

## 2. FIELD AND LABORATORY INVESTIGATIONS

Field and laboratory investigations were conducted by Honeywell with NYSDEC oversight in 1992, 1993, 1994, 1995, 1996, 1999, and 2000 to satisfy data requirements, as set forth in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and applicable USEPA guidance, for the Onondaga Lake Remedial Investigation (RI). Similarly, NYSDEC and TAMS Consultants, Inc. (TAMS) conducted a supplemental lake water investigation in December 2001 and supplemental Wetland SYW-6 sampling in May 2002. These investigations are listed in Table 2-1. This chapter summarizes the objectives, approach, and any modifications to the previously approved work plans for each of these investigations. In addition, each section of this chapter discusses how and where the respective data were used in this RI report, the Onondaga Lake Human Health Risk Assessment (HHRA) (TAMS, 2002b), and/or the Onondaga Lake Baseline Ecological Risk Assessment (BERA) (TAMS, 2002a).

It should be noted that while the information contained in this chapter is based on verified data, the NYSDEC or its representatives were not able to provide complete oversight of all sampling activities conducted by Honeywell and therefore cannot attest whether proper techniques were used by Honeywell in every instance.

The five major field investigations conducted by Honeywell in 1992 included the following:

- The geophysical survey (PTI, 1992a).
- The substance distribution investigation (PTI, 1993d).
- The mercury and calcite mass balance investigation (PTI, 1993c).
- The ecological effects investigation (PTI, 1993b).
- The bioaccumulation investigation (PTI, 1993a).

Each investigation was composed of several studies (18 total) that addressed specific issues, as shown in Table 2-1. In general, these investigations were designed to fill data gaps in the Onondaga Lake database in support of the RI objectives discussed in Chapter 1, Section 1.1. The rationale for each investigation is described in the Onondaga Lake RI/FS Work Plan (PTI, 1991c). The planned methods for conducting each investigation are presented in the two volumes of the sampling and analysis plan (SAP): the field sampling plan (PTI, 1991a) and the quality assurance project plan (QAPP) (PTI, 1991b).

The results of these five major investigations were submitted in separate reports (PTI, 1992a, 1993a,b,c,d) and approved by NYSDEC.<sup>1</sup> Each data report includes descriptions of the objectives and methods used, the data collected during the investigation, and results of data validation. The objectives, approach, and

---

<sup>1</sup>The Geophysical Survey Report, Substance Distribution Investigation Data Report, Mercury and Calcite Investigation Data Report, Ecological Effects Investigation Data Report, and Bioaccumulation Investigation Data Report were approved to the extent that these investigations were performed consistent with the approved Onondaga Lake RI/FS Work Plan (PTI, 1991c). However, the approval of the data reports was clarified by stating that the data reports were not necessarily complete from the standpoint of fulfilling all of the data needs for the RI and/or FS.

modifications to the work plan for each of the five major investigations and their component studies are presented in Sections 2.1 through 2.5.

Subsequent to the five major field investigations conducted in 1992, supplemental investigations were conducted in 1993, 1994, 1995, and 1996 to better evaluate the nature and extent of chemical parameters of interest (CPOIs) at the mouths of the tributaries (i.e., Sawmill Creek, Bloody Brook, Ley Creek, Onondaga Creek, Harbor Brook, the East Flume, Tributary 5A, and Ninemile Creek) to Onondaga Lake and to provide additional information about water column mercury methylation and possible remineralization rates in Onondaga Lake. Supplemental sediment sampling in the East Flume was performed by Honeywell in 1993, based on an approved work plan (PTI, 1993e). Supplemental sampling in the West Flume and Ninemile Creek was conducted in 1994 and 1995, based on approved work plans (PTI, 1995; PTI and Blasland, Bouck and Lee [BBL], 1994, 1995). Mercury methylation and remineralization studies were conducted in 1996, based on an approved work plan (PTI, 1996b).

The results of these supplemental investigations have been submitted in separate data reports (PTI, 1994a, 1996a, 1997). Each data report includes descriptions of the objectives and methods used, the data collected during the investigation, and results of data validation. Section 2.6 presents the objectives, approach, and modifications to the work plan for the supplemental studies conducted from 1993 through 1996.

Honeywell conducted two additional field investigations in 1999 and 2000, including supplemental lake water sampling in 1999 and the Phase 2A investigation in 2000, based on approved work plans (Exponent, 1999, 2000). Data for these investigations are included as appendices to this report, along with the results of data validation. Appendix A contains the supplemental lake water sampling data and Appendices B, C, and D contain the Phase 2A data, along with quality assurance reports. Sections 2.7 and 2.8 present the objectives and approaches of and modifications to the work plans for the 1999 and 2000 Phase 2A investigations.

In December 2001, NYSDEC and TAMS conducted the Phase 2B supplemental lake water investigation, based on an approved work plan (TAMS, 2001). Data for this investigation have not been presented in previous documents and are included in Appendix A6 of this report, along with the results of the data validation. Section 2.9 presents the objectives and approach of, and modifications to, the work plan for the Phase 2B supplemental water sampling.

In May 2002, NYSDEC and TAMS collected sediment/soil samples at five locations in Wetland SYW-6 adjacent to a location sampled during Phase 2A in 2000. Data for this investigation have not been presented in previous documents and are included in Appendix B3 of this report, along with the results of the data validation. Section 2.10 presents the objectives and approach for this supplemental Wetland SYW-6 sampling.

This chapter presents the objectives, investigative approach, and modifications to the work plan for each of the studies presented above.

## **2.1 Geophysical Investigation (1992)**

### **2.1.1 Objectives**

The geophysical investigation conducted from April 13 to 23, 1992, consisted of bathymetric, side-scan sonar, and sub-bottom profile surveys. The objective of the bathymetric survey was to map the water depth in Onondaga Lake. The objectives of the side-scan sonar and sub-bottom profiling surveys were to map the distribution of major surface and subsurface features of lake bed sediments, respectively. The geophysical survey was performed by Golder Associates Inc., under the direction of Exponent scientists on behalf of Honeywell. Results of the geophysical survey were presented in the Onondaga Lake RI/FS Geophysical Survey Report (PTI, 1992a) and are discussed in Chapter 3 of this document.

### **2.1.2 Description of the Investigation Approach**

The bathymetric, side-scan sonar, and sub-bottom profile surveys were performed on a series of parallel transects oriented east-west across the narrow dimension of the lake. The primary transect lines were spaced at 300-foot (ft) (91-meter [m]) intervals, and supplementary lines were run in selected areas at 100-ft (30.5-m) intervals. Cross-check lines running north-south were run at 1,000-ft (305-m) intervals. In addition, transects were run along the 3-m contour and the 10-m contour around the perimeter of the lake. A microwave positioning system with an accuracy of approximately  $\pm 1$  m was used to determine the horizontal location of the survey vessel.

A precision echosounder was used to record water depths with an accuracy of 0.03 m. The survey produced 79,494 pairs of depth-horizontal position observations. Side-scan sonar data were acquired with a 120 kHz transducer that produced a detailed image of the lake bed along the survey tracklines. This image was used to identify and map the distribution and variation of sediments, in addition to the location of unusual bathymetric features and discrete targets. The sub-bottom profiling system was accomplished with a Datasonics SBP-5000 high-energy sub-bottom profiling sonar system. This system was operated concurrently with the other geophysical systems.

### **2.1.3 Modifications to the Work Plan**

There were no modifications to the work plan.

## **2.2 Substance Distribution Investigation (1992)**

The substance distribution investigation data report (PTI, 1993d) presented the data associated with four studies: the sediment chemistry, lake water chemistry, groundwater chemistry, and petroleum hydrocarbon studies. The petroleum hydrocarbon study is included for informational purposes only since the investigation was conducted by Honeywell without informing NYSDEC until after the fact and, therefore, NYSDEC was not able to split samples or observe the field work. As listed in the work plan and Table 2-1, the four original studies were the lake water chemistry, groundwater chemistry, sediment chemistry, and sediment

nutrient studies. The sediment nutrient study is discussed in Section 2.3 and was presented as part of the mercury and calcite mass balance investigation data report, even though it was originally presented in the RI/FS Work Plan as being part of the substance distribution investigation. Table 2-2 summarizes the sampling and chemical analysis program. Figures 2-1 through 2-7 show sample locations for each investigation as determined by global positioning system (GPS). Some sample locations varied slightly between studies because studies were often conducted independently.

Chemical analysis described as “partial characterization” focused on substances of greatest interest for the study. Chemical analysis described as “full characterization” was performed on a few samples to confirm that all potential CPOIs were covered by the partial characterization. Results of the substance distribution investigation were presented in the Onondaga Lake RI/FS Substance Distribution Investigation Data Report (PTI, 1993d) and are discussed in Chapters 5 and 6 of this document. Data are also used in Chapter 3 of this document to describe physical characteristics of the site. Chemical data were used in the BERA and the HHRA (TAMS, 2002a,b).

## **2.2.1 Sediment Chemistry Study**

### **2.2.1.1 Objectives**

The objectives of the sediment chemistry study were to describe the horizontal and vertical distribution of substances in lake sediments and to determine mercury concentrations in surface sediment of the West Flume. However, these West Flume samples were not included in this Onondaga Lake RI since the West Flume is part of the Honeywell LCP Bridge Street site and corresponding RI report (NYSDEC/TAMS, 1998c).

In some cases, the sediment chemistry study failed to document the full extent of contaminant distribution in the lake and additional investigations were undertaken by Honeywell pursuant to approved work plans. Specifically, the petroleum hydrocarbon study, discussed above, is described in Section 2.2.4 and a more extensive investigation of sediment chemistry in the southwestern portion of the lake and at the mouth of Ninemile Creek was conducted in 2000 as part of the Phase 2A investigation (see Section 2.8). Investigations were conducted by Honeywell in Geddes Brook and Ninemile Creek in 1998 and 2001 and are documented in the Geddes Brook and Ninemile Creek RI report (Exponent, 2001d; currently under revision by NYSDEC).

### **2.2.1.2 Description of the Investigation Approach**

Sediment samples were collected from 114 locations in Onondaga Lake (Figure 2-1). Surface sediment (0 to 2 cm) was sampled at all locations. Additionally, sediment cores were collected at 73 locations in Onondaga Lake (Figure 2-2). Five surface sediment sample stations were located in both Otisco and Cross Lakes (Figure 2-3).

Surface sediment samples for full characterization analyses were collected at 19 stations in Onondaga Lake, all five stations in Otisco Lake, and all five stations in Cross Lake. Surface sediment samples for partial characterization analyses were collected from 95 stations in Onondaga Lake. All surface sediment samples were collected between July and September 1992.

The surface sediment samples were collected by Honeywell using a stainless-steel van Veen grab sampler. After a grab sample was deemed acceptable and the overlying water was siphoned off, the top 2 cm of sediment was removed. Additional grab samples were collected at each station until enough sample material was available for all analyses. Sediment material for volatile organic compound (VOC) and acid-volatile sulfide (AVS) analyses was prepared from an unhomogenized grab sample. The rest of the sediment was homogenized and placed in the remaining sample containers.

Sediment core samples were collected for full characterization analyses at 18 stations and for partial characterization analyses at 55 stations in Onondaga Lake (Table 2-2). Five additional cores were collected from Stations S12, S51, S73, S85, and S90 for detailed vertical stratigraphy analyses. Sediment cores were collected between May and October 1992.

Sampling in deeper waters was conducted from a 60-ft (18-m) research vessel using a 3-inch (7-cm) diameter, stainless-steel corer. The corer was lowered through the water column and allowed to penetrate the sediment under its own weight until the desired core length was achieved (about 2 to 5 ft [0.6 to 1.5 m], depending on the depositional environment in the lake). Sampling in shallow water was generally conducted from a 28-ft (8.5-m) pontoon boat. A slide-hammer corer was used to drive the corer into the sediments when the corer did not penetrate far enough under its own weight. The target length for stratigraphy cores was 8 ft (2.5 m).

### **2.2.1.3 Modifications to the Work Plan**

The following general modifications were made to the sampling and analysis strategy described in the work plan:

- The locations of several stations in the area between the outlets of Metro and the East Flume (Stations S15, S9, S3, S4, and S22) were modified by moving them to deeper water because of inaccuracies in the bathymetric contours used to select the station locations specified in the work plan. The presence of a broad shelf in this area prevented sampling at the 5-, 15-, and 25-ft (1.5-, 4.5-, and 7.6-m) water depths at the original sampling locations at the mouths of Metro, Harbor Brook, and the East Flume.
- Five stations were sampled in Otisco Lake to provide additional reference concentrations. Full characterization analyses were performed on surface sediment from those stations.

- The number of cores collected for stratigraphy was reduced from six to five. Five cores were considered sufficient to characterize the different historical deposition patterns of the lake. The original locations of the cores were changed to better define the depositional areas of the lake. The original locations were at Stations S15, S27, S51, S71, S73, and S90. However, Stations S51, S73, and S90 were considered sufficient to characterize the depositional history in the profundal and littoral zones, and Stations S15, S27, and S71 were replaced with Stations S12 and S85 to characterize deposition in the regions of Onondaga Creek and Ninemile Creek, respectively.
- Station S15 was sampled twice for the coring element of the sediment chemistry study because 1) the location surveyed for the initial sampling was uncertain, based on the recorded coordinates; and 2) visual observations of the first core collected suggested that substances of concern could be present at elevated concentrations below the deepest horizon initially sampled. For the second core collected, samples were analyzed to a greater depth for partial characterization analyses rather than full characterization analyses.
- Core depths were increased at some partial-characterization coring sites at the southern end of the lake where full-scan analyses of nearby cores showed elevated concentrations of VOCs at depth. Core depths were decreased at some partial-characterization coring sites at the northern end of the lake where full characterization analyses of nearby sites indicated the absence of elevated concentrations throughout the length of the core.
- Methanol was used instead of acetone as a decontamination solvent because it was more compatible with the sampling equipment.
- Simultaneously extracted metals (SEMs) were added to the list of analytes for stations where toxicity testing was performed to characterize the bioavailability of metals in surface sediments.
- Chlorinated benzenes and grain size were deleted from the list of analytes for stratigraphy cores because of sample size limitations. Grain size analyses were deleted because quantitative results from the coring survey indicated that grain size did not vary dramatically with depth. Mono-, di-, and trichlorinated benzenes were deleted from the list of analytes because the susceptibility of these compounds to degradation processes does not make them useful as stratigraphic indicators.
- A single station was considered sufficient for the full characterization analyses of subsurface sediments in the littoral zone between Bloody Brook and Sawmill Creek; therefore, Station S93, located midway between the tributaries, was

changed from a partial characterization surface station to a full characterization surface and core station. A core was not collected at Station S105, and the core collected at Station S73 was analyzed for partial characterization analytes.

