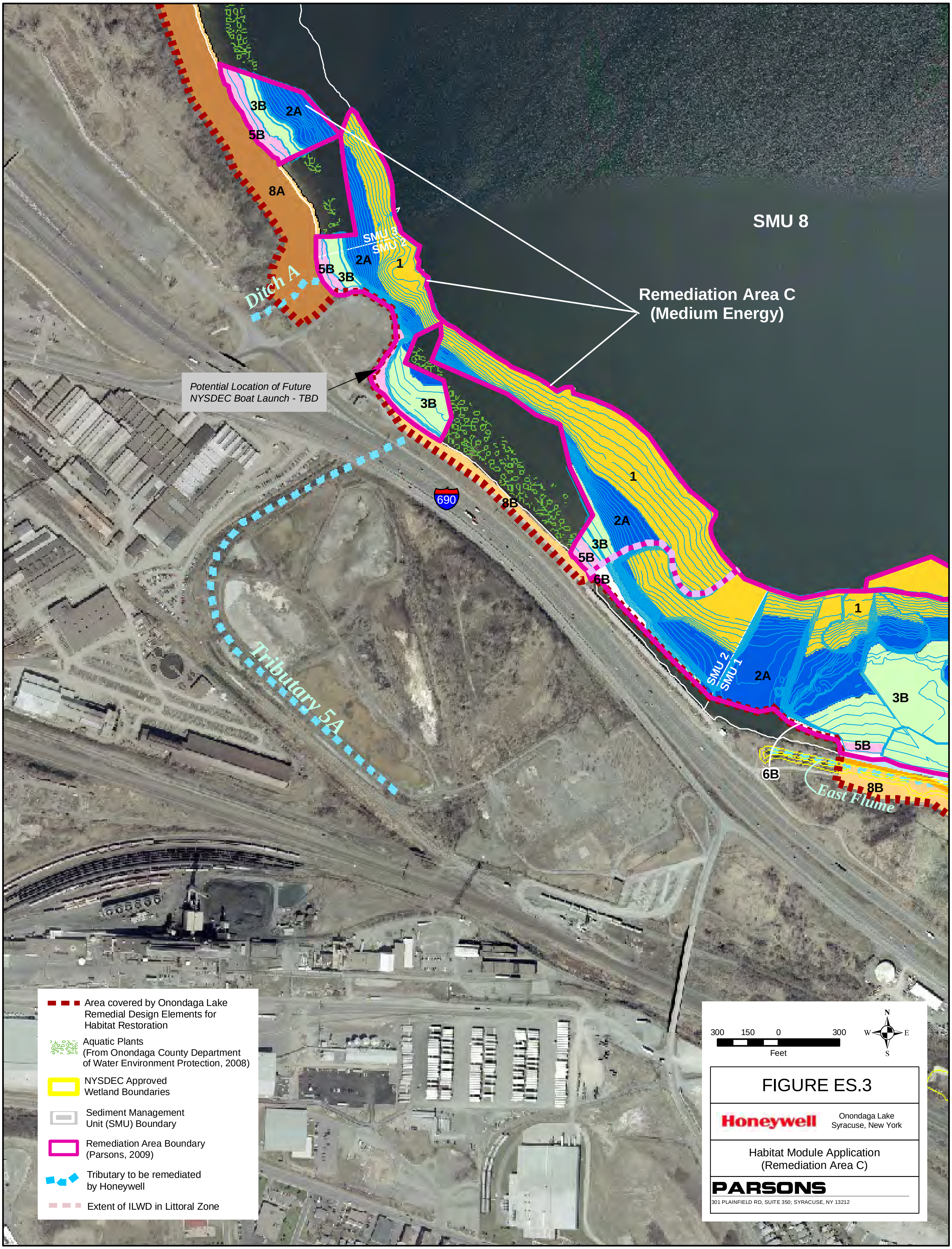


FIGURE ES.3

Honeywell

Onondaga Lake
Syracuse, New York

Habitat Module Application
(Remediation Area C)

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

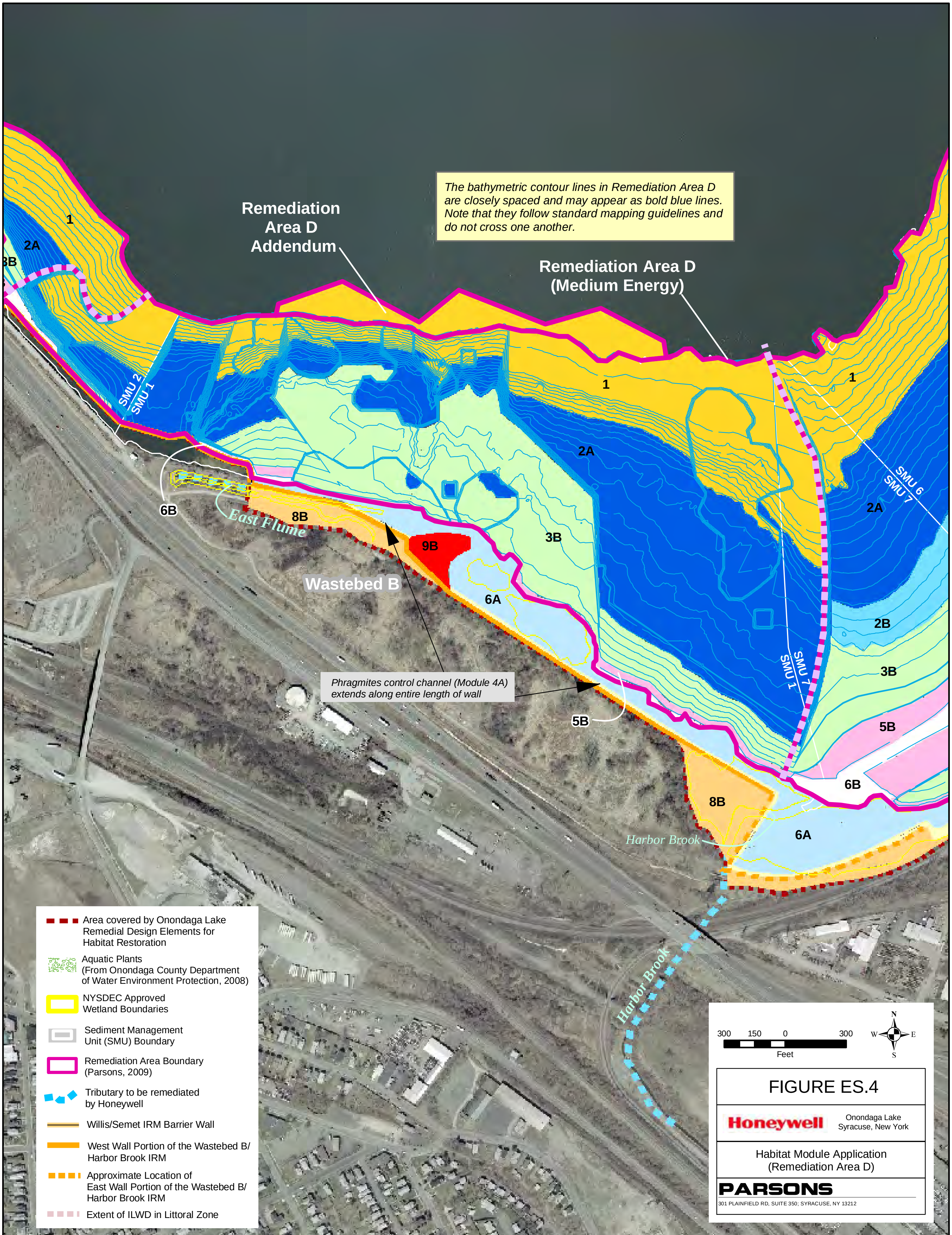
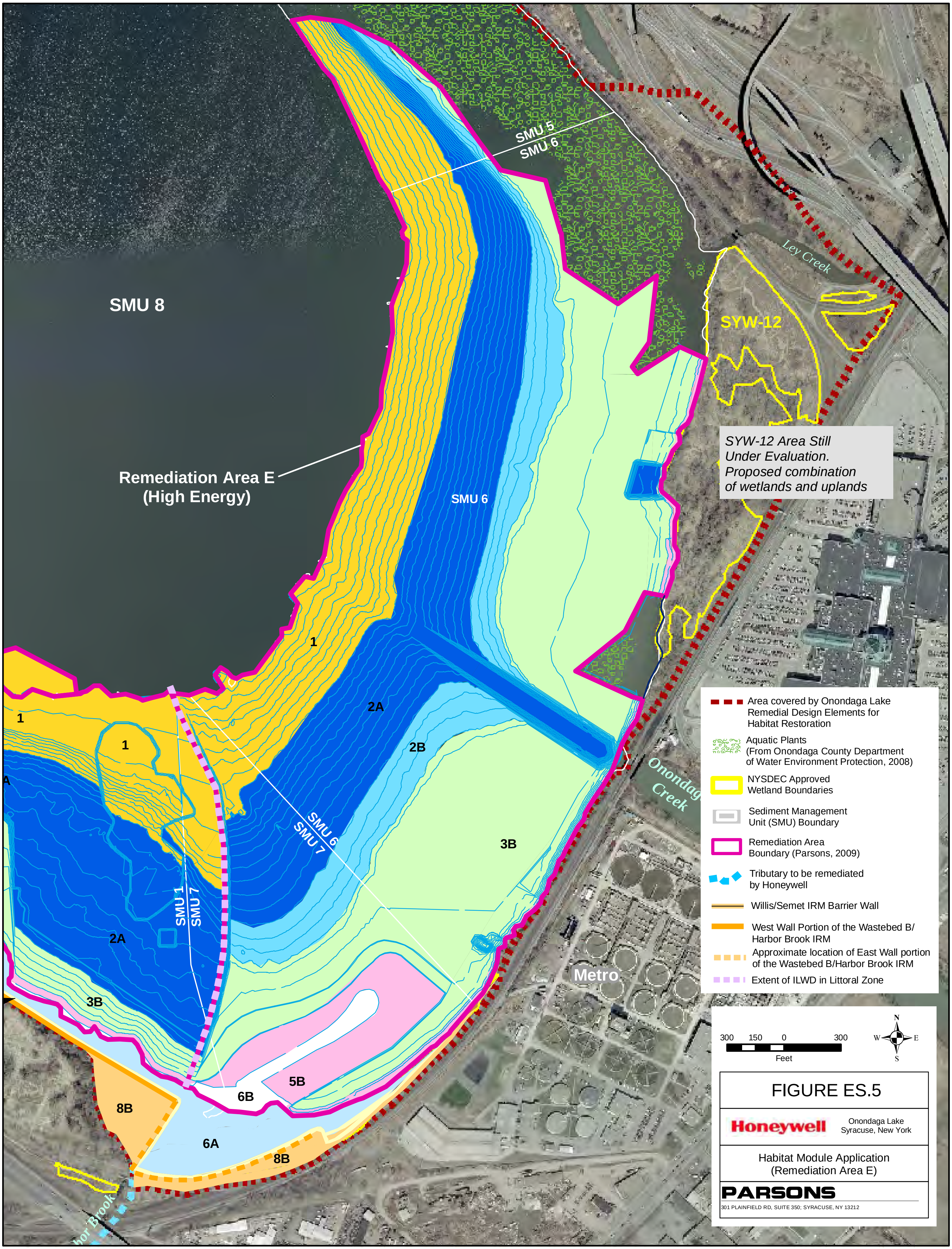


FIGURE ES.4

Honeywell
Onondaga Lake
Syracuse, New York

Habitat Module Application
(Remediation Area D)

PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212


SMU 8
SMU 5
SMU 6
Remediation Area E
(High Energy)
SMU 6
SYW-12
Ley Creek
SYW-12 Area Still Under Evaluation. Proposed combination of wetlands and uplands
1
1
1
2A
2B
2A
3B
3B
SMU 6
SMU 7
SMU 1
SMU 7
Onondaga Creek
Metro
5B
6B
6A
8B
8B
Area covered by Onondaga Lake Remedial Design Elements for Habitat Restoration
Aquatic Plants (From Onondaga County Department of Water Environment Protection, 2008)
NYSDEC Approved Wetland Boundaries
Sediment Management Unit (SMU) Boundary
Remediation Area Boundary (Parsons, 2009)
Tributary to be remediated by Honeywell
Willis/Semet IRM Barrier Wall
West Wall Portion of the Wastebed B/ Harbor Brook IRM
Approximate location of East Wall portion of the Wastebed B/Harbor Brook IRM
Extent of ILWD in Littoral Zone
300 150 0 300
Feet
N
W
E
S
FIGURE ES.5
Honeywell
Onondaga Lake
Syracuse, New York
Habitat Module Application
(Remediation Area E)
PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

Section 1: Introduction to the Habitat Plan

Restoring diverse, functioning and sustainable habitats in Onondaga Lake is a key component of the overall Onondaga Lake cleanup program that drives many other stages of remediation. Understanding the types of species that are native to the lake, their needs for habitat and where these habitats need to be restored are some of the main requisites for designing a plan that also takes into account the lake's history, natural setting and community importance. The group responsible for molding these requisites into a unique plan is known as the Habitat Technical Work Group (TWG), which combines experts from a cross-section of disciplines and organizations. This diversity of experts has allowed for a thorough and integrative approach in design.

This plan addresses the Remedial Design Elements for Habitat Restoration (hereafter referred to as the Habitat Plan). It presents conceptual designs for habitat restoration that will be integrated into the Onondaga Lake Bottom Remedy. This remedy pertains only to remediation areas in the lake related to sediment. However, because habitats are part of a complex ecosystem, designs are not restricted to lake-bottom sediments. Portions of adjacent Honeywell sites known as interim remedial measures (IRMs) will also be included in the habitat restoration process, and will incorporate habitat restoration into individual IRM remedies. The Onondaga Lake Bottom, a subsite of the Onondaga Lake Superfund Site, is on the New York Sate Registry of Inactive Hazardous Waste Sites. The New York State Department of Environmental Conservation (NYSDEC) and Honeywell have agreed to conditions under which Honeywell will design and implement the selected remedy, as set forth in the Consent Decree (United States District Court, Northern District of New York, 2007) (89-CV-815). The remedial investigation, planning, and design to date is the result of an intensive effort by scientists, engineers, and technicians working with the NYSDEC, United States Environmental Protection Agency (USEPA), and numerous public interest groups to formulate this Habitat Plan, placing Onondaga Lake on a path toward a restored natural resource.

The Consent Decree encompasses Onondaga Lake and several upland sites that have contributed to contamination to the lake system, many of which are IRMs. These various sites have been listed on USEPA's National Priorities List (NPL). The NYSDEC and USEPA have, to date, organized the environmental cleanup of the Onondaga Lake NPL site into eight subsites (Figure 1.1). In addition, Honeywell is responsible for the following NPL subsites: Linden Chemical and Plastics (LCP) Bridge Street, Semet Residue Ponds, Willis Avenue, Wastebed B/Harbor Brook, and Geddes Brook/Ninemile Creek. Other Honeywell sites (those not on the NPL) in proximity to the lake include Willis Ballfield, Wastebeds 1 through 8, Mathews Avenue Landfill and the Dredge

Spoils Area. See Section 3.2 of this Plan for more information on the IRMs.

1.1 General Description of Habitat Restoration at the Onondaga Lake NPL Site

Habitat is the physical and biological surroundings of an organism. It can be broadly defined as an area where plants and animals (including humans) normally live, grow, feed, reproduce, and otherwise exist for any portion of their life cycle. Habitat provides organisms or communities of organisms the necessary elements of life, such as space, food, water, and shelter (Federal Interagency Stream Restoration Working Group, 1998).

Great blue heron is a species that uses Onondaga Lake.

Habitat re-establishment and enhancement have been defined in the ROD (NYSDEC and USEPA, 2005) as noted below:

> "*Habitat re-establishment* is the restoration of habitat in areas where remediation substantially alters existing conditions. Re-establishment can be either restoring the same type of habitat that existed prior to remediation, or establishing a different type of habitat that has been deemed appropriate for the ecological conditions of the area."

> "*Habitat enhancement* is improvement of habitat conditions in areas where CERCLA contaminants do not occur at levels that warrant active remediation, but where habitat impairment due to stressors has been identified as a concern."

Habitat restoration (re-establishment, enhancement, replacement, and improvement) is an integral part of the overall cleanup plan for Onondaga Lake and will provide habitat value beyond what is currently available[2]. More specifically, restoration will be implemented in designated lake-bottom sediment, upland, and tributary (Tributary 5A, East Flume, Lower Harbor Brook) IRM areas, and Geddes Brook/Ninemile Creek. An overall goal of habitat restoration in these areas is to achieve ecological systems that function naturally, are self-sustaining, and are integrated with the surrounding habitats.

This Habitat Plan describes conceptual habitat restoration designs that will be implemented as part of, or following, remedial actions (*e.g.* dredging and/or capping). These restoration designs are based on the

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[2] All references in this Habitat Plan to habitat enhancement, habitat reestablishment, or restoration are limited to how those terms are defined in the ROD for the Onondaga Lake Superfund site. If Honeywell elects to claim natural resource damages credit for work described in this report, it shall do so pursuant to the term and conditions set forth in Paragraph 75 of the Consent Decree between Honeywell and the State of New York. Nothing herein shall constitute an agreement by New York State that any work described in this report is eligible for natural resource damages credit.

historical and current habitat (or ecological system) conditions within Onondaga Lake and the adjacent shoreline areas.

1.2 Habitat Design Background

Submerged aquatic vegetation

This Habitat Plan has been developed through a review and approval process with representatives from NYSDEC Division of Environmental Remediation, NYSDEC Fish and Wildlife, United States Environmental Protection Agency (USEPA), United States Fish and Wildlife Service, and the Honeywell team from the State University of New York College of Environmental Science and Forestry (SUNY ESF), Mississippi State University, Terrestrial Environmental Services (TES), AnchorQEA, O'Brien & Gere, and Parsons. The extensive team of local and national experts from all parties included wetland ecologists, limnologists, biologists, restoration ecologists and fisheries biologists. Collectively, the combined group was called the TWG as further discussed below.

1.2.1 Habitat Technical Work Group

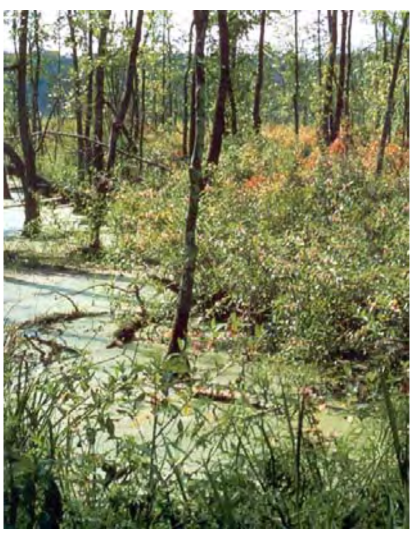
The TWG was formed shortly after the signing of the Consent Decree to provide a forum for technical experts to develop an approach for incorporating habitat considerations into the remedial design for Onondaga Lake. The TWG evaluated current habitat conditions, along with the selected or anticipated site remedies and IRMs adjacent to the lake to identify the potential effects of remediation on existing habitats. Based on this evaluation, the TWG defined the boundaries within which the conceptual habitat designs would be applied. This boundary, shown as a dashed red line on Figure 1.2 was selected to facilitate a holistic approach that integrates habitat restoration work *within* the lake with areas *adjacent* to the lake to provide habitat connectivity and transition areas.

Remediation Area D and the mouth of Harbor Brook

Once the areas where the habitat designs would be applied had been identified, the TWG reviewed historic and current conditions to identify representative species and habitat considerations for each remediation area. The habitat requirements for the representative species were then used to identify important factors such as current and future land use, topography (land surface), bathymetry (lake bottom surface), hydrology, and soils/substrate needed to support the various life cycles of the representative species and habitats. This information was used as the basis for developing the conceptual habitat designs and will also be integrated into the detailed design of the Lake Bottom Remedy. The detailed remedial designs will provide the overall plans and specifications for all of the areas requiring remediation or habitat enhancement.

The conceptual designs presented in this document have been integrated with upland IRMs and remedies and comply with applicable state and federal laws and regulations, executive orders and policies for floodplains, wetlands and surface waters.

1.3 Areas Requiring Remediation or Habitat Enhancement – Establishing a Framework



Scrub-shrub wetlands

To facilitate evaluation and remedy development during the Feasibility Study (FS), the lake 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 shallow (littoral) zone (less than 30 feet) 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 feet) (see Figure 1.2).

Since the submittal of the FS, a significant amount of new data has been collected throughout Onondaga Lake in accordance with the requirements of the ROD and Consent Decree. Based on an understanding of these additional data, an updated framework for identifying littoral (shallow) areas of the lake has been developed called “Remediation Areas.” The SMU designations have been left in this document for reference, but this Habitat Plan and future design documents will be organized by remediation area and include SMU 8 as a separate remedy area.

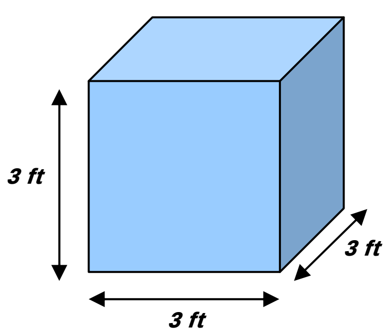
The remediation area designations help to identify the specific characteristics of each remediation area and focus the habitat restoration to enhance the entire lake system. The characteristics of each remediation area that are important for the habitat restoration designs include extent and type of remediation, location within the lake, presence of tributary stream discharge, wind/wave energy, adjacent habitats in the lake, adjacent habitat on the shoreline and in upland areas, adjacent land use, and opportunities for recreational access and use. Based on a survey of these defining factors, seven remediation areas were established.

Figure 1.2 illustrates these seven remediation areas as well as the SMU boundaries as defined in the ROD. Characteristics of each remediation area are summarized below. Note that a key consideration for all areas is the placement, monitoring, and maintenance of a multi-layered cap.

Remediation Area	Sediment Management Unit (SMU)	Key Characteristics and Considerations
A	SMU 4 and portions of SMUs 3 and 5	Low wave energy area Connectivity to Ninemile Creek Integration with SYW-10 wetlands and Wastebeds 1-8 remedy Public access and recreation considerations
B	SMU 3	Medium wave energy area Shoreline stabilization requirements Integration with Wastebeds 1-8 remedy and wetland mitigation areas
C	SMU 2 and small portion of SMU 3	Medium wave energy area Minor tributary (Ditch A) present Shoreline IRM Barrier Walls Public access and recreation considerations
D	SMU 1 and small portions of SMU 2 and SMU 7	Medium wave energy area Shoreline IRM Barrier Wall Shallow water from in-lake waste deposits Integration with shoreline wetlands along Wastebed B/Harbor Brook
D Addendum	Small portion of SMU 8	Very low energy Deep water (Profundal zone)
E	SMUs 7 and 6	High wave energy

Remediation Area	Sediment Management Unit (SMU)	Key Characteristics and Considerations
E	SMUs 7 and 6	Three major tributary systems (Onondaga Creek, Harbor Brook and Ley Creek) Navigation into Onondaga Creek IRM Barrier wall along shoreline near mouth of Harbor Brook Wetlands at mouth of Harbor Brook SYW-12 wetlands along shoreline Discharge from Metro wastewater treatment facility Active railroad track along shoreline
F	Small portions of SMU 5	Medium energy area Small areas that require dredging
	SMU 8	Profundal area Details of remedy will be included in subsequent design documents.

In addition to the remediation areas described above, the ROD identifies two distinct areas within the lake where Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) contaminants do not occur at levels that warrant active remediation, but where habitat impairment due to stressors has been identified as a concern -- the shoreline of SMU 3 and the calcite and oncolite deposits in SMU 5. Habitat enhancement activities planned to stabilize the Remediation Area B (SMU 3) shoreline are described following the description of restoration in Remediation Area B. The habitat enhancement activities for Remediation Area F (SMU 5) are described in Section 5.3.10.



One cubic yard is equivalent to a cube that is 3x3x3 ft.

1.4 Consent Decree and Record of Decision (ROD) Requirements

As a key component of the restoration program specified for Onondaga Lake, this Habitat Plan will meet the requirements specified in the decision documents for the lake. A general overview of the in-lake components of the selected remedy set forth in the Consent Decree is summarized below:

- dredging up to an estimated 2,653,000 cubic yards of contaminated sediments and wastes;
- placement of an isolation cap over an estimated 425 acres in shallow water areas (littoral zone);

- construction of a thin-layer cap over an estimated 154 acres in the deep water areas (profundal zone);
- performance of a pilot study that evaluates methods to prevent the formation of methylmercury in the deeper areas;
- re-establishment of habitat affected by implementation of the remedy and enhancement of habitat in certain near-shore areas in Remediation Areas B and F (SMUs 3 and 5);
- monitored natural recovery (MNR) in portions of the deep water areas (profundal zone);
- implementation of institutional controls; and
- long-term operation, maintenance and monitoring.

Additional details regarding the lake remedy are provided in Section 3 of this plan. Specific issues which this Habitat Plan must address are listed in the ROD, the Explanation of Significant Differences (ESD), and the Statement of Work (SOW), all of which are appended documents to the Consent Decree. Specifically, the issues that must be addressed in the Habitat Plan are:

- thickness and substrate of the habitat layer;
- habitat restoration following dredging and/or capping;
- habitat enhancement in Remediation Areas B and F (SMUs 3 and 5);
- the details for construction of the shoreline lakeward of the barrier wall in portions of Remediation Areas C and D (SMUs 1 and 2);
- mitigation of aquatic habitat lost as a result of the off-shore placement of the shoreline barrier wall in portions of Remediation Areas A and B (SMUs 1 and 2); and
- details for placement of the isolation cap in portions of the littoral area without prior dredging.

In addition to the list above, other issues that are addressed in this plan include the following:

- habitat goals for the conceptual design;
- representative species and habitats;
- water depth and substrate requirements for representative habitats;
- description and thickness of materials for habitat design;
- description and thickness of thin-layer capping; and
- monitoring and maintenance requirements for habitat restoration;

These topics are discussed in Section 5 of this Habitat Plan.

Habitat restoration activities for other areas impacted by the remedy or implementation of the remedy (staging/processing areas, dredge material pipeline and pump stations, SCA, etc.) will be addressed in the relevant design documents.

1.5 Goals of the Habitat Plan

The overall purpose of this Habitat Plan is to develop a habitat restoration and enhancement plan for remedial actions associated with the Lake Bottom Remedy and with remedies and IRMs for adjacent Honeywell sites that complies with applicable state and federal laws and regulations, executive orders and policies for floodplains, wetlands and surface waters. In addition, the implementation of the plan is intended to provide ecological, recreational and aesthetic benefits.

Specific objectives to achieve that goal are as follows:

- Objective 1 - Provide a comprehensive analysis of the habitats that will be affected by the various remedial activities in the lakeshore, floodplains, littoral, profundal, and wetland areas within and adjacent to Onondaga Lake.
- Objective 2 - Provide conceptual and/or preliminary design plans for:
  - Habitat restoration for the ROD in areas of the lakeshore, floodplains, littoral, profundal, and wetland areas that will be affected by the remedial activities for Onondaga Lake.
  - Habitat enhancement in Onondaga Lake as defined in the Onondaga Lake Bottom ROD.
  - Habitat restoration for the remedies and IRMs for adjacent Honeywell sites where remedial activities will affect Onondaga Lake lakeshore, floodplains, littoral, and wetland areas.

The “dashed red line” identified in Figure 1.2 indicates the areas of the lake and adjacent shoreline that are addressed by the Habitat Plan. The Habitat Plan will coordinate and describe the habitat restoration design requirements for remedial impacts within the “dashed red line”. However, the alignment may be adjusted following approval by Honeywell and NYSDEC based on new information regarding the extent of remediation. While the areas outside (and/or upland of) this line are not specifically addressed by this plan, the types and values of habitats in these areas will be considered when evaluating and identifying habitat restoration requirements within the area of study.

Scrub-shrub uplands

The “dashed red line” is generally aligned with the lakeshore and encompasses several lakeshore wetlands. A general description of the alignment adjacent to/within each of the littoral SMUs is provided below:

- SMU 1: The line is drawn along the alignment of the Willis IRM and Wastebed B/Harbor Brook IRM barrier walls.
- SMU 2: The line is drawn along the alignment of the Semet/Willis IRM barrier wall.

- SMU 3: The line is drawn along the upland edge of the shoreline area adjacent to Wastebeds 1-8.
- SMU 4: In the area east of Ninemile Creek, the line is drawn along the upland edge of the shoreline area adjacent to Wastebeds 1-8. In the immediate vicinity of Ninemile Creek, the line extends a short distance up Ninemile Creek. In the area west of Ninemile Creek, the line is drawn along the shoreline.
- SMU 5: The line is drawn along the shoreline.
- SMU 6: The line is generally drawn along the shoreline. However, in the area of Ley Creek, the line is drawn to encompass wetland SYW-12, which is currently being investigated by Honeywell.
- SMU 7: In the area immediately east of Harbor Brook, the line is drawn along the alignment of the Wastebed B/Harbor Brook IRM barrier wall. Further to the east, the line is drawn along the shoreline.

1.6 Organization of the Habitat Plan

This Habitat Plan consists of six sections and six appendices. A summary of the document is presented below:

- **Section 1**: Introduction – provides a general description of habitat restoration at the Onondaga Lake site and adjacent wetlands and goals and objectives of this Habitat Plan.
- **Section 2**: Conditions in Onondaga Lake – provides an overview of historical habitat conditions as well as existing habitat conditions and biological communities related to Onondaga Lake and adjacent Honeywell sites.
- **Section 3**: Potential Effects of Remediation on Onondaga Lake Habitat – describes the anticipated effects of remedial activities on lake and adjacent habitats.
- **Section 4**: Identification of Representative Habitats for Restoration – describes how the representative species were selected and provides a summary of the goals and objectives, as well as the framework for the restoration modules addressed in Section 5.
- **Section 5**: Preliminary Design for Lakewide Habitat -- furthers this discussion of modules by describing how they will be implemented in different parts of the lake. The modular approach helps create a holistic, sustainable method for restoring the targeted habitats in and around Onondaga Lake.
- **Section 6**: References
- **Appendix A:** *Amphibian and Reptiles Recorded in the Vicinity of Onondaga Lake* summarizes the number and types of amphibians and reptiles recorded in the vicinity of Onondaga Lake.

Damselfly is a representative species for benthic macroinvertebrates.

- **Appendix B:** *New York State Breeding Bird Atlas Results* contains information about birds found near Onondaga Lake
- **Appendix C:** *Macrophyte Coverage Figures from Habitat Preliminary Data Investigation (PDI) Report* contains information from the most recent Onondaga Lake macrophyte survey.
- **Appendix D:** *Suitability of Restoration in Remediation Areas for Representative Species* contains more detailed information about how each remediation area is suited for the representative species.
- **Appendix E:** *Master List of Plants* summarizes the plants targeted for use in the restoration of wetland and upland habitats in and around Onondaga Lake.

TABLE 1.1

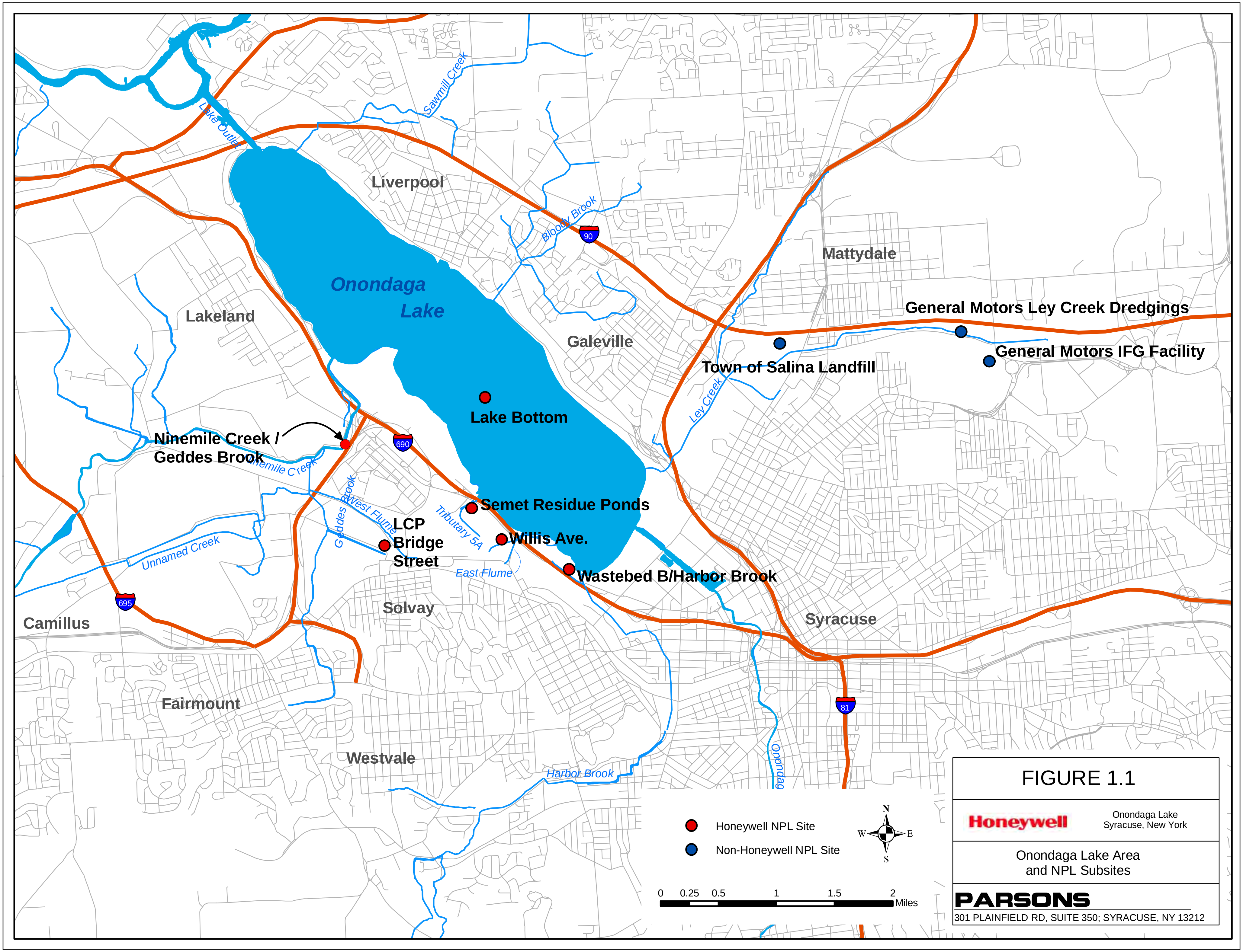
ARARS AND TBCS THAT PERTAIN TO HABITAT AND SPECIES CONSIDERATIONS

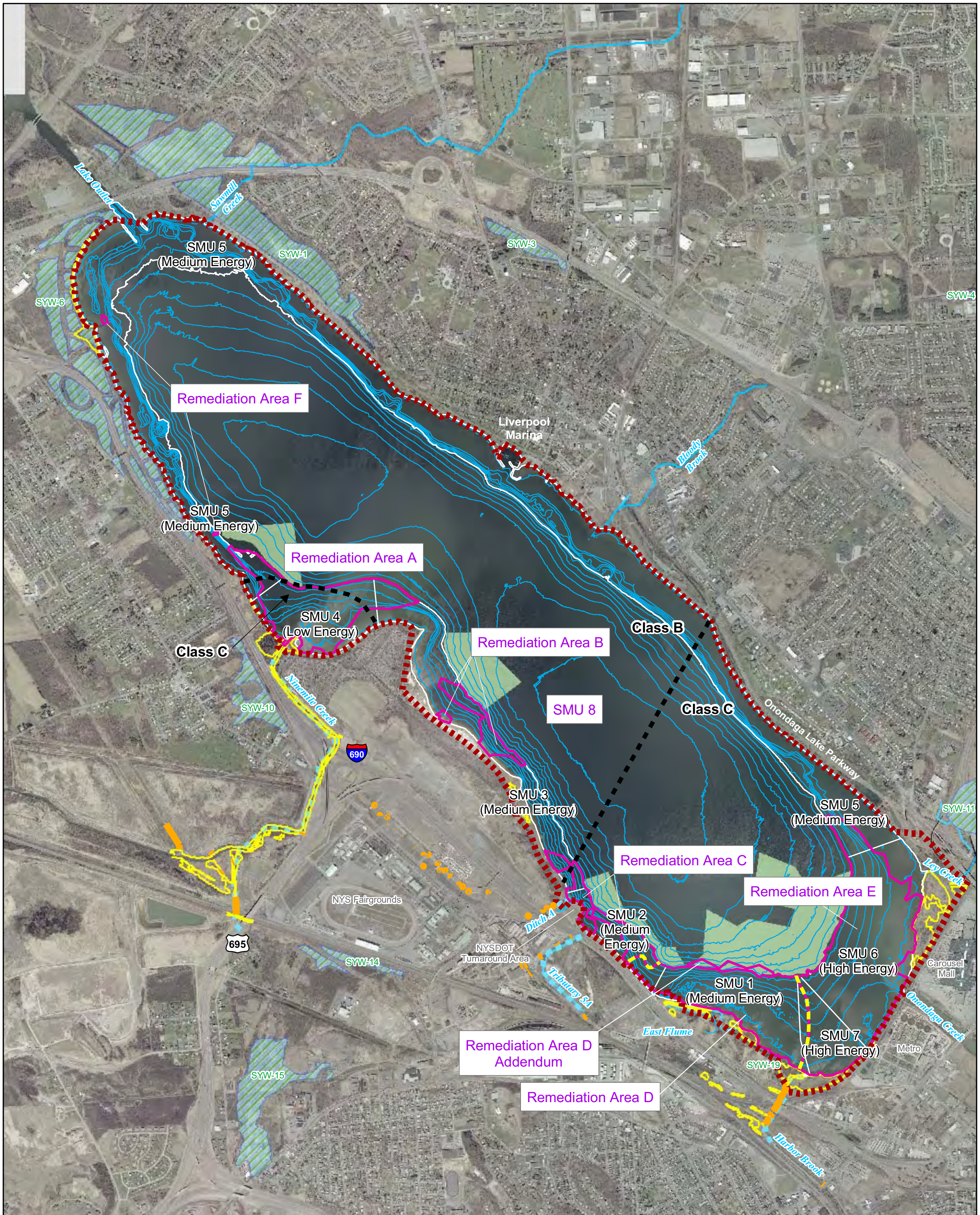
Medium/Authority	Citation	Requirement Synopsis
New York State Environmental Conservation Law (ECL) Article 15	6 NYCRR Part 608	Note that: Section 608(a) requires development and submission of a sufficiently detailed construction plan with a map): Section 608.9(a) requires that construction or operation of facilities that may result in a discharge to navigable waters demonstrate compliances with CWA §§ 301 – 303. 306 and 307 and 6 NYCRR §§ 751.2 (prohibited discharges) and 754.1 (effluent prohibitions; effluent limitations and water quality-related effluent limitations; pretreatment standards; standards of performance for new sources.)
New York State ECL Article 24	6 NYCRR Part 663	Defines procedural requirements for undertaking different activities in and adjacent to freshwater wetlands, and establishes standards governing the issuance of permits to alter or fill freshwater wetlands.
40 CFR Part 6, Appendix A Executive Order No. 11988 Executive Order No. 11990	Floodplain Management Wetlands Protection	Floodplain Management requires federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain. Federal agencies are required to avoid adverse impacts or minimize them if no practicable alternative exists. Protection of Wetlands requires federal agencies conducting certain activities to avoid, to the extent possible, the adverse impacts associated with destruction or loss of wetlands if a practicable alternative exists. Federal agencies are required to avoid adverse impacts or minimize them if no practicable alternative exists.
Policy on Floodplains and Wetland Assessments for CERCLA Actions	August 1985	Superfund actions must meet the substantive requirements of the Floodplain Management Emergency Executive Order (E.O. 11988) and The Protection of Response 1975 Wetlands Executive Order (E.O. 11990). This memorandum discusses situations that require preparation of a floodplain or wetlands assessment and the factors that should be considered in preparing an assessment for response actions taken pursuant to Section 104 or 106 of CERCLA. For remedial actions, a floodplain/wetlands assessment must be incorporated into the analysis conducted during the planning for the remedial action.
Section 10, Rivers and Harbors Act,	33 USC § 403	U.S. Army Corps of Engineers approval is generally required to excavate or fill, or in any manner to alter or modify the course, location, condition, or capacity of the channel of any navigable water of the United States.

TABLE 1.1 (Continued)

ARARS AND TBCS THAT PERTAIN TO HABITAT AND SPECIES CONSIDERATIONS

Medium/Authority	Citation	Requirement Synopsis
National Historic Preservation Act 16 USC § 470 *et seq*.	36 CFR Part 800	Remedial Action must take into account effects on properties in or eligible for inclusion in the National registry of Historic Places.
Endangered Species Act	16 USC 35	The stated purpose of the Endangered Species Act is not only to protect species, but also "the ecosystems upon which they depend." It encompasses plants and invertebrates as well as vertebrates. It does not expressly include fungi, which were widely considered to be plants in 1973. The ESA forbids Federal Agencies from authorizing, funding or carrying out actions which may "jeopardize the continued existence of" endangered or threatened species (Section 7(a) (2)). It forbids any government agency, corporation, or citizen from taking (i.e. harming, harassing, or killing) endangered animals without a permit. Once a species is listed as threatened or endangered, the ESA also requires that "critical habitat" be designated for that species, including areas necessary to recover the species (Section 3(5) (A)). Federal agencies are forbidden from authorizing, funding, or carrying out any action which "destroys or adversely modifies" critical habitat (Section 7(a) (2)).
New York State ECL Article 11, Title 5	6 NYCRR Part 182	The taking of any endangered or threatened species is prohibited, except under a permit or license issue by NYSDEC. The destroying or degrading the habitat of a protected animal likely constitutes a “taking” of the animal under NY ECL §11-0535.


Liverpool
Onondaga Lake
Lakeland
Galeville
Mattydale
General Motors Ley Creek Dredgings
General Motors IFG Facility
Town of Salina Landfill
Lake Bottom
Ninemile Creek / Geddes Brook
Semet Residue Ponds
LCP Bridge Street
Willis Ave.
Wastebed B/Harbor Brook
Solvay
Syracuse
Camillus
Fairmount
Westvale
Lake Outlet
Sawmill Creek
Bloody Brook
Ley Creek
Ninemile Creek
Geddes Brook
West Flume
Tributary 5A
East Flume
Unnamed Creek
Harbor Brook
Onondag
90
690
695
81
Honeywell NPL Site
Non-Honeywell NPL Site
N
W
E
S
0 0.25 0.5 1 1.5 2 Miles
FIGURE 1.1
Honeywell
Onondaga Lake
Syracuse, New York
Onondaga Lake Area
and NPL Subsites
PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



Sediment Management Unit (SMU) Boundary

Remediation Area Boundary (Parsons, 2009)

NYSDEC/EPA Approved Wetland Boundaries

NYSDEC Wetland (NYSDEC, 2007)

NYSDEC Water Quality Classification

Area Covered by Onondaga Lake Remedial Design Elements for Habitat Restoration

SMU 8 Thin-layer Capping (May by revised during design)

Culvert

Tributary to be remediated by Honeywell

Extent of ILWD in the Littoral Zone

Notes:
1. Water depth based on lake surface elevation of 362.5' NAVD88.
2. Bathymetry shown in 5' intervals.

N W E S

New York State Digital Orthoimagery from 2003

1,500 750 0 1,500
Feet

FIGURE 1.2

Honeywell
Onondaga Lake
Syracuse, New York

Surface Water Designations and Wave Energy

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

Section 2: Conditions in Onondaga Lake

This section provides a summary of historic and current habitat conditions in Onondaga Lake and adjacent Honeywell sites based on a review of literature sources. It is important to understand past and present habitat conditions because they provide a foundation for the goals outlined in this plan. The aim of this restoration project is to restore impacted areas of the lake and adjoining areas to reestablish habitat and function based on these findings.

2.1 Summary of Historical Conditions

A great blue heron preys on a mudpuppy.

2.1.1 Habitats

Onondaga Lake is a natural marl lake, which by definition contains sediments composed primarily of calcium carbonate that precipitate from the lake water. Historically, Onondaga Lake was a moderately productive lake with some dissolved nutrients (mesotrophic) with fresh to slightly saline water . Water in the lake was greenish, as is typical of mesotrophic lakes, likely a result from high concentrations of algae. The shores were covered with foam, possibly from winds concentrating minerals in the surface waters (Rowell, 1996).

The presence of salt springs influenced the vegetation found in the Village of Liverpool, and from this area to the southern end of the lake to the mouth of Ninemile Creek. These conditions contributed to the presence of salt marshes in several locations (Wurth, 1934). Salt marshes apparently extended inland from the lake in three locations: 1) along the western shore of the lake from Long Point south to approximately the current causeway area, 2) the eastern shore of the lake in the Village of Liverpool, and 3) in the southeastern portion of the lake extending up along the original location of Onondaga Creek and Ley Creek (Young, 2000).

Salt marshes were historically present around Onondaga Lake.

Inland salt marshes, a globally rare ecological community, existed in these shore areas. According to Young (2000), only eight inland salt marshes have been documented in NYS, with only three in existence today. These three sites are located in other parts of the state, including in the Montezuma Wetlands Complex Bird Conservation Area located approximately 28 miles west of Onondaga Lake. No inland salt marshes are currently located near Onondaga Lake; however, freshwater wetlands have filled in the land surface and have prospered in other shore areas since before the 1820s when higher lake levels existed (Vandruff and Pike, 1992; Ferrante, 2005).

2.1.2 Biological Communities

Vegetation

There are several incidental accounts of vegetation in and around Onondaga Lake, however, a thorough historical study of the lake's vegetation was never performed. Historical accounts of the 1800s and 1900s written by botanists, European settlers, and garden clubs indicate the presence of several plant species around Onondaga Lake more typical of salt marshes and seashores (Beauchamp, 1869; Goodrich, 1912; Wurth, 1934; Bye and Oettinger, 1969; Vandruff and Pike, 1992; McMullen, 1993). The lake's high salinity fostered the growth of salt-tolerant plants (halophytes) including oak-leaved goosefoot (*Chenopodium glaucum*) and glasswort (*Salicornia europaea*).

Other records indicate an abundance of tree species as well. Typical to central New York during this period were deciduous hardwoods, hemlock (*Tsuga canadensis*), and evergreens (Taylor, 1995). Although the types and distribution of many plant species around the lake have been modified considerably over the last 150 years, silverweed (*Potentilla anserina* or *Argentina anserina*) (a species found in salt marshes, shorelines, and open areas) is consistently abundant from as early as the mid-1800s through today (McMullen, 1993).

Mammals

Muskrat are currently present in the Harbor Brook area.

Abundant wildlife was also encountered in the area surrounding Onondaga Lake during this period. Henry Hudson and Samuel de Champlain wrote in their travel journals in 1656 about the abundance of bears in the region. In one account, they describe how members of their party killed thirty bears in a single day. Their journal also describes their finding a drowned animal-- a "wild cow…having horns like the stag's." Historians believe that the animal was probably a female elk (*Cervus elaphus)* or moose (*Alces alces*). Beaver (*Castor canadensis*) were also abundant in the region and were the source of pelts for the active fur trade. Other writings indicate that this area of central New York was also home to several species that no longer live in the region, including the gray wolf (*Canis lupus)*, elk, and the Canadian lynx (*Lynx canadensis*) (Ste. Marie among the Iroquois, 2006).

Fish

The earliest known report documenting fish in the lake was written by French Jesuit Father Simon LeMoyne in 1654. He observed Atlantic salmon (*Salmo salar*) (Beauchamp, 1908). Other early reports suggest that coldwater species, such American eel (*Anguilla rostrata*) and Onondaga Lake "whitefish" were once abundant in Onondaga Lake (Nemerow, 1964; Webster, 1982; Tango and Ringler, 1996). A relatively recent report suggests that the culturally significant whitefish species recorded in early accounts was likely a cisco (*Coregonus spp.*) and not a whitefish, based on the historic distribution of the lake herring throughout the Oswego River watershed (NYSDEC, 2004). Recent information indicates this species may have been *Coregonus artedi* or possibly *C. zenithicus* (Arrigo 1996), although Siniscal (2009) provides further evidence that it was likely *C. artedi*.

Transient cold water fish, such as this brown trout, have been included in the habitat designs for the Lake.

There are general accounts for a few other fish species in the lake before 1900. In 1825, yellow perch (*Perca flavescens*) were recorded by DeKay (Beauchamp, 1908). Nemerow (1964) draws on an account from 1866 where "large numbers of pike, perch, bass, and bullheads" were caught by fishermen. In 1872, "salmon, trout, and bass" were also stocked in the lake (Nemerow, 1964). Salmon, along with the Onondaga Lake whitefish, supported a commercial fishery that operated on the lake until 1890, with the whitefish lost by 1897 (Tango and Ringler 1996). The Atlantic salmon was forced out of existence (extirpated) from Onondaga Lake by the late 1800s, most likely because of mill dam construction and deforestation (Webster, 1982).

In 1927, J.R. Greeley performed the first documented scientific study of fish in Onondaga Lake (Ringler *et al*., 1996). He collected twelve fish species from Onondaga Lake, including the white sucker (*Catostomus commersonii)*, shorthead redhorse (*Moxostoma macrolepidotum)*, common carp (*Cyprinus carpio*), golden shiner (*Notemigonus crysoleucas*), emerald shiner (*Notropis atherinoides* Rafinesque), bluntnose minnow (*Pimephales notatus)*, grass pickerel (*Esox mericanus.vermiculatus*), banded killifish (*Fundulus diaphanus*), largemouth bass (*Micropterus salmoides),* pumpkinseed sunfish (*Lepomis gibbosus*), and yellow perch. Compared with other local lakes of similar size and volume, however, the lake's fish population was considered neither diverse nor plentiful. This lack of diversity was noted when a second fish survey conducted in 1946 revealed that 90% of 400 fish collected in a three day-period were common carp. The remaining 10% accounted for a total of 13 different species (Ringler *et al*., 1996).

Little scientific data are available for the early and mid-1960s except for notes on trap net catch data from NYSDEC from June 1963 and June 1964 (Ringler *et al*., 1996). The next comprehensive survey occurred in 1969 by Noble and Forney, who surveyed the fish community of Onondaga Lake using trap nets and gill nets (Noble and Forney, 1969; Ringler *et al*., 1996). This study identified 14 species of fish and described the fishery as a warm-water fish community with similar growth rates as other warm-water lakes in the northeastern United States. During surveys in the early 1980s by NYSDEC, 22 species were collected, dominated by white perch (*Morone americana*) and alewife (*Alosa pseudoharengus*) (Chiotti, 1981; Ringler *et al*., 1996). In addition, the overall dominance of common carp in the fish community declined sometime between the 1946 and the 1980 surveys. There were low rates of reproduction in the majority of fish species, except in white perch.

2.2 Changes from Historical Conditions around Onondaga Lake

Since the late 1700s increased settlement, urbanization and industrial development have increased pressures on Onondaga Lake and its surrounding habitats. These shifts have impacted the sustainability, population and diversity of various habitats. A brief outline of the human activity around the lake, along with some of the specific changes the activities have had on the lake, are discussed in the subsections below.

2.2.1 Water Level and Surface Area Modifications

An explorer's report from 1856 (Watson, 1856) indicates that the lake had a shallow outlet (about 1 foot) with continuous rapids down most of its length. The natural marl build up that occurred during late summer and early fall when calcium carbonate precipitated from the lake water resulted in the lake water level being approximately two feet higher than the Seneca River (Ferrante, 2005). In 1822, in an effort to improve navigation between the Seneca River and the lake, officials from NYS dredged and straightened the outlet. The change caused the lake level to drop 2 feet and reduced the surface area of the lake by 20% (Ferrante, 2005).

Around this time, local state officials also drained the wetlands at the southern end of the lake to help eliminate the breeding grounds for malarial mosquitoes. The draining of these wetlands on the southern end of the lake opened the area near the salt springs for urban settlement, and this area continued to grow as railroads were constructed throughout the region. In 1840, the construction of the Syracuse Northern Railroad impacted the lake itself, creating changes in the southeastern shoreline alignment, resulting in the narrow shoreline conditions that we have today in that area (Hohman, 2004).

The Phoenix Dam, located in Phoenix, New York, controls the level of Onondaga Lake.

Continued changes to the lake level and surface area occurred as the area around the lake became more urban and populations continued to increase. As roads were constructed, cut material was dumped into the lake, altering the shoreline and impacting the surface area. The lake level was altered again in early 1915 when the NYS Barge Canal was constructed. This new canal, along with the raising of the Phoenix Dam by 3.5 feet, raised the elevation of the lake to its pre-1822 elevation. Many of the wetland areas around the lake were also filled in by continued development (Ferrante, 2005). Due to various stages of industrialization that began in the mid 1800s, other changes included the creation of Wastebed B and the East Flume (54 acres), Wastebeds 1-8 (397 acres) and the in-lake waste deposit (ILWD) (98.5 acres). Some of these activities resulted in surface area modifications to the lake. Additional changes to the lake surface area occurred in the 1950s with the construction of Interstate 690 (I-690). Fill material from construction activities was placed along the shoreline (area along Remediation Area C [SMU 2]) in the southern portion of the lake (Effler and Harnett, 1996). In 1977, the surface area of the lake was again altered by the installation of a sewage force main, which resulted in the filling in of almost four acres of the lake in the vicinity of Remediation Area C (SMU 2) (Hohman, 2004). The creation of Wastebed B and Wastebeds 1 through 8 also resulted in surface area modifications to the lake.

Some of the most recent developments to the surface area of the lake are due to the early stages of remediation of Onondaga Lake. In 2007 the construction of the Willis Semet barrier wall and groundwater extraction system began along the south side of the lake near I-690 to prevent the flow of upland groundwater from entering the lake. This wall increased the width of the shoreline in this area by several hundred feet and shifted the alignment of the shoreline, slightly decreasing the lake's water surface area. Lake levels have not been dramatically impacted; however, since the water level is controlled by the NYS Barge Canal System. Changes to the lake level since 1822 are summarized on Table 2.1. Figure 2.1 illustrates how the lake footprint has been altered by urbanization and industrialization by depicting the shoreline in 1898, 1908, 1938, and today.

2.2.2 Development

White City Scenic Railway was a popular tourist attraction.

As the canal and railroads made the lake more accessible in the late 1800s, the area around Onondaga Lake became a popular tourist destination, and several lakeside resorts were constructed along the lakeshore. Many of these resorts contained amusement parks with a variety of attractions including roller coasters, carousels, dance pavilions, shooting galleries and bowling alleys. One of the more popular resort areas was the Iron Pier, which was located near the present site of the Carousel Mall. The resorts were popular with tourists until the early 1900s when industrial sites started to populate the shoreline areas more commonly.

The area near Onondaga Lake has had an industrial presence since the late 1700s and steadily increased with time as various industries took advantage of the naturally occurring salt in this region for use in the manufacture of various chemicals and chemical processes. The earliest documented industry was the salt industry which operated from 1793 to 1908 (Hohman, 2004). The region lost its monopoly on salt production due to changing industrial demands for salt and the discovery of large sources of salt in other areas of the United States. By 1920, the region around Onondaga Lake was a national center of manufacturing for

metal products, automobiles, typewriters, pottery, and other small machinery (de Laubenfels, 1977). By 1950, 139 industries used Onondaga Lake for waste disposal (Ferrante, 2005), with the Solvay Process Company being a significant contributor.
As industry increased around the Onondaga Lake, noticeable changes to the integrity of the lake became noticeable, particularly in its productivity rates. For instance, prior to human impacts, Onondaga Lake was moderately nutrient rich (mesotrophic) and fresh to slightly saline (Rowell, 1996). The high levels of productivity prevalent in the lake after the mid-1800s are correlated with cultural activity. The lake became highly nutrient rich and very productive (eutrophic) during the early to mid-1800s and excessively nutrient rich and very highly productive (hypereutrophic) shortly after World War II due to increased nutrient inputs. Lake salinity started to increase in the early 1800s when the expansion of the local salt industry developed, and a much larger increase occurred following the establishment of the Honeywell soda ash facility in 1884 (Rowell, 1996)."

A century of industrial pollution, urbanization and municipal waste impacted the habitat in Onondaga Lake, thus influencing the types and number of species as well as the location of where species are able to live in these altered conditions. Available fish spawning areas, for example, have been modified due to reduced plant life in both the lake and its tributaries because of lower levels of dissolved oxygen, increased turbidity, elevated ammonia concentrations, salinity and contamination. By 1900, both Atlantic salmon and whitefish (or lake herring [*Coregonus artedi*]) were absent from Onondaga Lake (Tango and Ringler, 1996). This was likely due to many factors including increased number of dams in the watershed, deforestation, and at least in part to increased anoxia in the deeper waters of the lake during summer when the overlying warmer water does not mix with the underlying cooler water (*i.e.*, stratification). The continued lower levels of dissolved oxygen in the lower waters of the lake limit the availability of suitable habitat for cold water species, such as salmonids, in the lake.

In 1927, surveys identified only 12 different species and in 1946, 14 species were recorded. As stated in the above section, in the 1950s, fishery surveys showed that more than 90% of the total fish netted in Onondaga Lake were common carp. No information was collected regarding smaller size classes. By 1969, a survey described the fishery as a warm-water fish community with 14 species captured (Noble and Forney, 1969).

The rarity of some species in Onondaga Lake is linked with regional impacts dating back over 100 years (Tango and Ringler, 1996). Mills *et al*., (1978) indicate that pickerel (*Esox niger*) and pike (*Esox lucius*) were common predators in the region in the late 1800s and early 1900s. However, draining of area wetlands and the construction of the Barge Canal system also reduced the availability of spawning habitats, and their abundances declined (Mills *et al.,* 1987). The eel fishery of the Oneida River, into which Onondaga Lake waters flow (Effler and Hennigan 1995), was abandoned shortly after 1913 as eels also declined in the region (Mills *et al*., 1987).

Industrial discharges resulting from the Solvay manufacturing process also resulted in habitat changes associated with sediment conditions within the lake (Effler and Harnett, 1996) and what is referred to as the ILWD in Remediation Area D (SMU 1 and portions of SMUs 2 and 7). These conditions are described further in Section 2.3.1.

The shoreline of Onondaga Lake has seen multiple configurations over the past century.

Since the 1900s, the cumulative effects of human-induced disturbances, such as tree clearing, agriculture, filling, dam construction, industrialization, and urbanization, have reduced terrestrial, floodplain, and aquatic habitats and altered species biodiversity within the watershed surrounding the lake as well. Some wildlife, such as wolves, bears, and bobcats have long been lost from central New York and the Onondaga Lake area. The loss of large tracts of forest and wetlands over the last two centuries has resulted in the fragmentation of natural communities (VanDruff and Pike, 1992). Existing land use/land cover is shown on Figure 2.2. This map illustrates how natural areas have been fragmented due to urban development.

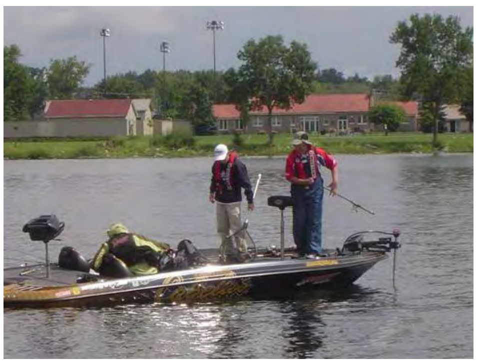
In addition to impacting fish and wildlife habitat, manufacturing also impacted how humans used the lake as a community and recreational resource. The manufacturing activities around Onondaga Lake led to continued population growth in Syracuse, but contributed to the demise of the tourist industry and decreased recreational opportunities on the lake.

By 1940, New York State no longer authorized permitted swimming beaches or sanctioned swimming areas at Onondaga Lake due to high bacteria and poor visibility. In 1970, the NYSDEC in concert with the Departments of Health and Agriculture and Markets, closed Onondaga Lake to all fishing due to the high levels of mercury contamination. Onondaga Lake was reopened to recreational fishing in 1986 on a “catch and release” basis. The New York State Department of Health (NYSDOH) health advisory for the lake at the time was to eat no fish from the lake. In 1999, some additional changes in the health advisory occurred. For 2009-2010, NYSDOH advises the public to consume no walleye, no bass greater than 15 inches in length, and to eat no more than one meal a month of all other species and smaller bass due to mercury, dioxins, and PCBs.

These advisories continue to be updated, and new information can be found on the NYSDOH web site (http://www.health.state.ny.us).

2.2.3 Present-day Community Benefits

Despite the impact of the industrial activities over the past century, Onondaga Lake continues to provide many beneficial aspects to the community. Some of these community benefits are listed below (TAMS 2002b):



Salt City Bassmasters fish on Onondaga Lake.

- Boating -The marina located on the eastern shoreline of the lake, and the lake's connection to the Seneca River, facilitate use of the lake by boaters. Onondaga Lake is home to the Onondaga Lake Yacht Club, the Syracuse University Crew teams, the Syracuse Chargers Rowing Club, and several local school rowing teams. Canoes and kayaks are available to the general public for rental. The lake has also received national attention as it was the recent site of the U.S. Open of Watercross personal watercraft races in May, 2009.
- Fishing – Onondaga Lake contains numerous fish species sought after by recreational anglers. Onondaga County hosts the yearly Fishing for Dollars tournament, and local groups such as the Salt City Bassmasters routinely fish on the lake. In 2007, ESPN hosted the 2007 Bassmasters Memorial Fishing Tournament on Onondaga Lake. The North American Fishing Club lists the Lake as one of the country's top locales for bass (www.onondagacountyparks.com).

Mink

- Hunting – Where permission has been granted by the appropriate landowner and when laws permit, the shores of Onondaga Lake provide hunting and trapping opportunities. Waterfowl and deer populations are abundant enough to support hunting. In addition, mink, fox, and other mammals can be trapped.
- Recreation – More than 75% of the shoreline of Onondaga Lake is owned by Onondaga County and is classified as parkland. Last year, 1.3 million visitors used the park for picnicking, walking, jogging, roller blading, and bicycling (Geraci, 2009). In addition, the recreational-use path along Onondaga Lake Park is being expanded along the southern shoreline across Ninemile Creek. The remainder of the lakeshore is currently being evaluated to create a continuous trail around the entire lake.
- Swimming – In the past, the lake has been used for recreational swimming. The northern two-thirds of the lake is classified by NYS for direct recreational contact (*i.e.*, Class B Waters), but swimming from shore is prohibited because of regulations

requiring a dedicated bathing beach with supervision, safety equipment, and protection from boats and jet skis.

- Inner Harbor – New development has occurred near the southern shore of Onondaga Lake, along Onondaga Creek and the Barge Canal, as part of the Syracuse Inner Harbor Project. Approximately 42 acres of land, which is currently owned by the NYS Canal Corporation, are being developed for recreational and commercial uses by the Lakefront Development Corporation (LDC).

Onondaga Lake Parkway is a popular spot for picnics and family fun.

- Commerce – Onondaga Lake has long served as a backdrop for a number of commercial and industrial sites. Historically, the shores of Onondaga Lake were extensively developed by restaurants, resorts, and eventually industries. The salt industry, in particular, flourished due to the lake's central location in the state, the salt deposits and the presence of water. Other industries also developed around the lake, some of which are still in operation today. Industrial sites have been converted to develop commercial properties in the vicinity of the lake, including Carousel Mall, the Regional Farmers Market, and the NYS Fairgrounds parking area.
- Tourism – The city of Syracuse, Onondaga County, and New York State are attempting to increase the tourism industry in Syracuse. The ongoing expansion of Carousel Mall, the development of the Inner Harbor, and the lakeside trail are all part of this effort. The lake is central to these efforts as a scenic and recreational area.
- Education – The Liverpool school district has developed a science program focused on Onondaga Lake. Fifth graders take part in the "Living Lake" program where they learn about ecosystems and habitats in and around the lake.
- Stormwater Retention – The lake and its surrounding wetlands and tributaries are used by Onondaga County for stormwater discharge. Onondaga County plans to implement sustainable measures to help decrease stormwater run-off and promote water retention. The use of green initiatives throughout the county, such as living roof tops, rain barrels, and porous pavements, will reduce runoff into the sewers and offer sustainable flood control (Knauss, 2009).

Metro's upgrades have greatly improved the water quality in Onondaga Lake.

2.2.3 Metro/CSO Loadings/Improvements

The City of Syracuse installed its first centralized sewage treatment system in 1896. The facility was located just south of the Barge Canal between Pulaski and Van Rensselaer Streets (G.M. Hopkins, Co., 1938). Primary treatment of sewage began in 1925. In 1950, Onondaga County established the Metropolitan Sewer District, which encompassed the City of Syracuse and some surrounding suburban areas. In 1960, the district completed construction of a large primary sewage treatment plant, Metro, along the southern shore of the lake immediately south of the mouth of Onondaga Creek. By 1979, the city began nutrient removal and secondary treatment (Ferrante, 2005).

Effluent wastewater is discharged to the lake via a 94.5 inch (7.875 feet) diameter shoreline outfall. Flows in excess of 150 million gallons per day were historically discharged via the old 59.1 inch (4.925 feet) diameter deep water outfall. The two outfalls are connected, and water flows through both pipes during rain storms (Effler, 1996).

This effluent is a source of domestic point-source compounds such as ammonia, phosphorus, and nitrate to the lake. Additionally, during heavy storm periods, a mixture of untreated sewage and street runoff overflows from the sewer system through combined sewer overflows (CSOs), which discharge primarily into Onondaga Creek and Harbor Brook and ultimately drain into Onondaga Lake (NYSDEC and USEPA, 2005).

NYSDEC and the Metro Sewage Treatment Plant

Based on these water quality issues, Onondaga County entered into an Amended Consent Judgement (ACJ) in January 1998 with the State of New York and the Atlantic States Legal Foundation (ASLF). The conditions of the judgment require that the County upgrade the treatment plant and develop a CSO program that (1) eliminates or captures for treatment at least 85% of the volume of the combined sewage collected in the system during precipitation events, (2) eliminates or minimizes floating substances in the lake from CSOs, and (3) achieves water quality standards for bacteria in the lake (ODCWEP, 2005).

Onondaga County designed, tested, and constructed modifications and additions to the Metro facility that enables year-round nitrification of ammonia and phosphorus removal. The County made the necessary upgrades ahead of schedule, and based on the modifications and additions made by the County, the effluent meets or exceeds water quality standards earlier than originally anticipated.

In January 2004, a biological aerated filter system (BAF) was brought online to provide year round treatment of ammonia. The plant met the Stage 2 ammonia limits on schedule (beginning in March 2004) and began meeting the Stage 3 ammonia limits in March 2005, over 7 years ahead of schedule. More recently, the high rate flocculated settling system (HRFS) for phosphorus removal came online. Through operation of the HRFS, the County is working to meet the Stage 2 phosphorus limits.

Improvements to the county's wastewater collection and treatment system at Metro are responsible for the improved water quality conditions in the Lake. Significant investment in wastewater treatment technology has achieved far lower discharges of wastewater-related pollutants, particularly ammonia and phosphorus (OCDWEP, 2009).

Onondaga County is also improving the water quality in Onondaga Lake with its many CSO projects. Regional treatment facilities remove any floating material and disinfect sewer overflow, sewer separation diverts contaminated sewer water away from storm sewers, floatable control facilities remove floating debris from water that may enter the lake, and an increased storage and transport capacity moves a larger volume of possibly contaminated water through pipes and into underground tanks. Together, these projects will reduce human health risks associated with the discharge of untreated sewage into Onondaga Lake and greatly improve overall water quality.

2.2.4 Remedial Actions/IRMs


[illegible]

BILL CLARK, a member of a crew from Peak Environmental in Owego, lowers steel on the shore of Onondaga Lake Thursday. The barrier wall Honeywell International is building will be comprised of thousands of square feet of these interlocking steel panels. The DEC says half of the wall should be up by the end of the year. The entire lake cleanup is expected to take nine years.

HOW TO DETOXIFY ONONDAGA LAKE

STEP ONE: BUILD A BARRIER WALL

By Delen Goldberg
Staff writer

This week, giant drills will plunge dozens of feet into the bottom of Onondaga Lake to bore huge holes in the lake floor.

[illegible] with steel pilings, the first step in Honeywell International's plan to build a barrier wall in the lake.

The underground wall will be 1.5 miles long, sit 30 to 50 feet deep, depending on the depth of the water, and in certain sections, snake up to 50 feet into the lake from the original shore — creating a new shoreline. It is designed to block contaminated groundwater from seeping into the lake from polluted properties in Solvay and Geddes that once were part of the Allied Chemical complex.

Portions of the lake will be filled with sand and gravel to create a new, artificial shoreline that follows the line of the barrier wall. The project will shrink the size of the 3,000-acre lake by about 2 acres, state Department of Environmental Conservation staffers said.

INSIDE
Collecting polluted water, cleaning it, returning it to the lake: How it works / PAGE A-22

Some environmental advocates criticize the placement of the wall.

By shrinking the lake — which already has lost 40 percent of its volume to pollution — state and Honeywell officials are doing more harm than good, said Joseph Heath, lawyer for the Onondaga Nation.

"To fill in another 6 million gallons is a step in the wrong direction," said Heath. "Who knows how many more corners they will slice off?"

ONONDAGA, PAGE A-22

KEEPING OUT THE POLLUTANTS

Honeywell International starts work this week on a barrier wall designed to keep polluted groundwater from reaching Onondaga Lake. To avoid lakeside highways, part of the 1.5-mile-long wall will extend into the lake — 50 feet away from the current shoreline in some places — essentially making the lake smaller. Mapped here in red is the portion of the wall that will extend into the lake.

Source:

THE LAKE
Average depth: 35 feet
Maximum depth: 63 feet
Dimensions: 1 mile wide, 4.6 miles long
Total size: about 3,000 acres

THE BARRIER WALL
Length: 1.5 miles long
Distance from shore: Parts up to 50 feet from current shoreline
Depth: 30 to 50 feet deep

How much smaller lake will be: about 2 acres

The barrier wall prevents contaminated groundwater from entering Onondaga Lake.

Honeywell has effectively completed the remediation at the LCP site in the Town of Geddes and an IRM at the lakeshore—both of which have directly reduced the migration of contaminants to Onondaga Lake. Under direction of NYSDEC, the cleanup program at the LCP site (a former Honeywell property that was once one of two major sources of mercury contamination to the lake) involved a combination of mercury removal from soil on the former plant property, excavation of contaminated sediments in surrounding areas, installation of an onsite groundwater collection system, and the construction of an f underground barrier wall to prevent any future contaminant migration from the site The barrier wall extends down to bedrock and ranges from 30 to 70 feet deep. The LCP remediation was completed in 2007 and the lakeshore IRM was completed in late 2006. The deep groundwater portion of the lakeshore IRM may be conducted at a later date based on ongoing data collection and evaluation.

The primary habitat-related benefits resulting from this action are associated with the remediation and habitat restoration of nine acres of adjacent wetland areas and the West Flume. These wetlands are connected via culverts to the West Flume, which ultimately drain to the lake via Geddes Brook and Ninemile Creek. Before remediation, these wetlands areas were low-quality wetlands for several reasons:

- substrate consisting predominantly of fill material;
- dominance of almost uniform stands of invasive *Phragmites*;
- lack of a connection to downstream aquatic systems;
- location within the upper end of the drainage system; and
- the disturbed nature of adjacent habitats.

These wetlands were fully restored and enhanced to a variety of habitat types including a wet meadow/scrub-shrub fringe, emergent wetland, aquatic bed, open water, and drainage channel.

These habitat types were created by the development of various water depth zones according to the wetland restoration plan (Parsons, 2004a). In order to limit invasive species, the restoration plan placed an emphasis on the development of aquatic bed and deep emergent marsh habitat types. The majority of wetland characterization at the LCP Site is ongoing, but to date, the following observations have been made regarding the restored and enhanced wetlands:

- Successful growth from plantings of trees and shrubs and seeding efforts;

- Emergent and aquatic bed wetland habitats have been established with some open water habitat;
- Wet meadow and scrub-shrub habitat has been established on the fringe of wetlands;
- Phragmites growth has been limited/controlled within the wetlands;
- The hydrologic connection between LCP Site wetlands and the West Flume has been improved; and
- Physical structure in this wetland has been improved with the addition of trees and rocks along the edges of the wetlands.

Honeywell has also made significant progress with installing a hydraulic barrier wall and groundwater treatment plant, as part of the Willis/Semet Barrier IRM, to prevent contaminated groundwater from entering the lake. Approximately 2,800 feet of an underground barrier wall, constructed of interlocking steel panels, has been installed near the southwest shoreline of Onondaga Lake since 2006. Honeywell also completed construction of a groundwater treatment plant in 2006, one year ahead of schedule, to collect, process, and treat contaminated groundwater behind the underground barrier wall. Due to the lack of rip-rap shoreline along the lake in this area the IRM has had minimal disruption on the existing habitat. See Section 3.2.3 for further details on this IRM.

2.3 Existing Habitats

Green frogs are currently present around Onondaga Lake.

This section summarizes existing habitat conditions within and adjacent to Onondaga Lake. In sub-sections 2.3.1 through 2.3.5, habitat conditions are described for five general areas: littoral zone (shallow water sediments), profundal zone (deep water sediments), wetlands, riparian zone (shoreline), and tributaries. Descriptions of existing biological communities, such as fish, aquatic plants, and wildlife are provided in Section 2.4. Information on endangered, threatened, and Section 2.4.

Onondaga Lake covers approximately 4.6 square miles (3,000 acres), is approximately 4.5 miles long and 1 mile wide, and has an average water depth of 36 feet. The lake has a northern basin and a southern basin that have maximum water depths of approximately 61 and 65 feet, respectively. The basins are separated by a saddle region at a water depth of approximately 56 feet. The lake is characterized by a nearshore shelf (less than 12 feet deep) which represents about 25% of the surface area of the lake. This nearshore shelf is bordered by a steeper offshore slope in water depths of 12 to 24 feet (TAMS, 2002a).

Onondaga Lake is part of a state system of canals maintained by the NYS Canal Corporation, which is part of the NYS Thruway Authority. A dam located approximately 15 miles downstream along the Oswego River in Phoenix, New York, maintains the water level in the lake. The current average surface elevation of Onondaga Lake is 362.8 feet

(NAVD 1988). NAVD 1988 is the most current vertical control datum used for surveying locations in North America and is used for reference due to its universal application for land and water surveying and mapping.

The current average elevation of the lake has been consistent for the past 30 years, however, the lake level can change seasonally due to spring run-off and dry summers as well as daily due to weather events. 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. Additional lake elevation data are provided in Table 2.2

The northern two thirds of the lake are classified by the State of New York as Class B waters, while the southern third of the lake and the area at the mouth of Ninemile Creek are classified as Class C waters (see Figure 1.2). Best usages for these waters are defined as:

- Class B – "primary and secondary contact recreation and fishing. These waters shall be suitable for fish propagation and survival" (6 NYCRR Part 701.7).
- Class C – "fishing. These waters shall be suitable for fish propagation and survival. The water quality shall be suitable for primary and secondary contact recreation although other factors may limit the use for these purposes" (6 NYCRR Part 701.8).

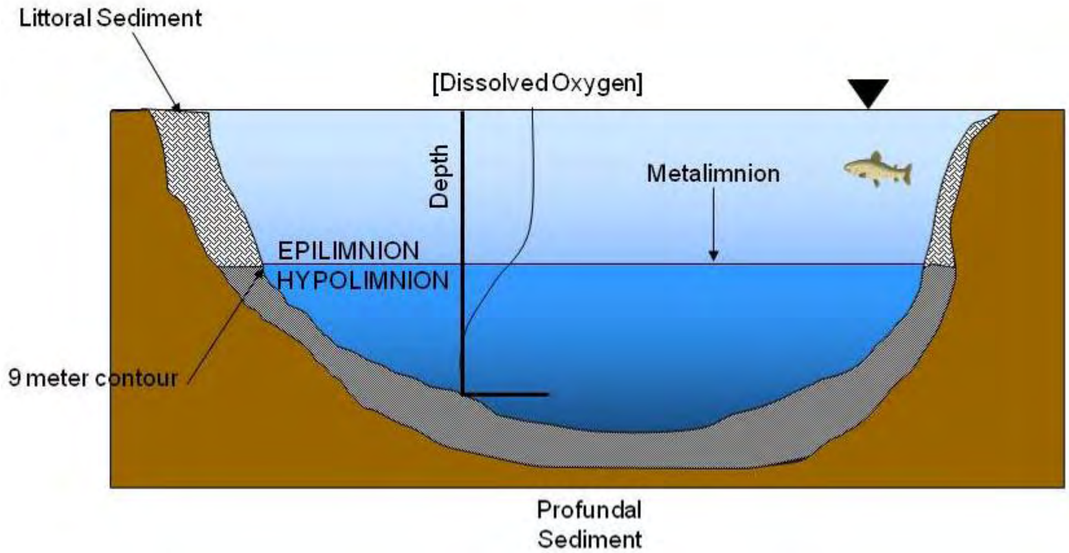
Habitats in the lake are influenced by water temperature, which varies seasonally. Like many inland northern lakes, the water of Onondaga Lake does not fully mix during summer. The lake is stratified, meaning that the upper layer of relatively warm water does not mix with the layer of cooler waters at the bottom of the lake. Summer stratification is most pronounced from May through mid-October due to temperature effects on water density.

During summer, the colder denser water, referred to as the hypolimnion, is unable to mix with the overlying warmer less dense water, referred to as the epilimnion. The boundary between these two layers is called the thermocline or metalimnion and is the region in the water column where the temperature changes most rapidly with depth. In Onondaga Lake, the metalimnion is located at approximately 30 feet (9 meters) below the water surface, although this varies seasonally from approximately 16 to 33 feet (5 to 10 meters). The upper, warmer waters continue to be mixed by wind and wave action, while the lower, cooler waters are relatively isolated beneath the metalimnion.

This stratification of the lake is important because it determines how flow from tributaries and from the Metro discharge impact in-water habitats. During summer stratification inflow from the tributaries is incorporated into the upper layer (epilimnion) rather than throughout the entire lake, and occasionally into the metalimnion if tributary flows are saline. During periods of weak or no stratification, as typically occur during winter months, plunging flows from Ninemile and Onondaga Creeks may enter the deeper waters of the lake directly.

Onondaga Lake is stratified during the summer months, meaning that warm water lies on top of cool water.

Note that oxygen decreases with water depth, as illustrated by the line graph in the graphic to the right.



In conjunction with these processes, the hypolimnion receives organic and inorganic solids that settle from the epilimnion toward the lake bottom. As the summer progresses, biodegradation of the organic solids deplete the oxygen in the hypolimnion, creating anoxic conditions. The presence of an anoxic hypolimnion is not uncommon in stratified lakes; however, oxygen depletion in the hypolimnion of Onondaga Lake was historically made worse by loading of phosphorus to the lake from tributaries and the Metro Plant discharge (Effler and Whitehead, 1996). Phosphorus is the critical nutrient that promotes the growth or productivity of phytoplankton, which in turn increases the organic loading of settling solids to the hypolimnion. Increased phytoplankton productivity also leads to decreased water clarity (due to the high mass of phytoplankton in surface water). Recent upgrades to Metro have resulted in reduced phosphorus loading and are associated with significant improvement in the extent and duration of oxygen depletion (OCDWEP, 2009).

Another characteristic about Onondaga Lake is that waters within the lake are more saline than in most inland lakes. Solvay Wastebeds 1 through 15 as well as Solvay waste that was disposed of directly in the lake and at other locations along and near the lakeshore are known to contribute calcium, sodium, and chloride to Ninemile Creek and/or the lake. Figure 4.1 illustrates the areas within the lake that contain Solvay waste as the substrate. The ILWD comprises approximately 98.5 acres in Remediation Area D. There are approximately 45 acres of Solvay waste in Remediation Area B and 1 acre is located within Remediation Area A.

In addition, naturally occurring salt brine, which was collected and evaporated in the vicinity of Onondaga Lake for many years, affects both groundwater and nearby surface water quality. Natural salt springs present near the lake result in saline discharges. The United States Geologic Survey (USGS) documented a saline spring in Onondaga Creek between Kirkpatrick and Spencer Streets (Kappel, 2003); however, the daily load (on the order of 10 tons [9,000 kilograms]) is a minor contribution to the salt budget of the lake. According to the *Geddes Brook/Ninemile Creek RI Report* the daily total dissolved solids load from Ninemile Creek to the lake is on the order of 440 tons (400,000 kg) based on two base-flow sampling events in 1998 (TAMS, 2003b).

For remediation purposes, the sediments in the lake are divided into two main regions: the littoral zone (shallower area) and profundal zone (deeper area). For purposes of this project, the littoral zone has been defined as sediments from the shoreline out to 30 feet of water that are in contact with the epilimnion, which is the uppermost warm-water layer as shown in the graphic presented above. The profundal zone includes sediments in the deep basins in more than 30 feet of water that are in contact with the hypolimnion, which are the deeper, colder, and denser waters. The intent of the littoral zone and profundal zone designations is to distinguish between the different biological, physical, and chemical processes of the epilimnion and hypolimnion.

The lake sediments are divided into two zones at a water depth of 30 ft—littoral (shallow zone shown as light blue) and profundal (deeper zone shown as dark blue).

