BASELINE MONITORING SCOPING DOCUMENT FOR THE ONONDAGA LAKE BOTTOM SUBSITE
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AMP	Ambient Monitoring Program
BSQV	Bioaccumulation-Based Sediment Quality Value
CPOI	Chemical Parameters of Interest
IDS	Initial Design Submittal
ILWD	In-Lake Waste Deposit
IRM	Interim Remedial Measure
LCP	Linden Chemicals and Plastics (former industrial plant off Willis Avenue)
MNR	Monitored Natural Recovery
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OCDWEP	Onondaga County Department of Water Environment Protection
OM&M	Operation, Maintenance, and Monitoring
OU	Operable Unit
PCBs	Polychlorinated Biphenyls
PDI	Pre-Design Investigation
PEC	Probable Effect Concentration
PECQ	Probable Effect Concentration Quotient
PRGs	Preliminary Remediation Goals
QAPP	Quality Assurance Project Plan
RAOs	Remedial Action Objectives
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
SCA	Sediment Consolidation Area
SECs	Sediment effect concentrations
SMU	Sediment Management Unit
SU	Syracuse University
SUNY ESF	State University of New York College of Environmental Science and Forestry
UFI	Upstate Freshwater Institute
USEPA	Environmental Protection Agency
USGS	United States Geologic Survey

BASELINE MONITORING SCOPING DOCUMENT FOR THE ONONDAGA LAKE BOTTOM SUBSITE

1.0 INTRODUCTION

This scoping document has been prepared on behalf of Honeywell International Inc. (Honeywell) and presents the scope and rationale for baseline monitoring for Onondaga Lake. The document also provides an overview of pre-remediation, performance, and post-remediation monitoring to be conducted as part of the effort to implement the remedy for Onondaga Lake. Implementation of the remedy for Onondaga Lake is being completed in accordance with a Consent Decree (United States District Court, Northern District of New York, 2007) (89-CV-815) between Honeywell and the New York State Department of Environmental Conservation (NYSDEC).

The remedy for Onondaga Lake is described in the Record of Decision (ROD; NYSDEC and United States Environmental Protection Agency (USEPA), 2005) for the Onondaga Lake Bottom Subsite of the Onondaga Lake Superfund Site. In addition to describing the remedy, the ROD also references environmental monitoring to be performed before, during, and following remediation of Onondaga Lake. These monitoring programs are being undertaken to:

- Provide a comprehensive description of baseline chemical and biological conditions and facilitate remedy design
- Evaluate potential effects on the lake during implementation of the remedy
- Evaluate the effectiveness of the remedy in achieving the remedial action objectives (RAOs) and preliminary remediation goals (PRGs) as well as the long-term integrity of the remedy

This scoping document defines the objectives and scope of the baseline monitoring program. Concurrence on the objectives is a necessary first step to designing the baseline monitoring program. Detailed work plans and quality assurance project plans (QAPPs) for various aspects of the baseline monitoring program have been and will continue to be submitted separately. In some cases, this scoping document references work plans associated with monitoring activities conducted previously by Honeywell that are also part of baseline monitoring. Because design of the remedy is ongoing and requires multiple years for Honeywell to complete, baseline monitoring is anticipated to occur during both the pre-remediation and remedial action periods. This scoping document will be revisited annually and revised if required to assess if monitoring efforts are meeting the objectives of the baseline monitoring program.

Honeywell has conducted extensive pre-design activities to date to support design of the selected remedy and to supplement data collected by Honeywell and by others for the Remedial Investigation (RI) (TAMS Consultants, 2002) from 1992 to 2002. Pre-design activities have included Feasibility Study (Parsons, 2004a) analyses, pre-design investigation activities, bench-scale tests, siting of the Sediment Consolidation Area (SCA), nitrate addition/oxygenation evaluations, cultural resource assessment, wetlands and floodplain assessment, interim remedial measure (IRM) design and construction, and coordination with other lake programs/projects. Pre-design investigation activities have been conducted since 2005 to accelerate the design process and included: geotechnical testing and a settlement pilot study at the SCA, geophysical surveys; sediment sampling for chemical and geotechnical analyses; *in situ* geotechnical testing of sediments; surface water and porewater sampling and analysis; seepage meter and Geoprobe™ measurements, sediment cores and borehole drilling to evaluate groundwater discharge and delineate contaminant extent, and installation and monitoring of two meteorological stations. These activities through 2007 alone provided more than 400 sediment cores, 60 borings, 7,300 environmental samples, and 120,000 chemical and geotechnical analyses to support design of the selected remedy. Additional pre-design activities were conducted in 2008 and 2009 and are being conducted in 2010 to support the remedial design.

Separate plans for performance-related monitoring and post-construction operation, maintenance, and monitoring (OM&M) programs to evaluate remedy effectiveness and long-term integrity will also be developed during the remedial design phase. To provide a comprehensive view of monitoring activities in Onondaga Lake, this document presents general information on monitoring activities (in addition to baseline monitoring) that are ongoing or likely to be conducted by Honeywell during the design phase as well as the performance and post-remediation phases of the project. This scoping document also summarizes ongoing monitoring conducted in Onondaga Lake by entities other than Honeywell. Finally, the document identifies the individual work plans that have been or are likely to be submitted for baseline monitoring.

2.0 BACKGROUND

Onondaga Lake is 4.5 miles long and one mile wide with an average water depth of 36 feet (ft.) (11 meters (m)). The lake has been divided for remedial planning and design purposes into eight sediment management units (SMUs). Seven of the SMUs make up the nearshore areas of the lake where water depths are 30 ft. (9 m) or less. SMU 8 is the deeper water portion of the lake. The lake is underlain by soft and unconsolidated sediments that are 80 to 300 ft. (24 to 91 m) thick. These sediments from top to bottom consist of layers of fill, marl, silt and clay, silt and fine sand, sand and gravel, and till overlying the shale bedrock. Groundwater within the fill and marl provides most of the discharge of groundwater to the lake, although quantities of water discharged via groundwater are much smaller than quantities of water discharged via surface water from the lake's 285 square mile drainage basin. Surface water primarily enters the lake through six tributaries: Ninemile Creek, Onondaga Creek, Ley Creek, Harbor Brook, Bloody Brook, and Sawmill Creek (see Figure 1). Approximately 81 percent of the surface water inflow to the lake is from Onondaga Creek, the Metropolitan Wastewater Treatment Plant (Metro), and Ninemile Creek. Highest inflows occur during the spring from snowmelt and springtime rain events. Surface water also enters the lake via an intermittent bidirectional flow from the Seneca River just north of the lake outlet.

Lake waters in SMU 8 are stratified during summer months, more weakly stratified during winter months, and vertically mixed during spring and fall months. During summer stratification, colder bottom waters (in the area called the hypolimnion) are not able to mix with overlying waters in the epilimnion. As summer progresses, biodegradation of organic solids deplete dissolved oxygen concentrations in the hypolimnion resulting in anoxic conditions. Following oxygen consumption, organic solids biodegradation uses nitrate until nitrate is depleted and then sulfate. Once sulfate reduction becomes an active pathway for biodegradation, methylmercury can form within mercury-contaminated sediments. Formation of methylmercury is a concern because of its mobility and its uptake by aquatic organisms. The boundary between the hypolimnion and the epilimnion occurs each summer at approximately 30 ft. (9 m) below the water surface.

The purpose and background for the remediation of the Onondaga Lake Bottom Subsite are summarized in the ROD (NYSDEC and USEPA, 2005) and presented in detail in the Feasibility Study Report (Parsons, 2004a). In general terms, the lake is impacted by resuspension of in-lake contaminated sediment and by runoff from upland contaminated sites that reaches the lake via tributaries, outfalls, direct surface water runoff, and groundwater migrating laterally to beneath the lake and then upwelling from below. The remedy for the lake specified in the ROD includes dredging and capping the most significantly impacted lake sediment following remediation of upland sources that affect the lake. The remedy for the lake specified in the ROD also includes an oxygenation pilot study in SMU 8 to determine the most effective way to reduce formation of methylmercury in the water column of the SMU 8 hypolimnion.

Subsequent to ROD issuance, research conducted by Upstate Freshwater Institute and Syracuse University indicated that nitrate addition could present an alternative method for reducing methylmercury production. Consequently, nitrate addition is also being evaluated as an alternative method of reducing methylmercury formation and possibly as a supplement to oxygenation. In early 2010, Honeywell proposed and the agencies agreed that Honeywell would conduct a pilot test during which Honeywell would add nitrate for three years starting in 2011 to minimize methylmercury formation in the SMU 8 water column during late summer and early fall prior to lake turnover. As summarized in the Statement of Work attached to the Consent Decree, if nitrate addition is shown to be effective and appropriate, NYSDEC will document this in an Explanation of Significant Difference, and Honeywell will implement nitrate addition in lieu of oxygenation. If NYSDEC determines that nitrate addition is not effective or appropriate, Honeywell will conduct an oxygenation pilot study and implement oxygenation as required by the ROD. Finally, the remedy includes habitat reestablishment in dredged and capped areas of the lake and habitat enhancement in other areas of the lake where stressors (e.g., calcite and oncolites) have been identified as a concern.

The ROD for Onondaga Lake defines RAOs for the site. RAOs are identifiable goals to protect human health and the environment. RAOs for Onondaga Lake, as per the ROD, are listed below.

- “RAO 1: To eliminate or reduce, to the extent practicable, methylation of mercury in the hypolimnion.

- "RAO 2: To eliminate or reduce, to the extent practicable, releases of contaminants from the in-lake waste deposit (ILWD) and other littoral areas around the lake.
- "RAO 3: To eliminate or reduce, to the extent practicable, releases of mercury from profundal (SMU 8) sediments.
- "RAO 4: To be protective of fish and wildlife by eliminating or reducing, to the extent practicable, existing and potential future adverse ecological effects on fish and wildlife resources, and to be protective of human health by eliminating or reducing, to the extent practicable, potential risks to humans.
- "RAO 5: To achieve surface water quality standards, to the extent practicable, associated with chemical parameters of interest (CPOIs)" (NYSDEC and USEPA, 2005, p. 35).

To achieve the RAOs, PRGs were developed to provide specific goals to address the three primary affected media within the lake: sediment, fish tissue, and surface water. PRGs for Onondaga Lake, as per the ROD, are listed below.