- Polycyclic aromatic hydrocarbons (PAHs) and hexachlorobenzene were added to the list of analytes for selected partial characterization stations in the southern portion of the lake, based on preliminary data results.
- Benzene, toluene, ethylbenzene, and xylenes (BTEX) were added to the list of site VOCs.
- Magnesium was added to the list of site metals.

In addition, the following oversights by Honeywell occurred:

- The sample collected at Station S81 was analyzed for site VOCs instead of Target Compound List (TCL) VOCs as specified in the work plan.
- Three sets of field replicate samples were analyzed for mercury, instead of the six sets specified in the work plan for the surface sediment study. However, seven sets of field replicate samples were collected for the sediment core study, four of which were from the surface (0 to 30 cm) interval.

## **2.2.2 Lake Water Chemistry Study**

### **2.2.2.1 Objectives**

The objective of the 1992 lake water chemistry study was to determine representative concentrations of substances in the epilimnion and hypolimnion of Onondaga Lake. In addition, lake water chemistry data were needed for nearshore sites where people are likely to be in contact with lake water during recreation activities. This data collection was undertaken by Honeywell in 1999 as part of the supplemental lake water sampling described in Section 2.7. Furthermore, as discussed in Section 2.9, NYSDEC and TAMS conducted additional water sampling in 2001 to evaluate resuspension of mercury from sediments in the littoral zone in the southwest corner of the lake.

#### **2.2.2.2 Description of the Investigation Approach**

Lake water samples were collected by Honeywell once in September 1992 at two stations located approximately in the centers of the northern (Station W2) and southern (Station W1) basins of the lake (Figure 2-4). Unfiltered water samples were collected at each station from two depths corresponding to the middle of the epilimnion (20 ft [6 m]) and the middle of the hypolimnion (40 ft [12 m]). Field measurements were taken using a Hydrolab Surveyor 3 (beginning with the upper depth) after sampling

at each station was completed. To avoid potential sample contamination, sampling for mercury was conducted using a special “clean-hands technique” (USEPA sampling method 1669) (USEPA, 1995).

### **2.2.2.3 Modifications to the Work Plan**

The following modifications were made to the sampling and analysis strategy described in the work plan:

- Use of the Kemmerer sampler was found to be faster than use of the peristaltic pump originally proposed for sampling. The peristaltic pump was used only for metals (including mercury species), cyanide, and total suspended solids (TSS). An acrylic Kemmerer sampler was used to sample water for the following analytes: ammonia, total alkalinity, total sulfate, total sulfide, total chloride, total inorganic carbon (TIC), and total organic carbon (TOC). A stainless-steel Kemmerer sampler was used to sample water for the following analytes: TCL VOCs, TCL semivolatile organic compounds (SVOCs), and TCL pesticides and polychlorinated biphenyls (PCBs).
- The sampling depths were changed from those proposed in the work plan as follows: the epilimnion was sampled at about 20 ft (6 m) instead of 16 ft (5 m), and the hypolimnion was sampled at about 40 ft (12 m) instead of 46 ft (14 m). These changes were made to be consistent with the sampling depths used for the water column processes study of the mercury and calcite mass balance investigations.
- The sampling depths were measured from taped markings on the Teflon® tubing of the pump system rather than by use of sonar, as specified in the work plan. The markings were found to provide a more accurate gauge of sampling depth than using sonar to locate the Teflon® and stainless-steel weights.
- Lake water chemistry sampling was conducted in September, rather than August, as specified in the work plan. This change is not believed to have influenced the representativeness of the data since the water column was still stratified during the time of sampling.
- One of the samples targeted for TCL VOC analysis was analyzed for site VOCs instead.

## **2.2.3 Groundwater Chemistry Study**

### **2.2.3.1 Objectives**

The objectives of the groundwater chemistry study were to determine whether Wastebeds 12 through 15 are significant sources of ammonia and mercury to groundwater and to assess the potential transport of



mercury and site VOCs from the Semet Residue Ponds and Willis Avenue sites to the lake. The number of groundwater monitoring wells was limited in this study. Therefore, the results of the groundwater chemistry study were considered, along with data from more extensive groundwater investigations subsequently conducted for RIs at the Semet Residue Ponds (O'Brien & Gere, 1991), the LCP Bridge Street facility (NYSDEC/TAMS, 1998c), the Willis Avenue site (O'Brien & Gere, 2002e), and Wastebeds 9 to 15 (BBL, 1999), as well as data collected by Honeywell during an aquifer pump test along the lakeshore of the Semet Residue Ponds and Willis Avenue plant sites in 2001 and 2002 (O'Brien & Gere, 2002f). Results of the groundwater investigations associated with other RIs are discussed in Chapters 4 and 6.

### **2.2.3.2 Description of the Investigation Approach**

Groundwater was collected from 12 monitoring wells located upgradient and downgradient of Wastebeds 12 through 15 in May and September 1992 (Figure 2-5). Samples were collected using two 1-L Teflon® bailers connected with Teflon® couplings, and were analyzed for ammonia, TSS, and mercury.

Piezometers were installed at 19 stations in the lake sediments offshore from the Semet Residue Ponds and the Willis Avenue plant (Figure 2-6). Piezometers were installed to a depth of 8 to 10 ft (2.4 to 3 m) below the sediment-water interface. Groundwater samples were collected from the piezometers using 1-L Teflon® bailers. Water samples from all stations were collected in May and June 1992 and analyzed for site VOCs. In addition, a sample was collected from Station PZ18 in June 1992 and analyzed for Target Analyte List (TAL) metals, TCL SVOCs, TCL pesticides, and PCBs. Samples from Stations PZ15, PZ17, and PZ18 were collected in October 1992 and analyzed for TSS and dissolved mercury.

### **2.2.3.3 Modifications to the Work Plan**

The following modifications were made to the sampling and analysis strategy described in the work plan:

- Monitoring well W-132 was not sampled because Honeywell failed to obtain access to the site.
- Because of the high turbidity of the groundwater found at some sites during sampling in May 1992, a turbidimeter was used to measure turbidity levels during the September 1992 sampling effort. Samples from wells that were found to have high turbidity were analyzed for TSS and dissolved mercury, in addition to ammonia and total mercury.
- 2-inch (5-cm) inside-diameter piezometers were installed after the installation of 3/8-inch mini-piezometers because the method of sampling the mini-piezometers involved the use of a peristaltic pump, which could contribute to degassing of the VOC samples. The piezometers were sampled using 2-inch (5-cm) diameter disposable bailers.

- Mini-piezometers were installed to 8 to 10 ft (2.4 to 3 m) below the sediment-water interface, rather than 3 to 6 ft (0.9 to 1.8 m) as specified in the work plan, because of the loose nature of the upper 3 ft (0.9 m) of the sediments.
- No grain size distribution analysis was performed on sediments near the piezometers because it was determined that analyses from sediment cores would provide better characterization.
- Piezometers were not sampled for VOCs in the fall of 1992. Because the piezometers were installed to 8 to 10 ft (2.4 to 3 m) below the sediment-water interface, instead of 3 to 6 ft (0.9 to 1.8 m) as specified in the work plan, it was determined that VOC data obtained from the piezometers would not be useful in determining chemical flux at the sediment-water interface.
- Piezometers were not sampled for mercury in the spring of 1992, because the piezometers contained an insufficient volume of groundwater.
- One sample was analyzed for TAL metals, TCL SVOCs, TCL pesticides, and PCBs.

## **2.2.4 Petroleum Hydrocarbon Study**

This study (PTL, 1992b) is included for informational purposes only, since the investigation was conducted by Honeywell without informing NYSDEC until after the work was completed. Therefore, NYSDEC was not able to split samples or observe the field work. An approved work plan does not exist for this investigation.

### **2.2.4.1 Objectives**

The objective of the petroleum hydrocarbon study was to determine the extent of petroleum hydrocarbons in surface sediment at the southern end of Onondaga Lake between Harbor Brook and Ley Creek (see Figure 2-7). Honeywell added the petroleum hydrocarbon study to the substance distribution investigation after initial sediment sampling in this area indicated the presence of petroleum products. The petroleum hydrocarbon study was limited in its identification of contaminants and contaminant distribution; therefore, a more extensive investigation of sediment chemistry in the southwestern portion of the lake was subsequently conducted, with NYSDEC oversight, as part of the Phase 2A investigation (see Section 2.8).

### **2.2.4.2 Description of Investigation Approach**

Surface sediment samples were collected, using a van Veen grab sampler, from 34 stations at the south end of Onondaga Lake during September 1992 (Figure 2-7). Sediment from the top 2 cm of each acceptable grab sample was placed, without homogenization, into a 250-mL glass jar. A photoionization detector was

used to measure organic vapors in the head space. If the vapor measurement and a visual assessment for the presence of a sheen showed probable petroleum contamination, the sample was selected for total petroleum hydrocarbon analysis. A total of 31 stations, out of 34 sampled, were submitted for laboratory analysis of total petroleum hydrocarbons.

## **2.3 Mercury and Calcite Mass Balance Investigation (1992)**

The mercury and calcite mass balance investigation consisted of three studies:

- An external loading and flushing study.
- A water column processes study.
- A sediment processes and methylation study.

The sediment processes study included the sediment nutrient study, which was initially identified in the work plan as a component of the substance distribution investigation. The sediment nutrient study was reclassified as a component of the mercury and calcite mass balance investigation because the objectives of the sediment nutrient study were more closely related to the overall objectives of this investigation. Table 2-3 summarizes the sample collection and analysis program for this investigation. Results of the mercury and calcite mass balance investigation were presented in Honeywell's Onondaga Lake RI/FS Mercury and Calcite Mass Balance Investigation Data Report (PTI, 1993c) and were discussed in NYSDEC's revisions to the mercury and calcite modeling reports (NYSDEC/TAMS, 1998a,b), as well as in Chapters 5 and 6 of this document.

### **2.3.1 Loading and Flushing Study**

#### **2.3.1.1 Objectives**

The objectives of the loading and flushing study were to:

- Identify and quantify the sources of total mercury, methylmercury, calcite, calcite components, and other substances (BTEX; mono-, di-, and trichlorinated benzenes; and hexachlorobenzene) to the lake.
- Quantify the loss of these substances through the outlet of the lake.
- Estimate the loading of total mercury and other substances to the lake from atmospheric deposition and groundwater (based on groundwater data from the groundwater chemistry study of the substance distribution investigation discussed above).

The samples collected by Honeywell specifically to support these objectives included high- and low-flow tributary samples and air samples. As discussed in Chapter 6, mercury data from the tributary and outlet

samples permitted estimation of mercury loading to Onondaga Lake for the sampling period. Loading of mercury and other contaminants via groundwater is discussed in Chapter 6, based on groundwater results from other RIs and data obtained more recently by Honeywell.

### **2.3.1.2 Description of Investigation Approach**

Surface water samples were collected from 11 locations on primary tributaries and point sources, two locations on secondary tributaries, four Metro connections, and Metro influent (Figures 2-4 and 2-8). Primary tributaries and point sources were the East Flume, Geddes Brook, Ley Creek, Ninemile Creek (locations at both the mouth and upstream of the wastebeds), Onondaga Creek, Harbor Brook, Tributary 5A, the lake outlet, the Metro outfall, and Seneca River. Secondary tributaries were Bloody Brook and Sawmill Creek. Metro sanitary connections consisted of connections at Honeywell, Church and Dwight Co. Inc., and Hydra-Co; a pump station near the Semet Residue Ponds; and Metro influent. Sampling locations were chosen based on locations of potential sources and ease of access for all flow conditions.

Grab or vertically integrated surface water samples from low-flow conditions were collected from the 11 primary tributaries and point sources once per month from April through December 1992 and from the four Metro connections once per month from September through December 1992. The two secondary tributaries were sampled once during June 1992 low-flow conditions using a depth-integrated sampler. To avoid potential sample contamination, sampling for mercury was conducted using a special clean-hands technique (USEPA method 1669) (USEPA, 1995).

Surface water composite samples for high-flow conditions were collected from nine of the 11 primary tributaries and point sources (all except Seneca River and the lake outlet) and four Metro connections once per month from August through December 1992. Composite samples were collected with ISCO Model 3700 automatic samplers that were set to trigger and begin sample collection when stream levels increased by 2 inches (5 cm). After the monthly ISCO samplers were retrieved from the field, four grab samples were collected at the 0-, 5-, 10-, and 15-ft (0-, 1.5-, 3-, and 4.6-m) depth intervals from the lake outlet. Lake outlet samples for mercury were collected using a depth-integrating sampler with a Teflon® collection bottle and for the remaining analytes using a Kemmerer grab sampler. No samples were collected from the Seneca River during high-flow conditions. A single three-hour composite sample was collected manually from each of the two secondary tributaries in December 1992.

Measurements of flow during low-flow conditions were made at the sampling locations for Ley Creek, the East Flume, upper and lower Ninemile Creek (as described above), Geddes Brook, the lake outlet, Bloody Brook, and Sawmill Creek. Flow measurements for Harbor Brook were made at a US Geological Survey (USGS) gauging station 0.5 miles (mi) (0.8 kilometers [km]) upstream of the sampling location. Flow measurements for Tributary 5A were made 0.25 mi (0.4 km) downstream of the sampling location. Flow rates for Metro effluent and Onondaga Creek were obtained from the Onondaga County Department of Drainage and Sanitation (OCDDS) and USGS, respectively.

Water surface elevations at each station during high-flow conditions were continuously monitored and recorded electronically from May through December 1992 using ISCO Model 3230 Bubbler Flowmeters. Water levels were converted to flow rates based on the stage discharge relationships developed for each sampling location. The FLUX model (Walker, 1987) was used to combine the long-term flow records and the monitoring data to develop loading estimates to Onondaga Lake.

Air samples were collected at one station located at the Liverpool marina on the eastern shore of Onondaga Lake. A total of three 24-hour air samples were collected during October and November 1992.