Other Onondaga Lake reports divide sediments into different areas based on characteristics of the sediments themselves. Johnson (1989) splits the sediments of Onondaga Lake into three zones: littoral (0 to 15 feet [4.5 meters]), profundal (greater than 40 feet [12 meters]), and littoroprofundal (between 15- and 40 feet [4.5- and 12 meters]). Littoroprofundal sediments are transitional between the two main regions. Auer *et al*. (1996) define profundal sediment as located below

20 feet (6 meters) in lake depth relatively undisturbed, and not subject to resuspension or bioturbation.

2.3.1 Littoral Zone

The littoral zone is considered the lake area between the shoreline and 30 feet (9 meters) of water. Much of the sediment in water depths of less than 15 feet (4.5 meters) consists generally of fine silts and clays, sand, and shell fragments (Johnson, 1989). Two major habitat types comprise the littoral zone: submerged aquatic plants and unconsolidated bottom. The submerged aquatic plants habitat is characterized by the presence of plants that grow entirely under water or have leaves that extend to and float on the water surface.

High concentrations of calcite exist within the littoral sediments throughout most of the lake due to past and present input of naturally calcitic sediments from the tributaries and, while the former Allied (now Honeywell) Main Plant was operating from 1884 to 1986, calcite precipitation in the lake. Additionally, erosion from the wastebeds along the shoreline contributed calcium carbonate and calcite to the lake. Oncolites are another form of calcite in littoral sediments of Onondaga Lake. Oncolites are small, oval or irregularly rounded, calcareous concretions that resemble elongated pebbles and occur in a variety of water environments around the world. Made up of calcium carbonate and a small fraction of organic material, they are found throughout the littoral sediments of the lake, especially along the northeast, north, and northwest shorelines. Oncolites are of relatively low mass and, therefore, are readily moved by waves and currents. Eventually, oncolites become stationary if they amass to a sufficient size (Golubic and Fisher, 1975).

Ninemile Creek Delta

While much of the littoral zone is considered non-depositional due to wind and wave action, discrete areas at the mouths of the tributaries are depositional. These areas, traditionally called deltas, are created when the tributary enters the lake, the flow rate drops sharply, and suspended solids settle to the lake bottom. Sediment in these areas accumulates and reflects the composition of the suspended solids that were transported by the tributary into the lake.

Another historically depositional area within the littoral zone in the southwest corner of Onondaga Lake is an area referred to in the ROD as the in-lake waste deposit (ILWD). The ILWD was formed primarily through the deposition of calcium carbonate and other wastes from the overflow of dikes around Wastebed B and through discharges via the East Flume. These discharges into the lake are believed to have included a combination of cooling water, sanitary waste, Solvay waste, mercury wastes, and organic chemical wastes, which settled out and formed a large delta that is at a higher elevation than surrounding areas of the lake bottom. The approximate extent of the ILWD in the littoral zone, based on sediment core data collected during the RI and subsequent pre-design investigations (Parsons, 2009a), is shown in Figure 1.2. The area of the ILWD in the littoral zone is approximately 98.5 acres.

2.3.2 Profundal Zone

Lake sturgeon currently exist in the profundal zone of Onondaga Lake.

As described above, the profundal zone is defined as the deeper basin in more than 30 feet (9 m) of water that is in contact with the hypolimnion, which is the denser, cooler, anoxic water during lake stratification (TAMS, 2002a; Parsons, 2004). Profundal sediment is characterized by small particle size and relatively high moisture content, as well as relatively high concentrations of phosphorus, nitrogen, and organic carbon (Auer *et al.*, 1996).

This sediment is comprised of two units (Effler *et al*., 1996). The first unit extends to approximately 35 inches (90 cm) below the sediment surface and is composed of black clay with distinct layers or laminations. The laminations are attributed to deposition of calcite, clays, and diatoms (silica) associated with erosion of the watershed, productivity cycles within the lake, and other annual events (Effler *et al.*, 1996). The presence of layers or laminations in the depositional sediment indicates that the sediment is relatively undisturbed (*i.e.*, not affected by wind-wave resuspension or bioturbation).

The second unit is comprised of dark gray clay called *gyttja* and was observed up to 16.4 feet (5 m) deep. Laminations are visible, although they become less distinct over the upper portion of the gyttja unit. Occasional gastropod shells and wood fragments occur throughout the unit. The sediment is progressively darker as the upper unit is approached (Effler *et al*., 1996).

2.3.3 Shoreline and Wetland Habitats

The Onondaga Lake shoreline near Harbor Brook has been modified by industrial activity and urbanization.

Both inland salt marshes and freshwater emergent and forested wetlands occurred historically around the lake and along the major tributaries inland from the lakeshore. These wetlands were likely diverse not only because of their undisturbed nature, but also because of the lack of the many invasive plant species that currently degrade the present wetlands in the area.

There is little detailed information in the available literature concerning the historical wetlands around the lake. While the lowering of the lake surface in the 1820s likely affected some of these wetlands, filling for wastebed use, transportation, and industrial facilities eliminated much of the original wetlands around the lake. Some of the wetlands that currently exist around the lake likely developed on disturbed soil or fill material.

Five NYSDEC-regulated wetlands occur along or near Onondaga Lake's shoreline. These wetlands (as shown on Figure 1.2) are located as follows: near the mouth of Sawmill Creek (SYW-1), near the mouths of Harbor Brook (SYW-19), Ley Creek (SYW-12), Ninemile Creek (SYW-10), and along the northwest portion of the lake (SYW-6).

State-regulated Wetland SYW-6 is being addressed as part of the Ninemile Creek Dredge Spoils Area (DSA), Wetland SYW-10 as part of the Geddes Brook/Ninemile Creek site, and Wetlands SYW-12 and SYW-19 as part of Wastebed B/Harbor Brook site.

Scientists use soil samples from wetlands around Onondaga Lake to help classify wetland types.

A wetland survey was also performed for the Wastebeds 1 through 8 Site. Details of this survey can be found in the revised *Onondaga Lake Wetland/Floodplain Report* (O'Brien & Gere and Parsons, 2009).

Further delineations of these wetlands were performed during various site investigations, and were delineated using the methods presented in wetland delineation manuals authored by the U.S. Army Corps of Engineers (Environmental Laboratory 1987) and NYSDEC (1995). These wetlands are illustrated on Figure 1.2.

In addition, Honeywell performed a wetlands and floodplain assessment in 2004 to characterize wetlands and floodplain adjoining Onondaga Lake that could potentially be impacted by lake remedial activities. The assessment was conducted in accordance with a NYSDEC-approved work plan (O'Brien & Gere and Parsons, 2004) and consistent with USEPA's policy on *Floodplains and Wetlands Assessment for CERCLA Actions* (1985) (O'Brien & Gere, 2009).

National Wetlands Inventory (NWI) wetlands as mapped by the USFWS are shown on Figure 2.3. These wetlands are somewhat different than the NYSDEC-regulated areas because of differences in classification.

The USFWS used the Cowardin classification scheme (Cowardin et al., 1979) for its NWI mapping project. Based on the NWI map (USFWS, 1978) for the study area, the Onondaga Lake shoreline is predominantly classified as *lacustrine, littoral* habitat. Lacustrine systems are habitats that are situated in topographic depressions; have less than 30% areal coverage of trees, shrubs, or persistent emergents; and are typically greater than 20 acres in size (Cowardin *et al*., 1979). The littoral subsystem is described under this system as habitat that extends from the shoreward boundary of a lacustrine system to a depth of 6.6 feet below low water or to a maximum extent of nonpersistent emergents (Cowardin *et al.*, 1979). Examples of littoral habitats include aquatic beds, nonpersistent emergents, and unconsolidated shore.

Habitat classes depicted on the NWI map for the Onondaga Lake shore include unconsolidated bottom and unconsolidated shore (USFWS

1978, USFWS, 2009). The water regime modifiers (hydrologic characteristics) for the Onondaga Lakeshore include permanently flooded, seasonally flooded, temporarily flooded, and intermittently exposed. Only one subclass, spoil(s), is listed for two of the littoral habitats present along the eastern lakeshore. The shoreline area is further discussed in Section 2.3.4, below.

Additional details regarding the wetlands near Onondaga Lake are available in the recent floodplain and wetlands report (O'Brien & Gere, 2009). Table 2.3 presents a summary of the wetlands contiguous with the lake and evaluated as part of other recent lake-related studies.

Wetland SYW-1

Wetland SYW-1 is located along the northeastern portion of Onondaga Lake. It is a Class I wetland (NYSDEC Freshwater Wetlands Classification System (6 NYCRR Part 664.5) that is separated from the lake by the lake trails and the Willow Bay picnic area.

A wetland is classified as a Class I wetland if any of the following criteria is met:

- wetland is kettlehole bog;
- wetland is a resident habitat of an endangered or threatened animal species;
- wetland contains an endangered or threatened plant species;
- wetland supports an animal species in abundance or diversity unusual for the state or for the major region of the state in which it is found;
- wetland is a tributary to a body of water which could subject a substantially developed area to significant damage from flooding or from additional flooding should the wetland be modified, filled, or drained;
- it is adjacent or contiguous to a reservoir or other body of water that is used primarily for public water supply, or it is hydraulically connected to an aquifer which is used for public water supply; and
- wetland contains four or more of the enumerated Class II characteristics.

This wetland falls outside of the Habitat Plan boundary, but it has been included due to its proximity to the lake. Sawmill Creek drains through Wetland SYW-1 and discharges into the lake in this area. Sawmill Creek has a NYS water quality classification of B. The portion of SYW-1 nearest the lake (south of the Thruway) is primarily a deciduous forest wetland. Dominant trees are green ash (*Fraxinus pennsylvanica*) and silver maple (*Acer saccharinum*).

Wetland SYW-19

Wetland SYW-19, which is located along Wastebed B on the southwest lakeshore at the mouth of Harbor Brook, is a Class I (NYSDEC

Freshwater Wetlands Classification System) freshwater palustrine wetland. A jurisdictional wetland delineation of the SYW-19 area was conducted in the summer of 2000 and summer of 2003 as part of the Harbor Brook Site Remedial Investigation/Feasibility Study (O'Brien & Gere, 2004). Wetland delineation findings are reported in *Jurisdictional Wetland Delineation Report, Harbor Brook Site* (O'Brien & Gere, 2003) and summarized below.

The SYW-19 area consists of four wetland areas (WL1, WL2, WL3, and WL4) located along the Onondaga Lake shoreline. WL1 and WL2 are located near the mouth of Harbor Brook, and WL3 and WL4 are located near the mouth of the Lower East Flume. Since these four wetland areas are contiguous with the lake, the transitional area between the palustrine and lacustrine habitats consist mostly of gravel-cobble shoreline and Solvay waste shoreline, as further described below.

Wetland 1 (WL1) runs along the southern shoreline of Onondaga Lake near the eastern end of Wastebed B and borders the eastern bank of Harbor Brook. WL1 comprises approximately 7.1 acres. Onondaga Lake forms the northern border and an abrupt rise in topography (*i.e.*, berm and railroad bed) defines the southern and eastern borders of this wetland. WL1 is vegetated primarily with a monoculture stand of *Phragmites*. Wetland soils were indicated via the presence of low matrix chroma and high organic content of the soil strata. Wetland hydrology was indicated by the presence of saturated soils (O'Brien & Gere, 2003).

Wetland 2 (WL2) is on the western side of Harbor Brook, opposite WL1. WL2 comprises approximately 2.8 acres. Onondaga Lake forms the northern border and a gentle rise in topography toward Wastebed B defines the western and southern borders of this wetland. Similar to WL1, the dominant vegetative species present at WL2 is common reed; however, portions of WL2 also contain grapevine (*Vitis sp*.), buckthorn (*Rhamnus cathartica*), box elder (*Acer negundo*), black willow (*Salix nigra*) and Eastern cottonwood (*Populus deltoides*). Low matrix chroma and organic streaking indicated wetland soils. Significant amounts of Solvay waste were observed in the soil strata. Wetland hydrology was indicated by the presence of saturated soils in the upper 1 ft of the soil (O'Brien & Gere, 2003).

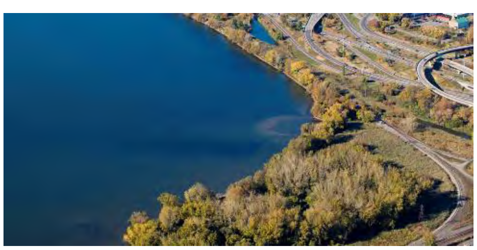
Wetland 3 (WL3) is just north of Wastebed B on the southern shore of Onondaga Lake. WL3 comprises approximately 1.7 acres. Onondaga Lake forms the northern border and the Lower East Flume forms the western border of this wetland. The former bulkhead that was constructed to retain the material deposited into Wastebed B primarily defines its southern border of WL3 (O'Brien & Gere, 2003). WL3 is vegetated primarily with common reed. Other vegetative species observed include purple loosestrife (*Lythrum salicara*), buckthorn, and box elder. Significant amounts of Solvay waste were observed within the soil strata. Wetland hydrology was indicated by the presence of saturated soils within 1 foot of the ground surface (O'Brien & Gere, 2003).

Wetland 4 (WL4) is an approximately 0.5-acre depression that is bounded to the west and south by the Lower East Flume and to the north and east by Onondaga Lake. It exhibits greater vegetative diversity than the other three wetlands. However, the dominant vegetative species observed are similar to those of wetlands WL1, WL2, and WL3 and include, but are not limited to, common reed, purple loosestrife, buckthorn, and box elder. Significant amounts of Solvay waste were observed within the soil strata. Wetland hydrology was indicated by the presence of saturation in 1 foot of the ground surface (O'Brien & Gere, 2003).

Soils mapped for these wetlands consist predominantly of bed areas of Solvay waste that may or may not be covered with vegetation (USSCS, 1977). The drainage characteristics of these soils range from somewhat poorly drained to poorly drained on the wastebed areas located near lake level (USSCS, 1977). As noted above, the soils observed in WL2 through WL4 during the wetland delineation effort were predominantly a mixture of weathered Solvay waste material with varying proportions of brown silty loam and organic (decomposed plant matter) material. In some instances, the presence of Solvay waste precluded the finding of positive indicators of hydric soils. Therefore, the delineation efforts focused on the prevalence of positive indicators of hydrophytic vegetation and wetland hydrology.

During the summer of 2000, sediment samples were collected in SYW-19 and areas located between SYW19 and the lake for the Onondaga Lake RI. During the completion of the Wastebed B / Harbor Brook Site RI, surface soil samples were collected from the WL1 area at a depth of 0 to 6 inches and a depth of 0.5 – 1.0 ft. The surface soils were collected in conjunction with soil boring locations and selected surface soil sampling locations. Also, surface soils and wetland soil samples were collected at unique locations during the RI. Additional investigation was conducted in 2008 within SYW-19. Soil and porewater samples were collected for analysis at depths between 0 and 20 ft bgs. VOCs, SVOCs, pesticides, and metals were detected at multiple sample locations during both the RI (O'Brien & Gere, 2007) and the 2008 investigation.

Wetland SYW-12


Ley Creek and adjacent Wetland SYW-12

Wetland SYW-12 is located along the shoreline of Onondaga Lake north of the mouth of Onondaga Creek and northwest of Carousel Mall. This wetland consists of several wetland cells, with the two largest cells located between Ley Creek and Onondaga Creek and immediately north of Ley Creek. SYW-12 is recognized by the NYSDEC as a Class I wetland, and it covers approximately 42 acres and has vegetative cover containing *Phragmites* and an area of floodplain deciduous forest. Portions of SYW-12 not included in this assessment (north of Ley Creek) have been documented as salt marsh habitat by the New York Natural Heritage Program (NYSDEC/TAMS, 2002).

O'Brien & Gere conducted a jurisdictional wetland delineation at a portion of wetland SYW-12 as part of wetland/floodplain assessment in September of 2004, and October and November of 2008. The portion of SYW-12 delineated and identified by O'Brien & Gere in 2004 (WL 1), consists of approximately 17 acres south of Ley Creek and south and west of the railroad tracks along the northeastern shoreline of Onondaga Lake. Onondaga Lake forms the western border of this wetland. An abrupt rise in topography (*i.e.*, berm and railroad bed) defines the eastern border of the wetland, and Ley Creek defines the northern boundary of this wetland area. This portion of SYW-12 is a combination of a monoculture stand of *Phragmites* and forested floodplain that comprise an overstory of predominantly eastern cottonwood trees. As this wetland is contiguous with the lake, the transitional area between the palustrine and lacustrine habitats consisted mostly of gravel-cobble shoreline and Solvay waste shoreline.

Soils mapped for this wetland cell included made land (*Ma*) and cut and fill land (CFL) soils (USSCS 1977). According to USSCS (1977), *Ma* consists predominantly of bed areas of waste material, which may or may not be covered with vegetation and CFL soils vary widely within Onondaga County.

The portions of SYW-12 identified and delineated by O'Brien & Gere in 2008 consist of two sub-wetlands (WL 2 and WL 3) south of Ley Creek and east of the railroad tracks that border WL 1. WL 2 is a 1.1-acre triangular-shaped area bordered on two sides by railroad tracks and by a dirt road on the third side. This delineated wetland is a monoculture of *Phragmites*. WL 3 is a 0.26-acre narrow strip of *Phragmites* bordered by railroad tracks and a dirt road.

Analytical samples for SYW-12 were collected during the summer of 2000 as part of the Onondaga Lake RI. Four locations were analyzed for VOCs, SVOCs, pesticides, polychlorinated biphenyls (PCBs), metals, total organic carbon (TOC), and percent solids. Results indicated the presence of each of these analytes at one or more of the four sample locations (TAMS, 2002a). A wetland subsurface investigation was performed in May 2000 by C&S Companies (C&S, 2001). Thirteen subsurface borings were advanced as part of this investigation. Borings were advanced to characterize subsurface soils and identify the potential existence of contamination. Soil samples were collected from the following three intervals:

- Interval 1: existing grade to approximately 6 to 12 inches below ground surface (bgs)
- Interval 2: from 6 or 12 inches below grade to a depth of the proposed finished wetland elevation
- Interval 3: from 6 inches immediately above the proposed wetland finished grade elevation to a depth of 18 to 20 inches below the proposed wetland finished grade elevation (C&S, 2001).

Samples collected from each of the three sampling intervals were analyzed for Target Analyte List (TAL) metals, pH, and total organic carbon (TOC). Samples collected from Interval 3 were analyzed for Target Compound List (TCL) VOCs, SVOCs, PCBs, and pesticides. One half of the samples collected from Intervals 1 and 2 were analyzed for TCL VOCs, SVOCs, PCBs, and pesticides (C&S, 2001).

A black tar-like layer was observed during the completion of eight of the borings. The black tar-like layer was identified 4 to 12-ft bgs depending on the borings location and exhibited a "heavy oil-like odor". The layer varied in thickness from 1 inch to 14 inches depending on location. Samples from the black tar-like layer were analyzed for TCL/TAL parameters, pH, and TOC (C&S, 2001).

VOCs were detected in six of the soil samples. Constituents included acetone, ethylbenzene, and xylenes. SVOCs at the site consisted mainly of polycyclic aromatic hydrocarbons (PAH) compounds and were consistently detected at concentrations greater than screening criteria. The majority of soil samples exceeded screening criteria for the following metals: aluminum, cadmium, calcium, chromium, copper, iron, magnesium, manganese, and zinc (C&S, 2001).

Four additional hand augured holes were advanced and sampled for metals as part of additional investigations (O'Brien & Gere 1995). Arsenic, cadmium, chromium, lead, and mercury were detected in these samples.

Wetland SYW-10

Wetland SYW-10, located along Ninemile Creek near its confluence with Onondaga Lake, is a 27-acre, Class I wetland (Figure 2.4). This wetland is divided by I-690. On the lake side of I-690, the wetland is dominated by emergent vegetation and floodplain forest. The wetland section on the west side of I-690 is dominated by emergent vegetation (primarily *Phragmites*). TES conducted a jurisdictional wetland delineation at the portion of wetland SYW-10 on the lake side of I-690 as part of the Geddes Brook/Ninemile Creek Feasibility Study (Parsons, 2005).

SYW-10 is forested wetland located near the mouth of Ninemile Creek.

The portion of the Wetland SYW-10 north of Ninemile Creek, consists of an approximate 5-acre area, with Onondaga Lake forming its eastern border. An abrupt rise in topography (the I-690 roadbed) defines the western border of the wetland, and a rise in typography along the southern edge of the wetland just north of Ninemile Creek defines the southern boundary. This portion of SYW-10 is predominantly forested floodplain that is comprised of an overstory of silver maple, American elm (*Ulmus americana*), and box elder. A monoculture stand of *Phragmites* is located on the southeastern portion of Wetland SYW-10 at the mouth of Ninemile Creek.

Additionally, at the south side of the mouth of Ninemile Creek exists an approximate 1.5-acre area also consisting of a monoculture stand of *Phragmites* which occurs as a delta that extends into the lake. As these wetlands are contiguous with the lake, the transitional area between the uplands and in-lake habitats consisted mostly of gravel-cobble shoreline and Solvay waste shoreline.

The Geddes Brook/Ninemile Creek BERA (TAMS, 2003a) evaluated surface soil/sediment samples from SYW-10 collected from 0 to 0.5 feet below the surface. Forty-one organic compounds exceeded screening criteria in SYW-10 surface soils/sediments. Inorganic constituents detected included arsenic, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, thallium, vanadium and zinc. Hexachlorobenzene, total polycyclic aromatic hydrocarbons (PAHs), total PCBs, 4,4-DDT, and PCDD/PCDFs were also detected.

These contaminated areas are being addressed by the Ninemile Creek remedy.

Wetland SYW-6

Wetland SYW-6, located at the northwest border of Onondaga Lake, is a 100-acre, Class I wetland. This property is owned by Onondaga County and the wetland is situated between I-690 and Onondaga Lake. This wetland is divided by a series of elevated berms which are typically used as biking and walking paths, but are large enough to support vehicles. The paths create cells in the wetland that are not connected by surface flows, though some are hydrologically connected to each other by culverts. Some portions of this wetland are directly connected to the lake through culverts under the paths. The cells in the wetland vary in vegetation type, but are dominated by floodplain forest or emergent wetland species. Two jurisdictional wetland delineations have been performed at portions of Wetland SYW-6.

Photograph of SWY-6 taken in early springtime from the trail along the southern shoreline of Onondaga Lake

Barton and Loguidice (B&L) Consulting Engineers, on behalf of the Onondaga County DOT, performed a jurisdictional wetland boundary delineation of Wetland SYW-6 in October 2000 (B&L, 2001). The wetland delineation effort focused on those areas associated with the Onondaga Lake west trail improvement project, including the existing pedestrian trail (Paved Trail), secondary trail (Nature Trail), and culverts. Both forested and emergent wetlands were mapped as part of this effort. The forested wetland was dominated by eastern cottonwood and common buckthorn with occasional red maple (*Acer rubrum*) and green ash. The emergent wetlands were vegetated with *Phragmites*, narrow-leaved cattail (*Typha angustifolia*), and common cattail (*Typha latifolia*). The berm banks were typically vegetated with common buckthorn and some staghorn sumac (*Rhus typhina*). The boundary of the entire wetland system was not delineated beyond the project areas, although the wetland cell boundaries are generally defined by the berms.

O'Brien & Gere, on behalf of Honeywell, also performed a jurisdictional wetland delineation at a portion of Wetland SYW-6 as part of the wetland/floodplain assessment previously discussed. This wetland section is located along the northwest lake shoreline between a paved portion of the Onondaga Lake trail system and the lakeshore.

SYW-6 is approximately 5.5-acres, based on the wetland boundary delineation. Onondaga Lake forms the eastern and southern borders, and an abrupt rise in topography associated with the lake trail defines the western and northern borders of the wetland. This wetland is predominantly forested floodplain with some smaller stands of *Phragmites* along the immediate lakeshore. The forested floodplain portion is approximately 3 to 4 acres and is composed of an overstory of predominantly silver maple, cottonwood, green ash, American elm and swamp white oak (*Quercus bicolor*). The remainder of this wetland consists of a narrow strip of deciduous trees and shrubs (American elm, green ash, cottonwood and buckthorn) along the lakeshore. The herbaceous species present included *Phragmites*, false nettle (*Boehmeria cylindrica*), and jewelweed (*Impatiens* sp.). As these wetlands are contiguous with the lake, the transitional area between the palustrine and lacustrine habitats consisted mostly of gravel-cobble shoreline and Solvay waste shoreline.

According to the Ninemile Creek/Dredge Spoils Area PSA Data Summary (O'Brien & Gere, 2005b), multiple VOCs, SVOCs, pesticides, PCBs, and metals were detected in the top 1 or 2 feet of surface soil/sediment samples were collected from the SYW-6 area. The DSA is the subject of ongoing remediation investigation efforts.

Other Wetland (BR4)

As part of the wetlands/floodplain assessment, a 0.11-acre wetland area, identified by O'Brien & Gere as BR-4, was delineated along the northwest lake shoreline near an unpaved portion of the Onondaga Lake Park trail system (O'Brien & Gere, 2009). Onondaga Lake forms the eastern border of this wetland and an abrupt rise in topography associated with the lake trail defines the western border. This wetland is predominantly a narrow strip (ranging from 3 to 10 feet wide) of *Phragmites* along the immediate lakeshore.

As this wetland is contiguous with the lake, the transitional area between the palustrine and lacustrine habitats consisted mostly of gravel-cobble shoreline and Solvay waste shoreline.

Wastebeds 1 through 8

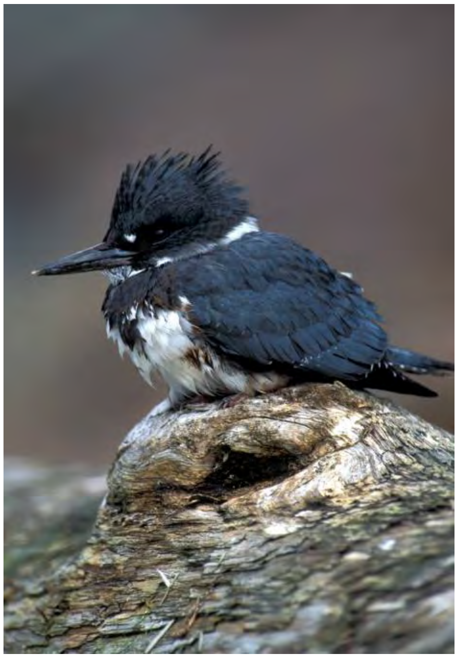
Wastebeds 1-8 site located adjacent to Onondaga Lake

O'Brien & Gere performed a wetland boundary delineation and floodplain assessment at the Wastebeds 1 through 8 site and is currently preparing a Baseline Ecological Risk Assessment in accordance with the *Wastebeds 1 through 8 Focused Remedial Investigation Work Plan* (O'Brien & Gere, 2005). Findings from the wetland/floodplain assessment are reported in *Wetland Delineation and Floodplain Assessment for the Wastebeds 1 through 8 Site* (O'Brien & Gere, 2006, 2009), currently under review by the NYSDEC, are summarized below.

During the July 2008 supplemental field efforts at the Wastebeds 1 through 8 site, two wetland habitats (A and B) totaling 0.72 acres were identified along the eastern Lakeshore Area site, located adjacent to Onondaga Lake. Wetland A is a 0.32-acre wetland dominated by *Phragmites* that is located near the northeastern Site boundary. Wetland B is a 0.40-acre wetland located southeast of Wetland A. Wetland B is also dominated by *Phragmites* with little to no other vegetative species observed.

2.3.4 Riparian Zone

The riparian zone (shoreline) of Onondaga Lake consists of maintained, natural, and disturbed areas. The City of Syracuse is located at the southern end of Onondaga Lake, and numerous towns, villages, and major roadways surround the lake (see Figure 1.1). The eastern shore of Onondaga Lake is urban and residential, while the northern shore is dominated by parkland, wooded areas and wetlands. The northern



Belted kingfisher and other birds nest in the riparian zone.

upland areas in Liverpool and Lakeland are mainly residential, with interspersed urban structures and several undeveloped areas. Much of the western and southern lakeshore is covered by wastebeds that received wastes generated from Honeywell's predecessor Allied Signal, Solvay operations. These wastebeds contain a mix of wetland and terrestrial plant communities typical of disturbed areas. Urban centers and industrial zones in Syracuse and Solvay dominate the landscape surrounding the southern and eastern shores of Onondaga Lake from approximately the NYS Fairgrounds south to Ley Creek.

As part of the wetlands and floodplain assessment (O'Brien & Gere and Parsons, 2009), a boat reconnaissance of the Onondaga Lake shoreline was performed to evaluate the presence of other potential wetland areas. The physical characteristics of portions of the lake shoreline, excluding the assessed wetlands described in Section 2.3.3, are broadly described as follows:

- Gravel and cobble shoreline that may include areas dominated by drift deposits including garbage and dead vegetative matter. This habitat type is predominant through much of the lakeshore.
- Solvay waste shoreline (*e.g.*, primarily Remediation Areas D (SMU 1), C (SMU 2), B (SMU 3), and the southern portion of Remediation Area A (SMU 4).
- Human-made, concrete causeway (Remediation Area C [SMU 2]) which is no longer at the shoreline due to the Willis IRM barrier wall discussed in Section 3.2.3.
- Armored (rip-rap lined) shoreline (*e.g.*, portions of Remediation Area F [SMU 5] at Onondaga Lake Park).

Based on the field investigations performed for the wetlands/floodplain assessment for Onondaga Lake (O'Brien & Gere and Parsons, 2004), the natural shoreline areas that were not identified as wetlands would be considered *lacustrine, littoral, unconsolidated bottom* (L2UB) habitat. Some of these shoreline areas, particularly along the eastern shoreline west of Ley Creek and north of Onondaga Creek, contained non-persistent emergent vegetation that was predominantly rooted in a substrate of sand, gravel, Solvay waste, or organic drift material (predominantly vegetative stems and detritus).

Floodplains were mapped by the Federal Emergency Management Agency (FEMA) throughout most of the Onondaga County watershed in the 1970s and 1980s. According to the FEMA data, floodplains are currently most extensive in the area around Onondaga Lake. There are significant areas of 100-year floodplain around the northern reaches of Ninemile Creek and the southern reaches of Onondaga Creek. The highest, or near highest, stream flows and lake levels on record for the area occurred in June/July 1972 in response to a storm event stemming from Hurricane Agnes. The maximum lake elevation recorded that year from the USGS site is 369.14 feet (NAVD 88). The current 100-year floodplain elevation for the Onondaga Lake area is 370 feet (NAVD 88).

Presently, there are no virgin forests near Onondaga Lake or in the remainder of Onondaga County (Harding, 1973). Historical clearing of forested areas for various land use purposes caused fragmentation of natural communities and loss of biodiversity. Invasive species including *Phragmites* and purple loosestrife have become some of the most dominant species on the moist disturbed sites along the southern and western edges of the lake and in shallow waters of wetlands (McMullen, 1993). Other common species now present near the lake include the eastern cottonwood, red maple, white oak, white ash (*Fraxinus americana*), and the American elm (Vandruff and Pike, 1992).

White oak foliage

As listed in the Lake BERA (TAMS, 2002b), three state and/or federal listed rare, threatened, or endangered plant species exist within 2 miles (3.2 km) of Onondaga Lake. These are Sartwell's sedge (*Carex sartewelli*), little-leaf tick-trefoil (*Desmodium ciliare*), and red pigweed (*Chenopodium rubrum*). All three plant species are known only from historical records. They have not been sighted in the Onondaga Lake area recently, but may be rediscovered. The general locations of listed plants near Onondaga Lake are shown in the Onondaga Lake BERA (TAMS, 2002b).

One of the submerged aquatic species noted during the recent surveys was slender naiad (Najas guadalupensis). Two rare natural plant communities have been recorded adjacent to the Onondaga Lake shoreline within 2 miles of the site. These communities are the Inland Salt Marsh and the Inland Salt Pond located southeast of Liverpool along the northern shore of Onondaga Lake. The NYNHP did not provide the exact locations of identified resources; however, their general location is presented in the Willis Avenue BERA (O'Brien & Gere, 2004c). Plant and animal endangered, threatened, and rare species as well as rare natural communities are discussed in greater detail in Section 2.4.8. Other endangered plants previously reported in and around the lake are also discussed in Section 2.4.8.

2.3.5 Tributaries

Onondaga Lake receives surface runoff from a drainage basin of approximately 285 square miles (Figure 2.5). Surface water flows primarily from the south and southeast into the lake through six natural tributaries; Ninemile Creek, Onondaga Creek, Harbor Brook, Ley Creek, Bloody Brook, and Sawmill Creek. Two engineered tributaries also flow into the lake; the East Flume and Tributary 5A, which are both currently in the remedial design stage. Ninemile Creek and Onondaga Creek are the two largest tributaries to Onondaga Lake. Each of the tributaries is described below. In addition to the tributaries, the treated effluent from Metro, located between Onondaga Creek and Harbor Brook, provides a significant portion of the water entering the lake.

The outlet of Onondaga Lake flows north to the Seneca River, which then combines flow with the Oneida River to form the Oswego River, and ultimately discharges into Lake Ontario approximately 40 miles north of the lake outlet. Water also enters the lake through intermittent bi-directional flow from the Seneca River at the outlet of the lake (Effler and Whitehead, 1996). Analyses to date indicate that inflow from the Seneca River varies significantly seasonally and from year to year, but that it can be a substantial portion of the total inflow (Effler *et al*., 2002).

Additional research is being conducted to better understand this bidirectional flow in the outlet, including collaborative work between the USGS and Onondaga County.

Upstream portion of Ninemile Creek

Ninemile Creek

Otisco Lake serves as the headwaters of Ninemile Creek in the town of Otisco. Ninemile Creek receives drainage from several tributaries including Geddes Brook. Ultimately, Ninemile Creek empties into Onondaga Lake along its western edge at Lakeland, adjacent to the NYS Fairgrounds. As defined in the Geddes Brook/Ninemile Creek RI (TAMS, 2003b) the section of Ninemile Creek located upstream of the Geddes Brook confluence to Amboy Dam is referred to as upper Ninemile Creek, while the section located downstream of the Geddes Brook confluence is referred to as lower Ninemile Creek. Ninemile Creek is the second largest natural tributary, contributing approximately 34% of the annual flow to Onondaga Lake (OCDWEP, 2001).

Ninemile Creek empties into Onondaga Lake.

The water quality classification for lower Ninemile Creek is Class C (suitable for fish propagation and fish survival). A Class C (T) designation applies to Ninemile Creek from the outlet of Otisco Lake to 0.6 miles (0.4 km) downstream of the Route 173 bridge in Amboy (downstream of the Amboy Dam). The C(T) designation indicates that, in addition to protection as Class C waters and uses, these waters are trout streams where the dissolved oxygen specification for trout waters applies (Title 6 of the State of New York Code of Rules and Regulations – 6 NYCRR - Part 895). Class C(T) waters are also "protected streams" subject to provisions specified in 6 NYCRR Part 608.

The fish assemblages in Geddes Brook and Ninemile Creek have been evaluated in three historical studies and, in a qualitative manner, during fish sampling performed for the Geddes Brook/Ninemile Creek RI field investigation in 1998 and 2000 by Exponent for Honeywell and supplemental young-of-year (YOY) sampling in 2002 performed by TAMS for NYSDEC (TAMS, 2003b). An extensive evaluation of habitats and biological resources for this tributary is presented in the *Ninemile Creek/Geddes Brook BERA* (TAMS, 2003a).

The fish community captured in Geddes Brook and Ninemile Creek in 1998 comprised a total of 21 species, with 20 captured from Ninemile Creek and 10 captured from Geddes Brook. The following species, presented in descending order of abundance, were captured from Ninemile Creek: white sucker, creek chub (*Semotilus atromaculatus*), tessellated darter (*Etheostoma olmstedi*), blacknose dace (*Rhinichthys atratulus*), longnose dace (*R. cataractae*), common shiner (*Luxilus cornutus*) , brown trout (*Salmo trutta*), yellow perch, pumpkinseed, smallmouth bass (*Micropterus dolomieu*), bluegill (*Lepomis macrochirus*), brook stickleback (*Culaea inconstans*), largemouth bass, fathead minnow (*Pimephales promelas*), banded killifish, logperch (*Percina caprodes*), golden shiner, satinfin shiner (*Cyprinella analostanus*), brown bullhead (*Ameiurus nebuolosus*), and rock bass (*Ambloplites rupestris*)

Exponent also conducted a field evaluation for Honeywell of potential spawning habitats for fish in Geddes Brook and lower Ninemile Creek in July 2000. The species of interest for this study were brown trout, blacknose dace, creek chub, smallmouth bass, tessellated darter, and white sucker (TAMS, 2002b). These species of interest prefer coarse substrate for spawning, and in general, the larger habitat segments (long pools or runs) of lower Ninemile Creek provide extremely limited or no spawning habitat value , primarily due to the dominance of fine grained sediments (mud/clay). In contrast, Geddes Brook provides abundant spawning habitat for all species of interest, except smallmouth bass.

Onondaga Creek

Onondaga Creek flows into Onondaga Lake near Metro.

Onondaga Creek originates in the southeastern portion of the watershed (Tully Valley) and flows north through the town of Tully, the Onondaga Nation, the town of Onondaga, and the City of Syracuse before emptying into Onondaga Lake (Figure 2.5). The main stem length is 27.5 miles (OCDWEP, 2001). The major tributaries to Onondaga Creek are the West Branch of Onondaga Creek, Hemlock Creek, and Rattlesnake Gulf. The creek receives runoff from 43 combined sewer overflows and contributes approximately 34% of the annual flow to Onondaga Lake (OCDWEP, 2001). The lower portion of the creek near the discharge point to Onondaga Lake is known as the Inner Harbor. This lower reach of Onondaga Creek is classified by the NYSDEC as a Class C waterway which, as designated by the regulations, is best suited for fishing and secondary water contact recreation such as boating (6 NYCRR 701).

According to the National Inventory of Dams (http://nid.usace.army.mil), there is one dam on Onondaga Creek (Onondaga Dam) located in the Tully Valley. No other dams were identified on this creek.

At its headwaters, Onondaga Creek historically received significant sediment inputs from the Tully Valley mudboils, located 13 miles upstream from Onondaga Lake. The mudboils discharge sediment-laden groundwater into the headwaters of Onondaga Creek, primarily in the form of clay minerals. In 1991, the Onondaga Lake Management Conference (OLMC) identified the Tully Valley mudboils as a source of turbidity being discharged into Onondaga Lake. Since 1992, the Onondaga Lake Partnership (OLP) has provided financial support to the USGS to remediate and reduce the sediment loading from the mudboils to Onondaga Creek. Today, the sediment loading is only a small fraction of what it once was. (Kappel and McPherson, 1998; and (Kappel, 2004).

At its mouth, Onondaga Creek is enriched with nutrients and suspended sediment. The creek is also enriched with salt from groundwater springs that continuously discharge brackish (salty) water to the lower reaches of the creek near Onondaga Lake. A sediment loading analysis in the early 1990s showed that 57% of the sediment load reaching Onondaga Lake was delivered by Onondaga Creek, although a more recent study (Prestigiacomo*et al.*, 2006) has shown that this may have actually been an underestimate. Thus, Onondaga Creek is the largest external source of sediment to Onondaga Lake.

Despite its water quality problems, there is interest to restore Onondaga Creek for recreational and ecological purposes. Research is underway to improve the status of Onondaga Creek, including CSO diversion into engineered wetlands for additional treatment and the rehabilitation of riparian areas. In addition, the OLP and Onondaga Environmental Institute (OEI) conducted a visioning program to advance the planning and future use of this area. This document is available on the SUNY ESF web site at http://www.esf.edu/onondagacreek/. Through continued improvement, Onondaga Creek will likely become an important resource to the community and have positive impacts on Onondaga Lake.

Harbor Brook

Harbor Brook originates southeast of Syracuse, New York, in the Town of Onondaga and flows through western Syracuse, discharging to the southwest corner of Onondaga Lake. The main stem length is 7.5 miles, and 18 CSOs discharge to its lower reaches. (OCDWEP, 2001; Blasland & Bouck, 1989). The lower portion of Harbor Brook, considered part of the Wastebed B/Harbor Brook site, is classified as a Class C stream by NYSDEC, and is routed through the City of Syracuse with most of the brook flowing through underground culverts. Harbor Brook contributes approximately 2% of the annual flow to Onondaga Lake (OCDWEP, 2001). According to the National Inventory of Dams (http://nid.usace.army.mil), the Velasko Road Basin Dam is the only dam located on Harbor Brook.

Harbor Brook flows into Onondaga Lake.

Phragmites *dominates the Harbor Brook wetland area.*

The information presented below is taken directly from the *Harbor Brook Site Baseline Ecological Risk Assessment*, which is currently under review by the NYSDEC (O'Brien & Gere, 2004b).

Harbor Brook is most consistent with the description of *confined river (*Edinger *et al.,* 2002). *Confined river* is described as an aquatic community of fast flowing sections of streams with moderate to gentle gradient. Although Harbor Brook is considered a natural water course, it has been channelized along much of its course through the developed areas of Syracuse. The majority of the lower portion of the brook is culverted through the City of Syracuse underground.

Fauna identified in and along the banks of Harbor Brook included mallard (*Anas platyrhynchos*), great blue heron (*Ardea herodias*), green heron (*Butorides virescens*), common carp, and muskrat (*Ondatra zibethicus*).

Phragmites and other miscellaneous grass and wildflowers are the predominant vegetative cover, when present, along the banks of Harbor Brook. A small section of the brook (approximately 300 feet) in area of study (AOS) #2 contains *successional shrubland* and *successional northern* hardwood cover along the banks, which is a more desirable cover for wildlife diversity (see SYW-19 discussion for additional information). However, habitat quality is low and few wildlife are able to utilize the area due to the development surrounding the brook, and the general public cannot easily access Harbor Brook. Due to its characteristics and relative location, the brook lacks a vegetative buffer zone.

Ley Creek discharges to the northeast corner of Onondaga Lake.

Ley Creek

The Ley Creek watershed drains 29.5 square miles and is located within the northeastern portion of the Onondaga Lake watershed. Ley Creek headwaters originate in the town of Dewitt and flow through the Town of Salina and the City of Syracuse. Approximately 90% of the land traversed by the creek is considered urban or commercial, and the remaining 10% is categorized as residential. Several industrial sites, dredge spoils areas, and closed landfills that formerly received both sanitary and industrial waste are also located in this area (OCDWEP, 2001). Ley Creek discharges to the southeast end of Onondaga Lake and contributes approximately 8% of the annual flow to Onondaga Lake. It is designated as a Class C stream by NYSDEC. According to the National Inventory of Dams (http://nid.usace.army.mil), there are no dams located on Ley Creek.

In the vicinity of the lake, Ley Creek likely supports a fish community similar to the other large tributaries. As presented in O'Brien & Gere (2001), fish sampling has been performed as part of investigative activities associated with General Motor's Former IFG Facility located approximately 3.5 miles upstream of the lake. The primary species observed as part of those investigations, conducted in 1985 and 1992, include bluegill, pumpkinseed, shiners, bullhead and carp. Although these observations were made a significant distance from the lake, it is likely that a similar fish assemblage exists in Ley Creek in reaches closer to the mouth of the creek.

Bloody Brook

Bloody Brook drains 3.9 square miles and flows into Onondaga Lake from the northeast just south of the village of Liverpool and passes through highly urbanized areas. The primary land use in this watershed is urban (approximately 58%). This tributary is designated as a Class B stream by NYSDEC. The best usage of Class B waters are primary and secondary contact recreation and fishing. These waters should be suitable for fish propagation and survival. Flow from Bloody Brook to the lake is a minor contributor (approximately 2% or less) to the lake water budget.

Sawmill Creek

Sawmill Creek flows into Onondaga Lake from the northeast. This creek flows through mixed forest, commercial and urban land cover. It flows through a large forested wetland complex in the northeastern corner of the lake, and is designated as a Class B stream by NYSDEC. Flow from Sawmill Creek to the lake is a minor contributor to the lake water budget.

The East Flume is a water conveyance system located along the southern shoreline of Onondaga Lake.

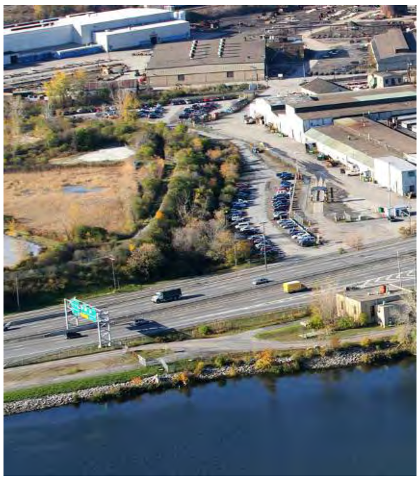
East Flume

The East Flume was built as a wastewater conveyance for the cooling waters from the former Main and Willis Avenue Plants. Today, this drainage ditch receives storm water from various industrial facilities and the Village of Solvay. Water depths within the flume typically range between 2 and 6 feet, and the channel width varies from a minimum of 20 feet to a maximum 150 feet (O'Brien & Gere, 2002). Flow from this conveyance to the lake is an insignificant portion of the water budget (less than 2%). The East Flume is currently being investigated as part of the Wastebed B/Harbor Brook site RI/FS. It is anticipated that a portion of the East Flume will be addressed through placement of the barrier wall associated with the Wastedbed B/Harbor Brook IRM.

Tributary 5A

Tributary 5A is currently being investigated as part of the Willis Avenue site RI/FS. The information presented below is taken directly from Section 2 of the BERA for the Willis Avenue Chlorobenzene Site (O'Brien & Gere, 2004c), currently under review by NYSDEC.

Tributary 5A receives discharge from 12 outfalls from Crucible, as well as surface runoff and shallow ground water discharge. Tributary 5A is therefore classified as an industrial effluent stream. The banks of the upper portion of the tributary, located south of the Willis Plant Area, are heavily vegetated by sumac, goldenrod, and *Phragmites* along both banks. Portions of these banks and the stream substrate consist of non-native fill material including railroad ties and other debris.



Tributary 5A flows into Onondaga Lake and will be restored prior to the lake cleanup activities.

Further downstream, the water depth shallows to approximately four inches with *Phragmites* dominant along the banks and within much of the channel. The channel parallels the railroad tracks for approximately 2000 feet before turning north into a culvert under the Crucible parking lot. The channel reappears from the culvert on the opposite side of the parking lot where the bank vegetation is again dominated by sumac and *Phragmites* and surface water is approximately 1 foot deep. This channelized portion of the tributary continues north for approximately 1,000 feet towards State Fair Boulevard. Tributary 5A flows through a second culvert for 400 feet underneath State Fair Boulevard and I-690 and into Onondaga Lake.

Tributary 5A assumes the class of the surface water to which it discharges, Onondaga Lake, which is a Class "C" surface water in this portion of the lake. Tributary 5A provides habitat for wildlife including various fish species. Fauna identified along the banks of Tributary 5A consisted of house sparrow (*Passer domesticus*), American kestrel (*Falco sparverius*), Northern flicker (*Colaptes auratus*) and muskrat. Banded killifish, bluegill, creek chub and several aquatic invertebrates were identified in the channel of Tributary 5A. Three muskrats were successfully trapped and released from the Tributary 5A area during BERA investigative activities. The use of Tributary 5A by the muskrat suggests potential usage by other terrestrial and/or semi-aquatic mammals. The corridor along Tributary 5A may be used by transient wildlife moving through this developed area.

2.4 Existing Biological Communities

Onondaga Lake supports a variety of plants and animals that interact with each other and the surrounding environment. Recent investigations have revealed that there are many thriving biological communities in and around the lake.

2.4.1 Submerged/Emergent Aquatic plants

Aquatic plants form an important part of lake ecosystems. They serve as food for other aquatic organisms and provide habitat for insects, fish, and other aquatic and semi-aquatic organisms. Most aquatic plants are rooted or attached to the sediment, although some free-floating forms exist. Little quantitative information existed on aquatic plant distributions in Onondaga Lake prior to 1991, when Madsen *et al.* (1992) conducted the first quantitative survey of aquatic plant distributions in the lake.

Madsen *et al*. have examined aquatic plants in Onondaga Lake periodically between 1991 and 2006. Between 1991 and 1995, the nearshore zone of Onondaga Lake was characterized as sparsely populated with aquatic plant beds and only six species of aquatic plants were identified—coontail (*Ceratophyllum demersum*), common waterweed (*Elodea canadensis*), water star grass (*Heteranthera dubia*), Eurasian water milfoil (*Myriophyllum spicatum*), curly-leaf pondweed (*Potamogeton crispus*), and sago pondweed (*P. pectinatus, subsequently reclassified as Stuckenia pectinata*). The typical number of aquatic plant species for a eutrophic lake in New York is fifteen (Madsen *et al.,* 1996). Results from Madsen's most recent studies indicate that the Lake's aquatic plant community has changed significantly in recent years (Madsen, 2006).

Coontail is a common aquatic plant species in Onondaga Lake.

Onondaga County Department of Water Environment Protection (OCDWEP) monitors aquatic plant communities within the lake as part of their Ambient Monitoring Program (AMP). This comprehensive, lakewide program uses a combination of digitized aerial photographs every year and a field survey every five years to monitor aquatic plant species composition, percent cover, and biomass. Onondaga County initiated the first aquatic plant survey in 2000 to establish baseline conditions. A second field sampling effort was performed in 2005 and included four additional sampling locations at Honeywell's request. The supplementary aquatic plant data provided information to support Honeywell's remedial design efforts for the lake bottom as well as complemented the County's monitoring program.

OCDWEP's studies indicate that the aquatic plant community has changed profoundly in recent years (see Figure 2.6). OCDWEP's AMP 2005 Annual Report documents that aquatic plant species richness has increased from 5 species in 1991 to 10 species in 2000 and 17 species in 2005 (EcoLogic *et al*., 2006). The percent cover and biomass of aquatic plants were, on average, slightly more than three times greater in 2005 compared to 2000 (EcoLogic *et al*., 2006). The range and percent cover in the lake is thought to be within an ideal range for largemouth bass production, approximately 40 to 50% aquatic plant coverage (Stuber *et al*., 1982a). In 2005, the catch rate of largemouth bass YOY was 2.5 times higher than any time in the previous five years (EcoLogic et al. 2006). The depth to which plants are growing in the lake has increased as well. In 2005, plants were documented growing to a water depth of 22 feet, which is about 10 feet deeper than in 2000 (EcoLogic *et al*., 2006). These changes to the aquatic plant community directly benefit species that use littoral habitats for all or a portion of their life cycle (*e.g.*, bass, northern pike, yellow perch).

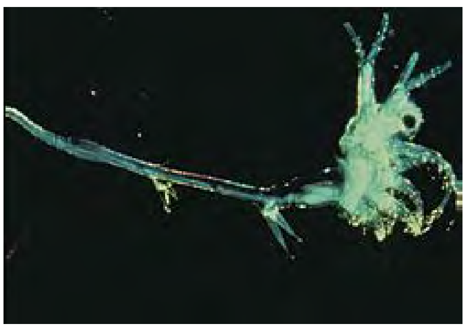
In 2008, SUNY ESF conducted a study that was designed to assess monthly plant composition, distribution, and biomass within the littoral zone of the lake from May to October (Parsons, 2009). Nineteen species of aquatic plants were identified. Two additional species were tentatively identified as a broadleaf pondweed and a sedge, but the lack of flower parts precluded definitive identification. The table below presents a list of the observed species. One of the unidentified species is an emergent aquatic plant that was observed in Remediation Area B (SMU 3) and Remediation Area E (SMU 6); the other unidentified species is a broad leaf pondweed that was observed at the mouth of Ley Creek in SMU 6.

Based on relative abundance, six species were characterized as "abundant" because they were found at more than 20% of the sample points for at least one month during the sampling season. Three species were characterized as "common" because they were observed during most months but in less than 20% of the sample points in any given month. Twelve species were characterized as "uncommon" because either they were observed sporadically in the aquatic plant community data or they were observed outside of the sampled area. These included more recently observed aquatic plants in Onondaga Lake such as white water lily (*Nymphaea odorata*), American pondweed (*Potamogeton nodosus*), stonewort (a plant-like algae species [*Chara*, spp.]), and the two unidentified species.

Certain subspecies of *Najas guadalupensis* are state-listed as endangered. It is not known whether the *N. guadalupensis* found in the lake and listed in the table below is one of those state-listed because it was not identified down to the subspecies level. The status of the species and location of collections are more fully discussed in Section 2.4.8.

Species	Common Name	Dominance Level
Myriophyllum spicatum	Eurasian water milfoil	Abundant
Elodea canadensis	Common waterweed	Abundant
Ceratophyllum demersum	Coontail	Abundant
Potamogeton pusillus	Small pondweed	Abundant
Potamogeton crispus	Curly-leaf pondweed	Abundant
Najas flexilis	Slender naiad	Abundant
Stuckenia pectinatus	Sago pondweed	Common
Potamogeton foliosus	Leafy pondweed	Common
Heteranthera dubia	Water star grass	Common
Lemna minor	Duckweed	Uncommon
Sagittaria latifolia	Common arrowhead	Uncommon
Najas guadalupensis (spp?)	Southern naiad	Uncommon
Spirodela polyrhiza	Great duckweed	Uncommon

Species	Common Name	Dominance Level
Trapa natans	Water chestnut	Uncommon
Ruppia maritima	Widgeon grass	Uncommon
Vallinseria americana	Wild celery	Uncommon
Chara	Stonewort	Uncommon
Nymphaea odorata	Fragrant water lily	Uncommon
Potamogeton nodosus	American pondweed	Uncommon
Unidentified broad leaf pondweed	NA	Uncommon
Unidentified emergent aquatic plant	NA	Uncommon



Cladocerans, commonly referred to as water fleas, are found in Onondaga Lake.

2.4.2 Phytoplankton and Zooplankton

Phytoplankton have been collected and identified for several studies in Onondaga Lake. In 1992, 36 phytoplankton taxa were identified in the lake, including flagellated green algae, nonflagellated green algae, diatoms, cryptomonads, and cyanobacteria (PTI, 1993; Stearns and Wheler, 1994) as detailed in the BERA (TAMS, 2002a). Between 1986 and 1989, 25 zooplankton taxa were collected from Onondaga Lake, with cladocerans, copepods, and rotifers dominating zooplankton communities, as documented in the BERA (TAMS, 2002a).

As part of the AMP, Onondaga County has performed a detailed analysis of the structure and abundance of the phytoplankton and zooplankton communities in Onondaga Lake. The dominant phytoplankton community consisted of *Bacillariophyta* (diatoms), *Chlorophyta* (green algae), *Chrysophyta* (golden brown algae), *Cryptophyta, Cyanophyta* (blue-green algae), *Euglenophyta, Pyrrhophyta* (fire algae), and miscellaneous microflagellates in 2005. *Xanthophyta* (yellow-green algae) was documented in 2002 for the first time since 1996, but not documented in 2003, 2004, or 2005 (EcoLogic *et al*., 2006).

In 2005, there was not a significant blue-green algae bloom as evidenced in 2002 and 2003 (EcoLogic *et al*., 2006). Data from 2005 indicated that the zooplankton was dominated by the small cladoceran, *Bosmina,* with reduced numbers of *Daphnia* species and near-absence of the calanoid copepods. It is hypothesized that this shift in zooplankton populations may be due to increased planktivory in the lake by plankton eating fish. *Cercopagis pengoi* (exotic) was also a significant contributor to the total number of zooplankton in mid-August and late September 2005 (EcoLogic *et al*., 2006).

Upstate Freshwater Institute, on behalf of Honeywell, continues to enumerate zooplankton and phytoplankton. The draft *Baseline*

Monitoring Data Assessment Report describes these findings in more detail (Parsons, 2009e).

2.4.3 Benthic Macroinvertebrates

Few quantitative data existed on benthic macroinvertebrates in Onondaga Lake prior to 1992. Benthic macroinvertebrate communities were sampled at 68 locations in 1992 and in an additional 15 locations in 2000 during the RI for Onondaga Lake (TAMS, 2002a). More than 100 benthic taxa were identified in the lake, of which, oligochaetes (like the common earthworm) and chironomids (a non-biting mosquito-like insect) were the numerically dominant benthic communities. These organisms are typical of lower quality sediments with a higher pollution tolerance than other benthic macroinvertebrates (Voshell, 2002). (Further details are available from the BERA)

This Caddisfly is an adult form of the nymph, a benthic macroinvertebrate.

OCDWEP has conducted the most recent studies of the macroinvertebrate communities in Onondaga Lake as part of their AMP. Significant findings of their monitoring efforts indicate that the combined influences of eutrophication and habitat degradation appear to be major structuring elements of the benthic community in Onondaga Lake (EcoLogic *et al*., 2006). In 2005, the macroinvertebrate community in the lake's littoral zone ranged from moderately to severely impacted, based on the NYSDEC Biological Assessment Profile (mean water quality values ranged from 1.0 to 4.9; EcoLogic *et al*., 2006), with the north end of the lake appearing less impacted than the south end, which is where the majority of the sediment remediation will occur. Oligochaetes were the numerically dominant benthic community, although the percentage of oligochates (compared to other taxa) had decreased significantly between 2000 and 2005. Other benthic macroinvertebrate communities observed in 2005 included chironomids, amphipods, and zebra mussels (EcoLogic *et al*., 2006).

Zebra mussels have helped to improve water quality and sediment stability in Onondaga Lake.

Cornell University, in conjunction with Upstate Freshwater Institute (UFI), has also completed field and laboratory studies of benthic macroinvertebrate distribution and its effects on bioturbation in Onondaga Lake over the last several years. This work includes placement of microbeads, which act as sediment tracers, on the surface of sediment cores and monitoring transport of the microbeads downward due to bioturbation over a five month period. Significant results from these studies include the general absence of benthic macroinvertebrates and lack of bioturbation in sediments collected in deeper waters that are anoxic during stratification. These studies are being conducted under the leadership of Professor Nelson Hairston at Cornell University and have not yet been published.

Since the early 1990s, zebra mussel (*Dreissena polymorpha*) veligers have been entering Onondaga Lake. However, despite the availability of appropriate substrate and food, and near-optimal temperature and primary water chemistry requirements, adult densities remained extremely low in the lake through 1998 (Effler, 1996; Spada *et al*., 2002). This may have been related to the negative effects on early life stages of zebra mussels from high concentrations of total ammonia (T-NH_3) and free (unionized) ammonia (NH_3) (Spada *et al.,* 2002). Following abrupt decreases in concentrations of T-NH_3 and NH_3 coincident with improvements at METRO, high densities of zebra mussels were first documented in the lake in 1999 (maximum of ~ 65,000 individuals/m^2) (Spada *et al*., 2002). The presence of zebra mussels has had a significant impact on water quality and ecological conditions within the lake including increased aquatic plant growth due to increased water clarity and stabilized sediments (EcoLogic *et al*., 2006).

The benthic macroinvertebrate community in Onondaga Lake was assessed in 2008 during the Honeywell baseline monitoring program (Parsons, 2009e). Surface sediments at 18 locations in the littoral zone (all at 3.2 to 5 feet water depth) around the lake were sampled and benthic macroinvertebrates were identified from 5 replicates per location. Procedures were consistent with the 2002 NYSDEC Division of Water's Quality Assurance Work Plan for Biological Stream Monitoring in NYS. Zebra mussels were fairly dominant at most locations, along with tubificid worms (*Annelida*) and scuds (*Amphipoda*). Aquatic insects were not highly abundant and were dominated by midges (*Diptera: Chirononmidae*).

White perch is a warm water species.

2.4.4 Fishes

SUNY ESF has been studying fishes in Onondaga Lake under the direction of Dr. Neil Ringler since 1986. Much of their earlier work was incorporated into the BERA (TAMS, 2002b). More recent work has included trapnet and gillnet fish sampling at up to 30 locations and characterization of the several populations. These studies are ongoing, including collection of additional field data in 2007, 2008 and 2009, with the results recently defended in master's theses of SUNY ESF students (Johnson, 2009; Kirby, 2009; Siniscal, 2009). Onondaga County's AMP represents one of the most long-term and comprehensive lake wide fish monitoring program in Onondaga Lake. The 2005 annual report (Ecologic, 2006) is available on the Onondaga County website, (www.ongov.net), and an overview of the fish community presented in this version of the AMP is presented below.

Contrary to the popular perception that Onondaga Lake is a dead lake, recent studies of the fish in Onondaga Lake have documented warm water, cool water, and coldwater fish species in the lake throughout most of the year. Cold water species reproduction in the lake has not been documented; until recently they did not reside in the lake year-round. Fish surveys conducted in the late 1980s through today have identified 60 fish species in Onondaga Lake, with annual averages around 35 species (Ringler *et al*., 1996; Gandino, 1996; Arrigo, 1996; Tango, 1999; and EcoLogic *et al*., 2006). Results of these studies indicate that the lake's fish community continues to be dominated by warm water species, including both pelagic planktivores/omnivores (*e.g.*, white perch and gizzard shad) and littoral planktivores/insectivores (*e.g.*, bluegill and pumpkinseed sunfish).

Smallmouth Bass is a popular game fish in Onondaga Lake.

The species present include desirable sport fish such as largemouth bass, smallmouth bass, and walleye (*Sander vitreus*). Brown trout and lake sturgeon (*Acipenser fulvescens*) have also been documented. Panfish, such as yellow perch, pumpkinseed sunfish, and bluegill sunfish, are abundant in the nearshore areas and provide good catch and release fishing for area residents. The alewife and gizzard shad (*Dorosoma cepedianum*) were dominant in 2005, which provide a good forage base for the fish community; however numbers have recently declined. This annual rise and fall in population numbers is typical for this species (Kirby, 2009; EcoLogic *et al*., 2006). A number of fish studies completed from the late 1980s to the mid-1990s concluded that reproduction in the lake seemed to be limited for many species (Ferrante, 2005). However, fish reproduction is evident in Onondaga Lake as indicated by the catch of several species of larval and YOY fish, including the following (EcoLogic *et al*., 2006) species: bluegill sunfish, pumpkinseed sunfish, carp, yellow perch, alewife, banded killifish, brown bullhead, gizzard shad, golden shiner, largemouth bass, smallmouth bass, rock bass (*Ambloplites rupestris*), tessellated darter, white perch, brook silverside (*Labidesthes sicculus*) , black crappie, bluntnose minnow, emerald shiner, log perch, longnose gar (*Lepisosteus osseus*), and northern pike (Kirby, 2009; EcoLogic *et al*,. 2006).

2.4.5 Amphibians and Reptiles

Snapping turtles have been seen in Onondaga Lake.

Amphibian and reptile species expected to occur in covertypes surrounding Onondaga Lake are reported in the BERA (TAMS, 2002b). Amphibians and reptiles recorded in the vicinity of Onondaga Lake from the *New York Herpetological Atlas* records are provided in Appendix A. Amphibian and reptile species found by Ducey *et al*. near Onondaga Lake between 1994 and 1997 included five species of anurans (*i.e.*, frogs and toads) and two species of salamanders (Ducey and Newman, 1995; Ducey, 1997; Ducey *et al.,* 1998). In addition, six reptile species, including three species of aquatic snakes and three species of turtles, were identified.

According to one report, no amphibian species bred in Onondaga Lake or wetlands connected to the lake from 1994 through 2000, although this has recently changed. From 2001 through 2004, research showed two amphibian species successfully breeding and surviving through adulthood in a wetland directly connected with the lake and two additional species attempting to breed in that same wetland. In addition, they recorded the first instances in ten years of amphibians attempting to breed in the lake itself (Ducey and West, 2004).

Common mudpuppy (*Necturus maculosus*) may be of interest since it inhabits large bodies of water; however, the NYS Herpetological Atlas has no records of the mudpuppy from either the Camillus or Syracuse West USGS quadrangles. Mudpuppies have been reported from a cluster of nearby quadrangles, specifically Manlius, Cleveland, Cicero, Mallory and Panther Lake. Of the toads and frogs listed, any or all of them might be found in the emergent wetlands, side sloughs, or small isolated water bodies surrounding the lake. Of the turtles on the list, eastern snapping turtle (*Chelydra s. serpentina*) and eastern painted turtle (*Chrysemys p. picta*) have been seen in the lake. Red-bellied cooter (*Pseudemys rubiventris*), a species introduced by release of pets, is a possibility in such an urban setting. Snake species that are possible inhabitants of the shoreline of Onondaga Lake include the northern water snake (*Nerodia s. sipedon*), which feeds in part on small fish. More terrestrial species that could be found in drier areas along the shoreline include common garter snake (*Thamnophis sirtalis*), eastern milk snake (*Lampropeltis t. triangulum*), and northern brown snake (*Storeria d. dekayi*). Eastern milk snakes have been reported by field personnel on Wastebed B and northern brown snakes were reported on Wastebeds 1-8. All of these species are common and are fairly tolerant of urbanization. See Appendix A for a complete list of species from the NYS Herpetological Atlas data for the lake vicinity.

Northern Water Snake

Mudpuppies are a representative species in this Habitat Plan.

Ospreys are representative species in this Habitat Plan.

2.4.6 Birds

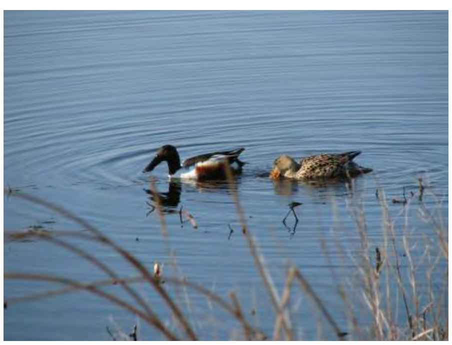
Onondaga Lake is within the Atlantic flyway and provides a variety of habitats for bird species. Onondaga Lake is recognized as an Important Bird Area (IBA) because of its value as a congregation area for waterfowl. The IBA program is an international bird conservation initiative with simple goals: to identify the most important places for birds, and to conserve them. IBAs are identified according to standardized, scientific criteria through a collaborative effort among state, national, and international non-governmental conservation organizations, state and federal government agencies, local conservation groups, academics, grassroots environmentalists, and birders. As a result, IBAs link global and continental bird conservation priorities to local sites that provide critical habitat for native bird populations. Currently, IBA programs exist in 130 countries around the world, including 21 countries in the Americas.

The *Onondaga Lake BERA* (TAMS, 2002b) documents that over 30 species of birds and 13 species of waterfowl have been observed around the lake. Much of the data presented in the BERA was based on the *Breeding Bird Atlas* of 2000. This comprehensive, state-wide survey of birds was updated in 2005, and identified over 80 species of birds/waterfowl frequenting the lake area (Appendix B). Some of the more common bird species include red-tailed hawk (*Buteo jamaicensis*), red-winged blackbird (*Agelaius phoeniceus*), mourning dove (*Zenaida macroura*), killdeer (*Charadrius vociferous*), blue jay (*Cyanocitta cristata*), barn swallow (*Hirunda rustica*) and ring-billed gull (*Larus delawarenis*). Common waterfowl species include Canada goose (*Branta canadensis),* wood duck (*Aix sponsa*), mallard, and common merganser (*Mergus merganser*).

American crow (*Corvus brachyrhynchos*), rock pigeon (*Columba livia*), mourning dove, wild turkey (*Mealeagris gallopavo*), house sparrow (*Passer domesticus*), northern cardinal (*Cardinalis cardinalis*), and northern mockingbird (*Mimus polyglottos*) are common birds around Onondaga Lake. Fish crows (*Corvus ossifragus*) breed in small numbers on the east side of the lake. Black-capped chickadee (*Poecile atricapilla*), white-breasted nuthatch (*Sitta carolinensis*), downy woodpecker (*Picoides pubescens*), and northern flicker are found in the wooded areas surrounding the lake. Great blue herons are found throughout the year. Black-crowned night herons (*Nycticorax nycticorax*) are occasionally recorded on the north end of the lake.

Red-winged blackbirds live on the shore of Onondaga Lake

Onondaga Lake is a known waterfowl concentration area during spring, fall, and winter. Diving ducks are found in deep water areas of the lake while dabbling ducks are found close to the shoreline and the mouth of the creeks. Common waterfowl that use the lake include common loon (*Gavia immer*), horned grebe (*Podiceps auritus*), redhead (*Aythya americana*), northern shoveler (*Anas clypeata*), gadwall (*Anas strepera*), American widgeon (*Anas americana*), greater scaup (*Aythya marila*), lesser scaup (*Aythya affinis*), bufflehead (*Bucephala albeola*), common merganser, and red-breasted merganser (*Mergus serrator*), mallard, black duck (*Anas rubripes*), and double-crested cormorant (*Phalacrocorax auritus*). A large number of common loons (approximately 100) was reported on November 26, 2004 (Purcell, 2005). Common mergansers have been sighted at Onondaga Lake, and can reach numbers of up to 5,000 birds at one time (Crumb, 2002).



Northern Shoveler

Data collected by the Onondaga Audubon Society as part of the annual “Christmas Count” provides early winter data from Onondaga Lake and surrounding areas (National Audubon Society, 2007). During the winter when much of the lake freezes, open water pockets can be found at the outlet of Ninemile Creek, Onondaga Creek, and the Metropolitan Sewage Treatment plant. Waterfowl will concentrate at these open water pockets. Herring gulls (*Larus argentatus*), ring-billed gulls (*Larus delawarensis*), and great black-backed gulls (*Larus marinus*) are the most common wintering gulls on Onondaga Lake. It is not uncommon to find thousands of gulls on the lake at one time (National Audubon Society, 2007). Bonaparte’s gulls (*Larus philadelphia*) have also been recorded in smaller numbers.

Onondaga Lake provides nesting habitat for killdeer and spotted sandpiper (*Actitis macularia*). Shorebirds use the lake edges for nesting and refueling during migration. Algae mats that wash up on the shoreline host a variety of invertebrates that provide a feeding opportunity for semi-palmated sandpiper (*Calidris pusilla*), least sandpiper (*Calidris minutilla*), semi-palmated plover (*Charadrius semipalmatus*), ruddy turnstone (*Arenaria interpres*), lesser yellowlegs (*Tringa flavipes*), greater yellowlegs (*Tringa melanoleuca*), stilt sandpiper (*Calidris himantopus*), and black-bellied plover (*Pluvialis squatarola*). In September 2003, shorebird numbers were quite high with 50 greater yellowlegs, 20 lesser yellowlegs, and 20 spotted sandpipers recorded (Purcell, 2004).

Spotted sandpipers use the edge of the lakeshore that has little to no vegetation.

Bald eagles (*Haliaeetus leucocephalus*) are much more widely reported on Onondaga Lake in recent years. They have been recorded perched in trees on the wooded west shoreline, near the Carousel Center, and at the open water pockets during the winter months (Purcell, 2006). A recent article in the *Syracuse Post-Standard* notes that a group of 12 adult and immature (young) bald eagles wintered along the lake (Kirst, 2009).

The cliffs on the west shore of the lake provide nesting habitat for bank swallows (*Riparia riparia*), and belted kingfisher (*Ceryle alcyon*). A survey of the bank swallow colony in 2000 found over 500 bank swallow nests (Crumb, 2002). Additional study of the bank swallow colony is ongoing as part of the Wastebed 1-8 site investigation.

2.4.7 Mammals

Otter

Onondaga Lake and surrounding lands provide a variety of habitats for mammal species. The *Onondaga Lake BERA* (TAMS, 2002b) lists 45 mammalian species that currently occur near Onondaga Lake. Some of the more common species include common opossums (*Didelphis marsupialis*), various shrew species, various rodent species, eastern chipmunks (*Tamias striatus*), various squirrel species, woodchucks (*Marmota monax*), muskrats, raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), and white-tailed deer (*Odocoileus virginianus*).

The shores of Onondaga Lake provide habitat for several mammal species. Recovering populations of otter appear to be moving toward the lake (NYSDEC, 2002; Stiles, 2001). Woodchuck (*Marmota monax*), muskrat (*Ondatra zibethicus*), and squirrels (e.g., *Scirus carolinensis*) are regularly observed on the shores of Onondaga Lake. These and other small-mammal species support predators such as mink (*Mustela vison*), fox (*Vulpes vulpes* and *Urocyon cinereoargenteus*), and coyote (*Canis latrans*). The less-disturbed shoreline of the northwest section of the lake can provide habitat for more reclusive or larger species, such as beaver (*Castor canandensis*) and deer (*Odocoileus virginianus*) (TAMS, 2002b).

SYW-6 and SYW-10, located on the west side of the lake between Ninemile Creek and the lake outlet, are dominated by floodplain forest and emergent wetlands, which could support insectivorous mammals such as the short-tailed shrew and little brown bat. Mink may also occupy these wetland habitats and the nearby streams and lake. They prefer wetland and riparian habitat with irregular shorelines, good cover, (*i.e.* woods and shrub), and suitable den sites. These species could also occupy upland regions surrounding the lake, such as the dredge spoils areas adjacent to the northwestern lakeshore (TAMS, 2002b).

Littoral areas have the potential to support mammalian species that forage within the inshore zone of the lake and are dependent upon indigenous aquatic organisms as their primary food source, such as mink and river otter. The Onondaga Lake shoreline is considered adequate to support a small river otter population (TAMS, 2002b).

2.4.8 Endangered, Threatened and Rare Species/Habitats

Several sources of information were used to identify endangered, threatened, and rare plant and animal species. Federally listed species known from Onondaga County were obtained from the USFWS website (http://www.fws.gov/northeast/nyfo/es/ColistCurrent.pdf). State-listed species were provided by The New York Natural Heritage Program (NYNHP) provided information on state-listed species in the vicinity of Onondaga Lake.

Rare Communities

The Danforth Salt Pool was a popular tourist attraction during the resort heyday of Onondaga Lake.

Inland salt marshes were formerly known to be at various locations around the southern half of the lake. The NYNHP indicates known records of this rare habitat, but currently only remnants of this habitat remain in this area. Danforth's pool, an inland salt pond (although severely degraded), still exists along the Onondaga Lake Parkway near the southeastern corner of the lake. A few listed plant species are still known from this pool and the ditches and other wetlands from Danforth's pool north to the railroad bridge.

Plants

Table 2.4 lists those species reported by the NYNHP as endangered, threatened, or rare with records for Onondaga County. The original (2002) response from the NYNHP lists three plant species of historic record for the area: Sartwell's sedge, little-leaf tick-trefoil, and red pigweed. Young (2000) reports salt marsh aster (*Aster subulatus,* now *Symphyotrichum subulatum*) and seaside bulrush (*Scirpus maritimis,* now *Bolboschoenus maritimis* ssp. *paludosus*) from the southeastern portion of the lake. Two state-listed aquatic plants were reported by the County surveys— southern naiad (*Najas guadalupensis*) and pondweed (*Potamogeton strictifolius*). The most recent (2009) response from the

NYNHP also lists troublesome sedge (*Carex molesta*) along the Seneca River just north of the lake outlet.

Sartwell's sedge, a state-listed threatened species, was reported by Goodrich in the 1800s (Bye and Oettinger, 1969). There are no known voucher specimens for this plant from Onondaga County (NYFA, 2005), but it is considered a potential occurrence (Young, 2007). This sedge "is an important wetland species in portions of the Midwest, but becomes increasingly uncommon and local eastward" (NYFA, 2005). Its habitat in the eastern portion of its range includes marsh fens, rich fens, rich swamps, wet meadows and shallow water (Gleason 1952, NYFA 2005, Fernald 1950, Wiegand and Eames 1926).

Hairy small-leaved tick-trefoil or little-leaf tick-trefoil was collected in 1991 in Onondaga County (NYFA, 2005). This species is considered threatened in New York State. Its habitat is "dry or sandy soil, sandy woods, clearings" (Gleason, 1952; Gleason and Cronquist, 1992; Fernald, 1950). There could be potential for this species to occur on the wastebeds that surround the lake.

Red pigweed is a threatened species in New York State. It was reported by Goodrich "among the salt vats" in the Town of Geddes in August 1897 (Goodrich, 1912) and was reported more recently in salt areas (Faust and Roberts, 1983). According to NYNHP records, a voucher specimen was collected by Fernald, Wiegand and Eames in 1922. This plant of saline soil (also referred to as a "halophyte") is found in salt marshes, saline soil, and brackish soil (Gleason, 1950; Gleason and Cronquist, 1993; Fernald, 1950). Potential exists for this species in areas of saline soils around the lake.

Salt marsh aster was recorded in the Danforth's Pool at the southern end of the Onondaga Lake Parkway (Young, 2007). Salt marsh aster is found on Long Island and the New York City area. Its occurrence in Onondaga County is a disjunctive population. Its habitat *is "coastal, primarily saline marshes with irregular inland distribution" (Gleason and Cronquist, 1992).*

Two halophytes, seaside bulrush and eastern annual salt marsh aster were recorded in the salt pools of Onondaga Lake by the NYNHP botanist Steve Young (Young, 2007). Seaside bulrush is found in "fresh saline, or alkaline marshes." This plant was found along Onondaga Lake Parkway along the southeastern portion of the lake; it occurred in a roadside ditch in a former salt marsh area and in a salt pond (Danforth's pool) in a mowed park. See Table 2.4 for more detailed information from the NY Natural Heritage Program.

Southern naiad is represented by one common subspecies (spp. *guadalupensis*) and two state-listed rare subspecies (spp. *muenscheri* and spp. *olivacea*). Spp. *olivacea* is known from central New York in Cayuga and Seneca Counties. Southern naiad was reported in five sampling locations in the 2005 aquatic plant sampling for Onondaga Lake. It was reported from just north of the Liverpool Yacht Club marina to the Maple Bay area; however, the specimens collected from Onondaga Lake were not identified to the subspecies level, so it is not known whether it represents a rare subspecies.

Straight-leaved pondweed (*Potamogeton strictifolius*) is an endangered species in New York State. This species was recorded in Onondaga Lake by EcoLogic in its 2005 *Onondaga Lake Macrophyte Survey*. This species was recorded at thirteen sampling locations spread around the lake. Its habitat is alkaline ponds and streams (Gleason and Cronquist, 1991).

Troublesome sedge, a state-listed threatened species, is a recent addition to Onondaga County, although *Carex brevior* from which this species was separated, is reported from Onondaga County by Bye and Oettinger (1969) in Lafayette woods. It is reported as a potential species in several New York counties by Young (2007), but only confirmed in three counties. A few plants were reported from only the Seneca River just north of the Onondaga Lake Outlet. Troublesome sedge is a calciphile (meaning that is thrives in soils with high amounts of calcium carbonate) that grows in various open habitats, such as fields, swales in fields, limestone woodlands and alvars (NYFA, 2005).

Birds

Bald eagles have become common visitors to Onondaga Lake.

Two state listed bird species are known from the vicinity of Onondaga Lake. These species are peregrine falcon (*Falco peregrinus*) and bald eagle.

Peregrine falcons nest in downtown Syracuse. A nest-box was placed on the State Tower Building in 2003. Peregrine falcons have successfully nested since 2004 in Syracuse. They fledged four birds in 2004 and 2005 and three birds in 2006 and 2007. Occasionally, peregrine falcons are reported in the vicinity of Onondaga Lake.

Bald eagles can be seen throughout the year at Onondaga Lake and have become common winter visitors to the Lake. During the winters of 2006-2008, an adult and immature eagles were frequently observed perched in trees at the southern-most portion of the lake. In 2009, 12 eagles were seen wintering in the same locations. Despite this winter-time use of the lake, bald eagles are not known to nest here.

Mammals

Of all the state- and federally-listed endangered species of mammals, the only known listed mammal for the vicinity of Onondaga Lake is Indiana bat (*Myotis sodalis*), which appears on both lists.

Indiana bats have been documented roosting in trees near the outlet of Onondaga Lake. During the spring of 2007, bats were radio-tracked from their winter residence (hibernaculum) at the Jamesville Quarry to a forested area near the confluence of the Seneca River and the Onondaga Lake outlet, as well as other locations along the Seneca River (Niver, 2007).

Bats use multiple trees for roosting. Spring and summer roosting locations are typically associated with forested floodplains, often in proximity to rivers or large wetland complexes. Trees selected for roosting include (a) trees with a narrow crack, such as a split trunk, (b) dead or dying trees with exfoliating bark, or (c) living trees with bark characteristics that offer shelter. Shagbark hickory is the most common example of the latter category.

A variety of other factors can influence the selection of roost trees. For example, adequate solar exposure of the roosting location is critical to the development of young bats. Thus, trees located on the edge of forested openings or trees tall enough to gain better exposure to sunlight are preferred. The absence of a dense shrub and understory layer, as well as the presence of open streams, also enhances the suitability of roosting areas by providing foraging conditions for adult bats.

Indiana bats would be expected to roost around the lake during the summer months where suitable roost trees exist. Such roost trees are most likely in the forested wetlands around the northern portion of the lake.

Reptiles

One federally listed reptile species, bog turtle (*Glyptemys muhlenbergii*), is of historical record in Onondaga County and one candidate species, eastern massasauga (*Sistrurus c. catenatus*), is known to occur in the county. Both species are state-listed as endangered. One of the best known locations in New York for eastern massasauga rattlesnake is Cicero Swamp located between Oneida Lake and the city of Syracuse. The bog turtle is a semi-aquatic species, preferring habitat with cool, shallow, slow-moving water, deep soft muck soils, and tussock-forming herbaceous vegetation (NYSDEC, 2009). Neither species is currently found in or adjacent to Onondaga Lake and suitable habitat does not exist in the lake vicinity for either species to occur there.