- "PRG 1: Achieve applicable and appropriate sediment effects concentrations (SECs) for CPOIs and the bioaccumulation-based sediment quality value (BSQV) of 0.8 mg/kg for mercury, to the extent practicable, by reducing, containing, or controlling CPOIs in profundal and littoral sediments.
- "PRG 2: Achieve CPOI concentrations in fish tissue that are protective of humans and wildlife that consume fish. This includes a mercury concentration of 0.2 mg/kg in fish tissue (fillets) for protection of human health based on the reasonable maximum exposure scenario and USEPA's methylmercury National Recommended Water Quality criterion for the protection of human health for the consumption of organisms of 0.3 mg/kg in fish tissue. This also includes a mercury concentration of 0.14 mg/kg in fish (whole body) for protection of ecological receptors. These values represent the range of fish tissue PRGs.
- "PRG 3: Achieve surface water quality standards, to the extent practicable, associated with CPOIs" (NYSDEC and USEPA, 2005, p. 35).

Because of the large volume and complexity of the data required, PDI activities for the lake bottom are being conducted in a phased approach. This approach allows the data from one phase to be interpreted and used to develop the appropriate scope for the next phase of investigation. This approach also ensures the overall quality and usefulness of the data and ensures that all data gaps are identified and fulfilled. PDI field efforts to date (Phases I through V) have been conducted since 2005 in accordance with the following NYSDEC-approved work plans that are available in the public document repositories:

- *Onondaga Lake PDI: Phase I Work Plan* (Parsons, 2005), which included the following appended documents: Appendix A - Sampling and Analysis Plan, Appendix B - Quality Assurance Project Plan, Appendix C - Project Safety Plan, and Appendix D - Emission and Odor Work Plan.

- *Onondaga Lake PDI: Phase II Work Plan* (Parsons, 2006), which also included the following appended documents: Addendum 1 - Porewater Sampling Plan; Addendum 2 - Wastebed 13 Work Plan, Addendum 3 - Wastebed 13 Work Plan, Addendum 4 - Groundwater Discharge Evaluation, Addendum 5 - Water Treatability, Effluent Elutriate, Odors and Column Settling Testing, and Addendum 6 - Cap Design Bench Scale Studies.
- *Onondaga Lake PDI: Phase III Work Plan* (Parsons, 2007b) which also included the following appended documents*:* Addendum 1 - Geotextile tube evaluation (for the SCA); Addendum 2 - in-lake waste deposit stability and porewater investigations and supplemental boreholes; Addendum 3 - capping bench-scale column studies; Addendum 4 - SCA borings and survey; Addendum 5 - lake temperature-conductivity probes and vibracores; Addendum 6 - monitored natural recovery work in SMU 8; and Addendum 7 - emission and odor testing.
- *Onondaga Lake PDI: Phase IV Work Plan* (Parsons, 2008b) which also included the following appended documents*:* Addendum 1 - Habitat; Addendum 2 - Cap Amendment Study Isotherm Development; Addendum 3 – continuation of capping column studies; Addendum 4 - Mechanical Dewatering Evaluation; Addendum 5 – supplemental treatability testing; Addendum 6 – bulk sediment collection and dewatering treatability study; Addendum 7 – pH cap amendment testing; and Addendum 8 – SMU 8 high-resolution cores.
- *Onondaga Lake PDI: Phase V Work Plan* (Parsons, 2009b) which also included the following appended documents*:* Addendum 1 - Habitat; Addendum 2 - Biological Decay Batch Study; Addendum 3 – Porewater; Addendum 4 – not used; Addendum 5 – not used; and Addendum 6 – Additional Sediment Sampling for SMU 5.
- *Onondaga Lake PDI: Phase VI Work Plan* (Parsons, 2010) which to date includes the following appended documents: Addendum 1 – carbon isotherm development; Addendum 2 – cap porewater pH neutralization column studies; Addendum 3 – not yet used : Addendum 4 – dredge stability and upwelling geotechnical borings; and Addendum 5 – SMU 8 PECQ Sediment Sampling.

In addition to past and ongoing monitoring efforts by Honeywell, various monitoring efforts have been completed within Onondaga Lake in recent years by NYSDEC, Onondaga County Department of Water Environment Protection (OCDWEP), Upstate Freshwater Institute (UFI), Syracuse University, the State University of New York College of Environmental Science and Forestry (SUNY-ESF), and the US Geological Survey. NYSDEC has conducted annual fish sampling in Onondaga Lake as the primary basis for the New York State Department of Health (NYSDOH) to annually assess the state fish consumption advisory. Onondaga County has conducted various types of monitoring on an annual basis in accordance with its requirements to address municipal wastewater discharges to the lake (see OCDWEP, 2007 for example). UFI has also conducted extensive annual monitoring within Onondaga Lake and its tributaries. SUNY-ESF has provided analyses of fish population size and fish migration patterns. The US

Geological Survey has provided flow measurements and input about regional groundwater characteristics. Efforts by these entities are described in Section 5 of this scoping document.

3.0 PROGRAM OBJECTIVES

The overall goal of baseline monitoring is to document the condition of the lake prior to remedial action. This monitoring will permit evaluation of changes that result from remedial action and verification of remedy effectiveness in achieving the RAOs and PRGs. Development of a monitoring program is best done through a systematic process, as discussed in USEPA's *Data Quality Objective Process for Hazardous Waste Site Investigations* (USEPA, 2000) and USEPA's *Guidance for Monitoring at Hazardous Waste Sites: Framework for Monitoring Plan Development and Implementation* (USEPA, 2004). Both the first document, which addresses remedial investigations, and the second, which focuses on post-construction monitoring, emphasize the need to define the purpose/objectives of the monitoring in order to identify the required data collection effort. Thus, program objectives for the Onondaga Lake baseline monitoring program have been developed and are shown in Table 1.

The Baseline Monitoring Program for Onondaga Lake has three program objectives:

- Establish a comprehensive description of baseline chemical and physical conditions prior to remediation to assess remedy effectiveness and to facilitate remedy design
- Provide additional data for future understanding of remedy effectiveness in achieving PRGs
- Provide habitat-related information

The first program objective addresses the need to document the condition of the lake prior to remedial action and to provide the data needed to support development of the performance-related monitoring and long-term OM&M programs. Establishing baseline chemical conditions is also necessary in order to evaluate trends over time (e.g., decrease in methylmercury concentration in the water column) as a function of the remedy or other factors. The data collection efforts for this program objective center around media for which PRGs were established in the ROD (i.e., sediment, fish tissue, and water), processes that were addressed in the RAOs (e.g., mercury methylation in the hypolimnion), or media that may be affected by the remedy (i.e., air and groundwater).

The second program objective addresses the need to understand factors that can reasonably be expected to impact achievement of the PRGs and RAOs. Such factors can be beyond the scope of the lake remedy (e.g., remediation of Honeywell upland sites that contribute mercury to the lake) or even beyond the control of Honeywell (e.g., food web dynamics in the lake) but can have significant impact on the outcome of the remedy. Data collection efforts for this program objective involve source monitoring and sampling of biota other than adult sport fish and prey fish (e.g., benthic macroinvertebrates).

The third program objective addresses the need to document baseline habitat conditions. This objective consists primarily of habitat characterization. Habitat monitoring results from

2008 and 2009 were incorporated into Honeywell's plans for habitat restoration (Parsons, 2009c).

4.0 PROGRAM ELEMENTS AND DATA USES FOR BASELINE MONITORING

The various data collection efforts mentioned above are defined as program elements in Table 1. Each program element has one or more data uses that can be divided into baseline monitoring for evaluation of remedy effectiveness and baseline monitoring for remedy design. These data uses are summarized in Table 1 and discussed in greater detail below by program element.

The goal of this section is to describe the rationale that will be used to design monitoring programs for each data use with particular attention to prior data collection activities and appropriate temporal and spatial scales. This rationale will serve as the basis for specifying monitoring activities in future baseline monitoring work plans.

4.1 Sediment Sampling

Sediment sampling is a program element associated with Objective 1 – Establish baseline chemical and physical conditions. There are three data uses associated with this program element: (1) provide basis to measure remedy effectiveness in achieving sediment remediation goals for the lake; (2) assist in providing basis for lake sediment remediation design efforts (*i.e.*, dredging, isolation capping, and thin-layer capping); and (3) provide data for refinement of the monitored natural recovery evaluation for SMU 8. The first data use represents baseline monitoring to assess remedy effectiveness while the second and third data uses represent baseline monitoring for remedy design. An explanation of each data use and the sampling rationale are provided below.

4.1.1 Provide Basis to Measure Achievement of PRG1 (Mean PECQ1, Mercury PEC, and Mercury BSQV for Sediment)

The baseline chemical concentrations in sediment including the extent of lake sediment that exceeds remediation goals established in the ROD (*i.e.*, the extent of sediment to be dredged and/or capped) is being defined for each of the eight SMUs in which the lake is divided (see ROD Figure 3 for a depiction of the SMUs). The probable effect concentration quotient (PECQ) was developed in the Feasibility Study (Parsons, 2004a) and used in the ROD to account for direct toxicity effects on lake organisms and also to take into consideration the presence and concentrations of multiple contaminants in lake sediments. The mean PECQ for a sediment sample is calculated based on the PECQs for each of five chemical groups, which are then averaged to quantify an overall mean PECQ for an individual sediment sample. A mean PECQ exceeding 1 or a mercury PEC exceeding 2.2 milligrams per kilogram in lake sediment is, according to the ROD, an indication that remediation is needed. To account for bioaccumulation effects of mercury on certain lake organisms, a BSQV of 0.8 milligrams per kilogram was developed in the ROD. Application of the BSQV to specific areas within Onondaga Lake is being determined as part of the remedy design work.

Sediment sampling was initiated by Honeywell in 1992 as part of the remedial investigation effort (reported in TAMS Consultants, 2002) and is continuing as part of Honeywell's pre-design investigation (PDI) efforts. Lake sediments have been collected from each SMU during PDI activities to characterize the chemical properties of the sediment. Chemical analyses have been performed at an independent laboratory in accordance with the Quality Assurance Project Plan appended to the Phase I PDI Work Plan (Parsons, 2005). Figure 1 presents the locations of sediment samples for remedial investigation and PDI work collected within Onondaga Lake through 2007.

Most of the sediment identified in the ROD as requiring dredging and/or isolation capping is in the southern and western nearshore SMUs (SMUs 1, 2, 4, 6, and 7). Some thin layer capping will be required in SMU 8 as defined in the ROD. A thin-layer cap will be placed over areas of SMU 8 that currently exceed the mean PECQ of 1. During remedy implementation, additional remedial measures may be needed (e.g., thin-layer capping) to meet the BSQV on an area-wide basis. These areas will be further delineated as needed as part of future monitoring work.