### **2.3.1.3 Modifications to the Work Plan**

The following general modifications were made to the sampling and analysis strategy described in the work plan:

- Low-flow sampling for the primary tributaries did not occur in March 1992 because of prolonged high-flow conditions.
- High-flow sampling for the primary tributaries was delayed until August 1992 because the equipment modifications needed to accommodate ultra-clean sampling requirements for mercury took longer than anticipated.
- The Seneca River was added as a primary sampling station for chemical analysis (low-flow sampling only), beginning in May 1992, to further characterize water exchange at the lake outlet.
- Three sanitary connections to Metro were sampled, rather than the four specified in the work plan, because the waste holding pond had been inadvertently listed in the work plan as both a sanitary connection and as a separate sampling location.
- Influent to and effluent from Metro were not sampled between April and July 1992.
- The Metro intermittent high-flow outfall was not sampled because loading to the lake during sampling never exceeded the 160 million gallons per day (mgd) flow capacity of the treatment plant.
- During high flow, grab samples at four depths were collected at the lake outlet, rather than one grab and one composite sample, to better characterize potential changes in flow direction and loading with depth.
- Two sets of air samples were collected in October and November, not in May, August, and November, as stated in the work plan.

- Low-flow samples from several tributaries collected in August 1992 were not analyzed for methylmercury because of an oversight by the analytical laboratory. Supplemental samples were collected in early September for the analysis of total mercury and methylmercury from all previously omitted tributaries except Ley Creek and Onondaga Creek.
- Hexachlorobenzene was added to the list of analytes for all stations where chlorinated benzenes were targeted for analysis based on preliminary data.

In accordance with the analytical strategy described in the work plan, BTEX and chlorinated benzene compounds were eliminated as target analytes for all low-flow sampling events subsequent to September 1992 for all specified sampling locations except for the East Flume, Tributary 5A, and Harbor Brook because these analytes were not detected at the eliminated stations prior to September 1992.

In addition, the following high-flow samples were not collected because of equipment damage (e.g., from floating debris, tangled lines), and equipment failure:

- **August 1992** – The grab sample (mercury and hexachlorobenzene) and composite sample (all analytes) for upper Ninemile Creek because of tubing bent by high flow rates; both grab and composite samples (all analytes) at the Semet pump station because of access problems; and the grab sample (conventional analytes and metals) for Harbor Brook because of a jammed distributor mechanism.
- **September 1992** – The composite sample (all analytes) and the grab sample (mercury only) for Ley Creek because of tubing bent by floating debris.
- **October 1992** – The grab sample (mercury only) for Ley Creek because of a misaligned sample outlet.
- **November 1992** – The grab sample (metals and conventional analytes) for Metro effluent because of a misaligned sample outlet; all samples for Metro influent because of twisted tubing; Ley Creek because of premature triggering of the automated sampling equipment; lower Ninemile Creek because of broken connections to tubing, strainer, and stilling pipe; and Geddes Brook because of premature triggering of the automated sampling equipment.
- **December 1992** – All grab and composite samples (total mercury and methylmercury) for Metro influent and a composite sample (total mercury) for the Hydra-Co sewer connection, probably because of twisted tubing.

For some high-flow sampling events, only a subset of the ISCO samplers was triggered because rainfall was localized and the flow criteria needed to trigger sampling were not met for all sampling stations. This limitation was anticipated during study design.

## **2.3.2 Water Column Processes Study**

### **2.3.2.1 Objectives**

The objectives of the water column processes study for mercury were to:

- Determine the speciation (e.g., the percent of total mercury that is present as methylmercury) and temporal and spatial distribution of mercury in the water column.
- Investigate the partitioning of mercury between the dissolved and particulate fractions in the water column.
- Estimate the sedimentation rate for particles in the water column and, consequently, the loss rate for mercury partitioned onto the particles.
- Estimate the rate of volatilization of dissolved elemental mercury and dimethylmercury.

These objectives were met, with three exceptions. It was later determined that more resolution was needed in water column sampling for mercury during fall turnover and during potential resuspension events. Supplemental lake water sampling was conducted in 1999 (Section 2.7) and 2001 (Section 2.9) to address these needs. Sediment traps were redeployed in 1996 to provide additional data on mercury sedimentation to assess the potential for release of mercury from settling particles (Section 2.6.4). A dimethylmercury volatilization rate was not estimated because dimethylmercury was undetected in almost all lake water samples.

The objectives of the water column processes study for calcite were to:

- Determine whether calcite is currently being precipitated or dissolved in Onondaga Lake.
- Quantify the rates of formation and dissolution of calcite in the lake.
- Estimate the sedimentation rate for particles in the water column and, consequently, the loss rate for calcite and calcite components associated with the particles.

### 2.3.2.2 Description of Investigation Approach

Lake water samples were collected monthly from April through November 1992 at two stations located approximately in the centers of the northern (Station W2) and southern (Station W1) basins of the lake (Figure 2-4). Unfiltered water samples were collected at each station from water depths of approximately 0, 10, 20, 30, 40, 50, and 60 ft (0, 3, 6, 9, 12, 15, and 18 m) during summer stratification (May through September) and from water depths of approximately 10, 30, and 50 ft (3, 9, and 15 m) during lake turnover and winter stratification (April and October through November, respectively). Filtered water samples (duplicate samples of some of the unfiltered water samples) from these same depths were collected at one of the two stations. Field measurements were taken after sampling at each station was completed, beginning with the upper sampling depth.

Sediment trap samples were collected monthly from June through November 1992 at four stations in the lake. Traps were set at the thermocline and near the lake bottom in the northern and southern basins, and one trap each was set near the lake bottom in the vicinity of Ninemile Creek and in the southwest corner of the lake (Figure 2-9). Sediment traps were also deployed in 1996 during a supplemental study (Section 2.6).

### 2.3.2.3 Modifications to the Work Plan

**Lake Water Sampling** – The following modifications were made to the lake water sampling and analysis strategy described in the work plan:

- The southern basin replicate station for lake water was eliminated from all sampling events subsequent to July 1992 because the data collected were believed to be redundant with the primary southern basin station (i.e., no additional information on spatial variability was obtained).
- To expedite sampling, starting in May 1992, Kemmerer samplers were used to collect all samples except those for metals (including mercury species) and TSS, which were collected using the peristaltic pump. An acrylic Kemmerer sampler was used to collect samples for ammonia, total alkalinity, carbon dioxide, total sulfate, total sulfide, total chloride, TIC, and TOC. A stainless-steel Kemmerer sampler was used to collect samples for site VOCs.
- Water samples were not collected in March and December 1992 because of ice cover on the lake.
- TSS were determined according to Brooks Rand Method BR0008 (PTI, 1991b) instead of USEPA Method 160.2 (USEPA, 1983). The filter pore size specified in BR0008 (0.4  $\mu\text{m}$ ) is smaller than that of the glass-fiber filter specified in USEPA Method 160.2.



- Dissolved (filtered) water samples were analyzed for mercury species (total mercury, methylmercury, ionic mercury), instead of suspended sediment, because sufficiently low detection limits for mercury species in particles could not be achieved due to small sample size. Mercury concentrations on particles were estimated by subtracting dissolved concentrations from whole water (unfiltered) concentrations. Volatile mercury species (dimethylmercury and elemental mercury) are lost during filtration and, therefore, were not analyzed in the filtered samples.
- Beginning in August 1992, carbon dioxide was measured in the field immediately following sampling because of concerns about losses in carbon dioxide associated with delays in laboratory analysis.

In accordance with the work plan, BTEX and volatile chlorinated benzene compounds were eliminated as target analytes for all sampling events subsequent to September 1992, based on the repeated absence of detected values prior to September 1992.

**Sediment Trap Sampling** – The following modifications were made to the sampling and analysis strategy described in the work plan and SAP:

- Sediment traps were not deployed in March or April 1992 because of delays in developing the technology for low-level mercury sampling.
- Sediment trap samples were not collected in December 1992 because of ice cover on the lake.
- Duplicate sediment traps containing preservatives (or poisons) to reduce microbial and zooplankton activity were not deployed. Previous sediment trap investigations on the lake (Effler and Driscoll, 1985) did not include poisons, and other limitations associated with poisons (e.g., the potential to complex with mercury, to contaminate the sample, and to interfere with laboratory analysis) justified the elimination of the poisoned traps.
- Navigational buoys were added to the sediment trap array to provide an easier method of locating sediment traps.
- Total mass of material in the sediment trap, inadvertently excluded from the analyte list in the work plan, was measured for each sediment trap sample.

### **2.3.3 Sediment Processes Study**

#### **2.3.3.1 Objectives**

The objectives of the sediment processes study were to:

- Quantify the fluxes of total mercury and methylmercury from representative littoral and profundal sediments to the overlying water.
- Quantify the rates of mercury methylation in the water column and sediment.

Technical difficulties and highly variable results limited the use of the flux and methylation data (NYSDEC/TAMS, 1998b). Mercury methylation rates were re-examined in the supplemental mercury methylation study using a slightly different method (addition of a radioisotope of mercury) (Section 2.6.4).

The sediment nutrient study, originally identified as a component of the substance distribution investigation, was reclassified as a component of the sediment processes study. The primary objectives of the nutrient study were to:

- Determine the concentrations of algal and macrophytic nutrients in sediments and interstitial water at stations representative of the range of sediment types and substance concentrations in Onondaga Lake.
- Determine the sediment variables that control the release of nutrients from the sediments.

The original intended use for these data was in support of a eutrophication model for the lake; however, this application was not pursued by Honeywell, and NYSDEC determined the model was not necessary in order to complete the lake RI/FS. Therefore, these data were not used in this report or the risk assessments.

#### **2.3.3.2 Description of Investigation Approach**

Sediment samples for all components of the sediment processes study were collected from six stations in Onondaga Lake (Figure 2-9). Two locations are shown for Station S29 because the boat drifted during sampling. The locations represent the two endpoints between which sampling was conducted. Samples for nutrients and related analytes in porewater and sediment and for nutrient flux chamber experiments (Table 2-3) were collected at all six stations. Samples for mercury species in porewater and sediment were collected from four of the six stations (Stations S4A, S73A, S83A, and S90A), and samples for mercury flux chamber and sulfate depletion experiments were collected at three stations (Stations S4, S73, and S90). Water column samples for mercury methylation rate experiments were collected from a single station (Station S90A) at three depths (10, 30, and 50 ft [3, 9, and 15 m]).

For nutrients and related analytes, samples for porewater, sediments, and sediment flux were collected in August and November 1992 to assess temporal variability in nutrient distribution and flux.

Based on past study results by Bloom and Effler (1990) for mercury species and related analytes, samples were collected in August of 1992 when both methylmercury concentrations and methylation production rates were predicted to be at their highest level. The data collected during this time period are thus assumed to provide a worst-case estimate of the fluxes of mercury and methylmercury from sediments and of mercury methylation rates in sediments and lake water.

### **2.3.3.3 Modifications to the Work Plan**

At the time the work plan (PTI, 1991c) and SAP (PTI, 1991a,b) were prepared, the methods for laboratory and field tests associated with the sediment processes study were under development. Methods for mercury flux and methylation experiments were provided in a supplemental plan (PTI, 1992c). Methods for the sediment nutrient study (originally classified as a component of the substance distribution investigation) were included in the work plan and SAP (PTI, 1991a,b,c), but were later enhanced to include the flux chamber experiments to be conducted in accordance with the methods developed for the Chesapeake Bay monitoring program (Burdige, 1989).

The following general modifications were made to the sampling and analysis strategy described in these planning documents:

- A nutrient flux experiment was added to the sediment processes study to provide a more reliable measure of nutrient exchange across the sediment-water interface.
- A sulfate depletion experiment was added to the sediment processes study to refine the assessment of sulfate reduction and its relationship to mercury methylation.
- Sediment samples for analysis of nutrients and related analytes in porewater and sediments and for nutrient flux experiments were collected in August and November 1992 instead of May, August, and November 1992 because of delays in scheduling and planning.
- Mercury and methylmercury in porewater and sediment were determined at four stations, rather than the three specified in the sediment processes study work plan (PTI, 1992c), to better characterize potential spatial variability in near surface porewater and sediment gradients.
- Water samples for the methylation experiment were collected from a single station at three depths instead of at two stations (northern and southern basin) and two depths. Results from the water column processes study indicated that differences

in horizontal variability between the northern and southern basin water column stations were minimal; therefore, only a single station was needed. Additional characterization of potential vertical variability in mercury methylation rates (and thus the addition of another depth horizon) was considered desirable.

- Chloride was included as an analyte in the nutrient flux experiments, as specified in the work plan, but it was eliminated from the mercury flux experiments because it was redundant with the nutrient flux experiments.
- Total organic carbon was added to the list of analytes for the sediment cores collected for nutrients. Field measurements (pH, conductivity, and temperature) and carbonate were deleted from the list of analytes. The deleted analytes were redundant with measurements made for the water column processes study and the sediment chemistry study.
- As specified in the sediment processes study work plan (PTI, 1992c), porewater and sediment profiles were generated for total mercury and methylmercury. The original work plan (PTI, 1991c) had specified additional mercury species (i.e., elemental mercury, dimethylmercury, and ionic mercury); however, if all analyses had been performed, analytical sample size would have had to be reduced, increasing detection limits to unacceptable levels.

## **2.4 Ecological Effects Investigation (1992)**

The ecological effects investigation included five studies: the sediment toxicity study, the benthic macroinvertebrate study, the nearshore fish study, the macrophyte distribution study, and the macrophyte transplant study. The primary objectives of this investigation were to:

- Describe the status and spatial distributions of various kinds of biological assemblages in Onondaga Lake.
- Evaluate the temporal variability of selected assemblages.
- Determine to what extent any observed adverse biological effects are related to substances in the lake.

Data were collected by Honeywell from two potential reference lakes, Cross and Otisco Lakes. Otisco Lake was determined to be the appropriate reference lake for the macrophyte transplant study, the sediment toxicity study, and the benthic macroinvertebrate study. Cross Lake was determined not to be an appropriate reference lake for these studies and, therefore, will not be further referenced with respect to these studies. A summary of the design specifications achieved for the ecological effects investigation is presented in Table 2-4. Each of the five studies is discussed below. Methods and results of the ecological

effects investigation were presented in the Onondaga Lake RI/FS Ecological Effects Investigation Data Report (PTI, 1993b) and are discussed in the BERA (TAMS, 2002a).