2.5. Summary of Onondaga Lake Conditions

Throughout the lake's history, there have been extensive changes to its waters and shoreline, often creating conditions in the lake that were unsuitable for a variety of species. Recent water quality improvements and remediation and restoration projects have greatly improved conditions in the lake. Within the last several years, there have been substantially increases in the number of fish and plants living in the lake, a key indicator that the lake is starting to recover. Species such as the bald eagle and the lake sturgeon that had been absent from the lake and its environs for many years are being seen more frequently. Improvements such as these are expected to continue as the remediation and restoration efforts are advanced in and around the lake.

TABLE 2.1

CHANGES TO LEVEL OF ONONDAGA LAKE

Date	Lake Level or Area Modification	Resulting Change	Source(s)
Pre-1822	Lake level was +/- 365 ft and was uncontrolled. Area that is now Carousel Mall was under water.	Not Applicable.	Effler and Harnett (1996); Pratt and Pratt (2003)
1822	New York State dredged and straightened outlet channel between lake and Seneca River.	Reduced lake level by approximately 2 ft. to approximately 363 ft.	Ferrante (2005); Hohman (2004)
1840s	Construction of the Syracuse Northern Railroad along the southeastern shoreline.	Construction of the railroad berm modified the alignment of the lakeshore. Impact to lake elevation is unknown.	Hohman (2004)
1907	Solvay Process waste was deposited in and adjacent to the lake shoreline in an area known as Wastebed B.	Waste material was placed on approximately 54 acres of the Wastebed B site within and adjacent to the lake. The East Flume was constructed on top of existing Wastebed B material. Construction of the Wastebed resulted in filling of former lake surface area (extent has not been determined), but the impact to lake level is unknown.	Hohman (2004); Lizlovs (2005)
Early 1900s	Construction of Barge Canal and the Phoenix Dam.	Installation of structures controlled river and lake levels. Lake level was +/- 365 ft.	Ferrante (2005)
1926 - 1944	Constuction and operation of Wastebeds 1-8	Ninemile Creek was moved to the current channel location. Construction of the Wastebeds resulted in filling of former lake surface area (extent has not been determined), but the impact to lake level is unknown. The approximate area of waste disposal is ~400 acres.	O'Brien and Gere (2009)

TABLE 2.1 (CONTINUED)

CHANGES TO LEVEL OF ONONDAGA LAKE

1930s to 1960s	Deposition of In-Lake Waste Deposit material	Overflow from Wastebed B and discharges from the East Flume resulted in a delta of Solvay waste material over approximately 100 acres within the lake. Water depth was modified, but changes to lake level are unknown. The discharges which created the ILWD also filled in the lake at/near the mouth of Harbor Brook, creating the wetland/upland areas designated as AOS#1 in the Wastebed B/Harbor Brook RI.	NYSDEC and USEPA (2005), TAMS (2002a)
1950s	Construction of Interstate 690 and interchange.	Fill material was placed in the southern end of the lake near the location of Metro. Impact to lake elevation is unknown.	Effler and Harnett (1996)
1977	Construction of force main required filling in of lake near the East Flume.	Loss of 3.7 acres of lake surface area.	Hohman (2004)
2008	Construction of Willis IRM Barrier Wall required filling in of lake near the Causeway Bridge.	Loss of 2.3 acres of lake surface area, which will be mitigated at the Wastebed 1-8 site.	Parsons (2009c)
2009	Lake level controlled to +/- 363 ft (NAVD 1988) from late spring to fall, with some higher seasonal levels.		Parsons (2004)

TABLE 2.2

ONONDAGA LAKE ELEVATIONS, 1970 TO 2009

Month	Minimum Water Level (feet)	Average Water Level (feet)	Maximum Water Level (feet)
January	361.63	362.87	366.64
February	361.33	362.87	366.74
March	361.00	363.39	367.88
April	361.83	363.66	369.18
May	361.44	362.98	368.33
June	361.68	362.61	368.55
July	361.70	362.51	368.55
August	361.73	362.35	364.58
September	361.64	362.38	366.33
October	361.65	362.60	366.17
November	361.85	362.86	365.78
December	361.56	363.07	366.33
Total	361.00	362.85	369.18

Notes:
1. Daily mean water levels from October 1, 1970 through April 1, 2009 obtained from http://waterdata.usgs.gov/ny/nwis/uv/?site_no=04240495&agency_cd=USGS.
2. Water levels referenced to the NAVD 88 vertical datum.
3. 100-year flood elevation is 366.96 ft. NAVD 88 (USGS).
4. Shaded areas inidcate duration of growing season.
5. Average water level during the growing season is ~362.5 ft.

TABLE 2.3

DELINEATED WETLANDS WITHIN THE HABITAT PLAN BOUNDARY

Area	Approximate Location	Delineation Conducted	Delineation Approval Status
SYW-10	Mouth of Ninemile Creek adjacent to SMU 4	Yes[1]	Under review by NYSDEC
SYW-12	North corner of lake, south of Ley Creek, adjacent to SMU 6	Yes[2]	WL1 approved per NYSDEC February 28, 2008 letter; WL2 and WL3 under review by NYSDEC
SYW-19	Southeast corner of lake adjacent to SMUs 1 and 7	Yes[3]	Approved per NYSDEC July 17, 2006 letter
Wetlands A & B	Wastebeds 1 through 8 Site adjacent to SMU 3	Yes[4]	Approved per NYSDEC May 14, 2009 letter
BR-4	Adjacent to where SMUs 4 and 5 meet	Yes[2]	Under review by NYSDEC
BR-7/SYW-6	Northwest corner of lake, adjacent to SMU 5	Yes[2]	Under review by NYSDEC
Floodplain	Lakeshore	No[5]	Not applicable

Notes:

[1] *Geddes Brook/Ninemile Creek Feasibility Study Report* (Parsons 2005); boundaries confirmed October 2008

[2] *Wetlands/Floodplain Assessment Revised Report* (O'Brien & Gere and Parsons 2009)

[3] *Jurisdictional Wetland Delineation Report, Harbor Brook Site* (O'Brien & Gere 2003)

[4] *Wetland Delineation and Floodplain Assessment Final Report, Wastebeds 1 through 8 Site* (O'Brien & Gere 2009)

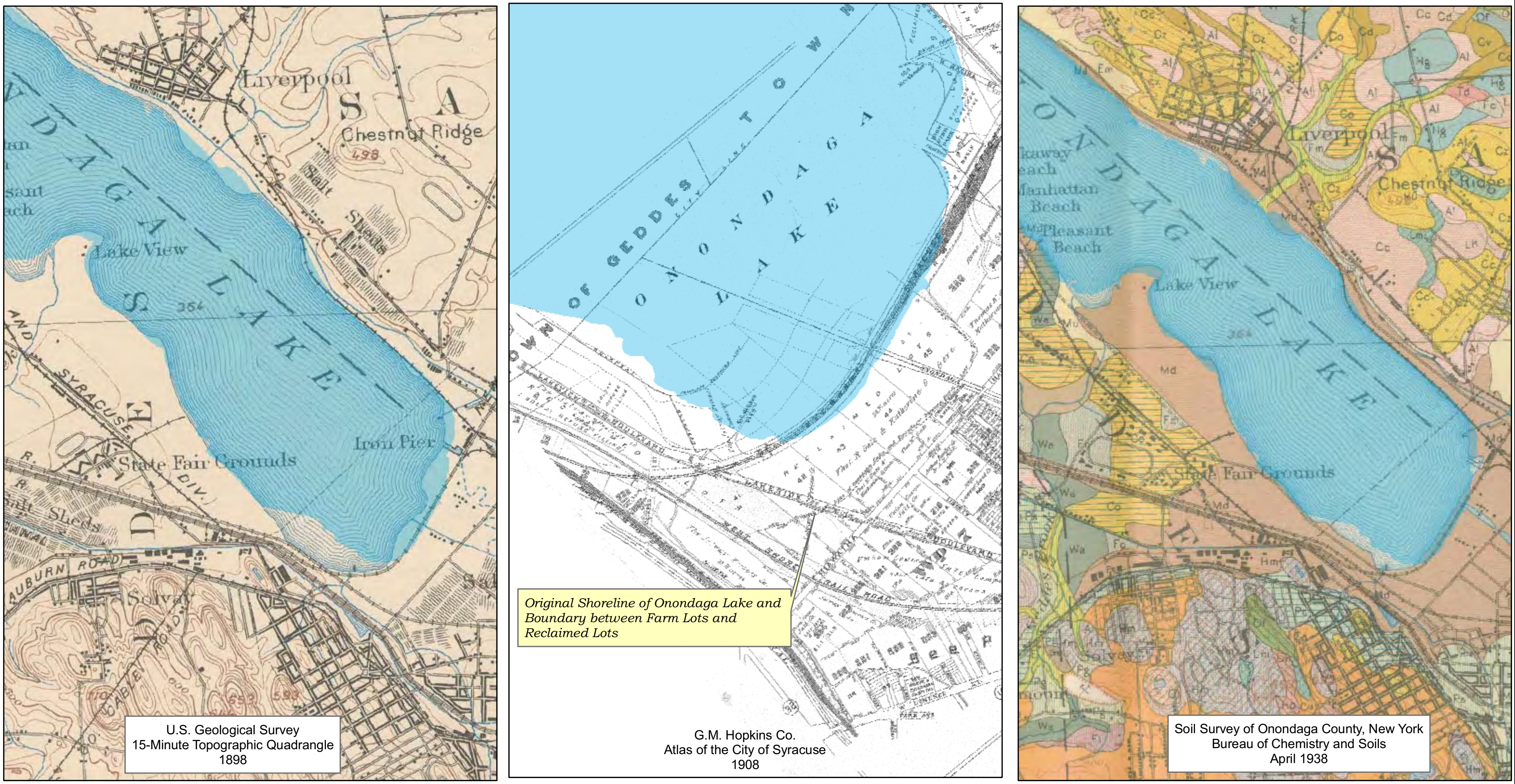
[5] Boundaries presented based on FEMA's *Flood Insurance Study* (1981)

BR = Boat Reconnaissance

NYSDEC = New York State Department of Environmental Conservation

SMU = Sediment Management Unit

SYW = Syracuse West USGS Quadrangle



U.S. Geological Survey
15-Minute Topographic Quadrangle
1898

G.M. Hopkins Co.
Atlas of the City of Syracuse
1908

Soil Survey of Onondaga County, New York
Bureau of Chemistry and Soils
April 1938

Dark blue areas in each panel represent the approximate current footprint of Onondaga Lake.

Historical maps were scanned and superimposed with the current lake footprint to help illustrate how the shoreline has changed through time.

Small discrepancies in alignment can be attributed to the original scale of the historical maps, the different cartographic techniques used to develop the original maps, and the "rubber-sheeting" effect that occurs when assigning real-world coordinates to a flat paper map.

FIGURE 2.1

Honeywell — Onondaga Lake, Syracuse, New York

Changes in Lake Level

PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

FIGURE 2.2

Honeywell

Onondaga Lake
Syracuse, New York

Land Use/Land Cover (2001)

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

FIGURE 2.3

Honeywell

Onondaga Lake
Syracuse, New York

National Wetlands Inventory
Habitats Associated with
Onondaga Lake

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212


SYW-10
Onondaga Lake
A
690
Wastebeds 1-8
B
Wastebeds 9-10
C
New York State Fairgrounds
695
State Fair Landfill
SYW-18
Floodplain was not delineated beyond this point.
Geddes Brook
Geddes Brook Culverts
Geddes Brook
Floodplain was not delineated beyond this point.
100-year Floodplain
NYSDEC/EPA Approved Wetland Boundary
500 250 0 500
Feet
FIGURE 2.4
Honeywell
Onondaga Lake
Syracuse, New York
Ninemile Creek Wetlands
PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

Figure 2.5
Onondaga Lake Watershed

Aquatic Plants - 2000

Aquatic Plants - 2008

Sediment Management Unit (SMU) Boundary

Remediation Area Boundary (Parsons, 2009)

Area Covered by Onondaga Lake Remedial Design Elements for Habitat Restoration

Notes:
1. Aquatic Plant data obtained from Onondaga County Department of Water Environment Protection (2000 and 2008).

N W E S

New York State Digital Orthoimagery from 2003

1,600 800 0 1,600
Feet

FIGURE 2.6

Honeywell

Onondaga Lake
Syracuse, New York

2000 and 2008
Aquatic Plant Coverage

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

Section 3: Effects of Remediation on Onondaga Lake Habitat

Honeywell has already made progress with the remediation of upland sites and impacted tributaries adjacent to the lake. The overall lake remedy relies on the control of contamination in these upland areas and tributaries to help mitigate the movement of contamination into the lake. Cleaning up the areas *around* the lake is the first step in a restored Onondaga Lake bottom.

Remediation in these upland sites and impacted tributaries is proceeding under schedules and administrative agreements that are separate from the lake remedy, but their remedies will impact the overall lake habitats in different ways; therefore, a discussion of those remedies is included here.

Restored wetland at the LCP site in Solvay, New York

Honeywell has completed the remediation at the former LCP Bridge Street site, which was once the primary source of mercury to Onondaga Lake. Honeywell has also started IRM construction activities, which include the construction and operation of a groundwater treatment plant and the initial underground barrier wall/groundwater collection system along the southern shoreline of Onondaga Lake to control ongoing releases of contaminated groundwater from upland sites/sources.

Extensive investigation and remedial alternative evaluation are also ongoing at many sites adjacent to the lake, such as Wastebeds 1 through 8 and Harbor Brook.

Littoral Zone Remedial Scope

The remedy for the littoral zone (from the shoreline to 30 feet water depth) includes a combination of sediment removal (dredging) and/or isolation capping to achieve sediment cleanup goals and the restoration of habitats. The selected remedy also includes habitat enhancement, which is an improvement of habitat conditions in areas where levels of CERCLA contaminants do not warrant active remediation, but where habitat impairment, due to stressors, has been identified as a concern. Habitat enhancement will be performed along an estimated 1.5 miles (2.4 km) of shoreline (Remediation Area B [SMU 3]) to reduce resuspension of Solvay Waste material and promote submerged vegetation in accordance with the ROD. Based on data collected since the ROD was released in 2005, habitat enhancement activities in SMU 5 may not be required due to the extensive growth of submerged vegetation in this area. Surveys conducted in 2008 of macrophyte coverage were provided in the habitat PDI data summary report. The four figures indicating overall coverage from July to October are included here as Appendix C.

The littoral zone remedy from the ROD includes dredging of sediment to remove mass and reduce contaminant concentrations within the ILWD, achieve favorable water depths for restoration of high quality habitat following placement of the isolation cap, and prevention of loss of lake surface area. The remedy also includes placing an isolation cap over a portion of the littoral zone, which will include a minimum 1-foot thick habitat layer as the upper portion of the cap.

The areas of dredging and/or capping have been refined since the ROD based on pre-design investigation data. The updated conceptual remediation areas are shown on Figures 3.1 and 3.2. Each of the areas shown in these figures will be subject to further refinement as the pre-design investigation and design progresses.

Dredging and/or capping in the shallow water adjacent to the shoreline is designed to remove and/or isolate contaminants and to achieve a post-capping water depth which promotes achievement of habitat-based goals. The cap thickness (including habitat material) along with the post-remedy water depth, were the main factors influencing the removal depth in areas outside the ILWD. Additionally, the representative biological communities and associated habitats have influenced the substrate type and thickness of the habitat layer.

Restoration strategies of the littoral and shoreline areas were evaluated for habitat suitability as well as their ability to provide stable conditions to limit resuspension and protect against erosion. The spatial extent of the nearshore areas and the process for determining post-capping habitat is discussed in more detail in Section 5 of this plan.

Hydraulic dredging operation

Additional dredging goals that were integrated into the habitat restoration strategy include dredging to cleanup criteria and dredging for removal of portions of the ILWD. Dredging to cleanup criteria refers to certain near-shore areas where the contamination will be removed via dredging to meet the ROD requirements without the use of an isolation cap. A habitat layer will be placed in the dredge to cleanup criteria areas just as it will be in all areas of remediation.

As specified in the ROD, an average dredge depth of 6.6 feet (2 m) of material will be removed from the area of the ILWD. The actual depth of dredging in the ILWD varies based on factors such as contaminant distribution and habitat and erosional considerations. An additional 3 feet (1 m) of ILWD material will be removed in areas defined as hot spots. The hot spot areas were defined by mapping the concentration of contaminants exceeding ROD-specified hot-spot criteria. Additional dredging of the ILWD may be performed to ensure geotechnical stability of the isolation cap.

Profundal Zone Remedial Scope

In the profundal zone (that is, in water depths of greater than 30 feet), organic contaminants and shallow mercury concentrations are much lower than they are in the littoral remediation areas. The remedy for the profundal sediment involves a combination of monitored natural recovery and thin layer capping to achieve the remedial objectives.

In addition, oxygenation and nitrate addition are being evaluated as potential methods for mitigating or reducing the formation of methylmercury in the deep water of the lake (hypolimnion) (Parsons 2009f). Methylmercury is a form of mercury that is more readily available to organisms in the water column and sediment, and is produced by bacteria in the absence of oxygen under sulfate-reducing conditions. These conditions are present in the lake during the summer stratification when the deep waters of the lake become anoxic and nitrate becomes depleted. As discussed in the SOW attached to the Consent Decree, an evaluation will be performed to determine if nitrate can effectively reduce formation of methyl mercury in the water column while preserving the normal cycle of lake stratification. A nitrate addition program will be implemented in lieu of oxygenation if NYSDEC determines from this evaluation that nitrate addition is effective and appropriate. The methods for adding nitrate and/or oxygen to the lake are still under evaluation and will be addressed in future design submittals.

These remedy efforts in both the littoral and profundal zones are expected to cause short-term (temporary) and long-term disturbances to habitat, but the overall result will be a more robust habitat supporting a wide variety of species.

Short-term Effects

A silt curtain reduces turbidity in the water, as shown in the above photo taken during the installation of the Willis IRM Barrier Wall. A curtain extends to the bottom of the lake to contain any resuspended material.

The ROD clearly states that the lake remedy will "not pose unacceptable short-term risks or cross-media impacts that cannot possibly be mitigated" (NYSDEC and USEPA, 2005, p. 82). Therefore, the remedial design is being prepared to decrease impacts due to the lake remedy in either the short- or long-term.

Short-term effects such as the complete removal of vegetation, resuspension of lake sediment, and an increased potential for erosion will most likely result from capping and dredging activities. Common best practices will be used to mitigate short-term effects associated with implementation of the lake remedy and may include silt curtains to decrease soil erosion, in addition to a monitoring program.

The installation of in-lake and shoreline structures is expected to cause a localized, temporary disturbance to vicinity habitat structures (*e.g.*, substrate, bathymetry, and aquatic plant beds) and their related functions (*e.g.*, aquatic invertebrate, fish, and wildlife habitat and sediment retention).

It is anticipated that implementation of the IRMs and other remediation activities may also cause temporary disturbances to vicinity habitat. For example, excavation of soil/substrate, which may be required to install a groundwater barrier wall and collection trench, remediate/restore wetlands, or implement other remedial measures, would result in temporary disturbance to habitat structure and functions (*e.g.*, wildlife habitat, flood attenuation, and sediment retention) during execution activities. Wetlands impacted by the remediation activities will be restored, reconstructed, or mitigated at another location based on consultations with the NYSDEC.

Other short-term impacts may include the temporary displacement of existing animal species at the construction site. Birds and fishes that may be temporarily displaced will be able to return to the restored habitats after construction. Honeywell will consider the timing of particular construction activities in order to protect the habitat requirements (such as breeding and/or nesting areas) for endangered species in and around the lake.

Long-term Effects

In addition to potential short-term impacts, the lake remedy will also have some long-term effects on habitats.

Long-term effects of the remedy in the remediation areas within the littoral zone are expected to include significant habitat benefits, including optimized water depths in nearshore areas, improved substrates for biota, and in-lake habitat structure (*e.g.*, large woody debris). These aquatic features will promote aquatic plant colonization and fish spawning, as well as increased area for benthic invertebrate colonization, and juvenile fish habitats.

The hatching of fish spawn is an indicator of a sustainable habitat.

Additionally, the integration of lake bottom and upland remediation/restoration will provide improved connectivity of nearshore littoral and adjacent shoreline areas, particularly wetlands. Along with improving the overall structure and functions of in-lake habitat, removing and/or isolating sediment impacted by contamination will greatly reduce the risks to ecological receptors.

Another positive long-term effect of the remedy includes the mitigation of wetlands that are not restored at their original locations, but are restored at a new location. This practice of creating new wetlands at another location ensures that no net loss of wetlands or wetland functions occurs. Mitigation requirements are addressed in more detail later in Section 3.4.

Other long-term effects may include change of substrate type, potential change in habitat type, alteration of shoreline bathymetry and alignment, and permanent removal of wetland habitats followed by subsequent restoration and mitigation of wetland acreage.

Best-management Practices

The lake remedy will contain specific examples of best management practices to mitigate risks and impacts to habitat associated with construction activities. These practices include the following:

- implementing controls to prevent the introduction or spread of non-native (exotic) or other undesirable species;
- implementing sediment resuspension control measures (*e.g.*, silt curtains), and monitoring for comparison to performance standards (to be developed);
- properly managing the transportation and disposal of remediation derived wastes;
- restricting sediment removal to specified areas and depths as per contract drawings and specifications;
- diffusing pumped water at an effluent discharge point to reduce water velocity and thereby prevent erosion and suspension of sediments;

- prohibiting equipment, material lay down, and soil stockpile areas in adjacent wetlands;
- prohibiting work-related activities such as anchoring in non-target wetlands and aquatic plant areas;
- covering, minimizing the size of, and expediting the removal of soil/sediment stockpiles from the floodplain;
- consideration of construction restrictions to avoid spawning, nesting, and breeding populations of endangered species;
- implementing erosion and sediment controls throughout the project;
- taking into consideration the size of the remedial work support area footprint to avoid excessive temporary habitat loss within and outside of the lake; and
- considering the schedule during the restoration of disturbed habitat to minimize temporal loss and disturbance.

Specific measures to minimize potential adverse effects that cannot be avoided will be evaluated and incorporated into the remedial design activities for the lake and other sites.

3.1 Onondaga Lake Bottom Remedy Expected Effects

Much of the lake remedy is focused on removing the impacts of hazardous substances that pose the risk of acute toxicity to the sediment-dwelling (benthic) organisms living on the lake bottom. Some remediation will extend beyond the lake to include the adjacent upland sites as part of the remedial design of these area, as well as shoreline areas. These areas are either included in the Habitat Plan design or they will be contiguous to the Habitat Plan boundary and addressed as part of an upland site design.

Canada geese preen on the shore of Onondaga Lake.

3.1.1 Shoreline/Wetlands

The substrates that will be placed during remediation will provide suitable near shore and shoreline conditions and moderate the transition from the lake to the adjacent shoreline habitats. As such, the long-term effects of the lake remedy are anticipated to provide improved connectivity of in-lake features with shoreline areas and adjacent wetlands.

Over 4 miles of shoreline will be addressed by the remedy, with the longest continuous areas in Remediation Areas, B (SMU 3) and D (SMU 1). In addition, approximately 34 acres of wetlands are located immediately adjacent to areas of the lake within the red line habitat boundary (Table 3.1). However, the full extent of impacts to these wetlands will be based on the results of ongoing investigations on Wastebed B/Harbor Brook (includes wetland SYW-12), Wastebeds 1 through 8 and Ninemile Creek (includes Wetland SYW-10).

Impacted wetlands will be restored or appropriately mitigated so that no net loss of wetlands or wetland functions occurs. Other impacts from staging areas, support areas, and the hydraulic dredging pipeline may also impact the shoreline.

3.1.2 Floodplain

The lake remedy is expected to cover the areas within the lake proper and do not include the floodplain. However, the floodplain will likely be affected by IRMs or other remediation sites as described in Sections 3.2 and 3.3. Other impacts from staging areas, support areas, and the hydraulic dredging pipeline may also impact the floodplain.

3.1.3 Littoral Zone (Remediation Areas A, B, C, D, E and F)

Dredging and/or isolation capping in the shallow waters of the lake will remove or cap existing substrates and associated biota (aquatic plants and benthic invertebrates) within the remediation areas. As previously discussed, the Remedial Design for dredging and/or isolation capping considers established habitat goals for representative biological communities and associated habitats, which are discussed in Section 4 of this Habitat Plan. Based on current information, approximately 408 acres of the littoral zone will be dredged and/or capped. Specific volumes of removal in these areas are discussed in more detail in the Cap and Dredge Area and Depth Technical Document (Parsons, 2009b).

Based on the aquatic plant mapping completed by Onondaga County in 2008, approximately 107 acres of aquatic plants were located within the remediation areas. The remaining 296 acres were described as unconsolidated bottom. These values differ from that in the ROD because these are estimates based on recent Pre-design Investigation data.

Expected Effects by Remediation Area

The use of SMUs to define areas within the lake has been updated with the more representative “remediation areas” as the lake remedy progresses out of the investigation phase into the design phase. In each remediation area, a combination of dredging and capping will have both short- and long-term impacts on habitat; however, the end result will be an improved habitat system. Changes in the lake bottom bathymetry will occur as a result of the remedy, and changes in water depth (pre- and post- remedy) are discussed in Section 5.1. A summary of dredge and/or cap areas is presented in the table below.

Remediation Area	Dredge To Cleanup Criteria (acres)	Dredge and Cap (acres)	Cap Only (acres)	Total Area Impacted by Remedy (acres)
A	6.5	17.1	59.9	83.5
B	0	2.9	13.2	16.1
C	2.0	4.9	18.6	25.5
D	0	89.2	9.3	98.5
D Addendum	0	0	5.6	5.6
E	10.8	73.0	100.8	184.6
F	0.6	0	0	0.6

Remediation Area A (SMU 4 and portions of SMUs 3 and 5)

In Remediation Area A, dredging will occur in approximately 24 acres near the shore. An isolation cap with habitat layer, or habitat layer only, will be placed over approximately 83.5 acres. Following placement of these materials, the resulting lake bottom will be deep enough to prevent a loss of lake surface area, protect the isolation cap from erosion, and to reestablish habitat.

Remediation Area B (portions of SMU 3)

In Remediation Area B, dredging will occur in approximately 3 acres near the shore. An isolation cap with habitat layer, or habitat layer only, will be placed over approximately 16 acres. Following placement of these materials, the resulting lake bottom will be deep enough to prevent a loss of lake surface area, protect the isolation cap from erosion, and to reestablish habitat.

Remediation Area C (SMU 2 and a small portion of SMU 3)

In Remediation Area C, dredging will occur in approximately 7 acres near the shore. An isolation cap with habitat layer, or habitat layer only, will be placed over approximately 24 acres. Following placement of these materials, the resulting lake bottom will be deep enough to prevent a loss of lake surface area, protect the isolation cap from erosion, and to reestablish habitat.

Remediation Area D (SMU 1 and small portions of SMUs 2 and 7)

In Remediation Area D, dredging will be performed to an average depth of 6.5 feet (2 m) plus hot spots over approximately 89 acres to prevent loss of lake surface area, reduce contaminant mass and average concentrations in sediments and/or wastes remaining under the isolation cap, for erosion protection, and to reestablish habitat. An isolation cap and habitat layer will be placed over the entire 98.5 acres in this area.

Remediation Area D - Addendum (Small portion of SMU 8)

In Remediation Area D Addendum area, an isolation cap and habitat layer will be placed over the entire 5.6 acres in this area.

Remediation Area E (SMUs 6 and 7)

In Remediation Area E, dredging will occur in approximately 84 acres near the shore. An isolation cap with habitat layer, or habitat layer only, will be placed over approximately 174 acres. Following placement of these materials, the resulting lake bottom will be deep enough to prevent a loss of lake surface area, protect the isolation cap from erosion, and to reestablish habitat.

Remediation Area F

Remediation Area F consists of two small areas (less than 1 acre combined area) where additional data collection is required to determine the most appropriate remedial approach, and will be addressed in future design submittals.

3.1.4 Profundal Zone (SMU 8)

A long-term goal of thin layer capping and monitored natural recovery to lake habitat includes reducing mercury concentrations in profundal sediments, thereby reducing mercury concentrations in biota (including fish). Because of the water depth (*i.e.*, greater than 30 feet {9 meters}), there are no aquatic plants located within the profundal zone.

Long-term effects of nitrate addition or oxygenation on the profundal zone are not certain at this time, but will be evaluated during the Pre-Design Investigation program and related design activities. An expected long-term effect associated with nitrate addition and oxygenation is the reduction of mercury methylation in the anoxic waters, resulting in a reduction in the methylmercury bioaccumulation in fish and other aquatic organisms. Oxygenation may improve habitat for coo water and/or coldwater species as well as benthic invertebrates, if provided in high enough concentrations (low levels of oxygenation will reduce methylation, but not provide suitable fish habitat). However, the overall effects of oxygenation on existing fish species and other parts of the food chain are uncertain given the complexities associated with lake biological communities.

The effects to biota mercury concentrations from colonization of the profundal zone are also uncertain. One possible effect caused by an increase in benthic invertebrates in profundal sediments may be a reduction in the rate of natural attenuation due to bioturbation and mixing of the surface sediments. Placement of a thin layer cap could bury the benthic community, if present. Recent sampling, however, indicates the near absence of benthic macroinvertebrates in profundal sediment (Parsons, 2004).

3.2 Interim Remedial Measures

3.2.1 Wastebed B/Harbor Brook IRM

Harbor Brook begins at a spring south of Onondaga Hill and meanders until it discharges into Onondaga Lake on the southwest shoreline. Near the shoreline the tributary is surrounded by Phragmites.

The Wastebed B/Harbor Brook IRM is focused on the shoreline area of the Wastebed B/Harbor Brook site, while the remainder of the site will be addressed as part of the overall site remedy. The Wastebed B/Harbor Brook area encompasses approximately 90 acres, which includes Harbor Brook, the Lakeshore Area, the Penn-Can Property, and the Railroad Area. For administrative purposes, the SYW-12 wetland is also covered under the Wastebed B/Harbor Brook site.

The Lakeshore Area (which is comprised of Wastebed B, the East Flume, Dredge Spoils Areas #1 and #2, the I-690 Drainage Ditch; as well as Wetland SYW-19 and Area of Study (AOS) #1)is shown on Figure 3.3. It is approximately 3,200 feet wide (east to west) and 800 feet deep (north to south) and is situated along the southern shore of Onondaga Lake, near the southwest corner of the lake. The area referred to as the Penn-Can property is to the south of the Lakeshore Area and south of I-690. This property has historically been utilized for the production and storage of asphalt products. The Railroad Area is situated to the south of the Penn-Can property and is bounded to the north, south, and east by railroad tracks. Habitats and biological communities for Harbor Brook and the Lakeshore Area are described in this section, below.

The objective of the Wastebed B/Harbor Brook IRM is to address contaminated groundwater and non-aqueous phase liquid (NAPL) discharges to Onondaga Lake and Harbor Brook. To accomplish this objective, a barrier wall and groundwater collection system will be constructed along the lakeshore. Furthermore, the IRM includes the installation of a groundwater collection system along the west bank of Harbor Brook extending approximately 400 feet upstream (south) of I-690. The scope for the IRM also includes the following items:

- removal of impacted sediment from the Harbor Brook, the I-690 drainage ditch, and other Harbor Brook tributaries;
- reconfiguration of the Lower Harbor Brook channel into a system of braided channels;
- upgrades to existing culverts; and
- grading and backfill of portions of Wastebed B to facilitate wall stability and site drainage.

Remediation of Wastebed B/Harbor Brook is also likely to include removal of contaminated soils/sediments in the wetland and upland areas between the proposed barrier wall and the lake (Figure 3.3). This work currently falls under the Wastebed B/Harbor Brook FS, but most likely will be conducted concurrently with the lake remediation adjacent to these areas. The Habitat Plan is intended to cover the restoration design for this area.

An Engineering Evaluation/Cost Analysis (EE/CA) for this area is also currently under evaluation to ensure it is addressed in parallel with the lake activities. The remaining scope of the remediation and restoration are to be outlined in the ROD for the Wastebed B/Harbor Brook site.

Habitats

Habitats associated with the Lakeshore Area of the site include aquatic (Harbor Brook, East Flume), wetland (SYW-19 and other delineated wetlands), and terrestrial habitats. NYS Wetland SYW-12, located in the northeast corner of the lake near the mouth of Ley Creek, was recently incorporated into the RI/FS scope of the Wastebed B/Harbor Brook. The habitats associated with Wetlands SYW-12 and SYW-19, Harbor Brook, and the East Flume were detailed previously. Habitats associated with the remainder of the site (Penn-Can property and Railroad Area) are not immediately adjacent to the lake, and will be addressed as part of the Wastebed B/Harbor Brook site documents.

Moisture Matters

Different Habitat Types Have Different Moisture Regimes:

Aquatic: an area that is under water the majority of the year

Wetland: an area that is inundated with shallow water, or saturated at or near the ground surface for long periods during the growing season

Terrestrial: land that is not saturated at or near the surface

Biological Communities

The biological communities expected to be found in cover types surrounding Onondaga Lake, including the Wastebed B/Harbor Brook area, were discussed in Sections 2.3 and 2.4. The wetland habitat and predominant plant communities associated with Wetlands SYW-12 and SYW-19 were discussed in Section 2.3.3. Biological communities observed in and along the banks of Harbor Brook were discussed in Section 2.4.

Expected Effects of Remedial Activities

Potential short-term impacts from this IRM scope are likely to include removal of soils and associated benthic communities, removal of *Phragmites*, and interruption of flow in Harbor Brook. Installation of the barrier wall and groundwater collection system will result in loss of wetland area(s) and cutting off wetlands from the lake. However, mitigation for wetlands impacted by the barrier wall will be completed such that there is no net loss of wetlands or wetland functions. Other elements of the IRM that will affect habitat restoration are the filling in of a portion of SYW-19, the reconfiguration of Harbor Brook into a braided channel system, and the removal of groundwater inputs to the remainder of the wetland.

A long-term result of the IRM is that the migration of contaminated groundwater and NAPL to the lake will be controlled and risks to ecological receptors will be significantly reduced. Other long-term effects of the IRM will include the removal of wetland acreage, restoration of wetland in new locations, alteration of groundwater inputs to the remaining wetland, the alteration of shoreline alignment, potential limitations on shoreline use, reconfiguration of Harbor Brook, and potential changes to the remaining wetland lakeside of the barrier wall. See Figure 3.6 for a summary of wetland impacts in this area.

3.2.2 East Flume IRM

The 95% Basis of Design Report for the East Flume IRM (O'Brien & Gere, 2004d) describes the original anticipated scope for the IRM.

Since the submittal of this report, the alignment of the Willis/Semet IRM barrier wall and Wastebed B/Harbor Brook barrier wall have been modified to reflect additional information collected as part of Onondaga Lake and Wastebed B/Harbor Brook pre-design investigation activities (Figure 3.3). The adjustment of these wall alignments, and the associated modifications to the IRM scopes (*e.g.* backfilling and regrading), will address the objectives identified in the Consent Order for the East Flume IRM.

The two primary objectives of the IRM are to (1) eliminate potential impacts to fish and wildlife, and (2) eliminate the transport of contaminants from the East Flume sediments to Onondaga Lake.

Final alignment of the barrier wall near the East Flume is identified on Figure 3.3. Areas inboard of the wall will be filled and outboard areas will be restored as wetlands.

Habitats

Geotextiles are permeable fabrics that have the ability to separate, filter, reinforce, protect, or drain when used in association with soils.

In 1977, the Upper East Flume was reconstructed to serve as a holding pond for the process cooling waters prior to their entry into a thermal diffuser and subsequent discharge to the lake. The upper portion was widened to a maximum width of approximately 150 feet and deepened to a maximum depth of approximately 6 feet. The bottom (substrate) of the Upper East Flume is constructed of crushed stone underlain by a geotextile. At the eastern end of the Upper East Flume are the thermal diffuser building (now the new groundwater pumping station) and a dam originally constructed to allow cooling water to flow when the diffuser pumps were turned off. The dam and a berm to the north separate the Upper East Flume from the Lower East Flume (described below) and Onondaga Lake, respectively (O'Brien & Gere, 2002).

The Lower East Flume is a narrower channel that is approximately 25 feet wide with water depths of 3 to 4 feet. The Lower East Flume meanders to the south and east and discharges to Onondaga Lake. The Lower East Flume is not specifically classified by NYSDEC, therefore, it receives the classification of the surface water to which it discharges (Onondaga Lake, Class C). The source of water in the Lower East Flume is primarily water from the Upper East Flume and, to a lesser degree, groundwater. The Lower East Flume discharges to Onondaga Lake near the north-central portion of the Wastebed B/Harbor Brook Site. The substrate of the Lower East Flume is primarily unvegetated sediment. Organic sediments, approximately 2 feet deep (2.3 feet measured maximum), are underlain by solidified Solvay waste (O'Brien & Gere, 2002). Sediments in the Lower East Flume will be remediated as part of the Outboard Area portion of the Wastebed B/Harbor Brook site.

O'Brien & Gere performed a survey of the East Flume for wetland characteristics in September 2003. Wetland habitat totaling approximately 1 acre, was delineated along the fringe of the Upper East Flume (O'Brien & Gere, 2004b). The outer boundary of the wetland is defined by the banks of the flume, and the inner boundary is defined by the presence of plants living in the water (hydrophytic vegetation), predominantly *Phragmites*.

Phragmites ***is an invasive species that has overgrown a large portion of the native vegetation around Onondaga Lake and its tributaries.***

Remediation designs include methods to remove this species and replace with native species.

Biological Communities

The bottom of the East Flume is primarily unvegetated, while the banks are vegetated predominantly with *Phragmites*. The existing biological characteristics of the East Flume were qualitatively assessed as part of efforts performed for the Harbor Brook Site Ecological Risk Assessment Problem Formulation Document (O'Brien & Gere 2004). Given the proposed remedial action for this area, additional characterization of the biological communities is not required.

Expected Effects of Remedial Activities

As design activities and restoration strategies for the East Flume are still under development, the final scope of the East Flume IRM and the resulting effects on habitat remain undefined at this time. However, it is likely that the existing biological communities of the Upper and Lower East Flume will be at least temporarily impacted as part of the IRM activities. However, the result of the mitigation and restored wetlands will be a more suitable habitat for many of the representative species.

3.2.3 Willis/Semet IRM

The site has been, and continues to be, used primarily for access to the Wastebed B/Harbor Brook Site and to the various utilities which run through the site. The Upper East Flume and wetlands around the East Flume are also areas affected by this IRM. The objective of the Willis/Semet IRM is to address groundwater and dense non-aqueous phase liquid (DNAPL) discharges from the two sites to Onondaga Lake. To accomplish this objective, a groundwater treatment plant has been constructed on the Willis Avenue Site, and a barrier wall and collection system has been constructed along the lakeshore, or up to approximately 100 feet into the lake down gradient of the two sites, as shown in Figure 3.3. To date, the northern-most quarter-mile stretch of the IRM barrier wall (referred to as Semet portion), with the accompanying groundwater collection trench, has been installed in the narrow section of land between Onondaga Lake and I-690. This area is a narrow grassy right-of-way area for Onondaga County and other utilities. The Willis portion of the barrier wall has been installed just off the shoreline of the lake and lightweight fill has been placed behind the wall. The collection trench for the Willis portion of the wall is scheduled to be completed during the late summer of 2009.

A portion of the Willis-Semet barrier wall is installed along the lakeshore.

Based on an investigation of the extent of NAPL in the nearshore lake sediments, the barrier wall alignment for the Willis portion of the barrier wall has been repositioned into the lake to contain NAPL areas. Approximately 2.3 acres of open water from the lake was filled in with light-weight fill behind the Willis portion of the barrier wall. Following completion of the groundwater collection trench and DNAPL extraction system, the causeway bridge will be removed, leaving the pilings supporting the existing utilities in place, and the area behind the barrier wall will be graded to an elevation consistent with the upland grade.

The utility bridge is being dismantled and the rip-rap shoreline is being planted and restored as an additional mitigation requirement for the Willis IRM barrier wall. To date, the following vegetation has been planted along the shoreline: Pussy willow (salix discolor), burr oak (Quercus macrocarpa), American sycamore (Platanus occidentalis), common spicebush (Lindera benzoin), and red maple (Acer rubrum). Planned restoration includes both an upland conservation seed mix and a wetland conservation seed mix.

Newly restored shoreline along the Willis IRM barrier wall

The finished slope in this area will be a combination of restored upland, naturalized shoreline and deep water nearshore to enhance public access and fishing opportunities. Completion of the IRM will incorporate other elements such as placement of topsoil, and restoration in accordance with the restoration mitigation design. Compensatory mitigation for the loss of 2.3 acres of lake surface area resulting from the wall installation will also be required at the Wastebeds 1 through 8 site (Figure 3.4). Based on the current Wastebed B/Harbor Brook barrier wall alignment, the design will provide 4.7 acres of inland wetlands along the eastern shoreline of the Wastebeds 1-8 site. Section 5 contains a discussion of the preliminary design of the restored shoreline lake ward of the barrier wall and the preliminary design of the mitigation.

Habitats

The Willis/Semet IRM affects the shoreline and near shore area of Onondaga Lake. The primary habitat associated with this area is the lake area (littoral habitat) to be encompassed by the portion of the barrier wall that is off-shore and the adjacent shoreline area. Onondaga Lake's littoral habitat is broadly described in Section 2.3. Presently, the predominant features of the lakeshore in this area are a riprap embankment for erosion protection and a concrete utility bridge (*i.e.*, causeway). This area does provide habitat for submerged aquatic vegetation, and the area tends to be favored by waterfowl.

Biological Communities

The biological communities include species that inhabit the shallow portions of Onondaga Lake and its shoreline. The biological communities expected to be found within Onondaga Lake and in cover types surrounding the lake are discussed in Section 2.4.

Expected Effects of Remedial Activities

A significant long-term effect associated with the Willis portion of the IRM is the conversion of an estimated 2.3 acres of aquatic habitat to terrestrial habitat resulting from placement of the barrier wall off-shore. The details of this design are still being developed, however, Honeywell will replace aquatic habitat lost as a result of the IRM along the shoreline of the Wastebeds 1 through 8 site. As a result of the complete IRM, mobile NAPLs in Remediation Area D (SMUs 1 and 2) will be contained behind the barrier wall reducing risks to ecological receptors. Other long-term effects known to impact habitat will be the creation of new shoreline (lake ward of the wall), temporal loss of shoreline habitat, and cut-off groundwater flow (along the barrier wall) to Onondaga Lake.

Short-term effects will include the temporary displacement of open water and wetland habitats during construction.

3.3 Other Remediation Sites

3.3.1 Ninemile Creek Dredge Spoils Area

The Ninemile Creek Dredge Spoils Area Site consists of 19 basins situated along the northwest shore of Onondaga Lake between Ninemile Creek and the lake outlet at the Seneca River, as shown in Figure 3.5. The basins were created between 1966 and 1968 to accommodate material dredged from the Ninemile Creek delta and sediment from the nearshore area between Ninemile Creek and the lake outlet, although many of them may not have been used for this purpose. The site is currently used by the public as a recreational area for walking, jogging, biking, cross-country skiing, etc. The Onondaga County Parks Department maintains paths at the site, which consist of paved and stone surfaces. Some of these paths are located on top of the berms associated with the basins.

The Ninemile Creek Dredge Spoils Area was investigated in 2000 as part of the Onondaga Lake RI/FS. A PSA was conducted at the site in 2004 and 2005, and a data summary was submitted to NYSDEC in September 2005. Compounds identified in the basins, including those outside of the delineated wetland boundaries, are discussed in the PSA Data Summary Report (O'Brien & Gere, 2005). The scope of any additional investigation or remedial actions at this site is currently undefined.

Habitats

The primary habitats associated with the Ninemile Creek Dredge Spoils Area are those associated with Wetland SYW-6, including emergent and forested wetlands and adjacent *successional old field* areas. The habitat conditions for Wetland SYW-6 are detailed in Section 2.3.3.

Biological Communities

The biological communities expected to be found in the vegetative cover types surrounding Onondaga Lake are discussed in Section 2.4. The predominant plant communities associated with Wetland SYW-6 are discussed in Section 2.3.3.

Expected Effects of Remedial Activities

The scope of any additional investigation or remedial actions at this site is currently undefined; therefore, the effects of remedial activities (if necessary) on habitat is uncertain.

3.3.2 Wastebeds 1 through 8

The Wastebeds 1 through 8 site is located on the southwestern side of Onondaga Lake and extends north to the mouth of Ninemile Creek and south to approximately Ditch A located near the I-690 off-ramp, as shown in Figure 3.4. The irregularly shaped beds extend roughly 1.5 miles along the shoreline to a maximum width of 0.5 miles and cover approximately 315 acres. The surface elevations of the site range from 363 to 430 feet (NAVD 88).

Wastebeds 1 through 8 are located along the southwestern and western shorelines of Onondaga Lake.

The wastebeds were constructed over a portion of the former Geddes Marsh, which was reclaimed from Onondaga Lake when the lake level was lowered (BBL, 2001). They are composed of perimeter dikes that were constructed of piles, sheeting, or earth depending on location. These dikes were used to contain waste materials (primarily Solvay waste) which consist largely of calcium carbonate, gypsum, sodium chloride (salt), and calcium chloride (O'Brien & Gere, 2005). These wastes were generated at the former Main Plant as part of soda ash production using the Solvay Process method.

Wastebeds 1 through 6 were in use before 1926 and may have begun use as early as 1916, although no definitive construction date is available. The construction of Wastebeds 5 and 6 required the diversion of Ninemile Creek, which was rerouted to the north around the perimeter of Wastebed 6. Wastebeds 7 and 8 were not utilized until after 1939 and remained in use with Wastebeds 1 to 6 until 1943 (BBL, 2001). After 1944, Wastebeds 1 through 8 were used for disposal various materials from Crucible Specialty Metals, Inc. in a permitted landfill, disposal of municipal sewage sludge by Onondaga County, and as a parking lot for the New York State Fairgrounds. The site, which was deeded to the people of New York in 1953, is currently owned by the State of New York and Onondaga County (Calocerinos & Spina, 1986). Onondaga County is planning to construct two miles of paved Class 1 trail on the West Shore of Onondaga Lake from the present trail end at Ninemile Creek to the State Fair parking lots near I-690 Exit 7 using Wastebeds 1 through 8.

A PSA was conducted in 2004 followed by an RI in 2006/2007 for this site. Supplemental RI activities, including further evaluation of site soils and the former Ninemile Creek sand-and-gravel unit, are currently underway. In addition, field activities to evaluate groundwater in the Marl unit along the eastern shoreline were conducted in 2008 and 2009 in support of Focused Feasibility Study for the site. Future remedial actions at this site have yet to be defined.

Habitats

O'Brien & Gere performed a wetland boundary delineation and floodplain assessment at the Wastebeds 1 through 8 site and is currently preparing a BERA in accordance with the *Wastebeds 1 through 8 Focused Remedial Investigation Work Plan* (O'Brien & Gere, 2005). Findings from the wetland/floodplain assessment are reported in the *Wetland Delineation and Floodplain Final Report for the Wastebeds 1 through 8 Site* (O'Brien & Gere, 2009) and are summarized below.

A portion of the site is used as a parking lot during NYS Fairground activities, while the rest of the site is currently vegetated (O'Brien & Gere, 2006). The exceptions to this are the Wastebed slopes along the shoreline of Onondaga Lake and east of the mouth of Ninemile Creek that contain exposed Solvay waste and minimal vegetation. Dominant terrestrial cover types on the site were identified as *successional northern hardwood* and *successional old field*. An aquatic cover type identified on the site was *ditch/artificial intermittent stream*. *Confined river* (Ninemile Creek) and *eutrophic dimictic lake* (Onondaga Lake) are the two dominant aquatic cover types that are identified adjacent to the site. Two small areas of wetland totaling 0.7 acre were delineated on the low-lying area of Wastebeds 1-8.

Biological Communities

A large portion of the site is characterized as *successional old field* and contains significant stands of common buckthorn (*Rhamnus cathartica*) and goldenrod (O'Brien & Gere, 2006). *Phragmites* was observed at many upland locations at the site. Vegetation on the general lakeshore area is dominated by *Phragmites,* which is also present on the Wastebed slopes (O'Brien & Gere, 2006). The general lakeshore area also contained an additional mix of wetland and upland vegetative species. Biological communities expected to be found in cover types surrounding Onondaga Lake are discussed in Section 2.4 of this Habitat Plan.

Expected Effects of Remedial Activities

Additional investigation of the low-lying area along the lake is currently ongoing. The scope of any additional investigation or remedial actions at this site is undefined; therefore, the effects of remedial activities on habitat is uncertain. Temporary impacts to the existing biological communities of Ditch A are likely as a result of the remedial efforts at the site. However, habitat restoration will be conducted at the site following completion of remedial activities.

3.3.3 Wastebed B/Harbor Brook

View of Wastebed B/Harbor Brook adjacent to I-690 and the railroad tracks

The RI/FS is currently in progress for Wastebed B/Harbor Brook (Figure 3.6). The scope of any additional remedial actions and resulting habitat effects outside the IRM scope at this site are currently undefined. Habitat restoration activities at this location will be integrated with the Habitat Plan as the design efforts progress.

Habitats

Habitats associated with Wastebed B/Harbor Brook are discussed in Section 3.2.1.

Biological Communities

Biological communities associated with Wastebed B/Harbor Brook are discussed in Section 3.2.1.

Expected Effects of Remedial Activities

The scope of remedial actions at this site is currently undefined, therefore the effects of remedial activities on habitat is uncertain.

3.3.4 Geddes Brook/Ninemile Creek

The *Geddes Brook/Ninemile Creek Feasibility Study Report* (FS) (Parsons, 2005) presents a variety of channel and floodplain alternatives for the site. Since submittal of that FS, the site has been organized into two operable units (OUs)—OU-1 and OU-2. In addition, a number of supplemental site investigations and assessments have been conducted. Based on these recent investigations and assessments, a Supplemental FS was prepared for both OU-1 in November 2008 (Parsons, 2008) and OU-2 in May 2009 (Parsons, 2009). NYSDEC and the USEPA also issued a Proposed Plan for OU-1 in November 2008 (NYSDEC/USEPA, 2008). The remedy recommended by both the OU-1 Supplemental FS and the OU-1 Proposed Plan is based on a better understanding of site conditions, opportunities for tailoring the remedy to site-specific features, and synergies between site remediation and habitat enhancement opportunities. A ROD was issued for OU-1 on April 29, 2009 (NYSDEC/USEPA, 2009).

Mouth of Ninemile Creek

Remedial alternatives under consideration for the remediation of Ninemile Creek include removal of impacted sediment within the channel and floodplain and contiguous wetland areas, followed by capping and/or habitat restoration. There is some overlap of the Onondaga Lake Remedy and the Habitat Plan with this site as Ninemile transitions into the lake. The remediation of sediments in the most downstream portion of Ninemile Creek (approximately 300 feet) is being addressed under the lake remedy. The habitat restoration in this overlap area may also be determined in part by the design for both sites. Even though much of this site actually occurs outside of the habitat restoration boundary, it is likely that the remediation may impact the lifecycles of various representative species.

The remediation of Geddes Brook has been outlined in a separate IRM to address impacted sediment and floodplain soils associated with the lower Geddes Brook. The scope of the IRM will include the removal of impacted sediments within the Geddes Brook channel and culverts. Additionally, removal of impacted floodplain soils and wetland sediments associated with Geddes Brook will be conducted in accordance with the ROD for Ninemile Creek.

Habitats

Habitats associated with the Geddes Brook/Ninemile Creek site are primarily associated with Ninemile Creek and the adjacent riparian corridor, including Wetlands SYW-18 and SYW-10.

Biological Communities

Biological communities associated with the Geddes Brook/Ninemile Creek site are primarily those associated with Ninemile Creek, discussed in Section 2.3.5, and the adjacent Wetland SYW-10, discussed in Section 2.3.3.

Expected Effects of Remedial Activities

The benthic zone includes the sediments that often house organisms called benthic macroinvertebrates.

The removal of soil/sediment would temporarily impact the existing benthic macroinvertebrate and terrestrial species in the area, and indirect effects may be experienced by fish that forage in the affected area due to temporary disruption of the benthic food web. Studies of benthic recolonization indicate that recovery occurs within one to three years.

These short-term impacts will be offset by the positive long-term effects of a clean cover system or backfill materials for benthic habitat. In addition, forested areas in the floodplain and wetland would be impacted by the removal of trees and soil/sediment. Some of the impacts would be temporary, while the re-establishment of mature trees would take longer. Although it would take many years for the trees to reach mature size, some wetland functions would be partially restored immediately following remediation (*e.g.*, nutrient removal), and the long-term benefits associated with the remediation and enhancement of the forested wetland and other portions of OU 2 are anticipated to offset the relatively shorter term impacts associated with the re-establishment of mature trees (Niemi *et al*., 1990). Refer to the Geddes Brook/Ninemile Creek ROD for more details regarding the remedial approach for the forested wetland.

3.4 Mitigation Requirements

Willis IRM Barrier Wall

Native plants like this White spruce were planted along the lakeshore as part of an event for Earth Day.

The two components of the Willis Wall IRM Restoration/Mitigation scheduled to be completed by the fall of 2009 include mitigation of the Semet Shoreline Area and restoration in the Willis Wall IRM Design Section 4 areas (Figure 3.3). The Design Section 4 portion of the Willis Wall includes the in-lake portion in the eastern area of SMU 2 and western area of SMU 1. Mitigation of the Semet shoreline area entails shoreline enhancement including the placement of topsoil over the existing riprap embankment and the establishment of a native plant community using upland and shoreline plantings and seeding. The Design Section 4 restoration includes amending the top 0.5 feet of light-weight fill with organic material (e.g. addition of compost, mulch, or biosolids), placing 0.5 feet of topsoil, and establishing native upland and shoreline vegetation communities by plantings and seeding. In addition, the barrier wall will be cut down to the final elevation of 365 feet (NAVD 1988).

Additional mitigation for the loss of 2.3 acres of open water in the lake due to the construction of the Willis IRM barrier wall will be conducted at the Wastebeds 1-8 site (Figure 3.6). A conceptual design for this mitigation was submitted to NYSDEC in November 2008 and consisted of the construction of a connected wetland along the shoreline. Future design submittals for this mitigation will be integrated with other considerations for the remedial approach for this part of the Wastebed 1-8 site.

Wastebed B/Harbor Brook IRM Barrier Wall

The Wastebed B/Harbor Brook IRM barrier wall will be installed near the shoreline in this area.

The placement of the IRM barrier wall along the lake shoreline near Wastebed B and Harbor Brook will have temporary and permanent impacts to the habitat at the site. The wall alignment bisects the site and creates two separate areas—the "inboard" area is that portion on the landward side of the wall, and the "outboard" area lies between the wall and the lake. The wall will displace some wetlands areas along the shoreline and alter open water areas. Figure 3.6 illustrates the existing conditions near the Wastebed B/Harbor Brook site. Currently, there are approximately 13.0 acres of wetlands, 2.3 acres of open water (East Flume and the Harbor Brook channel), and 8.5 acres of upland within the habitat plan boundary.

The current wall alignment will bisect this area and alter the distribution of the existing habitats (Figure 3.7). Design constraints also require that the wall be supported by a certain amount of material outboard of the barrier wall to maintain its stability. The alignment of the wall and the necessary engineering requirements will result in a net loss of approximately 0.5 acres of wetlands. Wetland mitigation will be required in this area at a ratio 2:1 to address filling of approximately 4.2 acres of existing wetlands behind the barrier wall. The 2.3 acres of open water area from the East Flume and Harbor Brook will be restored outside the wall alignment to ensure no net loss of open water. The remediation and restoration of the area outboard of the barrier wall is expected to take place at the same time as the adjacent remediation in the lake.

In the event that the final design of the Wastebed B/Harbor Brook IRM barrier wall design results in a net loss of wetland acreage, mitigation for those impacts in the form of additional wetland acreage will be conducted in the shoreline area of the Wastebeds 1-8 site. The design for this mitigation will be integrated with the remedy for the Wastebeds 1-8 site and other mitigation proposed in this area.

3.5 Summary of Habitat Areas to be Affected by Remediation Activities

Habitat areas to be affected by remedial activities associated with the lake bottom, IRMs, and other sites include aquatic, shoreline/wetland, and terrestrial habitats. Aquatic habitats include portions of the littoral and profundal zones within Onondaga Lake, as well as tributaries, such as Geddes Brook, Ninemile Creek, and Harbor Brook, and industrial conveyances, such as the East Flume. Wetland habitats situated along Onondaga Lake's shoreline to be affected by remedial activities include State regulated Wetlands SYW-10, SYW-12, and SYW-19. Terrestrial habitats to be affected by remedial activities are associated with the floodplain and upland portions of the IRMs and other site remedies.

TABLE 3.1

Preliminary Estimate of Areas Impacted by Onondaga Lake Remedy

Remediation Area[2]	General Location	Total Acreage of Remedation Area [5]	Shoreline Impacted by Remedy (feet) [4]	Wetland Areas within Habitat Plan Boundary (acres) [6]	Vegetated Areas (Acreage) [1, 3]	Unvegetated Areas (Acreage) [1, 3]
A	SMU 4	83.5	850.1	2.1	22.7	60.8
B	SMU 3	16.1	693.0	0.7	0.4	21.1
C	SMU 2	25.5	1470.0	0.0	2.9	22.6
D	SMU 1	98.5	5002.0	5.8	9.9	88.6
D Addendum	SMU 8	5.6	NA	0.0	0.0	5.6
E	SMU 6/7	184.6	4773.0	25.5	73.1	111.5
F	SMU 5	0.6	0.0	0.0	0.4	0.2
TOTALS		414.4	12788.1	34.1	109.3	305.1

NOTES:
NA - Not Applicable
SMU - Sediment Management Unit

REFERENCES:

1. EcoLogic (2009) *Onondaga Lake Ambient Monitoring Program, 2008 Annual Report* . Prepared for Onondaga County, New York.
2. Final areas of remediation to be determined during future discussions between Honeywell and NYSDEC.
3. Conditions are variable and vegetated areas should be considered a snapshot in time
4. SMU 3 - ROD identifies 1.5 miles of habitat enhancement.
5. SMU 5 - ROD identifies 23 acres of habitat enhancement; but may not be required
6. Areas are based on NYSDEC wetlands that are contiguous with the Onondaga Lake shoreline. All of these areas may not require remediation

TABLE 3.2

Wetland, Open Water, and Upland Acreage Assessment Within the Habitat Plan Boundary
Adjacent Shoreline Areas

Area	Type	Approximate Area Inboard of the IRM Barrier Wall Within the Habitat Boundary (Acres)[4]	Approximate Area Outboard of the IRM Barrier Wall Within the Habitat Boundary (Acres)	Type of Disturbance and Restoration
Wastebed B/Harbor Brook Area (1) (2) (3)				
WL1 (east of HB)	Wetland	1.0	5.8	Excavation of soil and placement of new substrate
WL2 (west of HB)	Wetland	2.3	0.7	Regrading (behind wall) and excavation of soil with placement of new substrate
WL3 (east of EF)	Wetland	0.0	1.7	Regrading (behind wall) and excavation of soil with placement of new substrate
WL4 (west of EF)	Wetland	0.0	0.5	Regrading (behind wall) and excavation of soil with placement of new substrate
WL7 (UEF fringe)	Wetland	0.9	0.1	Regrading (behind wall) and excavation of soil with placement of new substrate
Harbor Brook	Open Water	0.3	0.3	Realignment of Harbor Brook channel though new wetland complex
East Flume	Open Water	1.3	0.4	Backfilling of East Flume with placement of new substrate
Remaining Upland	Upland	1.5	7.0	Limited removal/regrading and placement of new substrate
Existing Wetlands		4.2	8.8	
Existing Open Water		1.6	0.7	
Existing Upland		1.5	7.0	
Total Existing		7.3	16.5	
Proposed Wetlands		0.0	12.5	
Proposed Open Water		0.0	2.3	
Proposed Upland		7.3	1.7	
Total Proposed		7.3	16.5	
Permanent Wetland Loss		4.2	0.0	
Permanent Open Water Loss		1.6	0.0	
Total Permanent Loss		5.8	0.0	
Temporary Loss of Wetlands		0.0	8.8	
Temporary Loss of Open Water		0.0	0.7	
Total Temporary Loss		0.0	9.5	

Acreage Summary

Existing Wetlands Inboard = 4.2
Existing Wetlands Outboard = 8.8
Total = 13.0

Proposed Wetlands Inboard = 0.0
Proposed Wetlands Outboard = 12.5
Total = 12.5

Mitigation Required at Wastebeds 1-8

Existing - Proposed acreage at WBB/HB area = 0.5 Acres
Acreage for 2:1 mitigation ratio behind barrier wall = 4.2 Acres
Total Mitigation = 4.7 Acres

(1) The eastern end of WL1 is extends beyond the Honeywell property; therefore, this area was not used in these calculations.
(2) Other wetlands on the BBB/HB site (WL5, WL6, and wetlands in Penn-Can and Railroad Areas) are not included herein since it is not expected that the barrier wall will impact these areas.
(3) 0.4 acres of WL7 is located outside the habitat plan boundary, but has been included here since it will be impacted by the IRM barrier wall.
(4) Acreage of permanent wetland loss inside the barrier wall will be mitigated at a ratio of 2:1.

TABLE 3.2 (Continued)
Wetland, Open Water, and Upland Acreage Assessment Within the Habitat Plan Boundary
Adjacent Shoreline Areas

Area	Type	Approximate Area Within the Habitat Boundary (Acres)	Type of Disturbance and Restoration
Wastebeds 1-8 Area	Wetland	0.7	0.7 acres of inland wetlands
	Upland	31.1	2.3 Acres of Connected Wetlands
			4.7 Acres of Inland Wetlands
			24.1 Acres of Vegetative Cover
Ninemile Creek Area	Wetland	2.1	Connected Wetlands
	Upland	0.2	0.2 Acres of Upland
	Open Water	0.2	0.16 Acres of Open Water
SYW-12 Area	Wetland	18.3	TBD [1]
	Upland	20.9	TBD [1]

Existing Wetlands	21.1	
Existing Open Water	0.0	
Existing Upland	52.2	
Total Existing	73.3	
Proposed Wetlands	TBD [1]	
Proposed Open Water	0.2	
Proposed Upland	TBD [1]	
Total Proposed	TBD [1]	
Permanent Wetland Loss	TBD [1]	
Permanent Open Water Loss	0.0	
Total Permanent Loss	TBD [1]	
Temporary Loss of Wetlands	TBD [1]	
Temporary Loss of Open Water	0.2	
Total Temporary Loss	TBD [1]	

(1) Pending resolution of remedial approach in this area.

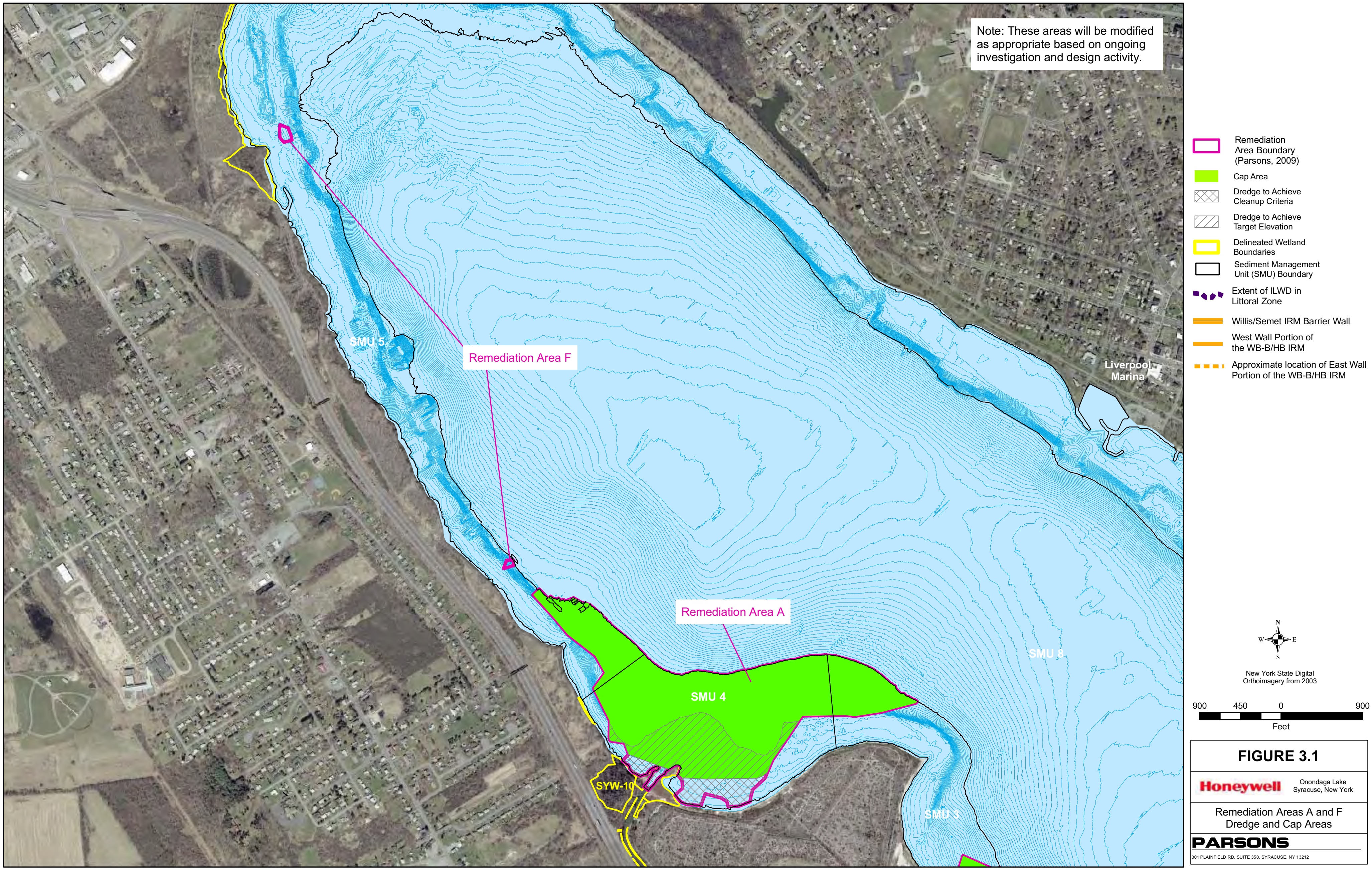


FIGURE 3.1

Honeywell

Onondaga Lake
Syracuse, New York

Remediation Areas A and F
Dredge and Cap Areas

PARSONS

301 PLAINFIELD RD, SUITE 350, SYRACUSE, NY 13212

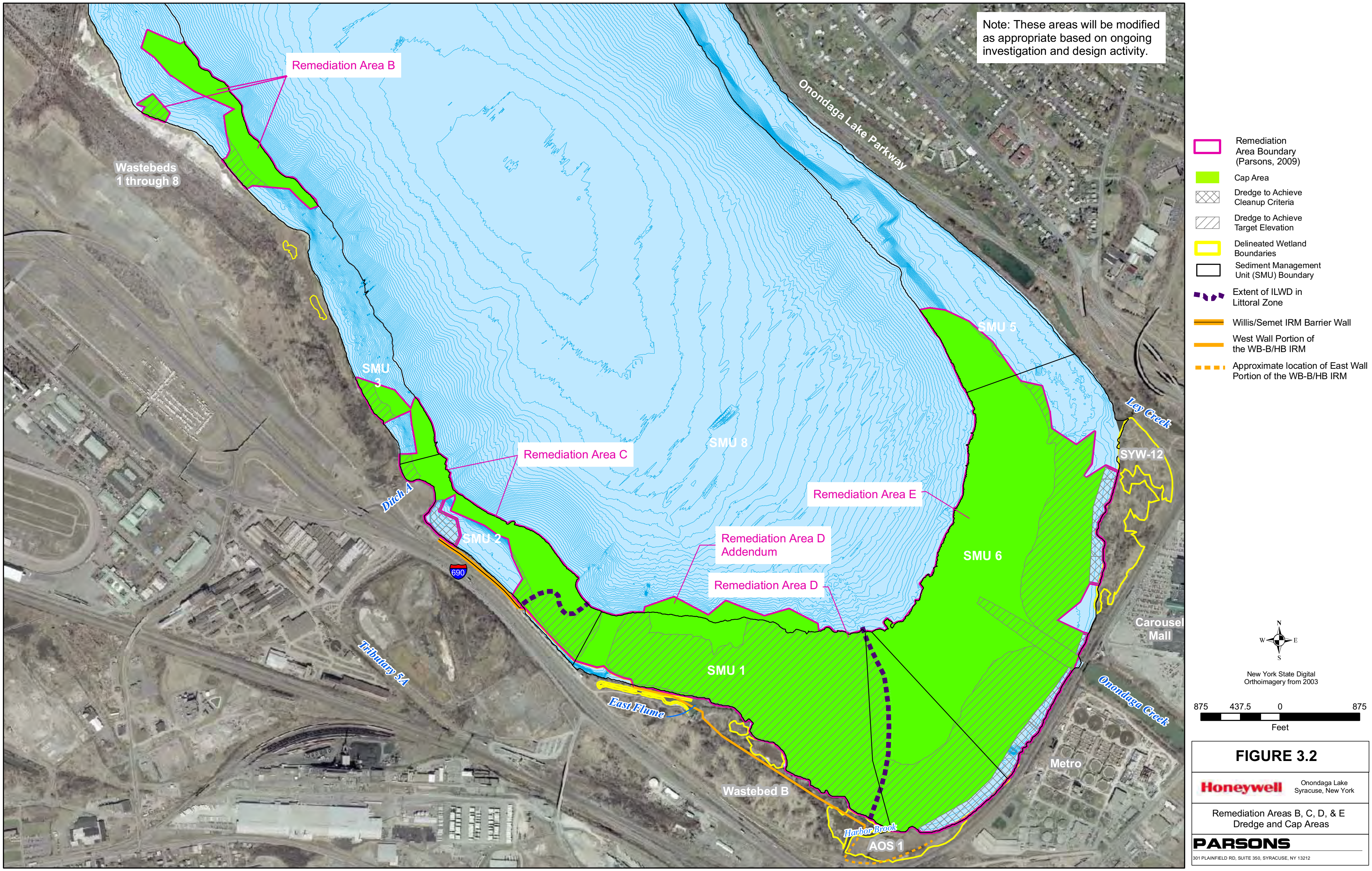


FIGURE 3.2

Honeywell — Onondaga Lake, Syracuse, New York

Remediation Areas B, C, D, & E
Dredge and Cap Areas

PARSONS
301 PLAINFIELD RD, SUITE 350, SYRACUSE, NY 13212

FIGURE 3.3

Honeywell

Onondaga Lake
Syracuse, New York

Willis-Semet, East Flume, and Wastebed B/Harbor Brook IRMs

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

Remediation Area Boundary (Parsons, 2009)

Sediment Management Unit (SMU) Boundary

Wastebeds 1-8 Site

NYSDEC Wetlands (NYSDEC, 2007)

NYSDEC/EPA Approved Wetland Boundaries

1,100 550 0 1,100

Feet

FIGURE 3.4

Honeywell

Onondaga Lake
Syracuse, New York

Wastebeds 1-8 Area

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

Remediation Area Boundary (Parsons, 2009)

Sediment Management Unit (SMU) Boundary

Dredge Spoils Area (DSA)

NYSDEC Wetlands (NYSDEC, 2007)

Delineated and Approved Portion of NYSDEC Wetland

1,200 600 0 1,200

Feet

FIGURE 3.5

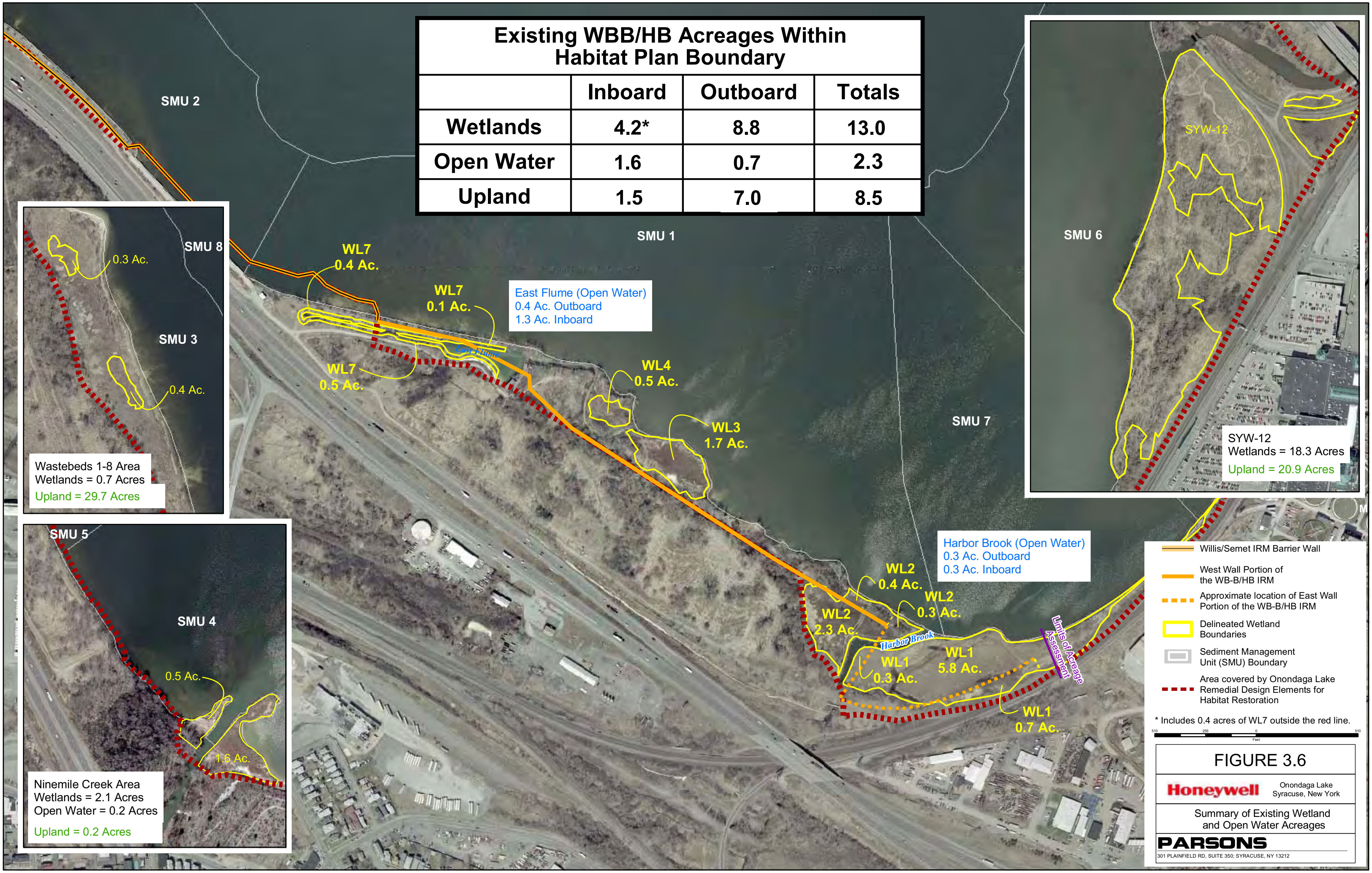
Honeywell

Onondaga Lake
Syracuse, New York

Dredge Spoils Area

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



Existing WBB/HB Acreages Within Habitat Plan Boundary

	Inboard	Outboard	Totals
Wetlands	4.2*	8.8	13.0
Open Water	1.6	0.7	2.3
Upland	1.5	7.0	8.5

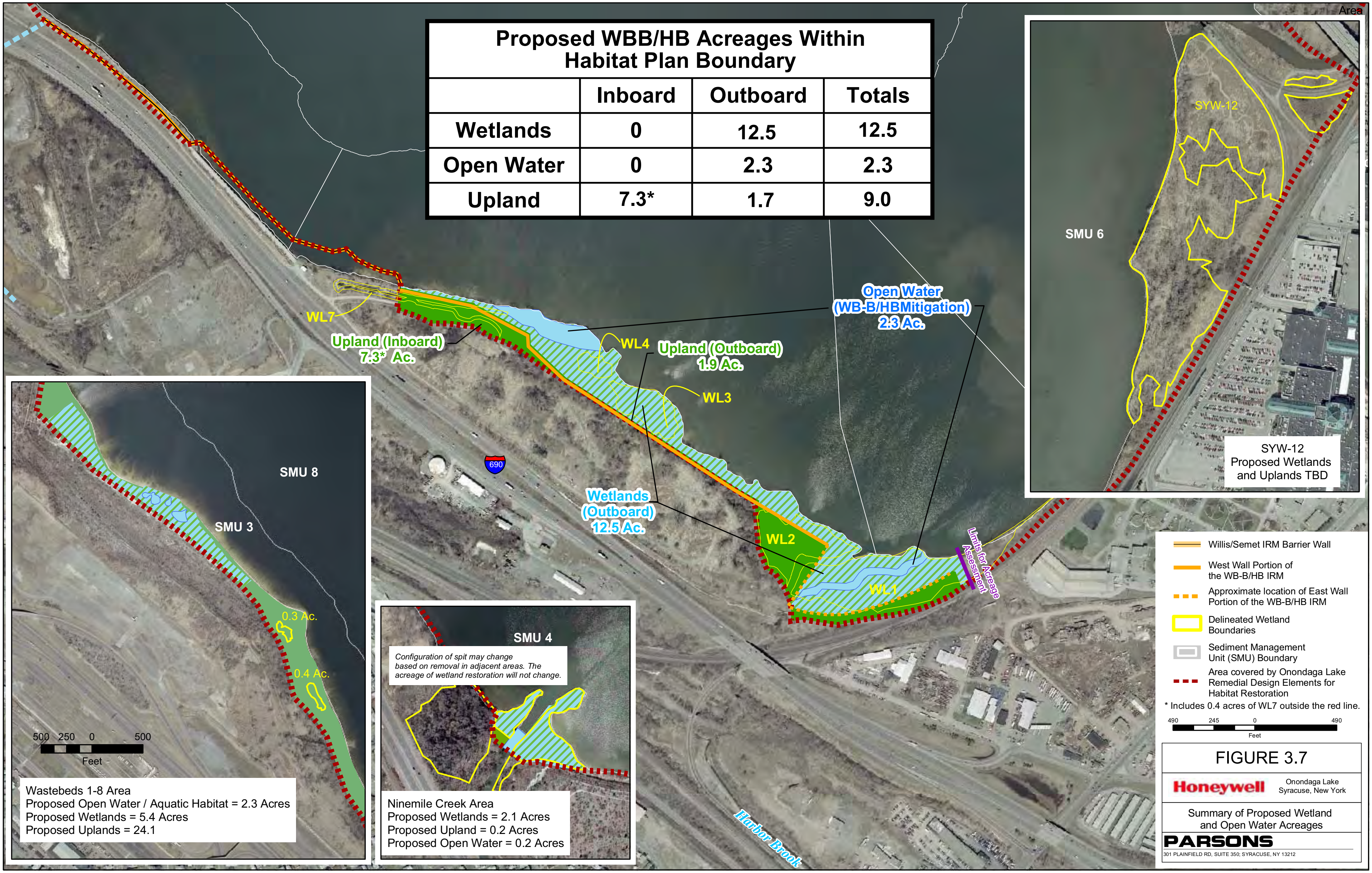
FIGURE 3.6

Honeywell — Onondaga Lake, Syracuse, New York

Summary of Existing Wetland and Open Water Acreages

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



Proposed WBB/HB Acreages Within Habitat Plan Boundary

	Inboard	Outboard	Totals
Wetlands	0	12.5	12.5
Open Water	0	2.3	2.3
Upland	7.3*	1.7	9.0

FIGURE 3.7

Honeywell
Onondaga Lake
Syracuse, New York

Summary of Proposed Wetland and Open Water Acreages

PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

Section 4: Identification of Habitats for Restoration

The overall goal of habitat restoration is to achieve ecological systems that function naturally, are self-sustaining, and are integrated with the surrounding habitats. The Habitat TWG worked through a process to develop more specific habitat restoration goals and objectives for the Onondaga Lake site, and through extensive discussion, developed the habitat restoration approach described in this plan.

4.1 General Restoration Goals

There are three general restoration goals that directed the habitat restoration. These goals focus on those areas (*e.g.*, shoreline), species, or processes (*e.g.*, function of the littoral zone) that (1) have been altered over time through urbanization and industrialization, and (2) where physical changes will occur as a result of remediation.

Goal #1

The first general restoration goal is to maintain or improve

- size, diversity, and ecological 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, and
- conserve and/or create habitats for threatened and/or endangered or rare species.

Goal #2

Eurasian watermilfoil is an aquatic plant that forms large, dense mats at the surface of lakes.

The mats prevent sunlight from penetrating through to native aquatic plants.

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

For example, habitat restoration designs will include physical means to slow or impede the colonization of *Phragmites* into wetland areas. Diverse and robust native submerged and floating aquatics will be planted in Modules 4A and 6A to help minimize establishment of invasive species such as Eurasian watermilfoil and water chestnut into restored areas.

Goal #3

The third general restoration goal is to develop conditions that require minimal maintenance and promote public use. Habitat restoration designs are intended to provide self-sustaining, functioning habitats that require little or no maintenance (such as removal of invasive species) over the long term. Monitoring of the restored areas will be performed to evaluate the physical characteristics and ecological function of the restored habitats. Restored areas should be open and accessible to the public to the extent practicable within the constraints of the remedy.