4.1.2 Assist in Remedy Design for Dredging, Isolation Capping, and Thin-Layer Capping

The second data use of sediment sampling is to provide information needed for designing the remedy in addition to data that defines exceedances of sediment remediation goals. Lake sediment samples have been collected from multiple SMUs during various pre-design investigation activities to characterize the physical properties and strength of the sediment. In addition, sediment porewater has been collected and analyzed from multiple SMUs. These data are being used in developing the sediment cap design. Sediment samples have been collected using several sampling techniques, including: grab sampler, Vibracore, borehole drilling, and standard penetration testing. Index testing (e.g., moisture content, grain size, Atterberg limits, specific gravity) and performance testing (consolidation and strength) have been performed on the collected sediment at an independent laboratory in accordance with standard methods. In addition, piezocone penetrometer testing and vane shear testing have been conducted *in situ* to evaluate the geotechnical properties of the sediment such as shear strength.

Future sediment sampling is envisioned for dredging and capping design. These future efforts may include: (1) focused geophysical investigation to support sediment cap and dredge area and depth design; (2) collection of geotechnical data to evaluate stability of the ILWD; and (3) sediment sampling to refine cap areas and dredge volumes and to support dredging and cap design.

4.1.3 Provide Data for Refinement of MNR Model During Design Phase

The third data use of sediment sampling is to refine the application of the model for monitored natural recovery (MNR) in SMU 8 to help determine if any additional remedial measures, such as additional thin-layer capping, will be needed in SMU 8. The lake remedy as specified in the ROD includes MNR in SMU 8 to achieve the mercury probable effect concentration (PEC) of 2.2 milligrams per kilogram (mg/kg or part per million) in the lake's profundal zone (where water depths exceed 9 m or 30 ft.) and to achieve the BSQV for mercury of 0.8 mg/kg on an area-wide basis, within 10 years following the remediation of upland sources, dredging and/or isolation capping of littoral sediment, and initial thin layer capping in the profundal zone.

Sediment sampling in SMU 8 of 0 to 2-centimeter (0 to 0.8 inch) and 0 to 30-centimeter (0 to 12 inch) depth intervals was initiated by Honeywell in 1992 as part of the remedial investigation for Onondaga Lake (TAMS Consultants, 2002). During the pre-design investigation, sediment sampling in SMU 8 was conducted by Honeywell in the fall of 2005 (Parsons, 2007a) from the top 2 centimeters to evaluate the then-current concentrations of mercury in sediment. Sediment sampling was also conducted by Honeywell in the fall of 2007 according to the PDI Phase III MNR Work Plan (Parsons, 2008a) with an emphasis on monitoring the top 15 centimeters of sediments as well as to provide more current data on MNR model parameters. As specified in the 2007 MNR Work Plan, high resolution cores were collected in 2008 and analyzed, and two different microbead markers were deployed in 2009 to assess sediment accumulation rates in future years. The high-resolution core effort is defined in a 2008 MNR Work Plan (Addendum 8 in Parsons, 2008b) which was approved by NYSDEC before the cores were collected. The work plan for microbead marker placement (Parsons, 2008c) was also approved by NYSDEC before the pre-mobilization field tests were conducted in October-November 2008. The two microbead markers were successfully placed during June-July 2009 at nine plots in SMU 8 each of which occupies an area of 1,400 square feet. Placement confirmation cores were collected during October-November 2009. Additional cores within the microbead marker plots were collected during July 2010. Sediment cores will also be collected from microbead marker plots during 2011 and every three years thereafter to monitor the microbead marker through the MNR period as described in the 2007 MNR Work Plan (Parsons, 2008a).

4.2 Sport and Prey Fish Sampling

Sport and prey fish sampling is a second program element associated with Objective 1 – Establish Baseline Chemical Conditions. There is one data use associated with chemical concentrations in fish: provide basis to measure achievement of PRG2 (fish tissue target concentrations). An explanation of the data use and the sampling rationale are provided below.

4.2.1 Provide Basis to Measure Achievement of PRG2 (Fish Tissue Target Concentrations)

The fish monitoring program has been designed to assess fish tissue concentrations in representative species prior to and during remediation. The last extensive sampling of fish for tissue analysis was in 1992 as part of the remedial investigation. Since then, sampling has been conducted by NYSDEC and by Onondaga County, with samples analyzed in NYSDEC labs and the data used by NYSDOH to determine appropriate fish consumption advisories. With respect to mercury, concentrations in fish tissue are variable from year to year, likely the result of several different factors. For purposes of baseline monitoring, it is important to collect sufficient numbers of fish (within the range of what is feasible) and to collect samples over multiple years in order to address interannual variability concerns. In addition, it is important to sample the same species of fish each year and to include species from several trophic levels (benthic invertivore, planktivore, piscivore) as mercury bioaccumulates and concentrations vary between species depending on trophic level. PRGs were established for both human health and ecological exposures; therefore, sampling includes both adult sport fish (from a range of legal size fish) and prey fish.

4.3 Lake Water Sampling

Lake water sampling is a third program element associated with Objective 1 – Establish Baseline Chemical Conditions. There are four data uses associated with this program element: (1) provide basis to measure achievement of PRG3 (surface water quality standards), (2) provide basis to measure success in controlling key processes (e.g., mercury methylation in the hypolimnion, sediment resuspension from the in-lake waste deposit, and mercury release from profundal sediment), (3) provide information for design of nitrate addition/oxygenation pilot tests and basis to measure results, and (4) provide basis to establish goals for water quality during implementation of the remedy. The first and second data uses represent baseline monitoring to assess remedy effectiveness while the third and fourth data uses represent baseline monitoring for remedy design. An explanation of each data use and the sampling rationale are provided below.

4.3.1 Provide Basis to Measure Achievement of PRG3 (Surface Water Quality Standards)

The surface water of Onondaga Lake has been sampled extensively over the years under various programs including the Honeywell remedial and pre-design investigations, the Onondaga County Ambient Monitoring Program, and Upstate Freshwater Institute's Annual Program. Sampling locations associated with these programs through 2007 are shown in Figure 2. As summarized in the Feasibility Study (Parsons, 2004a) with respect to contaminants, data presented in the remedial investigation report indicate that only mercury consistently exceeds surface water quality standards, specifically the standard for protection of wildlife (i.e., 2.6 nanograms per liter of dissolved mercury) and the standard for protection of human health [via fish consumption] (i.e., 0.7 nanograms per liter of dissolved mercury). These two standards are considered to be protective of wildlife and humans exposed to mercury via fish consumption and therefore take into account bioaccumulation of mercury from water into fish tissue. Surface water quality standards for other CPOIs are generally met in Onondaga Lake with the exception of slight exceedances for some volatile organic compounds (i.e., benzene, chlorobenzene, and dichlorobenzenes) in 1999 at stations located in areas now termed SMUs 1, 2, and 7.

Water quality monitoring to assess post-construction compliance with surface water quality standards will involve sample collection in both deep basin and littoral regions of the lake. This sampling will likely overlap with sampling conducted to provide information to design the nitrate addition/oxygenation pilot tests (Section 4.3.3) and to establish water quality goals during implementation of the remedy (Section 4.3.4).

Regarding deep basin sampling, a weekly monitoring program in the South Basin was implemented in 2006 by Syracuse University (SU) and Upstate Freshwater Institute (UFI) on behalf of Honeywell (Exponent, 2007; UFI and SU, 2007a) in order to evaluate the potential for nitrate addition to control mercury methylation. This monitoring included extensive sampling (multiple depths) and analysis for total mercury, methylmercury, and other parameters from April to November. Analysis for dissolved total mercury was conducted on a limited number of samples. Monitoring has continued annually since 2006 from April to November on a less frequent basis with a focus during 2007 on evaluating variability between the north and south basins (see UFI and SU, 2007b). Similar sampling will continue as part of the baseline monitoring program, allowing sufficient resolution to track dissolved total mercury concentrations in the deep basins throughout the sampling season and provide information needed to evaluate nitrate addition/oxygenation as described in Section 4.3.3.

Littoral water sampling for comparison to surface water quality standards was conducted during 2008 and is planned again for August 2010 to provide sufficient information on baseline conditions prior to the initiation of remedial activities.

4.3.2 Provide Basis to Measure Success in Controlling Key Processes (e.g., Mercury Methylation in the Hypolimnion, Sediment Resuspension from the In-Lake Waste Deposit, Releases of Mercury from Profundal Sediment)

The ROD identified three RAOs pertinent to key processes related to mercury cycling in the lake. The first remedial action objective related to mercury cycling, mercury methylation in the hypolimnion, was estimated to provide a significant portion of methylmercury to the lake. The importance of mercury methylation in the hypolimnion was confirmed in 2006 through water column monitoring (Exponent, 2007); however, results of water column monitoring since 2006 indicate that mercury methylation in the hypolimnion has been significantly reduced by the prolonged presence of oxygen and nitrate in the hypolimnion, as previously hypothesized (UFI and SU, 2007a). Monitoring of total mercury and methylmercury species at multiple depths at South Deep will continue during baseline monitoring.

The second remedial action objective related to mercury cycling, resuspension of sediment from the in-lake waste deposit, was estimated to provide a significant portion of total mercury to lake waters. This estimate was confirmed by Owens et. al. (2009) who undertook a more detailed study in 2005. Owens et. al. provided an updated estimate of particulate mercury suspended into the water column from the in-lake waste deposit and also concluded variations in suspension over time are linked to wind-driven wave action. At this time, no additional sampling is recommended during the baseline monitoring program to further assess resuspension from the in-lake waste deposit, because the potential importance and magnitude of this process has already been established.

The third remedial action objective related to mercury cycling, release of mercury from profundal sediments was hypothesized in the RI report to occur as a result of methane gas ebullition. Rates of ebullition are primarily a function of bacterial activity that generates methane and nitrogen gas and thus are subject to change as factors that influence bacterial activity (e.g., organic carbon in sediment, nitrate) change. Ebullition rates were measured for several years by UFI, including during 2006 and 2007 for Honeywell. Rates of ebullition were lower in 2006 compared to 1992, approximately 80 percent lower in 2007 compared to 2006, and approximately 40 percent lower in 2008 compared to 2006. Although mechanisms that control these rates are not clearly understood at this time, gas ebullition measurements were discontinued beginning in 2009, because peak methylmercury mass in the hypolimnion has declined significantly since 2006 and appears unrelated to the trends in gas ebullition rates. Gas ebullition is unlikely to be a significant process with respect to mercury release from profundal zone (SMU 8) sediment.

Water column monitoring will continue in order to document total mercury and methylmercury concentrations in the hypolimnion. Mercury water column concentrations have been and will continue to be compared to nitrate concentrations in the lake to continue to assess the relationship between mercury and nitrate concentrations in the hypolimnion. Other factors may be compared to water column mercury concentrations as well.