## **2.4.1 Sediment Toxicity Study**

### **2.4.1.1 Objectives**

The objective of the sediment toxicity study was to evaluate the toxicity of surface (0 to 2 cm) sediments to sensitive and representative test species (benthic macroinvertebrate assemblages) in relation to substance concentrations and conventional variables (e.g., grain size distribution, TOC, and AVS). Additional sediment toxicity testing was conducted during the Phase 2A investigation in 2000 (see Section 2.8.3.3) to enable comparison of the 10-day studies from 1992 with newer 40-day studies from 2000.

### **2.4.1.2 Description of Investigation Approach**

Sediment toxicity was evaluated at 79 stations in Onondaga Lake (Figure 2-10) and at five stations in Otisco Lake (Figure 2-3), the reference lake for this investigation. Sampling was conducted during July and August 1992 in conjunction with the sampling of surface sediments for the substance distribution investigation (Section 2.2.1) and the sampling of benthic macroinvertebrate assemblages for the ecological effects investigation (Section 2.4.2).

Sediment toxicity was evaluated using the amphipod (*Hyaella azteca*) and the chironomid (*Chironomus tentans*) tests. These are surrogate species selected to represent both epibenthic (*H. azteca*) and infaunal (*C. tentans*) macroinvertebrates. The laboratory methods used for the amphipod and chironomid tests were based on the standard methods recommended by the American Society for Testing and Materials (ASTM) (1991).

### **2.4.1.3 Modifications to the Work Plan**

The following modifications were made to the work plan:

- Methanol was used instead of acetone as a decontamination solvent because it was more compatible with the sampling equipment used during the RI/FS.
- One additional station (Station S15) was evaluated for sediment toxicity because the actual bathymetry in the southwest corner of the lake differed from the bathymetry presented in historical studies.
- The amphipod toxicity test was conducted at all stations evaluated for sediment toxicity, rather than at a subset of those stations.

- Triplicate samples were collected at two stations (Stations S1 and S17) to provide an indication of the field variability related to the toxicity results.

## **2.4.2 Benthic Macroinvertebrate Study**

### **2.4.2.1 Objectives**

The objectives of the benthic macroinvertebrate study were to:

- Evaluate the structure of the assemblages in Onondaga Lake in relation to substance concentrations, conventional variables (e.g., grain size distribution, TOC, and AVS), and sediment toxicity in surficial sediments.
- Provide an estimate of the amount of fish food organisms available in various parts of the lake.

Additional characterization of benthic assemblages was included in the Phase 2A investigation in 2000 (Section 2.8).

### **2.4.2.2 Description of Investigation Approach**

Benthic macroinvertebrate assemblages were evaluated at 66 stations in Onondaga Lake (Figure 2-10), eight stations in the tributaries to Onondaga Lake (Figure 2-10), and five stations in Otisco Lake (Figure 2-3), which was used as a reference lake for this investigation. Sampling was conducted during the summer (July through August 1992) in conjunction with the sediment toxicity study and sampling of surface sediments for the substance distribution investigation. Sediment samples collected from Onondaga Lake, the tributaries, and Otisco Lake were sieved using sieves with a mesh size of 0.6 mm (i.e., US Standard No. 30). All sieved samples were fixed with a 10 percent solution of buffered formalin.

### **2.4.2.3 Modifications to the Work Plan**

The following modifications were made to the work plan:

- Two stations (S3 and S4) were not sampled for benthic macroinvertebrate assemblages because the actual bathymetry in the southwest corner of the lake differed from the bathymetry presented in historical studies.
- Because riffle habitats were not found near the mouths of the tributaries, only pool habitats were sampled.
- A 0.023-m<sup>2</sup> petite Ponar grab sampler was used to sample benthic macroinvertebrate assemblages in pools of the tributaries because the 0.06-m<sup>2</sup> van

Veen grab sampler could not be operated from the small vessel that was required to sample the shallow waters of the tributaries. Because a smaller area of the bottom was sampled by the petite Ponar grab sampler, replication was increased from three grabs per station to five grabs per station in the tributaries. As the petite Ponar grab sampler is considered an appropriate device for sampling benthic macroinvertebrate assemblages (American Public Health Association [APHA], 1989), its use in the tributaries did not affect sample quality.

- Because of the preference of the taxonomic laboratory, the benthic macroinvertebrate samples were not stained with Rose Bengal prior to laboratory evaluations. As the use of Rose Bengal is considered optional, the decision not to use this stain did not affect sample quality.
- Because of the unusually large amount of material retained on the sieves at many stations, the taxonomic laboratory did not have the capacity to transfer the samples to ethanol within ten days from sample collection. Because this relatively short transfer time was arbitrary, it was waived and the laboratory was directed to transfer the samples to ethanol when they were capable of doing so. The use of fixation times longer than ten days did not affect sample quality.

### **2.4.3 Nearshore Fish Study**

#### **2.4.3.1 Objectives**

The objective of the nearshore fish study was to determine the characteristics of the fish assemblages in representative locations along the shoreline of Onondaga Lake and in the lower reaches of the tributaries to the lake.

#### **2.4.3.2 Description of Investigation Approach**

Nearshore fish assemblages were sampled at eight locations along the shoreline of Onondaga Lake and near the mouths of the eight tributaries to the lake (Figure 2-11). Sampling was conducted during June through July, August through September, and October through November 1992 to evaluate potential seasonal variability in assemblage characteristics. Nearshore fish assemblages were sampled using three different field collection methods that were most appropriate for the conditions encountered in the field, as follows:

- A beach seine was used along the shoreline of the lake.
- Minnow traps were used in Ley Creek, Onondaga Creek, Harbor Brook, the East Flume, Tributary 5A (summer and fall only), and Ninemile Creek.

- A backpack electroshocker was used in Tributary 5A (spring only), Sawmill Creek, and Bloody Brook.

### **2.4.3.3 Modifications to the Work Plan**

The following modifications were made to the work plan:

- Minnow traps were used to sample juvenile fish in the larger tributaries (i.e., Harbor Brook, Onondaga Creek, Ley Creek, and Ninemile Creek [Stations F9, F10, F11, and F15, respectively]) and the East Flume (Station F12) because electroshocking was not effective in those water bodies. Because electroshocking was not effective in Tributary 5A (Station F13) in the spring, minnow traps were used to sample juvenile fish in the summer and fall in that water body.
- In several cases where an unusually large number of juvenile fish was captured for a species, all individuals were counted and the total catch was randomly subsampled. Length and weight were determined only for the individuals included in the subsamples.
- In many cases, very small fish (generally <35 mm) were counted, but length and weight were not determined.
- Age, sex, and reproductive condition were not evaluated because most of the captured fish were juveniles.

## **2.4.4 Macrophyte Distribution Study**

### **2.4.4.1 Objectives**

The objective of the macrophyte distribution study was to qualitatively characterize the distribution of macrophyte assemblages throughout the littoral zone of Onondaga Lake.

### **2.4.4.2 Description of Investigation Approach**

An aerial photography survey was conducted by flying over the entire littoral zone of Onondaga Lake in a small plane in early July 1992 when the water was relatively calm and water clarity was fairly high. Macrophyte beds were visible as dark patches below the water surface. A visual survey was conducted from a small boat in August, after the results of the aerial survey had been evaluated. The ten largest macrophyte beds were visited, and their species composition and extent were determined (Figure 2-12).



#### **2.4.4.3 Modifications to the Work Plan**

The following modifications were made to the work plan:

- Because the side-scan sonar survey of the bathymetric investigation was conducted in spring and did not provide an adequate assessment of the extent of macrophyte beds throughout the entire littoral zone of Onondaga Lake, an aerial survey was conducted in July.
- Because the aerial survey provided an adequate assessment of the distribution of macrophyte beds, the visual survey focused on identifying the extent of major macrophyte beds, rather than evaluating beds throughout the entire littoral zone.

#### **2.4.5 Macrophyte Transplant Study**

##### **2.4.5.1 Objectives**

The objective of the macrophyte transplant study was to determine the extent to which representative macrophyte species found in various New York lakes can survive and grow in the sediments and water of the littoral zone of Onondaga Lake.

##### **2.4.5.2 Description of Investigation Approach**

Three macrophyte species (i.e., Sago pondweed [*Potamogeton pectinatus*], clasping-leaf pondweed [*P. richardsoni*], and water celery [*Vallisneria americana*]) were transplanted at two water depths (about 3.3 and 5 ft [1 and 1.5 m]) in six locations throughout the littoral zone of Onondaga Lake (Figure 2-11) and in Otisco Lake (Figure 2-3), which was used as a reference lake for this investigation. The transplant study was conducted during the summer (i.e., June 24 through August 27, 1992), when most macrophytes are growing rapidly.

##### **2.4.5.3 Modifications to the Work Plan**

The levels of sample replication were modified from the specifications of the work plan. At each station in Otisco Lake, four replicate sediment samples (instead of five) were evaluated for each species at each depth. At each station in Onondaga Lake, three replicates (instead of five) of the reference sediment and four replicates (instead of five) of Onondaga Lake sediment were evaluated for each species at each depth.

#### **2.5 Bioaccumulation Investigation (1992)**

The bioaccumulation investigation included three studies: the phytoplankton/zooplankton study, the benthic macroinvertebrate study, and the fish tissue study. The primary objectives of this investigation were to:

- Document the concentrations of substances in various groups of aquatic organisms.
- Evaluate the trophic transfer of substances to fish.
- Estimate the risk of substance exposure to terrestrial organisms (i.e., birds and mammals) and humans from consumption of organisms from the lake.

A summary of the sampling specifications achieved for the bioaccumulation investigation is presented in Table 2-5. An overview of each study is provided below. Methods and results of the bioaccumulation investigation were presented in the Onondaga Lake RI/FS Bioaccumulation Investigation Data Report (PTI, 1993a) and are discussed in Chapter 5 of this report and in the BERA (TAMS, 2002a).

## **2.5.1 Phytoplankton/Zooplankton Study**

### **2.5.1.1 Objectives**

The objectives of the phytoplankton/zooplankton study were to qualitatively characterize the phytoplankton and zooplankton assemblages and to determine the concentrations of methylmercury and total mercury in phytoplankton and zooplankton assemblages at representative locations in Onondaga Lake using standardized collection and analytical techniques.

### **2.5.1.2 Description of Investigation Approach**

Plankton assemblages were sampled at two stations that correspond to the locations at which monthly samples of lake water were collected for the water column processes study so that the results for plankton could be related directly to the results for water samples. Station W1 was located near the center of the southern basin of the lake, and Station W2 was located near the center of the northern basin of the lake (Figure 2-13). At each station, phytoplankton sampling was conducted at about 0, 10, 20, and 40 ft (0, 3, 6, and 12 m). Samples for mercury analysis were composited across the four depths, whereas discrete samples were collected at each depth for taxonomic analysis.

For zooplankton assemblages, triplicate samples were collected from a depth of about 33 ft (10 m) at each station. A fourth vertical sample from about 40 ft (12 m) was collected for taxonomic analysis at each station. For daphnids, two to four vertical samples were collected from about 33 ft (10 m) at each station and the samples were composited. Plankton assemblages were sampled during spring (May 26 through 29), summer (August 24 through 26), and fall (November 16 through 18) of 1992 to evaluate potential seasonal variability in bioaccumulation and assemblage characteristics. Zooplankton assemblages were analyzed for both total mercury and methylmercury.

### 2.5.1.3 Modifications to the Work Plan

The following modifications were made to the work plan:

- To avoid potential sample contamination during filtering, phytoplankton samples were filtered through the 0.8- $\mu$ m filters in the laboratory the day after collection, rather than immediately after collection in the field. Samples were passed through the 80- $\mu$ m Nitex netting in the field to remove large zooplankton predators prior to storage and to ensure that the influence of zooplankton grazing on the phytoplankton would be minimized.
- The design of the zooplankton net was changed from the one specified in the work plan, to conform to the design of the net used by Onondaga County. A simple ring net with a 24-cm mouth diameter was therefore used instead of a Wisconsin-style net with a 12-cm mouth diameter, and the mesh size of the net was increased from 60 to 80  $\mu$ m.
- An extended sampling effort in May of 1992 failed to yield a sufficient number of large zooplankton for bioaccumulation analysis. Therefore, small cyclopoid copepods were collected. However, because it was not possible to reduce the water in each sample to a single drop without losing copepods, it was not possible to conduct mercury analyses on those samples. The dominance of the spring zooplankton assemblages of Onondaga Lake by adult and copepodite stages of cyclopoid copepods (primarily *Cyclops vernalis* and *Cyclops bicuspidatus*) was found in 1987 by Auer et al. (1990). However, the authors do not present data for May. The abundances of larger zooplankton such as cladocerans (*Ceriodaphnia*, *Daphnia*, and *Diaphanosoma*) did not increase until late June and early July.
- After extended sampling efforts in August and November, the only large zooplankton found in sufficient numbers for bioaccumulation analyses were cladocerans. That taxon was therefore the only one sampled for mercury analyses. Auer et al. (1990) also found that cladocerans were the numerically dominant members of the zooplankton assemblages in Onondaga Lake from approximately late June to September. Those authors did not sample zooplankton assemblages in November.
- For selected zooplankton samples, the laboratory analyzed for methylmercury and ionic mercury in a single analysis, instead of analyzing for methylmercury and total mercury in separate analyses. However, recent evidence (Liang et al., 1992) indicates that for many biological samples (e.g., fish tissue, monkey blood, human

hair), the sum of the concentrations of methylmercury and ionic mercury provides an adequate estimate of the concentration of total mercury.

## **2.5.2 Benthic Macroinvertebrate Study**

### **2.5.2.1 Objectives**

The objective of the benthic macroinvertebrate study was to determine the concentrations of methylmercury and total mercury in ecologically important benthic macroinvertebrates (i.e., amphipods and chironomids) at representative locations throughout the littoral zone of Onondaga Lake. Additional sampling of benthic macroinvertebrates was conducted during the Phase 2A investigation in 2000 (see Section 2.8.3.2).

### **2.5.2.2 Description of Investigation Approach**

Amphipods and chironomids were sampled at eight stations throughout the littoral zone of the lake at depths of approximately 3.3 to 6.5 ft (1 to 2 m) (Figure 2-13). All sampling was conducted during the summer (August 13 through 14) of 1992 to collect organisms when they were growing rapidly and therefore had a high potential for bioaccumulation. The top 3 to 5 cm of sediment was collected from each station and sieved using a polyethylene sieve with a mesh size of 0.6 mm. Benthic macroinvertebrates were removed from the sieved samples and separated according to taxon. Three samples (composite of ten individuals) for each taxon were submitted for analysis of total mercury, methylmercury, and biomass.