The TWG developed more specific restoration objectives as described in Section 4.3 in order to meet the three general restoration goals.

4.2 Assessing Habitat Conditions

The TWG reviewed existing and historical conditions of Onondaga Lake to identify habitat types and species to help define specific restoration objectives. Specifically, the identified habitats and species were those that either historically existed within the lake, but that are currently lacking, or those that currently exist within the lake, but are currently degraded (*e.g.*, wetlands dominated by *Phragmites* or limited in distribution).

Understanding the existing habitat conditions on a lake-wide basis is important in the development of the restoration plan because habitat restoration for a given remediation area must fit in with the adjacent areas not requiring remediation *and* contribute to the diversity and abundance of organisms in the overall lake-wide habitat complex.

Wetland Habitat Types

Floating aquatic: dominated by plants that float at the water's surface

Non-persistent emergent: dominated by plants that are rooted in the bottom substrate, emerge above the surface of the water, but die back and are not evident during the winter months

Persistent emergent: dominated by plants that are rooted in the bottom substrate, emerge above the water surface and remain standing at least until the beginning of the next growing season

Existing conditions in and around Onondaga Lake were presented in Section 2. Included within that section is information gathered from literature sources and contacts with resource agencies, as well as information obtained from studies performed as part of the development of the remedy for the lake. Habitat types in and surrounding the lake were mapped using aerial photographs, maps of land use, and previously published investigative reports including wetlands and floodplain assessments.

The assessment of existing habitat conditions provides useful information on where different habitat types currently exist and the extent of these habitats in the overall lake system. Also, this assessment reveals what habitat types are absent. Important wetland fringe habitats (*e.g.,* floating aquatic wetlands, non-persistent emergent wetlands, and persistent emergent wetlands) are notably lacking in the lake system and, as a result, are targeted in the habitat restoration design. Field observations also indicate that in-water physical structure is a missing habitat component in certain areas.

Upland habitats and land uses in shoreline areas are important factors to consider when selecting habitat types for a specific in-lake area. It is important that the restored habitats complement and become integrated with the adjacent shoreline habitats/land uses. For example, in the habitat restoration design at the mouths of Ninemile Creek, Harbor Brook, and Onondaga Creek, it is necessary to maintain a free-interchange connection of aquatic and terrestrial habitats between the lake and these primary tributaries.

4.3 Habitat Restoration Objectives

Only those species which may be impacted by the remedial activities are included on the list of objectives. In particular, those species or

The American eel is a native species to Onondaga Lake, but due to blockages in the waterways such as dams, they are currently prevented from populating the lake.

habitats for which the lake remediation will not change the suitability of the lake for their occurrence, or does not affect the factors which limit their occurrence, have not been included in the objectives. For example, the American eel, a species that was historically present, is currently prevented from reaching Onondaga Lake due to blockages (dams) and other factors in the rivers and lakes between the ocean and Onondaga Lake. Remedial activities will not change the relationship between the lake and the surrounding rivers and lakes, so the American eel has not been included as a representative species. If the American eel were to return to Onondaga Lake, however, it would not be negatively impacted by remedial activities, and it would be able to use the restored habitat.

The specific habitat and species restoration objectives developed for this Habitat Plan include the following:

- maintain or increase diversity of habitats for fish, benthic macroinvertebrates, birds, reptiles, amphibians, and mammals including improvement of wetlands;
- maintain or increase diversity of native plant communities;
- provide or improve gradual and natural transitions between the lake, its tributaries, and the adjacent shoreline;
- minimize or eliminate restrictions to public use and access;
- provide deep water (*e.g.*, greater than 7 feet) nearshore to provide the opportunity for future projects that will allow fishing access and fishing piers;
- provide or enhance habitats suitable for fish species with limited populations in the lake such as northern pike, lake sturgeon, and walleye;
- create or enhance suitable habitat for transient cold water fish species (*e.g.,* brown trout, Atlantic salmon) to access Ninemile Creek and/or Onondaga Creek for spawning;
- reconstruct wetlands to be compatible with establishing pike spawning habitat;
- do not increase the acreage of habitats along the profundal zone boundary that may be under anoxic conditions during portions of the year;
- integrate substrate requirements from the remedial design (*e.g.*, erosion protection) and habitat restoration needs;
- include the use of structure to improve habitat value;
- evaluate the feasibility of restoring/creating at least one inland salt marsh;
- evaluate the feasibility of recreating habitat for historically or culturally significant species;
- evaluate the feasibility of recreating unvegetated shorebird habitat (*e.g.*, mudflats);

Red-winged blackbird eggs

- minimize the need for maintenance following completion of the remedy;
- provide suitable habitat for foraging and reproduction of reptiles and amphibians;
- provide suitable habitat for foraging for semi-aquatic mammals; and
- provide suitable habitat for breeding birds.

Section 5 of this Plan details how these goals and objectives will be met through implementing the habitat restoration designs.

4.4 Identification of Representative Habitats and Associated Species Requirements

In certain instances, the habitat restoration goals and objectives discussed above are specific to particular habitats or species. In some cases, however, other goals and objectives were less specific—for example, "re-create shorebird habitat," and "maintain or improve the function of the littoral zone." For these more general goals, the TWG identified *representative* species and habitats that could be used to guide the development of the restoration designs to meet the goal or objective. For example, to re-create wetland habitat, representative wetland plants were identified and their habitat requirements were used to guide the habitat design.

Representative species from various groups including plants, fish, benthic macroinvertebrates, mammals, amphibians, reptiles, and birds were identified after review of the historical and existing ecological conditions. Once representative species were identified, the TWG reviewed the scientific literature (including peer reviewed journals, books, and project specific documents) to identify the habitat requirements of each species. These habitat requirements included physical characteristics (*e.g.*, water depth and energy and substrate type) and water quality characteristics (*e.g.*, dissolved oxygen, turbidity, pH, temperature), as well as other factors (*e.g.*, vegetation cover, minimum habitat size) that each species may need for various life stages.

Guilds

A guild is a collection of species that use the same habitat resources in the same way, but may not otherwise be related.

For example, ospreys and kingfishers are both in the fish eating guild (piscivores), yet they are different species with different nesting requirements.

4.4.1 Representative Habitat and Species Selection

The TWG selected species to be used during the habitat restoration activities from groups of fish, plants, benthic macroinvertebrates, mammals, amphibians, reptiles, and birds. These "representative" species *represent* a larger group or guild of species that shares similar habitat requirements. Individual species within each of these groups were selected based on various criteria including the following:

- represents different guilds;

- includes a variety of habitat types;
- has important ecological, cultural, recreational, or economic value;
- is a species with limited populations that could be potentially be increased;
- represents a habitat type not currently found in the lake;
- represents a habitat or species historically known from the lake that is no longer present; or
- is a rare, threatened, or endangered species.

The selection of representative species was designed to include species that historically were found in the lake, currently reside in or near the lake, or are likely to be found in the vicinity of or transiting the lake (*e.g.*, shorebirds, coldwater fish). Species within each group were selected to represent the larger group; that is, the list does not include every species that could potentially use Onondaga Lake. The premise is that if the habitat requirements are met for the representative species, then other species with similar habitat requirements will also find favorable conditions in the lake.

4.4.2 Requirements of Representative Species

The habitat requirements for each species were developed from Habitat Suitability Index Models (when available), the current literature, professional experience, and judgment gained from field observations. Habitat requirements were identified for various life stages of each species for the following physical parameters: water depth, substrate type, wave energy, structure-vegetation cover, structure-woody debris, and rooting/burrowing depth. In addition, habitat requirements were identified for water quality parameters, including dissolved oxygen, temperature, nutrient source, turbidity, and pH. These habitat requirements are summarized in Tables 4.1 to 4.7. Each species has multiple physical, chemical, and biological habitat requirements. While those have been included in the tables, it is important to recognize the few key parameters that can be materially changed by the remediation and restoration activities. Specifically, remediation and restoration activities will focus on water depth, substrate type and structure (*e.g.*, vegetation, logs, and boulders). Other factors, such as dissolved oxygen and water temperature, will not be altered by remediation and restoration activities. The rationale for the development of each table is discussed below.

Representative Fish Species
Northern Pike
Lake Sturgeon
Smallmouth Bass
Largemouth Bass
Walleye
Pumpkinseed Sunfish
Golden Shiner
Emerald Shiner
Brown Trout

Fish

Habitat requirements for representative fish species are provided in Table 4.1. Nine species were selected to represent the various types of temperature requirements (warm water, cool water, and coldwater), as well as various trophic levels (planktivores [those fish that eat plant material], piscivores [fish that eat other fish], benthivores [fish that each benthic macroinvertebrates]). Coldwater species are represented by the brown trout, which is currently a transient species in the lake. The brown trout is considered representative for other coldwater species, such as Atlantic salmon and cisco (presumed by some experts to be the Onondaga Lake whitefish), which historically were found in the lake. The cool water species are represented by smallmouth bass, northern pike, walleye, and lake sturgeon. Three species were selected to represent this group due to different reproductive strategies (those fish that reproduce in river environments versus those that reproduce in lake environments) and feeding preferences (piscivorous versus benthivorous). Finally, four warm water species were selected: largemouth bass, pumpkinseed, golden shiner, and emerald shiner to represent various trophic levels and water depths. These species represent recreational fish species and trophic pathways within the lake.

Northern pike, lake sturgeon and walleye were identified as the top three priority species. Application of modules within each remediation area considered these three species first, prior to consideration of the other representative fish species. The walleye population in the lake appears to be limited based on spawning habitat, as juveniles have not been collected during recent sampling efforts (OCDWEP AMP, 2003; OCDWEP AMP, 2004; OCDWEP AMP, 2005; OCDWEP AMP, 2006). This species typically spawns in rocky crevices in tributaries or along shallow shoreline areas (McMahon *et al.,* 1984). Since the lake remedy is not targeted in the tributaries, there is limited opportunity for improving spawning habitat for walleye in the lake proper, but IRMs for adjacent sites are expected to improve habitat conditions in those areas. If tributaries became suitable for spawning populations, the lake would provide habitat for these life stages.

Northern pike require flooded wetlands within and adjacent to a water body for spawning (Inskip, 1982). In Onondaga Lake, northern pike are likely limited by spawning habitat because there are a limited number of flooded wetlands within and adjacent to the lake.

Lake sturgeon adults have been captured in the lake as recently as 2009 (Kirby, 2009). These fish have been stocked within the watershed, and adults are likely to occur in Onondaga Lake following remediation. Adult lake sturgeon are typically found in water 20 to 40 feet deep over a sand or cobble substrate with little or no vegetation. They are benthic invertivores and feed on a variety of organisms including insect larvae and nymphs, leeches, amphipods, snails, clams, and occasionally small fish. Substrate type is important for lake sturgeon as they are more commonly associated with these two substrates which allow for the colonization of benthic macroinvertebrates (Lemon, 2009).
Smallmouth bass and largemouth bass are two of the most abundant piscivores in the lake. While portions of the lake currently support all life stages, improvements can be incorporated into the remediation to create additional habitat for both species. Substrate type and plant cover are important factors that influence the sustainability of both species. Smallmouth bass prefer slightly cooler rocky areas, while largemouth can be found in areas with sufficient cover provided by vegetation and other types of cover (*e.g.*, woody debris). Pumpkinseed represents invertivores, and they will use similar habitats as the bass

Representative Aquatic Plant Species
Submerged Vegetation
Floating Vegetation/ Aquatic Beds
Nonpersistent Emergent Vegetation
Persistent Emergent Vegetation
Salt Marsh Vegetation
Unvegetated Shoreline/ Mudflats
Wet Meadow Wetland
Forested/Scrub-Shrub Wetlands
Forested Scrub-Shrub Uplands
Open Field Uplands

with preference for shallow water with adequate cover. Golden shiner and emerald shiner represent planktivorous minnows within the lake. These species have different habitat requirements; the golden shiner is typically located within the littoral zone associated with vegetation, and the emerald shiner typically inhabits the pelagic or open water zone of lakes moving within the water column with the planktonic food supply (Scott and Crossman, 1979).

Plants

For plants, physical and biological factors were identified for representative aquatic wetland and upland plant habitat types (Table 4.2a). These habitat types are representative of the different water regime zones that will be expected in the restoration areas. Several representative plant species are identified in Table 4.2a for each of these habitat types.

Table 4.2b presents phenology (*e.g*., flowering season) information for six selected aquatic plants. Four submerged and two floating-leaved aquatic plant species were selected as representative species within the littoral zone of the lake. In general, these plants require sandy, silty sand, or silt substrates for root development. Details regarding the substrate requirements for specific plant species will be provided in subsequent design submittals.

Benthic Macrointertebrates

Six representative orders (rather than species) of benthic macroinvertebrates were selected for the lake (Table 4.3). These orders included mayflies, caddisflies, true flies, dragonflies and damselflies, scuds, and crayfish and represent various trophic levels, such as grazers (herbivores), collector/gatherers (herbivores/detritivores), and predators (carnivores). They also represent substrate requirements, such as vegetation, rocks, woody debris, and soft organic sediments. Littoral areas of the lake provide most of the suitable habitat for benthic macroinvertebrates.

Benthic macroinvertebrates are represented by several insect orders, as well as amphipods and decapods (crayfish). Species within these groups are fairly diverse in their habitat requirements. Currently, species diversity is limited within the lake and is comprised primarily of amphipods and dipterans. The majority of the species within each of the representative groups is found in the littoral zone of lakes or within streams. Mayflies (*Ephemeroptera*) are typically found in lotic (moving-water) environments, however, a few families are found in lentic (still-water) habitats; most mayfly species are sensitive to water quality changes and typically their presence indicates high water quality. Caddisflies (*Trichoptera*) also are most diverse in cool running waters, however, several families are represented in lentic habitats; many caddisfly species are sensitive to water quality changes and typically their presence indicates high water quality. Damselflies (*Odonata:Zygoptera*) are typically found in association with aquatic plants, while dragonflies *(Odonata:Anisoptera)* tend to dominate in sand, silt, and detritus. Many species are moderately sensitive to water quality

Representative Benthic Macro-Invertebrates Species
Mayfly
Caddisfly
True Flies
Dragonfly/ Damselfly
Scud
Crayfish

changes, while some species can withstand periods of low dissolved oxygen. Amphipods *(Amphipoda)* are currently present in the lake residing on the surface sediment within the littoral zone. They are commonly found in association with aquatic plants, detritus, and gravel and cobble. The majority of species in this taxon are tolerant of moderate disturbance (including impaired water quality).

Crayfish are present within the Onondaga Lake watershed, but may be limited in the lake due to current conditions. These species typically live within the substrate among the interstitial spaces or within the woody debris, plants, and detritus along the littoral zone. The majority of species in this taxon are tolerant of moderate disturbance (including impaired water quality). Application of the habitat modules within each remediation area will improve conditions for these representative species and may result in greater diversity within each group. Substrate composition (type and size), such as sand, gravel, and cobble, which contain oxygen within the top several inches, is a critical component for invertebrate colonization.

Amphibians and Reptiles

Representative Amphibian and Reptile Species	
Spotted Salamander	Northern Water Snake
Mudpuppy	Snapping Turtle
Leopard Frog	Painted Turtle
Wood Frog	Musk Turtle
Green Frog	Red Spotted Newt

Habitat requirements for six representative amphibian species are provided in Table 4.5. Three salamander species (red-spotted newt [*Notophthalmus v. viridescens*], mudpuppy, and spotted salamander [*Ambystoma maculatum*] and three frog species (green frog [*Rana clamitans melanota*], leopard frog [*Rana pipiens*], and wood frog [*Rana sylvatica*]) were selected to represent the various habitats and food sources used by amphibians. Two distinct life stages (egg/juvenile and adult/eft) must be considered for amphibians because species may be aquatic during one phase and terrestrial during the other. Mudpuppy represents the only species that is entirely aquatic throughout its life cycle. For the other five species, adults generally utilize terrestrial and aquatic habitats for foraging and hibernation with reproduction and rearing occurring in permanent or temporary shallow water.

The TWG identified four representative reptile species: musk turtle (*Sternotherus odoratus*), snapping turtle, painted turtle, and northern water snake (Table 4.6). These species represent the range of habitat required for foraging and feeding, basking, and reproduction. The three representative turtles require softer upland substrates near water for nest excavation and egg deposition and use the littoral zone as adults and/or juveniles. Northern water snake is a live-bearer (meaning that it does not lay eggs) and does not require any specific habitat for reproduction. Depending on the species, the representative reptiles forage on both plants and animals (aquatic invertebrates, amphibians, and small fish), in shallow water areas. Other habitat considerations include basking sites, deeper water areas for overwintering for turtles, and structure in terrestrial areas (fissures and crevices) for northern water snake hibernation.

Representative Bird Species
Mallard
Common Goldeneye
Spotted Sandpiper and Semi-palmated Sandpiper
Bank Swallow
Red-winged Black Bird
Common Tern
Belted Kingfisher
Osprey
Great Blue Heron
Green Heron

Birds

Eleven bird species were selected to represent the various trophic levels (invertivores, piscivores, omnivores) nesting requirements and feeding strategies. The list of representative bird species includes diving and dabbling ducks, shorebirds, birds of prey, and wading birds. Habitat needs vary for each species, so a variety of habitats both in-water and along the shoreline will provide the most suitable habitat for each. Habitat requirements for the bird species are provided in Table 4.7.

Five of the representative bird species represent those birds that nest in available vegetation (green heron, great blue heron, osprey [*Pandion haliaetus*], common goldeneye [*Bucephala clangula*], and red-winged blackbird). These species typically nest in herbaceous wetlands, shrubs, or trees. Red-winged black bird will share the same habitat requirements as the snipe, which is a culturally significant species.

The remaining six species (mallard, common tern [*Sterna hirundo*], belted kingfisher, bank swallow, spotted sandpiper, and semi-palmated sandpiper) nest on the ground or in trees. The species with the most restrictive nesting requirements is bank swallow, which requires steep, unvegetated banks composed of soft substrate for burrow excavation. Foraging habitats range from grasslands adjacent to the lake (red-winged blackbird) to the profundal regions of the lake proper (common goldeneye).
The most common foraging habitat for the representative bird species is the littoral zone of the lake. Six of the 11 species (great blue heron, green heron, mallard, belted kingfisher, spotted sandpiper, and semi-palmated sandpiper) feed on aquatic vegetation, invertebrates, amphibians, or small fish in the shallow nearshore areas. The common tern and osprey feed on fish in the top several feet of the open water area of the lake proper, while the bank swallows feed on emerging insects above the open water.

Representative Mammal Species
Muskrat
Mink
Otter
Beaver
Indiana Bat

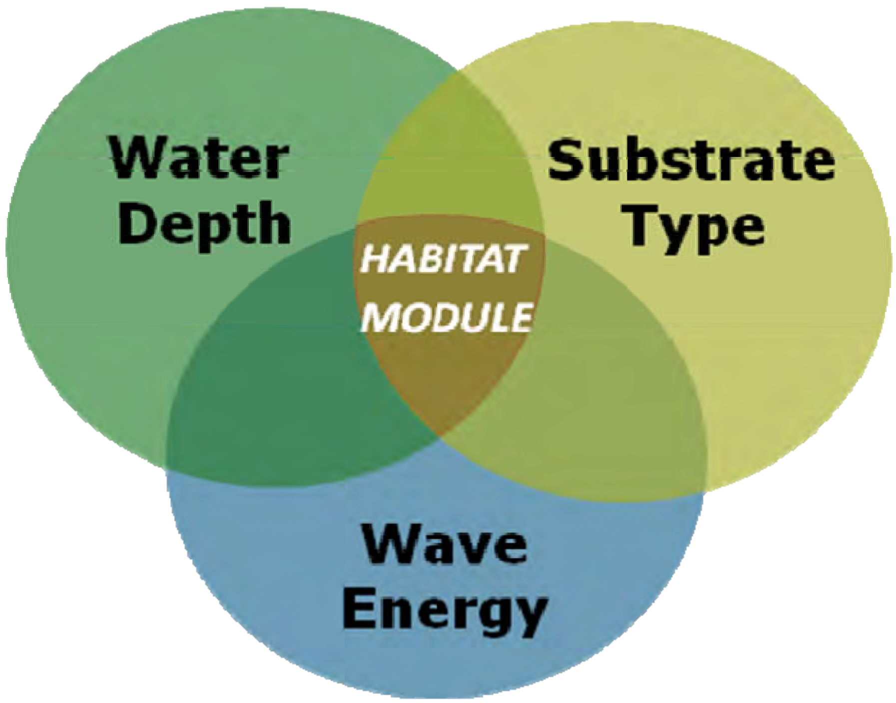
Mammals

Five species of mammals were identified as representative species, including Indiana bat, mink (*Mustela vison*), beaver (*Castor canadensis*), muskrat, and river otter (*Lontra canadensis)* (Table 4.4). With the exception of the Indiana bat, the mammal species are considered semi-aquatic and are found along shorelines of lakes, rivers, and streams. In general, these species prefer low energy environments with low water level fluctuations. Beaver, muskrat, mink, and otter also prefer habitat with sufficient cover (provided by woody debris, emergent vegetation or trees and shrubs) along the shoreline.

Indiana bat was included as a representative species because it is on the state endangered species list and federal threatened species list. Although suitable habitat for the bat does not occur within the lake, the bat may feed on flying insects and roost in large trees with exfoliating or cracked bark during the summer in areas adjacent to the lake.

4.5 Habitat Module Development

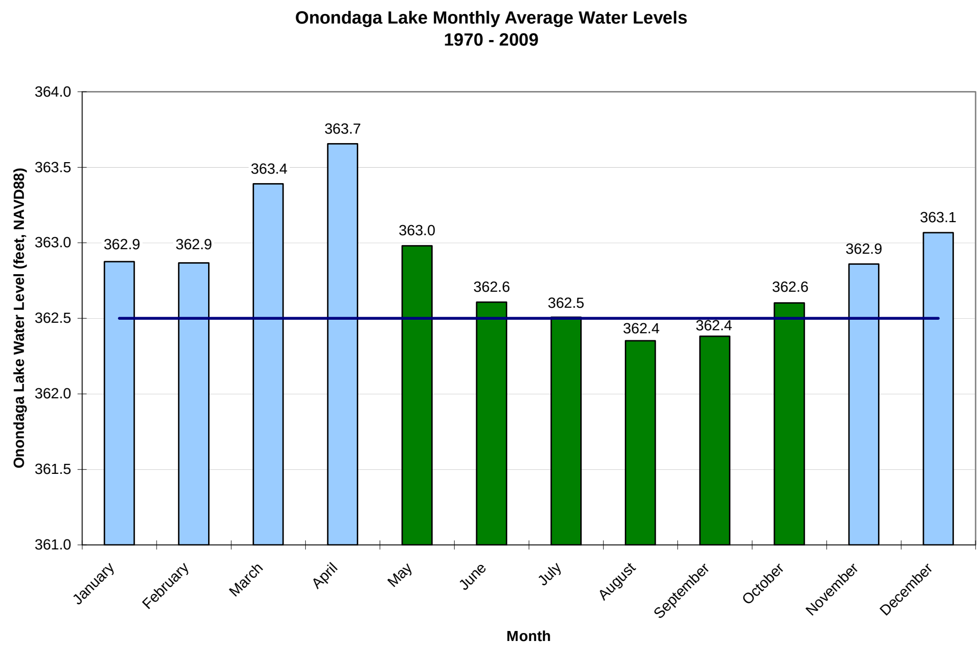
Following the identification of the habitat requirements of each representative species, the TWG developed a method to combine the representative species and their habitat requirements into areas, or "modules," which could be readily integrated with the remediation activities. The in-lake habitat modules are defined by three basic habitat parameters: water depth, substrate type, and wave energy (Table 4.8). Two upland modules were also developed. These habitat modules serve as the basis for the habitat restoration design.



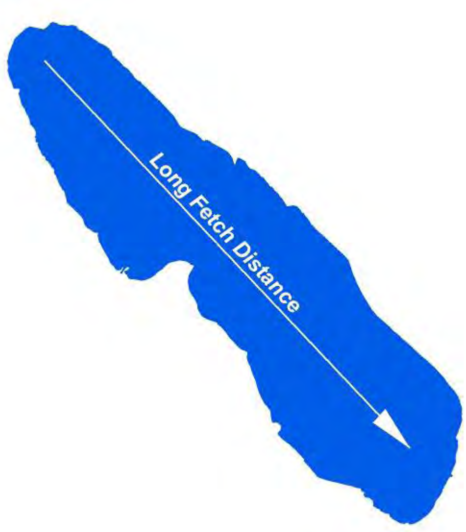
Fluctuations in lake water levels occur on a seasonal basis and during precipitation events, but levels are primarily controlled by the Phoenix Dam on the Oswego River in the Village of Phoenix. Lake levels are generally higher during the winter months than during the summer months. For habitat restoration purposes, the elevation of the lake water is critical during the late spring through early fall month (April to October). Lake level elevations are fairly consistent during this time as indicated by the record of lake water levels presented in Table 2.2. The water depths designated for the in-lake modules are assumed to be relative to the normal summer Onondaga Lake water level elevation of 362.5 feet (NAVD 88). This water level was based on an evaluation of the average water level during the growing season (May 1 to October 31) for the period of record from 1970 to 2008.

The bar chart shown here represents the average water level in the lake for each month of the year. During the growing season (green bars) the average fluctuates very close to 362.50 ft (NAVD 1988).

According to the United States Geological Society, the 100-year floodplain elevation for Onondaga Lake is 371.23 ft (NAVD 88).



Wave energy was identified as another basic parameter for in-lake habitat modules because it materially affects the type of substrate and structure that can occur within specific areas. Winds blowing across the surface of bodies of water transmit energy to the water, and waves are formed. The size of these wind-generated waves depends on the wind speed, the length of time the wind is blowing, and the extent of open water over which it blows (fetch). The longer the fetch distance or the faster the wind speed, the higher the waves are that are formed. To maximize the chance for success for the various types of habitat modules, the littoral regions of the lake were divided into "energy zones" based on the size of waves that could impact that area. The goal is to match the habitat module best suited for each area. A *low energy* zone is an area where there is a limited fetch and the wave heights are small. A *high energy* zone has longer fetches and higher wave heights. A *medium energy* zone lies in between these two zones.



Winds are predominately from the west and northwest near Onondaga Lake. Based on a review of 68 years of wind data collected from Hancock International Airport, as well as an assessment of wind-generated wave heights for various wind speeds and directions, the Remediation Areas have been divided into the following energy zone:

- Remediation Area A: A *low energy* zone. This area located along the western shore of the lake is protected from waves approaching from the southeast and has only a limited fetch in which waves could develop from the north and east. Wave heights, even during extreme events, are relatively low in this area.

- Remediation Areas B, C, and D: *Medium energy* zones. These areas are also located along the western shore of the lake and are protected from winds from the northwest. While having a limited fetch for winds from the south, these areas have longer fetch distances for waves approaching from the north and east.
- Remediation Area E. A *high energy* zone. This area is located at the southern end of the lake is has a long fetch for winds from the north and northwest. As a result, higher waves can impact this area.

Habitat Modules

The in-lake habitat modules presented on Table 4.8 are indicated by a number from 1 to 7, with each number corresponding to a specific water depth range. Limits of the water depth zones for each habitat module were established to define a recognized habitat type. Deep water limits of the habitat modules were established by the remedial activities. The majority of remedial activities will occur in the littoral zone, which was defined to a water depth limit of approximately 30 feet (9 meters) in the ROD. As a result, 30 ft was selected as the deep water limit of the modules (Table 4.8). The shallow water limit of Module 1 is 20 feet and represents the deep water habitats of the littoral zone. The profundal zone is defined as the area with water greater than 30 feet deep and the deep water module (Module 1) would also be applicable in this area if needed.

Generally, submerged aquatic vegetation in the lake is most abundant at a water depth less than 7 feet (approximately 2 meters). With this in mind, the mid-water depth of 7 to 20 feet (Module 2) represents the lake habitat from the approximate limit of submerged aquatic vegetation out to the limit of the deeper water module (Table 4.8).

Because of their water depths, Modules 1 and 2 are habitats that are primarily important to fish species, deeper water benthic macroinvertebrates, and some bird species. These two modules are generally beyond the limit of significant wave energy influences from wind/wave activities.

As indicated, the deep water limit of abundant submerged aquatic vegetation is approximately 7 feet. There is also a shallow water limit of about 2 feet for submerged aquatic vegetation, because wave energy is one of the factors limiting aquatic plant occurrence at shallow depths. As a result, a water depth zone of 2 to 7 feet (Module 3) is used to define the area for submerged aquatic vegetation (Table 4.8). This habitat module area is important for certain nesting fish species, benthic macroinvertebrates, and waterfowl, particularly dabbling ducks such as mallards.

The shallow water fringe areas of the lake were divided into three modules that are primarily defined by the zones of the dominant wetland vegetation. Wetland vegetation is known to occur in certain water depth zones and wetland classification systems use this recognized wetland zonation to define wetland types. As indicated on Table 4.8, the three water depth zones are: 1 to 3 feet deep – floating aquatic wetland vegetation (Module 4); 0.5 to 2 feet deep – non-persistent emergent wetlands (Module 5); and 1 foot above normal summer lake elevation to a water depth of 1 foot deep – persistent emergent wetlands (Module 6). These shallow water wetlands are noticeably lacking around the lake and are important habitat types for various fish and wildlife species.

Module 7 was originally planned as mudflat habitat, but it has not been included in the conceptual designs due to the lack of control over fluctuating water levels required to maintain mudflats along the shoreline. The relatively recent introduction of *Phragmites* (within the last 75 years) has also made the creation and long-term effectiveness of this type of environment very difficult. Additional details on Module 7 can be found in Section 5.3.

Two additional habitat modules (8 and 9) were also developed based on elevation and the habitat cover of adjacent areas. Upland areas may be part of the habitat restored as part of the restoration plan, especially in the transition zone between the lakeshore and landward habitat areas. These upland habitats (Module 8) would have water more than 1 foot below the ground surface - that is, having no standing water or saturation near the surface (Table 4.8).

Onshore or inland wetlands are also recognized as a habitat type identified as part of this plan. It is assumed that these wetlands are not necessarily associated with the lake waters, but generally have water at the surface or near the surface for extended duration during the growing season. These wetlands are represented by Module 9 (Table 4.8).

As is the nature of any biological entity, the water depth limits of the habitat modules are not discrete boundaries. There will be a transition or overlap zone from one module to the next at the specified outer limits of water depth for each module. The lake is a dynamic system that will cause changes to the lake bottom over time and the boundaries noted on the figures in this plan are intended to be a representation of the habitats that will exist following restoration.

For this reason, the wetland habitat modules (Modules 4, 5, and 6) have overlapping water depth limits. For example, it is expected, that submerged aquatic vegetation (Module 3) will occur at the deeper limit of the floating aquatic wetland (Module 4), and that non-persistent emergent wetland vegetation (Module 5) will occur at the shallow end of this module.

Habitat Module Modifiers

An “A” or “B” modifier is used to further define each numbered habitat module to reflect substrate and wave energy categories. The modifier A represents a finer substrate in an area of low wave energy, and the modifier B represents a coarser substrate in an area of medium to high wave energy (Table 4.8).

Modules 8 and 9 are not associated with lake water, so substrate types related to wave energy zones are not necessary. For Modules 8 and 9, the A and B modifiers relate to whether the dominant vegetation is herbaceous or woody, respectively.

Structure is another habitat module modifier. Structure can be tree stumps, rock piles, submerged vegetation, logs, or woody debris on the lake bottom or shoreline in any habitat module Certain species are dependent upon or benefit from the provision of physical structure as noted on Table 4.8. For example, mudpuppy, an aquatic salamander, requires some form of physical structure for many of its life stages.

Each habitat modifier can be applied to the appropriate habitat module. Module 3, for example, can have a habitat module subtype of 3A, which would represent Habitat Module 3 with a finer substrate in an area of low wave energy. It could be further defined to add in-water structure with the (s) modifier. So Habitat Module 3A(s) would represent Habitat Module 3, with a finer substrate in an area of low energy, and added in-water structure.

Certain modifiers would not be appropriate to apply to certain habitat modules. For example, Habitat Module 4 represents a floating aquatic wetland habitat type. The floating aquatic vegetation (*e.g.* water lilies such as *Nymphaea* or *Nuphar* spp.) that dominates this habitat type requires fine substrates and very low energy. The B habitat modifier, which is coarse substrate in areas of medium to high energy, would not be appropriate to apply to this habitat module.

4.6 Habitat Module Species Use

The ring-neck duck is a type of diving duck that will be supported by Habitat Module 1.

Each habitat module provides suitable habitat for many different plant and animal species. Table 4.8 summarizes how the different habitat modules can support the representative plant and animal species selected to guide the restoration designs. This table was developed using the physical and biological requirements of the representative species groups (Tables 4.1 – 4.7) as they relate to the characteristics provided by each individual habitat module. Table 4.8 describes the species or species group for which the module provides suitable habitat conditions, or in other words, what species would use that module.

A column is provided in Table 4.8 for each of the major species groups, which includes fish, aquatic and wetland plants, benthic macroinvertebrates, mammals, reptiles and amphibians, and birds. In the row across from each habitat module, the species, or in certain instances the life stage of a species, that would use that habitat module are provided for each of these species groups. Major benefits provided by each module are discussed in the following text.

Habitat Module 1

Habitat Module 1 (water depth of 20 to 30 feet) represents the deep water portion of the littoral zone. This module also generally applies to the Profundal zone, specifically Remediation Area D – Addendum. Transient cold water fish species and adult warm-water fish species will use this habitat area. Certain benthic macroinvertebrates, birds (diving ducks, osprey and over-water feeders) would use the area.

Habitat Module 2

Habitat Module 2 (water depth of 7 to 20 feet) will provide habitat for lake sturgeon, transient cold water fish, and adult warm-water species (Table 4.8). This module is beyond the limit of most submerged aquatic vegetation, although some will occur in the shallower water limits of this module. Coarse substrate habitats (B modifier) may limit vegetation growth. Benthic macroinvertebrates in various groups will occupy this habitat and some additional groups will benefit from the coarse substrates or added structure modifiers of B and (s), respectively. Although not currently known to occur in the lake, river otter would be the only mammal to use this area. Mudpuppy, an aquatic salamander that is also not currently known to be present in the lake, may occur in the future with the addition of in-water structure, a necessary habitat component for this species. A few birds that use deeper water habitat would be expected in this area.

Tapegrass (*Vallisneria americana*) is an aquatic plant that will be supported by Habitat Module 3.

Habitat Module 3

Habitat Module 3 (water depth of 2 to 7 feet) provides important spawning habitat for bass (*Micropterus* spp.) and other warm-water fish species, and young-of-year cover habitat for various species (Table 4.8). Cover habitat is provided by the abundant submerged aquatic vegetation that occurs within this module's depth range. Typical submerged plant species include: sago pondweed, tapegrass (*Vallisneria americana*), coontail, and water star grass (Table 4.2b). Coarse substrates may reduce the abundance of these aquatic plants. Various benthic macroinvertebrates will find this habitat suitable and may be more abundant where coarse substrates occur. Mammals may use the shallow water portion of this habitat module primarily for travel corridors, although river otters, if present, would feed in this area. Dabbling ducks, diving ducks, and other birds that feed by diving into the water, and certain wading birds, like great blue heron, would use this habitat type.

Habitat Module 4

Wood frogs would find suitable conditions in Habitat Module 5.

Habitat Module 4 (water depth of 1 to 3 feet) represents a floating aquatic vegetation wetland habitat (Table 4.8). It provides habitat for panfish, like pumpkinseed, and cover for various other fish species. Water lilies will likely populate this area. Use by benthic macroinvertebrates and mammals would be similar to Habitat Module 3. Snapping turtles and the basking turtles (painted (*Chrysemys picta*) and musk turtles will prefer the quiet water in this habitat and would further benefit from structure in the form of logs or other surface features. Dabbling ducks, herons, kingfisher, and other birds will use the area.

Habitat Module 5

Habitat Module 5 (water depth of ½ to 2 feet) represents non-persistent emergent wetlands (Table 4.8). Non-persistent emergent plants are rooted in the substrate, emerge above the surface of the water, but do not persist during the winter months. Northern pike (*Esox lucius*) may spawn in this habitat and cover would be provided for pumpkinseed and various other young-of-year fish species. Added structure would enhance the habitat for these species, and coarse substrates would provide better habitat for walleye. Non-persistent emergent wetland plants, such as pickerelweed (*Pontederia cordata*), are targeted in this habitat area (Table 4.2b). Coarse substrates can reduce the abundance of these plant species. Caddisflies (*Trichoptera*), mayflies (*Ephemeroptera*), and crayfish (*Decapoda*) are the representative benthic macroinvertebrates for this habitat area. The aquatic mammals previously mentioned would use this area. Muskrat would feed on some of the plant species. Turtles and frogs would use this habitat, as would northern water snakes, which would prey on the frogs and small fish in the area. With the addition of structure, this habitat may be used by mudpuppy. Bird species use of this habitat module area would be similar to that indicated for Habitat Module 4.

Habitat Module 6

Habitat Module 6 (ground surface 1 foot above water to a water depth of 1 foot) represents a persistent emergent wetland habitat type (Table 4.8). Persistent emergent plants are rooted in the bottom substrate, emerge above the surface of the water, and persist during the winter months. Cattails are a good example of a persistent emergent species.

Great blue herons would use fringe areas that are unvegetated at certain times of the year.

Persistent emergent wetlands are an important habitat type for many plants and animals. With the exception of areas around the lake that are degraded by the invasive *Phragmites*, an emergent wetland fringe is lacking in the lake ecosystem and therefore it is targeted for restoration in many areas. It should also be noted that this habitat module includes salt marshes, which have similar physical requirements to persistent emergent wetlands.

Northern pike, an early spring spawner in wetland areas, can use persistent emergent wetlands for spawning. The deeper water portions of the persistent emergent wetland will provide cover for various other fish species. Persistent emergent plants (*e.g.* cattails, bulrushes (*Scirpus* spp.), burreed (*Sparganium* spp.), and sedges (*Carex* spp.)) and salt marsh plants (*e.g.* salt marsh cordgrass (*Spartina alterniflora*), salt marsh hay (*Spartina patens*), prairie cordgrass (*Spartina pectinata*), rose mallow (*Hibiscus mocheutos*), and black grass (*Juncus gerardii*)) could be abundant in these areas (Table 4.2b). Control of *Phragmites* would be necessary in this habitat module to avoid habitat degradation by this invasive grass species. Various benthic macroinvertebrates would occur in this habitat module, especially dragonflies (*Odonata*), mayflies, and crayfish. All representative aquatic mammals would find this habitat suitable. Persistent emergent marshes, especially cattail marshes, are the primary habitat for muskrats. Various salamanders, frogs, turtles, and snakes would use the area. Dabbling ducks, herons and other wading birds, and both native and migratory shorebirds would use this habitat module. Emergent marshes provide primary habitat for red-winged blackbird.

Habitat Module 7

Habitat Module 7 (ground surface 0.6 feet above water to a water depth of 0.6 feet) represents mudflats or exposed shoreline areas (Table 4.8). Mudflats were once present at the mouths of both Ninemile Creek and Harbor Brook, but these areas were overrun with *Phragmites*. Mudflats, by definition, provide limited to no habitat for fish and plants. They provide travel corridors for aquatic mammals and turtles. Mudflats and exposed shoreline areas are, however, important habitat for resident and migratory shorebirds, such as spotted sandpipers and semi-palmated sandpiper. They are also used by herons.

Habitat Module 8

Open field uplands is one option for Habitat Module 8.

Habitat Module 8 is an upland habitat of herbaceous or woody species cover (Table 4.8). These habitats would likely be transition areas between restored lake habitats or fringe wetland habitats and adjacent uplands. In the open field uplands, various grasses, goldenrods, and asters would be common. In restored wooded uplands, common trees would be eastern cottonwood, trembling aspen (*Populus tremuloides*), shagbark hickory (*Carya ovata*), hackberry (*Celtis occidentalis*), and paper birch (*Betula papyrifera*). Representative shrub species are shadbush (*Amelanchier* sp.), gray-stem dogwood (*Cornus foemina* ssp. *racemosa*), silky dogwood (*Cornus amomum*), and staghorn sumac. Mammals would forage in these areas, and with suitable trees in woody areas, food would be provided for beavers. Open fields, especially those near wetlands are good foraging areas for leopard frogs () and possibly nesting habitat for certain turtle species. Red-winged blackbirds and several other bird species would occupy this habitat.

Habitat Module 9

Forested wetland would be a suitable condition for Habitat Module 9.

Habitat Module 9 (saturated soils to seasonally pooled water) represents a wetland habitat that is not necessarily contiguous with the lake (Table 4.8). No or limited fish habitat would be provided in this module. The wetlands in this habitat module could be wet meadow or persistent emergent wetland types dominated by herbaceous plant species or they could be scrub-shrub or forested wetlands dominated by woody plant species. Plants common in the persistent emergent wetlands would be similar to those listed for Module 6. In the forested wetlands, silver maple, green ash, swamp white oak, and black willow are expected dominants. Wetland shrub species would include silky dogwood, red-osier dogwood (*Cornus sericea*), pussy willow (*Salix discolor*), peach-leaf willow (*Salix amygdaloides*), and musclewood (*Carpinus caroliniana*). Muskrat, mink, and beaver would use this habitat when it is vegetated with herbaceous species and smaller shrub species. Mink would use the wooded areas. Frogs, red-spotted newts, and water snakes would utilize these wetland habitats. Leopard frogs are found in emergent wetland and forage extensively in wet meadow areas. Various bird species noted under the Habitat Module 6 description would occur in these wetlands. Nesting for green heron would be provided in the forested wetlands.

4.7 Existing Conditions Illustrated as Modules

In order to better characterize the existing conditions in and around the lake, and to quantify the changes in habitat types before and after remediation, the TWG applied the newly defined habitat modules to illustrate existing conditions.

Existing habitat conditions in and around the lake were categorized out to the limits of an area called the habitat plan boundary, which is identified as a dashed red line on Figure 4.1. This boundary takes into account the need for connected habitats between the lake and upland areas.

The distribution of existing habitats is presented on Figures 4.2 through 4.5. The habitat modules described above were applied to the lake and acreages were estimated of the various types of habitat that currently exist within and immediately adjacent to the lake.

A summary of the existing and restored habitat acreages for in-lake and lakeshore areas is presented on Table 4.9. These tables illustrate changes in habitat modules with the planned restoration.

TABLE 4.1
SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR FISH

Representative Species / Habitat Considerations

Habitat Requirements	Northern Pike[1**]	Lake sturgeon[2**]	Walleye[3**]
Water Depth - Adult	Rarely below thermocline	Prefer depths <29.5 ft (9 m) in cooler months, may go deeper in summer or to overwinter; in deeper lakes typically 19.7-39.3 ft (6-12 m); shallow lakes with depths <22.9 ft (7 m) will occupy all depths	Shallow shoreline areas. Adults typically <49.2 ft (15 m) during day; move to shoreline at night;
Water Depth - Fry/Juvenile	< 13.1 ft (4m)	Shallow river mouths or adjacent bays	NA
Water Depth - Spawning	3.9-27.5 in 1(0-70 cm (best))[10]	0.3-6.5 ft (0.1-2 m)	Spawning depth 0.9-4.9 ft (0.3-1.5 m)
Spawning location	7.9-11.8 in (20-30 cm)[(3)]	Tributary	Shallow shoreline areas, shoals, riffles; lacustrine populations typically migrate up rivers or streams to spawn
Spawning Substrate	Dense mat of short vegetation; eggs broadcast	Coarse gravel, cobble; broadcast eggs	Gravel, rubble [1-5.9 in (2.5 to 15 cm)]; eggs broadcast (no nest)
Fry/Juvenile Substrate	Primary habitat need regarding substrate is area with adequate cover	Silt	Primary habitat need regarding substrate is area with adequate cover
Adult Substrate	Primary habitat need regarding substrate is area with adequate cover	Sand, cobble, mud, silt, and boulder	Primary habitat need regarding substrate is area with adequate cover
Energy (Velocity) during spawning	<1.96 in/sec (5 cm/sec)	1.6-4.2 ft/sec (0.5-1.3 m/sec)	Moderate
Energy (Velocity) Fry/juveniles	NS	NS	Critical velocity for 7.9 in (20 cm) (FL) fish is 23.6 in/sec (60 cm/sec)
Energy (Velocity) Adults	NS	NS	Critical velocity for 11.8 in (30 cm) (FL) fish is 29.1 in/sec (74 cm/sec)

TABLE 4.1
SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR FISH

Representative Species / Habitat Considerations

Habitat Requirements	Northern Pike[1**]	Lake sturgeon[2**]	Walleye[3**]
Macrophyte Cover (Juveniles)	Fry dense vegetation; juveniles 30-70 % midsummer area	Little; generally avoid aquatic vegetation	25 to 45 %
Macrophyte Cover (Adults)	30-70 % midsummer area; prefer the interface between vegetation and open water	Little; generally avoid aquatic vegetation	25 to 45 %
Large Woody Debris; Boulders (Adults)	NA	Shoals	25 to 45 %[9]
Large Woody Debris; Boulders (Juveniles)	NA	Shoals	25 to 45 %[9]
Rooting / Burrowing/Nest Depth	NA	NA	NA
Dissolved Oxygen	≥ 5 ppm	≥ 5ppm	≥ 5ppm
Growing Season Temperature (Adult)	20-25^{o}C	12-19^{o}C	20-24^{o}C
Growing Season Temperature (Fry/Juveniles)	Fry 18-25^{o}C; juvenile 19-21C optimum	12-19^{o}C	Fry 22-31^{o}C; juveniles 20-24^{o}C
Food Source	Piscivorous (primarily clupeids, yellow perch, white sucker; also invertebrates)	Benthic invertivore (insect larvae, leeches, snails, small clams, small fish)	Piscivorous (primarily yellow perch, clupeids, centrarchids; also invertebrates)
Turbidity/ Suspended Solids	NS	NS	Secchi depth 3.2-6.5 ft (1-2 m)
pH	6.0-9.0	6.5-8.5	6.0-9.0
Minimum Habitat Size	Not specified in Inskip 1982. Farrell (2001)[11] reported spawning in patches as small as 1205 ft^2 (112 m^2)	Minimum size of spawning habitat is not specified, but high gradient reaches of large rivers are ideal; rocky, wave-washed lake shores are sometimes used.	Minimum habitat area unknown; however, lakes >247 acres (100 ha) are more likely to provide suitable conditions for spawning, i.e., 20 percent of area of lake is between 0.9 and 4.9 ft (0.3 and 1.5 m) deep with gravel/cobble substrate)[1]

TABLE 4.1
SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR FISH

Representaitve Species / Habitat Considerations

Habitat Requirements	Smallmouth Bass[4]	Largemouth Bass[5]	Pumpkinseed Sunfish[6]	Golden Shiner[7]	Emerald Shiner[7]	Brown Trout[8]
Water Depth - Adult	<39.3 ft (12 m) deep; typically drops off away from vegetation; dark, quiet water	9.8-49.2 ft [(3-15 m) for overwintering]	Littoral zone; deeper water to overwinter	NS	deep water during day move to surface at night to feed	>15 cm
Water Depth - Fry/Juvenile	Fry shallow water; juveniles slightly shallower than adults	Similar to adults	Littoral zone	NS	NS	<15 cm
Water Depth - Spawning	0.9-22.9 ft (0.3-7 m)	1.64-24.6 ft (0.15-7.5 m)	1 to 3 m	NS	NS	0.122 to 0.914 m
Spawning location	Rocky lake shoals, river shallows or backwaters	Littoral zone	Littoral zone	Littoral zone	Profundal zone	Tributary
Spawning Substrate	Gravel, cobble 0.63 to 0.78 in (1.6-2.0 cm) and boulder with interstitial space; nest builder	Gravel: 0.02-2.5 in (0.2-6.4 cm); nest builder	Sand, fine gravel; nest builder	Vegetation	Open water	0.3 to 10 cm
Fry/Juvenile Substrate	Gravel, broken rock and boulders with large amount of interstitial space	Primary habitat need regarding substrate is area with adequate cover	primary habitat need regarding substrate is area with adequate cover	NS	NS	NA
Adult Substrate	Gravel, broken rock and boulders with large amount of interstitial space	Primary habitat need regarding substrate is area with adequate cover	primary habitat need regarding substrate is area with adequate cover	NS	sand or gravel	
Energy (Velocity) during spawning	Quiet water or very slow current	< 0.13 ft/sec (4 cm/sec)	<7.5 cm/sec	NS	NS	40-70 cm/s
Energy (Velocity) Fry/juveniles	Quiet water [4.3-12.6 in/sec (10.9 - 32.0 cm/sec) reported from one lake]	Fry <0.13 ft/sec (4 cm/sec); juvenile <2.4 ft/sec (6 cm/sec)	<5.0 cm/sec	NS	NS	NA
Energy (Velocity) Adults	Quiet water [4.3-12.6 in/sec (10.9 - 32.0 cm/sec) reported from one lake]	<2.4 ft/sec (6 cm/sec)	<10 cm/sec	NS	NS	

TABLE 4.1
SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR FISH

Representaitve Species / Habitat Considerations

Habitat Requirements	Smallmouth Bass[4]	Largemouth Bass[5]	Pumpkinseed Sunfish[6]	Golden Shiner[7]	Emerald Shiner[7]	Brown Trout[8]
Macrophyte Cover (Juveniles)	25-50 %	Fry 40-80 percent of littoral area; juvenile: 40 to 60 percent of littoral area[10]	15 to 30 percent	some	NS	NA
Macrophyte Cover (Adults)	Prefer rocky cover	40 to 60 % of littoral area[10]	15 to 30 percent	some	NS	NA
Large Woody Debris; Boulders (Adults)	25 to 50 percent; stumps, trees, boulders	40 to 60 % of littoral area[10]	20 to 60 percent	NS	NS	>35%
Large Woody Debris; Boulders (Juveniles)	Adults: 25 to 50 %	40 to 60 % of littoral area[10]	20 to 60 percent	NS	NS	NA
Rooting / Burrowing/Nest Depth	NS	NS	NS	NA	NA	16 cm below water substrate interface
Dissolved Oxygen	≥ 5 ppm	≥ 5 ppm	≥ 5ppm	≥ 5ppm	≥ 5ppm	≥ 5ppm
Growing Season Temperature (Adult)	21-27^oC	24-30^oC	20-27C	NS	NS	12-19C
Growing Season Temperature (Fry/Juveniles)	Fry 25-29^oC; juveniles 25-31^oC	Fry: 27-30^oC; juveniles 24-30^oC	fry 25-32C; juveniles 22-34C	NS	NS	NA
Food Source	Piscivorous (species dependent on abundance and availability); crayfish	Piscivorous (fish; crayfish), amphibians	Invertivore	Planktivore (diatoms, green algae; zooplankton)	Planktivore (algae; zooplankton; midge larvae)	Invertivore/piscivore (alewife)
Turbidity/ Suspended Solids	<25 JTU	5-25 ppm	<50 ppm (max. monthly average)	NS	NS	NS
pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
Minimum Habitat Size	NS	NS	NS	NS	NS	NS

TABLE 4.1
SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR FISH

NOTES:

NA - Not applicable to this species

NS - Information not specified

*Species that utilize the tributaries for spawning also contribute an important forage base for the lake (e.g., white sucker)

**Walleye, northern pike, and lake sturgeon are considered priority species since viable habitat is limited in the lake

REFERENCES:

1. Inskip 1982. Habitat Suitability Index Models: Northern Pike. USFWS.
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3. McMahon et al. (1984). Habitat Suitability Information: Walleye. USFWS. Note that the total of 25-45 percent cover can be provided by macrophytes and/or large woody debris.
4. Edwards et al. (1983). Habitat suitability Information: Smallmouth Bass. USFWS.
5. Stuber et al. (1982a). Habitat Suitability Information: Largemouth bass. USFWS. Note that the total of 40-60 percent cover can be provided by macrophytes and/or large woody debris.
6. Stuber et al. (1982b). Habitat Suitability Index Models: Bluegill. USFWS.
7. Hasse and Stegemann. 1992. http://www.dec.ny.gov/animals/7040.html; http://www.fishbase.org
8. Hasse and Stegemann. 1992. http://www.dec.ny.gov/animals/7040.html; http://www.fishbase.org
9. Raleigh et al. 1986. Habitat Suitability Index Models and Instream Flow Suitability Curves: Brown trout, revised. USFWS. Atlantic salmon habitat requirements are covered under this category.
10. Note that the total percent cover can be provided by macrophytes and/or large woody debris.
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12. Farrell, J.M. 2001. Reproductive success of sympatric northern pike and muskellunge in an upper St. Lawrence River Bay. Trans. Amer. Fish. Soc. 130:796-808.

TABLE 4.2a
OVERVIEW OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR AQUATIC PLANTS

Habitat Requirements	Representative Species/Habitat Considerations				
	Submerged Vegetation	**Floating Vegetation/Aquatic Beds**	**Nonpersistent Emergent Vegetation**	**Persistent Emergent Vegetation**	**Salt Marsh Vegetation**
Water Depth	Depth of light penetration will determine maximum colonization depth. The majority of macrophytes are located in water depth of 7 ft (2 m) or less[5]. Submerged vegetation can typically colonize up to two times the secchi transparency[8, 10]	From 2-4 ft (0.6-1.2 m) for floating aquatic vegetation[7].	Water depth ranges from 0.5-2 ft (15-60 cm) for nonpersistent emergent vegetation. Water depth should be 12-18 in (30-45 cm) or greater to prevent *Phragmites* colonization.	Area from 0.5 ft (15 cm) above mean summer lake level to a water depth of 1.0 ft (30 cm). Initial eradication and future control of *Phragmites* required.	Area from 1.0 ft (30 cm) above mean summer lake level to a water depth of 1.0 ft (15 cm). Initial eradication and future control of *Phragmites* required.
Representative Species	Examples of typical species are: *Stuckenia pectinata, Elodea canadensis, Vallisneria americana, Ceratophyllum demersum* and *Zosterella dubia.*	Examples of typical species are: *Nuphar, Nymphaea* and *Potamogeton nodosus.*	Examples of typical species are: *Pontederia cordata, Peltandra virginica, Sagittaria latifolia, Polygonum amphibium* and *Alisma subcordatum.*	Examples of typical species are: *Typha latifolia, Typha angustifolia, Scirpus tabernaemontani, Scirpus americanus, Scirpus robustus, Sparganium eurycarpum, Justicia americana, Decodon verticillatus* and *Carex lacustris.*	Examples of typical species are: *Spartina alterniflora, Hibiscus moscheutos, Spartina patens, Spartina pectinata, Juncus gerardii, Distichlis spicata, Solidago sempervirens, Aster subulatus* and *Panicum virgatum.*
Substrate	Sand and finer grained material to support colonization; organic content less than 20%[2].	Silty sand or finer material with organic matter content of 3-8%.	Silty sand or finer material with organic matter content of 3-8%.	Silty sand or finer material with organic matter content of 3-8%.	Silty sand or finer material with organic matter content of 3-8%.
Energy	Wave energy may preclude colonization in near shore areas (1-3 ft deep) (0.3-1 m)[(6)].	Wave energy may preclude plant establishment. Energy breaks or low energy areas required fro establishment (Rea *et al.* 1998).	Wave energy may preclude plant establishment. Energy breaks or low energy areas required for establishment (Weisner 1991).	Wave energy may preclude plant establishment. Energy breaks or low energy areas required for establishment.	Wave energy may preclude plant establishment. Energy breaks or low energy areas required for establishment.
Vegetation Cover	NA	NA	NA	NA	NA
Large Woody Debris	NA	NA	NA	NA	NA
Rooting/Burrowing Depth	7.9-11.8 in (20-30 cm)[(3)]	5.9-17.7in (15-45 cm)	11.8-23.6 in (30-60 cm)	11.8-23.6 in (30-60 cm)	11.8-23.6 in (30-60 cm)
Dissolved Oxygen	NA	NA	NA	NA	NA
Temperature	NA	NA	NA	NA	NA

TABLE 4.2a
OVERVIEW OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR AQUATIC PLANTS

Habitat Requirements	Representative Species/Habitat Considerations				
	Submerged Vegetation	**Floating Vegetation/Aquatic Beds**	**Nonpersistent Emergent Vegetation**	**Persistent Emergent Vegetation**	**Salt Marsh Vegetation**
Nutrient Source	Nutrients in sediment, water column; dissolved inorganic carbon[1].	Nutrients within the sediment.	Nutrients within the sediment.	Nutrients within the sediment.	Nutrients within the sediment.
Turbidity/Suspended Solids	Influences depth of the photic zone-see water depth[1].	NA	NA	NA	NA
pH	5.5-9.0[9].	6.0-8.5	6.0-8.5	6.0-8.5	7.0-8.5 Appropriate salinity in water or substrate required for plants to persist. Water salinity range of 20 to 35 parts per thousand or average soil conductivity of 25-60 decisiemans per meter may be appropriate[a].

NOTES:

NA: Not applicable to this species.

NS: Information not specified.

REFERENCES:

1. Barko, J. W., M. S. Adams, and N. L. Clesceri. 986. Environmental factors and their consideration in the management of submersed aquatic vegetation: A review. Journal of Aquatic Plant Management 24:1-10.
2. Barko, J. W. and R. M. Smart. 1986. Sediment-related mechanisms of growth limitation in submersed macrophytes. Ecology 67:1328-1340.
3. Bottomley, E. Z. and I. L. Bayley. 1984. A sediment porewater sampler used in root zone studies of the submerged macrophyte, *Myriophyllum spicatum* .Limnology and Oceanography 29:671-673.
4. Chambers, P. A., and J. Kalff. 1985. Depth distribution and biomass of submersed aquatic macrophytes communities in relation to Secchi depth. Canadian Journal of Fishers and Aquatic Sciences 42:701-709.
5. EcoLogic 2006: Onondaga County Ambient Monitoring Program.
6. Madsen, J. D., P.A. Chambers, W. F. James, E. W. Koch, and D. F. Westlake. 2001. The interaction between water movement, sediment dynamics, and submersed macrophytes. *Hydrobiologia* 444:71-84.
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8. Middleboe, A. L. and S. Markager. 1997. Depth limits and minimum light requirements of freshwater macrophytes. Freshwater Biology 37:553-568.
9. Pagano, A. M. and J. E. Titus. 2004. Submersed macrophyte growth at low pH: Contrasting responses of three species to dissolved inorganic carbon enrichment and sediment type. Aquatic Botany 79:65-74.
10. Sheldon, R. B., and Boylen, C. W. 1977. Maximum depth inhabited by aquatic vascular plants. American Midland Naturalist 97, 248- 254.

TABLE 4.2a

OVERVIEW OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR AQUATIC PLANTS

Habitat Requirements	Representative Species/Habitat Considerations					State Listed Species of Concern	
	Unvegetated Shoreline/Mudflats	**Wet Meadow Wetland**	**Forested/Scrub-Shrub Wetlands**	**Forested/Scrub-Shrub Uplands**	**Open Field Uplands**	**Narrowleaf Pondweed (*Potamogeton strictifolius*)**	**Southern Naiad (*Najas guadalupensis*)(b)**
Water Depth	Areas from 0.5 ft (15 cm) above mean summer lake level to water depth of 0.5 ft (15 cm).	Seasonally inunundated, water primarily below ground during growing season.	Seasonally inundated, water primarily below ground surface during growing season.	No water at or near the soil surface.	17.7-23.6 in (45-60 cm)	Submerged vegetation can typically colonize to two times the secchi transparency. Minimum depth of colonization may be limited by high wave energy. Narrowleaf pondweed has the highest relative abundance in transects with an average maximum depth of 13.5	Submerged vegetation can typically colonize to two times the secchi transparency. Minimum depth of colonization may be limited by high wave energy. Southern naiad has the highest relative abundance in transects with an average maximum depth of 15.9 ft (
Representative Species	NA	Common species are: *Scirpus cyperinus, Scirpus atrovirens, Carex vulpinoidea, Carex stipata, Carex lurida, Juncus effusus, Glyceria striata,* and *Agrostis gigantea.*	Common trees are: *Acer saccharinum, Fraxinus pennsylvanica, Ulmus americana, Salix nigra,* and *Quercus bicolor.* Common shrubs are: *Cornus amomum, Cornus sericea, Salix discolor, Carpinus caroliniana,* and *Salix amygdaloides.*	Examples of typical species are: *Typha latifolia, Typha angustifolia, Scirpus tabernaemontani, Scirpus americanus, Scirpus robustus, Sparganium eurycarpum, Justicia americana, Decodon verticillatus* and *Carex lacustris.*	Examples of typical species are: *Spartina alterniflora, Hibiscus moscheutos, Spartina patens, Spartina pectinata, Juncus gerardii, Distichlis spicata, Solidago sempervirens, Aster subulatus* and *Panicum virgatum.*		
Substrate	Gravel to silty sand or finer material with organic matter content of 2-8%.	Good quality topsoil, sand or loamy texture, organic matter content 3-5%.	Good quality topsoil; sand or loamy texture, organic matter content 3-8+%.	Good quality topsoil, sand or loamy textures, organic matter content 2-4%.	Good quality topsoil, sand or loamy textures, organic matter content 2-4%.	Sand and finer grained material to support colonization; organic content less than 20% [1].	Sand and finer grained material to support colonization; organic content less than 20% [1].
Energy	Wave energy may preclude colonization in near shore areas (1-3 ft deep) (0.3-1 m)[(6)].	NA	NA	NA	NA	Wave energy may preclude colonization in near shore areas [1-3 ft (0.3-0.9 m) deep].	Wave energy may preclude colonization in near shore areas [1-3 ft (0.3-0.9 m) deep].
Vegetation Cover	NA	NA	NA	NA	NA	NA	NA
Large Woody Debris	NA	NA	NA	NA	NA	NA	NA
Rooting/ Burrowing Depth	7.9-11.8 in (20-30 cm)[(3)]	17.7-23.6 in (45-60 cm)	17.7-23.6 in (45-60 cm)	17.7-23.6 in (45-60 cm)	17.7-23.6 in (45-60 cm)	7.9-11.8 in (20-30 cm) [(2)]	7.9-11.8 in (20-30 cm) [(2)]
Dissolved Oxygen	NA	NA	NA	NA	NA	NA	NA
Temperature	NA	NA	NA	NA	NA	25-30°C	25-30°C

TABLE 4.2a

OVERVIEW OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR AQUATIC PLANTS

Habitat Requirements	Representative Species/Habitat Considerations					State Listed Species of Concern	
	Unvegetated Shoreline/Mudflats	Wet Meadow Wetland	Forested/Scrub-Shrub Wetlands	Forested/Scrub-Shrub Uplands	Open Field Uplands	Narrowleaf Pondweed (*Potamogeton strictifolius*)	Southern Naiad (*Najas guadalupensis*)(b)
Nutrient Source	NA	Nutrients from topsoil.	Nutrients from topsoil.	Nutrients from topsoil.	Nutrients from topsoil.	Nutrients in sediment, water column; dissolved inorganic carbon[1].	Nutrients in sediment, water column; dissolved inorganic carbon[1].
Turbidity/ Suspended Solids	NA	NA	NA	NA	NA	Influences depth of the photic zone-see water depth[1].	Influences depth of the photic zone-see water depth[1].
pH	NA	6.0-8.5	6.0-8.5	6.0-8.5	6.0-8.5	5.5-9.0	5.5-9.0

NOTES:
NA: Not applicable to this species.
NS: Information not specified.

a. Salinity ranges based on information provided by Tony Eallonardo and Don Leopold of ESF from their work on settling basins and other NY inland salt marshes.
b. In New York, there are two state-listed subspecies of *N. guadalupensis* (ssp. *munscheri* and spp. *olivacea*) and one common subspecies (ssp. *guadalupensis*) Although *N. guadalupensis* was found in the lake during the 2005 macrophyte surveys, it was not identified to subspecies, so it it not known whether what was found in the lake is rare.
c. Appendix 10: 2005 Onondaga Lake Aquatic Macrophyte Survey (Ecologic 2006).

REFERENCES:

1. Barko, J. W., M. S. Adams, and N. L. Clesceri. 1986. Environmental factors and their consideration in the management of submersed aquatic vegetation: A review. Journal of Aquatic Plant Management 24:1-10.
2. Bottomley, E. Z. and I. L. Bayley. 1984. A sediment porewater sampler used in root zone studies of the submerged macrophyte, *Myriophyllum spicatum*. Limnology and Oceanography 29:671-673.

TABLE 4.2b

PHENOLOGY INFORMATION FOR SELECTED AQUATIC PLANTS

Event	Submersed Aquatic Plants				Floating Leaved Aquatic Plants	
	Sago pondweed[1] (*Stuckenia pectinata*)	Water celery[2] (*Vallisneria americana*)	Coontail[3] (*Ceratophyllum demersum*)	Canadian waterweed (*Elodea canadensis*)	American pondweed[4,5,6, 7] (*Potamogeton nodosus*)	White water lily[6] (*Nymphaea odorata*)
Seed germination	April [8]	10-14°C, April	NS	NA	NS	April
Propagule sprouting	April [1,4]	10-14°C, April [2,4]	NA	NA	April [5]	April
Maximum biomass	July	28-32C, August-September	NS	August-September	September [6]	September
Flowering	July	July-August	April - September	July-August	June [6]	May
Fruiting	July	June-September, 20°C	June - September	August-September	July-October [7]	June
Propagule formation	July-August	August - October	NA	NA	NS	NS
Senescence	August-September	September-October	Evergreen perennial	September-October	October [4]	October

NOTES:

NA: Not applicable to this species

NS: Information not specified

REFERENCES:

(1) Madsen, J.D. and M.S. Adams. 1988. The seasonal biomass and productivity of the submerged macrophytes in a polluted Wisconsin stream. Freshwater Biology 20:41-50.

(2) McFarland, D. 2006. Reproductive ecology of Vallisneria americana Michaux. SAV Technical Notes Collection (ERDC/TN SAV-06-4). Vicksburg, MS: U.S. Army Engineer Research and Development Center.

(3) Flora of North America Project, www.eFloras.org, Ceratophyllum demersum page, http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=200007091, accessed 4/13/2009.

(4) David, J.D. and A.J. McDonnell. 1997. Development of a partitioned-biomass model for rooted macrophyte growth. Aquatic Botany 56:265-276.

(5) Spencer, D.F., G.G. Ksander, J.D. Madsen, and C.S. Owens. 2000. Emergence of vegetative propagules of *Potamgeton nodosus* , *Potamogeton pectinatus* , *Vallisneria americana* , and *Hydrilla verticillata* based on accumulated degree-days. Aquatic Botany 67:237-249.

(6) Penfound, W.T., T.F. Hall, and D. Hess. 1945. The spring phenology of plants in and around the reservoirs in north Alabama with particular reference to malaria control. Ecology 26:332-352.

(7) Magee, D.W. and H. E. Ahles. Flora of the Northeast. Amherst, MA. University of Massachusetts Press. 1999

(8) Yeo, R. R. 1965. Life history of sago pondweed. Weeds 13:314-321.

TABLE 4.3
SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR BENTHIC MACROINVERTEBRATES

	Representative Species/Habitat Considerations					
Habitat Requirements	**Mayfly (Ephemeroptera)**	**Caddisfly (Trichoptera)**	**True Flies (Diptera)**	**Dragonfly/Damselfly (Odonata)**	**Scud (Amphipoda)**	**Crayfish (Decapoda)**
Water Depth	Varilable	Variable	Variable	Variable	< 3.2 ft (1 m)	3.2-6.6 ft (1-2 m)
Substrate	Cobble, gravel, aquatic plants, coarse detritus, sand and silt	Variable	Variable	Aquatic plants, sand, silt and detritus	Littoral benthos (one species *Pontoporeia affinis* occurs in profundal benthos)	Coarse mineral or organic substrates
Energy	Flowing water (lotic-erosional); some lentic littoral species	Lotic and lentic	Variable	Still water (lentic littoral or loctic depositional)	Lentic littoral	Variable
Macrophyte Cover	7.9-11.8 in (20-30 cm)[(3)]	NS	NS	For phytophilous species	NA	Important
Large Woody Debris	NS	NS	NS	NS	NS	NS
Rooting / Burrowing Depth	Up to 3.9 in (10 cm) for *Hexagenia limbata* [1,2]	Up to 3.1 in (8 cm) for *Polycentropus* spp.[1]	Up to 2.9 in (7.5 cm) for *Chironomus* spp and 2 cm for *Glyptotendipes* spp. and *Procladius* spp.[1]	5.9 in (15 cm)	5.9 in (15 cm)	5.9 in (15 cm)
Dissolved Oxygen	> 5 mg/l	NS	NS	NS	NS	NS
Temperature	NS	NS	variable	NS	NS	NS
Food Source	Detritus and plant material	Diatoms, algae and decaying plant matter	Detritus, plankton and benthic organisms	Zooplankton and insects	Detritus	Plant material, invertebrates and carrion
Turbidity/Suspended Solids	NS	NS	NS	NS	NS	NS
pH	NS	NS	NS	NS	NS	NS

NOTES:

NA: Not applicable to this species

NS: Information not specified

1. Charbonneau, P. and L. Hare. 1998. Burrowing behavior and biogenic structures of mud-dwelling insects. J. N. American Benthological Soc. 17:239-249.

2. Charbonneau and Hare (1998) reference Hilsenhoff (1966) observation of *Chironomus plumosus* larvae burrowing up to 50 cm at 5^{o}C

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TABLE 4.4

SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR MAMMALS

Habitat Requirements	Representative Species/Habitat Considerations				
	Otter[1]	Beaver[2]	Muskrat[3]	Mink[4]	Indiana Bat[5]
Water Depth	Variable - ditches to deep lakes	Low water fluctuations	1.5-4 ft (0.5-1.2 m) low water fluctuations	Variable, hunts along shoreline	NA
Substrate	NA	Variable	Sediments fine w/ some organics; bank material < 90% sand and gravel with slope greater than 30%	NA	NA
Energy	Low to high velocity	Low velocity	Low velocity	Low velocity	NA
Vegetative Cover	7.9-11.8 in (20-30 cm)[(3)]	NA	Persistent emergent herbaceous vegetation within 32.8 ft (10 m) of waters edge; no woody material	Trees and shrubs along waters edge for cover; persistent emergent vegetation. Canopy cover comprised of trees and shrubs within 328 ft (100 m) of waters edge	Larger trees with exfoliating bark or narrow cracks required for summer roosting
Large Woody Debris	Submerged hollow logs provide cover	Created by beaver activity	Downfall, debris, log jams provide cover along shoreline	Downfall, debris, exposed roots, undercut banks provide cover along shoreline	NA
Rooting / Burrowing Depth	NA	Entrance to bank dens 2-5 ft (0.6-1.5 m) below water surface	Entrance to bank dens 1-3 ft (0.3-0.9 m) below surface	Will use abandoned muskrat and beaver dens	NA
Dissolved Oxygen	NA	NA	NA	NA	NA
Temperature	NA	NA	NA	NA	NA
Food Source	Fish and crayfish	Water lily, duck potato, aspen, willow and cottonwood	Cattail, sweetflag, water lily, arrowhead, olney 3-square and bulrush	Fish, crayfish, waterfowl, muskrats, rabbits and rodents	Insects (flies and caddis flies)
Turbidity/Suspended Solids	NA	NA	Low	NA	NA
pH	NA	NA	NA	NA	NA
Minimum Habitat Size	NA	Minimum area of 0.5 mi^2 (1.3 km^2) of lake or marshland habitat for colonization[2]	Any freshwater or estuarine cover type large enough to be classified assuming adequate food, water stability, and cover are provided[3]	Any wetland or wetland associated habitat large enough to be identified and evaluated should be large enough for mink	NA

NOTES:

NA: Not applicable to this species

REFERENCES:

1. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.127). 23 PP. [First printed as: FWS/OBS-82/10.61, October 1983]
2. Allen, A. W. 1983. Habitat suitability index models: Beaver. US. Fish and Wild. Serv. FWS/OBS-W10.30 Revised. 20 pp.
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4. Allen, A.W. 1986. Habitat suitability index models: mink, revised.
5. U.S. Fish and Wildlife Service (USFWS). 2007. Indiana Bat (Myotis sodalis) Draft Recovery Plan: First Revision. U.S. Fish and Wildlife Service, Fort Snelling, MN. 258 pp.

USDA Forest Service Species Database; http://www.fs.fed.us/database/feis/animals/mammal/luca/all.html

TABLE 4.5

SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR AMPHIBIANS

Habitat Requirements	Representative Species/Habitat Considerations[1]		
	Red-spotted newt	**Mudpuppy**	**Spotted salamander**
Water Depth	Shallow, permanent water bodies which are wet long enough for development to the eft stage.	Completely aquatic. Adults can live in a variety of water depths (large deep lakes or shallow, muddy streams), but generally nest in 3 ft (1 m) of water; water must be deep enough not to freeze or go anoxic where larvae overwinter.	Adults prefer fishless ponds and vernal pools to breed in; larvae spend several months in pool before emerging.
Substrate	Prefer mud bottoms, but will use rocky and sandy bottoms. Prefer densely vegetated shallow waters. Efts require sufficient forest floor litter for dry periods.[7]	Require rocks or other debris for shelter and for egg laying.	Prefer "muddy" substrate in water. Nests generally under rocks on sandy bottoms. Prefer soils with low, but variable moisture (loamy soil). Spotted salamander egg masses laid on underwater structure.
Energy	Low	Low	Low
Structure/ Macrophyte Cover	Terrestrial life stage (juveniles): prefer deciduous or mixed hardwood forest with $\geq$80% of the trees with a dbh$\leq$19.1 cm; aquatic life stages: $\geq$75% submergent or emergent herbaceous vegetation in the littoral zone, especially for larval stage.[7]	Always associated with some form of aquatic cover (logs, rocks, or even bottom vegetation). In streams, more often found in pools than riffles, likely because of available cover rather than depth.	Terrestrial life stage: prefer deciduous or mixed hardwood forest; aquatic life stage: prefer some submergent vegetation, especially for juveniles.
Structure/Large Woody Debris	Stumps and other woody debris and litter, herbaceous canopy cover of 20-40% important to red eft (juvenile) stage for moisture retention.[7]	Submerged shelters of some sort are required (e.g. rocks or sunken logs).	Rocks, logs, and floating vegetation are important for shelter and egg laying. Rotting logs and woody debris on forest floor important for spotted salamanders.
Burrowing Depth	Adults and efts may overwinter in terrestrial hibernacula, but efts rarely burrow.[7]	The mudpuppy is totally aquatic species. A female digs a nest cavity under stones or logs, at water depths of 4 - 60 in (10 -150 cm). Mudpuppies are active year round and do not hibernate. [8]	Some bury themselves in mud underwater; others hibernate under cover of vegetative debris, rocks, and/or soil pockets. On land, adults spend most of their time in burrows made by other animals. Most hide within a few centimeters of the soil surface.
Dissolved Oxygen	Sensitive to significant fluctuations.	Can survive in water with very low oxygen concentrations.	Sensitive to significant fluctuations.

TABLE 4.5 (Continued)

SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR AMPHIBIANS

Habitat Requirements	Green frog	Leopard frog	Wood frog
Water Depth	Green frogs prefer permanent pools and small ponds where water is deep enough not to freeze for larval and adult overwintering.	Hibernate in streams with minimum depth 35 in (90 cm), moderate mid-depth water velocity, minimal sedimentation, and rocks with average diameter of 8 in (20 cm).	Wood frogs breed in seasonal pools, shallow ponds, marshy lake edges, flooded meadows, and quiet stretches of streams. Tadpoles usually live in the shallowest, warmest parts of the wetland.[5]
Substrate	Prefer a soft-muddy substrate in water.	Prefer wetlands with gradual slope at edge. Hibernates in surface mud of ponds and streams.	Prefer a "muddy" substrate in water. On land frogs prefer loose soil and/or a vegetated ground layer.
Energy	Low	Low	Low
Structure/ Macrophyte Cover	Prefer vegetated to thickly vegetated riparian area in and out of the water.	Prefer open areas like meadows and grasslands.	Frequents temporary pools in or near woodlands with emergent vegetation such as willows, sedges, or winter-killed cattails; forages along forest floor, often near seepage areas; hibernates in leaf litter; prefer forested areas.
Structure/Large Woody Debris	Not necessary for green frogs.	Prefer rocks, logs, floating vegetation or dams to sun on, with adjacent access to water. Submerged vegetation, logs or rocks to hide in.	Wood frogs are largely terrestrial, but are not usually found far from water. They inhabit marshes, riparian areas, wet meadows, moist brush, forested areas and open grassy areas adjacent to such habitats. [5]
Burrowing Depth	Larvae can overwinter in unfrozen mud at the bottom of pond along and in water greater than 6.5 feet (>2m) in depth.	Some bury themselves in mud underwater; others hibernate under cover of vegetative debris, rocks, and/or soil pockets.	Wood frogs hibernate in the soil, using root channels and burrows made by other animals. The soil and snow pack provide insulation and protection to the frogs.[5]
Dissolved Oxygen	Sensitive to significant fluctuations.	Sensitive to significant fluctuations.	Sensitive to significant fluctuations.

TABLE 4.5 (Continued)

SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR AMPHIBIANS

Habitat Requirements	Representative Species/Habitat Considerations[1]		
	Red-spotted newt	**Mudpuppy**	**Spotted salamander**
Temperature	Activity rates increase significantly as temperature rises.[7] Adults and larvae require permanent lentic waters deep enough not to completely freeze in winter.	Sensitive to significant fluctuations.	Sensitive to significant fluctuations.
Food Source	All life stages are opportunistic predators eating available invertebrates and/or smaller amphibians and larvae.[7]	Adults eat mainly invertebrates (e.g. insects, earthworms, and crustaceans) and small fish. Juveniles feed mainly on insects and their larvae.	Adults eat mainly terrestrial and aquatic invertebrates (e.g. earthworms, spiders, insects, crustaceans, snails and slugs); larvae are generalized predators.
Turbidity/ Suspended Solids	Sensitive to significant fluctuations.	Sensitive to significant fluctuations. During winter mudpuppies are found in waters with slow to moderate current, often near outlets.	Sensitive to significant fluctuations.
pH	Sensitive to significant fluctuations.	Sensitive to significant fluctuations.	Sensitive to significant fluctuations; breed successfully above pH 5.5 (optimal pH 7-9).
Minimum Habitat Size	Average eft home range 0.07 acres (270 m^{2}), density of 300 efts/ha. Terrestrial eft habitat (mixed and deciduous forests) may be up to 0.5 mile (800 m) from water.[7]	Individuals can live entire life in small stretch of one river [likely < 0.6 miles (1 km)].	Spotted salamanders tend to stay in an area of 0.002-0.004 acres (8-15 m^2) of forest floor.[8] Most live within 328 ft (100 m) of their breeding pond, though a few have been found as far as 820 ft (250 m).[8]

TABLE 4.5 (Continued)
SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR AMPHIBIANS

Habitat Requirements	Green frog	Leopard frog	Wood frog
Temperature	Can survive freezing temperatures. Tadpole feeding rates increase with temperature.[3]	Feeding rates decrease significantly below 20°C.[4]	Can survive temperatures as low as 21°F (-6°C). The frogs actually freeze solid at these low temperatures, but protect their cells from damage by producing their own cryoprotectant or "antifreeze". Juvenile and adult frogs hibernate terrestrially to survi
Food Source	Green frogs east insects, worms, snails, millipedes, molluscs, and other small invertebrates. Tadpoles are herbivores, and feed on algae and other plant material.[6]	Adults are carnivorous and eat beetles, ants, flies, worms, smaller frogs, including their own species, and even birds, and garter snakes.[4]	Wood frogs east insects, worms, snails, millipedes, molluscs, and other small invertebrates. Tadpoles are herbivores, and feed on algae and other plant material.[5]
Turbidity/ Suspended Solids	Sensitive to significant fluctuations - moderate mid-depth water velocity, mineral sedimentation.	Sensitive to significant fluctuations - moderate mid-depth water velocity, minimal sedimentation.	Sensitive to significant fluctuations.
pH	Sensitive to significant fluctuations; acid tolerance increases during development and varies within and between populations.[2]	Sensitive to significant fluctuations; acid tolerance increases during development and varies within and between populations.[2]	Sensitive to significant fluctuations; acid tolerance increases during development and varies within and between populations.[2]
Minimum Habitat Size	Territories are found in shallow water and are reported to be 3 - 20 feet (0.9 to 6.1 m) in diameter.[8] In New York, green frogs migrate up to 0.3 miles (560 m) from breeding ponds to overwintering sites.[9]	Leopard frogs do not establish territories, except in the breeding pond, where males will establish small calling territories. Leopard frogs migrate to breeding ponds in the spring and may forage in meadows and grasslands during the summer. In the winter	Wood frogs tend to be territorial and generally occupy an area of about 0.025 acres (100 m^2).[8]

NOTES:

1. Unless otherwise noted, information was collected from: Environment Canada. *Habitat Rehabilitation in the Great Lakes Techniques for Enhancing Biodiversity.* http://www.on.ec.gc.ca/wildlife/docs/habitat-rehabilitation4-e.html.