4.3.3 Provide Information for Design of Nitrate Addition/Oxygenation Pilot Tests and Basis to Measure Results

The premise of nitrate addition/oxygenation is that nitrate and oxygen control the production of methylmercury in the hypolimnion of Onondaga Lake during the annual summer-fall stratification. Therefore, careful measurement of redox parameters (e.g., dissolved oxygen, various nitrogen species, sulfide) as well as mercury is required. One goal of this monitoring is to understand the relationship between methylmercury concentrations and nitrate and oxygen concentrations. Because nitrate and oxygen concentrations vary strongly with water depth, sampling is needed at multiple depths in the water column to better understand this relationship. In addition, frequent sampling is needed, particularly during the late summer-fall period of nitrate depletion that follows oxygen depletion and is thought to trigger methylmercury production.

In addition to the deep basin sampling described in Section 4.3.1, the program since 2007 has included transects of the lake using the *in situ* ultraviolet spectrophotometer (ISUS), which is a high-resolution, rapid profiling technique for measuring nitrate concentrations. This work will be an important method of tracking nitrate concentrations during the nitrate addition pilot test. The monitoring associated with the nitrate addition pilot test is described in a draft Honeywell work plan currently under review by the agencies.

4.3.4 Provide Basis to Establish Water Quality Goals During Implementation of the Remedy

In order to assess the effects of remedial activities on water quality in Onondaga Lake, it will be necessary to define water quality in the Lake prior to remediation, and to establish water quality goals that can be used as a basis for evaluating effectiveness of control measures. A scope for monitoring during implementation of the lake remedy is being formulated and will likely consist of monitoring stations located near active dredging/capping operations (near-field monitoring stations) as well as far-field station monitoring stations.

The goal of the near-field stations will be to serve as indicators. Exceeding water quality goals at a near-field station while the remedy is being implemented will alert the remediation team when remedial activities may be adversely affecting water quality beyond the near field area. If such adverse effects are observed, other actions may be warranted at that time, such as conducting additional monitoring or implementing engineering controls.

Data collected at the far-field stations during remedial activities will be compared to water quality goals to assess the effects of remedial activities on lake-wide water quality. Exceeding water quality goals at a far-field station during remediation will require a response, which may include additional monitoring or engineering controls.

Honeywell is developing a sampling program to address this data use. To date, water quality has been monitored for the various chemical parameters of interest during November 2008 prior to collecting bulk sediment from SMU 1 for treatability testing as part of Phase IV PDI Addendum 6.

4.4 Air Quality Characterization

Honeywell is developing a plan for baseline monitoring of air quality based on results from ongoing emissions evaluations. The purpose of baseline air quality monitoring will be to establish baseline air quality for volatile organics and odors in the vicinity of the SCA. Continuation of meteorological monitoring at the two meteorological stations established by Honeywell will be included. These stations monitor wind, precipitation, air temperature, and other parameters near the lake shoreline and at the SCA. In addition to the vicinity of the SCA, baseline air quality characterization may also be needed in the vicinity of the lake dredging and/or near-shore processing facility and potentially along the pipeline route between the lake and the SCA.

4.5 SCA Characterization

Characterization of the SCA includes settlement monitoring that was performed by Honeywell as part of the settlement pilot study. In addition, groundwater elevations throughout the SCA continue to be monitored quarterly and groundwater quality baseline data will also be needed in the vicinity of the SCA.

4.6 Source Monitoring

Source monitoring is a program element associated with Objective 2 – Provide additional data to assist in understanding future effectiveness of the lake remedy in achieving PRGs. There are three data uses associated with this program element: (1) quantify external loading of mercury, (2) verify effectiveness of remedies at upland Honeywell sites, and (3) identify and quantify other non-Honeywell sources of CPOIs to the lake. An explanation of each data use and the sampling rationale are provided below.

4.6.1 Quantify External Loadings of Mercury

Ninemile Creek and Onondaga Creek were identified as the two largest tributary sources of total mercury and methylmercury to the lake in 1992. Ninemile Creek was identified as the largest contributor, due to discharges from the former LCP Bridge Street facility. With the exception of the placement of a permanent cover at the site, remediation at LCP was completed in 2007. Remediation of contaminated sediment and floodplain soil/sediment in and around Geddes Brook and Ninemile Creek will be completed by Honeywell. Onondaga Creek is the second largest tributary contributor of mercury to Onondaga Lake, primarily due to its large flow of water into the lake. Sampling of sediment in Ninemile Creek will be conducted as part of pre-remediation monitoring and post-remediation monitoring associated with the Geddes Brook/Ninemile Creek remediation.

The other tributaries monitored during the Onondaga Lake remedial investigation (i.e., Sawmill Creek, Bloody Brook, Harbor Brook, East Flume, Ley Creek, and Tributary 5A) are minor sources of total mercury and methylmercury to the lake as described in the RI report, but they were monitored periodically during 2009 nonetheless.

Another major external source of mercury to the lake as determined during the Onondaga Lake remedial investigation was groundwater. Significant work by Honeywell is ongoing along the southwest shoreline of Onondaga Lake to address groundwater upwelling into the lake. In 1992, groundwater was estimated to contribute 21 percent of total mercury and 15 percent of methylmercury to the lake (TAMS Consultants, 2002). These estimates were calculated in 1992 using data for total mercury and methylmercury in onshore wells and hydraulic conductivity data from upland site wells. Following construction of the shoreline barrier walls, the flow of groundwater to the lake is expected to be reduced significantly. To verify the effectiveness of upland groundwater remedies, an assessment of groundwater loadings to the lake will be updated by incorporating upland site monitoring data and groundwater upwelling flow estimates, using the procedure for estimating loadings to the lake developed in 1992.

In addition to these external sources, other sources that contribute significant loads of total mercury or methylmercury to the lake will be evaluated, as warranted.

4.6.2 Verify Effectiveness of Remedies at Upland Honeywell Sites for All CPOIs

Upland Honeywell sites having the potential to impact Onondaga Lake are summarized in Table 2. These sites are currently at various stages of investigation and remediation. Prior to implementation of the lake remedy, it must be verified that the remedies implemented for the upland sites have been effective and that these sites are not expected to impact the lake remedy. At the same time groundwater loading of mercury is evaluated as part of the monitoring of upland site remedies to quantify external loadings to the lake, groundwater containment effectiveness will be evaluated for the shoreline barrier wall based on CPOIs from the adjacent upland sites and based on hydraulic gradients in the vicinity of the wall.

Contamination from upland sites may reach the lake through surface water transport in Ninemile Creek, Harbor Brook, East Flume, and Tributary 5A. Surface water monitoring in Ninemile Creek for the previous data use will assess remediation of Geddes Brook/ Ninemile Creek and the wastebeds. An assessment of the remedies for Wastebeds 1 through 8, Harbor Brook, the Wastebed B area, and Tributary 5A will be conducted as part of the work associated with the remedy for each of these areas. In addition, the final design for LCP Bridge Street

(Operable Unit-1 or OU-1) (Parsons, 2004b) includes a preliminary operations and maintenance manual which identifies an assessment to be conducted on the effectiveness of the LCP OU-1 remedy by monitoring the West Flume. Monitoring associated with this data use will occur following remediation of the upland sites and before dredging in the lake is initiated. If, upon review, monitoring of tributaries under the upland site remedial programs is not sufficient, then consideration will be given to initiating additional monitoring of these tributaries under the lake program.

4.6.3 Identify Non-Honeywell Sources to the Lake

This data use pertains to the importance of ascertaining the potential contribution of non-Honeywell sources of CPOIs to the lake, to the extent that they may impact the lake remedy. Table 3 lists potential non-Honeywell sources that were identified in the Feasibility Study (Parsons, 2004a). Additional potential sources may be identified. Existing data associated with these sources is being assessed along with additional sediment data collected in lower Onondaga Creek and lower Ley Creek in 2009 to determine if additional data are needed to assess ongoing contaminant loadings from these sources to the lake. Monitoring to address the potential for impacts from these sources on the lake remedy may later include sediment sampling near the mouth of such tributaries and/or sampling of surface water or other existing, ongoing discharges.

4.7 Other Biota Sampling

Like source monitoring, this program element falls under Objective 2 – Provide data to assist in understanding future effectiveness of remedy in achieving PRGs. The primary data use is to assess biological factors that may contribute to variability in fish mercury concentrations. An explanation of the data use and the sampling rationale are provided below.

4.7.1 Assess Biological Factors that May Contribute to Variability in Fish Mercury Concentrations

Mercury concentrations in fish in Onondaga Lake and other systems vary from year to year, from species to species, and even within species as a function of age. Because uptake of methylmercury through the diet accounts for more than 90 percent of total methylmercury uptake in fish (Weiner et al., 2003), this data use focuses on the biological component of variability in fish mercury concentrations. The actual assessment of variability in fish mercury concentrations is a component of the fish sampling described in Section 4.2.1. Concentrations of mercury and methylmercury in sediment and water, which clearly impact mercury concentrations in biota, are being assessed through sediment and water sampling activities described in Sections 4.1.1 and 4.3.1, respectively. The primary biological factors that influence mercury concentrations in fish are mercury concentrations and abundance of fish prey, food web structure (e.g., primary prey items for various species, number of trophic levels), and fish community composition. Each of these factors is being assessed as part of the ongoing baseline monitoring program.

Regarding fish prey, three groups of organisms are potentially important for understanding the bioaccumulation of mercury in fish in Onondaga Lake as they serve as important prey for various fish species: zooplankton, benthic macroinvertebrates, and zebra mussels. Zooplankton samples were collected and analyzed for mercury in 1992 for the remedial investigation on behalf of Honeywell. Beginning in 2007, UFI collected zooplankton samples on behalf of Honeywell and samples were analyzed for total mercury and methylmercury by Syracuse University (UFI and SU, 2007b and 2008a). In addition, a paper on total mercury concentrations in archived zooplankton samples from Onondaga Lake was presented at the Onondaga Lake Forum in November 2007 (Todorova et al, unpublished). Zooplankton samples are also collected annually by the County and UFI for analysis of community composition. Analysis of mercury concentrations in zooplankton and assessment of the zooplankton community are components of the baseline monitoring program.

Benthic macroinvertebrates were collected during the remedial investigation in 1992 and 2000 and during the pre-design investigation in 2008 for both community analysis and mercury concentration (Figure 3). Benthic macroinvertebrate sampling and analysis is being conducted again during 2010. Benthic macroinvertebrates are also collected every five years for community analysis by OCDWEP as part of the Ambient Monitoring Program (locations shown in Figure 3). The concentration of mercury in benthic macroinvertebrates and their community analysis/abundance are not expected to change significantly from year to year as they are, by definition, sediment-dwelling organisms and sediment conditions are unlikely to fluctuate as much as water quality. Nevertheless, it is important to assess benthic macroinvertebrate mercury concentrations and community structure and these analyses were components of the 2008 baseline monitoring work and are components of the 2010 baseline monitoring work. This community structure work was performed during 2008 in conjunction with habitat-related monitoring. Additional monitoring of benthic macroinvertebrates is being conducted on behalf of Honeywell during 2010.