### **2.5.2.3 Modifications to the Work Plan**

The following modifications were made to the work plan:

- Because an extended sampling effort yielded only a single amphipod at Station B1, that taxon was not analyzed for mercury at that station.
- The laboratory analyzed benthic macroinvertebrate samples for methylmercury and ionic mercury in a single analysis, instead of analyzing for methylmercury and total mercury in separate analyses. However, recent evidence (Liang et al., 1992) indicates that for many biological samples (e.g., fish tissue, monkey blood, human hair), the sum of the concentrations of methylmercury and ionic mercury provides an adequate estimate of the concentration of total mercury.

## **2.5.3 Fish Tissue Study**

### **2.5.3.1 Objectives**

The fish tissue study had the following four primary objectives:

- Determine the concentrations of methylmercury and total PCBs in the edible muscle tissue of adults of seven of the numerically dominant fish species in Onondaga Lake. Total mercury was also measured in three individuals of each species. The target species were gizzard shad (*Dorosoma cepedianum*), carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), white perch (*Morone americana*), bluegill (*Lepomis macrochirus*), smallmouth bass (*Micropterus dolomieu*), and walleye (*Stizostedion vitreum*).
- Determine the concentrations of all TAL and TCL substances in the edible muscle tissue of four recreationally important fish species in the lake. The target species were channel catfish, white perch, smallmouth bass, and walleye.
- Determine the concentrations of methylmercury and total mercury in the whole bodies of adults of four of the numerically dominant fish species in the lake. The target species were gizzard shad, white perch, bluegill, and smallmouth bass.
- Determine the concentrations of methylmercury, total mercury, and total PCBs in the whole bodies of juveniles of the numerically dominant fish species in the lake, and the eight tributaries to the lake (including the East Flume). The target species, which included gizzard shad, banded killifish (*Fundulus diaphanus*), brook silversides (*Labidesthes sicculus*), white perch, pumpkinseed (*Lepomis gibbosus*), bluegill, and unidentified sunfishes (Centrarchidae), were selected after sampling had been conducted.

Insufficient sample size limited analysis in some cases, as detailed below. Additional fish sampling was conducted during the Phase 2A investigation in 2000 (see Section 2.8.3).

### 2.5.3.2 Description of Investigation Approach

The adult fish evaluated for mercury and total PCBs in edible muscle tissue were collected from the littoral zone in the northern, western, and southern parts of the lake (Figure 2-13).

### 2.5.3.3 Modifications to the Work Plan

The unusually high water levels experienced in Onondaga Lake in the summer of 1992 appeared to influence fish assemblages in the lake. In particular, the numbers of juvenile fish captured in beach seines were considerably lower than the numbers captured in recent years as part of the State University of New York (SUNY) College of Environmental Science and Forestry (ESF) studies of the fish assemblages of the lake and some of its tributaries. The numbers of adult and juvenile fish in the lake and juvenile fish in the tributaries may also have been affected by the high water levels. Because the catches of fish in the lake were generally lower than expected, a considerable sampling effort was required to capture the numbers

of individuals required for bioaccumulation analysis. In some cases (described below), the extended sampling effort did not yield the required number of individuals for analysis.

The following modifications were made to the work plan:

- Because few carp were captured in the trap nets, eight of the 20 individuals submitted for evaluation of mercury and total PCBs in fillets were collected using a bow and arrow. The arrow tip was made of stainless steel and was decontaminated between samples using methanol and hexane.
- Only nine walleye were captured in the northern part of the lake for evaluation of mercury and total PCBs in fillets. Eleven walleye from the southern part of the lake were therefore submitted for analysis so that the total number of walleye evaluated from the entire lake was 20, the number specified in the work plan.
- Due to an error, 11 channel catfish from the southern part of the lake were submitted for analysis of mercury and total PCBs in fillets, rather than the 10 specified in the work plan. A total of 21, rather than 20, channel catfish from the entire lake were therefore submitted for analysis.
- Due to a misunderstanding of the specifications in the work plan, the evaluation of mercury in whole bodies of adult fish was conducted on fish that were not evaluated for mercury in fillets, rather than fish that were evaluated for mercury in fillets. Although this lack of direct correspondence between the two kinds of data introduces uncertainty to comparisons made between the two kinds of data (i.e., because they were not based on the same individuals), the fish used for the whole-body analyses were collected at the same locations and at the same times as many of the individuals used for analyses of fillets. The fish used for the whole-body analyses should, therefore, be relatively representative of the fish used for analyses of fillets. In addition, the resulting mean values for the four target species suggest that the expected pattern of similar mercury concentrations in whole bodies and fillets was found. The mean mercury concentrations (mg/kg wet weight) in whole bodies and fillets, respectively, for the four target species were:
  - Gizzard shad: 0.18 and 0.22.
  - White perch: 1.01 and 1.14.
  - Bluegill: 0.17 and 0.32.
  - Smallmouth bass: 0.63 and 0.75.
- Minnow traps were used to sample juvenile fish in the larger tributaries (i.e., Harbor Brook, Onondaga Creek, Ley Creek, and Ninemile Creek [Stations F9, F10, F11, and F15, respectively]) and the East Flume (Station F12) because

electroshocking was not effective in those water bodies. As electroshocking was also not effective in Tributary 5A (Station F13) in the spring, minnow traps were used to sample juvenile fish in the summer and fall in that water body.

- Insufficient numbers of juvenile fish were collected from Onondaga Creek (Station F10) and Tributary 5A (Station F13) for evaluation of mercury and total PCBs in whole bodies.
- The target sample size of 10 juvenile fish for each composite sample for evaluation of mercury and total PCBs in whole bodies was not achieved for the samples from Stations F4 (n=5) and F5 (n=7) in the lake, because an insufficient number of fish was captured at those sites.
- Eleven centrarchids and 12 brook silversides, rather than 10 each, were submitted for analysis of mercury and total PCBs in whole bodies for Stations F6 and F7 in the lake, respectively. Because most of the individuals from those two stations were small, additional individuals were added to each composite sample to increase the mass of tissue for chemical analysis.
- Two, rather than one, composite samples of juvenile fish were analyzed for mercury and total PCBs from three stations, to provide estimates of interspecific variability (for Stations F3 and F7 in the lake) and intraspecific variability (for the East Flume [Station F12]) of the analytical results.
- Because several fish were larger than anticipated, they exceeded the capacity of the analytical balances and were therefore not weighed. These fish included 20 carp, five catfish, and seven walleye. Due to an oversight in the field, the weight of one walleye was not measured. However, the weights of these individuals can be estimated from length/weight regression relationships based on other studies conducted in the lake.
- The age of adult fish was not determined for 2 of 30 gizzard shad, 2 of 20 carp, 3 of 35 white perch, 4 of 40 bluegill, 15 of 45 smallmouth bass, and 1 of 25 walleye because the annuli of the scales were not sufficiently distinct to be counted accurately.
- Sex and reproductive condition were not determined for the 40 adult fish evaluated for mercury in whole bodies, to avoid the risk of contaminating those individuals by opening their body cavities prior to laboratory analysis.
- Due to oversights in the field, the sex of adult fish for which bioaccumulation in fillets was evaluated was not determined for 13 of 20 gizzard shad, 1 of 20 carp,

1 of 25 channel catfish, 7 of 25 white perch, 4 of 30 bluegill, 11 of 35 smallmouth bass, and 1 of 25 walleye. In addition, the reproductive condition of adult fish for which bioaccumulation in fillets was evaluated was not determined for 20 of 20 gizzard shad, 10 of 20 carp, 10 of 25 channel catfish, 14 of 25 white perch, 19 of 30 bluegill, 26 of 35 smallmouth bass, and 11 of 25 walleye. Although ancillary biological data such as sex and reproductive condition provide additional information on the fish evaluated for bioaccumulation, such data are not essential for interpreting the results of the bioaccumulation analyses.

- The laboratory analyzed fish tissue samples for methylmercury and ionic mercury in a single analysis, instead of analyzing for methylmercury and total mercury in separate analyses. However, recent evidence (Liang et al., 1992) indicates that for many biological samples (e.g., fish tissue, monkey blood, human hair), the sum of the concentrations of methylmercury and ionic mercury provides an adequate estimate of the concentration of total mercury.

## **2.6 Supplemental Studies (1993 – 1996)**

Subsequent to the five major field studies conducted in 1992 as part of the Onondaga Lake RI/FS (discussed above), further investigations were conducted to better evaluate the nature and extent of CPOIs in Onondaga Lake and its tributaries. Three additional studies involved supplemental sampling in the East Flume, Ninemile Creek, and the West Flume. Table 2-6 summarizes the sampling and analysis program for the supplemental investigations. Results of the supplemental sampling in the East Flume were presented in a separate data report (PTI, 1994b). The results of the West Flume and Ninemile Creek studies were combined into a single data report (Onondaga Lake RI/FS West Flume Mercury Investigation and Supplemental Sampling and Ninemile Creek Supplemental Sampling Data Report [PTI, 1996a]). The results of these three studies should be considered an addendum to the Onondaga Lake RI/FS Substance Distribution Investigation Data Report (PTI, 1993d).

A fourth investigation was undertaken in 1996 to provide additional determinations of mercury water column methylation and remineralization rates in Onondaga Lake. The results of this investigation were presented in the Onondaga Lake RI/FS Supplemental Mercury Methylation and Remineralization Studies Data Report (PTI, 1997), and are discussed in Chapter 6 of this RI report. The sampling and analysis program for this investigation is included in Table 2-6.

### **2.6.1 Supplemental Sampling at Onondaga Lake – East Flume**

#### **2.6.1.1 Objectives**

The objective of the supplemental sediment sampling in the East Flume in 1993 was to further characterize East Flume CPOI sediment concentrations in support of evaluating the potential effects of CPOIs on fish and wildlife in the area.



### **2.6.1.2 Description of Investigation Approach**

Sediment samples were collected at five stations below the spillway in the East Flume (Figure 2-14). At each station, three surface sediment samples (0- to 2-cm depth) were collected along transects across the flume channel. Sampling points were located at the south end, middle, and north end of each transect.

## **2.6.2 West Flume Mercury Investigation and Supplemental Sampling**

### **2.6.2.1 Objectives**

The general objectives of the West Flume mercury investigation and supplemental sampling in 1994 and 1995 were to 1) further quantify the significance of mercury sources to the West Flume under low-flow conditions, and 2) characterize the mercury load carried by the West Flume during high-flow conditions. These general objectives were achieved through the following five specific objectives:

- Determine mercury concentrations in surface water in the West Flume, at one location in Geddes Brook upstream of the confluence with the West Flume, and in the ponded area at the site.
- Determine mercury concentrations in groundwater within the vicinity of the LCP Bridge Street facility that discharges to the West Flume.
- Determine surface water flow rates in the West Flume, and calculate groundwater flow rates to the West Flume.
- Estimate the mass load of total mercury input to the West Flume and Geddes Brook from the flow rate and total mercury concentrations.
- Determine the distribution of mercury in West Flume sediments.

Mercury loading to the West Flume was re-evaluated with additional data during the LCP Bridge Street facility RI (NYSDEC/TAMS, 1998c).

### **2.6.2.2 Description of Investigation Approach**

Samples were collected from 21 surface water stations and 16 groundwater monitoring wells. Grab samples of unfiltered surface water were taken at 15 stations during the first round of sampling (August 1994), and surface water from six additional locations was sampled in Round 2 (November 1994). Flow rate was determined at each surface water sampling station, and continuous water level was monitored. Unfiltered groundwater samples were collected during Round 1 from 16 monitoring wells located adjacent to the West Flume.

During Round 2, eight groundwater samples were collected from two wells to evaluate the effect of postponement of filtration and preservation of high pH samples on total mercury concentration. Eight groundwater monitoring wells were also sampled later in Round 2 (July 1995) to provide samples under hydrologic conditions different from those during the 1994 collection. Sediment cores were collected from eight stations in the West Flume in September 1994, and six sediment samples were collected from two stations in November 1994.

Low-flow sampling of surface water in the West Flume was conducted for 18 stations in August 1995, and surface water samples were collected from two stations during two high-flow events in September 1995. Sampling locations are shown in Figure 2-15.

### **2.6.2.3 Modifications to the Work Plan**

**Surface Water and Groundwater Characterization** – The following modifications were made to the sampling strategy for surface water and groundwater described in the West Flume mercury investigation work plan (PTI and BBL, 1994):

- No surface water samples were collected during a precipitation (high-flow) event in 1994. Supplemental sampling in 1995 included surface water sampling during two high-flow events.
- The second groundwater sampling, which was to be conducted during wetter conditions and at least three months after the initial sampling, occurred in July 1995.
- Drainage from two additional pipes (12-inch and 36-inch diameter) was sampled to determine if the pipes were sources of mercury to the West Flume.

Modifications made to the analytical strategy described in the West Flume mercury investigation work plan (PTI and BBL, 1994) are documented in Jacobs (pers. comm., 1994) and apply to groundwater samples collected in July 1995 as part of Round 2 sampling. These modifications include the following:

- Groundwater samples from two wells (MW-17S and MW-21S) were filtered, preserved in the field, and analyzed for mercury to address NYSDEC concerns regarding the stability of high-pH samples during transport to the laboratory.
- Only groundwater samples that were visibly turbid were analyzed for dissolved mercury.
- Only samples from wells with elevated mercury concentrations were analyzed for methylmercury.

- Samples from selected wells were analyzed for elemental mercury.
- Measurement of oxidation-reduction potential (Eh) was added to the list of field measurements of groundwater.
- Selected samples were analyzed for major ions.

In addition, conductivity, pH, and temperature were not measured in the field for the Round 2 groundwater samples collected in July 1995.

## **2.6.3 Ninemile Creek Supplemental Sampling**

### **2.6.3.1 Objectives**

The objectives of the Ninemile Creek supplemental sampling in 1995 were to assess the contribution of mercury to Ninemile Creek from Geddes Brook and from sediment resuspension during high-flow events. The loading of mercury to Geddes Brook from the West Flume was quantified during the LCP Bridge Street facility RI (NYSDEC/TAMS, 1998c). Resuspension proved to be difficult to quantify and, therefore, the second objective was not met. However, this shortcoming is not believed to be an impediment to the Onondaga Lake RI/FS process.