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TABLE 4.6

SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR REPTILES

Habitat Requirements	Representative Species/Habitat Considerations[1]	
	Musk turtle	Snapping turtle
Water Depth	Prefers a permanent body of water, like shallow streams, ponds, rivers, or clear water lakes, and it is rare to find the turtle elsewhere. While in the water, the musk turtle stays mainly in shallow areas.	Located anywhere there is slow-moving or permanent impoundments of water.
Substrate	Inhabits virtually any permanent body of freshwater having a slow current and soft bottom. [5]	Prefers water bodies with muddy bottoms; need well-drained soils for egg-laying.
Energy	Low	Low
Structure/ Plant Cover	7.9-11.8 in (20-30 cm)[(3)]	They prefer water bodies with muddy bottoms and abundant vegetation because concealment is easier.[4]
Structure/Large Woody Debris	Muskrat lodges are favorite for nesting. Bask on nearby fallen tree trunks or in the branches of trees overhanging the water. [3]	Basks on shore, logs and rocks near water. Generally bottom dwellers. [4]
Burrowing Depth	Usually hibernate buried in as much as 12 in (30.48 cm) of mud on the bottoms of ponds or other water areas.[9] Females known to dig shallow nests at the water's edge under rotting logs or dead leaves, and sometimes will nest two or more times a year.	Hibernates on bottom of ponds or in excavations along banks of rivers. Female excavates a hole, normally in sandy soil, to lay eggs.[4]
Temperature	Above freezing, as hibernation requires that ice not reach the bottom.	Above freezing, as hibernation requires that ice not reach the bottom.
Food Source	Active night feeder, eats small amounts of plants, mollusks, small fish, insects, and even carrion. Generally forages on the muddy bottom of streams or ponds. [3]	Snapping turtles will eat nearly anything that they can get their jaws around. They feed on carrion, invertebrates, fish, birds, small mammals, amphibians, and a surprisingly large amount of aquatic vegetation (leaves and algae). [4]
Turbidity/ Suspended Solids	Generally tolerant of turbidity.	Generally tolerant of turbidity.
pH	Generally tolerant of variability.	Generally tolerant of variability.
Minimum Habitat Size	Home range is likely confined to one waterbody. Males mean home range 4.32 acres (1.75 ha) and females 2.32 acres (0.94 ha). [8]	Will live in even the smallest of water bodies; HSI model assumes any permanent or semi-permanent body of water will be suitable.[7]

Notes:

1. Unless otherwise noted, information was collected from: Environment Canada. *Habitat Rehabilitation in the Great Lakes Techniques for Enhancing Biodiversity.* http://www.on.ec.gc.ca/wildlife/docs/habitat-rehabilitation4-e.html.

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TABLE 4.6 (Continued)

SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR REPTILES

Habitat Requirements	Representative Species/Habitat Considerations[1]	
	Painted turtle	**Northern water snake**
Water Depth	Prefers a permanent body of water in which ice does not reach to the bottom. They will avoid open water, but will cross deep water either just above submerged vegetation or the substrate.	Generally still, quiet water bodies with 1 inch (2 cm) to 2 ft (0.6 m) depth. Small snakes generally use shallow water because these areas contain fish of the appropriate size to consume.[2]
Substrate	In water, fine grain silty soils that allow for burrowing/hibernating and as anchor for plants used for basking and feeding. On land, sandy, loose soil with adequate drainage required for nesting sites.	Various, including rock, gravel, sand, and mud.
Energy	Low	Low
Structure/ Plant Cover	Prefer porous vegetated mats (e.g., filamentous algae) that allow easy access and escape and surrounding stands of emergent vegetation for cover.	Cattails (*Typha latifolia*) and flooded meadow (primarily *Phalaris spp.* and *Carex spp.*) are preferred. Feed in thick vegetation mats and emergent vegetation.
Structure/Large Woody Debris	Bask in large groups on logs in ponds, rocks, or floating vegetation.	Bask in shrubs, low trees, driftwood, on loose rocks adjacent to water, wharfs, docks, stone walls, beaver lodges, dried cattail stems, causeways, and most shallow areas.
Burrowing Depth	Muddy bottom for burrowing to hibernate, and as anchor for plants used for basking and feeding.	Use fissures and crevices in limestone, brush piles, shoreline ledges, rock piles in abandoned quarries, old cisterns, sink holes, hollow logs, stone causeways, flood walls, levees, ant mounds, crayfish burrows, muskrat bank burrows, muskrat and beaver lodges.
Temperature	Above freezing, as hibernation requires that ice not reach the bottom; feeding occurs when water temperature is above 15^{o}C; breeding starts in late May to early June, when temperature is 8^{o}C; nest temperatures generally below 29^{o}C.	Maximum basking temperature is 33^{o}C.
Food Source	Omnivorous, equally divided between plant and animal sources - eats aquatic invertebrates, frogs, small fish, and aquatic plants (no plant preference).	Aquatic invertebrates, frogs, small fish, and aquatic plants.
Turbidity/ Suspended Solids	Generally tolerant of turbidity.	Generally tolerant of turbidity.
pH	Generally tolerant of variability.	Generally tolerant of variability.
Minimum Habitat Size	Home range fluctuates depending on available conditions; not territorial.	Home range of 13.34 acres (5.4 ha) has been reported with a concentrated core area of 7.7% (0.98 acres or 0.4 ha).

Notes:
1. Unless otherwise noted, information was collected from: Environment Canada. *Habitat Rehabilitation in the Great Lakes Techniques for Enhancing Biodiversity.* http://www.on.ec.gc.ca/wildlife/docs/habitat-rehabilitation4-e.html.

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TABLE 4.7
SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR BIRDS

Habitat Requirements	Representative Species/Habitat Considerations [1]			
	Great blue heron (Wading Birds)	Green heron (Wading Birds)	Mallard (Dabbling Ducks)	Common goldeneye (Diving Ducks)
Water Depth	Feed by wading in water generally less than <20 in (50 cm) deep.[4]	Feeds by standing next to water.	Water depth of 1-5 ft (0.3-1.5 m) for feeding and brood rearing.	Can dive deep for food - up to approximately 90-160 ft (27-49 m) or more.[2]
Substrate	Muddy margins of ponds/lakes or sand flats during low tides of estuarine habitats.	Muddy margins of ponds/lakes or streams.	Highly variable ranging from sand to heavy clay to exposed bedrock. Wetland soils with high fertility, preferably those on a limestone substrate.	Dives underwater to capture prey on soft bottoms of ponds, lakes, or rivers.[5]
Energy	Forages in still open water and edges of lakes, marshes, streams, ponds and bays.[2]	Forages in edges of lakes, ponds, marshes, and streams.[5]	Still or slowly moving water is preferred; however, use fast flowing water that doesn't freeze on northern wintering areas.	Still or slow moving water is preferred.
Structure/Cover	Aquatic habitat with bushes, thickets, or small trees. Supporting vegetation may provide dense cover, or may be dead and provide little cover.	Aquatic habitat with bushes, thickets, or small trees.	Approximately 50:50 ratio of emergent vegetation to open water. Utilizes scattered islands, floating logs, cattail mats and muskrat houses.	NA
Structure/Nesting	Nest - often colonial in high snags or live trees (up to 130 ft) with open canopy, near water.[10] Has also nested on duck blinds.[2] May build nest on the ground, rock ledges, or cliffs.[2]	Breeds in swampy thickets.[5]	Often nests on the ground, utilizing vegetation for nest and cover. Natural nesting structures also include tree cavities, tree crotches and muskrat houses.	Nests usually near pond, lake, or river, but may nest in woodland up to a mile from water. Nests in natural cavity in large hardwood tree, in abandoned woodpecker hole or nest-box.[6]

TABLE 4.7
SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR BIRDS

Habitat Requirements	Target Species/Habitat Considerations [1]			
	Great blue heron (Wading Birds)	**Green heron (Wading Birds)**	**Mallard (Dabbling Ducks)**	**Common goldeneye (Diving Ducks)**
Temperature	Above freezing.[9]	Above freezing.[9]	Above freezing.[9]	Enjoys cold water, but must be above freezing.[7]
Food Source	Primarily fish. Amphibians and a wide variety of vertebrates and invertebrates are also eaten. Generally stabs prey with its bill.[2]	Small fish, invertebrates, insects, frogs, and other small animals.[5]	Invertebrates, aquatic and upland seeds, aquatic tubers, vegetation, and some species make extensive use of waste agricultural grain. Additional food sources: insects, minnows, frogs, tadpoles, snails and small salamanders.[2]	Herbivore and invertivore -aquatic insects, crustaceans and aquatic plants in summer and fall, and crustaceans, mollusks, small fishes and some plant material during winter.[6]
Turbidity/ Suspended Solids	Water clarity makes foraging easier.	Water clarity makes foraging easier.	NA	Water clarity very important for diving/foraging. High turbidity may limit diving abilities and forage base.
Minimum Habitat Size	Shoreline length 423.2 ft (129 m) and mean area of 1.48 acres (0.6 ha).	NS	Breeding territory 988 acres (400 ha).[11]	Breeding territory 1.98 acres (0.8 ha).[11]

TABLE 4.7
SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR BIRDS

Habitat Requirements	Representative Species/Habitat Considerations [1]					
	Osprey (Birds of Prey)	**Spotted sandpiper and Semi-palmated sandpiper (Shorebirds)**	**Common tern (Gulls/Terns)**	**Belted kingfisher (Kingfishers)**	**Bank swallow (Swifts/Swallows)**	**Red-winged blackbird (Perching Birds)**
Water Depth	An osprey is capable of diving up to 3.3 ft (1 m).[8]	Depth generally less than 4 in (<10 cm).	Water depth varies from 1.6-5 ft (0.5-1.5 m). Water level fluctuations and actual drought are important to recycle nutrients so that large invertebrate blooms result on reflooding.	Fishing confined to maximum depth of 24 in (60 cm), and most done at 4.5-6 in (12-15 cm), usually shallow.	Forages over water especially with emerging invertebrates.	NA
Substrate	NA	Muddy soils, where invertebrate abundance is highest.	Variable. In wetlands: soils with high fertility, preferably those on a limestone substrate.	NA	Muddy soils, where invertebrate abundance is highest.	NA
Energy	Open water with good visibility.	Slow falling water levels create a continuous supply of food.	Both flat and moving water habitats are used. Water quality high enough to produce adequate fish and aquatic invertebrates.	Still waters and streams for foraging.	Variable	NA
Structure/Cover	Elevated perches such as trees, posts, and telephone wires important for foraging.[8]	Prefers shores with rocks, wood, or debris.[6] Also utilizes mudflats and shallow water with less than 25% vegetation cover. When vegetation is present it is usually very short.	Grasses and miscellaneous herbaceous wetlant plant species.[6] Perching sites quite important, may get 1-2 dozen perched on dead snags near their nesting area.	Bare tree branches at water's edge are a favorite perch. Elevated perches such as trees, posts, and telephone wires important for foraging. Woody vegetation around a wetland also provides foraging perches, roosting sites and cover for young birds.	Grasslands with miscellaneous herbaceous plant species for foraging.[6]	Use scattered trees and fenceposts near their breeding territories as observation posts.[14] Forages in grasslands and meadows adjacent to water.
Structure/Nesting	Nesting: built of sticks in tall dead trees or snags. Will nest on buoys and man-made nesting platforms. [8] Nests often used in successive years.[6]	Nests are grass-lined with leaves and moss. Nests generally built near water on grassy slope or mound surrounded by short vegetation.[16]	Nesting: among pebbles, gravel, grasses, and other vegetation. Scratch a slight depression in soil, smooth and shape it by sitting in the hollow and turning body.[2]	Nesting: nest built in well drained, sandy clay soil on bank or steep side slopes. Minimum sand content of 75% and maximum clay content of 7% . Excavate burrows in vertical earth banks to nest. Banks may be natural (e.g. eroded stream banks) or man-made.	Nesting areas: burrowing into soft banks, nest of mud and grass on cliff sides or other vertical surfaces.[7]	Nests in freshwater and herbaceous wetlands, bushes, and small trees along watercourses and certain upland cover types.[14]

TABLE 4.7
SUMMARY OF PHYSICAL AND BIOLOGICAL FACTORS IN HABITAT DESIGNS FOR BIRDS

Habitat Requirements	Representative Species/Habitat Considerations [1]					
	Osprey (Birds of Prey)	Spotted sandpiper and Semi-palmated sandpiper (Shorebirds)	Common tern (Gulls/Terns)	Belted kingfisher (Kingfishers)	Bank swallow (Swifts/Swallows)	Red-winged blackbird (Perching Birds)
Temperature	Usually migrates south by October.	Migrate south for winter.[6]	Above freezing.[9]	Above freezing.[9]	Migrate south for winter.[6]	Migrates south for winter.[14]
Food Source	Primarily fish. Captures fish by diving into water and using their talons. Opportunistic feeder on a variety of other non-fish prey.[8]	Terrestrial and aquatic invertebrates.	Adults: aquatic and flying insects, small fish, and occasionally, tadpoles, snails, mollusks, worms, crayfish, and can be scavengers of urban areas. Young: are fed a variety of insects and small fish.[1, 7]	Capture fish by diving into the water. Sometimes, when fish are less accessible, as when turbidity is high or ice is present, crayfish comprise a large proportion of the diet. Other food: amphibians, reptiles, insects, young birds, and small mammals.	Flying insects, emergent invertebrates, and some small fruits and/or berries when insects are not available. [7]	Omnivores, eating seeds, grains, and insects.[5]
Turbidity/ Suspended Solids	Water clarity very important for foraging. High turbidity may limit fish as a forage base.[8]	NA	NA	Water clarity very important for foraging. High turbidity may limit fish as a forage base.	NA	NA
Minimum Habitat Size	Breeding ospreys are known to travel as far as 8.7 mi (14 km) from their nest during hunting forays. Non-breeding individuals are known to travel as far as 6.2 mi (10 km) between their daytime feeding grounds and their roosts.[13]	Spotted Sandpiper-NS; Semi-palmated sandpiper: breeding territory-0.25 acres (0.1 ha).[11]	NS	Territory averages 3,168 ft (960 m) long.[5]	The length of nesting banks in California ranges between 42.6 ft (13 m and 6,233.6 ft (1,900 m).[12]	Wetland must contain at least 0.25 acres (0.10 ha) in emergent herbaceous vegetation.[14]

NOTES:

NS - Not specified.

NA - Requirements are not applicable.

1. Unless otherwise noted, information was collected from: Environment Canada. *Habitat Rehabilitation in the Great Lakes Techniques for Enhancing Biodiversity: Significant Biological Parameters.* http://www.on.ec.gc.ca/wildlife/docs/habitat-rehabilitation4

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TABLE 4.8
HABITAT MODULE CHARACTERISTICS
ONONDAGA LAKE REMEDIAL DESIGN PROGRAM

HABITAT MODULE AREAS[(a) (b) (e)]	REPRESENTATIVE SPECIES/HABITAT						
	Fish	**Plants**	**Benthic Macroinvertebrates[(c)]**	**Mammals**	**Reptiles and Amphibians**	**Birds**	**Minimum Habitat Layer Thickness[(d)]**
1. Deep water (20-30 ft) (6-9 m) Sand substrate Low to medium energy Note: This module also generally applies to deeper water (profundal) areas. [(f)]	Transient cold water fish (brown trout), lake sturgeon, emerald shiner, bass, walleye and pumpkinseed	None	Amphipoda (Pontoporeia affinis), Annelida (Oligochaeta, Diptera (Chironomidae), Mollusca, and Annelida	None	None	Common goldeneye, mallard, osprey and bank swallow	1 ft. (30 cm) (Average of 1.25 ft.)
2A. Mid water depth (7-20 ft) (2-6 m) Sand/fine gravel substrate Low to medium energy	Lake sturgeon, transient cold water fish, bass, northern pike and pumpkinseed; additionally, walleye and bass if structure is present	Submerged aquatics in shallow portion	Diptera (Chironomidae) Annelida, Ephemeroptera, Odonata, and Mollusca; diptera if structure is present	Otter	None; mudpuppy if structure is present	Mallard, common tern, osprey and bank swallow	1 ft. (30 cm) (Average of 1.25 ft.)
2B. Mid water depth (7-20 ft) (2-6 m) Coarse gravel/cobble substrate High energy	Lake sturgeon, transient cold water fish, bass, smallmouth bass and pumpkinseed; additionally walleye if structure is present	Limited	Diptera (Chironomidae)	Otter	None; mudpuppy if structure is present	Mallard, common tern, osprey and bank swallow	1 ft. (30 cm) (Average of 1.25 ft.)
3A. Shallow water depth (2-7 ft) (0.5-2 m) Sand/fine gravel substrate Low energy	Largemouth bass, pumpkinseed, golden shiner and northern pike	Medium to dense submerged aquatic vegetation	Ephemeroptera, Trichoptera, Diptera, Odonata, Amphipoda, and Decapoda	Otter, mink, beaver; additionally muskrat if structure is present	Snapping turtle; additionally mudpuppy if structure is present	Mallard, belted kingfisher, osprey, great blue heron and bank swallow	1.5 ft. (45 cm) (Average of 2.0 ft.)
3B. Shallow water depth (2-7 ft) (0.5-2 m) Coarse gravel/cobble substrate High energy	Bass, pumpkinseed, golden shiner and northern pike	Sparse to medium submerged aquatic vegetation	Ephemeroptera, Trichoptera, Diptera, Odonata, Amphipoda, and Decapoda	Otter, mink, beaver, muskrat	Limited/none; mudpuppy and snapping turtle if structure is present	Mallard, belted kingfisher, great blue heron, common tern and bank swallow	1.5 ft. (45 cm) (Average of 2.0 ft.)

Footnotes:
a. High, medium, and low energy designations were developed by Anchor-QEA in the Wind/Wave Analysis from the Capping and Dredge Area and Depth Technical Document (Parsons, 2009).
b. Selection of modules for specific areas around the lake will consider the presence/occurrence of invasive species.
c. Diversity of species for benthos will be evaluated during the next phase of design.
d. See representative species Tables 4.1 to 4.7 for substrate depth and minimum habitat size information for specific organisms.
e. Structure can be added to any module. Species that would benefit from structure have been noted on the table.
f. A habitat layer will not be required in areas of the Profundal zone that do not have an isolation cap.

TABLE 4.8 (Continued)
HABITAT MODULE CHARACTERISTICS
ONONDAGA LAKE REMEDIAL DESIGN PROGRAM

HABITAT MODULE AREAS[(a) (b) (e)]	REPRESENTATIVE SPECIES/HABITAT						
	Fish	Plants	Benthic Macroinvertebrates[(c)]	Mammals	Reptiles and Amphibians	Birds	Minimum Habitat Layer Thickness[(d)]
4A. Floating aquatics wetland (1-3 ft) (0.3-1 m) Organics/fines/sand substrate Very low energy	Northern pike and Pumpkinseed	Floating aquatics, some submerged aquatics in deeper portions, some nonpersistent emergents in shallower portion	Ephemeroptera, Trichoptera, Diptera, Odonata, Amphipoda, and Decapoda	Otter, mink, muskrat and beaver	Snapping turtle, painted turtle, musk turtle and water snake; additionally mudpuppy if structure is present	Mallard, belted kingfisher, great blue heron, common tern, green heron and bank swallow	2.0 ft. (60 cm) (Average of 2.5 ft.)
5A. Non-persistent emergent wetland (0.5-2 ft) (0.1-0.6 m) Organics/fines/sand substrate Low energy	Northern pike and pumpkinseed	Non-persistent emergent vegetation. Some persistent emergents in shallows.	Ephemeroptera, Trichoptera, Diptera, Odonata, Amphipoda, and Decapoda	Otter, mink, muskrat and beaver	Snapping turtle, painted turtle, musk turtle, water snake, red spotted newt, green frog and leopard frog; additionally mudpuppy if structure is present	Mallard, belted kingfisher, great blue heron, green heron, common tern and bank swallow	2.0 ft. (60 cm) (Average of 2.5 ft.)
5B. Shoreline shallows/limited emergent wetland (0.5-2 ft) (0.1-0.6 m) Gravel/cobble substrate High energy	Smallmouth bass; additionally walleye if structure is present	Limited/none	Limited numbers Trichoptera, Ephemeroptera; Trichoptera, Ephemeroptera and Decapoda if structure is present	Otter and mink	Limited/none; Turtle, water snake, and mudpuppy if structure is present	Mallard, belted kingfisher, great blue heron, green heron and bank swallow	2.0 ft. (60 cm) (Average of 2.5 ft.)

Footnotes:

a. High, medium, and low energy designations were developed by Anchor-QEA in the Wind/Wave Analysis from the Capping and Dredge Area and Depth Technical Document (Parsons, 2009).
b. Selection of modules for specific areas around the lake will consider the presence/occurrence of invasive species.
c. Diversity of species for benthos will be evaluated during the next phase of design.
d. See representative species Tables 4.1 to 4.7 for substrate depth and minimum habitat size information for specific organisms.
e. Structure can be added to any module. Species that would benefit from structure have been noted on the table.
f. A habitat layer will not be required in areas of the Profundal zone that do not have an isolation cap.

TABLE 4.8 (Continued)
HABITAT MODULE CHARACTERISTICS
ONONDAGA LAKE REMEDIAL DESIGN PROGRAM

HABITAT MODULE AREAS[(a) (b) (e)]	REPRESENTATIVE SPECIES/HABITAT						
	Fish	Plants	Benthic Macroinvertebrates[(c)]	Mammals	Reptiles and Amphibians	Birds	Minimum Habitat Layer Thickness[(d)]
6A. Persistent emergent wetland or salt marsh (1 ft above water to 1 ft deep) (0.3 m above water to 0.3 m deep) Organics/fines/sand substrate Low energy	Northern pike	Persistent emergent vegetation, salt marsh vegetation	Trichoptera, Diptera, Odonata and Decapoda; additionally Amphipoda if structure is present	Otter, mink, muskrat and beaver	Snapping turtle, painted turtle, musk turtle, water snake, red-spotted newt, leopard frog and green frog; additionally mudpuppy if structure is present	Mallard, spotted sandpiper, semi-palmated sandpiper, red-winged blackbird, great blue heron, green heron, common tern and bank swallow	2.0 ft. (60 cm) (Average of 2.5 ft.)
6B. On shore to shallows/limited emergent wetland or salt marsh (1 ft above water to 1 ft deep) (0.3 m above water to 0.3 m deep) Cobble/coarse gravel/sand High energy	Limited use	Limited/none	Trichoptera, Ephemeroptera and Decapoda	Otter and mink	Limited/none, snapping turtle	Mallard, spotted sandpiper, semi-palmated sandpiper, great blue heron, green heron and bank swallow	2.0 ft. (60 cm) (Average of 2.5 ft.)cm)
7A. Mudflats/unvegetated shoreline (0.7 ft above water to 0.7 ft deep) (0.2 m above water to 0.2 m deep) Fines/sand substrate or cobble/gravel High energy or fluctuating water levels	None	Limited/none	Limited-Annelida	Otter and mink	Snapping turtle	Mallard, spotted sandpiper, semi-palmated sandpiper, great blue heron and green heron	2.0 ft. (60 cm) (Average of 2.5 ft.)

Footnotes:
a. High, medium, and low energy designations were developed by Anchor-QEA in the Wind/Wave Analysis from the Capping and Dredge Area and Depth Technical Document (Parsons, 2009).
b. Selection of modules for specific areas around the lake will consider the presence/occurrence of invasive species.
c. Diversity of species for benthos will be evaluated during the next phase of design.
d. See representative species Tables 4.1 to 4.7 for substrate depth and minimum habitat size information for specific organisms.
e. Structure can be added to any module. Species that would benefit from structure have been noted on the table.
f. A habitat layer will not be required in areas of the Profundal zone that do not have an isolation cap.

TABLE 4.8 (Continued)
HABITAT MODULE CHARACTERISTICS
ONONDAGA LAKE REMEDIAL DESIGN PROGRAM

HABITAT MODULE AREAS[a] [b] [e]	REPRESENTATIVE SPECIES/HABITAT						
	Fish	Plants	Benthic Macroinvertebrates[c]	Mammals	Reptiles and Amphibians	Birds	Minimum Habitat Layer Thickness[d]
8A. Shoreline uplands/riparian Topsoil substrate	None	Successional fields	None	Otter and mink	Leopard frog	Mallard, great blue heron, green heron and red-winged blackbird	1.5 ft. (45 cm) (Average of 2.0 ft.)
8B. Shoreline uplands/riparian Topsoil substrate	None	Scrub-shrub or forested	None	Otter, mink, beaver and Indiana bat	Leopard frog and water snake	Mallard and green heron	1.5 ft. (45 cm) (Average of 2.0 ft.)
9A. Inland wetlands not associated with the lake (saturated soils to pooled water that may be temporary) Topsoil substrate	None	Wet meadow and persistent emergent wetland species, primarily herbaceous	Limited numbers/species, Annelida and Mollusca	Muskrat and mink	Leopard frog, red spotted newt, water snake and green frog	Red-winged blackbird, green heron, great blue heron, spotted sandpiper and bank swallow	2.0 ft. (60 cm) (Average of 2.5
9B. Inland wetlands not associated with the lake (saturated soils to pooled water that may be temporary) Topsoil substrate	None	Forested wetland and scrub-shrub wetland species	Limited numbers/species, Annelida and Mollusca	Mink and beaver	Spotted salamander and wood frog	Red-winged black bird and green heron	2.0 ft. (60 cm) (Average of 2.5

SPECIAL FEATURES/CONSIDERATIONS

Endangered aquatic plants (*Potamogeton strictifolius, Najas guadalupensis* var. muenscheri, or Najas *guadalupensis* var. olivacea)	Potential for these species where submerged aquatic vegetation is targeted. These would most likely fall under Module 3A.
Northern Pike Spawning Wetlands	Provide spawning habitat for northern pike.

Footnotes:
a. High, medium, and low energy designations were developed by Anchor-QEA in the Wind/Wave Analysis from the Capping and Dredge Area and Depth Technical Document (Parsons, 2009).
b. Selection of modules for specific areas around the lake will consider the presence/occurrence of invasive species.
c. Diversity of species for benthos will be evaluated during the next phase of design.
d. See representative species Tables 4.1 to 4.7 for substrate depth and minimum habitat size information for specific organisms.
e. Structure can be added to any module. Species that would benefit from structure have been noted on the table.
f. A habitat layer will not be required in areas of the Profundal zone that do not have an isolation cap.

TABLE 4.9
SUMMARY OF ACREAGES WITHIN THE AREAS OF REMEDIATION

IN-LAKE

	RA-A		RA-B		RA-C		RA-D		RA-D Addendum		RA-E		RA-F		TOTAL	
Habitat Module	**Existing**	**Restored**	**Existing**	**Restored**	**Existing**	**Restored**	**Existing**	**Restored**	**Existing**	**Restored**	**Existing**	**Restored**	**Existing**	**Restored**	**Existing**	**Restored**
1	36.8	35.2	9.5	8.3	14.0	12.8	24.2	26.7	5.6	5.6	41.4	35.0	0.2	0.2	131.6	123.7
2A	23.5	24.4	4.0	4.7	5.2	6.2	30.9	40.6			69.2	45.3	0.1	0.1	132.9	121.3
2B												20.4				20.4
3A	20.8	8.4	1.6	1.4	1.1								0.3	0.3	23.7	10.1
3B					2.9	4.2	38.9	27.3			67.1	70.0			108.9	101.6
4A		4.8														4.8
5A	2.5	4.4	1.1	1.7	0.9										4.5	6.1
5B					1.4	2.3	4.5	2.1			6.9	9.2			12.8	13.6
6A		6.3														6.3
6B						0.0		1.8				4.7				6.5
TOTAL	83.5	83.5	16.1	16.1	25.5	25.5	98.5	98.5	5.6	5.6	184.6	184.6	0.6	0.6	414.4	414.4

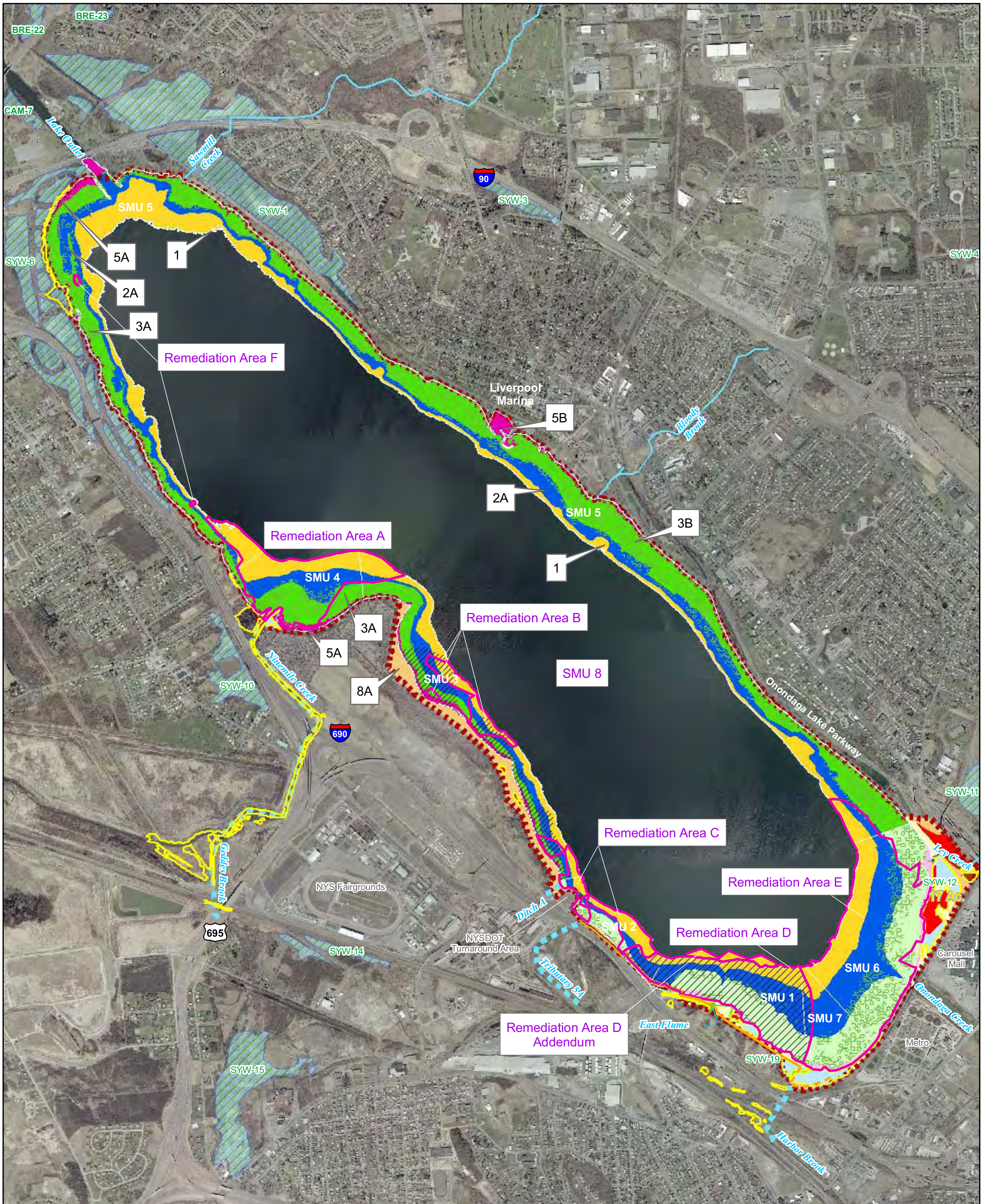
Notes:
(1) TBD - To Be Determined.
(2) Modules with structure have not been broken out separately.

TABLE 4.9 (Continued)
SUMMARY OF ACREAGES WITHIN THE AREAS OF REMEDIATION

LAKESHORE AREA

	WB-B/Harbor Brook		WB 1-8		Mouth of Ninemile Creek		SYW-12		Semet Shoreline		TOTAL	
Habitat Module	Existing	Restored	Existing	Restored	Existing	Restored	Existing	Restored	Existing	Restored	Existing	Restored
3A	2.9										2.9	0.0
3B											0.0	0.0
4A											0.0	0.0
5A											0.0	0.0
5B											0.0	0.0
6A	12.3	14.4		2.3	2.2	1.6	8.8	TBD			23.3	TBD
6B											0.0	0.0
8A	2.4		31.1	24.1			6.3	TBD	1.3		41.0	TBD
8B	6.5	9.9	-				8.5	TBD		1.3	16.3	TBD
9A	0.3		0.7				3.1	TBD			4.1	TBD
9B	1.0	1.2		5.4	0.3	0.9	12.8	TBD			14.1	TBD
TOTAL	25.4	25.4	31.8	31.8	2.5	2.5	39.4	TBD	1.3	1.3	101.6	TBD

Notes:
(1) TBD - To Be Determined.
(2) Modules with structure have not been broken out separately.



Aquatic Plants (From Onondaga County Department of Water Environment Protection, 2008)

NYSDEC/EPA Approved Wetland Boundaries

NYSDEC Wetland (NYSDEC, 2007)

Sediment Management Unit (SMU) Boundary

Area Containing Solvay Waste or ILWD

Remediation Area Boundary (Parsons, 2009)

Area Covered by Onondaga Lake Remedial Design Elements for Habitat Restoration

Tributary to be remediated by Honeywell

Willis/Semet IRM Barrier Wall

West Wall Portion of the WB-B/HB IRM

Approximate Location of the East Wall Portion of the WB-B/HB IRM

N W E S

New York State Digital Orthoimagery from 2003

980 490 0 980
Feet

Water depth based on lake surface elevation of 362.5' NAVD88.

FIGURE 4.1

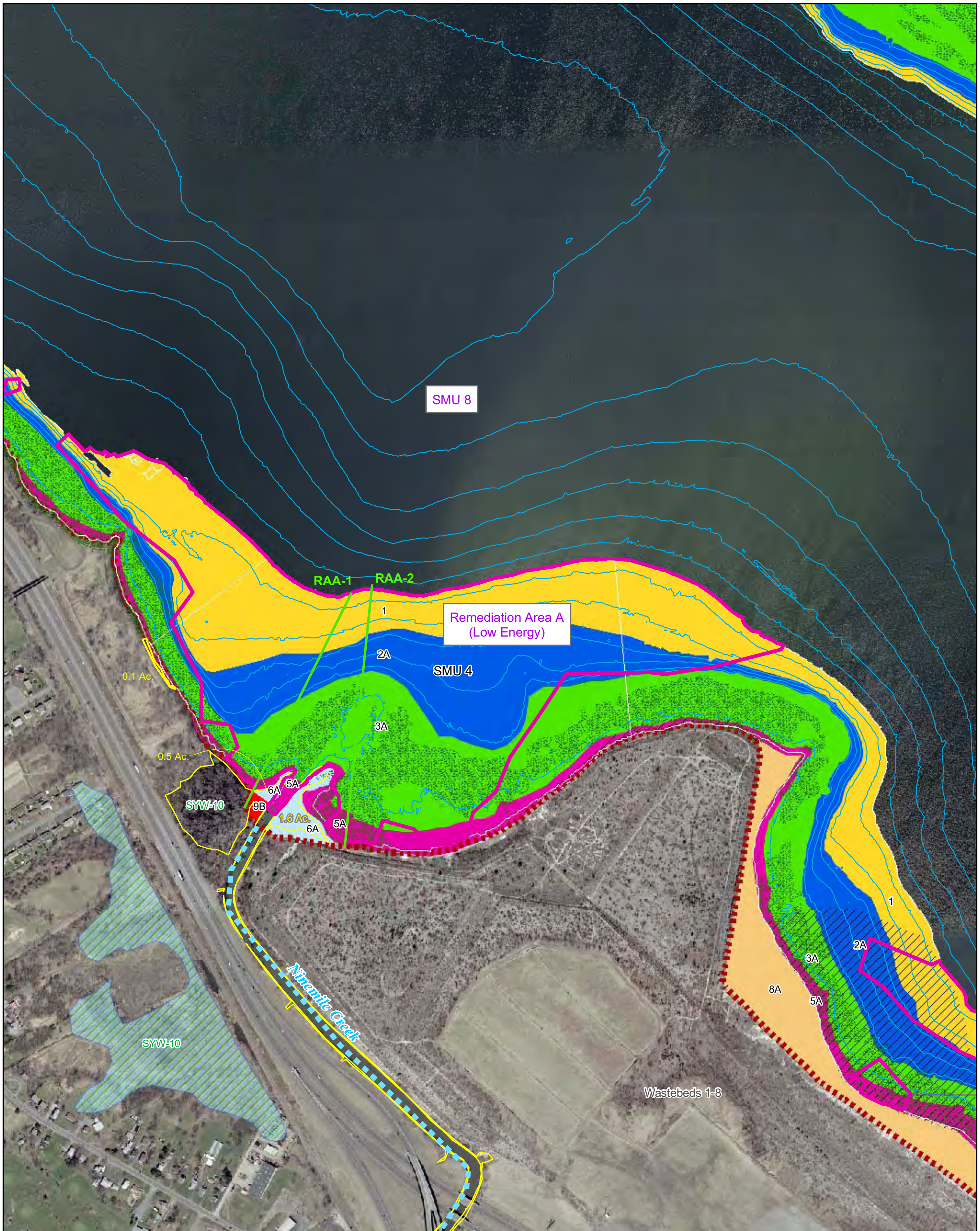
Honeywell

Onondaga Lake
Syracuse, New York

Existing Habitat Modules With The Habitat Plan Boundary

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



Aquatic Plants (From Onondaga County Department of Water Environment Protection, 2008)

NYSDEC/EPA Approved Wetland Boundaries

Sediment Management Unit (SMU) Boundary

NYSDEC Wetland (NYSDEC, 2007)

Area Containing Solvay Waste or ILWD

Remediation Area Boundary (Parsons, 2009)

Cross-section Location and Identification

Area Covered by Onondaga Lake Remedial Design Elements for Habitat Restoration

Tributary to be remediated by Honeywell

N
W E
S

New York State Digital Orthoimagery from 2003

350 175 0 350

Feet

Water depth based on lake surface elevation of 362.5' NAVD88.

Contour interval = 5'

FIGURE 4.2

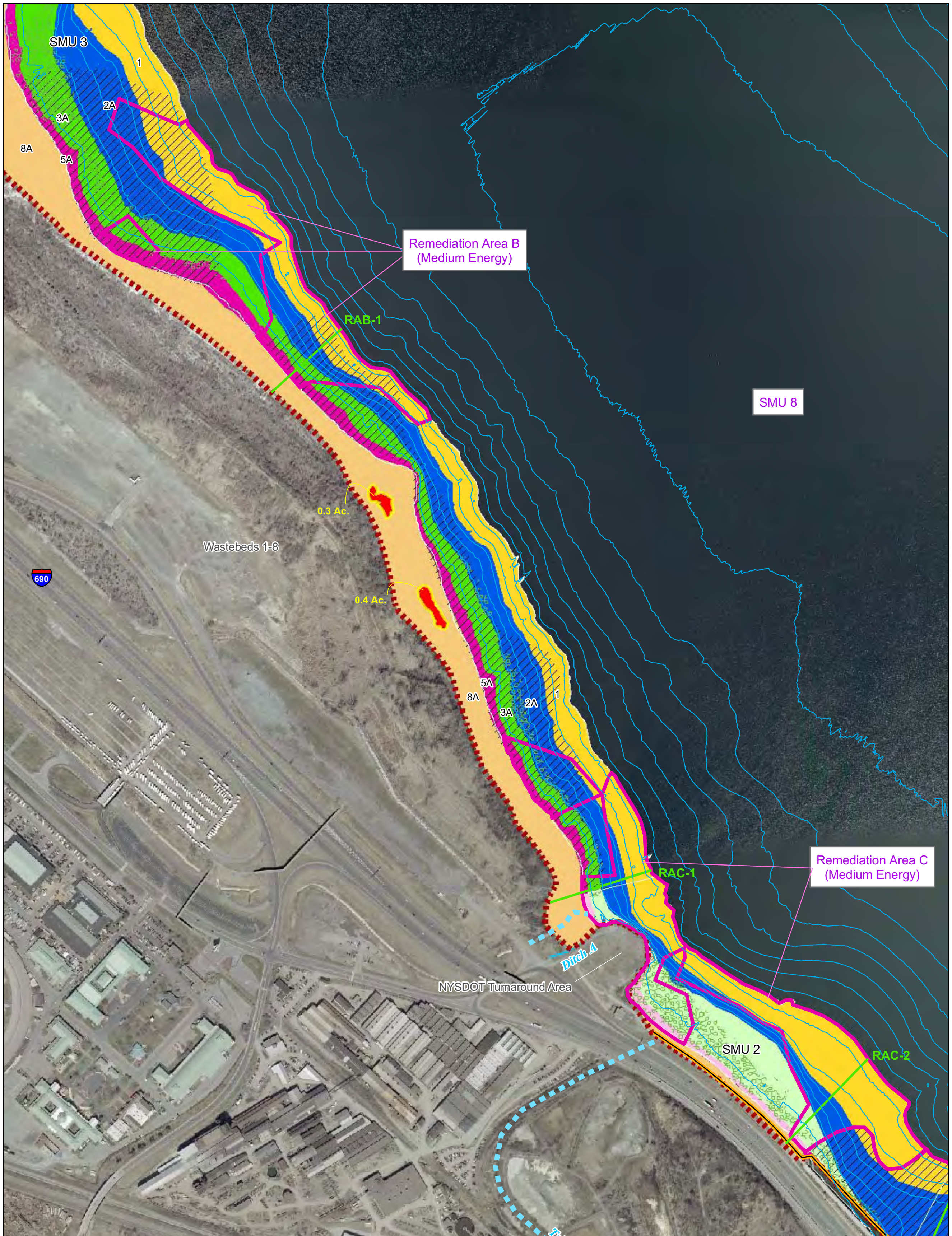
Honeywell

Onondaga Lake
Syracuse, New York

Existing Habitat Modules
Remediation Area A

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



Aquatic Plants (From Onondaga County Department of Water Environment Protection, 2008)

NYSDEC/EPA Approved Wetland Boundaries

Sediment Management Unit (SMU) Boundary

Area Containing Solvay Waste or ILWD

Tributary to be remediated by Honeywell

Remediation Area Boundary (Parsons, 2009)

Area Covered by Onondaga Lake Remedial Design Elements for Habitat Restoration

Willis/Semet IRM Barrier Wall

West Wall Portion of the WB-B/HB IRM

RAB-1 Cross-section Location and Identification

N W E S

New York State Digital Orthoimagery from 2003

350 175 0 350
Feet

Water depth based on lake surface elevation of 362.5' NAVD88.

Contour interval = 5'

FIGURE 4.3

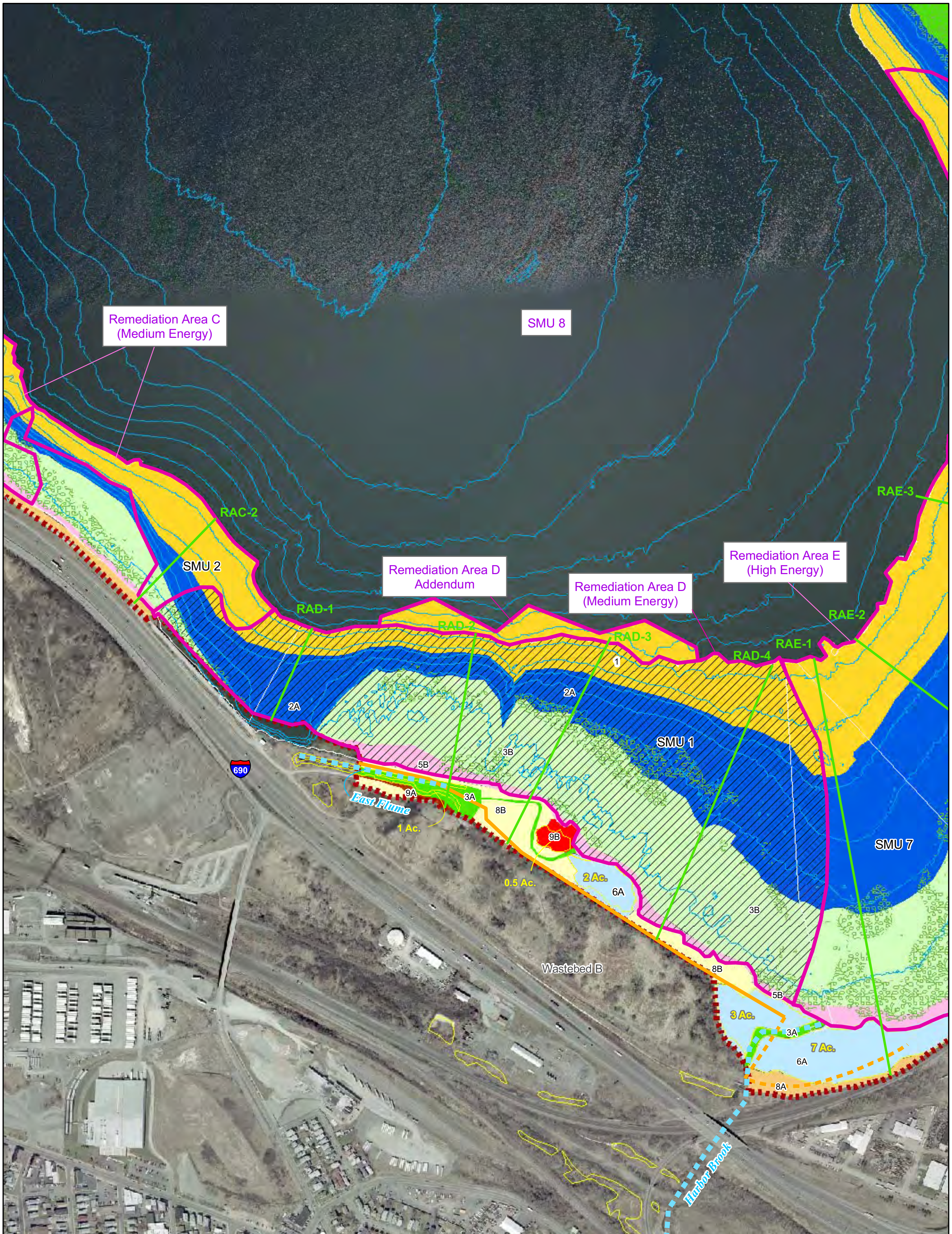
Honeywell

Onondaga Lake
Syracuse, New York

Existing Habitat Modules
Remediation Areas B & C

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



Aquatic Plants (From Onondaga County Department of Water Environment Protection, 2008)

NYSDEC/EPA Approved Wetland Boundaries

Sediment Management Unit (SMU) Boundary

Area Containing Solvay Waste Within the Lake

Remediation Area Boundary (Parsons, 2009)

RAD-1 Cross-section Location and Identification

Area Covered by Onondaga Lake Remedial Design Elements for Habitat Restoration

Tributary to be remediated by Honeywell

Willis/Semet IRM Barrier Wall

West Wall Portion of the WB-B/HB IRM

Approximate Location of the East Wall Portion of the WB-B/HB IRM

N E S W

New York State Digital Orthoimagery from 2003

350 175 0 350

Feet

Water depth based on lake surface elevation of 362.5' NAVD88.

Contour interval = 5'

FIGURE 4.4

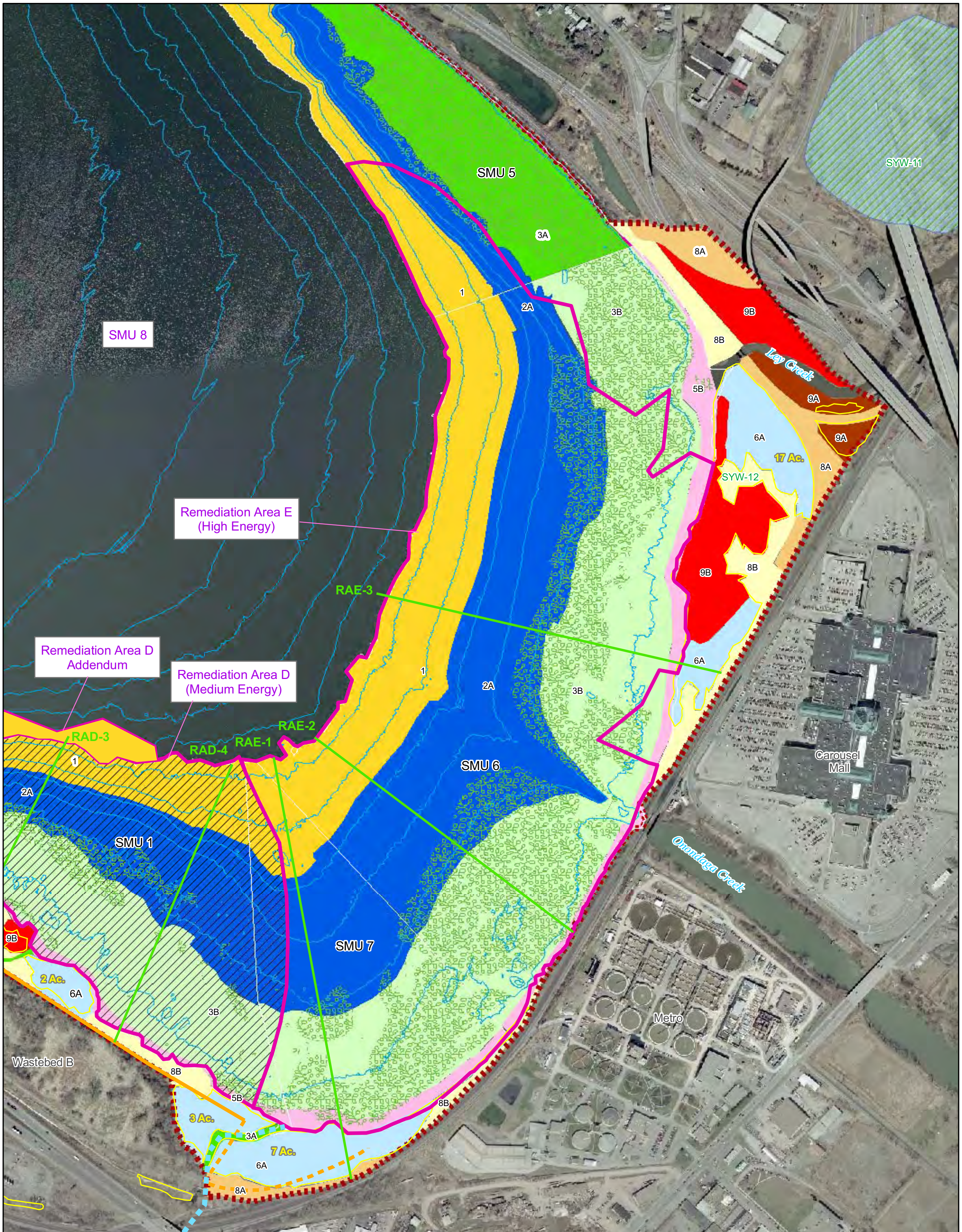
Honeywell

Onondaga Lake
Syracuse, New York

Existing Habitat Modules
Remediation Area D

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



Aquatic Plants (From Onondaga County Department of Water Environment Protection, 2008)

NYSDEC/EPA Approved Wetland Boundaries

Sediment Management Unit (SMU) Boundary

Area Containing Solvay Waste Within the Lake

Remediation Area Boundary (Parsons, 2009)

RAE-1 Cross-section Location and Identification

Area Covered by Onondaga Lake Remedial Design Elements for Habitat Restoration

Tributary to be remediated by Honeywell

Willis/Semet IRM Barrier Wall

West Wall Portion of the WB-B/HB IRM

Approximate Location of the East Wall Portion of the WB-B/HB IRM

N W E S

New York State Digital Orthoimagery from 2003

350 175 0 350
Feet

Water depth based on lake surface elevation of 362.5' NAVD88.

Contour interval = 5'

FIGURE 4.5

Honeywell Onondaga Lake Syracuse, New York

Existing Habitat Modules
Remediation Area E

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

Section 5: Preliminary Designs for Lakewide Habitat Restoration

One of the top priorities of the Onondaga Lake remedial program is to maintain or improve the habitat conditions that will result after completion of the remediation and restoration efforts. Development of a variety of habitats that will diversify and enhance the lake system is at the forefront of the various design evaluations.

This section of the Habitat Plan describes the approach used to combine the existing and historical information presented in Section 2 with the changes that will occur within the lake as part of remediation described in Section 3 to develop habitat restoration designs that meet the goals and objectives for habitat restoration described in Section 4.

The remedial dredging and capping areas fall within two general categories, those areas within the ILWD and areas outside of the ILWD. Within the ILWD, the ROD required an average depth of removal of 6.5 feet with an additional 3.3 feet of removal in hot spots. As a result, the post-remediation water depths will largely be determined by the dredge and cap designs for the ILWD, as well as considerations for habitat restoration, which are currently in progress. In near shore areas outside of the ILWD, the post-remediation water depths are primarily directed at creating specific conditions suitable for the representative species and habitats. Because the areas outside of the ILWD comprise the majority of remediation acreage, the habitat module approach described in this section provides a unique opportunity to conduct large scale habitat improvements within areas being remediated in Onondaga Lake.

5.1 Generation of Restoration Approach

This Habitat Plan presents the preliminary draft habitat restoration design. These designs are the result of many factors, including the integration of representative species habitat needs with the multiple considerations and constraints associated with the cleanup criteria and design specified in the ROD, the approach specified in the draft Capping and Dredge Area and Depth IDS (Parsons, 2009g), the physical constraints of the site, and the habitat goals and objectives discussed in Section 4.

Specific examples of habitat, dredging, and capping considerations that were integrated into the plan include required isolation cap thickness, habitat layer thickness, cap-induced settlement, ice scour, wind/wave energy, erosion protection requirements, dredging depth, slope stability, and substrate size. These considerations, which can vary depending on the type of remedy and the location in the lake, were then used as guiding assumptions in developing the habitat restoration designs based on the habitat modules.

Due to the iterative nature of integrating habitat, dredging, and capping considerations into the final design for the lake and adjacent shoreline areas, there may be some modification to the application of the modules. Based on public input, future investigations, studies, and/or remedial decisions, changes to the application of these modules may occur; however, the overall distribution and variety of modules will be consistent with this plan.

One of the key components of the restoration design is the post-remediation water depth. This water depth is important for determining the type and extent of habitat modules, selecting appropriate plant species, designing the erosion protection layer, and potentially controlling invasive species. These issues were evaluated during the development of the habitat modules based on a variety of documents including the Onondaga Lake FS (Parsons, 2004), the ROD (NYSDEC and USEPA, 2005), standards for grain size distribution (ASTM D, 2007), and the draft *Capping and Dredge Area and Depth IDS* (Parsons, 2009g), which includes the cap induced settlement estimates and the wind/wave analysis prepared by AnchorQEA.

A major factor that directly impacts post remediation water depth is the thickness of the habitat material that will be placed after dredging and/or capping is conducted. Habitat materials will be placed in areas that require isolation capping (habitat layer) as well as areas identified for dredging to cleanup criteria (habitat reestablishment material).

The purpose of the habitat layer is to provide a suitable substrate that representative species can utilize while not impacting the chemical isolation layer of the cap. The habitat layer will be placed on top of the isolation layer or erosion protection layer and vary from a minimum of 1.0 feet (average of 1.25 feet) in the deep water to a minimum of 2.0 feet (average of 2.5 feet) in the nearshore areas (Section 5.2 and Table 5.1). These thicknesses were developed based on the specific habitat being created and the types of organisms that will most likely inhabit these areas.

A habitat layer will be placed in the nearshore areas where dredging to cleanup criteria has been proposed and isolation capping is not required. This material will be a minimum of two feet thick and will be consistent with the grain size and habitat modules identified for the nearshore areas (Table 4.8 and Figures 5.1-5.24).

The Habitat TWG evaluated the multiple constraints and established design assumptions with input from other technical teams (e.g. capping) for each of the remediation areas in the lake (Figures 3.1 and 3.2), while meeting each of the habitat goals and objectives. During this process, the group developed a post-remedy surface of the lake bottom that represents the restored lake bottom after the dredging and capping are complete.

The habitat modules were applied to the new lake bottom surface so that the restored module is applied to areas with the appropriate water depth range. The applied modules are conceptual and the boundaries may fluctuate since the lake is a dynamic, natural system. The upland portions adjacent to the lake that fall under the scope of the Habitat Plan have also been included. However, modules for the lower bench of the Wastebeds 1 through 8 site and the SYW-12 site have not been proposed since those sites are still going through the RI/FS process and remedies have not been established. The status of these areas is further described below under Remediation Area B and E, respectively.

These new lake bottom surfaces were then used to develop cross sections that depict the current water level, the existing bathymetry (water depth), dredge cut, and the restored final lake bottom surface (after dredging and placement of the cap and habitat materials) (Figures 5.2, 5.3, 5.5, 5.7, 5.8, 5.10, 5.11, 5.12, 5.13, 5.15, 5.16, 5.17). Along the bottom of each cross section, the current and restored habitat modules are illustrated as color-coded blocks that correspond to the habitat module table (Table 4.8) introduced in Section 4.

Details regarding the development of the cross sections can be found in Appendix F of the Capping and Dredge Area and Depth IDS (Capping IDS) (Parsons, 2009g).

The cross sections contained in this Habitat Plan are very similar to those found in the Capping IDS; however, there are some slight differences. The Capping IDS includes cross sections that illustrate the elevation of the cap at the *time of placement*. The cross sections contained in this plan show the thickness of the cap (including the habitat/erosion protection lay*er) after the underlying sediment has settled due to the weight of the cap*. These cross sections also illustrate post-remedy bathymetry using the most conservative estimates of overplacement in order to meet the more critical nearshore water depths required for habitat modules 3, 4, and 5.

The amount of settlement was calculated based on the type of existing sediment, the depth of water, geotechnical conditions, rates of compression, etc. These settlement calculations were accounted for in assessing the post-remedy water depths for assigning habitat modules. Details regarding the evaluation and calculation of settlement can be found in the Capping IDS.

Settlement was also taken into consideration when calculating the change in water depth over the areas of remediation between existing conditions and the post-remedy conditions. This change in water depth is shown on Figures 5.20-5.24. Approximately 276 acres will be shallower and 131 acres will be deeper following remediation and restoration.

5.2 Habitat Layer Characteristics and Thickness

The placement of a habitat layer on top of the isolation cap is a key component of the Onondaga Lake remedy. The purpose of the habitat layer is to provide a suitable substrate that representative species (*e.g.*, plants, animals, and fish) can use while remaining isolated from the underlying contaminants. A secondary purpose of the habitat layer is to allow biological activity to occur without affecting the integrity of the underlying isolation cap. As specified in the ROD for Onondaga Lake, the habitat layer will be a minimum of 1 foot thick and will be the top layer of the isolation cap.

The uppermost layer of soil/substrate specified in each module is dedicated habitat material and will consist of either finer material (silts and sands) or coarser material (gravel and cobble) depending upon desired habitat in that area. The specific grain sizes that will be used are designed to allow movement under the dynamic conditions of the lake and are not intended to be stable during storm events like the erosion protection layer. The grain size of the habitat material can affect the suitability of the module for plant and animal species. In some instances, the grain size may be a disadvantage for certain species or species groups, but an advantage to others. For example, coarse substrates may tend to reduce or limit the suitability of an area for plants to root, while at the same time it may increase or enhance the area for certain fish species and groups of benthic macroinvertebrates. These suitability differences are presented in the habitat module table (Table 4.8) and discussed in Section 4.6.

For the wetland habitat modules and modules specified for onshore areas, the uppermost portion of the habitat layer will be topsoil with a specified minimum organic content. The specifications for the different types of soil/substrate are presented in Section 5.5. The grain sizes for the different types of soil/substrate are presented in Section 5.5.

The need for organic content in each of the modules will be determined as part of subsequent design submittals.

The last column on Table 4.8 identifies the habitat layer thickness considered appropriate for each habitat module. These habitat layer thicknesses were developed by a group of technical staff from the USEPA; USFWS; NYSDEC; NYSDEC Division of Fish, Wildlife, and Marine Services; and national and local habitat experts from SUNY ESF, Mississippi State University, Parsons, O'Brien and Gere, TES, AnchorQEA, and the University of Louisiana at Lafayette. This process involved multiple meetings and extensive discussions to evaluate the biological factors that dictate the appropriate thickness of the habitat layer. Specifically, information on plant rooting depth, animal burrowing depth, depth of fish nests and bioturbation were reviewed from the scientific literature, guidance documents on subaqueous cap design, and site-specific data and observations from Onondaga Lake and adjacent areas.

While each of these biological factors was determined to be important, the group's review and professional experience identified plant rooting depth and animal burrowing depth as the critical factors. In general these factors result in the need for thicker habitat layers in shallower areas where plants root deeper and along the shoreline where animals may burrow. The depth of plant roots in shallow water wetlands and near shore environments is a function of several factors, but is primarily determined by the characteristics of a species and how the hydrology and substrate in the area affect the duration and depth of anaerobic conditions. Under flooded conditions, plant species have shallower root systems. In wetlands dominated by woody species, roots are typically confined to the upper 1 to 1.5 feet of substrates, or generally above the water table. The roots need oxygen and do not survive in the saturated zone where water forces out the oxygen. An emergent wetland of herbaceous species typically has water levels near the sediment/soil surface and the majority of the roots in the top 0.5 to 1 feet of material. In deeper waters where submerged and floating aquatic vegetation may be present, the rooting depth is largely determined by nutrient availability, since water is readily available. Nutrients do not percolate into the sediment, but are deposited from the overlying water column. This typically results in the highest nutrient concentrations near the sediment/water interface (0 to 0.5 feet) where the root systems of submerged and floating plants are found (Mitsch and Gosselink, 2003; Service Engineering Group, 2002; Spencer and Ksander, 2005; Thiebaut, 2005; Lehmann *et al*., 1997; Wigand *et al*., 1997).

In addition to the review of biological factors, there were also extensive discussions regarding the operational considerations of how the cap and habitat material will be placed in the lake. The way in which the contractor will place the material and the requirements stated in the contract are important factors that ultimately affect the thickness of each layer. The contract requirements may specify that the contractor will need to place a minimum thickness for each layer. The most effective and efficient means that contractors have to be certain they have met the required minimum thickness is to place *more* material than is needed for that layer, which is called “over placement.” For each specific layer (e.g. chemical isolation, erosion protection, and habitat) the contract documents may specify the minimum thickness and the allowable amount of over placement. The typical end result of this approach is that the final thickness of each layer is more than the specified minimum thickness in each area.

Based on the biological and operational considerations noted above, as well as the 1-foot minimum thickness specified in the Onondaga Lake ROD, and the need to keep biota and from contacting the underlying isolation cap, the technical team has developed habitat layer thicknesses for the littoral zone in Onondaga Lake as summarized below:

Water Depth	Minimum Habitat Layer Thickness
7 ft to 30 ft	1 ft (Estimated 1.25 ft average)
3 ft to 7 ft	1.5 ft (Estimated 2 ft average)
+1 foot to 3 ft	2 ft (Estimated 2.5 ft average)

Based on recommendations of the NYSDEC and discussions with the TWG, it was determined that the materials of the habitat layer should be finer grained and allowed to move, unlike the erosion protection layer. This finer grained material will be placed following completion of the isolation layers in various portions of the lake. Due to the dynamic nature of the physical processes present in the Onondaga Lake system, measurements of the habitat layer will be made once placement of the material is completed to ensure the minimum thicknesses noted above are met. Some movement of substrate within the habitat layer is expected following confirmation of the thicknesses noted above due to the dynamic nature of the lake system and a new equilibrium being reached following restoration. The details of the acceptable levels of movement and maintenance requirements for the habitat layer will be included in subsequent design submittals. Additional details on the monitoring program are noted in Section 5.5.2.

5.3 Application of Habitat Modules to Remediation Areas

The most challenging step in the restoration of habitats is selecting what specific habitat type (or in this instance, habitat module) should be targeted in each area. Applying these modules provides an opportunity to diversify and improve the terrestrial and aquatic habitat of the lake system. Such improvement can occur by creating new habitats that do not currently exist or were historically present (*e.g.* wetland fringe habitats), or by enhancing existing habitats (*e.g.* by providing different water depth/substrate types or eliminating invasive species).

Mudflats are covered under Habitat Module 7 and may exist in fringe areas following restoration.

Each of the habitat modules presented on Table 4.8 was applied at some location within a remediation area. Presently, mudflats (Module 7) have not been included due to the lack of control over fluctuating water levels required to keep the mudflat area unvegetated, the presence of the canal system that controls water levels in the lake, and the high potential for colonization by the invasive *Phragmites*. However, shorelines and shallow water areas that are exposed during periods of low lake level will provide shorebird habitat similar to that of mudflats.

The application of habitat modules is shown in the cross sections and plan views presented on Figures 5.1, 5.4, 5.6, 5.9, and 5.14. These figures depict an approach that accounts for the various physical constraints and considerations noted in the ROD and the Capping Area and Dredge Depth Technical Document (Parsons, 2009b). The deep water portion of the lake (SMU 8) may require some active remediation (*i.e.* thin layer capping); however, habitat designs have not yet been developed for these areas as the final location for these areas are still undefined.

Remediation is required in the portions of the lake where contaminants exceed the criteria specified in the ROD. Remediation efforts are required in the portion of the lake from near the mouth of Ninemile Creek southeast along the lake to the mouth of Harbor Brook and the southern portion of the lake to near the mouth of Ley Creek. With a few minor exceptions, active remediation will not be required in the eastern, northern, or northwestern portions of the lake. The remedy for each of the remediation areas in the lake requires isolation capping, dredging to cleanup criteria or a combination of dredging and isolation capping (Figures 3.1 and 3.2).

Although the remediation areas are defined by the lake shoreline, the habitat modules within the additional shoreline areas covered by the Habitat Plan (dashed red line on figures) are also shown. The restored habitat for each remediation area is fully discussed in the following section.

Table 4.9 offers a summary of the changes in area for the existing and restored habitat modules in the areas of the lake requiring remediation and in the adjacent upland Lakeshore Area.

5.3.1 Remediation Area A (SMU 4) and Mouth of Ninemile Creek

As indicated on Figure 1.2, Remediation Area A is the lake area located at the mouth of Ninemile Creek. This remediation area includes a cap area in deeper water and a dredge and cap area closer to shore. Habitat restoration in this area includes the remediation area and the on-shore areas up to the red line habitat plan limit.

The location, distribution, and extent of the restored habitat modules, as well as the cap areas are shown on Figure 5.1. Two cross-sections (Sections RAA-1 and RAA-2) each showing existing and restored habitats are shown on Figures 5.2 and 5.3, respectively. This presentation allows comparison of the restored habitat modules to existing habitats. The cross section also shows the restored substrate type in each portion of the habitat module.

Overview of Habitat Restoration in Area A

The primary consideration in developing a restoration plan for Remediation Area A included the following concepts: recognized area of low wave energy environment, importance of the Ninemile Creek tributary, importance of connection between lake and Ninemile Creek, bird and waterfowl use of the area, and adjacent on-shore habitats.

The mouth of Ninemile Creek and the shoreline wetlands are part of the restoration activities in the Habitat Plan.

Maintaining the connectivity between Ninemile Creek and the lake is an important part of the habitat designs.

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. This is significant because low energy is beneficial for the development of non-persistent emergent wetlands (Habitat Module 5A) and necessary for the floating aquatic wetlands (Habitat Module 4A) in this area.

The nearshore area east of Ninemile Creek will be dredged to create a deeper channel for floating aquatic species in the low energy area along the shoreline (Module 4A). The shallow water module offshore of this area (Module 6A) will support persistent emergent vegetation. The deeper water nearshore also will help reduce the ability of *Phragmites* to spread out into the floating aquatic vegetation and emergent wetlands near the lakeshore. A shallow channel is also planned to further reduce the threat of *Phragmites* spreading into the restored emergent wetlands. The channel will be 2 to 3 feet deep and 20 to 30 feet wide to limit habitat suitability for *Phragmites* (USEPA, 2008).

The importance of maintaining a significant connection between the lake and Ninemile Creek is recognized in the habitat restoration plan for this area by the provision of a deeper channel (Module 3A, 2 to 7 foot water depths) at the creek mouth to maintain fish passage and recreational boat access.

The approach for Remediation Area A provides for a natural transition from the lake to the forested and emergent wetlands and upland areas immediately adjacent to this area. These wetland and upland areas are part of the Geddes Brook/Ninemile Creek site. Module 9 (forested wetlands) will also be present along the shore on either side of Ninemile Creek where it joins the lake to help maintain the existing forested wetland in the area and also to reduce *Phragmites* along the edges. The shade created by the trees will reduce the suitability of the area for this invasive species.

5.3.2 Remediation Area B (SMU 3)

Remediation Area B is located along the base of Wastebeds 1 through 8 in a medium energy environment (Figure 5.4). The remedy for this area consists of dredging and capping of select areas, and habitat enhancement along the shoreline as specified in the ROD (p. 75). The total acreage for this area is minor compared to the adjacent areas. A cross-section through one of the restored remediation areas is presented on Figure 5.5.

This Habitat Plan also covers the shoreline area of Wastebeds 1-8, which is adjacent to Remediation Area B.

Overview of Habitat Restoration in Area B

Shoreline stabilization will be integrated with the remedy for Wastebeds 1 through 8 to reduce resuspension and turbidity along the shoreline of SMU 3. The shoreline stabilization will use a combination of various bioengineering techniques to develop a natural shoreline area that provides a transition zone from the low-lying area of Wastebeds 1 through 8 to SMU 3. Details of the shoreline stabilization enhancement are presented in Section 5.3.3.

Other objectives that are addressed by the restored habitat in this area include increasing water depth in nearshore areas by dredging and maintaining a steep offshore shelf to create topographic heterogeneity. The restored habitat modules attempt to maximize the area suitable for submerged aquatic plants and maintaining mid-water depth modules (*e.g.* Module 2A) in areas with sufficient oxygen.

Most of the remediation work in this area is in the deeper water depths. As a result, Habitat Modules 1 and 2 have been applied to this area. Areas of remediation work within the submerged aquatic vegetation water depth will be restored in-kind with Habitat Module 3.

The low-lying bench of Wastebeds 1 through 8 has been included within the boundary of the Habitat Plan due to the low elevation of this area and proximity to the lakeshore. The RI/FS is currently ongoing for this site and a proposed plan for remediation and restoration, if necessary, has not been established. The potential to create wetlands in this area will be further evaluated as the RI/FS progresses. A portion of the low-lying bench area has modules assigned for the purposes of wetland and open water mitigation, and the shoreline stabilization areas for the Remediation Area B shoreline will be integrated with the habitat modules for this area.

5.3.3 Habitat Enhancement (SMU 3 Shoreline)

The ROD identified two specific locations where habitat enhancement activities would be applied-- the areas are along an estimated 1.5 miles (2.4 km) of shoreline (SMU 3) and over approximately 23 acres (SMU 5) to stabilize calcite deposits and oncolites and promote submerged aquatic plant growth. The status of the habitat enhancement activities for SMU 5 is described in Section 5.3.9. The following section describes the habitat enhancement activities planned to stabilize the SMU 3 shoreline.

This exposed Solvay Waste along the shoreline of Wastebeds 1-8 will be addressed as part of the habitat enhancement activities discussed in this section.

The shoreline stabilization is designed to reduce resuspension and turbidity along the shoreline of SMU 3 and will ultimately be integrated with the remedy for Wastebeds 1 through 8. It is anticipated that the shoreline stabilization will use a combination of bioengineering techniques to provide a natural shoreline area to provide transition zones from the low lying area or Wastebeds1 through 8 and SMU 3. However, the feasibility study has not been completed and no remedial approach has been identified for Wastebeds 1 through 8. As such, the shoreline stabilization described in this section is specific to the shallow water portion of SMU 3 up to an elevation of approximately 365 feet (NAVD 88), 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 feet [NAVD 88]). Stabilization measures for the shoreline areas above the 365 feet (NAVD 88) elevation will be developed once the remedial approach for WB 1 through 8 has been determined.

Approach

As discussed in the Onondaga Lake FS, the shoreline of SMU 3 has the potential to erode during wind/wave events. Stabilization of the shoreline would minimize the potential for resuspension of nearshore and shoreline material due to frequent wave events, reducing erosion and potentially improving water quality conditions in the nearshore littoral zone for submerged aquatic plant growth. The approach for stabilizing the calcite deposits along the SMU 3 shoreline will use bioengineering techniques to the greatest extent possible to minimize hardening of the shoreline and provide a transition between the Wastebeds1 through 8 remediation and in-lake remediation in SMU3. These bioengineering techniques may include the use of a live crib wall, live fascines (woody vegetation bundles such as *Salix spp*.) and vegetative mattresses (brush material buried in trenches). The majority of bioengineering techniques incorporate larger sized stone near the toe of the slope which corresponds with the surf zone of SMU 3. The larger sized stone will be used to stabilize substrate and reduce resuspension. If possible, non-angular graded gravel will be used for habitat enhancement, but in areas where erosion protection is necessary, the preferred material may be angular. This angular material has more stability than rounded material and may better withstand erosive forces.

The results of the wind/wave analysis completed for Onondaga Lake were used to determine the extent of the surf zone and the size of stone needed to stabilize the substrate (Parsons, 2009b). The surf zone associated with the 10-year storm event period was selected as the basis of design for defining the treatment area. This is essentially the area with a 10% probability of receiving a large storm with 2.5 ft waves in any year. Based on the wind/wave analysis, the surf zone (and corresponding wave height) extends to a water depth of approximately 2.5 feet for waves associated with the 10-year return period. The treatment area for stabilizing the substrate will be set at the 2.5 feet contour within SMU 3, for a total treatment area of 16.2 acres.

The design event for determining the stable particle size should be the same as the design event used to define the surf zone so that the material placed within the surf zone will be stable. However, the design event should not be so conservative as to require unnecessarily large stone sizes that could limit the habitat suitability of the material. As a result, the 10-year return period was used as the basis of design for determining the stable particle size to balance between stability and particle size. Based on this analysis, graded gravel with a median particle size of 0.08 to 0.1 feet will be placed within the surf zone to stabilize the substrate to reduce resuspension and at the toe of the slope where bioengineering treatments are anticipated. This material will be placed along the entire SMU 3 shoreline to a water depth of 2.5 feet, coincident with the depth that demarks the shallow edge of Module 3 and will extend partially into SMU 4 towards the mouth of Ninemile Creek. As such, there is no overlap of the shoreline stabilization areas with the limited area of Module 3 or deeper water modules planned for Remediation Area B.

Substrate type

As previously stated, the substrate type that will be placed within the surf zone and along the toe of the slope will be graded gravel with a D_{50} (median stone size) of 0.08 to 0.1 feet. The gravel will be placed on top of a fabric that will support the gravel and keep the Solvay waste from working up through the material. Ongoing work on Wastebeds 12 through 15 will be used to determine the types of soil amendments that may be needed to support vegetation within the bioengineering treatments that will be applied as part of the Wastebeds 1 through 8 site remediation. The need to place soil amendments in other portions of Wastebeds 1 through 8, including areas adjacent to the shoreline stabilization treatments, will be evaluated once the remedy for that area has been determined.

Substrate thickness

Graded gravel 0.5 feet thick will be placed to a water depth of 2.5 feet to stabilize the substrate along the SMU 3 shoreline, which will reduce the turbidity during wind/wave events in this area.

In the area between the average lake elevation (362.5 feet) and the highest elevation for the habitat enhancement treatment (365 feet), the gravel will be 1 foot thick, mixed with topsoil. In addition, vegetation (including live stakes, shrubs, and riparian seeds for example) will be planted in the area.

5.3.4 Low-lying Portion of Wastebeds 1 through 8 (adjacent to Remediation Area B [SMU 3])

The low-lying portion of Wastebeds 1 through 8 is immediately adjacent to the shoreline stabilization area and Remediation Area B. The area is currently under investigation as part of a focused feasibility study and comprehensive feasibility study. Habitat restoration designs will be dependent on the final remedy for the site and have not been identified at this time.

The low-lying portion of the shoreline of Wastebeds 1-8 is addressed by this Habitat Plan.

There are certain habitat restoration activities that are expected to occur in this area as part of the mitigation to offset impacts associated with remedial activities in other portions of the lake. Impacts associated with the installation of a portion of the barrier wall along Willis Avenue resulted in the loss of approximately 2.3 acres of lake surface area. Wetland areas near the mouth of Harbor Brook will also be affected by the installation of a barrier wall and other remediation activities. These impacts will be offset through the creation of a wetland/open water complex on the low lying portion of Wastebeds 1-8 along the southern shoreline of Onondaga Lake. The mitigation will consist of creating aquatic habitat and wetlands adjacent to the lake. The current design provides for 5.4 acres of inland wetland and 2.3 acres of connected wetlands (Figure 3.7). The specific size and location of this wetland / open water complex and type of wetland system will be determined during intermediate design.

5.3.5 Remediation Area C (SMU 2)

Remediation Area C (SMU 2 and a small portion of the southern end of SMU 3) is located in the southwestern portion of the lake just south of the State Fair parking lot (Figure 3-4). I-690 is adjacent to Remediation Area C, with an exit from I-690 and a gravel parking lot and a NYSDOT turnaround area just west of the lakeshore. This gravel parking lot provides a place for viewing wildlife on the lake and there is also an unimproved boat launch for boat access to the lake. Existing and future recreational use and access are important aspects of this area. Ditch A, a small tributary that drains from the State Fair parking lot, enters the lake just north of the gravel parking lot.

NYSDOT turnaround area off of I-690 and adjacent to Remediation Area C.

Remediation Area C is a medium energy environment. The remedy for this area consists of limited removals along the shoreline followed by capping throughout the majority of the littoral zone. The remedy for this area is also directly affected by the Willis/Semet IRM barrier wall, which stops contaminated groundwater from discharging to Onondaga Lake.

Overview of Habitat Restoration in Area C

Habitat modules for this area are shown on Figure 5.6, and two cross-sections that show existing and future bathymetry and substrates are shown on Figures 5.7 and 5.8. A boat launch may be constructed along the shoreline in this area in the future, which could be located along the south side of the gravel parking lot.

The habitat modules are designed to maintain deep water nearshore for fishing access and public use (Module 2A), as well as placing coarse grained material along the shoreline to support fish spawning and limit invasive species (Modules 3B and 5B). These considerations will help increase the recreational use of the Remediation Area C shoreline in the future and are consistent with the habitat priorities and goals.

5.3.6 Remediation Area D (SMU 1)

Remediation Area D (SMU 1 and small portions of SMUs 2 and 7) is located in the southwestern portion of the lake. This remediation area is currently characterized by a large area of ILWD, which has created shallow water and poor quality substrates throughout this remediation area.

Remediation Area D is also characterized by the existing and proposed segments of the onshore barrier wall, and extensive restoration (primarily wetland habitat modules) will be conducted between the barrier wall and the current lake shoreline (Figure 5.9). Recreational use potential, especially in the northern end of this remediation area, also influences the habitat restoration plans. The Wastebed B area provides undeveloped habitat that separates the barrier wall from I-690.

Remediation Area D is located adjacent to the Wastebed B/Harbor Brook site.

The dredging approach required in Remediation Area D to satisfy the ROD requirements (*i.e.* removal depth equal to an average of 6.6 feet [2 meters] over the current boundary of the ILWD and the additional removal in hot-spot areas) is still being developed. The current remedy for this area includes dredging and capping with deeper excavation in hot-spot areas.

An addendum has been added to Remediation Area D to cover a small area within SMU 8 adjacent to Remediation Area D. This area is approximately 5.6 acres in size and has elevated Mean PECQ levels and will require an isolation cap and habitat layer (Figure 5.9).

Overview of Habitat Restoration in Area D

Habitat modules for Restoration Area D and adjacent onshore areas are shown on Figure 5.9. Cross sections through this area are illustrated on Figures 5.10, 5.11, 5.12, and 5.13. In-lake areas of Remediation Area D include Habitat Modules 1 and 2, with an extensive area of deeper water (Module 2) close to shore in the northern area of this remediation area. The Remediation Area D Addendum area will also consist of additional Module 1 in this small portion of SMU 8. The design noted above creates significant fishing opportunities from the shore for an extensive reach. Water depths in the shallow ILWD areas will be increased by the application of Habitat Module 3 and a clean, more suitable substrate provided, which will support many aquatic plants and animals. Areas of hot-spot removal will create a diversity of water depths within the Module 3 area, and a deep pocket of Module 2. These features will provide additional habitat opportunities for aquatic species.

Nearshore areas of Remediation Area D will be restored with shallower depth modules, which will act as a wave break, reduce the wave energy, and protect the on-shore wetlands, which are described in Section 5.3.8.

5.3.7 Remediation Area E (SMUs 6 and 7)

Remediation Area E (SMU 6 and 7) is located between Harbor Brook and Ley Creek on the eastern shoreline of the lake.

Remediation Area E is a fairly extensive area located at the very southern end of Onondaga Lake. It is an area of high wave energy due to the long fetch of the lake. Onondaga Creek, the primary tributary to the lake, and Harbor Brook discharge into the lake in this area. Emergent wetlands, currently degraded by the presence of waste material and the prevalence of *Phragmites*, occur around the lower reach of Harbor Brook. The barrier wall is also proposed to extend into portions of this wetland complex.

Two other considerations in the restoration of this area are the presence of the discharge from the Syracuse Metro wastewater facility, and the navigational concerns at the mouth of Onondaga Creek. Channel depth at the mouth of Onondaga Creek must be sufficient to accommodate commercial boat traffic that uses Onondaga Creek and the Inner Harbor, and water depth must be sufficient enough to keep Metro discharge from collecting at the end of the lake.