Zebra mussels have recently appeared in Onondaga Lake and are becoming more important in terms of affecting water quality and providing a food source to benthivorous fish. Both Onondaga County and the Upstate Freshwater Institute have been monitoring zebra mussel occurrence and abundance. Onondaga County sampling locations for zebra mussels are included on Figure 3. These organisms filter overlying water and are thus exposed to conditions in the epilimnion. Therefore, analysis of total mercury and methylmercury concentrations in these organisms was a component of the 2008 baseline monitoring work. Additional monitoring of zebra mussels is being conducted on behalf of Honeywell during 2010.

In addition to mercury concentrations in prey items, food web structure and fish population and community composition are important factors that can influence mercury concentrations in fish. Thus, baseline monitoring during 2008 and 2009 included analysis of the food web (by analysis of fish gut contents) and an assessment of fish population and community composition (in conjunction with fish sampling for chemical analysis). Additional food web, fish population, and community composition analyses is being conducted on behalf of Honeywell during 2010.

4.8 Habitat Characterization

Honeywell working with NYSDEC and USEPA has developed data uses and sampling rationale for characterizing lake and adjacent wetland habitat and for providing the basis for determining success of future habitat restoration efforts. Efforts related to habitat characterization conducted on behalf of Honeywell during 2008 and 2009 included food web, fish population, and community composition analyses focusing on target species that are currently being identified.

5.0 OTHER MONITORING ACTIVITIES

Onondaga Lake continues to be monitored extensively by Honeywell, Onondaga County, and UFI among others. In addition to baseline monitoring described in Section 4, Honeywell will be conducting monitoring during remediation and post-construction OM&M in Onondaga Lake. Monitoring conducted to date by Onondaga County, UFI, SUNY ESF, and United States Geological Survey (USGS) within the lake and its tributaries is summarized in Table 4 and also discussed briefly in this section. When developing specific baseline monitoring work plans, effort will be made to use or supplement these existing monitoring programs to minimize duplication of effort.

5.1 Other Pre-Remediation Monitoring by Honeywell

During the design phase, Honeywell is conducting several monitoring activities (in addition to those described for baseline monitoring) to assist in design of the remedy. These activities include measurement of current velocities in the hypolimnion and sediment incubation tests to determine the concentration of nitrate and/or oxygen that inhibits mercury flux from sediments; and capping bench and column tests to provide additional basis for design of the isolation cap layer (Parsons, 2007b). Data from these activities are being used to design the lakewide nitrate/addition pilot as well as the dredging/capping portions of the remedy.

5.2 Performance Monitoring and Post-Construction OM&M by Honeywell

Performance monitoring and post-construction OM&M programs will be developed during the design phase so details are unavailable at this time. The purpose of performance monitoring is to evaluate potential effects on the lake during implementation of the remedy. Monitoring activities will likely include water sampling to monitor water quality that may be affected by dredging/capping. Baseline monitoring of water and biota is likely to continue during the construction phase of the remedial program.

The purpose of post-construction OM&M is to evaluate the effectiveness of the remedy in achieving the RAOs and PRGs as well as the long-term integrity of the remedy. In addition to monitoring media for which PRGs have been defined (i.e., sediment, water, fish), OM&M will likely include assessment of the isolation cap, thin-layer cap, and SCA integrity and effectiveness.

5.3 Monitoring by Entities Other Than Honeywell

Onondaga Lake monitoring activities described herein are primarily being conducted by the NYSDEC, the OCDWEP and UFI. In addition to NYSDEC, OCDWEP, and UFI, the SUNY ESF, under Dr. Neil Ringler, is conducting fish monitoring and the USGS conducts tributary monitoring. Monitoring activities conducted since 1994 are summarized in Table 4. These monitoring programs will be evaluated to see if they can supplement the baseline monitoring required for the Onondaga Lake remedial program.

NYSDEC has sampled and analyzed adult game fish annually in recent years. The purpose of this work is to provide data with which NYSDOH can adjust the lake fish consumption advisory as warranted. Since 2003, this fish sampling has consisted of at least 20 samples of largemouth and smallmouth bass analyzed primarily for mercury, lipid content, and percent moisture in fillet samples. Every other year since 2003, the analyses by NYSDEC have also included hexachlorobenzene, PCBs, and pesticides.

Each year, the OCDWEP collects and analyzes more the 20,000 water quality samples and hundreds of biological samples from the lake and its watershed for its Ambient Monitoring Program (AMP). Samples are typically collected each year from ice out in late March or early April until November following fall turnover. The primary purposes of these County efforts are to evaluate water quality and biological conditions and assess compliance with water quality compliance given the County's ongoing efforts to provide more advanced wastewater treatment and control of combined sewer overflows. The data analysis and interpretation plan was recently summarized by EcoLogic (2006). In addition, the County provides annual updates of results for public consideration (OCDWEP, 2007 and 2008).

The County water sampling for the lake has two distinct elements: (1) continuous monitoring for a few parameters every 15 minutes at one location in the deeper portion of the lake's south basin (called South Deep) and at the lake outlet; and (2) biweekly to quarterly monitoring for many more parameters and at many more locations than is practicable with continuous monitoring. The biweekly to quarterly monitoring includes South Deep, the lake's north basin at a location called North Deep, the lake's nearshore zone, the lake's outlet near the Seneca River, several tributaries, and effluent from the County's Metropolitan Wastewater Treatment Plant (called Metro) released into the lake's south basin. Analytes monitored on a regular basis are primarily indicators of water quality and some metals. Organic contaminants are not analyzed. In addition to water quality monitoring, Onondaga County's AMP also investigates biological indicators to evaluate the overall vitality of the lake ecosystem. Biological monitoring focuses primarily on fish studies to monitor success in fish reproduction. The program involves counts of fish nests, samples of larval and adult fish, and tagging of adult fish to track individual histories. The monitoring program also includes studies of phytoplankton, zooplankton, macroinvertebrates, and aquatic plants. OCDWEP sample locations for water and benthic invertebrates are included in Figures 2 and 3.

Similar to the County, UFI monitors Onondaga Lake water quality beginning at ice out and continuing through the week following fall turnover. UFI's monitoring is primarily conducted at a location in the middle of the southern basin of the lake called South Deep. UFI's data set for Onondaga Lake goes back to 1978 and includes water quality, zooplankton, phytoplankton, and sediment traps at multiple water depths. UFI also has conducted water quality monitoring at Onondaga Creek, Ninemile Creek, Ley Creek, and at the lake outlet. Tributary and lake outlet monitoring are conducted by UFI every two weeks from April through November. UFI's water monitoring associated with the evaluation of nitrate addition for Honeywell (described in Section 4.3) is not included in Table 4.

SUNY ESF began sampling adult fish in 1986. The primary purpose of fish monitoring by SUNY ESF is to estimate fish population size and fish migration patterns. Most of this fish monitoring is conducted in the areas close to shore where water depths are less than 30 ft. (9 m). The sampling program varies from year to year depending on funding and student interests. During 2005 and 2006, fish netting efforts by SUNY ESF resulted in particularly large numbers of fish being measured, weighed, and then marked with a tag prior to being released back to the lake.

The USGS has completed multiple efforts involving surface water in the Onondaga Lake watershed. USGS measures tributary flow rates in the major tributaries to the lake (Onondaga Creek, Ninemile Creek, Ley Creek, Harbor Brook) and at the lake outlet. Flow rates are measured and recorded every 15 minutes. USGS also recently completed a three-year watershed-wide surface water quality evaluation of nonpoint runoff and sediment and nutrient loads reaching lake tributaries (Coon et. al., 2009).

6.0 SCHEDULE AND ANTICIPATED DELIVERABLES

The baseline monitoring program for Onondaga Lake was formally initiated by Honeywell in 2008. The following baseline monitoring work plans (or books) were approved by NYSDEC and USEPA for 2008 and 2009:

- Book 1 – Deep Basin Water and Zooplankton Sampling and Analysis (UFI and SU, 2008b)
- Book 1 Work Plan Addendum 1 for 2009 (UFI and SU, 2009)
- Book 2 – Fish, Invertebrate, and Littoral Water Sampling and Analysis (Parsons, Exponent and QEA, 2008)
- Book 2 Work Plan Addendum 1 for 2009 (Parsons, Exponent, and Anchor QEA, 2009)

The Baseline Monitoring (Book 3) Work Plan for Tributary Monitoring (Parsons and Exponent, 2009) has also been prepared on behalf of Honeywell and is under review by NYSDEC.

In addition to these books, the following work plans related to MNR baseline monitoring have been approved by NYSDEC and USEPA:

- Onondaga Lake Microbead Marker Work Plan for Monitoring Natural Recovery in SMU 8 (Parsons, 2008c)
- Onondaga Lake PDI: Phase IV Pre-Design Investigation Work Plan (Parsons, 2008b), Addendum 8 – SMU 8 high-resolution cores.
- Onondaga Lake PDI: Phase VI Pre-Design Investigation Work Plan (Parsons, 2010), Addendum 5 – SMU 8 PECQ Sediment Sampling

The following work plan related to habitat characterization baseline monitoring was also approved by NYSDEC and USEPA for 2008 and 2009:

- Onondaga Lake PDI: Phase IV Work Plan (Parsons, 2008b), Addendum 1 – Habitat
- Onondaga Lake PDI: Phase V Work Plan (Parsons, 2009b), Addendum 1 – Habitat

Future revisions or updates to these books and work plans will be issued as additional addenda to the respective baseline monitoring work plan or PDI work plan.

Data reports for each of these books are being submitted separately on an annual basis. Data will also continue to be submitted to the agencies in the interim (prior to validation) on a regular basis as they become available from the laboratory.

As indicated in the Remedial Design Work Plan (Parsons, 2009a), subsequent design submittals following the initial design submittals for Onondaga Lake will include a Performance Monitoring Plan and a Post-Construction Monitoring Plan as warranted for the SCA, for dredging and SCA operations, for sediment capping, and for SMU 8.