### **2.6.3.2 Description of Investigation Approach**

Surface water samples were collected from upper Ninemile Creek, lower Geddes Brook, and lower Ninemile Creek during five rain events in September and October 1995 (Figure 2-16). In October and November 1995, water level and flow measurements were taken in Geddes Brook at the confluence with Ninemile Creek and water level measurements were taken at the lower Ninemile Creek stations. The difference between the flow rates at the two stations was assumed to represent the flow rate in Ninemile Creek just above the confluence with Geddes Brook.

### **2.6.3.3 Modifications to the Work Plan**

Modifications made to the sampling and analysis strategy described in the Ninemile Creek supplemental sampling work plan (PTI, 1995) include the following:

- Flow measurements were taken only at the Geddes Brook sampling station.
- Long-term flow records for the mouth of Ninemile Creek were obtained from USGS. Because of problems with the flow record for the Lakeland gauge during the fall of 1995, only average daily flow rates (rather than 15-minute flow rates) were reported by USGS.

- Station NMSW-3 was moved upstream to reduce the effects of lake water level on stream stage and to improve access.
- The three samples collected from each station for mercury analysis during the September 9, 1995 rain event were analyzed for total mercury in whole water and filtered samples and for methylmercury in whole water samples only. Samples submitted for mercury analysis were not analyzed for TSS concentration or mercury concentration on particles because of a miscommunication. Therefore, determination of total mercury and methylmercury in solids (either by analysis or calculation) was not possible for these samples.
- One of the lower Ninemile Creek samples from the October 5, 1995 rain event (NMSW03-0519) was found to have insufficient volume for analysis of TSS and mercury concentrations on particles. Therefore, only particulate total mercury and methylmercury concentrations (on a volumetric basis) were analyzed and reported.

## **2.6.4 Supplemental Mercury Methylation and Remineralization Studies**

### **2.6.4.1 Mercury Methylation**

**Objective** – The objective of the mercury methylation study was to confirm the 1992 estimates of net water column methylmercury production rates in the hypolimnion of Onondaga Lake (PTI, 1997). The mercury methylation study incorporated the following two refinements to the 1992 experiments:

- Use of a radioisotope (i.e., addition of  $^{203}\text{Hg}$ -mercury to the sample and measurement of  $^{203}\text{Hg}$ -methylmercury production) rather than measurements of ambient methylmercury concentrations.
- Incubation of samples for approximately 48 hours (rather than seven weeks), with intensive subsampling during the first 24 hours.

**Description of Investigation Approach** – Experiments for determining net methylmercury production in Onondaga Lake were conducted under the direction of Dr. Cynthia Gilmour of the Academy of Natural Sciences of Philadelphia, Estuarine Research Center. Water column samples from various depths were collected for mercury analysis and for net methylmercury production rate determination. Nine depths in the southern basin (Station W1) of Onondaga Lake and one depth in the northern basin (Station W2) were sampled for total mercury, methylmercury, and ancillary parameters (e.g., temperature, dissolved oxygen [DO], sulfate) on July 10 and 11, 1996 (see Figure 2-4). Five depths at the southern basin station were also sampled at this time to determine net methylmercury production rate. From September 17 through 19, 1996, six depths at the southern basin station and four depths at the northern basin station were also sampled for total mercury, methylmercury, and ancillary parameters. Three depths at the southern basin station and two depths at the northern basin station were also sampled during this time period to determine

net methylmercury production rate. Methylation rates were obtained for one (September) of two sampling dates.

**Modifications to the Work Plan** – The following modifications were made to the sampling strategy described in the work plan (PTI, 1996b):

- Because of adverse weather conditions in July, mercury methylation experiments and mercury depth profiles were performed only in the southern basin.
- Mercury methylation samples were incubated in glass serum vials rather than Teflon® bottles.
- Sample bottles for mercury methylation were incubated in coolers, submerged in ambient lake water, and maintained at in situ temperatures.

#### **2.6.4.2 Mercury Remineralization**

**Objective** – The objective of the mercury remineralization study was to confirm the rates of gross sedimentation, net sedimentation, and potential remineralization of total mercury and methylmercury in the water column of Onondaga Lake determined in 1992. Refinements to the 1992 experiments included the following:

- Deployment of traps for two-week, rather than four-week, intervals.
- Deployment of both long-term (four, six, eight, and 16-week) traps and short-term (two-week) traps.

The mercury remineralization study provided rates of gross and net sedimentation of total mercury and methylmercury; however, the study design failed to demonstrate remineralization (NYSDEC/TAMS, 1998b).

**Description of Investigation Approach** – Three sediment traps were deployed at the sediment-water interface in the southern basin (Station W1) of Onondaga Lake beginning on June 5, 1996 (see Figure 2-4). One of the three traps was retrieved approximately every two weeks. The second trap of the three was deployed on a four-, six-, and eight-week sequential schedule. The third trap was initially deployed for four weeks, and then redeployed for 16 weeks. TSS samples were collected during the initial deployment of sediment traps and during each subsequent sampling event. During the first four sampling events, only water-column samples were collected for TSS. Beginning with the fifth sampling event, an additional TSS sample was collected from the overlying water drained from the top of the sediment trap.

For estimation of net sedimentation, one 85-cm core and two surface sediment samples were collected from different locations in the deep southern basin in September and October 1996.

**Modifications to the Work Plan** – The following modifications were made to the sampling strategy described in the work plan (PTI, 1996b):

- Rather than deploying single sediment traps at two stations, three sediment traps were deployed at a single station in the southern basin.
- If suspended material was present in the sediment traps, it was sampled for total mercury and methylmercury analysis.
- Water overlying sediment in the traps was sampled for TSS analysis.
- All three sediment traps were retrieved after four weeks (because of tangling in the lines), and then redeployed independent of a central anchor.
- The 16-week sediment trap apparently was deployed on its side and data associated with the trap were deemed unusable.
- An Ekman sampler and spoon, rather than a core, were used to collect surface sediment samples.

## **2.7 Supplemental Lake Water Sampling (1999)**

Supplemental lake water sampling was conducted in 1999 to provide additional data on lake water chemistry. The sampling was performed according to the approved work plan (Exponent, 1999) developed in conjunction with NYSDEC. Results of the supplemental lake water sampling are presented in Appendix A and discussed in Chapters 5 and 6 of this report and in the BERA and HHRA (TAMS, 2002a,b). A summary of the sampling specifications achieved for the supplemental lake water sampling is presented in Table 2-7.

### **2.7.1 Surface Water Sampling**

The objective of the surface water sampling was to evaluate the concentrations of CPOIs in surface water of Onondaga Lake at locations where people are likely to be in contact with lake water during recreational activities.

#### **2.7.1.1 Sampling Location and Frequency**

Eleven surface water samples were collected once from nine nearshore (Stations W50 through W58) and two mid-basin (Stations W1 and W2) locations during the week of September 27, 1999. Station locations are presented in Figure 2-17. In addition, one surface water sample was collected at each of three (Stations W52, W54, and W58) of the nine nearshore locations during the third profile event described below. These

three stations were chosen because they are not located near any significant water (tributary) or known mercury contaminant source areas. Sample locations were documented using a differential GPS.

#### **2.7.1.2 Field Collection Methods**

A boat and experienced operator were used for the surface water investigation. Care was taken to collect surface water samples upwind of the boat and away from waters that came in contact with the boat or motor. At the nearshore stations, samples were collected at mid-depth in water depths less than 1 m. At the mid-basin locations, samples were collected near the surface (1 m). Samples were collected using a 2-L Teflon® bottle, according to the procedures outlined in Standard Operating Procedure (SOP) 17, Surface Water Sampling (Exponent, 1998b; Appendix C). The 2-L Teflon® bottle was cleaned with dilute nitric acid between each sample location and rinsed three times with site water prior to sample collection. Unfiltered water samples were transferred directly from the 2-L Teflon® bottle to appropriate sample containers.

Water samples designated for filtered mercury and methylmercury analysis were filtered in the field using a single-use, disposable filtration apparatus. The filtrate was retained and transferred to the appropriate sample container. All mercury samples were handled using the clean-hands technique in accordance with SOP 72, Clean-Hands Technique for Water Sampling of Mercury (Exponent, 1998b). Field measurements included temperature, conductivity, pH, Eh, DO, and depth.

All samples were kept on ice from the time they were collected to receipt at the analytical laboratory. Mercury and methylmercury samples were shipped via priority overnight shipping service to Frontier Geosciences within a day or two of collection. The remaining samples (non-profiles) were delivered to the O'Brien & Gere analytical laboratory located in Syracuse, New York.

#### **2.7.1.3 Laboratory Analyses**

For the surface water samples, laboratory analyses included TSS, metals in unfiltered water (chromium, lead, manganese, and nickel), total mercury and methylmercury in filtered and unfiltered water, and TCL VOCs in unfiltered water. The TCL VOC analysis routinely includes BTEX and chlorobenzene, among others. For this investigation, the VOC analysis was expanded to include 1,2-dichlorobenzene and 1,4-dichlorobenzene.

#### **2.7.1.4 Modifications to the Work Plan**

There were no modifications to the work plan.

### **2.7.2 Water Column Profile Sampling**

The objective of the water column profile sampling was to characterize the influence of the fall turnover event on mercury concentrations in the water column of Onondaga Lake and the fate of hypolimnetic

mercury (e.g., transported out of the lake or to the littoral zone, or back down to the sediments upon contact with oxygenated water).

### **2.7.2.1 Sampling Location and Frequency**

Water column profile sampling was conducted during five events, as follows:

- The first event occurred prior to lake turnover in conjunction with the initial surface water sampling described above.
- Event 2 was conducted immediately following the onset of fall turnover (approximately one day after thermal stratification disappeared), based on daily monitoring.
- Event 3 occurred approximately one week after Event 2 (along with the three nearshore samples).
- Event 4 occurred after lake turnover was complete, approximately two weeks after Event 3.
- Event 5 occurred after lake turnover was complete, approximately two weeks after Event 4.

The scheduling of Events 2 through 5 was agreed upon with NYSDEC prior to sampling, based on results of turnover monitoring (described below).

Water samples were collected from mid-basin Stations W1 and W2 (southern and northern basins, respectively) during Events 1 through 3. Only Station W1 was sampled during Events 4 and 5. Samples were collected from the lake outlet Station W12 during events 1, 2, 3, and 5. Nearshore Stations W52, W54, and W58 were sampled during Event 3.

Water samples were collected from seven depths in the water column (about 0, 10, 20, 30, 40, 50, and 60 ft [0, 3, 6, 9, 12, 15, and 18 m]) during Events 1 through 5 off the side of a stationary boat. These depths corresponded to the same sample depths employed during the 1992 field investigation (PTI, 1991c). During Events 1 through 3, Station W2 was sampled before Station W1 to minimize the potential for cross-contamination. Samples at the lake outlet were collected at two water depths (middle of surface layer and middle of bottom layer) if the lake outlet was stratified, and at one depth if the lake outlet was not stratified (as determined by water quality monitoring).



### **2.7.2.2 Field Collection Methods**

Water samples were pumped from the appropriate depth with a Sureflow® pump and pre-cleaned C-flex and Teflon® tubing directly into the appropriate sample container. Samples designated for dissolved mercury, methylmercury, iron, and manganese analysis were filtered in the field using a single-use, disposable filtration apparatus. The filtrate was retained for analysis and transferred to the appropriate sample container. Field measurements included temperature, conductivity, pH, Eh, DO, and depth.

All samples were kept on ice from the time they were collected to receipt at the analytical laboratory. Mercury and methylmercury samples were shipped via priority overnight shipping service to Frontier Geosciences within a day or two of collection. The remaining samples (non-profiles) were delivered to the O'Brien & Gere analytical laboratory located in Syracuse, New York. Selected samples were delivered to the UFI laboratory in Syracuse, New York.

### **2.7.2.3 Laboratory Analyses**

For water column profile samples, laboratory analyses included iron and manganese in filtered and unfiltered water; total mercury and methylmercury in filtered and unfiltered water; TSS, including fraction organic carbon; sulfate; sulfide; alkalinity; and chlorophyll.

### **2.7.2.4 Modifications to the Work Plan**

Due to an oversight in the field, the lake outlet was not sampled during the fourth sampling event.

## **2.7.3 Turnover Monitoring**

The objective of turnover monitoring was to determine the timing of fall turnover and, thus, the timing of water column profile sampling based on in situ measurements of temperature, conductivity, DO, pH, Eh, and turbidity levels in the water column (continuous with depth) in the southern basin.

### **2.7.3.1 Sampling Location and Frequency**

Lake turnover conditions were monitored by staff from UFI (under contract to NYSDEC and TAMS) approximately twice weekly from the week of September 27, 1999, until after turnover was complete. More frequent monitoring (i.e., daily) was conducted during the turnover event. In consultation with Honeywell, NYSDEC approved the starting date and duration of daily monitoring. Monitoring returned to a twice-weekly basis for three weeks after turnover was completed.

### **2.7.3.2 Field Collection Methods**

Continuous water column profiling was conducted using a Hydrolab® and/or Seabird® to record field measurements of temperature, conductivity, DO, pH, Eh, turbidity, and depth. Monitoring was conducted

at Station W1. Weather conditions that could have influenced the timing of lake turnover, especially wind speed and air temperature, were recorded and interpreted on a daily basis along with the monitoring data.

### **2.7.3.3 Modifications to the Work Plan**

There were no modifications to the work plan.

## **2.8 Phase 2A Investigation (2000)**

From July 10 to August 18, 2000 and from September 19 to September 22, 2000, Exponent, on behalf of Honeywell, collected supplemental data for the Onondaga Lake RI/FS. The three major components of the Phase 2A investigation and their study elements are as follows:

- Sediment Investigation
  - Surface sediment
  - Wetlands
  - Subsurface sediment
  - Dredged material
- Porewater Investigation
- Aquatic Ecological Investigation
  - Whole fish
  - Benthic macroinvertebrates
  - Sediment toxicity

The rationale, methodology, and QAPP for each investigation is described in the work plan (Exponent, 2000). A summary of the sampling specifications achieved for the Phase 2A study is presented in Table 2-8. The water depths and station coordinates for the Phase 2A study are presented in Tables 2-9 through 2-14. All field logbooks and field notes are on file at Exponent's Bellevue, Washington office.