Overview of Habitat Restoration in Area E

Habitat restoration plans for Remediation Area E are shown on Figure 5.14. Cross-sections for this area are shown on Figures 5.15, 5.16, and 5.17. For the Harbor Brook area, details of restoration efforts are shown on Figures 5.18 and 5.19.

The habitat modules in Remediation Area E were designed to account for the high energy in this area, consistent with NYSDEC priority 2, and accommodate the flow of Onondaga Creek and the discharge from the Metro facility into the lake. The restoration approach specifically incorporates several NYSDEC priorities for this remediation area, including shallow shelves to break high energy waves outboard of the shoreline and Wetland SYW-12; deeper water nearshore by removal of impacted material (dredging to cleanup criteria); and creation of a deep water for boat access to Onondaga Creek and the Inner Harbor.

Habitat restoration in the deeper water portions of this area (Modules 1 and 2) will provide water depths similar to current conditions, but with a clean sand and fine gravel substrate.

A large area of Habitat Module 3B is present across this remediation area. Water depths vary in this model and it is intended to reduce some of the wave energy that would reach the shore. Restored substrates are coarse gravel because of the high energy environment. Although these substrates will limit submerged aquatic vegetation establishment, they will benefit certain fish species and benthic organisms.

Near the Harbor Brook area a shallower water area of Habitat Modules 5B and 6B has been included. This area is intended to provide a wave break to protect the wetland habitats around the lower reach of Harbor Brook. Those portions of Habitat Module 6B that are above the lake level at times will provide mudflat habitat beneficial to resident and migratory shorebirds.

5.3.8 Harbor Brook Wetland Complex (On-shore Region Straddling Remediation Areas D and E)

On shore areas between the barrier wall and existing shoreline will be restored to wetlands that will enhance the habitat function and value in this area. Most of the area will be persistent emergent wetland (Habitat Module 6), with a small portion of forested wetland (Habitat Module 9). Good quality emergent wetlands are a noticeably missing habitat around the lake and these areas will enhance and diversify the lake system for aquatic and terrestrial organisms.

As with other persistent emergent wetlands around the lake, the encroachment of *Phragmites* is a concern. For this reason, a *Phragmites* control channel will be constructed along the landward edge of the emergent wetland. This deeper channel is designed to limit the invasion of *Phragmites*, but it will also be good habitat for floating aquatic (Module 4) and non-persistent wetland species (Module 5). As a result, it will be part of the overall wetland complex.

The area of forested wetland (Habitat Module 9) for the on shore area is designed to replace some wooded wetlands, diversify the restored habitats, and to provide some shelter for the adjacent emergent wetlands in the area. The shape of this wetland should create a protected cove in its lee on the southeast side.

During periods of high lake water levels (at or over an elevation of 363.5 feet [NAVD 88]), the creation of these 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.

Restoration of the upland habitat areas between the landward edge of the wetlands and the top of the barrier wall and uplands landward of the barrier wall will also be conducted. Module 8B is proposed in those areas and will allow for the use of shade trees and shrubs in this area.

Currently, the lower portion of Harbor Brook is a channelized reach surrounded by a wetland composed of a monoculture of *Phragmites*. It is degraded by the presence of waste material and the prevalence of *Phragmites* with limited value to terrestrial and aquatic organisms.

Significant habitat restoration efforts are planned for this area within and adjacent to Harbor Brook. These efforts will greatly enhance and diversify the habitats in this area and provide benefits to a diverse array of aquatic and terrestrial species.

An overview of the restoration for the Harbor Brook area is shown on Figure 5.9. More detailed plans are presented on Figures 5.18 and 5.19.

The habitat restoration approach for this area includes the reconfiguration of Harbor Brook into a braided stream wetland complex

(Figures 5.18 and 5.19). The reconfiguration of Harbor Brook would allow for increased stream stability, development of improved habitats suitable for a variety of species, and improvement of the connectivity of wetlands with the lake habitats. The wetlands restoration will include a persistent emergent wetland complex (Module 6A) that is specifically designed with shallow channels to enhance the area for northern pike spawning. Slightly higher mounds have been included to provide areas for waterfowl nesting.

The barrier wall extends into the Harbor Brook area. Upland habitat modules (Modules 8A and 8B) will be restored to transition from the wetlands up to the wall, and to restore the areas on the landward edge of the wall. Wetlands and side slopes, open fields, and scrub-shrub habitat landward of the wall will benefit a variety of wildlife species.

SYW-12 Area

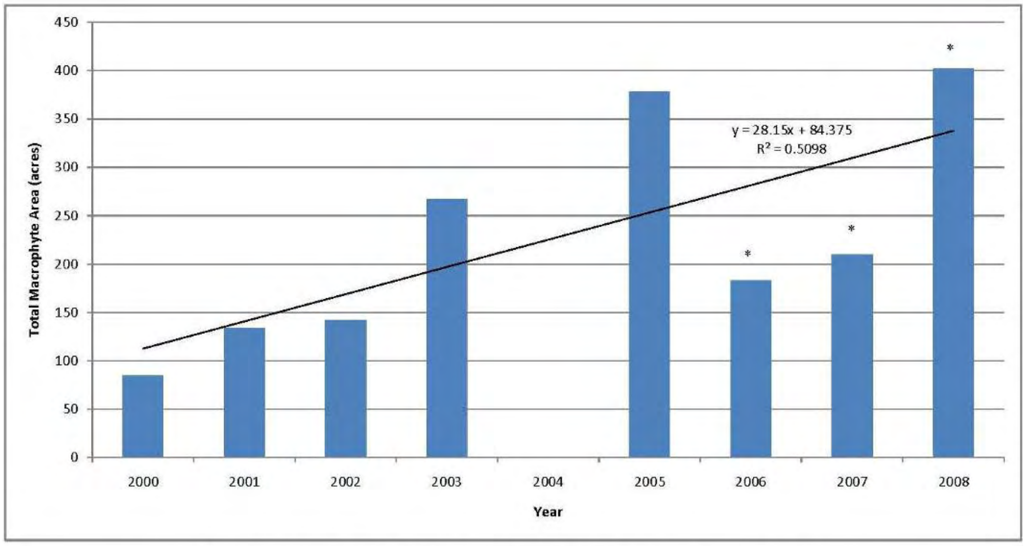
The SYW-12 area is currently under investigation to determine the nature and extent of contamination in this area. Once these data have been fully evaluated, an approach for remediation and restoration of SYW-12 wetland and adjacent area will be addressed through the RI/FS process for the Wastebed B/Harbor Brook site.

5.3.9 Remediation Area F

Based on additional data collected as part of the pre-design investigation since the issuance of the ROD, the area requiring active remediation is Remediation Area F has been updated (Figure 3.1). In two small isolated areas (S-95 and S-111) that total less than 1 acre of area, 1 foot of sediment will be dredged to cleanup criteria to remove the contamination in these areas.

5.3.10 Habitat Enhancement (SMU 5)

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. 1982a). The information used in the ROD was based on 2000 plant surveys, which documented a total of 17.8 acres in Remediation Area F (SMU5) (EcoLogic, 2001) within the optimal water depth for plants.



TOTAL PLANT COVER IN ONONDAGA LAKE: 2000 to 2008

Notes: Plant cover was not determined in 2004.
** Plant cover was determined in June during 2000-2005, but could not be photographed until August during 2006-2008 due to water clarity issues in early summer.*

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 plants (personal communication, Dave Synder, Onondaga County). 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 habitat enhancement activities, which were designed to increase aquatic plant cover to provide optimal habitat for the largemouth bass, may not be necessary to meet the objectives noted in the ROD.

SMU 8 is located in the center of the lake in greater than 30 feet of water.

5.3.11 Profundal Zone (thin-layer capping - SMU 8)

As specified in the ROD, thin layer capping may be required in areas of the profundal zone that exceed the remedial criteria. The profundal zone is defined as the portion of the lake where water depths exceed 30 feet (SMU 8). This section describes the thin layer capping that may be completed in portions of the profundal zone.

Approach

Thin layer capping is intended to provide an immediate decrease in surface sediment concentrations by adding a layer of clean material that would then be incorporated into the surface sediments through natural processes such as bioturbation and sedimentation. The Remedial Action Objective for SMU 8 is to "eliminate or reduce, to the extent practicable, releases of mercury from profundal sediments." The basis of design for selecting the areas to cap and the thickness of the cap was determined based on surface sediment concentrations of mercury and exceedances of the mean PECQ of 1, as well as the bioaccumulation-based sediment quality value (BSQV) for mercury of 0.8 mg/kg on an area-weighted basis.

Application

A half foot of sand will be placed in areas meeting the requirements for thin layer capping as described above. Since the profundal zone is not exposed to wind or wave action, there is no need for an erosion protection layer in addition to the 0.5 feet of sand. Since the remedy will not change oxygen availability in the hypolimnion during summer stratification, use of the profundal zone by organisms, including the reference species, is not likely to change following remediation. If oxygenation is used to reduce mercury methylation, oxygen concentrations, although greater than under nitrate addition, may not be sufficient to sustain fish or aerobic benthic macroinvertebrates. If nitrate addition is used to reduce mercury methylation, there still will be periods of anoxia during the summer.

5.4 Suitability of Remediation Areas for Representative Species

The TWG evaluated the suitability of the habitat modules in the remediation areas for the representative species within each major species group to determine how these species may use each area following the restoration. See Table 5.2 for a summary of potential locations for the representative species described in this section.

5.4.1 Fish

Suitable habitat for fish will be provided in each remediation area. Northern pike spawning and rearing habitat will be provided in Remediation Area A, Remediation Area B, and in the Harbor Brook area adjacent Remediation Area E. Specific habitat designs were incorporated into the Harbor Brook restoration to promote northern pike spawning. Adult northern pike habitat will be provided in Remediation Areas A, B, C, D, and E. Deeper water modules will also provide habitat for the northern pike in Remediation Area E. Habitat for walleye will also be provided primarily by the deeper water modules. Adult walleye habitat will be provided in Remediation Area A, B, C, D and E. Juvenile walleye habitat will be provided in Remediation Area C. The habitat suitability for walleye in these areas would be improved with the addition of structure.


Lake sturgeon use deep water habitats.

The two deepest water modules (i.e., 1 and 2) will provide habitat for the lake sturgeon in Remediation Areas A, B, C, D, and E. Habitat for the emerald shiner and brown trout will also be provided by the deeper water modules in all remediation areas. Golden shiners prefer weedy, quiet, shallow waters, and the best habitat will be provided in Remediation A. The submerged aquatic vegetation in Remediation Areas B and C will also provide habitat for the golden shiner.

Largemouth and smallmouth bass habitat will be provided in both deeper water modules (for adults) and the shallower water modules (for spawning and juveniles) in each remediation area. The suitability of the shallow water modules (i.e., areas of wetlands and submerged aquatic vegetation) for both the large and smallmouth bass would be improved with the addition of structure. Pumpkinseed habitat would be provided in these same areas.

The application of the habitat modules also takes into account the fact that there are limited fishing opportunities on the western shore of the lake, particularly areas where fish characteristic of deeper water habitats can be reached using shore fishing techniques. As such, deeper water areas have been applied along the shore in Remediation Area D to provide access for fishing.

A more detailed discussion on the suitability of each Remediation Area for the representative fish species is provided in Appendix D.

5.4.2 Plants

Plants such as cattail will be used to replace invasive species like Phragmites.

The sandy substrate in the shallow water portions of Remediation Areas A and B will be suitable habitat for representative submerged aquatic vegetation species such as coontail, sago pondweed, tapegrass, and elodea (*Elodea canadensis*), as well as other pond weeds and submerged aquatic plants common in the lake. Submerged aquatic vegetation habitat will also be provided in Remediation Areas C, D, and E. However, because of the wave energy in these locations, the use of coarse substrate for the habitat layer will be required and it may take longer for these areas to support the same level of submerged aquatic plants as in other Remediation Areas.

In general, the representative lakeshore wetland plant species prefer lower wave energy environment, shallow water depths, and fine substrates for Remediation Area A, B, D, and the Harbor Brook area adjacent to Remediation Area E. Remediation Area A is the only area in the lake that will provide suitable habitat for floating aquatic vegetation which includes white water lily, yellow pond lily, American pondweed, and potentially free-floating duckweeds. The planned wetlands in Remediation Areas A, B, D, and the Harbor Brook area adjacent to Remediation Area E will provide habitat for representative non-persistent and persistent emergent species. Non-persistent emergent species include pickerel weed, arrow arum, arrowhead, water plantain, and water smartweed.

Persistent emergent wetland species include cattail, soft-stem bulrush, river bulrush, burreed, willow-weed, water-willow, and sedge. A deeper water trench will also be created along the shoreline in Remediation Areas A and E to limit *Phragmites* encroachment into the wetland areas. These areas will provide habitat for non-persistent emergent species. Wetlands are also planned for Remediation Area E. However, the wave energy in this area will require the use of coarse substrate which could limit the density of wetland plants.

Forested wetland habitat is planned adjacent to Remediation A and Remediation Area D. Habitat for silver maple, American elm, and black willow, which are common in the existing forested wetland near Remediation Area A, will be provided in these areas.

A more detailed discussion on the suitability of each Remediation Area for the representative plant species is provided in Appendix D.

Appendix E includes a master list of plants suitable for the restored habitat areas.

5.4.3 Benthic Macroinvertebrates

Habitat for benthic macroinvertebrates will be provided in each remediation area, primarily due to the placement of clean substrate. The addition of structure will increase habitat diversity and provide additional habitat for some species, especially crayfish, in the shallow waters of each Remediation Area. The shallow waters of each remediation area will support diverse and suitable habitat for lentic species of all the representative invertebrate orders. The deeper waters of each remediation area will provide suitable habitat for amphipods and true flies.

A more detailed discussion on the suitability of each Remediation Area for the representative benthic macroinvertebrate species is provided in Appendix D.

Remediation Area A is one of the best locations for mammals within Onondaga Lake.

5.4.4 Mammals

The combination of habitat requirements for the representative species (*e.g.*, low energy areas, emergent vegetation, trees or other cover along the shoreline) makes Remediation Area A the best location within the lake for the creation of suitable habitat for beaver, mink, muskrat and otter. The proximity to Ninemile Creek further enhances the suitability of these areas for mink and otter which can use the tributary as a travel corridor. In addition, the current and planned forested areas near the mouth of the creek could potentially provide habitat for the Indiana bat.

Remediation Areas B, D, and E will also provide habitat for beaver, mink, muskrat and otter. In general, the shallower portion of these remediation areas will provide habitat for all four species, while deeper waters would provide habitat for the otter, mink and beaver. The inland wetland areas located outside the boundaries of the remediation area and adjacent to Remediation Area D will provide suitable habitat for mink and beaver and potentially Indiana bat. The large wetland complex adjacent to Remediation Area D will provide suitable habitat for mink, otter, beaver, and in particular, muskrat. The realigned Harbor Brook and associated wetland complex adjacent to Remediation Area E will provide suitable habitat for mink, otter, beaver, and muskrat. Muskrats should be significantly favored by these habitat changes.

A more detailed discussion on the suitability of each Remediation Area for the representative mammals is provided in Appendix D.

5.4.5 Reptiles and Amphibians

The representative reptile species, musk turtle, painted turtle, snapping turtle, and northern water snake prefer lower energy environments with shallow water and access to cover or some type of structure. Habitat for the reptile species will be provided in the shallow water portions of Remediation Areas A, B, D, and the Harbor Brook area adjacent to Remediation Area E. Specifically, the shallow water areas would provide suitable habitat for hibernation and feeding for the four representative reptile species. The wetland, submerged aquatic and floating aquatic (Remediation Area A only) vegetation would provide areas of cover for escape and feeding for the painted turtle and northern water snake as well as nesting areas for musk turtle. Musk turtle also may find suitable nesting habitat in the wetland areas. Snapping turtle would use the natural transition from emergent wetlands in the lake to upland areas in Remediation Area A, Remediation Area B, and Remediation Area E. The vegetated cover Remediation Area C would provide cover for species such as the snapping turtle, painted turtle, and northern water snake.

Restored wetlands will support a variety of species including this painted turtle.

The representative amphibian species (red spotted newt, mudpuppy, spotted salamander, green frog (*Rana clamitans melanota)*, leopard frog (*Rana pipiens-s. utricularius*), and wood frog generally prefer shallow water environments. Mudpuppy will also use deeper areas, but will nest in water less than 3 feet deep. The wetlands planned in Remediation Area A, B, C, D, and the Harbor Brook area adjacent to Remediation Area E will provide suitable habitat for all of the representative amphibian species, and provide a transition from the lake to terrestrial areas. The fine substrate that will be used in Remediation Area A, B, and Harbor Brook area adjacent to Remediation Area E would also provide suitable foraging and hibernating areas for red-spotted newt, green frog, leopard frog, and wood frog. Mudpuppy habitat would be provided by the wetlands and by Harbor Brook during the cooler spring and fall months. The wetlands would also provide suitable habitat for concealment and foraging for the red-spotted newt, leopard frog, and wood frog.

Sediments composed of finer grain sizes and organic matter would provide vegetation important for concealment and egg deposition, as well as providing a gradual transition to persistent emergent wetlands for cover and foraging. The seasonal temporary pools that will be created as part of the inland wetland complex located outside the boundaries of the remediation area will provide suitable breeding habitat for the wood frog and would provide sufficient shallow areas for tadpole survival. In addition, the waterfowl nesting mounds included in this complex will provide habitat for the green frog and leopard frog.

Red-spotted newt and spotted salamander spend their adult stages terrestrially and the habitats planned adjacent to Remediation Area A and E would provide cover and suitable habitat. The deeper water portions of all Remediation Areas would provide habitat for the mudpuppy, particularly with the addition of structure. Snapping turtles may also use these areas.

A more detailed discussion on the suitability of each Remediation Area for the representative reptiles and amphibians is provided in Appendix D.

5.4.6 Birds

The deeper water portions of the littoral zone will provide suitable foraging and feeding habitat for mallard, common goldeneye, common tern osprey, bank swallow and the belted kingfisher. The vegetated shoreline areas transitioning from wetlands to submerged aquatic plants will provide foraging habitat for great blue heron, green heron, and sandpipers in Remediation Area A, Remediation Area B, and the Harbor Brook area adjacent to Remediation Area E. These same areas would provide suitable habitat for mallards to forage and provide access to adjacent terrestrial locations for nesting, and also provide an invertebrate food base for species such as the spotted sandpiper and semi-palmated sandpiper.

Common Goldeneye is a species that would be suitable for several remediation areas.

Currently, the steep banks adjacent to Remediation Areas A and B will provide nesting habitat for bank swallows and belted kingfisher. The forested wetlands in Remediation Area A and D will provide perching structures for osprey, red-winged blackbird, and green heron and cover for nesting in bushes, thickets, and small trees for the green heron, red-winged blackbird, common goldeneye, and mallard.

Areas where herbaceous cover is planned in Remediation Areas B, C, and D and the Harbor Brook area adjacent to Remediation Area E, will provide suitable nesting areas for the common tern and red-winged blackbird. Habitat for shorebirds, such as the spotted sandpiper and semi-palmated sandpiper, will be provided from the coarser, rockier areas along the shoreline of Remediation Area C.

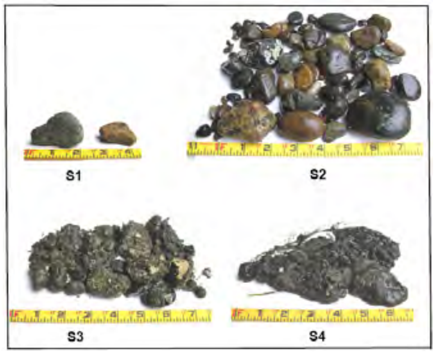
The shallow water wetland and banks of Harbor Brook in the area adjacent to Remediation Area E would provide foraging areas for the great blue heron, green heron, belted kingfisher, red-winged blackbird, spotted sandpiper, and the semi-palmated sandpiper. The waterfowl nesting mounds would provide ideal habitat for nesting for the mallard, as well as protection of nests from terrestrial predators. Insect production of the wetland will provide foraging opportunities for bank swallows.

A more detailed discussion on the suitability of each Remediation Area for the representative birds is provided in Appendix D.

5.5 General Specifications for Habitat Restoration

5.5.1 Substrate Types

References to substrate types in this section are based on the Unified Soil Classification System (USCS). Substrate type is usually



Many types of substrate will be used in the habitat restoration design.

categorized based on grain size, and those sizes are listed below. Soils seldom exist in nature separately as sand, gravel, or any other single component. They are usually found as mixtures with varying proportions of particles of different sizes; each component part contributes its characteristics to the soil mixture. Soils are primarily identified as coarse grained, fine grained, and highly organic. If possible, rounded material will be used in the habitat layer design. Likewise, angular material may be more suitable for the erosion protection layer. Detailed specifications for substrate (including grain size distribution, appropriate source material, and organic content)will be provided in subsequent design submittals.

Component	Size
Cobbles	Above 3 inches
Gravel	0.167 inch to 3 inches
Coarse	0.75 inch to 3 inches
Fine	0.167 inch to 0.75 inch
Sand	0.003 inch to 0.167 inch
Coarse	0.167 inch to 0.0787 inch
Medium	0.0787 inch to 0.0167 inch
Fine	0.0167 inch to 0.003 inch
Fines (silt or clay)	Less than 0.003 inches (no minimum)

In the text of Section 5, coarse substrates are those shown in the previous table as coarse gravel and cobble, and fine substrates have particle sizes of fine gravel and smaller. Figures 5.25 – 5.29 illustrate the substrate material associated with the restored habitat in each of the remediation areas.

5.5.2 Monitoring Requirements

Comparisons to baseline conditions, threshold values, or reference conditions are methods that can be used to complete an assessment of the overall performance of the habitat restoration. There are currently numerous programs on the lake and tributaries being conducted by Onondaga County, Upstate Freshwater Institute (UFI), SUNY-ESF, and Honeywell. These studies include data collection on water quality, sediment characterization, macrophytes, fish populations and community structure, benthic community, and wetland delineations.

As a part of the Operations, Maintenance and Monitoring (OM&M) plan, a monitoring program will be developed to assess the performance of the habitat restoration/enhancement actions and evaluate whether the objectives outlined in this plan are being met by comparing to baseline conditions, threshold values or reference conditions. Monitoring will also provide information that can improve the implementation and performance of any maintenance activities (*e.g.*, corrective actions).

The monitoring program will begin immediately after completion of the habitat restoration/enhancement activities. Specifically, the monitoring program will be used to:

- assess the performance of the restoration/enhancement activities relative to the project goals;
- provide information that can be used to improve the performance of the project through the adaptive management protocols; and
- provide information to interested parties.

The specific elements and the duration of the monitoring program will be dictated by the final habitat restoration/enhancement designs. Monitoring will occur annually and include:

- assessment of the areal extent of each habitat module;
- assessment of substrate suitability and placement;
- list of plant species and percent cover of dominant plants in each planted habitat module;
- assessment of percent survival of installed plant material (submerged aquatic plants, emergent vegetation, shrubs, trees);
- percent cover of invasive species; and
- assessment of the use of restored/enhanced habitats by biological organisms.

Additional monitoring metrics may be warranted based on the final habitat restoration designs. Collected data will be compared to success criteria that will also be established as part of the final designs. The success criteria will include specific measures that must be met for the project to be considered successful. For example, for wetland restoration areas, one criterion would be to achieve a specific percent cover (e.g., 85%) after a specific period of time (e.g., 5 years). The success criteria will also take into consideration that the water depth limits of the habitat modules are not discrete boundaries. There will be a transition or overlap zone from one module to the next and one habitat type to the next. For example, submerged aquatic vegetation (primarily associated with Module 3) will occur at the deeper limit of the floating aquatic wetland (Module 4), and non-persistent emergent wetland vegetation (associated with Module 5) can occur at the shallow end of the floating aquatic wetland module. In addition, the success criteria will be focused on providing suitable habitat for the representative species (i.e., the successful implementation of the habitat modules) rather than the occurrence of the representative species. The status of certain species which are rare (e.g., lake sturgeon) or are not currently present (e.g. mudpuppy) in the lake may be related to factors other than habitat suitability. As such, the successful implementation of the habitat modules may not change their status.

The site-specific monitoring program will be developed based on the final habitat restoration designs. This information will be provided in an Operations, Maintenance and Monitoring Plan to be submitted as part of the final designs.

5.5.3 Maintenance Requirements

The monitoring program will be designed to provide data necessary to identify and correct potential concerns within an adaptive maintenance program. For example, if the vegetative cover has not met the desired percent cover, bare areas may be reseeded or replanted. Additional measures to control invasive species (*e.g.*, *Phragmites*, Eurasian watermilfoil) or herbivory within the restored areas may also be warranted, if indicated by the monitoring data.

Maintenance actions to correct deficiencies identified during monitoring would be undertaken at the time the condition is observed or within the appropriate seasonal (*e.g.*, planting) window and may potentially include the following.

- Control of invasive species in restored areas by physical, mechanical or chemical methods. Any use of chemical control would require further evaluation for compliance with ARARs.
- Targeted plantings to increase percent cover and/or replace missing or dead plant material. This maintenance activity would not include complete replanting of an area unless the cause(s) for the initial failure of the plantings has been identified and corrected/controlled.
- Maintenance of structures included in the habitat restoration designs, consistent with design specifications.

The site-specific monitoring and maintenance program will be developed based on the final habitat restoration designs. This information will be provided in an Operations, Maintenance and Monitoring Plan to be submitted as part of the final designs.

5.5.4 Design Details for Habitat Restoration

This conceptual level document is intended to convey the approach for habitat restoration in the remedial areas within the lake and select shoreline areas adjacent to the lake. In accordance with standard designs procedures, additional details for each of the concepts presented in this plan (e.g. types and size of structure or material specifications) will be further developed and documented in subsequent design submittals. Additional details will be provided in those design submittals for items such as the following:

- thin layer cap details;
- habitat layer material specifications, performance and maintenance;
- design details for mitigation areas;
- microtopography, structure, other habitat features (*e.g.,* turtle nesting) within wetland complexes;
- placement and types of structure;

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- substrate composition, grain-size distribution, organic content, source;
- plants considered for seeding or planting;
- techniques for establishment of microtopography within habitat modules;
- tolerances for placement of habitat layer;
- success criteria;
- monitoring program; and
- maintenance requirements.

5.6 Summary of Habitat Restoration Design

Honeywell has placed habitat considerations at the forefront of the restoration designs for Onondaga Lake, and habitat restoration will continue to play a key role as the remedial activities are advanced. A sustainable habitat that allows for public access has been, and will continue to be, an integral part of the approach for restoring Onondaga Lake and returning this key resource to the people of central New York.

The Habitat Restoration Plan is the result of almost two years of effort by the TWG, which consisted of local and national experts from the Honeywell team and several state and federal agencies. During the preparation of this plan the Onondaga Nation and local interest groups provided several suggestions for specific habitat considerations for Onondaga Lake.

Many different considerations were involved in the design of the Habitat Restoration Plan. Critical among these considerations were historical and current habitat conditions in the lake; established goals, objectives, and priorities of the habitat restoration; numerous remedial design elements; location of adjacent tributary systems; and adjacent shoreline land uses and habitats.

Establishing existing and historical habitat conditions and the collection of information available for the lake was important in the development of this plan. Representative plant and animal species were selected from different groups of organisms and their habitat requirements were assessed to help direct the habitat restoration efforts. Habitat modules were established to represent habitat areas defined by the basic elements of water depth, substrate type, and wave energy. The application of these modules was used to define the restored habitat in each area specified for remediation.

The habitat designs described in this plan were developed using many different criteria, including the integration of habitat needs for representative species with the requirements associated with the dredging and capping design specified in the Onondaga Lake Bottom Record of Decision, the physical conditions of the site, and the habitat goals and objectives. The holistic approach for integrating multiple remedial considerations from the related lake and shoreline areas will result in improved conditions for a wide variety of species in these areas.

TABLE 5.1
SUMMARY OF PARAMETERS FOR ONONDAGA LAKE CAP DESIGN

Remediation Area	Water Depth (ft)	Minimum Mixing and Chemical Isolation Thickness (ft)	Total Erosion Protection/Habitat Layer Thickness (ft)	Habitat Grainsize	Minimum Cap Thickness (ft)	Assumed Maximum Cap Thickness with Over Placements (ft)	Calculated Average Settlement at 2 years (ft)
RA-A (Cap Model Areas A-1 and A-2)	0 - 3	1.25	2	medium sand	3.25	5.0	1.4
	3 - 7	1.25	1.5	fine gravel	2.75	4.25	1.3
	7 - 20	1.25	1	medium sand	2.25	2.75	1.1
	20 - 30	0.75	1	medium sand	1.75	2.25	1.0
RA-B	0 - 3	1.5	2	fine gravel	3.5	5.7	1.9
	3 - 7	1.5	1.5	fine gravel	3.0	5.2	1.9
	7 - 10	1.5	1	coarse sand	2.5	4.0	1.8
	10 - 30	1.5	1	medium sand	2.5	3.5	1.6
RA-C	0 - 3	1.75	2	fine gravel	3.75	5.5	1.1
	3 - 7	1.75	1.5	fine gravel	3.25	5.0	1.2
	7 - 10	1.75	1	fine gravel	2.75	3.75	1.1
	10 - 30	1.75	1	medium sand	2.75	3.25	1.1
RA-D	0 - 3	1.5	2	medium sand	3.5	5.7	NA[5]
	3 - 7	1.5	1.5	medium sand	3.0	5.2	NA[5]
	7 - 10	1.5	1	medium sand	2.5	4.0	NA[5]
	10 - 30	1.5	1	medium sand	2.5	3.5	NA[5]
RA-D Addendum	30+	1.5	1	medium sand	2.5	3.5	n/a
RA-E (Cap Model Areas E-1 and E-2)	0 - 3	1.25	2	coarse gravel	3.25	5.25	1.5
	3 - 7	1.25	1.5	coarse gravel	2.75	4.75	1.7
	7 - 10	1.25	1	coarse gravel	2.25	4.75	1.7
	10 - 20	1.25	1	fine gravel	2.25	3.25	2.0
	20 - 30	0.75	1	coarse sand	1.75	2.25	1.6

Notes:

1. See Capping and Dredge Area and Depth IDS (Parsons, 2009) for details and assumptions.
2. Both cap model areas in Remediation Area A and E have the same cap-design thickness.
3. Minimum combined erosion protection/habitat and additional habitat layer material. Average total habitat thickness will be greater due to estimated over placements allowed for operational considerations of cap placement.
4. 50% safety buffer is included in the chemical isolation thickness for RA-C. Cap modeling has shown that it can be included in the habitat layer for all other model areas.
5. Due to the complexities associated with the ILWD removal approach (average 2 meters plus hot spots), settlement calculations have not been estimated in Remediation Area D for this conceptual design.

TABLE 5.2

SUMMARY OF POTENTIAL LOCATIONS FOR REPRESENTATIVE SPECIES WITHIN REMEDIATION AREAS OF ONONDAGA LAKE

Remediation Area [1][2]	REPRESENTATIVE SPECIES					
	Fish	Plants	Benthic Macroinvertebrates	Mammals	Reptiles / Amphibians	Birds
Remediation Area A (SMU 4)	• Brown trout • Lake sturgeon • Emerald shiner • Large and smallmouth bass • Walleye • Pumpkinseed • Northern pike • Golden shiner	• Submerged aquatic vegetation • Floating aquatic vegetation • Non-persistent emergent vegetation • Persistent emergent vegetation	• Scud • True Flies • Mayfly • Dragonfly/Damselfly • Caddisfly • Crayfish	• Otter • Mink • Muskrat • Beaver	• Snapping turtle • Painted turtle • Musk turtle • Northern water snake • Red spotted newt • Green frog • Leopard frog • Mudpuppy • Spotted salamander • Wood frog	• Common goldeneye • Mallard • Osprey • Bank swallow • Common tern • Belted Kingfisher • Great blue heron • Green heron • Spotted sandpiper • Semi-palmated sandpiper • Red-winged blackbird

NOTES:
TBD – To Be Determined
1) Representative species noted for each area indicates that habitat conditions will be suitable for these species following remedial activities. Every species may not populate all specified locations in the future.
2) Remediation Area F has not been included since it is less than one acre. Species would be similar to the deep water portion of Remediation Area A.

TABLE 5.2 (continued)
SUMMARY OF POTENTIAL LOCATIONS FOR REPRESENTATIVE SPECIES WITHIN REMEDIATION AREAS OF ONONDAGA LAKE

Remediation Area [1][2]	REPRESENTATIVE SPECIES					
	Fish	Plants	Benthic Macroinvertebrates	Mammals	Reptiles / Amphibians	Birds
Remediation Area B (SMU 3)	• Brown trout • Lake sturgeon • Emerald shiner • Large and smallmouth bass • Adult walleye • Pumpkinseed • Northern pike • Golden shiner	• Submerged aquatic vegetation • Non-persistent emergent vegetation	• Scud • True Flies • Mayfly • Dragonfly/Damselfly • Caddisfly • Crayfish	• Otter • Mink • Muskrat • Beaver	• Snapping turtle • Painted turtle • Musk turtle • Northern water snake • Red-spotted newt • Green frog • Mudpuppy	• Common goldeneye • Mallard • Osprey • Bank swallow • Common tern • Belted Kingfisher • Great blue heron • Green heron • Sandpipers • Red-winged Blackbird

NOTES:
TBD – To Be Determined
1) Representative species noted for each area indicates that habitat conditions will be suitable for these species following remedial activities. Every species may not populate all specified locations in the future.
2) Remediation Area F has not been included since it is less than one acre. Species would be similar to the deep water portion of Remediation Area A.

TABLE 5.2 (continued)
SUMMARY OF POTENTIAL LOCATIONS FOR REPRESENTATIVE SPECIES WITHIN REMEDIATION AREAS OF ONONDAGA LAKE

Remediation Area [(1)(2)]	REPRESENTATIVE SPECIES					
	Fish	**Plants**	**Benthic Macroinvertebrates**	**Mammals**	**Reptiles / Amphibians**	**Birds**
Remediation Area C (SMU 2)	• Brown trout • Lake sturgeon • Emerald shiner • Large & small-mouth bass • Walleye • Pumpkinseed • Lake sturgeon • Northern pike • Golden shiner	• Submerged aquatic vegetation	• Scud • True Flies • Mayfly • Dragonfly/Damselfly • Caddisfly • Crayfish	• Otter • Mink • Muskrat • Beaver	• Snapping turtle • Northern water snake • Mudpuppy	• Common goldeneye • Mallard • Osprey • Common tern • Belted Kingfisher • Great blue heron • Green heron

NOTES:
TBD – To Be Determined
1) Representative species noted for each area indicates that habitat conditions will be suitable for these species following remedial activities. Every species may not populate all specified locations in the future.
2) Remediation Area F has not been included since it is less than one acre. Species would be similar to the deep water portion of Remediation Area A.

TABLE 5.2 (continued)
SUMMARY OF POTENTIAL LOCATIONS FOR REPRESENTATIVE SPECIES WITHIN REMEDIATION AREAS OF ONONDAGA LAKE

Remediation Area (1)(2)	REPRESENTATIVE SPECIES					
	Fish	Plants	Benthic Macroinvertebrates	Mammals	Reptiles / Amphibians	Birds
Remediation Area D (SMU 1)	• Brown trout • Lake sturgeon • Emerald shiner • Large and smallmouth bass • Pumpkinseed • Walleye • Northern pike • Golden shiner	• Submerged aquatic vegetation	• Scud • True Flies • Mayfly • Dragonfly/Damselfly • Caddisfly	• Otter • Mink • Muskrat • Beaver	• Snapping turtle • Northern water snake • Mudpuppy	• Common goldeneye • Osprey • Mallard • Common tern • Belted Kingfisher • Great blue heron • Green heron • Spotted sandpiper • Semi-palmated sandpiper

NOTES:
TBD – To Be Determined
1) Representative species noted for each area indicates that habitat conditions will be suitable for these species following remedial activities. Every species may not populate all specified locations in the future.
2) Remediation Area F has not been included since it is less than one acre. Species would be similar to the deep water portion of Remediation Area A.

TABLE 5.2 (continued)
SUMMARY OF POTENTIAL LOCATIONS FOR
REPRESENTATIVE SPECIES WITHIN REMEDIATION AREAS OF ONONDAGA LAKE

Remediation Area [(1)(2)]	REPRESENTATIVE SPECIES					
	Fish	Plants	Benthic Macroinvertebrates	Mammals	Reptiles / Amphibians	Birds
Remediation Area E (SMU 6/7)	• Brown trout • Lake sturgeon • Emerald shiner • Large and smallmouth bass • Walleye • Pumpkinseed • Northern pike • Golden shiner	• Submerged aquatic vegetation	• Scud • True Flies • Mayfly • Dragonfly/Damselfly • Caddisfly • Crayfish	• Otter • Mink • Muskrat • Beaver • Indiana Bat	• Snapping turtle • Northern water snake • Mudpuppy	• Common goldeneye • Mallard • Osprey • Common tern • Belted Kingfisher • Great blue heron • Green heron • Spotted sandpiper • Semi-palmated sandpiper
SMU 8	• Brown trout • Lake sturgeon • Emerald shiner • Large and smallmouth bass • Walleye • Pumpkinseed	Not Applicable	• Scud • True Flies	• Not Applicable	• Not Applicable	• Common goldeneye • Mallard • Osprey

NOTES:
TBD – To Be Determined
1) Representative species noted for each area indicates that habitat conditions will be suitable for these species following remedial activities. Every species may not populate all specified locations in the future.
2) Remediation Area F has not been included since it is less than one acre. Species would be similar to the deep water portion of Remediation Area A.

TABLE 5.2 (continued)
SUMMARY OF POTENTIAL LOCATIONS FOR REPRESENTATIVE SPECIES WITHIN REMEDIATION AREAS OF ONONDAGA LAKE

Remediation Area (1)(2)	REPRESENTATIVE SPECIES					
	Fish	Plants	Benthic Macroinvertebrates	Mammals	Reptiles / Amphibians	Birds
Wetlands at Mouth of Ninemile Creek	• Northern Pike spawning • Young of year for various species	• Persistent emergent vegetation • Forested wetland and scrub-shrub wetland species	• Caddisfly • True Flies • Dragonfly/Damselfly • Crayfish	• Otter • Mink • Muskrat • Beaver • Indiana Bat	• Snapping turtle • Painted turtle • Musk turtle • Northern water snake • Red-spotted newt • Leopard frog • Green frog • Spotted salamander • Wood frog	• Mallard • Spotted sandpiper • Semi-palmated sandpiper • Red-winged blackbird • Great blue heron • Green heron • Common tern

NOTES:
TBD – To Be Determined
1) Representative species noted for each area indicates that habitat conditions will be suitable for these species following remedial activities. Every species may not populate all specified locations in the future.
2) Remediation Area F has not been included since it is less than one acre. Species would be similar to the deep water portion of Remediation Area A.

TABLE 5.2 (continued)
SUMMARY OF POTENTIAL LOCATIONS FOR REPRESENTATIVE SPECIES WITHIN REMEDIATION AREAS OF ONONDAGA LAKE

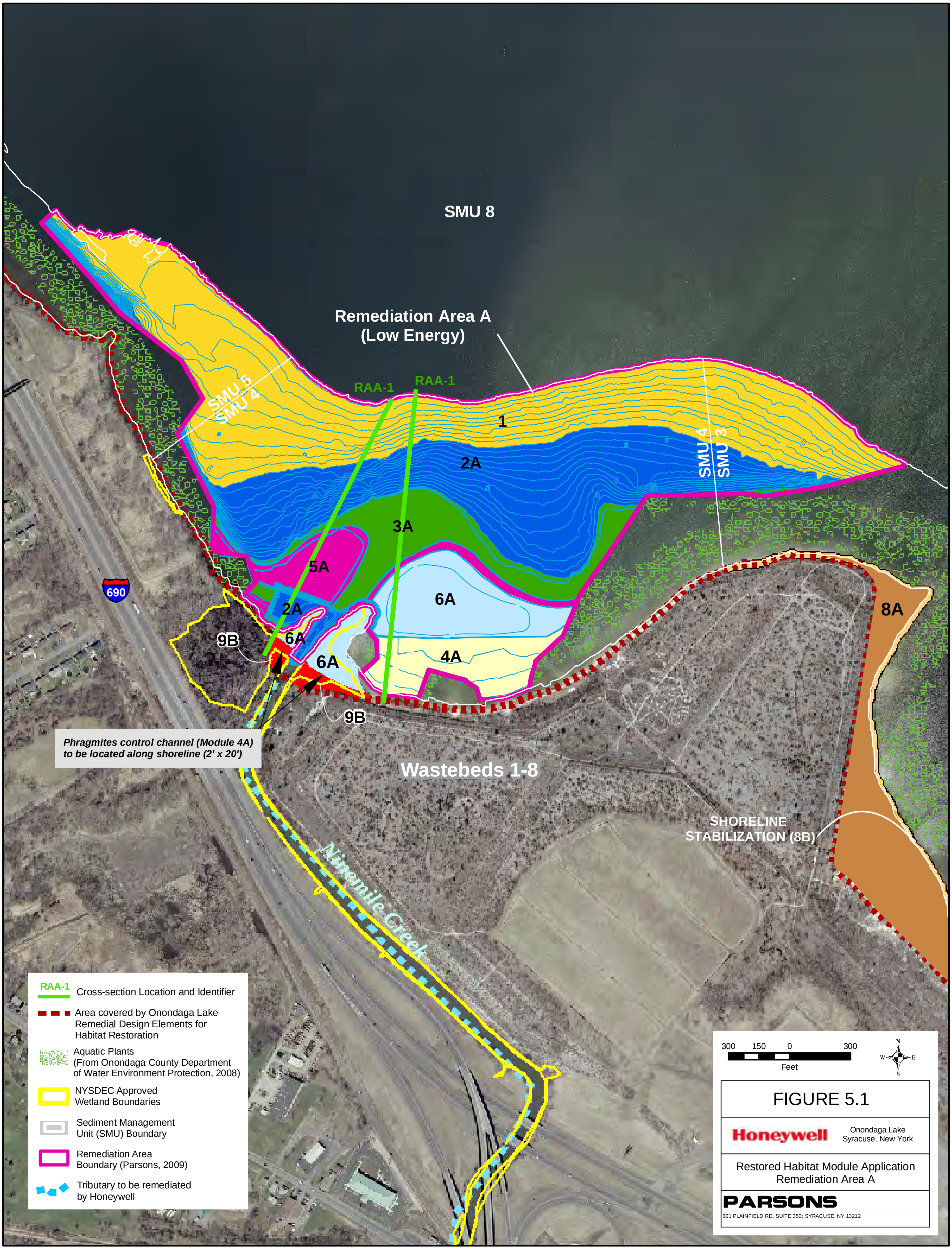
Remediation Area (1)(2)	REPRESENTATIVE SPECIES					
	Fish	**Plants**	**Benthic Macroinvertebrates**	**Mammals**	**Reptiles / Amphibians**	**Birds**
Low Lying Area of Wastebeds 1-8	• Northern Pike spawning • Young of Year for various species	• Persistent emergent vegetation • Scrub-shrub vegetation • Floating Aquatic vegetation • Non-persistent emergent vegetation • Open Fields	• True Flies • Mayfly • Dragonfly/Damselfly • Caddisfly • Crayfish	• Otter • Mink • Muskrat • Beaver • Indiana Bat	• Snapping turtle • Painted turtle • Musk turtle • Water snake • Red-spotted newt • Leopard frog • Green frog • Spotted salamander • Wood frog • Mudpuppy	• Osprey • Common Goldeneye • Belted Kingfisher • Bank Swallow • Mallard • Spotted sandpiper • Semi-palmated sandpiper • Red-winged blackbird • Great blue heron • Green heron • Common tern

NOTES:
TBD – To Be Determined
1) Representative species noted for each area indicates that habitat conditions will be suitable for these species following remedial activities. Every species may not populate all specified locations in the future.
2) Remediation Area F has not been included since it is less than one acre. Species would be similar to the deep water portion of Remediation Area A.

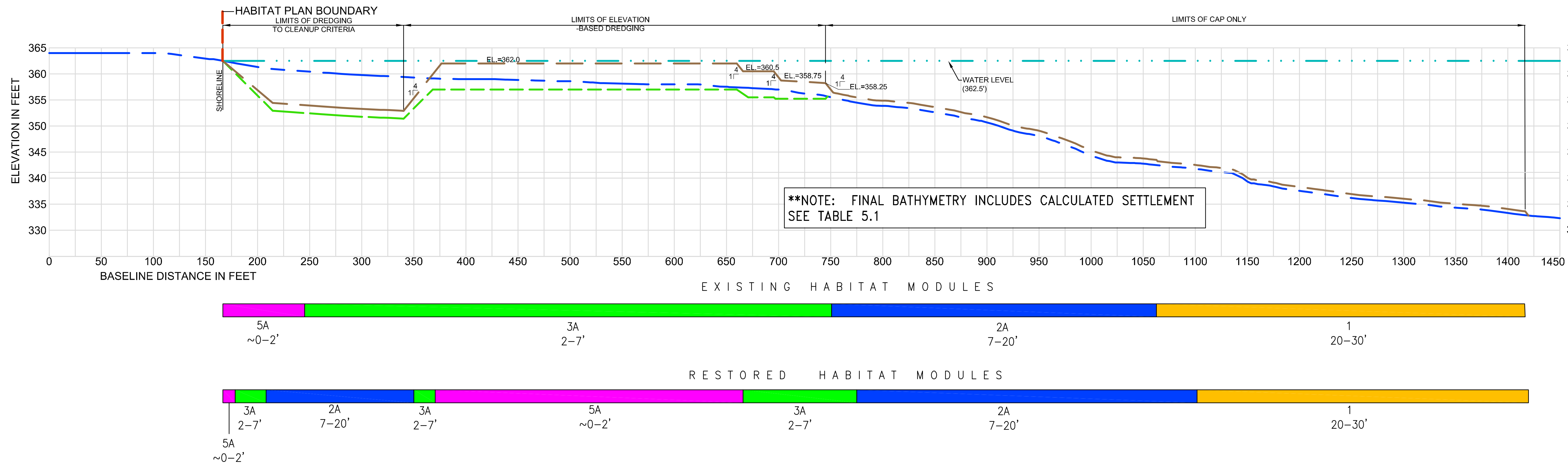
TABLE 5.2 (continued)
SUMMARY OF POTENTIAL LOCATIONS FOR
REPRESENTATIVE SPECIES WITHIN REMEDIATION AREAS OF ONONDAGA LAKE

Remediation Area (1)(2)	REPRESENTATIVE SPECIES					
	Fish	Plants	Benthic Macroinvertebrates	Mammals	Reptiles / Amphibians	Birds
Wastebed B / Harbor Brook Wetland Area	• Northern Pike spawning • Young of Year for various species	• Persistent emergent vegetation • Scrub-shrub vegetation • Forested wetland • Floating Aquatic vegetation • Non-persistent emergent vegetation	• True Flies • Mayfly • Dragonfly/Damselfly • Caddisfly • Crayfish	• Otter • Mink • Muskrat • Beaver • Indiana Bat	• Snapping turtle • Painted turtle • Musk turtle • Water snake • Red-spotted newt • Leopard frog • Green frog • Spotted salamander • Wood frog • Mudpuppy	• Osprey • Common Goldeneye • Belted Kingfisher • Bank Swallow • Mallard • Spotted sandpiper • Semi-palmated sandpiper • Red-winged blackbird • Great blue heron • Green heron • Common tern
Wetland SYW-12	TBD	TBD	TBD	TBD	TBD	TBD

NOTES:
TBD – To Be Determined
1) Representative species noted for each area indicates that habitat conditions will be suitable for these species following remedial activities. Every species may not populate all specified locations in the future.
2) Remediation Area F has not been included since it is less than one acre. Species would be similar to the deep water portion of Remediation Area A.



SMU 8
Remediation Area A
(Low Energy)
RAA-1
RAA-1
SMU 5
SMU 4
1
2A
SMU 4
SMU 3
3A
5A
6A
690
2A
6A
9B
6A
4A
8A
9B
Phragmites control channel (Module 4A)
to be located along shoreline (2' x 20')
Wastebeds 1-8
SHORELINE
STABILIZATION (8B)
Ninemile Creek
RAA-1 Cross-section Location and Identifier
Area covered by Onondaga Lake Remedial Design Elements for Habitat Restoration
Aquatic Plants
(From Onondaga County Department of Water Environment Protection, 2008)
NYSDEC Approved Wetland Boundaries
Sediment Management Unit (SMU) Boundary
Remediation Area Boundary (Parsons, 2009)
Tributary to be remediated by Honeywell
300 150 0 300
Feet
N
W
E
S
FIGURE 5.1
Honeywell
Onondaga Lake
Syracuse, New York
Restored Habitat Module Application
Remediation Area A
PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



REMEDIATION AREA A – SECTION RAA-1

Vertical: 1"=20'-0"
Horizontal: 1"-100'-0"

LEGEND:

- WATERLINE (362.5 NAVD 88) (GROWING SEASON)
- EXISTING GRADE
- DREDGE GRADE
- CAP GRADE

**NOTE

1. DETAILED ASSUMPTIONS FOR CAP THICKNESS AND SETTLEMENT ARE CONSISTENT WITH THOSE SPECIFIED IN THE CAPPING AND DREDGE AREA AND DEPTH IDS
2. CROSS SECTION IS CONSISTENT WITH SECTION 2/D-2 FROM CAPPING AND DREDGE AREA AND DEPTH IDS

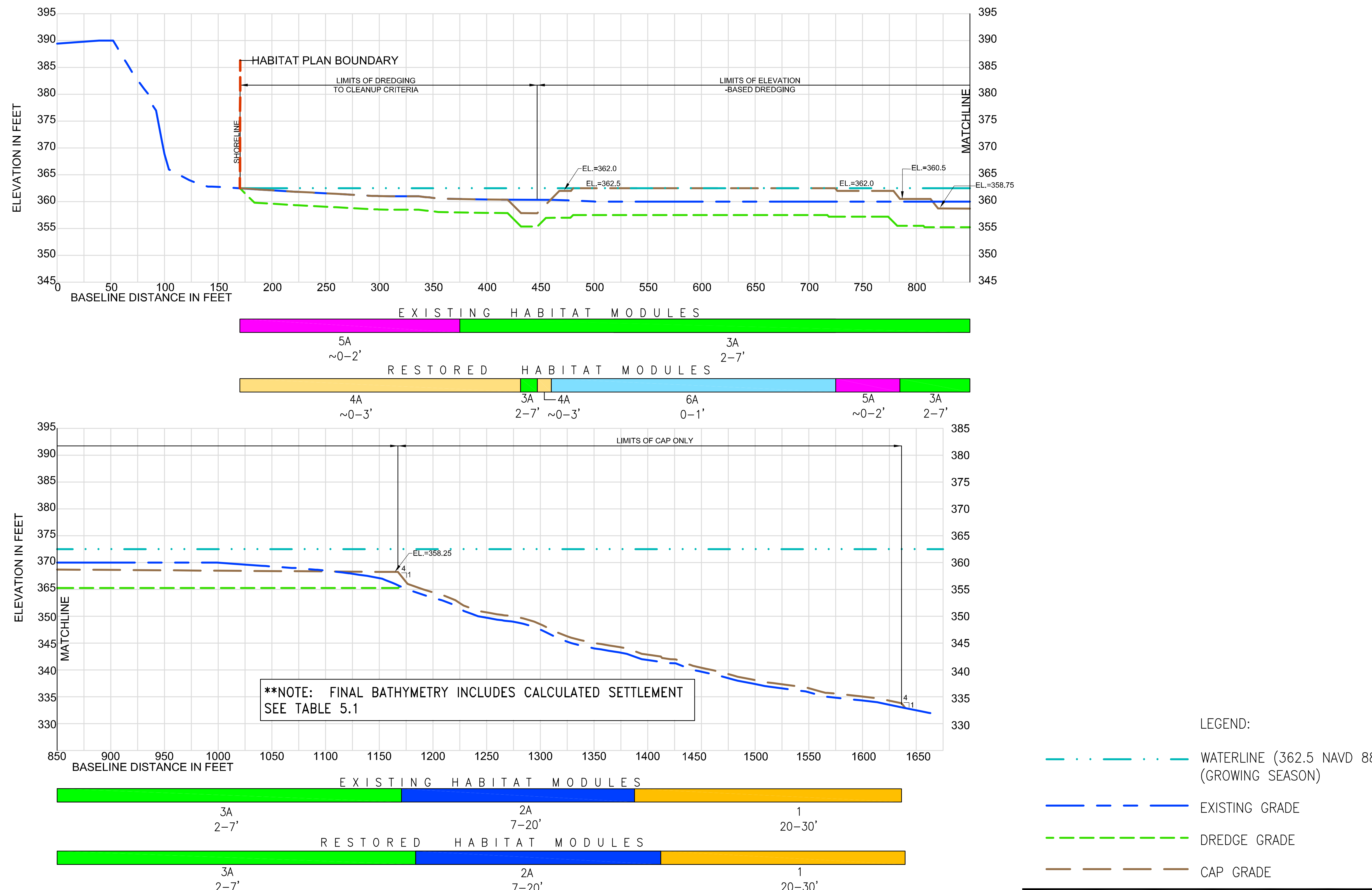
FILE NAME: P:\HONEYWELL -SYR\444284 – HABITAT AND CPP II\10 TECHNICAL CATEGORIES\10.1 CAD\FROM ANCHOR QEA\HABITAT 11-09 XSEC5.DWG
PLOT DATE: 12/14/2009 9:39 AM PLOTTED BY: NEUMANN, JEREMY

FIGURE 5.2

Honeywell

CONCEPTUAL CROSS SECTION
REMEDIATION AREA A (SMU 4)
SECTION RAA-1

PARSONS
310 PLAINFIELD ROAD ▪ SUITE 350 ▪ SYRACUSE, NY 13212 ▪ 315/451-9560
OFFICES IN PRINCIPAL CITIES



**NOTE
1. DETAILED ASSUMPTIONS FOR CAP THICKNESS AND SETTLEMENT ARE CONSISTENT WITH THOSE SPECIFIED IN THE CAPPING AND DREDGE AREA AND DEPTH IDS
2. CROSS SECTION IS CONSISTENT WITH SECTION 4/D-12 FROM CAPPING AND DREDGE AREA AND DEPTH IDS

REMEDIATION AREA A – SECTION RAA-2

Vertical: 1"=20'-0"
Horizontal: 1"-100'-0"

FIGURE 5.3

Honeywell

CONCEPTUAL CROSS SECTION
REMEDIATION AREA A (SMU 4)
SECTION RAA-2

PARSONS
310 PLAINFIELD ROAD * SUITE 350 * SYRACUSE, NY 13212 * 315/451-9560
OFFICES IN PRINCIPAL CITIES

FILE NAME: P:\HONEYWELL -SYR\444284 – HABITAT AND CPP II\10 TECHNICAL CATEGORIES\10.1 CAD\FROM ANCHOR QEA\HABITAT 11-09 XSEC5.DWG
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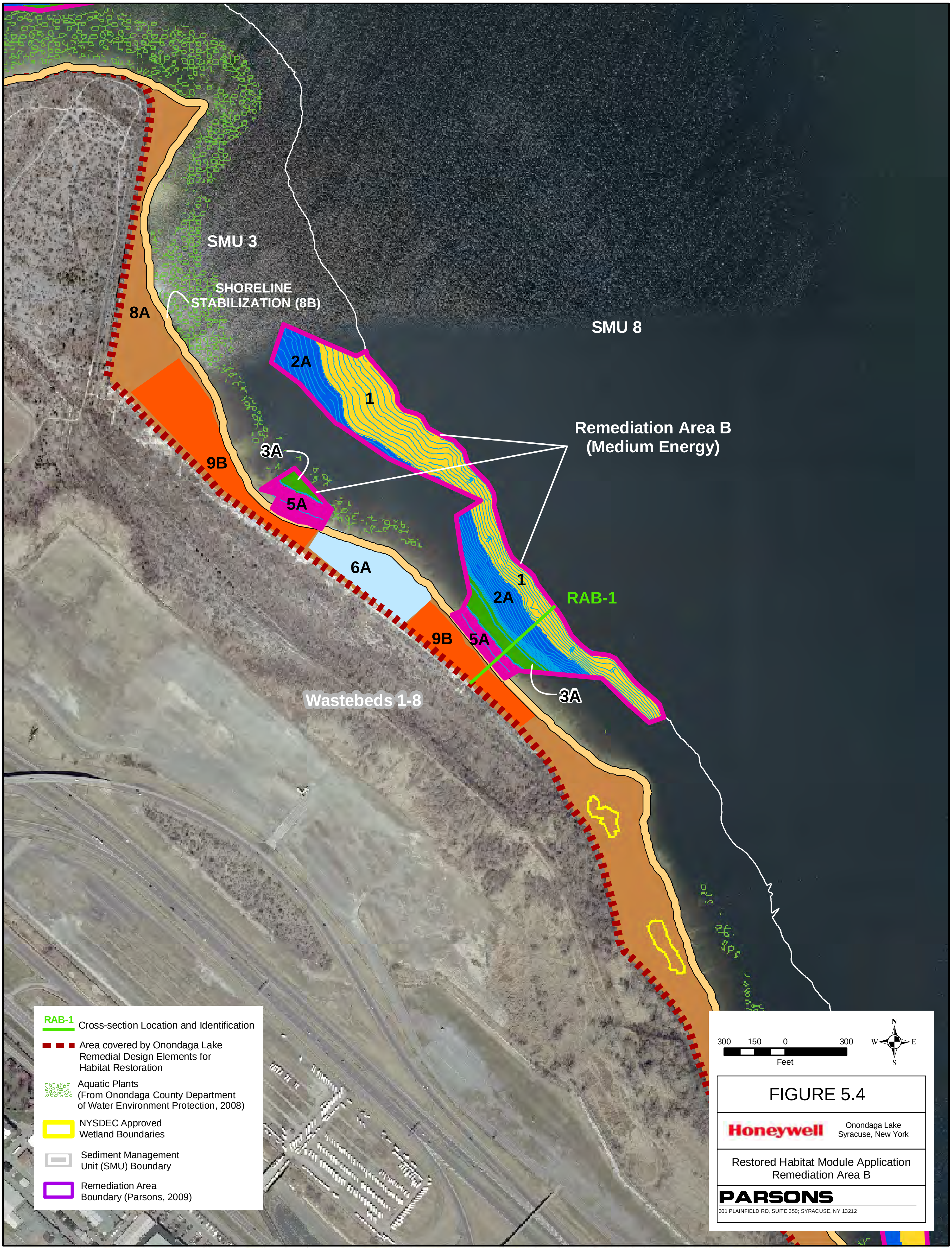


FIGURE 5.4

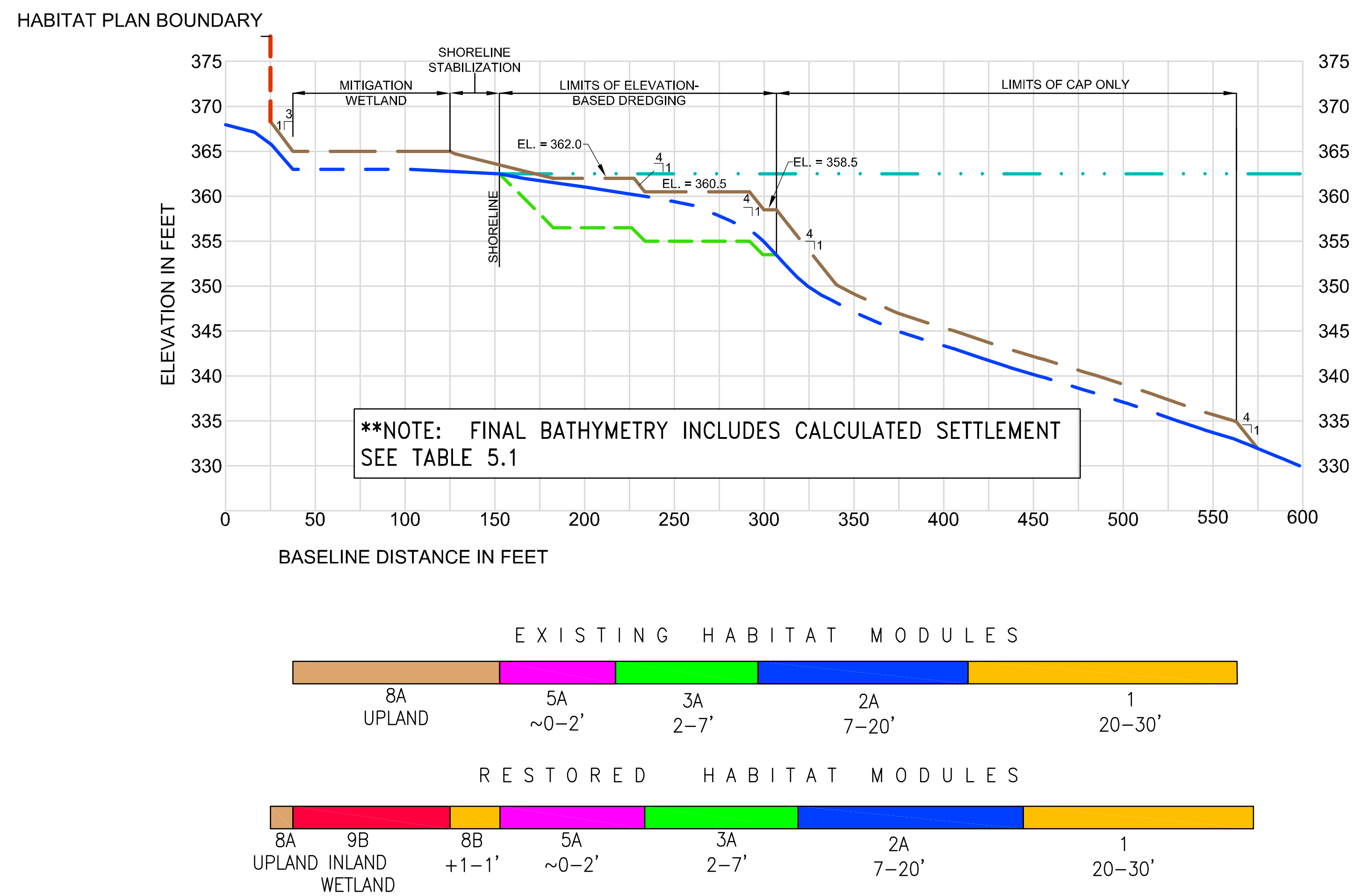
Honeywell

Onondaga Lake
Syracuse, New York

Restored Habitat Module Application
Remediation Area B

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



REMEDIATION AREA B – SECTION RAB-1

Vertical: 1"=20'-0"
Horizontal: 1"-100'-0"

**NOTE
1. DETAILED ASSUMPTIONS FOR CAP THICKNESS AND SETTLEMENT ARE CONSISTENT WITH THOSE SPECIFIED IN THE CAPPING AND DREDGE AREA AND DEPTH IDS
2. CROSS SECTION IS CONSISTENT WITH SECTION 9/D-14 FROM CAPPING AND DREDGE AREA AND DEPTH IDS

LEGEND:
- WATERLINE (362.5 NAVD 88) (GROWING SEASON)
- EXISTING GRADE
- DREDGE GRADE
- CAP GRADE

FIGURE 5.5

Honeywell

CONCEPTUAL CROSS SECTION
REMEDIATION AREA B (SMU 3)
SECTION RAB-1

PARSONS
310 PLAINFIELD ROAD * SUITE 350 * SYRACUSE, NY 13212 * 315/451-9560
OFFICES IN PRINCIPAL CITIES

FILE NAME: P:\HONEYWELL -SYR\444284 - HABITAT AND CPP II\10 TECHNICAL CATEGORIES\10.1 CAD\FROM ANCHOR QEA\HABITAT 11-09 XSEC5.DWG
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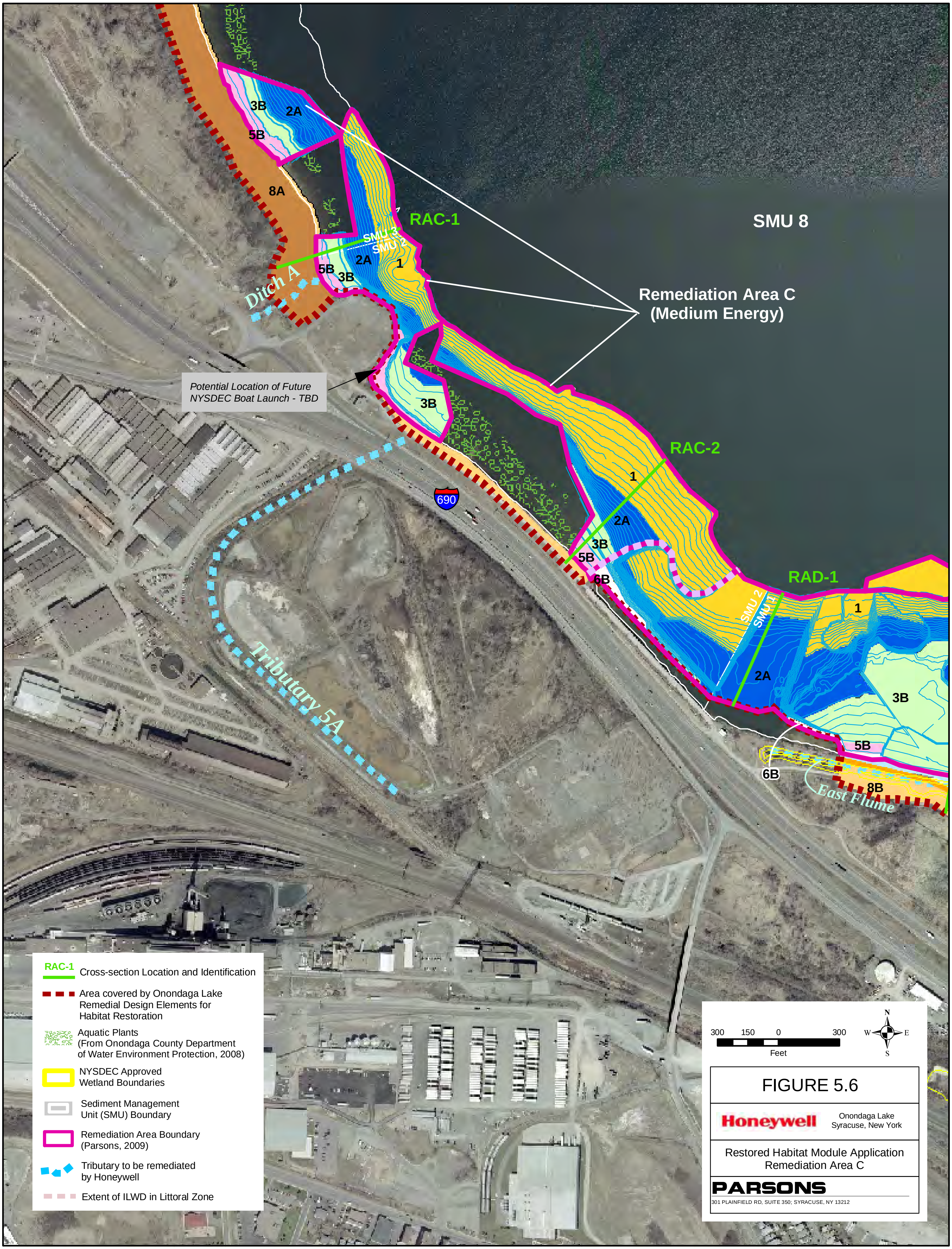
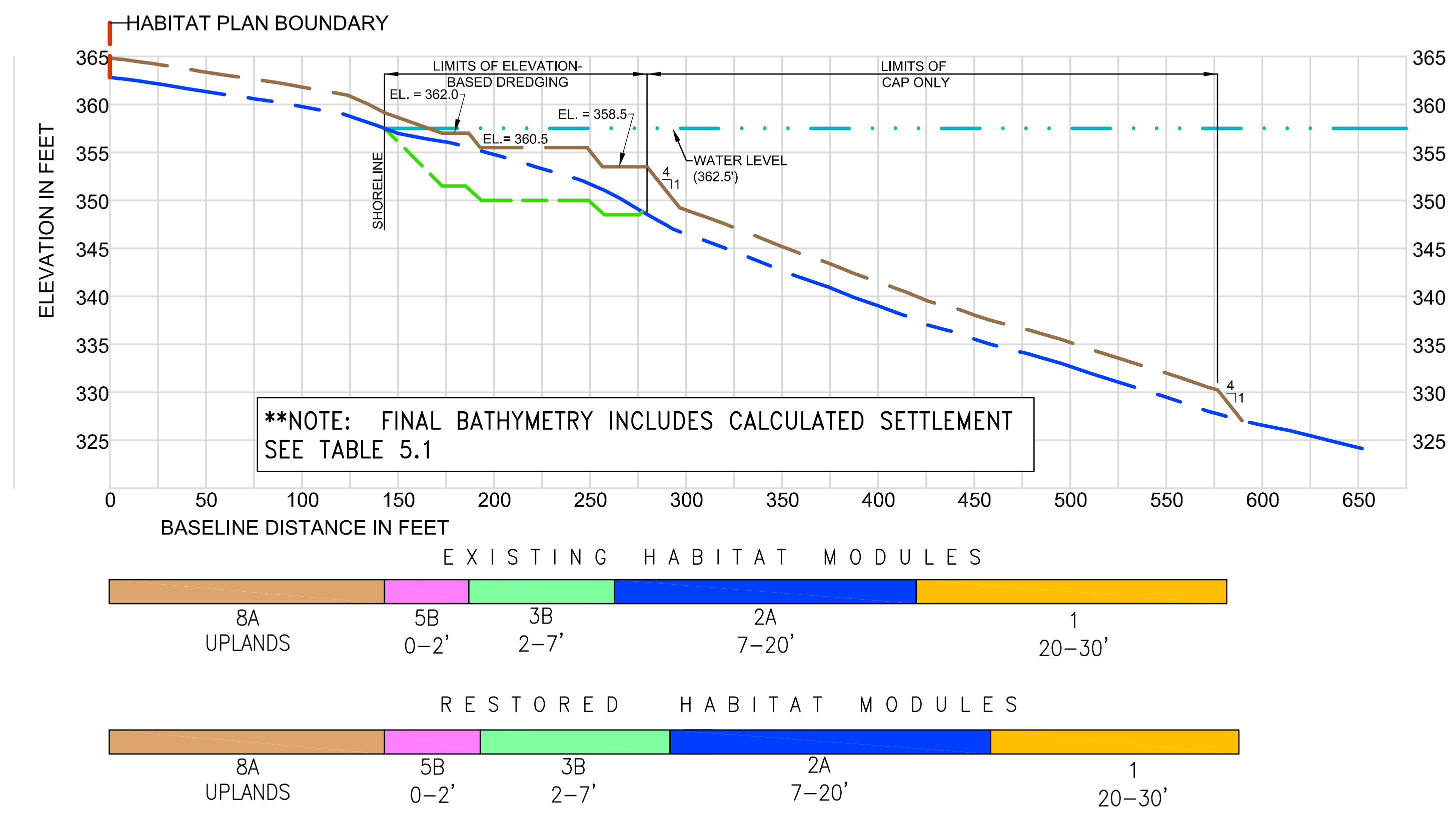

SMU 8
Remediation Area C
(Medium Energy)
RAC-1
RAC-2
RAD-1
SMU 3
SMU 2
SMU 1
Ditch A
Tributary 5A
East Flume
Potential Location of Future
NYSDEC Boat Launch - TBD
690
1
2A
3B
5B
6B
8A
8B
RAC-1 Cross-section Location and Identification
Area covered by Onondaga Lake Remedial Design Elements for Habitat Restoration
Aquatic Plants (From Onondaga County Department of Water Environment Protection, 2008)
NYSDEC Approved Wetland Boundaries
Sediment Management Unit (SMU) Boundary
Remediation Area Boundary (Parsons, 2009)
Tributary to be remediated by Honeywell
Extent of ILWD in Littoral Zone
300 150 0 300
Feet
N
S
E
W
FIGURE 5.6
Honeywell
Onondaga Lake
Syracuse, New York
Restored Habitat Module Application
Remediation Area C
PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



REMEDIATION AREA C – SECTION RAC-1

Vertical: 1"=20'-0"
Horizontal: 1"-100'-0"

**NOTE
1. DETAILED ASSUMPTIONS FOR CAP THICKNESS AND SETTLEMENT ARE CONSISTENT WITH THOSE SPECIFIED IN THE CAPPING AND DREDGE AREA AND DEPTH IDS
2. CROSS SECTION IS CONSISTENT WITH SECTION 11/D-15 FROM CAPPING AND DREDGE AREA AND DEPTH IDS

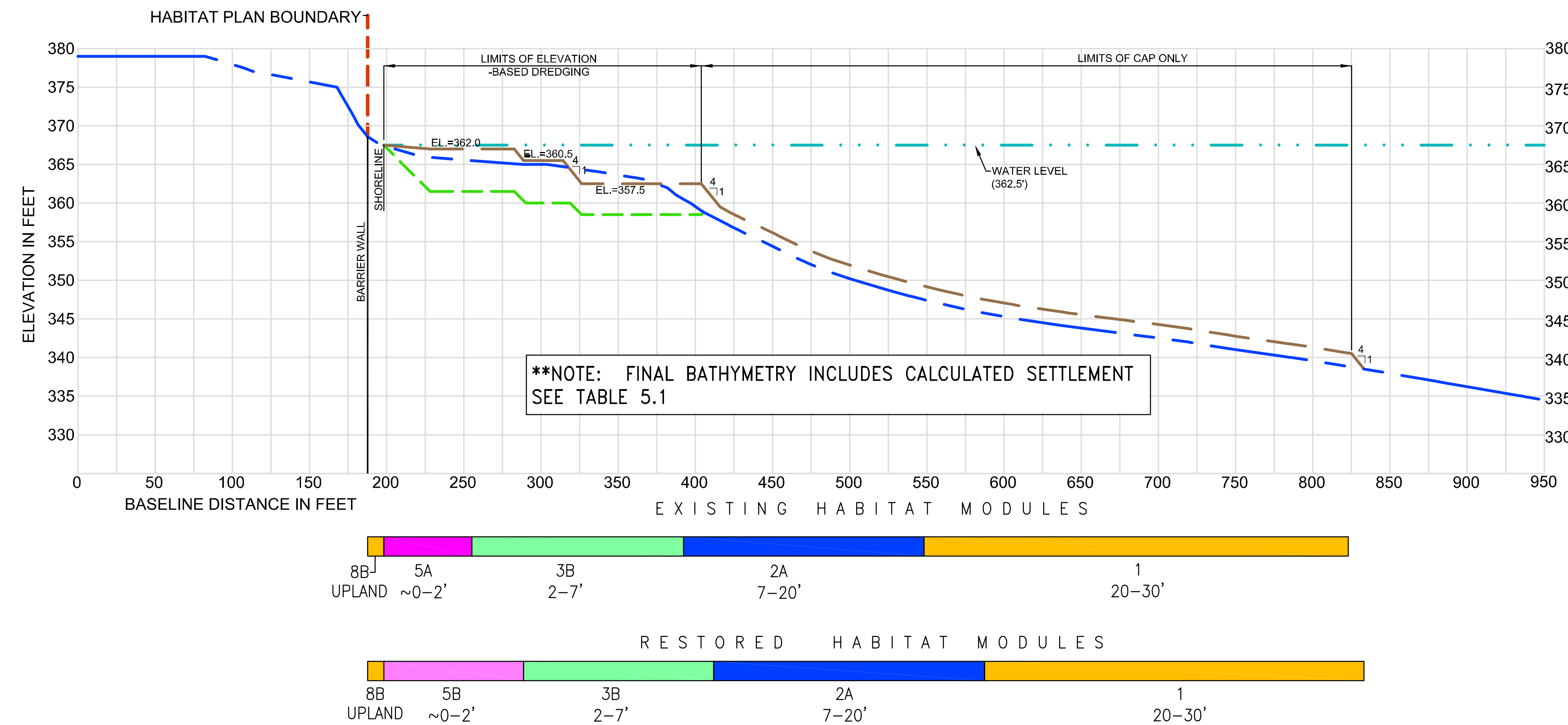
LEGEND:
- WATERLINE (362.5 NAVD 88) (GROWING SEASON)
- EXISTING GRADE
- DREDGE GRADE
- CAP GRADE

FILE NAME: P:\HONEYWELL -SYR\444284 - HABITAT AND CPP II\10 TECHNICAL CATEGORIES\10.1 CAD\FROM ANCHOR QEA\HABITAT 11-09 XSEC5.DWG
PLOT DATE: 12/14/2009 9:31 AM PLOTTED BY: NEUMANN, JEREMY

FIGURE 5.7

Honeywell
CONCEPTUAL CROSS SECTION
REMEDIATION AREA C (SMU 2)
SECTION RAC-1

PARSONS
310 PLAINFIELD ROAD * SUITE 350 * SYRACUSE, NY 13212 * 315/451-9560
OFFICES IN PRINCIPAL CITIES



REMEDIATION AREA C – SECTION RAC–2

Vertical: 1"=20'–0"
Horizontal: 1"–100'–0"

**NOTE
1. DETAILED ASSUMPTIONS FOR CAP THICKNESS AND SETTLEMENT ARE CONSISTENT WITH THOSE SPECIFIED IN THE CAPPING AND DREDGE AREA AND DEPTH IDS
2. CROSS SECTION IS CONSISTENT WITH SECTION 14/D–16 FROM CAPPING AND DREDGE AREA AND DEPTH IDS

LEGEND:
- WATERLINE (362.5 NAVD 88) (GROWING SEASON)
- EXISTING GRADE
- DREDGE GRADE
- CAP GRADE

FIGURE 5.8

Honeywell

CONCEPTUAL CROSS SECTION
REMEDIATION AREA C (SMU 2)
SECTION RAC–2

PARSONS
310 PLAINFIELD ROAD * SUITE 350 * SYRACUSE, NY 13212 * 315/451-9560
OFFICES IN PRINCIPAL CITIES

FILE NAME: P:\HONEYWELL –SYR\444284 – HABITAT AND CPP II\10 TECHNICAL CATEGORIES\10.1 CAD\FROM ANCHOR QEA\HABITAT 11–09 XSEC5.DWG
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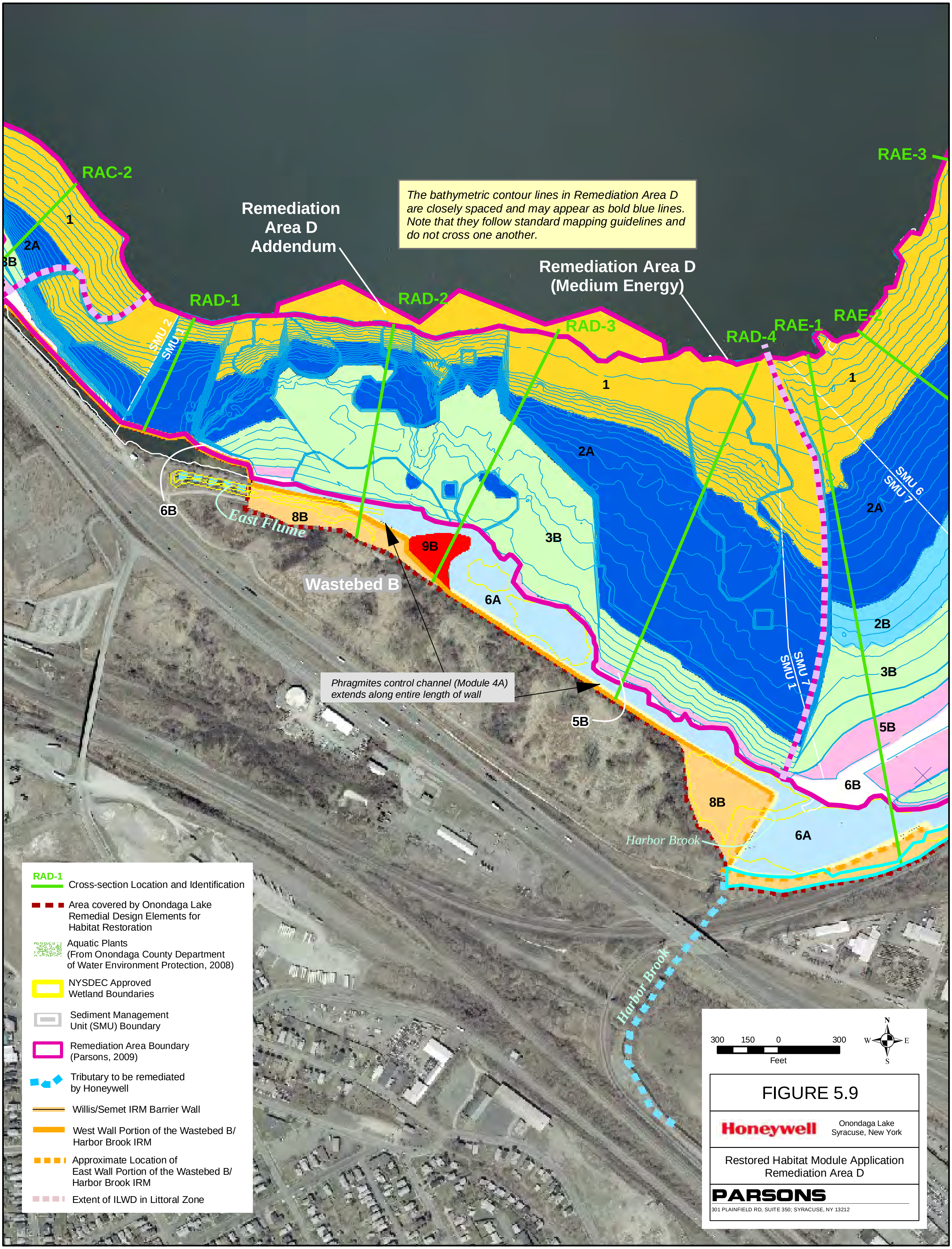