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Appendix A *Phase I Sampling And Analysis Plan*

Appendix B *Quality Assurance Project Plan*

Appendix C *Project Safety Plan*

Appendix D *Emissions and Odor Work Plan*

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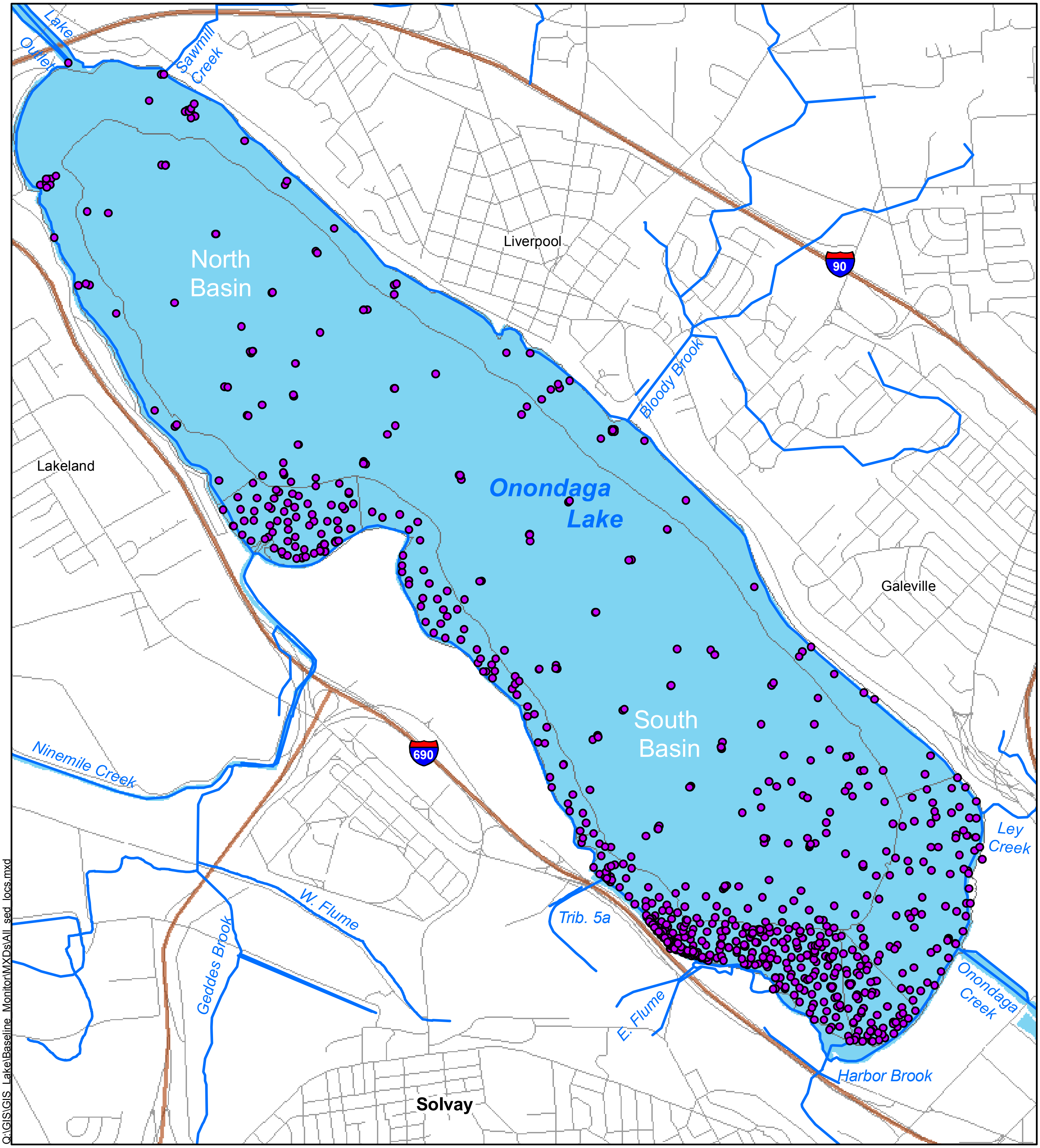
FIGURES



- RI and PDI Sediment Sampling Locations
- River or Brook
- Major Road
- Minor Road
- SMU Boundaries

Note: Locations include sediment samples collected from the 1992 RI through 2007 Phase III PDI.

0 | 1,250 | 2,500 | 5,000 | 7,500
Feet

Revised: 05/27/2010

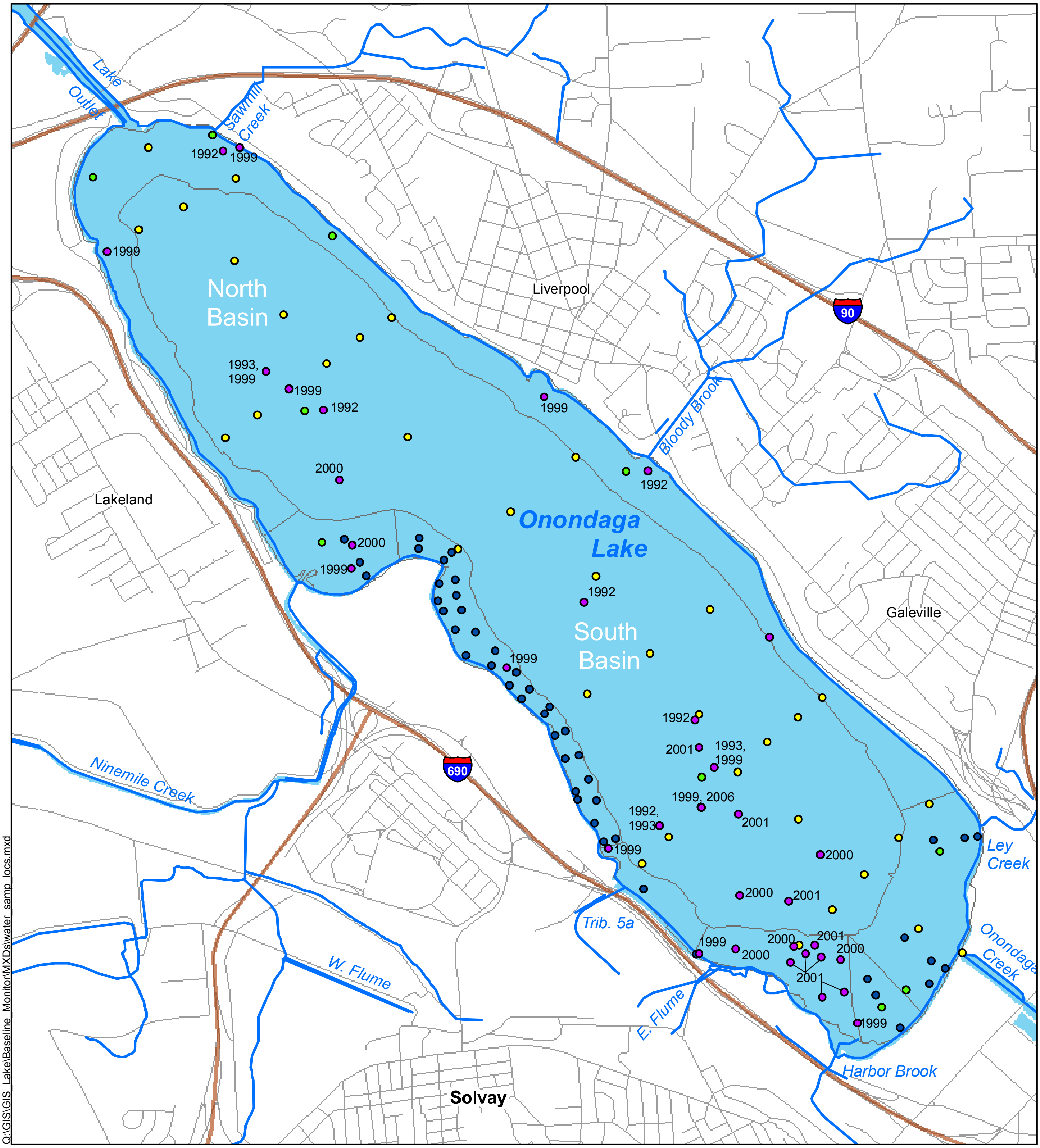
Figure 1

Honeywell — Onondaga Lake, Syracuse, New York

Sediment Sampling Locations Through 2007

PARSONS

290 ELWOOD DAVIS RD, SUITE 312, LIVERPOOL, NY 13088 Phone:(315)451-9560



- PDI (2005-2007) Water Sample Locations
- RI (1992-2001) Locations
- County Surface Water Locations
- UFI Surface Water Locations
- River or Brook
- Major Road
- Minor Road
- SMU Boundaries

0 1,250 2,500 5,000 7,500
Feet

Revised: 05/27/2010

Figure 2

Honeywell

Onondaga Lake
Syracuse, New York

Surface Water Sampling Locations Through 2007

PARSONS

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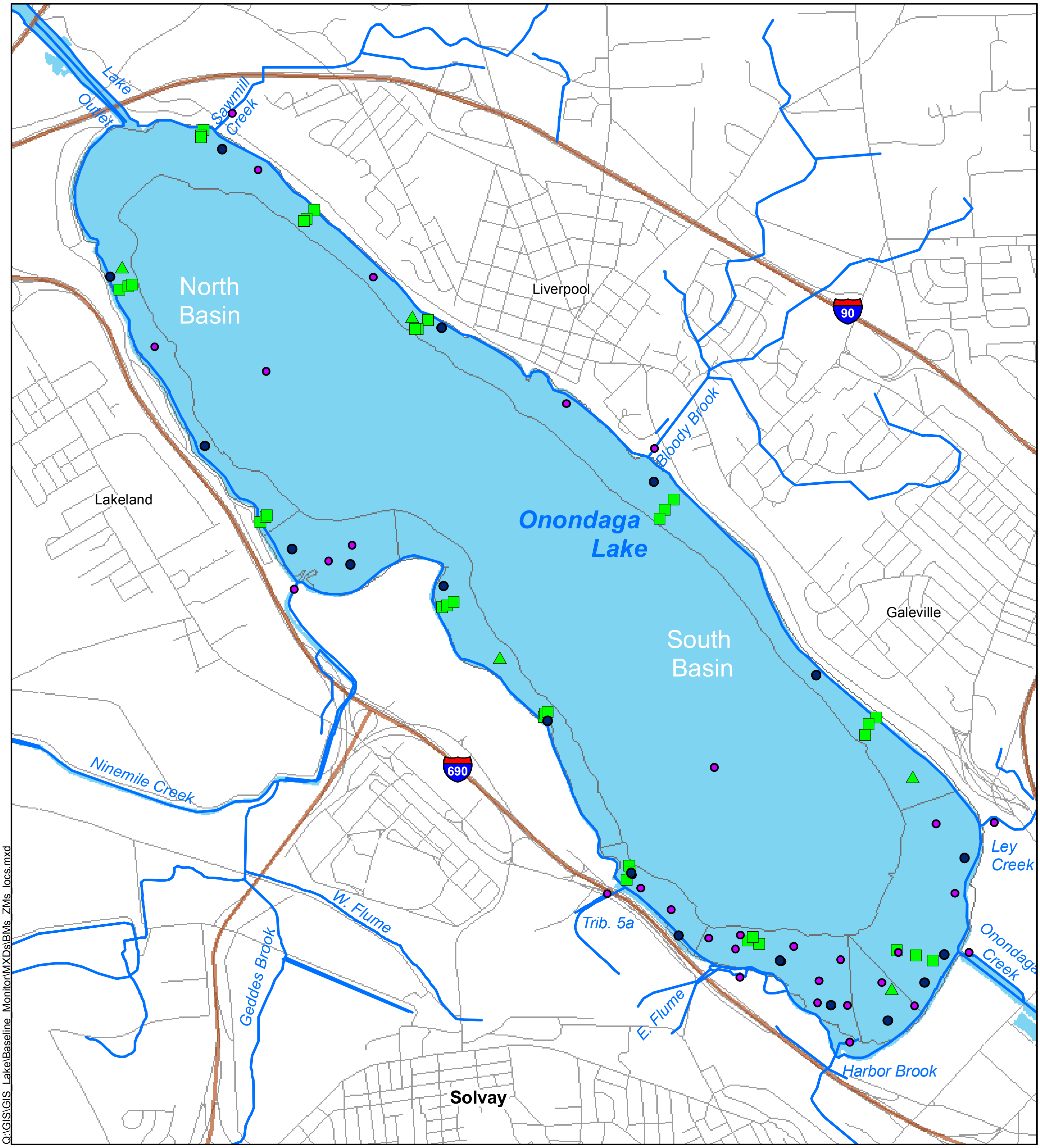