Results of the Phase 2A investigation are presented in Appendices B through E of this RI, as follows:

- Appendix B presents the chemistry data.
- Appendix C presents the toxicity test data.
- Appendix D presents the benthic macroinvertebrate assemblages data.
- Appendix E presents the geotechnical data.

Data from the Phase 2A investigation were used to define the nature and extent of contamination (Chapter 5) and in the BERA and HHRA (TAMS, 2002a,b). Data from the Phase 2A investigation are also used in Chapter 3 to describe physical characteristics of the site. Results pertaining to benthic macroinvertebrate

community analysis and sediment toxicity are discussed in the BERA (TAMS, 2002a) and not in this RI report.

This section is divided into three major subsections: the sediment investigation, the porewater investigation, and the aquatic ecological investigation. Within each major section the following items are discussed:

- The locations of sampling stations and the frequency with which sampling was conducted.
- The methods used to collect samples in the field.
- The methods used to analyze samples in the field (if applicable, porewater investigation and subsurface sediment study only).
- Any modifications that were made to the study design specifications identified in the work plan.

### **2.8.1 Sediment Investigation**

The objectives of the sediment investigation were to address additional data needs for the Onondaga Lake RI, BERA, and HHRA and to provide information for the FS. The specific objectives of each study element are provided below.

#### **2.8.1.1 Surface Sediment**

The surface sediment study element was designed to provide information to meet the following objectives:

- To expand the spatial coverage of chemicals in surface sediments collected along the lake shoreline near known and potential sources to Onondaga Lake.
- To determine concentrations of CPOIs in the nearshore surface sediment in Onondaga Lake and in a reference lake (i.e., Otisco Lake).
- To obtain additional data for determining potential human health risk for exposure to sediment in nearshore environments that were identified as potential future recreational areas or likely contact areas.

**Sampling Locations and Frequency** – Surface sediment (i.e., 0 to 0.5 ft [0 to 0.15 m]) was evaluated at 15 stations in Onondaga Lake (Figure 2-18) and at two stations in Otisco Lake (Figure 2-19). The water depths and coordinates of these stations are presented in Table 2-9. Sampling was conducted from July to August 2000 in conjunction with the sampling of surficial sediments for sediment toxicity and the

sampling of benthic macroinvertebrate assemblages (where applicable). In addition, all other cores taken were subsampled for the 0 to 0.5 ft (0 to 0.15 m) interval as well.

**Field Collection Methods** – Surface sediments sampled for chemical analysis were collected using either a stainless-steel, modified Ekman dredge, a stainless-steel Klein dredge, a piston corer, or a vibracorer, as described in the work plan. Samples were collected from either a 23-ft (7-m) pontoon boat, a 28-ft (8.5-m) pontoon boat, or a >33-ft (>10-m) pontoon boat. All of the sampling vessels were equipped with A-frames, winches, davits, and pulley assemblies. Stations were initially located on the basis of the target water depths and positioned along the shoreline as identified in the work plan (Exponent, 2000). A buoy was used to mark each station prior to sampling and the position of each station was documented prior to sample collection using a differential GPS with an absolute accuracy of  $\pm 6.5$  ft ( $\pm 2$  m) and a repeatable accuracy of  $\pm 3.3$  ft ( $\pm 1$  m).

All sample compositing equipment was constructed of stainless steel and was decontaminated prior to sampling according to the procedures described in the work plan. The sediments used for chemical analyses were placed in chemically cleaned glass jars with TFE-lined lids and held at 4°C prior to testing.

**Modifications to the Work Plan** – The following modifications were made to the work plan:

- As mentioned above, various kinds of sampling equipment were used to collect surface sediments during the sampling event. However, a box corer, which was mentioned in the work plan, was not one of the kinds of sampling equipment used to collect surface sediments during the Phase 2A sampling event.
- After repeated attempts, the full penetration of 0 to 0.5 ft (0 to 0.15 m) could not be obtained at some stations due to a hard layer of sediment encountered at approximately 0.2 to 0.5 ft (0.05 to 0.14 m) (see Table 2-9).
- While in the field, at the request of Onondaga County, an additional surface sediment station was added (Station S435) (see Figure 2-18). As requested by the Onondaga County representative, the 0 to 0.5 ft (0 to 0.15 m) interval was collected. The objective of this additional surface sediment sample was to provide additional chemical data for sediments in the vicinity of a nearby drainage outfall (Tributary 5A).

### 2.8.1.2 Wetlands

The objective of the wetlands study was to provide data necessary to determine the potential impacts of contaminated lake water on lake-connected wetlands.

**Sampling Locations and Frequency** – Sediment (i.e., 0 to 1 ft [0 to 0.3 m]) was evaluated at four locations in each of the four Onondaga Lake-connected wetlands (16 stations total) (Figure 2-18). The coordinates of these stations are presented in Table 2-11. Sampling was conducted during August 2000.

**Field Collection Methods** – Sediments sampled for chemical analysis were collected using a piston corer, according to the SOPs provided in the work plan. Stations were located by NYSDEC personnel and the position of each station was documented prior to sample collection using a differential GPS with an absolute accuracy of  $\pm 6.5$  ft ( $\pm 2$  m) and a repeatable accuracy of  $\pm 3.3$  ft ( $\pm 1$  m).

To collect samples using a piston corer, a decontaminated 3.5-inch-diameter Lexan<sup>®</sup> tube was attached to a piston head. The piston core was manually “driven” into the sediment to a target penetration of just greater than 1 ft (0.3 m). The core was kept intact by placing a rubber stopper at the bottom of the core tube. Wetland sediments were then extruded out the top of the core tube using a hydraulic pump. Sediments were extruded in two discrete sample intervals: 0 to 0.5 ft (0 to 0.15 m) and 0.5 to 1 ft (0.15 to 0.3 m). At some locations, an expanded chemical parameter list required the collection of a second core to provide an adequate volume of sediment for the 0 to 0.5 ft (0 to 0.15 m) and 0.5 to 1 ft (0.15 to 0.3 m) intervals. The intervals from both cores were then homogenized before sampling, with exception of the sediments for analysis of VOCs, which were prepared prior to homogenizing the sample.

All sample compositing equipment was constructed of stainless steel and was decontaminated prior to sampling according to the procedures described in the work plan. The sediments used for chemical analyses were placed in chemically cleaned glass jars with TFE-lined lids and held at 4°C prior to testing.

**Modifications to the Work Plan** – There were no modifications from the work plan for the wetlands sediment sampling component of the field event. However, it was determined, based on the data, that supplemental sampling would be needed at three of the four wetland areas. Supplemental sampling of Wetland SYW-6 was performed by NYSDEC and TAMS in May 2002 for this Onondaga Lake RI (see Section 2.10). Supplemental sampling of Wetlands SYW-10 and SYW-19 is a component of the RIs for the Geddes Brook/Ninemile Creek and Wastebed B/Harbor Brook sites, respectively.

### **2.8.1.3 Subsurface Sediment**

The subsurface sediment study element was designed to provide information to meet the following objectives:

- To characterize contaminant concentrations at depth in sediment cores to provide information on the nature and extent of contamination and to assess potential remedial measures.
- To provide physical data from the sediment to evaluate remedial alternatives in the FS.

**Sampling Locations and Frequency** – The chemical composition of subsurface sediment was evaluated at 19 stations (0 to 1 ft [0 to 0.3 m]), 33 stations (0 to 6.6 ft [0 to 2 m]), and 23 stations (0 to 26 ft [0 to 8 m]) in Onondaga Lake (Figure 2-18). In addition to the subsurface sediment collected for chemical analysis, 8.2-ft (2.5-m) cores were also collected for consolidation testing at ten stations in Onondaga Lake (Figure 2-18). In-situ shear tests were also performed at 20 stations in the lake (Figure 2-18). The water depths and coordinates of these stations are presented in Table 2-10. Sampling was conducted from July to August 2000.

**Field Collection Methods** – Subsurface sediments sampled for chemical analysis were collected using either a piston corer or a vibracorer. Subsurface sediments sampled for consolidation testing were collected with a vibracorer. SOPs for sediment sample collection with these pieces of equipment are provided in the work plan. Samples were collected from either a 23-ft (7-m) pontoon boat or a >33 (>10-m) pontoon boat. Both of the sampling vessels were equipped with A-frames, winches, davits, and pulley assemblies. Stations were initially located on the basis of the target water depths and positioned along the shoreline, as identified in the work plan (Exponent, 2000). A buoy was used to mark each station prior to sampling and the position of each station was documented prior to sample collection using a differential GPS with an absolute accuracy of  $\pm 6.5$  ft ( $\pm 2$  m) and a repeatable accuracy of  $\pm 3.3$  ft ( $\pm 1$  m).

To collect samples using a piston corer, a decontaminated 3.5-inch-diameter Lexan® tube was attached to a piston head. The piston core was carefully lowered through the water column and manually “driven” into the sediment to a target penetration of just greater than 6.5 ft (2 m). The core was kept intact by placing a rubber stopper at the bottom of the core tube. Sediments were then extruded out the top of the core tube using a hydraulic pump.

To collect samples using a vibracorer, a decontaminated 4-inch-diameter Lexan® tube was attached to a vibrating head. The vibracorer was carefully lowered through the water column. Coincident with the nose cone of the vibracorer sampling barrel coming into contact with the sediments, the vibracorer motor was turned on. The vibracorer was then allowed to slowly penetrate the sediments. On completion of the required penetration, or upon experiencing vibracore penetration refusal, the motor was turned off and the vibracorer was slowly withdrawn from the sediments and raised to the surface. The core nose cone was then removed and the core liner was immediately sealed by placing a plastic cap over the open end. The core was then cut into 6.5-ft (2-m) sections, capped, and marked with permanent marker using a unique number for each core section and segment orientation.

If the target penetration depth of 6.5 ft (2 m) or 26.2 ft (8 m) was not achieved during sampling activities, then two additional attempts were made at a given station until either the desired penetration length was achieved or the core recovery was greater than 80 percent of the sediment penetration. Penetration and recovery depths for each core are provided in Table 2-10.

All acceptable cores were kept in an upright position until the sample was processed. The overlying water in the sample tube was drained or siphoned off the sediment surface prior to sample processing. The 1-ft (0.3-m) and 6.5-ft (2-m) cores were extruded and processed onboard the sampling vessel. The 26-ft (8-

m) cores were removed from the sampling vessel as soon as possible after collection and transferred to the onshore field processing area for core segmentation and sample processing. The 8-ft (2.5-m) cores for consolidation testing were transported intact to the local testing facility in an upright position. Consolidation testing is described in Appendix E.

With the exception of cores designated for consolidation testing, the sediment cores were sectioned into distinct intervals for chemical testing. The exact sample intervals for each core are provided in Table 2-10, and detailed descriptions of the sediment at each interval are provided in Appendix G. The presence of distinct layers observed in core sections deeper than 0.3 m altered the sectioning pattern outlined in the work plan (Exponent, 2000) (i.e., 0 to 0.5 ft [0 to 0.15 m], 0.5 to 1 ft [0.15 to 0.3 m], and 1 to 3.3 ft [0.3 to 1 m], with the remainder of the core being sectioned into 3.3 ft [1 m] intervals to the bottom of the core). In addition, at three sediment locations designated for human health assessment, the 0 to 0.5 ft (0 to 0.15 m) depth interval was sectioned into 0 to 0.06 ft (0 to 0.02 m) and 0.06 to 0.5 ft (0.02 to 0.15 m) intervals.

At some locations, an expanded chemical parameter list required the collection of a second core to provide an adequate volume of sediment for the 0 to 0.5 ft (0 to 0.15 m) and 0.5 to 1 ft (0.15 to 0.3 m) intervals. The intervals from both cores were then homogenized before sampling, with exception of the sediments for analysis of VOCs, which were prepared prior to homogenizing the sample.

All core sectioning and sample compositing equipment was constructed of stainless steel and was decontaminated prior to sampling according to the procedures described in the work plan. The sediments used for chemical analyses were placed in chemically cleaned glass jars with TFE-lined lids and held at 4°C prior to testing.

**Field Testing Methods** – In situ shear tests were performed at 20 stations in Onondaga Lake (see Figure 2-18) from an anchored >33-ft (>10-m) pontoon boat, and are described in detail in Appendix E. The in situ shear tests were performed according to ASTM D2573 methodology at 3.3-ft (1-m) intervals down to a depth of 6.5 ft (2 m) at 6.5-ft (2-m) core locations and to a depth of 26 ft (8 m) at 26-ft (8-m) core locations. The in situ shear tests were performed at least 3.3 ft (1 m) from the coring locations in order to obtain data representative of undisturbed conditions.

**Modifications to the Work Plan** – The following modifications were made to the work plan:

- Several 6.5-ft (2-m) cores were collected with a vibracoring device instead of with the piston corer. This modification was necessary due to a hard layer encountered at approximately 1.6-ft (0.5-m) depth. The manual-push technique of the piston corer did not achieve adequate penetration at these locations. Most of these locations were located near the southwest shoreline of Onondaga Lake.
- It was decided that if the desired penetration length could not be achieved for a 6.5-ft (2-m) core (after several attempts), the core would be considered acceptable if the core recovery was greater than 80 percent of the sediment

penetration. This is the same allowance that was applied and agreed upon for the 26-ft (8-m) cores in the work plan (Exponent, 2000).

- While in the field, at the request of Onondaga County, an additional subsurface sediment station was added (Station S434). As requested by Onondaga County, the 0 to 6.5 ft (0 to 2 m) interval was collected. The objective of obtaining this additional core was to provide additional chemical data on sediments in the vicinity of a nearby drainage outfall (Tributary 5A).
- Prior to sample collection, NYSDEC and Onondaga County requested that Stations S333, S334, S335, and S336 be placed closer together to better characterize the releases from the I-690 storm drains and the area in front of the causeway and the Willis Avenue site. Station S337 was also moved slightly to remain in line with Station S336.
- Station S339 was moved to westward to fill the spatial gap that was created by clustering Stations S333 through S336. The in-situ vane shear test and an 8-ft (2.5-m) core for consolidation testing were collected at the original location of Station S339 (now referred to as Station S339A).
- It was decided that because Station S339 was relocated, the 0 to 0.06 ft (0 to 0.02 m) interval would not be collected at Station S339, but would be collected at Station S340.
- To obtain the required sample volume for the specified chemical analyses, all 0 to 0.06 ft (0 to 0.02 m) sediment intervals were collected with an Ekman grab sampler, not a coring device as specified in the work plan.