FIGURE 5.9

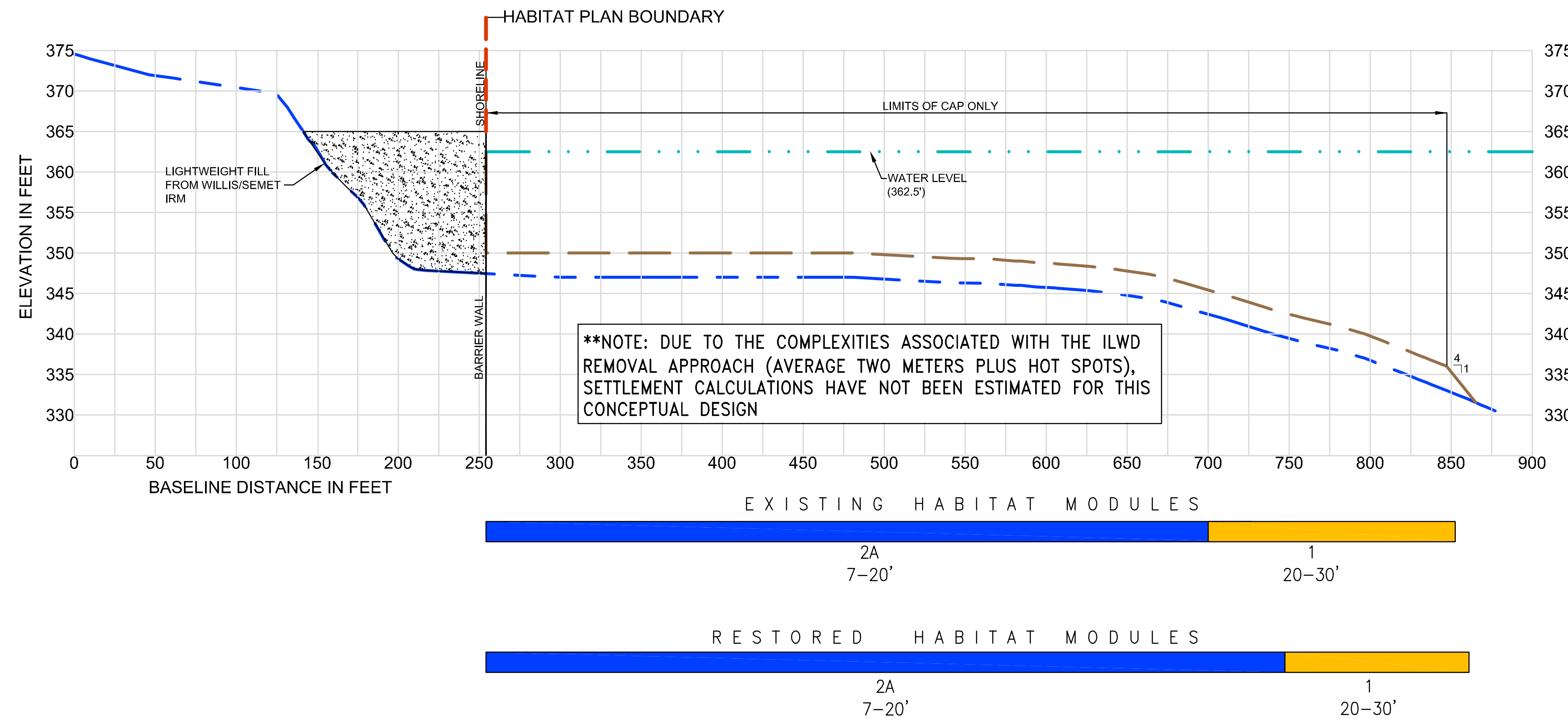
Honeywell

Onondaga Lake
Syracuse, New York

Restored Habitat Module Application
Remediation Area D

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



REMEDIATION AREA D – SECTION RAD–1

Vertical: 1"=20'–0"
Horizontal: 1"–100'–0"

**NOTE
1. DETAILED ASSUMPTIONS FOR CAP THICKNESS AND SETTLEMENT ARE CONSISTENT WITH THOSE SPECIFIED IN THE CAPPING AND DREDGE AREA AND DEPTH IDS

LEGEND:
- WATERLINE (362.5 NAVD 88) (GROWING SEASON)
- EXISTING GRADE
- DREDGE GRADE
- CAP GRADE

FIGURE 5.10

Honeywell

CONCEPTUAL CROSS SECTION
REMEDIATION AREA D (SMU 1)
SECTION RAD–1

PARSONS
310 PLAINFIELD ROAD * SUITE 350 * SYRACUSE, NY 13212 * 315/451-9560
OFFICES IN PRINCIPAL CITIES

FILE NAME: P:\HONEYWELL –SYR\444284 – HABITAT AND CPP II\10 TECHNICAL CATEGORIES\10.1 CAD\FROM ANCHOR QEA\HABITAT 11–09 XSEC5.DWG
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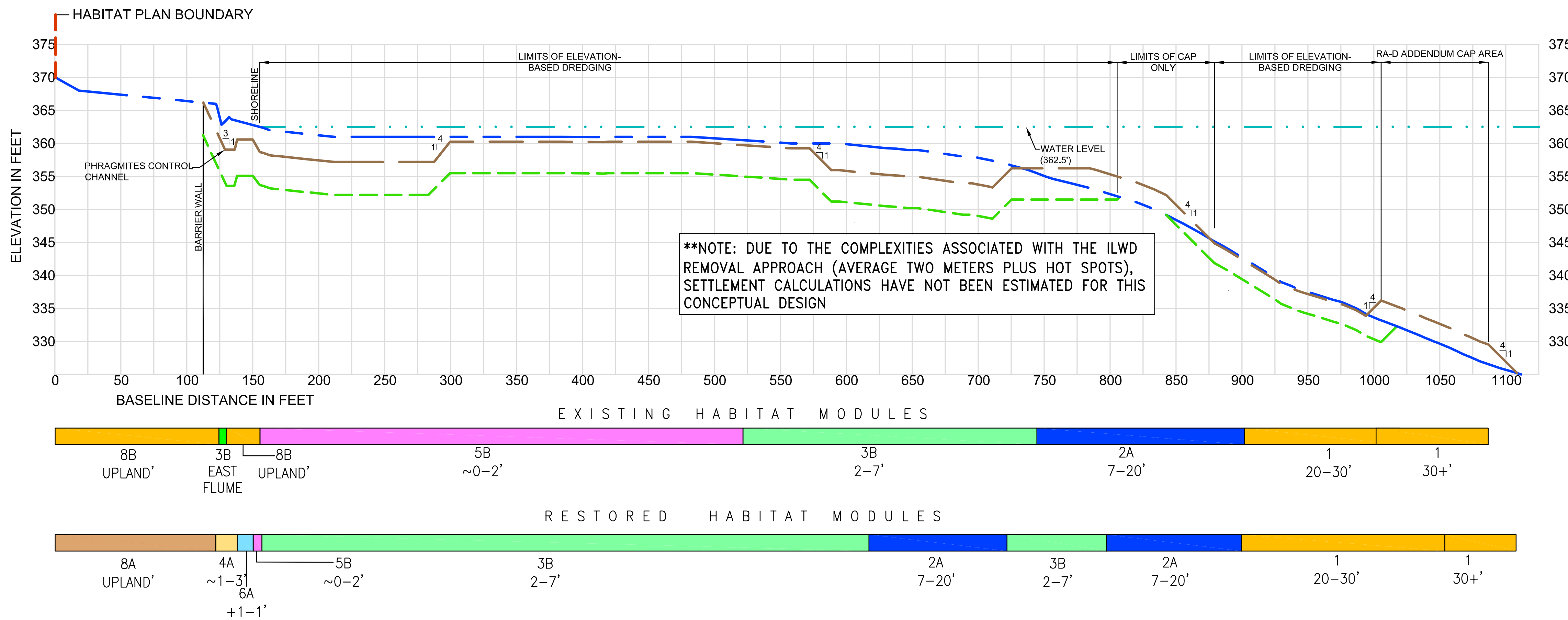

REMEDIATION AREA D – SECTION RAD-2

Vertical: 1"=20'-0"
Horizontal: 1"-100'-0"

**NOTE
1. DETAILED ASSUMPTIONS FOR CAP THICKNESS AND SETTLEMENT ARE CONSISTENT WITH THOSE SPECIFIED IN THE CAPPING AND DREDGE AREA AND DEPTH IDS
2. CROSS SECTION IS CONSISTENT WITH SECTION 18/D-18 FROM CAPPING AND DREDGE AREA AND DEPTH IDS

LEGEND:
- WATERLINE (362.5 NAVD 88) (GROWING SEASON)
- EXISTING GRADE
- DREDGE GRADE
- CAP GRADE

FIGURE 5.11

Honeywell

CONCEPTUAL CROSS SECTION
REMEDIATION AREA D (SMU 1)
SECTION RAD-2

PARSONS
310 PLAINFIELD ROAD * SUITE 350 * SYRACUSE, NY 13212 * 315/451-9560
OFFICES IN PRINCIPAL CITIES

FILE NAME: P:\HONEYWELL -SYR\444284 – HABITAT AND CPP II\10 TECHNICAL CATEGORIES\10.1 CAD\FROM ANCHOR QEA\HABITAT 11-09 XSEC5.DWG
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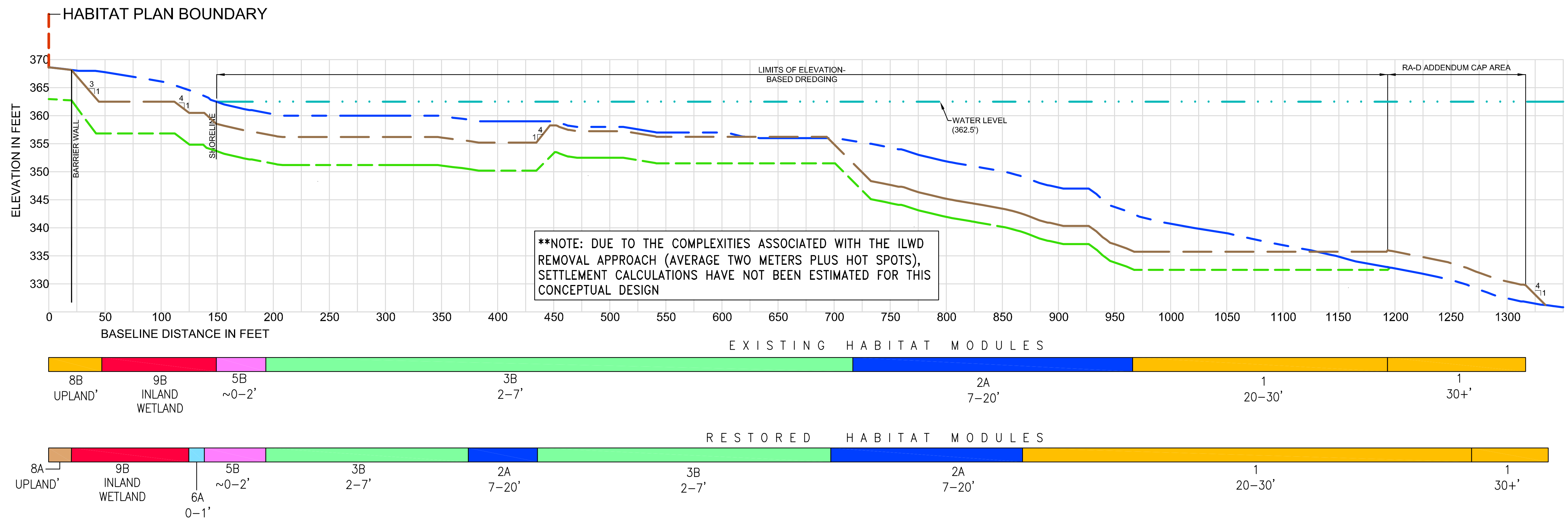


REMEDIATION AREA D – SECTION RAD-3

Vertical: 1"=20'-0"
Horizontal: 1"-100'-0"

**NOTE
1. DETAILED ASSUMPTIONS FOR CAP THICKNESS AND SETTLEMENT ARE CONSISTENT WITH THOSE SPECIFIED IN THE CAPPING AND DREDGE AREA AND DEPTH IDS
2. CROSS SECTION IS CONSISTENT WITH SECTION 19/D-19 FROM CAPPING AND DREDGE AREA AND DEPTH IDS

LEGEND:
- WATERLINE (362.5 NAVD 88) (GROWING SEASON)
- EXISTING GRADE
- DREDGE GRADE
- CAP GRADE

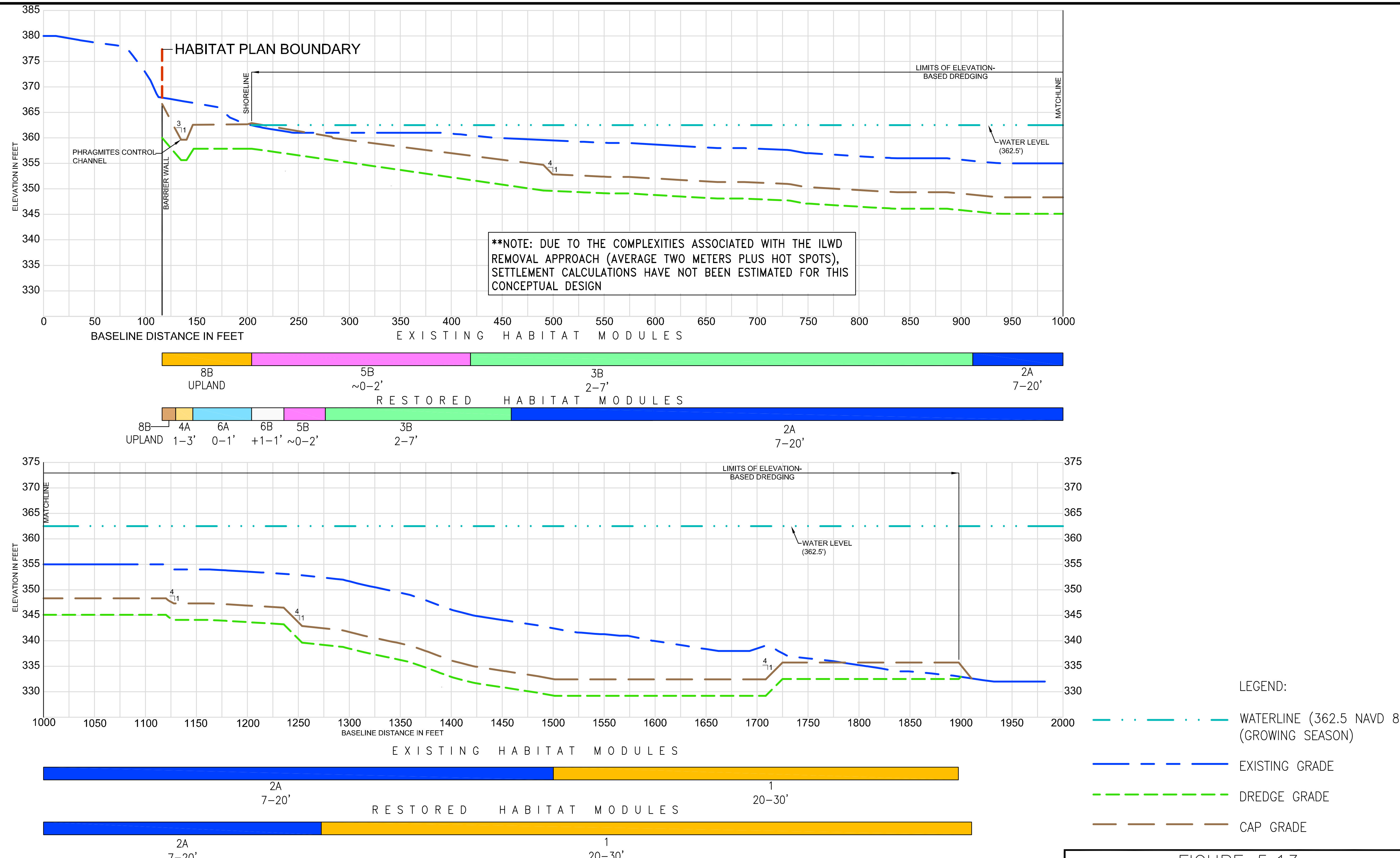
FILE NAME: P:\HONEYWELL -SYR\444284 - HABITAT AND CPP II\10 TECHNICAL CATEGORIES\10.1 CAD\FROM ANCHOR QEA\HABITAT 11-09 XSEC5.DWG
PLOT DATE: 12/14/2009 9:20 AM PLOTTED BY: NEUMANN, JEREMY

FIGURE 5.12

Honeywell

CONCEPTUAL CROSS SECTION
REMEDIATION AREA D (SMU 1)
SECTION RAD-3

PARSONS
310 PLAINFIELD ROAD ▪ SUITE 350 ▪ SYRACUSE, NY 13212 ▪ 315/451-9560
OFFICES IN PRINCIPAL CITIES



**NOTE
1. DETAILED ASSUMPTIONS FOR CAP THICKNESS AND SETTLEMENT ARE CONSISTENT WITH THOSE SPECIFIED IN THE CAPPING AND DREDGE AREA AND DEPTH IDS
2. CROSS SECTION IS CONSISTENT WITH SECTION 21/D-20 FROM CAPPING AND DREDGE AREA AND DEPTH IDS

REMEDIATION AREA D – SECTION RAD-4

Vertical: 1"=20'-0"
Horizontal: 1"-100'-0"

FIGURE 5.13

Honeywell

CONCEPTUAL CROSS SECTION
REMEDIATION AREA D (SMU 1)
SECTION RAD-4

PARSONS
310 PLAINFIELD ROAD * SUITE 350 * SYRACUSE, NY 13212 * 315/451-9560
OFFICES IN PRINCIPAL CITIES

FILE NAME: P:\HONEYWELL -SYR\444284 - HABITAT AND CPP II\10 TECHNICAL CATEGORIES\10.1 CAD\FROM ANCHOR QEA\HABITAT 11-09 XSEC5.DWG
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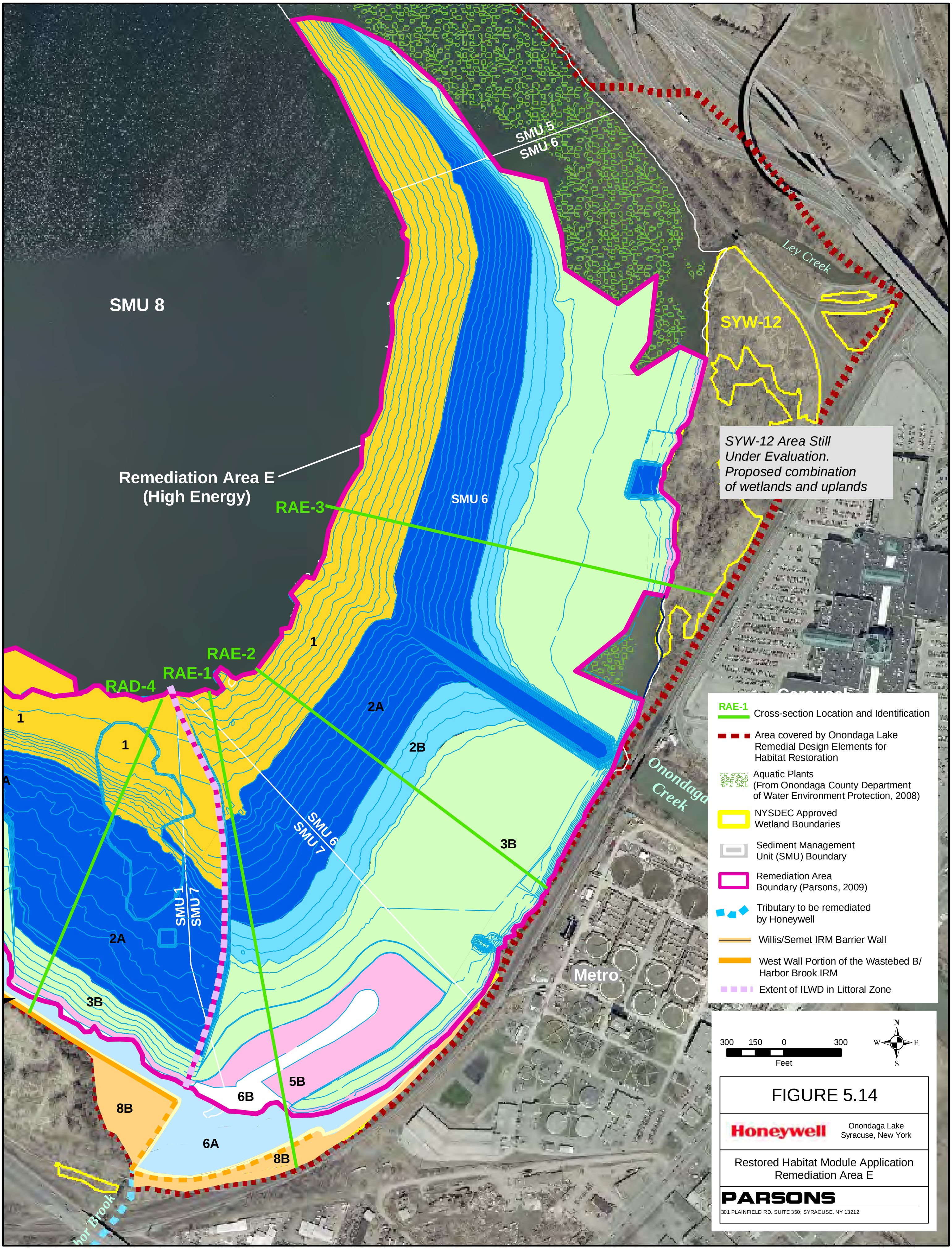


FIGURE 5.14

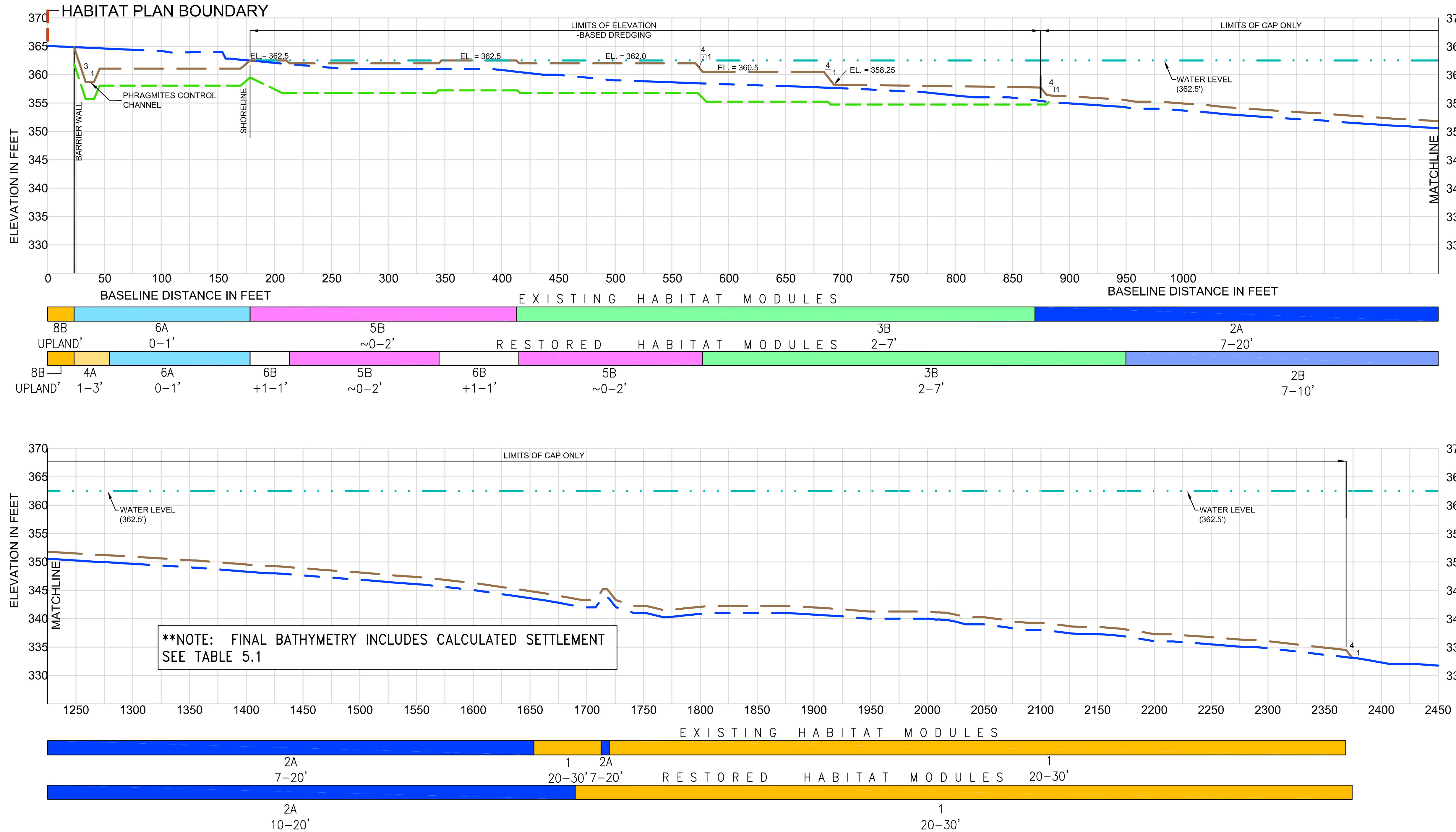
Honeywell

Onondaga Lake
Syracuse, New York

Restored Habitat Module Application
Remediation Area E

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



REMEDIATION AREA E – SECTION RAE–1

Vertical: 1"=20'–0"
Horizontal: 1"–100'–0"

**NOTE
1. DETAILED ASSUMPTIONS FOR CAP THICKNESS AND SETTLEMENT ARE CONSISTENT WITH THOSE SPECIFIED IN THE CAPPING AND DREDGE AREA AND DEPTH IDS
2. CROSS SECTION IS CONSISTENT WITH SECTION 23/D–21 FROM CAPPING AND DREDGE AREA AND DEPTH IDS

LEGEND:
- WATERLINE (362.5 NAVD 88) (GROWING SEASON)
- EXISTING GRADE
- DREDGE GRADE
- CAP GRADE

FIGURE 5.15

Honeywell

CONCEPTUAL CROSS SECTION
REMEDIATION AREA E (SMU 7)
SECTION RAE–1

PARSONS
310 PLAINFIELD ROAD • SUITE 350 • SYRACUSE, NY 13212 • 315/451-9560
OFFICES IN PRINCIPAL CITIES

FILE NAME: P:\HONEYWELL –SYR\444284 – HABITAT AND CPP II\10 TECHNICAL CATEGORIES\10.1 CAD\FROM ANCHOR QEA\HABITAT 11–09 XSEC5.DWG
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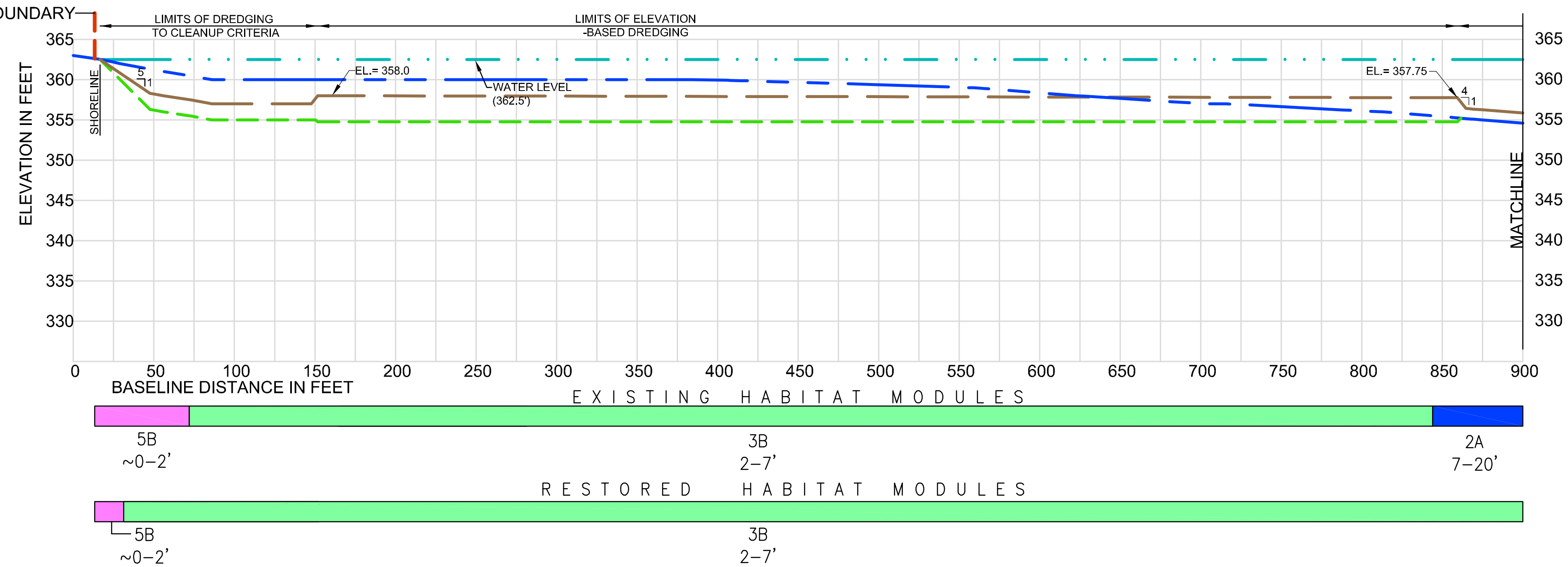

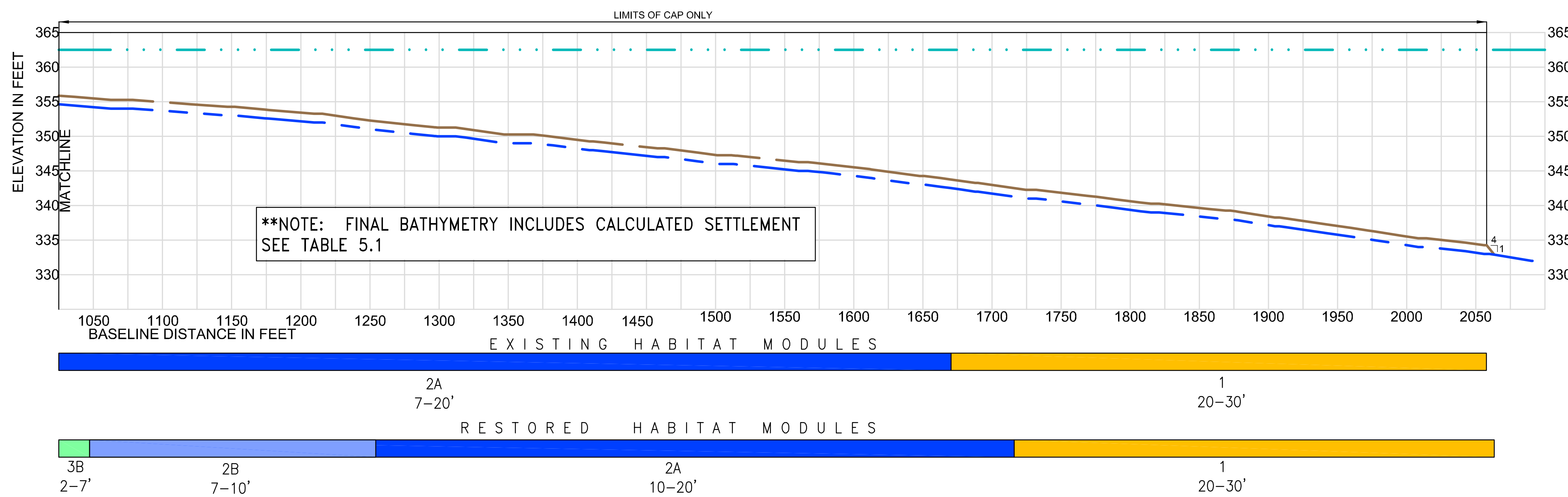

REMEDIATION AREA E – SECTION RAE-2

Vertical: 1"=20'-0"
Horizontal: 1"-100'-0"

**NOTE

1. DETAILED ASSUMPTIONS FOR CAP THICKNESS AND SETTLEMENT ARE CONSISTENT WITH THOSE SPECIFIED IN THE CAPPING AND DREDGE AREA AND DEPTH IDS
2. CROSS SECTION IS CONSISTENT WITH SECTION 27/D-23 FROM CAPPING AND DREDGE AREA AND DEPTH IDS

LEGEND:

- WATERLINE (362.5 NAVD 88) (GROWING SEASON)
- EXISTING GRADE
- DREDGE GRADE
- CAP GRADE

FIGURE 5.16

Honeywell

CONCEPTUAL CROSS SECTION
REMEDIATION AREA E (SMU 6/7)
SECTION RAE-2

PARSONS
310 PLAINFIELD ROAD ▪ SUITE 350 ▪ SYRACUSE, NY 13212 ▪ 315/451-9560
OFFICES IN PRINCIPAL CITIES

FILE NAME: P:\HONEYWELL -SYR\444284 - HABITAT AND CPP II\10 TECHNICAL CATEGORIES\10.1 CAD\FROM ANCHOR QEA\HABITAT 11-09 XSEC5.DWG
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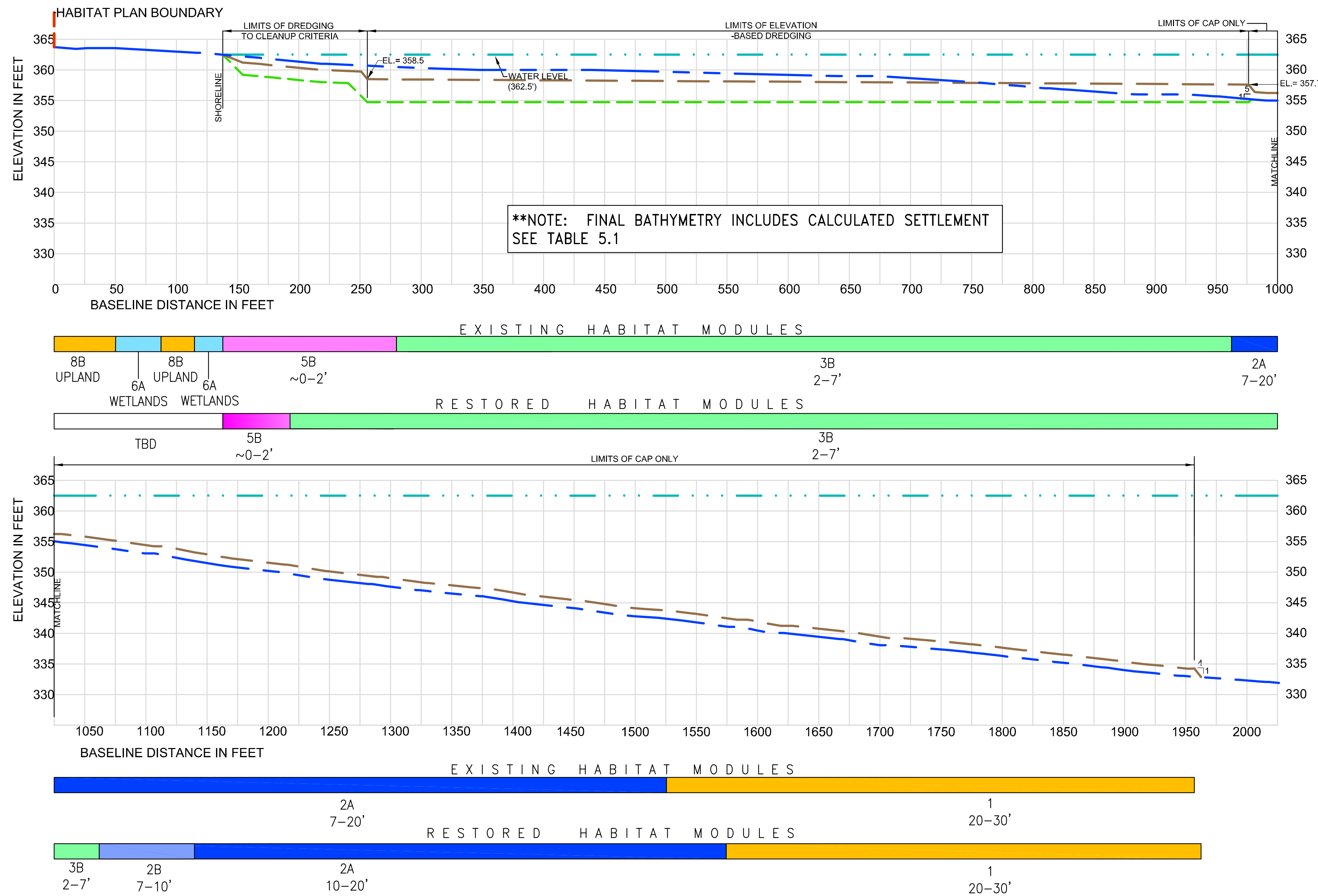

REMEDIATION AREA E – SECTION RAE-3

Vertical: 1"=20'-0"
Horizontal: 1"-100'-0"

**NOTE
1. DETAILED ASSUMPTIONS FOR CAP THICKNESS AND SETTLEMENT ARE CONSISTENT WITH THOSE SPECIFIED IN THE CAPPING AND DREDGE AREA AND DEPTH IDS
2. CROSS SECTION IS CONSISTENT WITH SECTION 31/D-25 FROM CAPPING AND DREDGE AREA AND DEPTH IDS

LEGEND:
- WATERLINE (362.5 NAVD 88) (GROWING SEASON)
- EXISTING GRADE
- DREDGE GRADE
- CAP GRADE

FIGURE 5.17

Honeywell

CONCEPTUAL CROSS SECTION
REMEDIATION AREA E (SMU 6/7)
SECTION RAE-3

PARSONS
310 PLAINFIELD ROAD ■ SUITE 350 ■ SYRACUSE, NY 13212 ■ 315/451-9560
OFFICES IN PRINCIPAL CITIES

FILE NAME: P:\HONEYWELL -SYR\444284 – HABITAT AND CPP II\10 TECHNICAL CATEGORIES\10.1 CAD\FROM ANCHOR QEA\HABITAT 11-09 XSEC5.DWG
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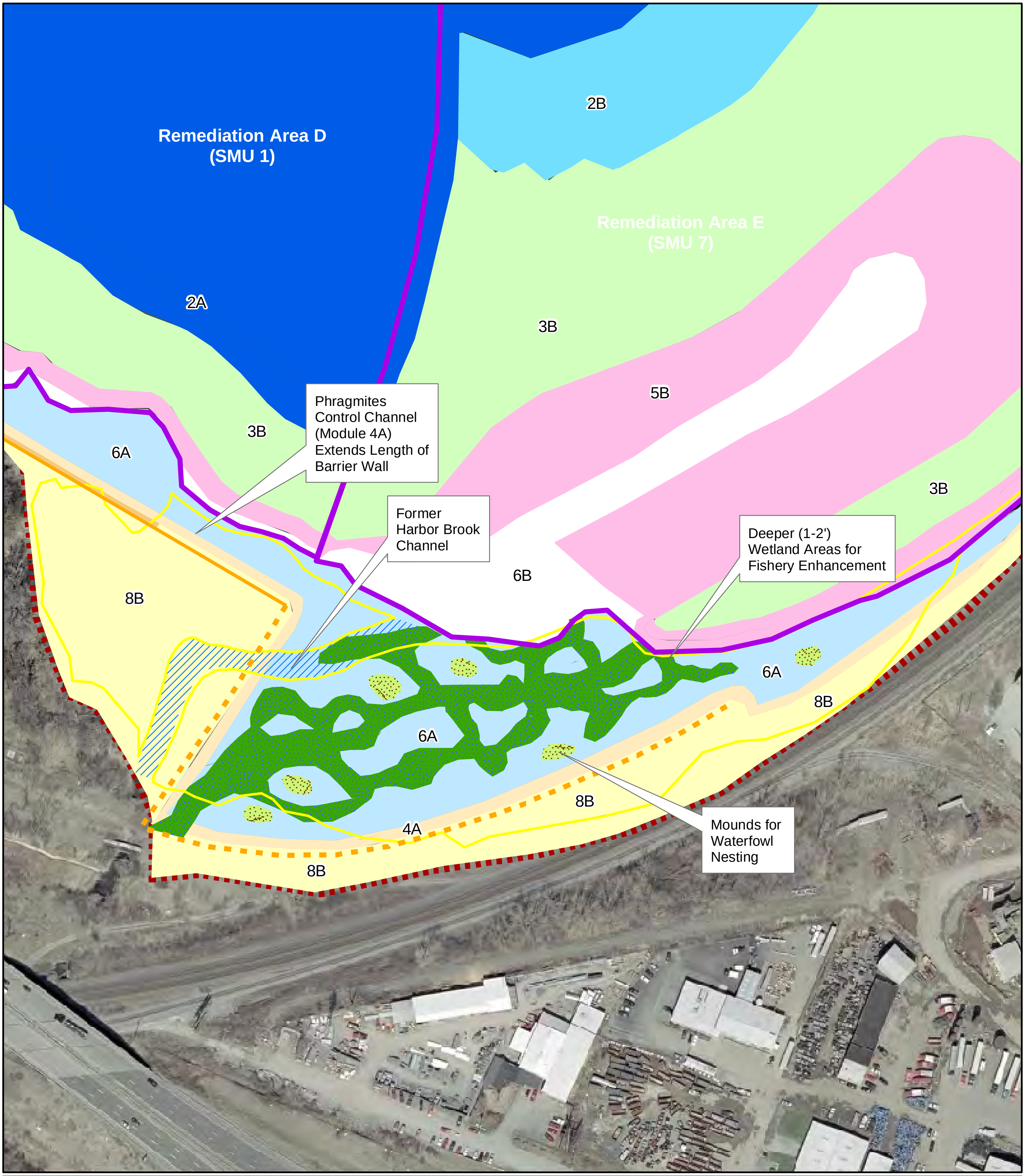


NYSDEC Approved Wetland Boundaries

Sediment Management Unit (SMU) Boundary

Remediation Area Boundary (Parsons, 2009)

Area covered by Onondaga Lake Remedial Design Elements for Habitat Restoration

West Wall Portion of the WB-B/HB IRM

Approximate location of East Wall Portion of the WB-B/HB IRM

N W E S

New York State Digital Orthoimagery from 2003

90 45 0 90
Feet

FIGURE 5.18

Honeywell

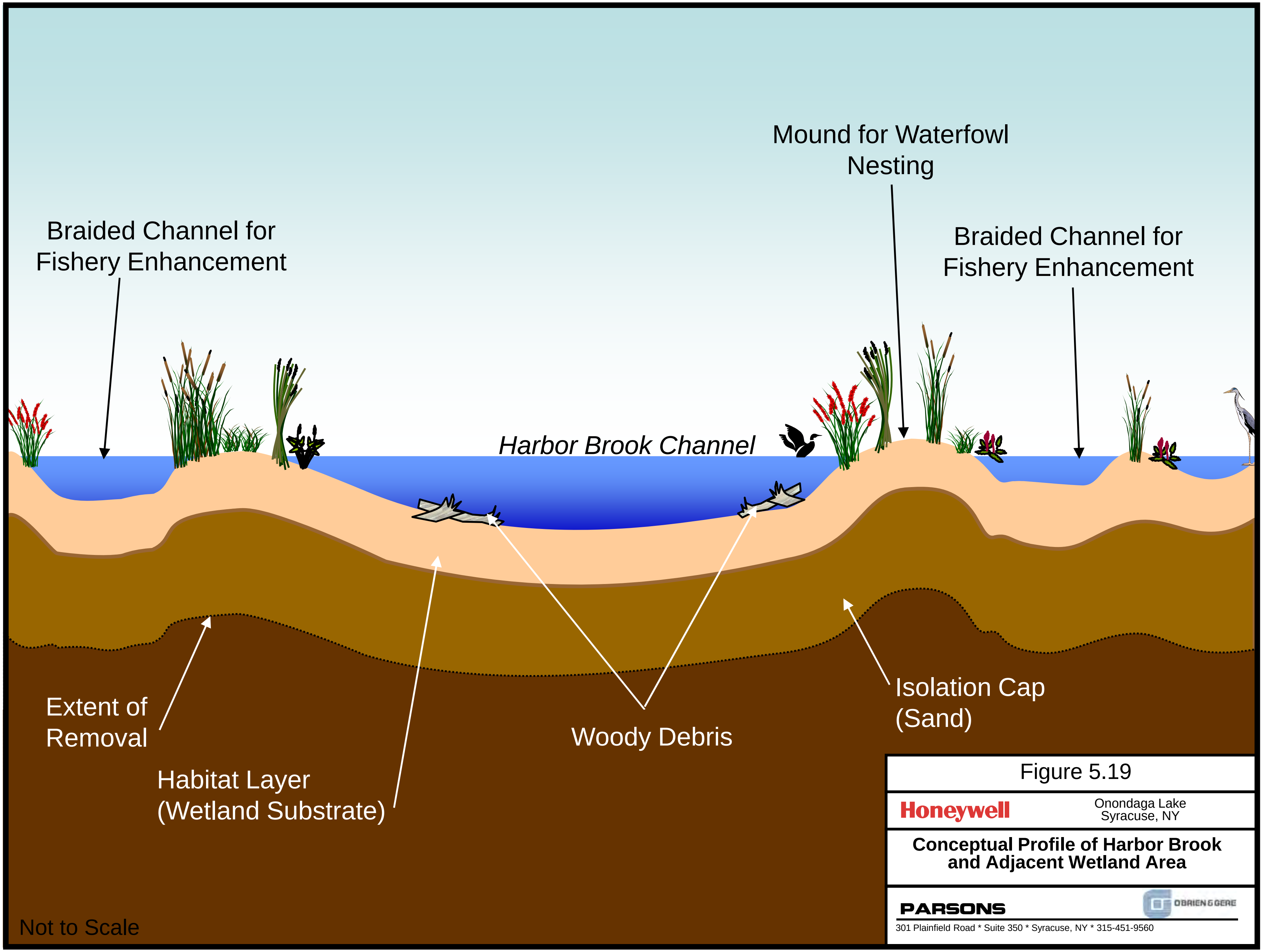
Onondaga Lake
Syracuse, New York

Conceptual Plan for Lower Harbor Brook and Adjacent Wetland Areas

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

(Q:\GIS\GIS_Lake\HAB_PAHB_graphic.mxd) 9/11/2008 -- 9:04:32 AM


Mound for Waterfowl Nesting
Braided Channel for Fishery Enhancement
Braided Channel for Fishery Enhancement
Harbor Brook Channel
Extent of Removal
Woody Debris
Isolation Cap (Sand)
Habitat Layer (Wetland Substrate)
Not to Scale
Figure 5.19
Honeywell
Onondaga Lake
Syracuse, NY
Conceptual Profile of Harbor Brook and Adjacent Wetland Area
PARSONS
O'BRIEN & GERE
301 Plainfield Road * Suite 350 * Syracuse, NY * 315-451-9560


SMU 8
Remediation Area A
SMU 5
SMU 4
0-1' Shallower
SMU 4
SMU 3
1-3' Deeper
690
3-5' Shallower
3-5' Deeper
1-3' Shallower
3-5' Shallower
Wastebeds 1-8
Ninemile Creek
Remediation Area Boundary (Parsons, 2009)
Area covered by Onondaga Lake Remedial Design Elements for Habitat Restoration
Post-Remedy Change in Water Depth
1-3' Deeper
3-5' Deeper
1-3' Shallower
3-5' Shallower
300 150 0 300
Feet
N
W E
S
FIGURE 5.20
Honeywell
Onondaga Lake
Syracuse, New York
Change in Water Depth
Remediation Area A
PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

FIGURE 5.21

Honeywell

Onondaga Lake
Syracuse, New York

Change in Water Depth
Remediation Area B

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

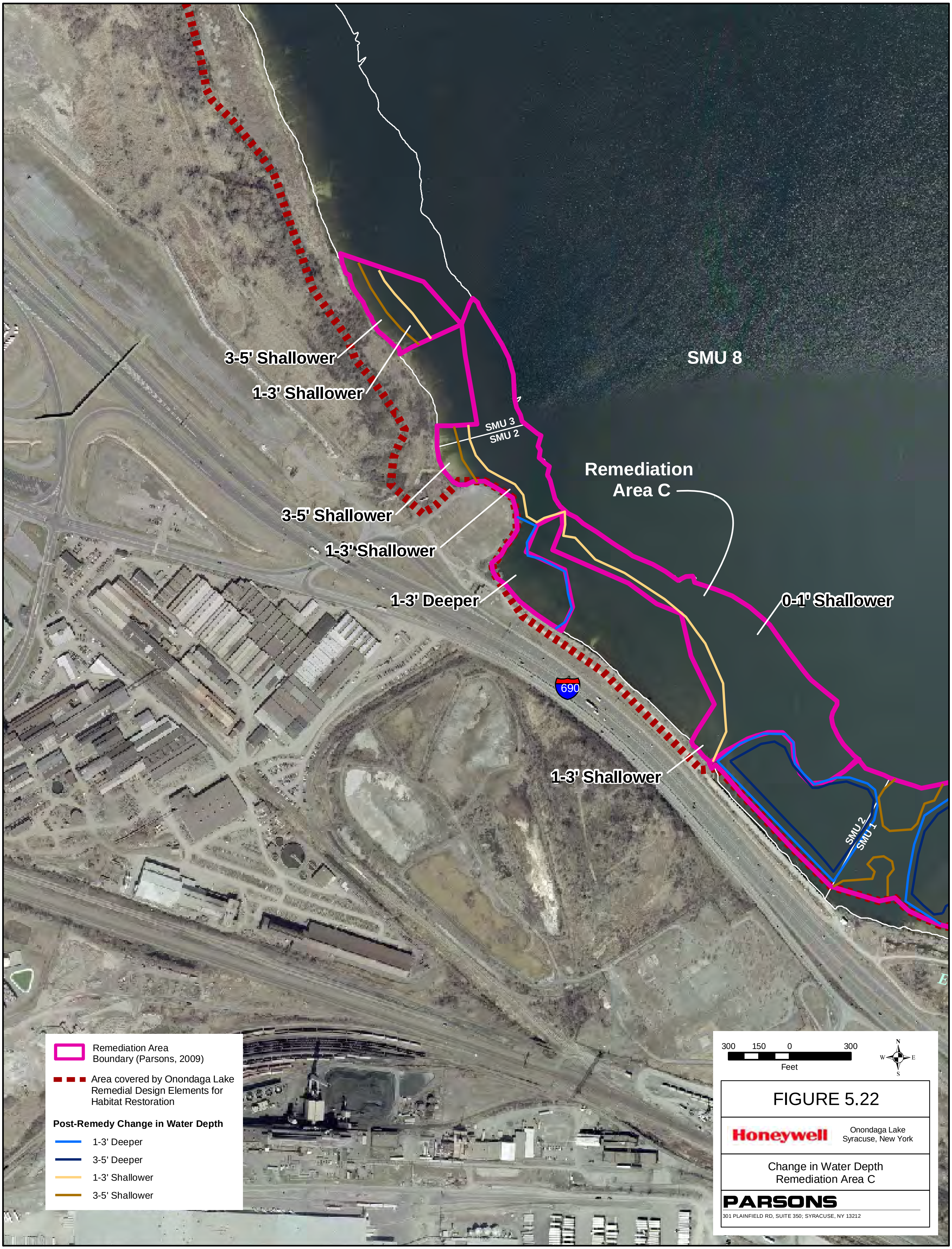


FIGURE 5.22

Honeywell

Onondaga Lake
Syracuse, New York

Change in Water Depth
Remediation Area C

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

FIGURE 5.23

Honeywell

Onondaga Lake
Syracuse, New York

Change in Water Depth
Remediation Area D

PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

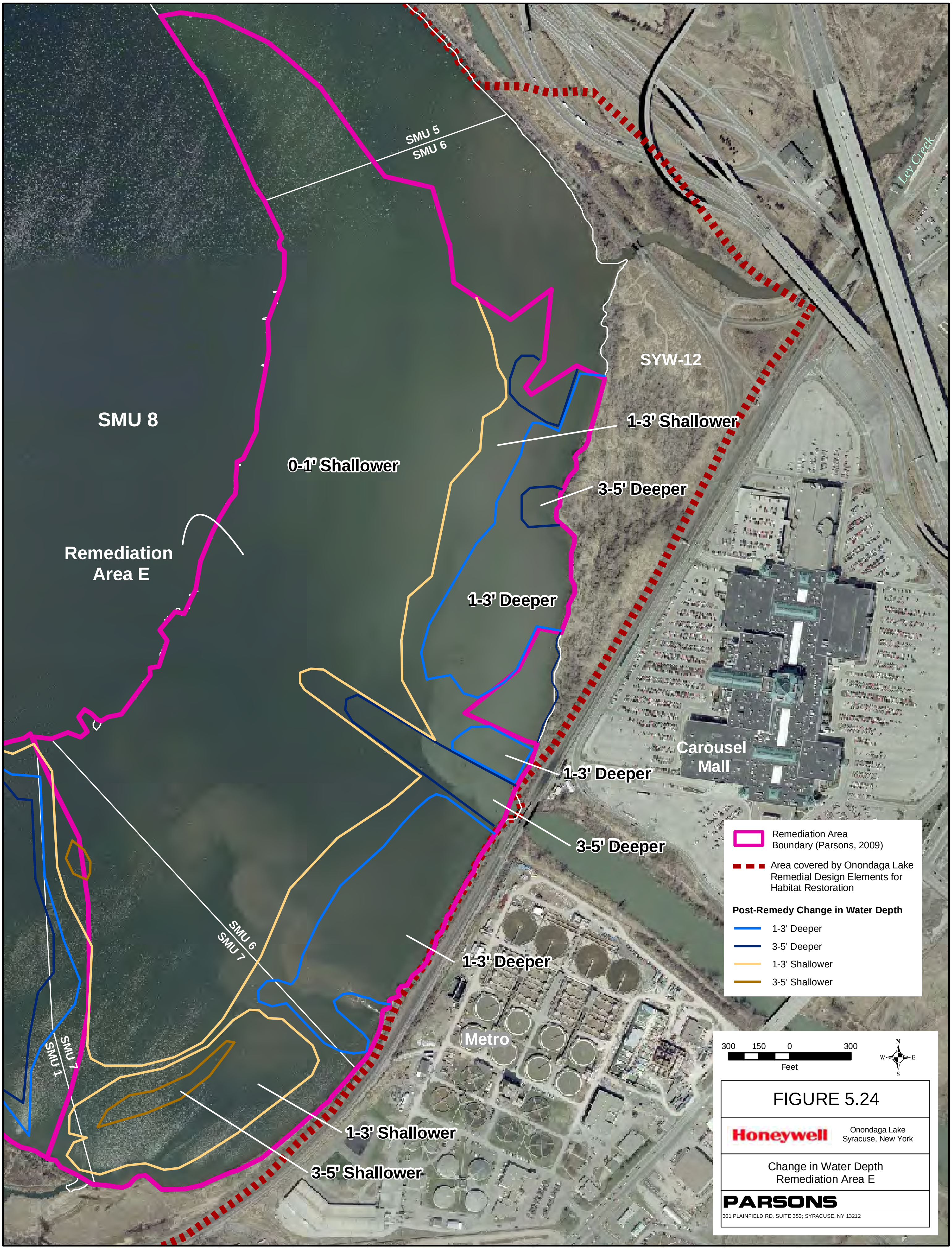


FIGURE 5.24

Honeywell

Onondaga Lake
Syracuse, New York

Change in Water Depth
Remediation Area E

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

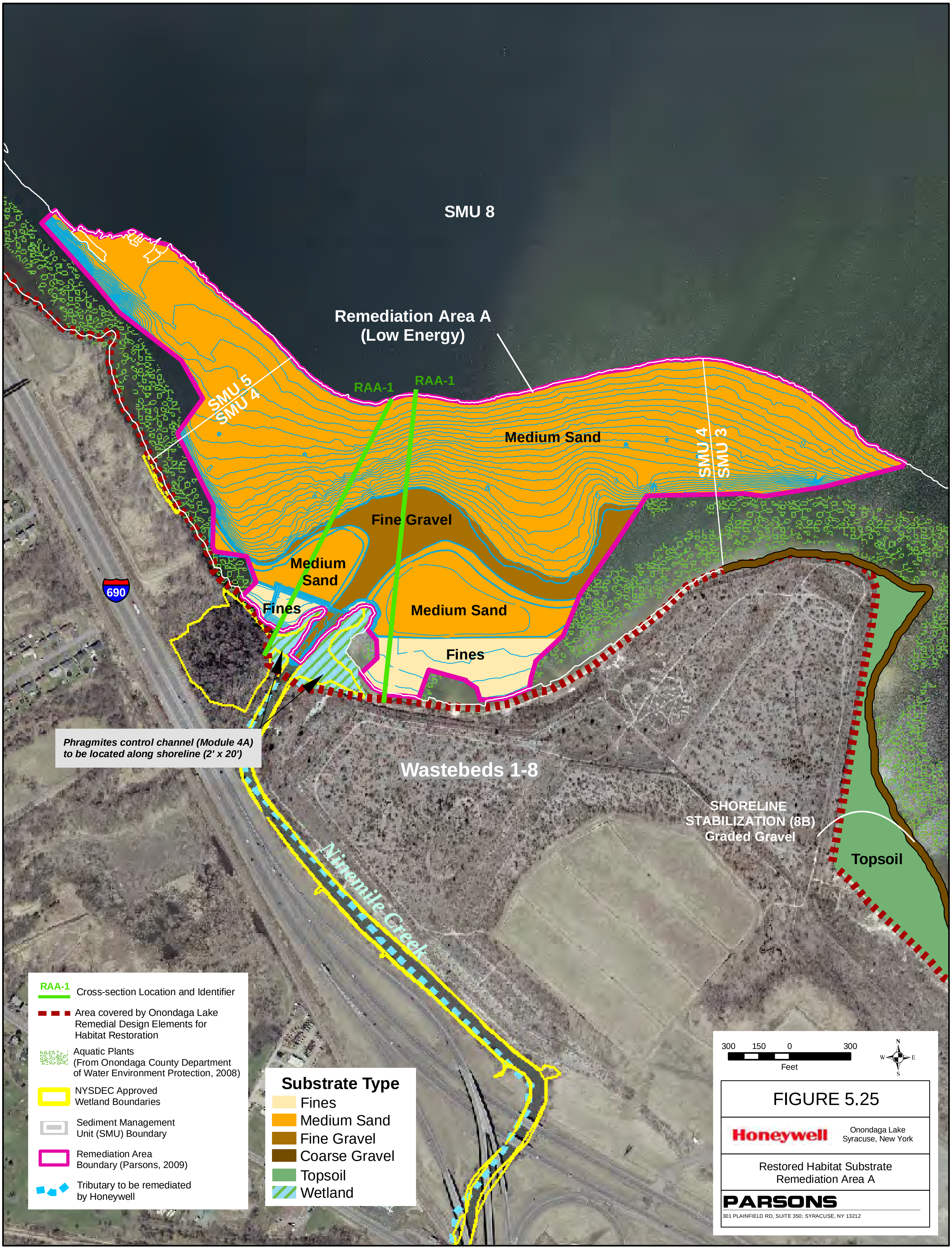


FIGURE 5.25

Honeywell

Onondaga Lake
Syracuse, New York

Restored Habitat Substrate
Remediation Area A

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

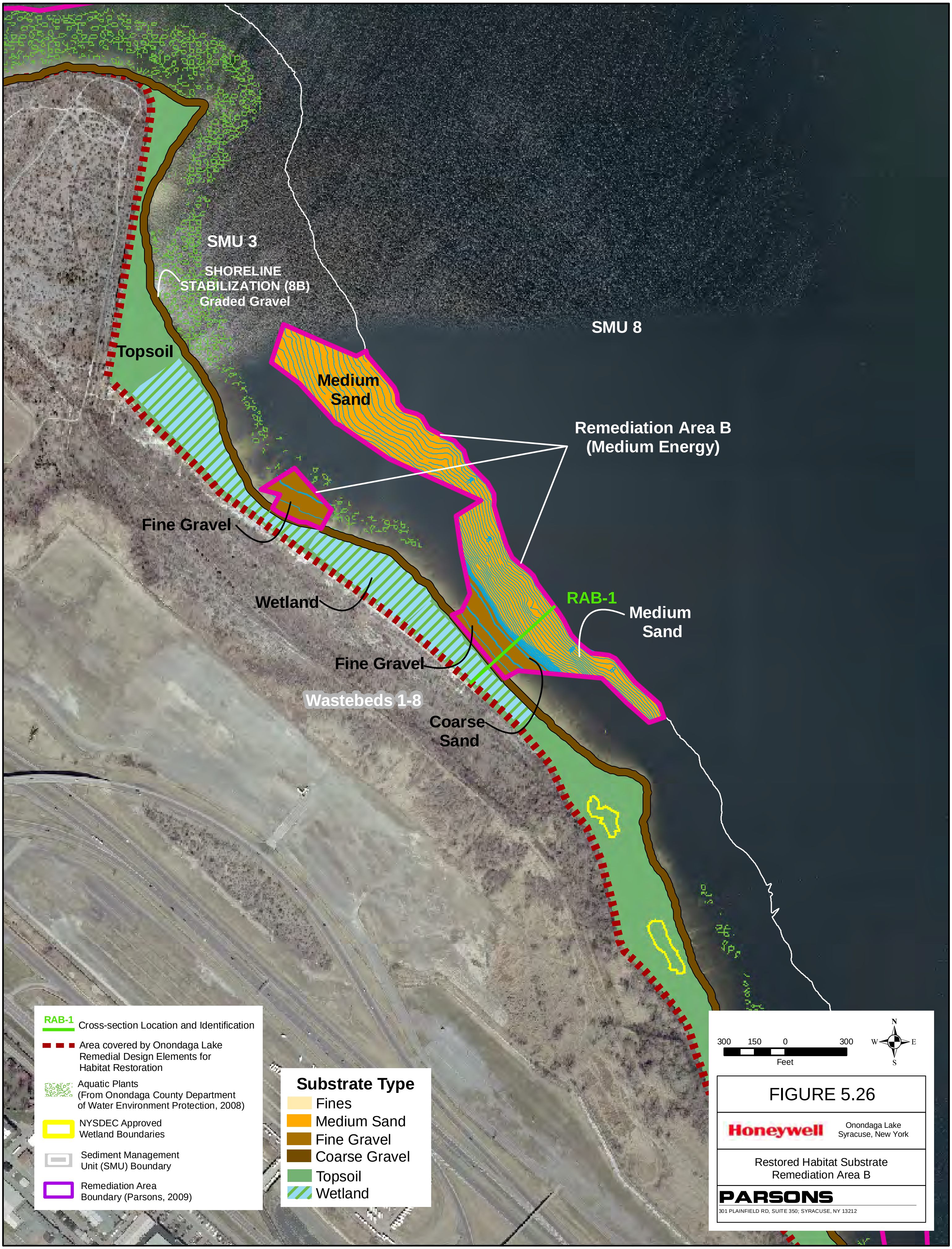


FIGURE 5.26

Honeywell
Onondaga Lake
Syracuse, New York

Restored Habitat Substrate
Remediation Area B

PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

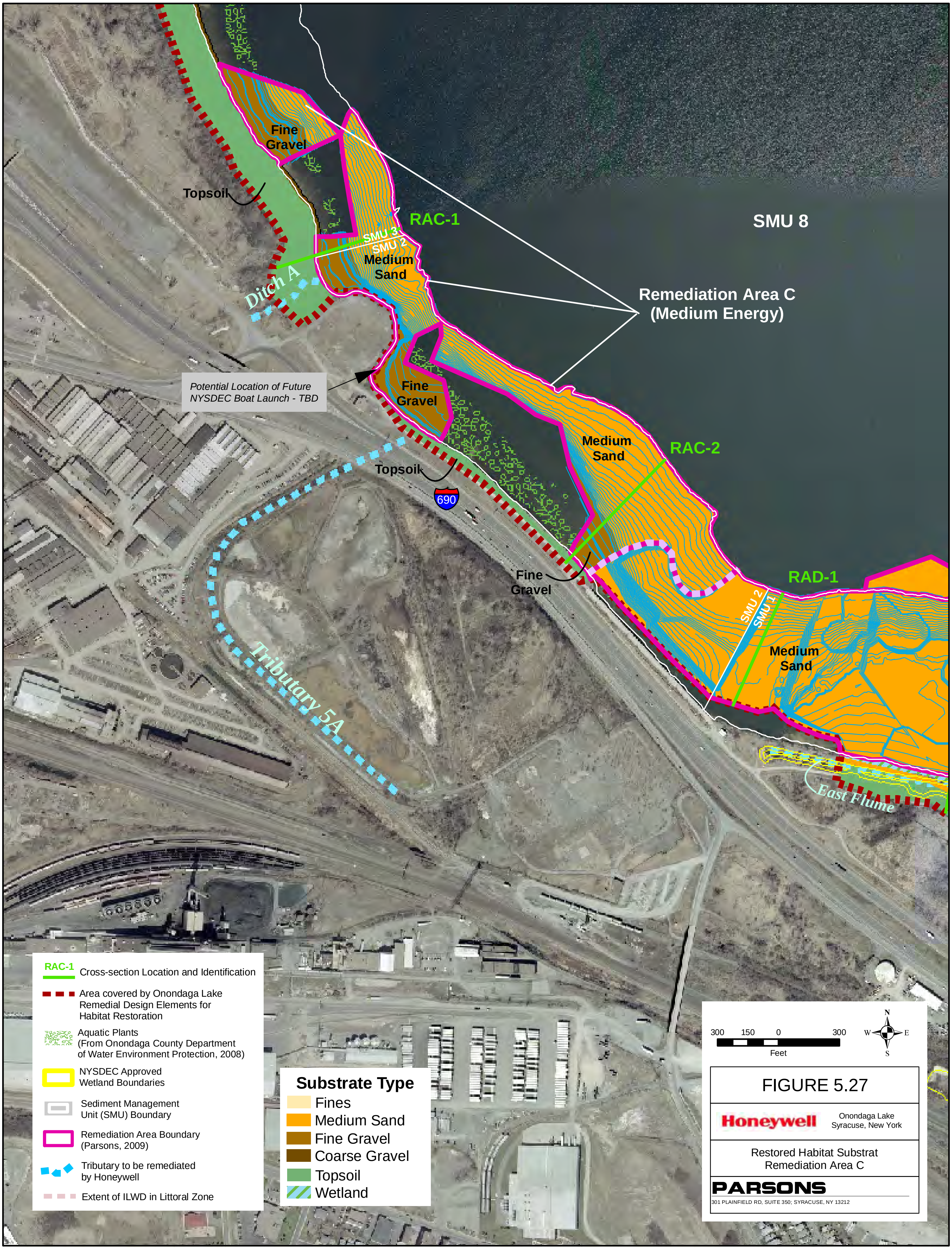
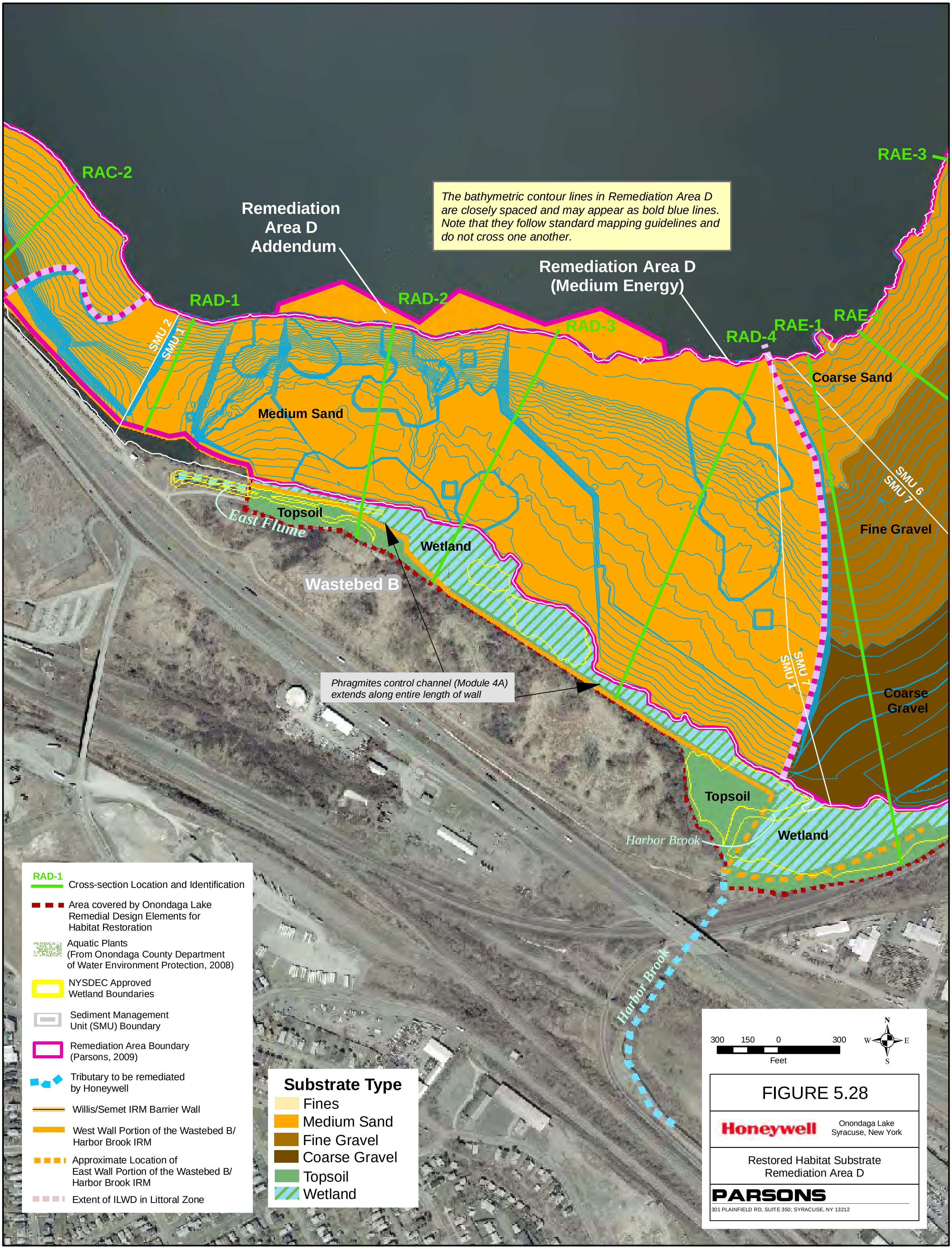


FIGURE 5.27

Honeywell Onondaga Lake Syracuse, New York

Restored Habitat Substrat Remediation Area C

PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212



The bathymetric contour lines in Remediation Area D are closely spaced and may appear as bold blue lines. Note that they follow standard mapping guidelines and do not cross one another.
RAC-2
Remediation Area D Addendum
Remediation Area D (Medium Energy)
RAD-1
RAD-2
RAD-3
RAD-4
RAE-1
RAE-2
RAE-3
SMU 2
SMU 1
SMU 6
SMU 7
SMU 7
SMU 1
Medium Sand
Coarse Sand
Fine Gravel
Coarse Gravel
Topsoil
East Flume
Wetland
Wastebed B
Phragmites control channel (Module 4A) extends along entire length of wall
Topsoil
Wetland
Harbor Brook
Harbor Brook
RAD-1 Cross-section Location and Identification
Area covered by Onondaga Lake Remedial Design Elements for Habitat Restoration
Aquatic Plants (From Onondaga County Department of Water Environment Protection, 2008)
NYSDEC Approved Wetland Boundaries
Sediment Management Unit (SMU) Boundary
Remediation Area Boundary (Parsons, 2009)
Tributary to be remediated by Honeywell
Willis/Semet IRM Barrier Wall
West Wall Portion of the Wastebed B/ Harbor Brook IRM
Approximate Location of East Wall Portion of the Wastebed B/ Harbor Brook IRM
Extent of ILWD in Littoral Zone
Substrate Type
Fines
Medium Sand
Fine Gravel
Coarse Gravel
Topsoil
Wetland
300 150 0 300
Feet
N
W
E
S
FIGURE 5.28
Honeywell
Onondaga Lake
Syracuse, New York
Restored Habitat Substrate
Remediation Area D
PARSONS
301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

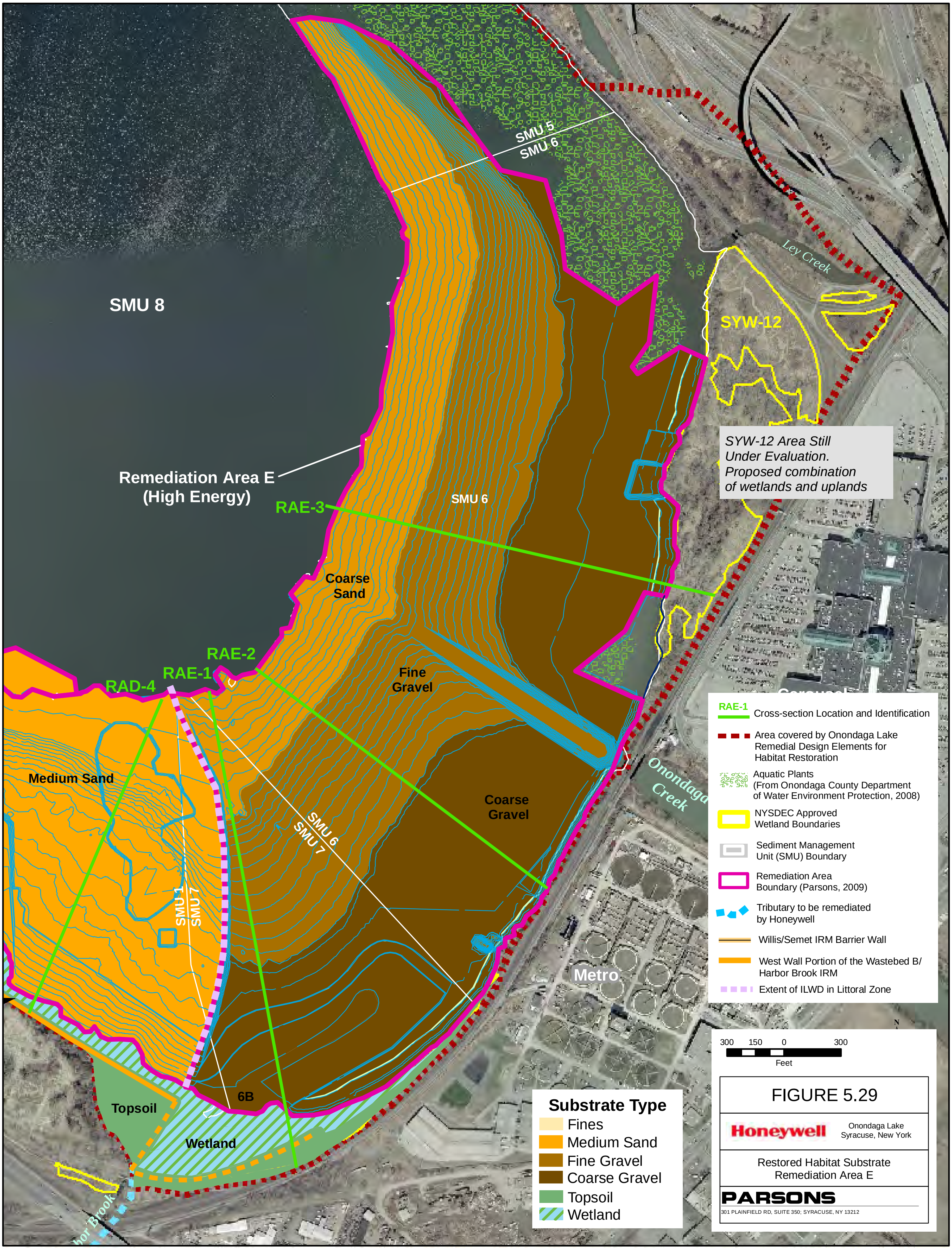


FIGURE 5.29

Honeywell

Onondaga Lake
Syracuse, New York

Restored Habitat Substrate
Remediation Area E

PARSONS

301 PLAINFIELD RD, SUITE 350; SYRACUSE, NY 13212

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Appendix A

Amphibians and Reptiles Recorded in the Vicinity of Onondaga Lake, Onondaga County, New York

APPENDIX A

AMPHIBIANS AND REPTILES RECORDED IN THE VICINITY OF ONONDAGA LAKE, ONONDAGA COUNTY, NEW YORK

SALAMANDERS			
Standard English Name[a]	**Scientific Name**	**ATLAS[b]**	**STATUS[c]**
Common Mudpuppy	*Necturus maculosus*	ADJ	
Jefferson Salamander	*Ambystoma jeffersonianum*	ADJ	SPEC
Blue-spotted Salamander	*Ambystoma laterale*	ADJ	SPEC
Spotted Salamander	*Ambystoma maculatum*	IN	
Red-spotted Newt	*Notophthalmus v. viridescens*	IN	
Northern Dusky Salamander	*Desmognathus fuscus*	IN	
Allegheny Mountain Dusky Salamander	*Desmognathus ochrophaeus*	IN	
Northern Red-backed Salamander	*Plethodon cinereus*	IN	
Northern Slimy Salamander	*Plethodon glutinosus*	IN	
Four-toed Salamander	*Hemidactylium scutatum*	ADJ	
Northern Spring Salamander	*Gyrinophilus p. porphyriticus*	ADJ	
Northern Two-lined Salamander	*Eurycea bislineata*	IN	

TOADS AND FROGS			
Standard English Name[a]	**Scientific Name**	**ATLAS[b]**	**STATUS[c]**
Eastern American Toad	*Bufo a. americanus*	IN	
Gray Treefrog	*Hyla versicolor*	IN	
Northern Spring Peeper	*Pseudacris c. crucifer*	IN	
American Bullfrog	*Rana catesbeiana*	IN	
Northern Green Frog	*Rana clamitans melanota*	IN	
Wood Frog	*Rana sylvatica*	IN	
Northern Leopard Frog	*Rana pipiens*	IN	
Pickerel Frog	*Rana palustris*	ADJ	

[a] Common and scientific names according to Crother (2000), and updates through 2003.
Crother, B. I. (2000) Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. *Soc. Stud. Amph. Rept*: St. Louis. Circular 29.
[b] NY Herpetological Atlas records (1990-1999). IN = Recorded in Camillus or Syracuse West Quadrangles, ADJ = Recorded in one or more of 10 adjacent quadrangles. (http://www.dec.ny.gov/animals/7140.html accessed 11-01-09)
[c] NY State Listed: END = Endangered, THR = Threatened, SPEC = Special Concern.
(d) The status column is left blank if a species is not listed.