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RI (1992-2000) Locations

- Benthic Macroinvertebrates (chemistry only)

Baseline Monitoring (2008) Benthic Macroinvertebrates

- Benthic Macroinvertebrates

County Locations by Type

- Benthic Macroinvertebrates (community survey only)
- Zebra Mussels (biomass only)

- River or Brook
- Major Road
- Minor Road
- SMU Boundaries

0 1,400 2,800 5,600 8,400

Feet

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Figure 3

Honeywell

Onondaga Lake
Syracuse, New York

Benthic Invertebrate Sampling Locations Through 2008

PARSONS

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TABLES

TABLE 1
ONONDAGA LAKE BASELINE MONITORING
PROGRAM OBJECTIVES, PROGRAM ELEMENTS, AND DATA USES

PROGRAM OBJECTIVE	PROGRAM ELEMENT	DATA USE	
		Baseline for Remedy Effectiveness	**Baseline for Remedy Design**
Establish baseline chemical and physical conditions	Sediment sampling	Provide basis to measure achievement of PRG1 (mean PECQ1, mercury PEC, and mercury BSQV)	Assist in remedy design for dredging, isolation capping, and thin layer capping
			Provide data for refinement of MNR model during design phase
	Sport and prey fish sampling	Provide basis to measure achievement of PRG2 (fish tissue target concentrations)	
	Lake water sampling	Provide basis to measure achievement of PRG3 (surface water quality standards)	Provide information for design of nitrate addition/oxygenation pilot tests and basis to measure results
		Provide basis to measure success in controlling key processes (e.g., mercury methylation, sediment resuspension from the in-lake waste deposit, mercury release from profundal sediment)	Provide basis to establish goals for water quality during implementation of the remedy
	Air quality characterization	Establish baseline air quality in the vicinity of remedial activities	
	SCA characterization	Establish baseline groundwater quality in the vicinity of the SCA	Provide basis for design of sediment consolidation area
Provide additional data for future understanding of remedy effectiveness in achieving PRGs	External source monitoring	Quantify external loading of mercury	Identify other potential non-Honeywell sources of CPOIs to the lake
		Verify effectiveness of upland Honeywell remedies for all CPOIs	
	Other biota sampling[a]	Assess biological factors that may contribute to variability in fish mercury concentrations	
Provide habitat-related information	Habitat characterization	To be determined by Habitat Technical Work Group	Provide basis for design of habitat layer in sediment cap

[a]Other than adult sport and prey fish.

BSQV - bioaccumulation-based sediment quality value
CPOI - chemical parameter of interest
MNR - monitored natural recovery
PEC - probable effects concentration
PECQ - probable effects concentration quotient
PRG - preliminary remediation goal
SCA - sediment consolidation area

TABLE 2
HONEYWELL UPLAND SITES AND THEIR CONTRIBUTION OF CPOIs TO ONONDAGA LAKE

Site	Potential Transport Pathway	Primary CPOIs	Ongoing Monitoring, Construction, and/or Post-Construction Sampling
Willis Avenue / East Flume	Surface runoff, surface water, I-690 drains, shoreline seeps, groundwater	Mercury, BTEX, chlorinated benzenes (dissolved and DNAPL), PAHs, PCDD/PCDFs	I-690 storm drain rehab completed. Shoreline wall is now in place from Tributary 5A south to Wastebed B. The third section of shoreline wall (called the West Wall) is being installed beginning in 2010. The upper portion of the East Flume will be filled following installation of the West Wall. The lower portion of the East Flume will be remediated as part of ongoing shoreline remediation.
Semet Residue Ponds	Groundwater discharge to Tributary 5A and Willis Avenue Site	BTEX, PAHs	A Beneficial Use Determination for the Semet material has been completed. A Focused Feasibility Study is being revised. . Tributary 5A remediation will include a groundwater collection trench and sediment removal. Monitoring will follow.
Harbor Brook / Wastebed B[a]	Surface runoff, seeps, sediment, groundwater	Mercury, BTEX, PAHs, naphthalene, NAPL	Shoreline wall to be extended from Willis/Semet along Wastebed B past Harbor Brook. Monitoring will follow.
Wastebeds 1 through 8	Erosion, surface water, seeps, groundwater	BTEX, PAHs, phenols, and metals and dissolved ionic waste[b]	A Focused Feasibility Study for shallow groundwater is nearly complete. Monitoring will follow the remedial action.

TABLE 2 (CONTINUED)
HONEYWELL UPLAND SITES AND THEIR CONTRIBUTION
OF CPOIs TO ONONDAGA LAKE

Site	Potential Transport Pathway	Primary CPOIs	Ongoing Monitoring, Construction, and/or Post-Construction Sampling
LCP Bridge Street / West Flume	Surface runoff, surface water, and groundwater to Geddes Brook	Mercury	Post-construction sampling is ongoing.
Wastebeds 9 through 15	Surface runoff, seeps, and groundwater to Geddes Brook and Ninemile Creek	Dissolved ionic waste[b]	Closure will be completed. Quarterly outfall monitoring is ongoing. Shrub willow remedy will include a monitoring component.
Geddes Brook / Ninemile Creek	Surface water sediment and floodplain soil/sediment	Mercury, hexachlorobenzene, arsenic, lead, PCBs, PAHs, phenol, PCDD/PCDFs, and calcite	The site remedy is being designed. Post-construction sampling will follow remedial action.

[a] Including former Barrett Paving facility

[b] Dissolved ionic waste contains calcium, chloride, iron, magnesium, manganese, potassium, sodium, and total dissolved solids. These dissolved ionic constituents are considered CPOIs that are potentially being transported from the wastebeds to Geddes Brook / Ninemile Creek and Onondaga Lake via surface runoff, seeps and groundwater.

TABLE 3
NON-HONEYWELL UPLAND SITES AND THEIR POTENTIAL CONTRIBUTION OF CPOIs TO ONONDAGA LAKE

Site or Location	Potential Transport Pathway	Primary CPOIs
General Motors former Inland Fisher Guide facility and Ley Creek Deferred Media Site	Surface runoff, surface water via Ley Creek, and groundwater	PCBs, solvents, copper, nickel, chromium
GM Old Ley Creek Channel Site	Surface water via Ley Creek	PCBs, metals
Ley Creek PCB Dredgings Site	Surface water via Ley Creek	PCBs
Town of Salina Landfill	Surface water via Ley Creek	PCBs, paint sludges
Oil City area	Groundwater and Onondaga Creek	BTEX, PAHs, chlorinated hydrocarbons, PCBs
Former Niagara Mohawk Power Corporation manufactured gas plants on Hiawatha and Erie Boulevards	Groundwater from Hiawatha Boulevard site and groundwater-surface water to Onondaga Creek	PAHs, BTEX, phenols, cyanides, metals (DNAPL plume observed at both sites)
Metro Plant	Treated wastewater, partially treated wastewater and stormwater from combined sewer overflows during significant wet events	Metals, PAHs, and other urban and industrial compounds
American Bag and Metal Site	Surface water via Onondaga Creek	PCBs, paint wastes
Roth Steel, Hiawatha Blvd site	Surface water and groundwater	PCBs, metals
Crucible Materials Corporation and Crucible Lake Pump Station disposal site	Surface water via Tributary 5A and in-lake wastes. Groundwater via historic waste disposal area.	Metals
Electronics Park facility	Surface water via Bloody Brook	Cadmium
Urban runoff	Overland flow	PAHs, lead, chromium, copper, nickel, zinc
Syracuse Harbor	Dredge spoils from prior dredging effort	Unknown

Based primarily on information provided in the Remedial Investigation report (TAMS Consultants, 2002). Additional non-Honeywell potential sources may be identified.