TURTLES			
Standard English Name[(a)]	**Scientific Name**	**ATLAS[(b)]**	**STATUS[(c)]**
Eastern Snapping Turtle	*Chelydra s. serpentina*	IN	
Stinkpot	*Sternotherus odoratus*	IN	
Spotted Turtle	*Clemmys guttata*	ADJ	SPEC
Wood Turtle	*Glyptemys insculpta*	IN	SPEC
Redbellied Cooter	*Pseudemys rubiventris*	IN	
Eastern Painted Turtle	*Chrysemys p. picta*	ADJ	
Midland Painted Turtle	*Chrysemys picta marginata*	IN	

SNAKES			
Standard English Name[(a)]	**Scientific Name**	**ATLAS[(b)]**	**STATUS[(c)]**
Northern Watersnake	*Nerodia s. sipedon*	IN	
Northern Brownsnake	*Storeria d. dekayi*	IN	
Northern Red-bellied Snake	*Storeria o. occipitomaculata*	IN	
Common Gartersnake	*Thamnophis sirtalis*	IN	
Eastern Hog-nosed Snake	*Heterodon platirhinos*	ADJ	SPEC
Northern Ring-necked Snake	*Diadophis punctatus edwardsii*	IN	
Smooth Greensnake	*Opheodrys vernalis*	ADJ	
Eastern Ratsnake	*Elaphe spiloides*	IN	
Eastern Milksnake	*Lampropeltis t. triangulum*	IN	
Eastern Massasauga	*Sistrurus c. catenatus*	ADJ	END

Appendix B

New York State Breeding Birds Atlas Results

Map

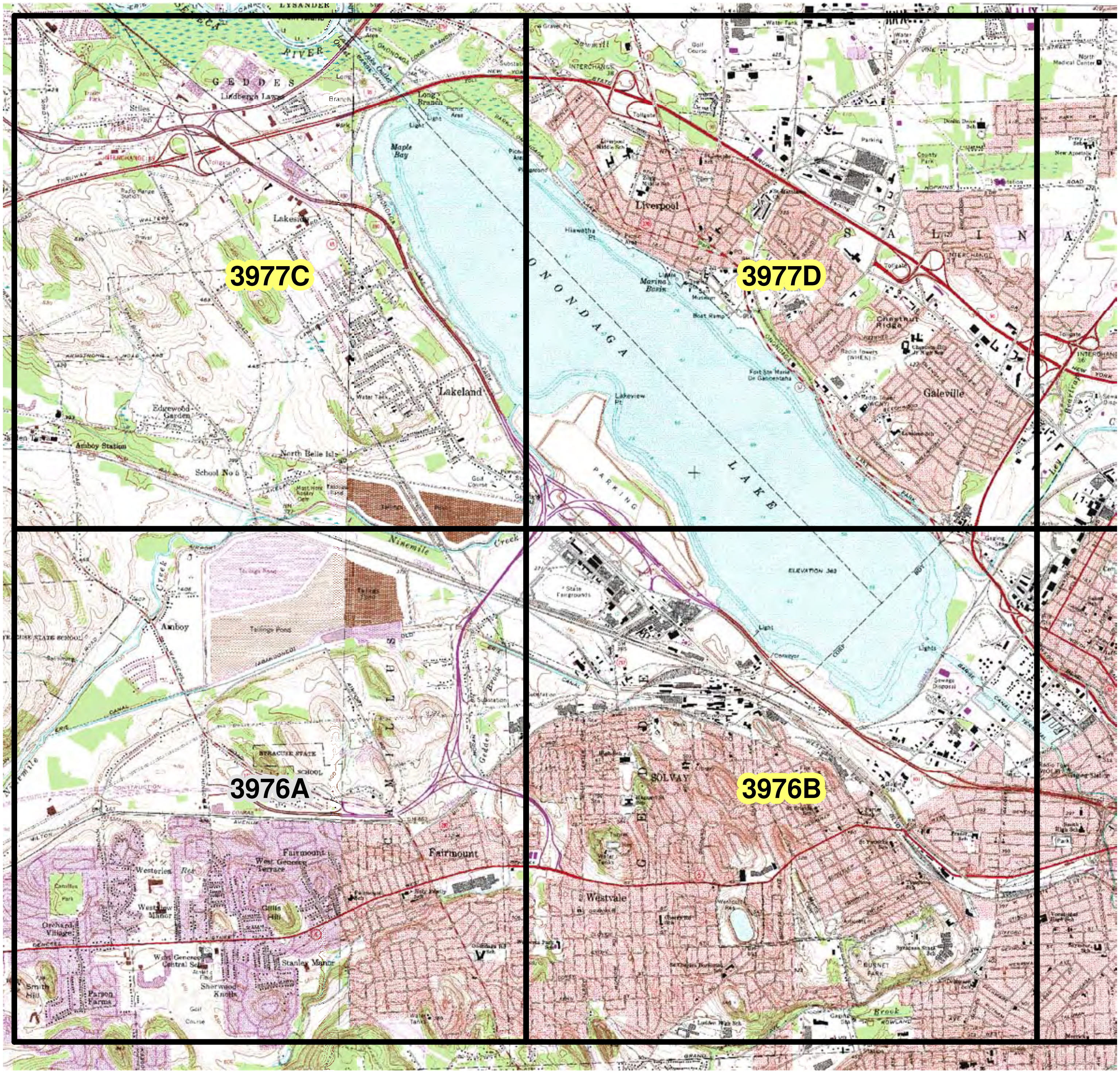
List of Species Breeding in Atlas Block 3977C

List of Species Breeding in Atlas Block 39770

List of Species Breeding in Atlas Block 3976B

FIGURE 1

N



This document was developed in color. Reproduction in B/W may not represent the data as intended.

LEGEND

ATLAS BLOCK

NOTES:
1. BLOCKS HIGHLIGHTED IN YELLOW HAVE DATA REFERENCED IN THIS REPORT.
2. ATLAS BLOCKS APPROXIMATED FROM "NEW YORK STATE BREEDING BIRD ATLAS 2000 [INTERNET]."

HONEYWELL
ONONDAGA LAKE
SYRACUSE, NEW YORK

NEW YORK STATE BREEDING BIRD ATLAS

2000-2005

0 2,250 4,500
Feet

MAY 2009
1163.43776

O'BRIEN & GERE

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NAME: ReidLS
DATE: 5/6/2009 10:25:36 AM

NEW YORK STATE
DEPARTMENT OF
ENVIRONMENTAL CONSERVATION

NYS Breeding Bird Atlas

ATLAS 2000

Block 3977C

2000-2005

Navigation Tools

Perform Another Search
Show All Records
Sort by Field Card Order
Sort by Taxonomic Order
View 1985 Data

Block 3977C Summary

Total Species:	65
Possible:	13
Probable:	22
Confirmed:	30

Click on column heading to sort by that category.

List of Species Breeding in Atlas Block 3977C

Common Name	Scientific Name	Behavior Code	Date	NY Legal Status
Great Blue Heron	*Ardea herodias*	X1	6/23/2000	Protected
Green Heron	*Butorides virescens*	P2	6/17/2001	Protected
Turkey Vulture	*Cathartes aura*	X1	6/23/2000	Protected
Canada Goose	*Branta canadensis*	FL	7/10/2000	Game Species
Mallard	*Anas platyrhynchos*	FL	7/1/2004	Game Species
Cooper's Hawk	*Accipiter cooperii*	FY	7/1/2001	Protected-Special Concern
Red-tailed Hawk	*Buteo jamaicensis*	DD	6/17/2001	Protected
American Kestrel	*Falco sparverius*	X1	7/8/2000	Protected
Wild Turkey	*Meleagris gallopavo*	FL	6/7/2001	Game Species
Killdeer	*Charadrius vociferus*	DD	5/28/2000	Protected
Spotted Sandpiper	*Actitis macularia*	X1	6/23/2000	Protected
Rock Pigeon	*Columba livia*	FL	7/11/2004	Unprotected
Mourning Dove	*Zenaida macroura*	FL	7/11/2004	Protected
Black-billed Cuckoo	*Coccyzus erythropthalmus*	P2	5/28/2000	Protected
Ruby-throated Hummingbird	*Archilochus colubris*	X1	6/24/2000	Protected
Belted Kingfisher	*Ceryle alcyon*	ON	7/10/2000	Protected
Red-bellied Woodpecker	*Melanerpes carolinus*	FY	6/18/2000	Protected
Downy Woodpecker	*Picoides pubescens*	FY	6/18/2000	Protected
Hairy Woodpecker	*Picoides villosus*	FY	5/28/2000	Protected
Northern Flicker	*Colaptes auratus*	T2	6/12/2000	Protected
Pileated Woodpecker	*Dryocopus pileatus*	X1	5/28/2000	Protected
Eastern Wood-Pewee	*Contopus virens*	X1	6/18/2000	Protected
Alder Flycatcher	*Empidonax alnorum*	X1	6/16/2001	Protected
Willow Flycatcher	*Empidonax traillii*	X1	5/28/2000	Protected
Eastern Phoebe	*Sayornis phoebe*	T2	5/28/2000	Protected
Great Crested Flycatcher	*Myiarchus crinitus*	D2	6/17/2001	Protected
Eastern Kingbird	*Tyrannus tyrannus*	T2	7/2/2001	Protected

Warbling Vireo	*Vireo gilvus*	FY	6/17/2001	Protected
Red-eyed Vireo	*Vireo olivaceus*	T2	5/28/2000	Protected
Blue Jay	*Cyanocitta cristata*	P2	6/17/2001	Protected
American Crow	*Corvus brachyrhynchos*	FY	5/28/2000	Game Species
Tree Swallow	*Tachycineta bicolor*	D2	6/12/2000	Protected
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	P2	7/13/2004	Protected
Bank Swallow	*Riparia riparia*	ON	7/8/2000	Protected
Barn Swallow	*Hirundo rustica*	NY	7/14/2001	Protected
Black-capped Chickadee	*Poecile atricapillus*	FY	5/28/2000	Protected
Red-breasted Nuthatch	*Sitta canadensis*	S2	6/18/2000	Protected
White-breasted Nuthatch	*Sitta carolinensis*	S2	6/18/2000	Protected
Eastern Bluebird	*Sialia sialis*	P2	6/9/2001	Protected
Wood Thrush	*Hylocichla mustelina*	S2	7/1/2001	Protected
American Robin	*Turdus migratorius*	FY	5/28/2000	Protected
Gray Catbird	*Dumetella carolinensis*	FL	7/10/2004	Protected
Northern Mockingbird	*Mimus polyglottos*	FY	7/8/2000	Protected
Brown Thrasher	*Toxostoma rufum*	X1	6/16/2001	Protected
European Starling	*Sturnus vulgaris*	FL	6/16/2001	Unprotected
Cedar Waxwing	*Bombycilla cedrorum*	P2	5/28/2000	Protected
Yellow Warbler	*Dendroica petechia*	FL	7/14/2001	Protected
American Redstart	*Setophaga ruticilla*	FL	7/14/2001	Protected
Mourning Warbler	*Oporornis philadelphia*	X1	6/18/2000	Protected
Common Yellowthroat	*Geothlypis trichas*	T2	5/28/2000	Protected
Scarlet Tanager	*Piranga olivacea*	T2	5/28/2000	Protected
Eastern Towhee	*Pipilo erythrophthalmus*	S2	7/1/2001	Protected
Chipping Sparrow	*Spizella passerina*	FY	5/28/2000	Protected
Savannah Sparrow	*Passerculus sandwichensis*	S2	7/1/2001	Protected
Song Sparrow	*Melospiza melodia*	DD	6/16/2001	Protected
Northern Cardinal	*Cardinalis cardinalis*	P2	5/28/2000	Protected
Bobolink	*Dolichonyx oryzivorus*	T2	6/16/2001	Protected

Red-winged Blackbird	*Agelaius phoeniceus*	FY	5/28/2000	Protected
Eastern Meadowlark	*Sturnella magna*	FY	6/16/2001	Protected
Common Grackle	*Quiscalus quiscula*	FY	6/10/2000	Protected
Brown-headed Cowbird	*Molothrus ater*	FY	6/29/2002	Protected
Baltimore Oriole	*Icterus galbula*	X1	5/28/2000	Protected
House Finch	*Carpodacus mexicanus*	X1	6/18/2000	Protected
American Goldfinch	*Carduelis tristis*	B2	7/14/2001	Protected
House Sparrow	*Passer domesticus*	NY	7/8/2000	Unprotected

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Block 3977D Summary

Total Species:	61
Possible:	14
Probable:	18
Confirmed:	29

Click on column heading to sort by that category.

List of Species Breeding in Atlas Block 3977D

Common Name	Scientific Name	Behavior Code	Date	NY Legal Status
Great Blue Heron	*Ardea herodias*	S2	6/22/2002	Protected
Green Heron	*Butorides virescens*	FL	8/4/2003	Protected
Turkey Vulture	*Cathartes aura*	X1	7/10/2002	Protected
Canada Goose	*Branta canadensis*	FL	4/29/2002	Game Species
Wood Duck	*Aix sponsa*	X1	5/25/2002	Game Species
Mallard	*Anas platyrhynchos*	NE	5/20/2000	Game Species
Osprey	*Pandion haliaetus*	X1	7/23/2003	Protected-Special Concern
Red-tailed Hawk	*Buteo jamaicensis*	FL	6/5/2000	Protected
American Kestrel	*Falco sparverius*	FY	6/5/2000	Protected
Killdeer	*Charadrius vociferus*	FL	7/10/2002	Protected
Spotted Sandpiper	*Actitis macularia*	FL	7/10/2002	Protected
Rock Pigeon	*Columba livia*	N2	6/16/2002	Unprotected
Mourning Dove	*Zenaida macroura*	FL	7/10/2002	Protected
Chimney Swift	*Chaetura pelagica*	P2	6/22/2002	Protected
Ruby-throated Hummingbird	*Archilochus colubris*	X1	8/1/2004	Protected
Belted Kingfisher	*Ceryle alcyon*	X1	6/5/2000	Protected
Red-bellied Woodpecker	*Melanerpes carolinus*	X1	5/25/2002	Protected
Downy Woodpecker	*Picoides pubescens*	FL	5/25/2002	Protected
Northern Flicker	*Colaptes auratus*	FL	8/1/2004	Protected
Willow Flycatcher	*Empidonax traillii*	X1	5/25/2002	Protected
Eastern Phoebe	*Sayornis phoebe*	S2	6/16/2002	Protected
Great Crested Flycatcher	*Myiarchus crinitus*	S2	6/16/2002	Protected
Eastern Kingbird	*Tyrannus tyrannus*	FL	8/1/2004	Protected
Warbling Vireo	*Vireo gilvus*	T2	5/25/2002	Protected
Red-eyed Vireo	*Vireo olivaceus*	P2	5/25/2002	Protected
Blue Jay	*Cyanocitta cristata*	FY	8/1/2004	Protected
American Crow	*Corvus brachyrhynchos*	FY	6/16/2002	Game Species

Fish Crow	*Corvus ossifragus*	FY	8/4/2003	Protected
Tree Swallow	*Tachycineta bicolor*	S2	6/16/2002	Protected
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	ON	6/18/2002	Protected
Bank Swallow	*Riparia riparia*	UN	7/20/2000	Protected
Barn Swallow	*Hirundo rustica*	NY	6/22/2002	Protected
Black-capped Chickadee	*Poecile atricapillus*	FY	6/16/2002	Protected
Tufted Titmouse	*Baeolophus bicolor*	X1	5/25/2002	Protected
White-breasted Nuthatch	*Sitta carolinensis*	S2	6/22/2002	Protected
Carolina Wren	*Thryothorus ludovicianus*	S2	6/22/2002	Protected
House Wren	*Troglodytes aedon*	FY	7/10/2002	Protected
Wood Thrush	*Hylocichla mustelina*	S2	6/22/2002	Protected
American Robin	*Turdus migratorius*	FY	6/5/2000	Protected
Gray Catbird	*Dumetella carolinensis*	FL	8/1/2004	Protected
Northern Mockingbird	*Mimus polyglottos*	T2	7/10/2002	Protected
European Starling	*Sturnus vulgaris*	NY	5/25/2002	Unprotected
Cedar Waxwing	*Bombycilla cedrorum*	D2	5/25/2002	Protected
Blue-winged Warbler	*Vermivora pinus*	X1	6/22/2002	Protected
Yellow Warbler	*Dendroica petechia*	X1	7/28/2004	Protected
Chestnut-sided Warbler	*Dendroica pensylvanica*	X1	5/25/2002	Protected
Yellow-rumped Warbler	*Dendroica coronata*	X1	5/25/2002	Protected
Common Yellowthroat	*Geothlypis trichas*	S2	6/16/2002	Protected
Scarlet Tanager	*Piranga olivacea*	P2	5/25/2002	Protected
Chipping Sparrow	*Spizella passerina*	FL	8/1/2004	Protected
Field Sparrow	*Spizella pusilla*	X1	8/1/2004	Protected
Song Sparrow	*Melospiza melodia*	FY	6/16/2002	Protected
Northern Cardinal	*Cardinalis cardinalis*	FY	8/1/2004	Protected
Red-winged Blackbird	*Agelaius phoeniceus*	FY	6/16/2002	Protected
Eastern Meadowlark	*Sturnella magna*	X1	7/10/2002	Protected
Common Grackle	*Quiscalus quiscula*	FY	6/5/2000	Protected
Brown-headed Cowbird	*Molothrus ater*	FY	6/16/2002	Protected

Baltimore Oriole	*Icterus galbula*	B2	5/25/2002	Protected
House Finch	*Carpodacus mexicanus*	P2	8/1/2004	Protected
American Goldfinch	*Carduelis tristis*	P2	7/10/2002	Protected
House Sparrow	*Passer domesticus*	NY	5/25/2002	Unprotected

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Block 3976B Summary

Total Species:	68
Possible:	9
Probable:	20
Confirmed:	39

Click on column heading to sort by that category.

List of Species Breeding in Atlas Block 3976B

Common Name	Scientific Name	Behavior Code	Date	NY Legal Status
Great Blue Heron	*Ardea herodias*	X1	7/13/2002	Protected
Green Heron	*Butorides virescens*	P2	7/13/2002	Protected
Turkey Vulture	*Cathartes aura*	P2	6/25/2004	Protected
Canada Goose	*Branta canadensis*	FY	7/11/2004	Game Species
Wood Duck	*Aix sponsa*	X1	5/28/2004	Game Species
Mallard	*Anas platyrhynchos*	FL	7/13/2002	Game Species
Red-tailed Hawk	*Buteo jamaicensis*	FL	6/12/2004	Protected
American Kestrel	*Falco sparverius*	FY	7/12/2002	Protected
Ring-necked Pheasant	*Phasianus colchicus*	S2	7/13/2002	Game Species
Wild Turkey	*Meleagris gallopavo*	FL	7/20/2004	Game Species
Sora	*Porzana carolina*	X1	6/19/2004	Game Species
Killdeer	*Charadrius vociferus*	FY	7/11/2004	Protected
Spotted Sandpiper	*Actitis macularia*	P2	5/21/2004	Protected
Rock Pigeon	*Columba livia*	NE	5/19/2004	Unprotected
Mourning Dove	*Zenaida macroura*	FY	6/28/2004	Protected
Chimney Swift	*Chaetura pelagica*	P2	7/13/2002	Protected
Ruby-throated Hummingbird	*Archilochus colubris*	X1	6/25/2004	Protected
Belted Kingfisher	*Ceryle alcyon*	FY	6/25/2004	Protected
Red-bellied Woodpecker	*Melanerpes carolinus*	S2	6//2002	Protected
Downy Woodpecker	*Picoides pubescens*	ON	5/21/2004	Protected
Hairy Woodpecker	*Picoides villosus*	FL	6/19/2004	Protected
Northern Flicker	*Colaptes auratus*	ON	5/21/2004	Protected
Pileated Woodpecker	*Dryocopus pileatus*	FY	7/9/2004	Protected
Eastern Wood-Pewee	*Contopus virens*	S2	6//2002	Protected
Willow Flycatcher	*Empidonax traillii*	FL	7/20/2004	Protected
Least Flycatcher	*Empidonax minimus*	S2	6/12/2004	Protected
Eastern Phoebe	*Sayornis phoebe*	X1	5/19/2004	Protected
Great Crested Flycatcher	*Myiarchus crinitus*	FY	6//2002	Protected
Eastern Kingbird	*Tyrannus tyrannus*	NE	6/19/2004	Protected
Yellow-throated Vireo	*Vireo flavifrons*	X1	6/19/2004	Protected

Warbling Vireo	*Vireo gilvus*	S2	5/28/2004	Protected
Red-eyed Vireo	*Vireo olivaceus*	P2	5/19/2004	Protected
Blue Jay	*Cyanocitta cristata*	T2	7/13/2002	Protected
American Crow	*Corvus brachyrhynchos*	FY	6//2002	Game Species
Tree Swallow	*Tachycineta bicolor*	FY	7/13/2002	Protected
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	ON	6/5/2004	Protected
Barn Swallow	*Hirundo rustica*	NE	7/13/2002	Protected
Black-capped Chickadee	*Poecile atricapillus*	FY	6//2002	Protected
Tufted Titmouse	*Baeolophus bicolor*	S2	7/13/2002	Protected
White-breasted Nuthatch	*Sitta carolinensis*	P2	7/13/2002	Protected
House Wren	*Troglodytes aedon*	FY	6//2002	Protected
Wood Thrush	*Hylocichla mustelina*	S2	6/5/2004	Protected
American Robin	*Turdus migratorius*	FY	6/4/2002	Protected
Gray Catbird	*Dumetella carolinensis*	ON	6/28/2004	Protected
Northern Mockingbird	*Mimus polyglottos*	FL	6/19/2004	Protected
European Starling	*Sturnus vulgaris*	FY	6/4/2002	Unprotected
Cedar Waxwing	*Bombycilla cedrorum*	NE	6/21/2004	Protected
Blue-winged Warbler	*Vermivora pinus*	S2	6/5/2004	Protected
Yellow Warbler	*Dendroica petechia*	FY	7/13/2002	Protected
American Redstart	*Setophaga ruticilla*	S2	6/5/2004	Protected
Common Yellowthroat	*Geothlypis trichas*	FY	7/13/2002	Protected
Scarlet Tanager	*Piranga olivacea*	X1	6/11/2004	Protected
Eastern Towhee	*Pipilo erythrophthalmus*	X1	5/19/2004	Protected
Chipping Sparrow	*Spizella passerina*	FY	6/11/2004	Protected
Field Sparrow	*Spizella pusilla*	S2	6/19/2004	Protected
Song Sparrow	*Melospiza melodia*	DD	7/13/2002	Protected
Swamp Sparrow	*Melospiza georgiana*	S2	5/28/2004	Protected
Northern Cardinal	*Cardinalis cardinalis*	FY	6//2002	Protected
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	T2	7/13/2002	Protected
Indigo Bunting	*Passerina cyanea*	P2	6/11/2004	Protected
Red-winged Blackbird	*Agelaius phoeniceus*	FY	6/4/2002	Protected
Common Grackle	*Quiscalus quiscula*	FY	7/6/2002	Protected

Brown-headed Cowbird	*Molothrus ater*	FL	6/11/2004	Protected
Orchard Oriole	*Icterus spurius*	X1	5/19/2004	Protected
Baltimore Oriole	*Icterus galbula*	NY	6/12/2004	Protected
House Finch	*Carpodacus mexicanus*	FY	7/3/2004	Protected
American Goldfinch	*Carduelis tristis*	FL	8/25/2004	Protected
House Sparrow	*Passer domesticus*	FY	6/4/2002	Unprotected

Appendix C

Macrophyte Coverage Figures from the Habitat Preliminary Design Investigation Report

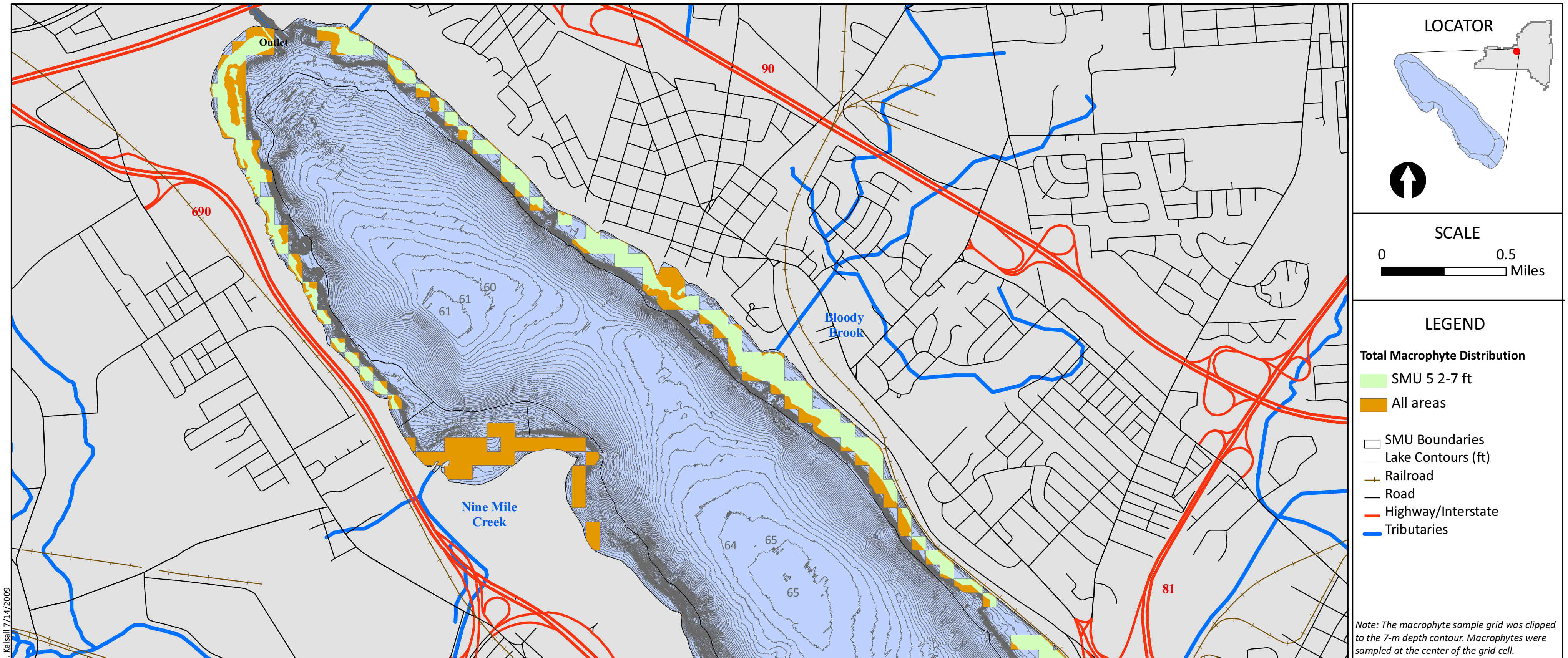
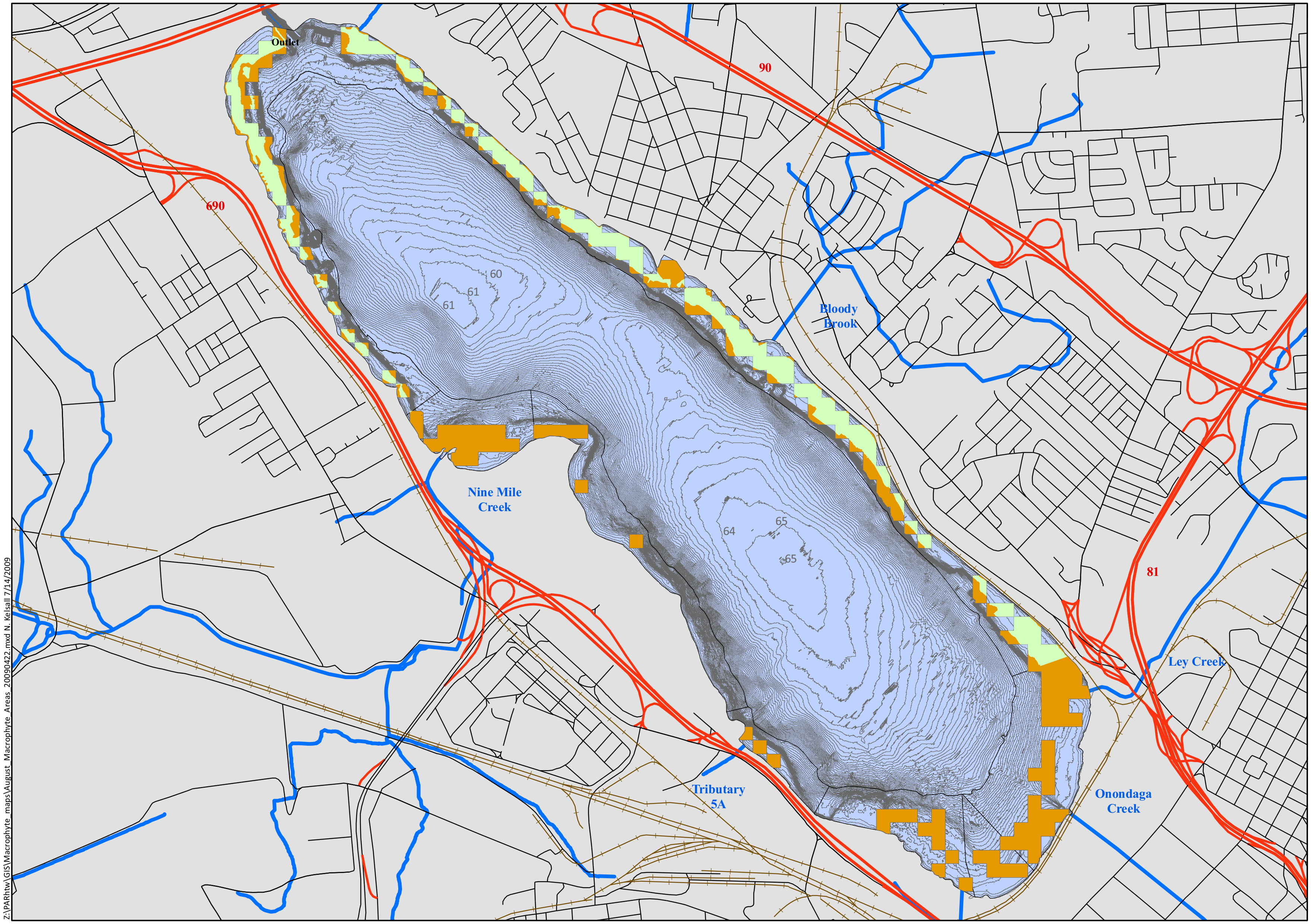


Figure 16.
Macrophyte distribution in Onondaga Lake: July 2008.
Honeywell Inc./PARhtw:141
July 14, 2009

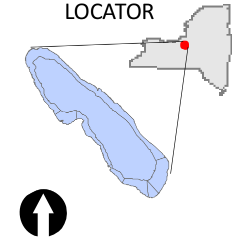
Honeywell
PARSONS
ANCHOR QEA

PARhtw:141 July 2009



Z:\PARhtw\GIS\Macrophyte_maps\August_Macrophyte_Areas_20090422.mxd N. Kelsall 7/14/2009

LOCATOR



SCALE

0 0.5 Miles

LEGEND

Total Macrophyte Distribution

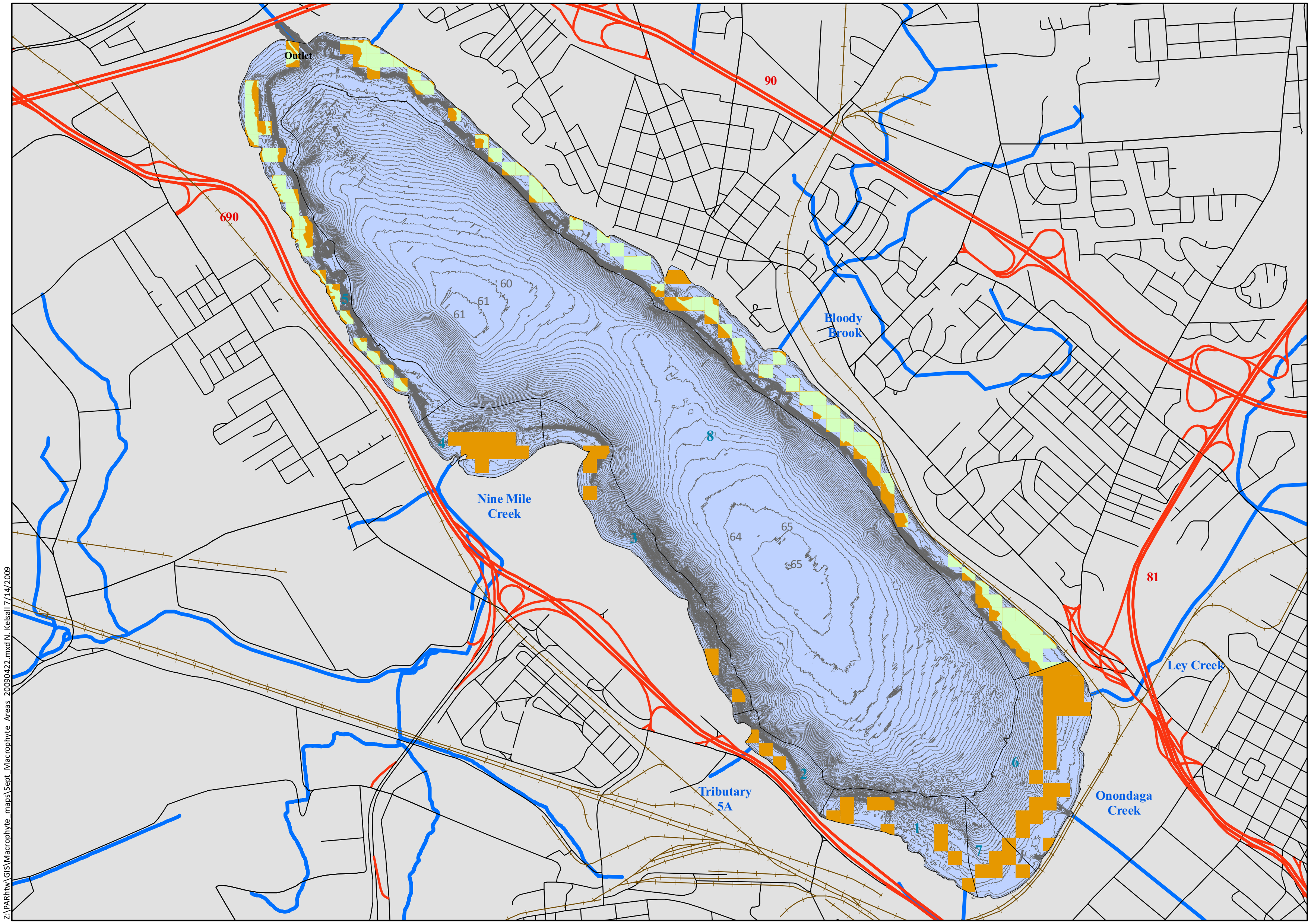
- SMU 5 2-7 ft
- All areas
- SMU Boundaries
- Lake Contours (ft)
- Railroad
- Road
- Highway/Interstate
- Tributaries

Note: The macrophyte sample grid was clipped to the 7-m depth contour. Macrophytes were sampled at the center of the grid cell.

Figure 17.
Macrophyte distribution in Onondaga Lake: August 2008.
Honeywell Inc./PARhtw:141
July 14, 2009

Honeywell
PARSONS
ANCHOR QEA

PARhtw:141 July 2009



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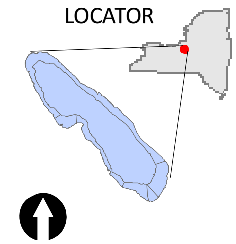


SCALE

0 0.5 Miles

LEGEND

Total Macrophyte Distribution

- SMU 5 2-7 ft
- All areas
- SMU Boundaries
- Lake Contours (ft)
- Railroad
- Road
- Highway/Interstate
- Tributaries

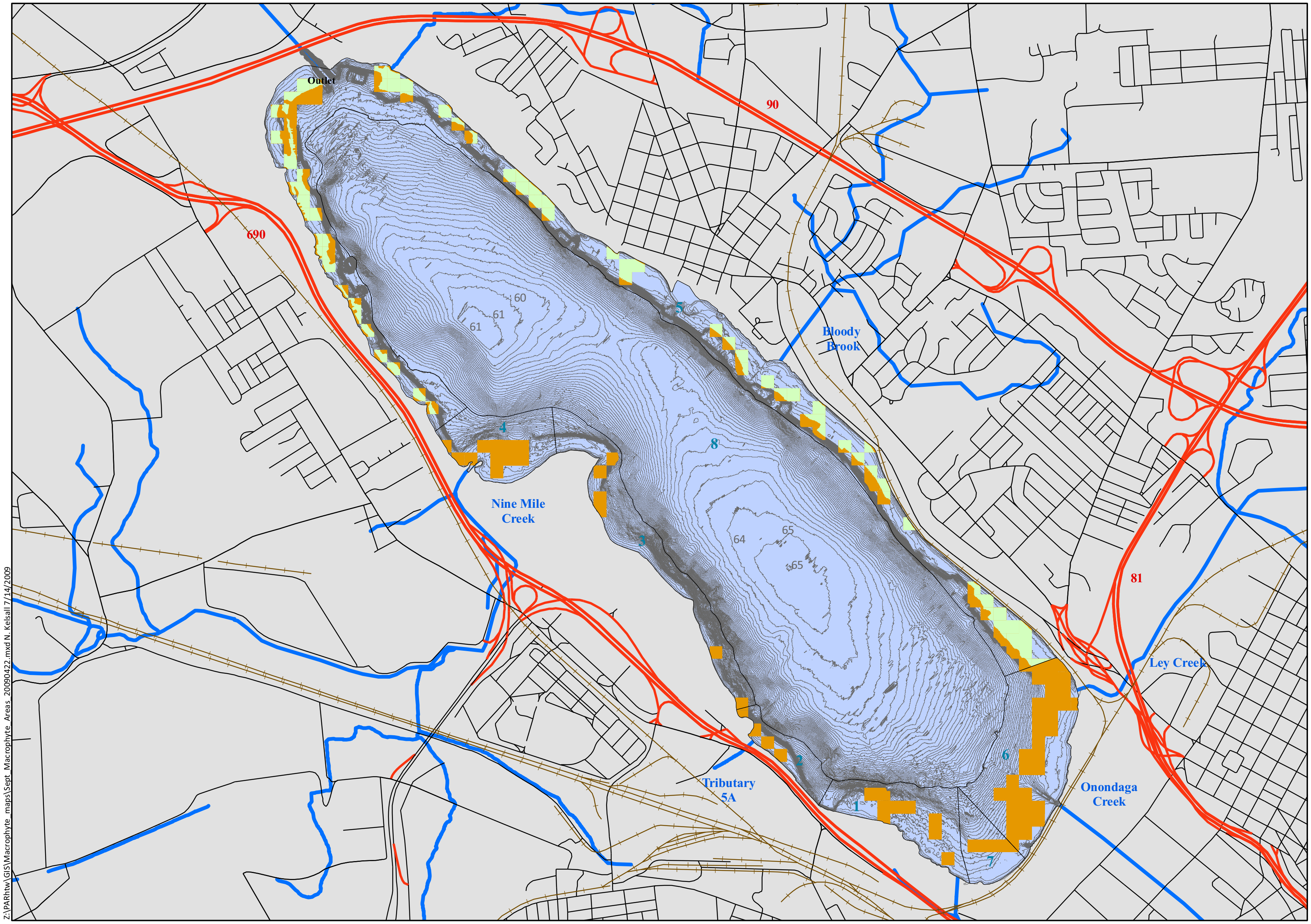
Note: The macrophyte sample grid was clipped to the 7-m depth contour. Macrophytes were sampled at the center of the grid cell.

Figure 18.
Macrophyte distribution in Onondaga Lake: September 2008
Honeywell Inc./PARhtw:141
July 14, 2009

Honeywell PARSONS

ANCHOR QEA

Z:\PARhtw\GIS\Macrophyte_maps\Sept_Macrophyte_Areas_20090422.mxd N. Kelsall 7/14/2009



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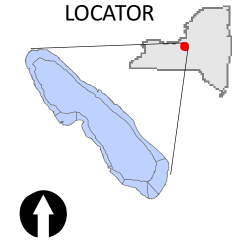

SCALE

0 0.5 Miles

LEGEND

Total Macrophyte Distribution

- SMU 5 2-7 ft
- All areas
- SMU Boundaries
- Lake Contours (ft)
- Railroad
- Road
- Highway/Interstate
- Tributaries

Note: The macrophyte sample grid was clipped to the 7-m depth contour. Macrophytes were sampled at the center of the grid cell.

Figure 19.
Macrophyte distribution in Onondaga Lake for October 2008
Honeywell Inc./PARhtw:141
July 14, 2009

Honeywell
PARSONS
ANCHOR QEA

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Appendix D

Suitability of Restoration in Remediation Areas for Representative Species

Suitability of Restoration in Area A for Representative Species

The technical work group evaluated the suitability of the habitat modules proposed in Remediation Area A for the representative species within each major species group to provide insight into how these species may use each area following the proposed restoration.

Remediation Area A - Habitat Modules:

- 1
- 2A
- 3A
- 4A
- 5A
- 6A
- 9B

Fish - In Remediation Area A, the lower energy and variety of submerged, emergent, and floating vegetation proposed for this area will provide suitable habitat for different life stages of all of the representative fish species. Habitat Modules 4A, 5A, and 6A will provide suitable habitat for northern pike spawning and rearing, largemouth bass adults and juveniles, pumpkinseed adults and juveniles, and golden shiner. Remediation Area A is likely to be the most suitable area for golden shiners since they prefer weedy, quiet, shallow sections of lakes. The deeper modules (3A, 2A, and 1) will provide suitable habitat for walleye, smallmouth bass, lake sturgeon, emerald shiner, and brown trout. The addition of structure to Modules 3A and 2A will improve suitability for walleye and smallmouth bass.

Plants - The lower wave energy environment, shallow water depths, and fine substrates proposed for Remediation Area A will provide a wide variety of habitats for submerged aquatic vegetation, persistent and non-persistent emergent wetland species, and floating aquatic vegetation. This area provides the best opportunity for restoration of lower energy environments within the remediation areas of the lake.

The shallow water limits of Module 2A (approximately 7 to 9 ft) will provide habitat for submerged aquatic vegetation. A large area of Module 3A is proposed in Remediation Area A; this habitat includes representative submerged aquatic vegetation for species such as coontail, sago pondweed, tapegrass, and elodea (*Elodea canadensis*), as well as other pond weeds and submerged aquatics common in the lake. The sandy substrate proposed in this area will be suitable for each of these species. The shallower water depths in Modules 5A and 6A will provide habitat for non-persistent and persistent emergent wetland species, respectively. Representative non-persistent emergents that should be found in Module 5A are pickerel weed, arrow arum (*Peltandra virginica*), arrowhead (*Sagittaria latifolia*), water plantain (*Alisma* *subcordatum*), and water smartweed (*Polygonum amphibium*). The shallower water depth zone in the large area of Module 6A proposed off-shore in Remediation Area A will not only provide habitat for persistent emergent vegetation, but will also reduce wave energy for the areas of floating aquatic wetland vegetation (Module 4A) proposed in the adjacent near shore area. Representative plant species that may be found in the persistent emergent wetland area (Module 6A) include cattail (*Typha latifolia* and *T. angustifolia*), soft-stem bulrush (*Scirpus tabernaemontani*), river bulrush (*Scirpus fluviatilis*), burreed (*Sparganium eurycarpum*), willow-weed (*Justicia americana*), water-willow (*Decodon verticillatus*), and sedge.

Nearshore of Module 6A, areas of slightly deeper Module 4A (floating aquatic zone) are proposed. With the lower wave energy of Remediation Area A, protection afforded by the off-shore Module 6A area, and proposed fine substrates, this is the best location to provide habitat for floating aquatic species. This is a habitat currently lacking in the lake environment. The deeper water in Module 4A would also protect the proposed off shore Module 6A area from being invaded by *Phragmites*. A deeper water trench is also proposed along the shoreline to further limit *Phragmites* encroachment. Although some of the free-floating duckweeds (*Lemna minor, Lemna trisulca,* and *Spirodela polyrhiza*) may occur in the floating aquatic zone (Module 4A), the representative rooted floating aquatics targeted for this area are white water lily, yellow pond lily (*Nuphar lutea*), and American pondweed. Submerged aquatic species will likely occur in this zone as well.

The wetlands at the mouth of Ninemile Creek have been included within the boundary of the Habitat Plan due to their location directly adjacent to the lake shoreline and the mouth of the Ninemile Creek. Removal of *Phragmites* in the two spits adjoining the mouth of Ninemile Creek would be necessary to establish a productive area of emergent wetland (Module 6A). Forested wetlands (Module 9B) are proposed along the shore to increase the amount of existing forested wetland and to help reduce the threat of *Phragmites* extending into the Module 6A area. Silver maple American elm, and black willow, which are common in the existing forested wetland, are targeted for this area.

Benthic Macroinvertebrates - The lower energy habitats proposed for Remediation Area A will create diverse and suitable habitat for lentic species of all the representative invertebrate orders. Suitable habitat for most of these species will be located within the shallower habitat modules (3A, 4A, 5A, and 6A), although Module 2A may be suitable for some dragonfly, caddisfly, true fly (*Diptera*), and mayfly species. The addition of structure (plants, logs, etc.) to any of these modules will increase the habitat diversity and provide additional habitat for some species, especially crayfish. Habitat Module 1 will provide suitable habitat for amphipods and true flies.

Mammals- In Remediation Area A, the combination of habitat requirements for the representative species (*e.g.*, low energy areas, emergent vegetation, trees or other cover along the shoreline) makes for the best location within the lake for the creation of suitable habitat for the representative mammal species. Suitable habitat for beaver, mink, muskrat and otter will be created by application of habitat module 4A, 5A, and 6A. The addition of structures to any of these modules would improve the habitat suitability for mink. The proximity to Ninemile Creek further enhances the suitability of these areas for mink and otter which can use the tributary as a travel corridor. The deeper offshore modules will provide suitable habitat for otter (Modules 2A and 3A) as well as mink and beaver (Module 3A). The addition of structure to Module 3A will provide suitable habitat for muskrat.

Habitat Module 9B along the shoreline at the mouth of the creek could potentially provide habitat for Indiana bat.

Reptiles and Amphibians - The representative reptile species, musk turtle, painted turtle, snapping turtle, and northern water snake prefer lower energy environments with shallow water and access to cover or some type of structure. Shallow water modules (3A, 4A, 5A, 6A) in Remediation Area A will provide suitable habitat conditions for each of these representative species. Module 4A (floating aquatics) in Remediation Area A would provide areas of cover for escape and feeding for the painted turtle and northern water snake as well as nesting areas for musk turtle. Musk turtle also may find suitable nesting habitat in Modules 6A and 5A. Snapping turtle would benefit most from the natural transition from lake to emergent (Modules 5A and 6A) and upland wetland (Module 9B) areas within and adjacent to Remediation Area A. Habitat would be most suitable for egg deposition in these areas, and the species would be well concealed within the wetland vegetation. The three shallowest modules (4A, 5A, and 6A) also would provide suitable habitat for hibernation and feeding for the four representative reptile species.

The representative amphibian species (red spotted newt, mudpuppy, spotted salamander, green frog (*Rana clamitans melanota)*, leopard frog (*Rana pipiens-s. utricularius*), and wood frog (*Rana sylvatica*), generally prefer shallow water environments. Mudpuppy will also use deeper areas (Modules 2A and 3A), but will nest in water less than 3 ft deep. The shallow areas (Modules 4A, 5A, and 6A) will provide suitable habitat for all of the representative species, and provide a smooth transition from the lake to terrestrial areas. In addition, the calm waters and soft substrate of these modules (4A, 5A and 6A) would also provide suitable foraging and hibernating areas for red-spotted newt, green frog, leopard frog, and wood frog. Red-spotted newt and spotted salamander spend their adult stages terrestrially, and Module 9B in the adjacent area will provide cover and suitable habitat.

Birds - Remediation Area A will provide breeding and/or foraging areas for each of the representative bird species.

The deeper water areas (Modules 1 and 2A) of this area will provide suitable foraging and feeding habitat for mallard, common goldeneye, common tern (*Sterna hirundo*), osprey (*Pandion haliaetus*), and bank swallow. Species such as spotted sandpiper, semi-palmated sandpiper, mallard, great blue heron, green heron, red-winged blackbird, and bank swallow would benefit from the foraging opportunities provided by the soft substrate (Module 6A), while a natural transition to the forested wetland areas adjacent to Remediation Area A (Module 9B) provides perching structures for osprey, red-winged blackbird, and green heron. Wetlands (Modules 5A, 6A) in the near shore areas provide suitable nesting habitat for the common tern, mallard, common goldeneye, and red-winged blackbird. Species such as common goldeneye, mallard, kingfisher, great blue heron, and osprey would benefit from the mid-depth open water areas (Module 3A) for foraging.

Suitability of Restoration in Area B for Representative Species

Plant and animal species that will benefit from the habitat restoration proposed in Remediation Area B are discussed below. Additional benefits are provided by the proposed shoreline stabilization, which are also discussed below and in the following section.

Remediation Area B Habitat Modules:

- 1
- 2A
- 3A
- 5A

Fish - The design of the remedy in Remediation Area B limits the shallow water habitats available for representative fish species. The relatively steep slope to the deeper water habitats (Modules 2A and 1) may provide suitable habitat for adult walleye, emerald shiner, lake sturgeon, smallmouth bass, largemouth bass, and brown trout. Habitat Module 5A has been applied at two locations along the shoreline which will provide suitable habitat for golden shiner and juvenile pumpkinseed, largemouth bass, and northern pike. Module 3A will provide suitable habitat for golden shiner, pumpkinseed, largemouth bass, smallmouth bass, and northern pike adults and juveniles. Addition of structure will increase suitability of Module 3A for bass and pumpkinseed.

Plants - Limited remediation work is proposed in Remediation Area B in areas that would support vegetation. These targeted dredge areas, although slightly deeper after remediation, will provide better habitat for submerged aquatic vegetation (Module 3A) than what currently exists, because of the more suitable substrate. A narrow strip along the shore may provide habitat for non-persistent emergent wetland vegetation (Module 5A), although wave energy may limit its abundance. Common plant species targeted for these modules are detailed under the Remediation Area A plant discussion.

Stabilization efforts proposed along the shore of Remediation Area B (see below) will reduce the resuspension of Solvay waste material and would benefit many plant species. Shrub species, such as the willows (*Salix* spp.) and dogwood (*Cornus* spp.), will potentially be targeted for those shoreline stabilization areas. The rooting ability of these species and other herbaceous plants will greatly enhance this shoreline reach.

Benthic Macroinvertebrates - The narrow areas of Module 5A and 3A along the shoreline and shallow water areas will provide suitable habitat for each representative order due to the placement of more suitable substrate. The addition of structure to Module 5A would improve the habitat suitability for crayfish.

Mammals – Remediation Area B has a relatively steep littoral zone and only a narrow area where habitat modules can be applied that provide suitable habitat for the representative mammal species. Habitat Module 5A applied at two locations along the shoreline will provide suitable habitat for mink, otter, beaver, and muskrat. The addition of structure to this module will improve the habitat suitability for mink. The deeper off-shore modules will provide suitable habitat for otter (Modules 2A and 3A), mink, and beaver (Module 3A). The addition of structure to Module 3A will provide suitable habitat for muskrat.

Reptiles and Amphibians- The shallow water modules (3A and 5A) in Remediation Area B will provide suitable habitat conditions for the representative species. Modules 3A and 5A will provide suitable habitat for musk turtle due to the cover and vegetation for foraging. Musk turtle may also find suitable nesting habitat in Module 5A. Suitable habitat for snapping turtle can be found at the natural transition from lake (Module 3A) to emergent wetlands (Module 5A) and adjacent upland habitat on WB 1-8, which is currently undergoing a remedial investigation. The species would be well concealed within the wetland vegetation. The shallow 5A Module would also provide suitable habitat for hibernation and feeding for the four representative species.

The shoreline areas of the restored Remediation Area B contain non-persistent wetlands (Module 5A) that will provide habitat for snapping turtle and other species of reptiles. The substrate is suitable for egg laying and provides cover for concealment. The abundance of vegetation within such areas also provides a sufficient food base. Many reptilian species feed on both aquatic and terrestrial resources, and the connectivity of the different habitats within Remediation Area B allows for the development of multiple food bases. The shallow waters (Module 3A), for example, will support fish, a prey of northern water snake. The area where the shoreline stabilization is currently proposed will support more terrestrial food sources for the representative reptile species.

The open water areas (Modules 2A and 3A) of Remediation Area B would provide habitat for a completely aquatic species, such as mudpuppy. The shallow water areas with a fine sand substrate (Module 5A) will support non-persistent vegetation and the representative species of amphibians. The wetlands, although they cover a relatively small area, will provide vegetation to serve as cover for breeding and tadpole development for green frog. The shoreline stabilization area of Remediation Area B and areas where Module 5A will be applied will provide beneficial cover and foraging for such species within both terrestrial and wetland areas.

Birds - Suitable habitat conditions for representative bird species in Remediation Area A are provided by Module 5A (nearshore) and Modules 2A and 3A (off-shore). Specifically, the open water habitats created by Modules 2A and 3A provide deep, mid-depth, and shallow water areas suitable for diving birds, such as osprey, common tern, common goldeneye, and kingfisher. The vegetated shoreline areas transitioning from wetland (Module 5A) to submerged macrophytes (Module 3A) provide foraging habitat for great blue heron, green heron, and sandpipers. Module 3A also would provide suitable habitat for mallards to forage and provide access to adjacent terrestrial locations for nesting.

The soft substrate in nearshore areas of Remediation Area B associated with Module 5A will provide an invertebrate food base for species such as the spotted sandpiper and semi-palmated sandpiper. The common tern and belted kingfisher could find suitable nesting areas in the herbaceous plant cover in the adjacent shoreline stabilization area or adjacent portions of WB 1-8. The steep banks at the Remediation Areas A/B border will provide nesting habitat for bank swallows and belted kingfisher.

Suitability of Shoreline Stabilization in Area B for Representative Species

The shoreline stabilization will occur along the entire length of the SMU 3 shoreline. However, in areas where there is capping up to the shore, the in-lake portion of the stabilization will not be required since an erosion protection layer will be required for the cap design in those near-shore areas. The shoreline stabilization approach being used in Remediation Area B will largely equate to the application of Modules 5B and 6B. Due to the coarse substrate in these modules, no wetland vegetation would be expected. However, as previously mentioned, the purpose of the shoreline stabilization is to reduce resuspension and improve water quality conditions for submerged macrophytes (Module 3) that would be expected farther offshore. In addition, other representative species that would use this area are discussed below.

Fish – The shoreline stabilization areas will provide suitable habitat for smallmouth bass spawning and juvenile walleye (with the addition of structure).

Plants - As mentioned, due to the coarse substrate, vegetation is not anticipated in this area.

Benthic Macroinvertebrates - The coarse substrate will create suitable habitat for crayfish. There will be limited suitability for mayflies and caddisflies.

Mammals – The shoreline stabilization area could provide suitable habitat for mink and otter foraging. The coarse substrate and lack of vegetation will limit the suitability of this module for muskrat and beaver.

Reptiles and Amphibians- The shoreline stabilization areas would provide habitat for the snapping turtle, which is the reptilian species most tolerant of moderate energy expected in this area and may use some of the adjacent low lying areas.

Birds – Habitat for shorebirds, such as the spotted sandpiper and semi-palmated sandpiper, will be provided by the coarse substrates proposed in the stabilization areas, which will limit vegetation and allow for optimum foraging along the shoreline.

Suitability of Restoration in Area C for Representative Species

An evaluation was made of the suitability of the habitat modules proposed in Remediation Area C for the representative species within each major species group as described below.

Remediation Area C Habitat Modules:

- 1
- 2A
- 3B
- 5B
- 6B

Fish – Proposed habitat restoration in Remediation Area C maintains deep water habitats close to shore to allow for shoreline angling. With appropriate structure added along the transition from Module 3 to Module 2, suitable habitat can be provided for bass, pumpkinseed, adult northern pike, golden shiner and adult walleye in these areas. Module 1 will provide suitable habitat for brown trout, emerald shiner, walleye, bass and lake sturgeon. Habitat Module 5B, located along the shoreline, will provide suitable habitat for smallmouth bass spawning and juvenile walleye (with the addition of structure).

Plants - Wave energy, coarse substrate, and deeper water areas proposed nearshore for boat access will limit the establishment of vegetation in portions of Remediation Area C. However, the somewhat protected cove at the mouth of Ditch A and the area southeast of the Department of Transportation turn-around will be suitable areas for submerged aquatic vegetation in Module 3B areas. The rooting ability of submerged aquatics in the shallower portions of Module 3B where a cobble substrate is proposed will limit such vegetation in these areas. As mentioned in the Remediation Area A discussion, submerged aquatic vegetation will occur in the shallower end of Module 2A. Characteristic submerged aquatic species expected in these areas are presented under the Remediation Area A plant discussion.

Benthic Macroinvertebrates - The slightly higher energy in Remediation Area C allows for application of Habitat Module 5B, which, with slightly larger substrate, will create suitable habitat for crayfish. There will be limited suitability of this module for mayflies and caddisflies. The deeper off-shore modules (2A and 3B) will provide suitable habitat for each of the representative invertebrate orders.

Mammals - Due to the slightly higher energy in Remediation Area C, Module 5B has been applied to the shallow nearshore areas. This module could provide suitable habitat for mink and otter foraging. The larger substrate material of Module 5B compared to 5A limits the suitability of this module for muskrat and beaver. However, the use of this area by aquatic mammals will be somewhat limited because of the recreational activities, adjacent Route 690, and developed land uses, which reduces the on-shore habitat for these species.

Reptiles and Amphibians- Modules 5B and 3B would provide habitat for the snapping turtle, which is the reptilian species most tolerant of moderate energy systems and may utilize some of the terrestrial resources provided along the lakeshore in this area. Other reptilian species, such as musk turtle, painted turtle, and northern water snake, would use the semi-protected areas of Remediation Area C that may allow for species colonization.

Modules 3B, 5B, and 8A in shallow water portions and shoreline areas of Remediation Area C, will provide both aquatic and terrestrial food sources for each of the representative reptilian species. Module 3B along the shoreline area of SMU 2 will provide some vegetated cover for species such as the snapping turtle, painted turtle, and northern water snake.

Areas where Module 3B is applied in the open water areas will provide habitat for mudpuppy and snapping turtle, particularly with the addition of structure. Similarly, the deeper water areas within Module 2A will provide habitat for mudpuppy. In the transitional areas nearshore, Module 5B could potentially support snapping turtles, mudpuppy, and water snake with the addition of structure.

Birds – Remediation Area C will provide breeding and foraging areas for some of the representative bird species. Deeper water off-shore areas where Module 1 will be applied will provide foraging habitat for common goldeneye, mallard, and osprey. Modules 2A and 3B will support foraging by great blue heron, green heron, and belted kingfisher (Module 3B). The open water areas of Module 2B can provide habitat for plunge-diving birds, such as the osprey and common tern, and other diving species including the common goldeneye.

Herbaceous areas created by Module 8A in the near shore areas along the barrier wall will provide suitable nesting habitat for red-winged blackbird. The vegetative cover provides protection while maintaining a proximity to feeding areas and perching posts.

Habitat for shorebirds, such as the spotted sandpiper and semi-palmated sandpiper, will be provided from the coarser, rockier areas along the shoreline of Remediation Area C created by Module 5B which has limited vegetation and allows for optimum foraging along the shoreline.

Suitability of Restoration in Area D for Representative Species

An evaluation was made of the suitability of the habitat modules proposed in Remediation Area D for the representative species within each major species group as described below.

Remediation Area D Habitat Modules:

- 1
- 2A
- 3B
- 5B
- 6A
- 6B
- 8A
- 9B

Fish - The diversity of habitat modules in Remediation Area D provides suitable habitat for several representative fish species. Module 5B will provide suitable habitat for smallmouth bass spawning. The deeper offshore modules will provide suitable habitat for lake sturgeon, brown trout, emerald shiner, and bass (Module 2A) and smallmouth bass spawning, pumpkinseed spawning, northern pike, and walleye (Module 3B). The extensive area of Module 3 and clean substrates will greatly improve the area for these species. With the addition of structure to Module 2A, suitable habitat will be provided for walleye.

Fishing opportunities provided by the deep water areas along the shore are an important aspect of Remediation Area D. There are limited fishing opportunities on the western shore of the lake, particularly areas where fish characteristic of deeper water habitats may be reached using shore fishing techniques.

The emergent wetlands proposed along the shore of Remediation Area D will provide habitat for some fish species during the early spring high water levels. Northern pike spawning habitat will be provided in this area.

Plants- Wave energy and required coarse substrate will affect the abundance of macrophyte growth in Remediation Area D. The shallow water portions of Module 2A and those portions of Module 3B where sand and fine gravel substrates are proposed will be suitable for submerged aquatic species, as discussed under the Remediation Area A plant section. Coarse gravel substrates in Modules 5B and 6B areas will limit rooting potential for species. However, it is likely that as time passes finer grained material will occur and provide a more favorable rooting substrate for submerged aquatic vegetation. The diverse bottom elevations in Module 3 and pockets of deeper areas will likely create places for finer substrates to occur and increase submerged aquatic vegetation.

Proposed persistent emergent wetlands (Module 6A) and forested wetlands (Module 9B) will provide tremendous opportunities for wetland plant species discussed for these modules in previous sections of this report. These wetland fringe habitats will greatly enhance the lake habitat system.

Benthic Macroinvertebrates - The diversity of habitat modules in Remediation Area D provides suitable habitat for all representative invertebrate species. The addition to structure to Modules 6B and 5B will improve the habitat suitability for crayfish.

Mammals - The diversity of habitat modules in Remediation Area D provides suitable habitat for several representative mammal species. Modules 5B and 6B will provide suitable habitat for mink and otter. The deeper offshore modules will provide suitable habitat for otter (Module 2A) and mink, otter, beaver, and muskrat (Module 3B). The habitat suitability will be enhanced once vegetation has become established in Module 3B.

The inland wetland areas (Module 9B) adjacent to Remediation Area D will provide suitable habitat for mink and beaver and potentially Indiana bat. The associated larger wetland complex (Module 6A) adjacent to Remediation Area D will provide suitable habitat for mink, otter, beaver, and muskrat. Muskrat, in particular, will use this habitat. Module 8A provides a transition from wetland to upland and will provide habitat for mink and otter (Module 8A).

Reptiles and Amphibians- Remediation Area D is a medium energy area with a shoreline shelf proposed to reduce energy within the wetlands proposed along the shoreline area. Habitat modules 3B, 5B, and 6B with coarser substrates and more wave action will limit suitable habitat for reptiles that would use the shallow areas of the lake. Northern water snakes could find suitable prey in the shoreline area adjacent to Remediation Area D, as the fish in shoreline shallows would be the optimal size for consumption. The area along the shoreline would also provide adequate cover for the northern water snake and snapping turtle while supporting a food base of benthic macroinvertebrates, plants, and frogs.

Suitable habitat for all representative reptiles will be provided by the large on-shore area of Module 6A. The persistent emergent wetlands of Module 6A will provide habitat for musk turtles, snapping turtles, painted turtles, and northern water snake. Turtles would have access to aquatic and adjacent terrestrial food sources (Modules 8A and 8B) and the wetlands (Module 6A) would provide sufficient cover for concealment. Northern water snakes would find suitable prey (small fish) within the wetland shallows. The vegetative area would also provide adequate cover for the northern water snake, while supporting a food base of aquatic invertebrates, plants, and frogs for all the reptiles listed.

Habitat Modules 3B, 5B, and 6B with coarser substrates and more wave action will limit suitable habitat for amphibians that would use the shallow areas of the lake. The mid-depth and deep open water areas of Module 2A would support mudpuppy, particularly with the addition of structure.

Modules 6A, 8A, and 9B will provide habitat for many of the representative amphibian species. The wetlands would provide suitable habitat for concealment and foraging for red-spotted newt, leopard frog, and wood frog. Sediments composed of finer grain sizes and organic matter would provide vegetation important for concealment and egg deposition, as well as providing a gradual transition to persistent emergent wetlands for cover and foraging. The seasonal temporary pools that will be created as part of the inland wetland complex will provide suitable breeding habitat for spotted salamander and wood frog and would provide sufficient shallow areas for tadpole survival.

Birds – Remediation Area D will provide breeding and foraging areas for most of the representative bird species. Shorebirds such as the spotted sandpiper and the semi-palmated sandpiper would benefit most from the unvegetated shallow water areas of Remediation Area D provided by Module 6B which will support a benthic macroinvertebrate food source. The shallow shoreline would allow wading birds access to open shorelines and food without compromising access to more enclosed, sheltered locations.

Osprey, an obligate piscivore, would benefit from the open water habitat areas provided by Modules 1A and 2A. Other birds that often forage in open water habitats include common tern and common goldeneye. These species also would benefit from the mid-depth open water areas for foraging (Modules 1A and 2A).

The variability of habitats and the connectivity of wetlands adjacent to Remediation Area D would be beneficial to common tern and ducks, such as mallard, by providing foraging habitat within shoreline waters and wetland areas. The presence of aquatic invertebrates and small fish would support the forage base for the common tern and belted kingfisher, as well as allow perching and nesting areas among the vegetation on the fringes of wetter areas along the shoreline.

The shallow water wetland of Module 6A would provide foraging areas for great blue heron, green heron, belted kingfisher, red winged blackbird, spotted sandpiper, and the semi-palmated sandpiper. Adjacent areas of Module 9B would provide cover for nesting in bushes, thickets, and small trees for the green heron, red-winged blackbird, common goldeneye, and mallard. The common tern, and red-winged blackbird could find suitable nesting areas in the herbaceous plant cover provided by Module 8A in the near shore areas. The waterfowl nesting mounds would provide ideal habitat for nesting for the mallard, as well as protection of nests from terrestrial predators. Insect production of the wetland will provide foraging opportunities for bank swallows.

Suitability of Restoration in Area E for Representative Species

An evaluation was made of the suitability of the habitat modules proposed in Remediation Area E for the representative species within each major species group.

Remediation Area E Habitat Modules:

- 1
- 2A
- 2B
- 3B
- 5B
- 6A
- 6B
- 8B

Fish – Remediation Area E is a high energy area. The deeper offshore modules will provide suitable habitat for the lake sturgeon, brown trout, emerald shiner, pumpkinseed, northern pike, and bass (Modules 1, 2A, 2B, and 3B). Habitat Modules 2A and 2B will be most suitable for walleye with the addition of structure. The habitat suitability will be enhanced if vegetation becomes established in Module 3B. The area of Module 5B along the shoreline of this area will provide suitable habitat for smallmouth bass spawning and with added structure suitable habitat for walleye.

Plants - Due to the wave energy expected in this area, coarser substrate modules are proposed, which may initially slow the establishment of vegetation in portions of Remediation Area E. However, within the deeper water limits of Module 3B and in the somewhat protected areas between Module 6B and the lake shore, finer substrates are expected to accumulate over time and provide more suitable habitat for submerged aquatic vegetation over a substantial area. Characteristic submerged aquatic species expected in these areas are presented under the Remediation Area A plant discussion.

Benthic Macroinvertebrates- The proposed application of the habitat modules in Remediation Area E should result in suitable habitats to support benthic organisms. Current substrate conditions limit colonization; substrate composed of more native materials (*e.g.*, sand and gravel) should improve habitat suitability for invertebrate colonization. Habitat Module 5B, with the addition of structure, will provide some habitat for crayfish; however, the area where this module can be applied is limited. The deeper off-shore modules will provide suitable habitat for each of the representative orders. The habitat suitability will be enhanced if vegetation becomes established in Module 3B.

Mammals - Habitat Module 5B will provide some habitat for mink and otter; however, the area where this module can be applied is limited. The deeper off-shore modules will provide suitable habitat for the otter (Modules 2B and 3B) and mink, otter, beaver, and muskrat (Module 3B). The habitat suitability will be enhanced if vegetation becomes established in Module 3B. However, use of this area by aquatic mammals will likely be more closely related to the on-shore habitats at the mouth of Harbor Brook and the SYW-12 area. Waters near these extensive shore habitat areas will be more suitable for such species.

Reptiles and Amphibians - Habitat for several representative reptilian species will be provided by Modules 2A, 2B, 3B and 5B. Specifically, the addition of structure would provide suitable habitat for mudpuppy (Modules 2A and 2B), snapping turtle (Modules 3B and 5B) and northern water snake (Module 5B). As with mammals, reptile and amphibian use of this remediation area will be higher near the Harbor Brook and SYW-12 wetland complexes.

Birds - The deep water of Remediation Area E provided by Module 2B would support an aquatic food base for birds such as the common goldeneye and osprey. Module 3B would help break high energy waves, creating foraging habitat for ducks, such as mallards, as well as common terns, where an invertebrate community becomes established.

Habitat for wading birds, such as great blue heron and green heron, would be provided in shallow areas by Modules 3B and 5B. The common tern, belted kingfisher, and red-winged blackbird could find suitable nesting areas in the herbaceous plant cover in the near shore area of SYW-12.

The warm water discharge from the Metro facility keeps the southern portion of Onondaga Lake ice-free during the winter months. As a result, this is an important wintering area for waterfowl and foraging area for bald eagles. The habitat restoration proposed will not diminish the use of the area for these species.

Suitability of Restoration in the Harbor Brook Wetland Complex (On-shore region straddling Remediation Areas D and E)

Fish - Based on current conditions and the preliminary remediation approaches being considered, it was determined that the area near Harbor Brook, adjacent to Remediation Area E, provides the most suitable area to create spawning habitat for northern pike. The habitat modules were applied to create a large area of emergent wetland (Module 6A) that is preferred by spawning northern pike. Habitat Module 6A will also provide suitable habitat for juvenile stages of many species including bass and pumpkinseed. The transitional areas (Modules 8A and 8B) will not provide suitable habitat for any of the representative fish species, since these habitats do not have standing water.

Plants - Nearly all the Harbor Brook area outboard of the proposed barrier wall is currently proposed to be restored to wetlands. Large expanses of persistent emergent wetlands (Module 6A) are proposed. All the emergent wetland species noted under the Remediation Area A plant discussion will be expected in this area. These areas are made suitable for emergent wetlands because of the shallow wave break areas (Module 6B) proposed off-shore.

In addition, a *Phragmites* control channel is proposed along the entire shore of the Wastebed B area to help limit the intrusion of *Phragmites* into the emergent wetland areas. This channel will be part of the wetland complex and is expected to provide suitable habitat for floating aquatic vegetation, intermixed with non-persistent emergent species (Module 5A).

The brook will be rerouted along a more sinuous path through an area of persistent emergent wetland (Module 6A). Deeper wetland areas are proposed for fish spawning enhancement and will diversify the wetland complex with non-persistent emergent and floating aquatic wetland zones. All the plant species discussed under Remediation Area A for these habitats will benefit from these changes.

Benthic Macroinvertebrates - The realigned Harbor Brook and associated wetland complex (Module 6A) will provide suitable habitat for each of the representative invertebrate groups. The transitional habitats (8A and 8B) will not provide suitable habitat for any of the invertebrate species since these habitats do not have standing water.

Mammals - The realigned Harbor Brook and associated wetland complex adjacent to Remediation Area E will provide suitable habitat for mink, otter, beaver, and muskrat. Muskrats should be significantly favored by these habitat changes. Modules 8A and 8B provide a transition from wetland to upland and will provide habitat for mink, otter, and beaver (Module 8B).

Reptiles and Amphibians- Suitable habitat for all representative reptiles will be provided by Module 6A in the low energy regime at the Harbor Brook wetland area. The wetland shallows (fishery enhancement areas) and persistent emergent wetlands of Module 6A will provide habitat for musk turtles, snapping turtles, painted turtles, and northern water snake. Turtles would have access to aquatic and adjacent terrestrial food sources (Modules 8A and 8B) and the wetlands (Module 6A) would provide sufficient cover for concealment. Northern water snakes would find suitable prey (small fish) within the wetland shallows. The vegetative area would also provide adequate cover for the northern water snake, while supporting a food base of benthic macroinvertebrates, plants, and frogs for all the reptiles listed.

Modules 6A, 8A, and 9B in the Harbor Brook wetland area will provide habitat for each of the representative amphibian species. Mudpuppy habitat would be provided by the wetland shallows (Module 6A) and by Harbor Brook during the cooler spring and fall months. The wetlands would also provide suitable habitat for concealment and foraging for the red-spotted newt, leopard frog, and wood frog. Sediments composed of finer grain sizes and organic matter would provide vegetation important for concealment and egg deposition, as well as providing a gradual transition to persistent emergent wetlands for cover and foraging. The seasonal temporary pools that will be created as part of the inland wetland complex will provide suitable breeding habitat for the wood frog and would provide sufficient shallow areas for tadpole survival. In addition, the waterfowl nesting mounds included in this complex will provide habitat for the green frog and leopard frog.

Birds - The shallow water wetland of Module 6A and banks of the realigned Harbor Brook would provide foraging areas for the great blue heron, green heron, belted kingfisher, red winged blackbird, spotted sandpiper, and the semi-palmated sandpiper. The common tern and red-winged blackbird could find suitable nesting areas in the herbaceous plant cover provided by Module 8A in the near shore areas. The waterfowl nesting mounds would provide ideal habitat for nesting for the mallard, as well as protection of nests from terrestrial predators. Insect production of the wetland will provide foraging opportunities for bank swallows.

Appendix E

Master List of Plants

Introduction

The following is a master list of plants that are targeted for use in the restoration of wetland and upland habitats in and around Onondaga Lake. There are separate lists for different vegetation types/habitat modules. As indicated, these habitat types are generally defined by hydrological conditions. Nearly all the plants are native species. The plants are listed alphabetically by scientific name, with nomenclature according to Mitchell and Tucker (1997).

Wetland Woody Vegetation
(Module 9B, Water at Surface to 1 Foot Below Surface)

Common Name	**Scientific Name**
TREES	
Box elder	*Acer negundo*
Red maple	*Acer rubrum*
Silver maple	*Acer saccharinum*
Black gum	*Nyssa sylvatica*
American sycamore	*Platanus occidentalis*
Eastern cottonwood	*Populus deltoides*
Trembling aspen	*Populus tremuloides*
Swamp white oak	*Quercus bicolor*
Bur oak	*Quercus macrocarpa*
Pin oak	*Quercus palustris*
Black willow	*Salix nigra*
Northern white cedar	*Thuja occidentalis*
American elm	*Ulmus americana*
SHRUBS	
Speckled alder	*Alnus rugosa*
Canada serviceberry	*Amelanchier canadensis*
Black chokeberry	*Aronia melanocarpa*
Musclewood	*Carpinus caroliniana*
Buttonbush	*Cephalanthus occidentalis*
Silky dogwood	*Cornus amomum*
Gray dogwood	*Cornus foemina*
Red-osier dogwood	*Cornus sericea*
Witch-hazel	*Hamamelis virginiana*
Winterberry	*Ilex verticillata*
Common spicebush	*Lindera benzoin*
Northern bayberry	*Myrica pensylvanica*
Mountain holly	*Nemopanthus mucronatus*
Peach-leaf willow	*Salix amygdaloides*
Pussy willow	*Salix discolor*
Shining willow	*Salix lucida*
Basket willow	*Salix purpurea*
Black elderberry	*Sambucus canadensis*
Meadowsweet	*Spiraea alba/latifolia*

**Wetland Woody Vegetation
(Module 9B, Water at Surface to 1 Foot Below Surface)
(Continued)**

Common Name	Scientific Name
Highbush blueberry	*Vaccinium corymbosum*
Southern arrowwood	*Viburnum dentatum*
Nannyberry	*Viburnum lentago*
Withe-rod	*Viburnum nudum*

[a.] Scientific names according to Mitchell and Tucker (1997) *"Revised Checklist of New York State Plants."*

Northeast Wetland Seed Mix
(Modules 6A and 9A, Wetland Edges, Saturated Soils)

Common Name	Scientific Name
Redtop	*Agrostis gigantea*
Autumn bent	*Agrostis perennans*
Swamp milkweed	*Asclepias incarnata*
New England aster	*Aster novae-angliae*
Beggar-ticks	*Bidens cernua*
Nodding beggar-ticks	*Bidens cernua*
Cosmos sedge	*Carex comosa*
Lake sedge	*Carex lacustris*
Blunt broom sedge	*Carex scoparia*
Fox sedge	*Carex vulpinoidea*
Creeping spikerush	*Eleocharis obtusa*
Virginia wild rye	*Elymus virginicus*
Joe-pye-weed	*Eupatorium maculatum*
Boneset	*Eupatorium perfoliatum*
Grass-leaf goldenrod	*Euthamia graminifolia*
Fowl mannagrass	*Glyceria striata*
Blue flag	*Iris versicolor*
Soft rush	*Juncus effusus*
Path rush	*Juncus tenuis*
Common monkeyflower	*Mimulus ringens*
Smooth panic grass	*Panicum dichotomiflorum*
Fowl bluegrass	*Poa pratensis*
Marsh smartweed	*Polygonum hydropiperoides*
Pennsylvania smartweed	*Polygonum pensylvanicum*
Green bulrush	*Scirpus atrovirens*
Woolgrass	*Scirpus cyperinus*
Leafy bulrush	*Scirpus polyphyllus*

Northeast Wetland Seed Mix
(Modules 6A and 9A, Wetland Edges, Saturated Soils)
(Continued)

Common Name	**Scientific Name**
Annual rye	*Secale cereale*
Wrinkled goldenrod	*Solidago rugosa*
Eastern burreed	*Sparganium americanum*
Broad-leaf cattail	*Typha latifolia*
Blue vervain	*Verbena hastata*

[a.] Scientific names according to Mitchell and Tucker (1997) *"Revised Checklist of New York State Plants."*

Shallow Emergent (Persistent) Wetland Plantings
(Module 6, Water 1 foot below surface to 1 foot deep)

Common Name	Scientific Name
Sweetflag	*Acorus americanus*
Swamp milkweed	*Asclepias incarnata*
Lake sedge	*Carex lacustris*
Fox sedge	*Carex vulpinoidea*
Water willow	*Decodon verticillatus*
Creeping spikerush	*Eleocharis obtusa*
Spikerush	*Eleocharis obtusa*
Joe-pye-weed	*Eupatorium maculatum*
Soft rush	*Juncus effusus*
Willow weed	*Justicia americana*
Rice cutgrass	*Leersia oryzoides*
Sensitive fern	*Onoclea sensibilis*
Marsh smartweed	*Polygonum hydropiperoides*
Arrowhead	*Sagittaria latifolia*
Hard-stem bulrush	*Scirpus acutus*
Three-square	*Scirpus americanus*
Green bulrush	*Scirpus atrovirens*
Woolgrass	*Scirpus cyperinus*
Saltmarsh bulrush	*Scirpus robustus*
Soft-stem bulrush	*Scirpus tabernaemontani*
Eastern burreed	*Sparganium americanum*
Giant burreed	*Sparganium eurycarpum*
Freshwater cordgrass	*Spartina pectinata*
Narrow-leaf cattail	*Typha angustifolia*
Broad-leaf cattail	*Typha latifolia*
Blue vervain	*Verbena hastata*

[a.] Scientific names according to Mitchell and Tucker (1997) *"Revised Checklist of New York State Plants."*

Deep Emergent (Nonpersistent) Wetland Plantings
(Module 5, Water 1 to 2 feet deep)

Common Name	Scientific Name
Water plantain	*Alisma subcordatum*
Arrow arum	*Peltandra virginica*
Water smartweed	*Polygonum amphibium*
Pickerel-weed	*Pontederia cordata*
Arrowhead	*Sagittaria latifolia*
Freshwater cordgrass	*Spartina pectinata*
Narrow-leaf cattail	*Typha angustifolia*
Bladderwort	*Utricularia vulgaris*
Wild rice	*Zizania aquatica*

[a.] Scientific names according to Mitchell and Tucker (1997) *"Revised Checklist of New York State Plants."*

Aquatic Bed
(Modules 3 and 4A, Water 1 to 4 feet deep)

Common Name	**Scientific Name**
Coontail	*Ceratophyllum demersum*
Sago pondweed	*Coleogeton pectinatum*
Water weed	*Elodea canadensis*
Yellow water lily	*Nuphar lutea*
White water lily	*Nymphaea odorata*
Pondweed	*Potamogeton nodosus*
Wild celery	*Vallisneria americana*
Water stargrass	*Zosterella dubia*

[a.] Scientific names according to Mitchell and Tucker (1997) *"Revised Checklist of New York State Plants."*

Salt Marsh
(Module 6A, Water 1 foot below surface to 1 foot deep)

Common Name	Scientific Name
Saltmarsh aster	*Aster subulatus*
Alkali grass	*Distichlis spicata*
Rose mallow	*Hibiscus moscheutos*
Black grass	*Juncus gerardii*
Switchgrass	*Panicum virgatum*
Saltmarsh bulrush	*Scirpus robustus*
Seaside goldenrod	*Solidago sempervirens*
Saltgrass	*Spartina alternifolia*
Salt-meadowgrass	*Spartina patens*
Freshwater cordgrass	*Spartina pectinata*

[a.] Scientific names according to Mitchell and Tucker (1997) *"Revised Checklist of New York State Plants."*

Upland Woody Vegetation
(Module 8B, Water at more than 1 foot below surface)

Common Name	Scientific Name
TREES	
Red maple	*Acer rubrum*
Sugar maple	*Acer saccharum*
Yellow birch	*Betula alleghaniensis*
White birch	*Betula papyrifera*
Shagbark hickory	*Carya ovata*
American hackberry	*Celtis occidentalis*
White ash	*Fraxinus americana*
White spruce	*Picea glauca*
Red pine	*Pinus resinosa*
White pine	*Pinus strobus*
Trembling aspen	*Populus tremuloides*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*
Red oak	*Quercus rubra*
Eastern hemlock	*Tsuga canadensis*
SHRUBS	
Shadbush	*Amelanchier canadensis*
Black chokeberry	*Aronia melanocarpa*
Alternate-leaf dogwood	*Cornus alternifolia*
Silky dogwood	*Cornus amomum*
Gray dogwood	*Cornus foemina*
Beaked hazelnut	*Corylus cornuta*
Witch-hazel	*Hamamelis virginiana*
Smooth sumac	*Rhus glabra*
Staghorn sumac	*Rhus hirta*
Bladdernut	*Staphylea trifolia*
Southern arrowwood	*Viburnum dentatum*
Nannyberry	*Viburnum lentago*
Highbush cranberry	*Viburnum opulus*

[a.] Scientific names according to Mitchell and Tucker (1997) *"Revised Checklist of New York State Plants."*

Conservation Seed Mix
(Module 8A, Uplands and Side Slopes)

Common Name	**Scientific Name**
Big bluestem	*Andropogon gerardii*
Partridge pea	*Chamaecrista fosciculata*
Showy tick-trefoil	*Desmodium canadense*
Canada wild rye	*Elymus Canadensis*
Ox-eye sunflower	*Heliopsis helianthoides*
Switchgrass	*Panicum virgatum*
Black eyed Susan	*Rudbeckia hirta*
Little bluestem	*Schizachyrium scoparium*
Partridge pea	*Senna hebecarpa* (Mitchell and Tucker)
Indian grass	*Sorghastrum nutans*

[a.] Scientific names according to Mitchell and Tucker (1997) *"Revised Checklist of New York State Plants."*

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