TABLE 4

SUMMARY OF ONGOING MONITORING ACTIVITIES IN ONONDAGA LAKE AND ITS TRIBUTARIES CONDUCTED BY ENTITIES OTHER THAN HONEYWELL 1994 TO PRESENT

Program	Parameter	Water Body	Station/Depth	Organization	Duration	Period	Frequency/Depths
Hydrodynamic Data	Flow rate	Onondaga Creek	Dorwin Ave	USGS	1994 - present	year-round	Daily/15-minute
		Onondaga Creek	Spencer St	USGS			
		Ley Creek	Park St	USGS			
		Ninemile Creek	Lakeland	USGS			
		Harbor Brook	Hiawatha Blvd	USGS			
		Harbor Brook	Holden	USGS			
		Tributary 5A	---	OCDWEP			Monthly
		East Flume	---	OCDWEP			Monthly
		Metro	Metro Effluent (Outfall 001)	OCDWEP			Daily
		Metro	Metro Bypass (Outfall 002)	OCDWEP			Daily
		Onondaga Lake Outlet	Upstream of John Glenn Blvd	USGS	2003 - present		15-minute (velocity data summarized into vertical flow bins)
		Onondaga Lake Outlet	Southern channel of the Seneca River around Klein Island	USGS			
		Onondaga Lake Outlet	Northern channel of the Seneca River around Klein Island	USGS			
Water Quality Parmeters Measured On Site	Temperature and salinity	Onondaga Lake Outlet	Long Branch Road at 2-foot water depth	OCDWEP	1994 - present	year-round	Biweekly
		Onondaga Lake Outlet	Long Branch Road at 12-foot water depth	OCDWEP	1994 - present	year-round	Biweekly
	Temperature, pH, salinity, conductivity, dissolved oxygen, redox potential, turbidity and chlorophyll-a	Onondaga Lake Outlet	Upstream of John Glenn Blvd	OCDWEP	2003 - present	year-round	Every 15-minutes (at 1 and 3-meter water depths)
	Temperature, pH, salinity, conductivity, dissolved oxygen, redox potential, and (at water surface only) turbidity and chlorophyll-a	Onondaga Lake	South Deep Station (at 2, 6, 12, and 15-meter water depths)	OCDWEP	2000 - present	April - November	Every 15 minutes
	Temperature and salinity	Onondaga Lake	South Deep Station (every 0.5 meter from 0 to 18 meter water depth)	OCDWEP	1994 - present		Biweekly
		Onondaga Lake	North Deep Station (every 0.5 meter from 0 to 18 meter water depth)	OCDWEP	1994 - present		Quarterly

TABLE 4 (cont.)

**SUMMARY OF ONGOING MONITORING ACTIVITIES
IN ONONDAGA LAKE AND ITS TRIBUTARIES CONDUCTED BY ENTITIES OTHER THAN HONEYWELL
1994 TO PRESENT**

Program	Parameter	Water Body	Station/Depth	Organization	Duration	Period	Frequency/Depths
Water Quality Data	Metals (Cd, Cr, Cu, Ni, Pb, Se, Zn, As, K)	Onondaga Lake	North Deep Station	Onondaga County Department of Water Environment Protection (OCDWEP)	1994 - present	April - November	Quarterly (upper mixed layer composite and lower water layer composite)
	Hg (DL=0.1 ng/L THg, 0.02 ng/L MeHg)						Quarterly (at 3 and 18-meter water depths)
	Metals (Ca, Na, Mg, Mn, Fe) and Conventionals (Cl, SO_4)						Quarterly (upper mixed layer composite and lower water layer composite)
	Inorganics (TS, TSS, VSS, TVS, TDS, SiO_2, TOC, TOC-F, TIC)						Quarterly (at 0, 6, 12, and 18-meter water depths)
	Turbidity						Quarterly (upper mixed layer composite)
	BOD_5, NO_3, NO_2, ALK-T						Quarterly (upper mixed layer composite and lower water layer composite)
	TP, SRP, TDP, TKN, NH_3-N, Org-N, F-TKN						Quarterly (every 3 meters from 0 to 18-meter water depth)
	Biological (Fecal Coliform, E. Coli)						Quarterly (surface)
	Biological (chlorophyll-a, phaeophytin a, phytoplankton, zooplankton)						Quarterly (upper mixed layer composite, zooplankton additionally at 15 meters, and chlorophyll-a additionally as photic zone composite)
	Sulfide						Quarterly (at 12, 15, and 18-meter water depths)
	Surface Water Quality (pH, temperature, salinity, conductivity, redox potential, DO)						Quarterly (every half meter from 0 to 18 meter water depth)
	Underwater illumination profile, secchi disk transparency						Quarterly

TABLE 4

SUMMARY OF ONGOING MONITORING ACTIVITIES
IN ONONDAGA LAKE AND ITS TRIBUTARIES CONDUCTED BY ENTITIES OTHER THAN HONEYWELL
1994 TO PRESENT

Program	Parameter	Water Body	Station/Depth	Organization	Duration	Period	Frequency/Depths
Water Quality Data	Metals (Cd, Cr, Cu, Ni, Pb, Se, Zn, As, K)	Onondaga Lake	South Deep Station	OCDWEP	1994 - present	April - November	Quarterly (upper mixed layer composite and lower water layer composite)
	Hg (DL=0.1 ng/L THg, 0.02 ng/L MeHg)						Quarterly (at 3 and 18-meter water depths)
	Metals (Ca, Na, Mg, Mn, Fe) and Conventionals (Cl, SO_4)						Biweekly (upper mixed layer composite and lower water layer composite)
	Inorganics (TS, TSS, VSS, TVS, TDS, SiO_2, TOC, TOC-F, TIC)						Biweekly (at 0, 6, 12, and 18-meter water depths)
	Turbidity						Biweekly (upper mixed layer composite)
	BOD_5, NO_3, NO_2, ALK-T						Biweekly (upper mixed layer composite and lower water layer composite)
	TP, SRP, TDP, TKN, NH_3-N, Org-N, F-TKN						Biweekly (every 3 meters from 0 to 18-meter water depth)
	Biological (Fecal Coliform, E. Coli)						Biweekly (surface)
	Biological (chlorophyll-a, phaeophytin a, phytoplankton, zooplankton)						Biweekly (upper mixed layer composite, zooplankton additionally at 15 meters, and chlorophyll-a additionally as photic zone composite)
	Sulfide						Biweekly (at 12, 15, and 18-meter water depth)
	Surface Water Quality (pH, temperature, salinity, conductivity, redox potential, DO)						Biweekly (every half meter from 0 to 18 meter water depth)
	Underwater illumination profile, secchi disk transparency						Biweekly
Water Quality Data	Field parameters (pH, temperature, salinity, conductivity, redox potential, and oxygen)	Onondaga Lake	South Deep Station	UFI	1994 - 1999	April - November	Weekly
					2000 - present	April - November	Daily
	Nutrients, carbon, solids, pH, and other parameters	Onondaga Lake	South Deep Station	UFI	1994 - present	April - November	Weekly at multiple depths
	Phytoplankton, zooplankton, sediment traps, and gas sampling	Onondaga Lake	South Deep Station	UFI	1994 - present	April - November	Weekly
	Fecal Coliform, E. Coli, turbidity, secchi disk, temperature	Onondaga Lake	Onondaga Lake Littoral Zone (9 stations around the lake)	OCDWEP	1994 - present	May - September	Weekly (at less than 1-meter water depth)

TABLE 4 (cont.)

SUMMARY OF ONGOING MONITORING ACTIVITIES
IN ONONDAGA LAKE AND ITS TRIBUTARIES CONDUCTED BY ENTITIES OTHER THAN HONEYWELL
1994 TO PRESENT

Program	Parameter	Water Body	Station/Depth	Organization	Duration	Period	Frequency/Depths
Tributary Water Quality Sampling	Metals (Cd, Cr, Cu, Ni, Pb, Hg (DL=0.02 ug/L), Zn, As, K) and cyanide	Tributaries	Ninemile Cr. At Rte. 48, Harbor Brook at Hiawatha Blvd., Harbor Brook at Velaski Rd., Onondaga Creek at Kirkpatrick St., Onondaga Creek at Dorwin Ave., Ley Creek at Park St., Tributary 5A at State Fair Blvd., Metro Effluent , Allied East Flume, Onondaga Lake Outlet at Long Branch Rd - 2 feet, Onondaga Lake Outlet at Long Branch Rd., 12 feet, Bloody Brook at Onondaga Lake Parkway, Sawmill Creek at Onondaga Lake Recreational Trail, Onondaga Creek at Spencer St.[1]	OCDWEP	1994 - present	year-round	Quarterly
	Inorganics (NH_3, NO_2, NO_3, TP, SRP, TSS, TDP, BOD_5, TDS, Cl)						Biweekly and during storm events at selected tributaries (Onondaga Creek, Ley Creek, Harbor Brook)
	Metals (Ca, Na, Mg, Mn, Fe)						Biweekly
	Conventionals (SiO_2, SO_4, TOC, TOC-F, TIC, ALK-T, Turbidity, Fecal Coliform)						Biweekly and during storm events at selected tributaries (Onondaga Creek, Ley Creek, Harbor Brook)
	Field parameters (pH, temperature, salinity, conductivity, redox potential, DO, and chlorophyll-a)						Biweekly and during storm events at selected tributaries (Onondaga Creek, Ley Creek, Harbor Brook)
	Field measurements for temperature and conductivity. Lab analyses of samples for nutrients, solids, carbon, chloride, and cations	Tributaries	Ley Creek, Ninemile Creek, Onondaga Creek, and lake outlet	UFI	1994 - present	April - November	Biweekly
Aquatic Plants	Macrophyte coverage	Onondaga Lake	Aerial survey plus two samples in each of five strata to verify species identification	OCDWEP	2000 - present		Annually
	Macrophyte species diversity		Multiple transects in each of the five strata		2000 - present		Every 5 years
	Macroalgae percent cover and proliferation		9 near shore sites		2004 - present	April - November	Weekly
Fishes and Macroinverte-brates	Adult fish (tagged for community analysis)	Onondaga Lake	Up to 30 locations to 9 meter water depth	SUNY ESF	1986 - present	Summer	Varies
	Adult fish (contaminant analysis)		Throughout lake	NYSDEC	1970 - present		Annually
	Zebra mussel length frequency and density		8 habitat zones around the lake from 0 to 4.5-meter water depth	OCDWEP	2002, 2005, 2006 - present		Annually
	Zebra mussel length frequency and density		40 locations around the lake in littoral zone	UFI	2000-2003, 2007		Varies
	Adult fish, juveniles, fish larvae		Up to 24 from less than 1 meter to 5.5-meter water depth	OCDWEP	2000 - present		Twice annually to biweekly
	Macroinvertebrate indices, types, species richnesss		18 in each of 5 strata from shoreline to 1.5-meter water depth				Every 5 years

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SUMMARY OF ONGOING MONITORING ACTIVITIES
IN ONONDAGA LAKE AND ITS TRIBUTARIES CONDUCTED BY ENTITIES OTHER THAN HONEYWELL
1994 TO PRESENT

Program	Parameter	Water Body	Station/Depth	Organization	Duration	Period	Frequency/Depths
Meteorological Data	Air temperature, wind speed and direction, relative humidity, precipitation, and barometric pressure	Onondaga Lake	Near lake shoreline at Metro	OCDWEP	2000 - present	present	Every 10 minutes
	Air temperature, wind speed, relative humidity, daily average incident light, percent of cloudless maximum light, dew point temperature, specific humidity	Onondaga Lake	South Deep Station	UFI	2000 - present	April - November	Daily

Note:
1. A subset of parameters is measured at some tributaries and some tributaries are not sampled each year (OCDWEP, 2006).