#### **2.8.1.4 Dredged Material**

The objective of the dredged material study was to characterize the contaminant concentration in dredged material from the mouth of Ninemile Creek (i.e., material now located on the northwestern shoreline of Onondaga Lake).

**Sampling Locations and Frequency** – Surface and subsurface soils were evaluated at two locations in each of four dredged material disposal areas adjacent to Onondaga Lake (eight stations total) (Figure 2-18). The coordinates and depths of these stations are presented in Table 2-12. Sampling was conducted during August 2000.

**Field Collection Methods** – Soils sampled for chemical analysis were collected using either a tripod with a 140-pound hammer or with a hydraulic coring device, as described in the work plan. Stations were located by NYSDEC personnel and the position of each station was documented prior to sample collection.



using a differential GPS with an absolute accuracy of  $\pm 6.5$  ft ( $\pm 2$  m) and a repeatable accuracy of  $\pm 3.3$  ft ( $\pm 1$  m).

Surface and subsurface soils were collected using a 3-inch split spoon. A field geologist determined that different deposition horizons correlated to different filling activities, and a sample was collected at each of these horizons. Borings were completed through the dredge spoil material down to native material.

All sample compositing equipment was constructed of stainless steel and was decontaminated prior to sampling according to the procedures described in the work plan. The soils used for chemical analyses were placed in chemically cleaned glass jars with TFE-lined lids and held at 4°C prior to testing.

**Modifications to the Work Plan** – The following modifications were made to the work plan:

- After the first borehole was sampled, the use of the hammer to drive the split spoon was abandoned. Prior to sample collection at subsequent stations, in agreement with NYSDEC, subsequent boreholes were advanced using a hydraulic coring device.
- No dredge-like materials were encountered in two test locations in Basin 4. At the request of NYSDEC, a third borehole was advanced to confirm the lack of dredged materials in this basin.

## **2.8.2 Porewater Investigation**

The objective of the porewater investigation was to characterize mercury concentrations in porewater. The data resulting from this investigation were used to determine the relationship between porewater and bulk sediment mercury concentrations and the relationship between porewater and overlying water mercury concentrations.

### **2.8.2.1 Sampling Locations and Frequency**

Subsurface sediment (i.e., depths down to 3.67 ft [1.12 m]) was evaluated at seven stations in Onondaga Lake, including Stations S303, S305, S344, S354, S355, S402, and S405 (Figure 2-18). The water depths and coordinates of these stations are presented in Table 2-13. Sampling was conducted in July 2000.

### **2.8.2.2 Field Collection Methods**

Subsurface sediments sampled for chemical analysis were collected using a piston corer as described in the work plan. Samples were collected from a 23-ft (7-m) pontoon boat that was equipped with A-frame, winch, davit, and pulley assembly. Stations were initially located on the basis of the target water depths and positioned along the shoreline, as identified in the work plan (Exponent, 2000). A buoy was used to mark

each station prior to sampling and the position of each station was documented prior to sample collection using a differential GPS with an absolute accuracy of  $\pm 6.5$  ft ( $\pm 2$  m) and a repeatable accuracy of  $\pm 3.3$  ft ( $\pm 1$  m).

To collect samples using a piston corer, a decontaminated 3.5-inch-diameter Lexan<sup>®</sup> tube was attached to a piston head. The piston core was carefully lowered through the water column and manually “driven” into the sediment to a target penetration of just greater than 6.5 ft (2 m). The core was kept intact by placing a rubber stopper at the bottom of the core tube. At each location, three replicate cores were collected for porewater extraction. In addition, a fourth core was collected as a contingency. The overlying water was retained on the sediment surface, and the core was capped with a plumber’s-style test plug in a manner that avoided entrapping air bubbles between the cap and the sediment surface. The cores were transferred intact and upright to the field processing laboratory.

One water column sample was collected at each of the porewater locations, approximately 30 cm above the sediment-water interface. Samples were collected off the side of a stationary boat with a Sureflow<sup>®</sup> pump and pre-cleaned C-flex and Teflon<sup>®</sup> tubing and pumped directly into the appropriate sample container. Stringent mercury-free protocols were adhered to throughout overlying water sampling. Field measurements were made for DO concentration, temperature, and conductivity. The water quality measurements are presented in Table 2-14.

### **2.8.2.3 Field Testing Methods**

**Porewater Analysis** – Sediment was collected from seven stations for porewater analysis, with three replicate cores collected at each station. Porewater samples were extracted in the field processing laboratory by a scientist from Frontier Geosciences as soon as possible after collection, in accordance with the extraction method described in the work plan. All sample processing was done in an inert atmosphere (i.e., nitrogen-purged glove box). Each core was inserted through a hole drilled in the bottom of the glove box so that the surface of the sediment core always remained inside the glove box.

Based on sediment core data collected in 1992 (PTI, 1993d) and 1996 (PTI, 1997), different intervals of the core were collected at different station locations. Three sediment intervals per core were sampled at each station and porewater was obtained from each interval. The top interval sampled in each core was 0 to 4 cm. The second interval was 4 to 8 cm at Stations S303, S305, S344, S402, and S405; and 8 to 12 cm at Stations S354 and S355. The third interval sampled was 30 to 34 cm at Stations S354, S355, and S402; 60 to 64 cm at Stations S305 and S344; and 1.06 to 1.10 m at Stations S303 and S405. In order to provide NYSDEC with sufficient volume of porewater for a split sample, additional sediment (i.e., an increased interval size) was collected from one of the replicate cores at each of Stations S303, S305, S405, and S344, and the third interval sampled for NYSDEC split samples was 58 to 66 cm at Stations S305 and S344, and 1.04 to 1.12 m at Stations S303 and S405.

Each sample from the respective sediment core was extruded in appropriate intervals. Each interval was homogenized, taking care to exclude sediment that had contacted the wall of the core tube. A subsample

of sediment from each interval was placed in the appropriate sample container and shipped to an analytical laboratory for chemical analysis of bulk sediments. In addition, sediment from each interval was placed in pre-cleaned Teflon® centrifuge tubes and centrifuged for 30 to 60 minutes at 3,000 rpm to separate the porewater. The porewater was then filtered through an acid-cleaned 0.2-µm disposable nitrocellulose membrane filtration unit according the work plan. The filtered porewater from each interval was transferred to an appropriate container, labeled, double-bagged, and sent to the analytical laboratory on the same day as sediment collection and processing.

**Sulfide Analysis** – Seventy-nine sulfide measurements (71 samples and eight blanks) were performed at the field processing laboratory using Standard Method 4500-S<sup>2-</sup> D (i.e., the methylene blue method). Stringent air-free protocols were adhered to throughout the field sulfide analysis.

#### **2.8.2.4 Modifications to the Work Plan**

Based on discussions with NYSDEC personnel prior to porewater extraction, the sampling interval was increased slightly (i.e., 4 cm) to obtain enough porewater for NYSDEC split porewater samples at four stations (i.e., Stations S303, S305, S405, and S344).

#### **2.8.3 Aquatic Ecological Investigation**

The aquatic ecological investigation was designed to supplement information gathered during previous field investigations to complete the Onondaga Lake RI/FS BERA. The specific objectives of each study element are provided below.

This investigation was designed to study the effect of chemical substances in Onondaga Lake on three types of biological indicators: fish, benthic macroinvertebrates, and amphipods and chironomids. Fish populations in Onondaga Lake were evaluated to determine the characteristics of assemblages of adult and young-of-the-year (YOY) fish sampled from locations along the shoreline of the lake and in mouths of the tributaries to the lake, using standardized collection and analytical techniques. YOY fish were evaluated for the following reasons:

- They provide an indication of whether fish are successfully reproducing in the lake.
- They are important prey of many piscivorous fish and terrestrial animals.
- They generally have smaller home ranges than adult fish.

Benthic macroinvertebrate assemblages and their tissue concentrations were evaluated because they play an important role in the cycling of organic material in lakes, they are important prey of many fish, and their relatively limited mobility makes them particularly susceptible to toxic substances in the environment. Sediment toxicity was evaluated using amphipods and chironomids because this method provides an integrated empirical assessment of the effects of substances on representative aquatic organisms.

### 2.8.3.1 Whole Fish

The whole fish study element was designed to provide information to meet the following objectives:

- To fill gaps in contaminant characterization of fish by size range.
- To determine current contaminant concentrations in whole fish, thereby reducing the uncertainty associated with the 1992 fish data in which the whole fish concentrations were obtained by extrapolation from concentrations in fillets.

**Sampling Locations and Frequency** – Whole adult fish were collected in the lake near the mouth of Ninemile Creek and near the lakeshore from Tributary 5A to Harbor Brook. Composite YOY fish were collected from the mouths of Ninemile Creek, East Flume, Ley Creek, Harbor Brook, Onondaga Creek, Sawmill Creek, and Bloody Brook. Fish were collected from September 19 to 22, 2000. Table B1-46 of Appendix B presents the sample collection information for the fish samples.

**Field Collection Methods** – Several techniques (i.e., electroshock, seine nets, trapnets) were used to obtain both YOY and adult fish. A boat-mounted electrofishing unit was used to collect fish in Onondaga Lake and the mouths of Ninemile Creek, Onondaga Creek, and Ley Creek. Because several of the tributaries are too small to navigate with an electrofishing boat (i.e., an 18-ft [5.5-m], flat-bottom aluminum boat), alternative equipment (i.e., backpack electroshocker, seine nets, trapnets) were used to collect fish samples from the mouths of the creeks. All taxonomic identifications were made using standard reference texts.

Twenty-nine adult fish were collected during the sampling event, including seven bluegill, five channel catfish, 11 carp, and six smallmouth bass. The bluegill were all collected along the Tributary 5A/Harbor Brook reach. The channel catfish, carp, and smallmouth bass were collected from the mouth of Ninemile Creek and the Tributary 5A/Harbor Brook reach. Two of the 11 carp and two of the six smallmouth bass were collected in the lower reach of Ninemile Creek. Of the 29 adult fish collected, 17 fish were sent to the testing laboratory for whole-body tissue analysis and 12 fish were eviscerated and frozen for analysis of fish fillets.

YOY fish were also collected during the sampling event. Each composite YOY sample consisted of at least six fish of a single species. YOY fish were identified primarily by their sizes at capture. The species of YOY fish that were collected during the sampling event are listed below and the sizes of individual fish collected for analysis were less than or equal to the following maximum sizes:

- 80 mm – bluegill.
- 130 mm – largemouth bass.
- 80 mm – pumpkinseed.

As fish were collected, they were sorted by species and size and stored appropriately until they were sent to the testing laboratory. Samples were selected for analysis to ensure that at least one species was represented at all locations (except for adult bluegill, which could only be obtained along the Tributary 5A/Harbor Brook reach). The fish were analyzed for mercury and other metals, hexachlorobenzene, pesticides, PCBs, and polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/PCDFs).

Sample processing was conducted in accordance with the SOP entitled New York State General Fish Collection and Handling Procedures (NYSDEC, 2000). At the time of collection, the species, total length (to the nearest 1.0 mm) and weight (to the nearest 1.0 g wet weight), presence of grossly visible abnormalities (e.g., parasites, tumors, and skeletal abnormalities), and the sample location were recorded for each individual fish. In addition, the maturity, sex, and reproductive state of each individual adult fish were also recorded.

After length and weight measurements were made and the scales, spines, or fins (depending on the fish species collected) were removed for age determination, the fish designated for whole-body analysis were double-bagged in two plastic Ziploc® bags that contained a sample identification label. Fish designated for archiving for fillet analysis at some future date were eviscerated in the field and rinsed in lake water prior to placing the fish in doubled Ziploc® bags. Fish for composite samples were bagged together in doubled Ziploc® bags.

All pieces of equipment used to handle and process fish (e.g., fish boards, scales, and knives) were thoroughly scrubbed with an Alconox solution and well rinsed between sample stations.

**Modifications to the Work Plan** – The primary modification to the work plan was due to the inability to collect all fish specified in the work plan. NYSDEC was notified of these circumstances during the sampling. The following modifications were made to the work plan:

- Although every effort was made (e.g., different types of fish collection apparatus), it was not possible to obtain the 30 adult fish specified in the work plan (Exponent, 2000). A total of 29 adult fish (including 12 fish for filleting) were collected during the sampling event. The number of individuals collected per species and the locations of these collections (see Appendix B, Table B1-46) varied from the work plan (Exponent, 2000).
- While two large individual adult bluegill were to be collected at each location, no bluegill were collected near Ninemile Creek.
- Although every effort was made (e.g., different types of fish collection apparatus), only four of the adult fish species stipulated in the work plan (Exponent, 2000) were collected in Onondaga Lake. Furthermore, no adult white perch were collected during the sampling event.

- Twelve adult fish were collected, filleted, and frozen for analysis of fish fillets. At the request of NYSDEC, these samples were analyzed with the whole fish, since only 17 of the required 30 whole fish were analyzed; these data are included in this report and are used in the BERA and HHRA (TAMS, 2002a,b).
- The composite YOY sample of largemouth bass consisted of six to eight fish instead of the minimum of ten YOY fish per species stipulated in the work plan.
- Although every effort was made (e.g., different types of fish collection apparatus), it was not possible to obtain YOY banded killifish, carp, channel catfish, smallmouth bass, yellow perch, white perch, or walleye during the sampling event.
- Although every effort was made (e.g., different types of fish collection apparatus), it was not possible to obtain composite YOY samples from three species at each sampling location. Only one composite was collected at each of the Harbor Brook and the East Flume stations, and only two composites were collected at each of the Bloody Brook and Sawmill Creek stations.
- Although every effort was made (e.g., different types of fish collection apparatus), it was not possible to obtain a composite YOY fish sample near the Metro outfall.

### **2.8.3.2 Benthic Macroinvertebrates**

The benthic macroinvertebrate study element was designed to provide information to meet the following objectives:

- To determine the density and distribution of benthic macroinvertebrates in select sediment samples and update the 1992 sediment quality values presented in the draft Onondaga Lake RI/FS Baseline Ecological Risk Assessment (Exponent, 1998a).
- To determine mercury concentrations and total PCB concentrations (if a sufficient amount of tissue can be collected) in benthic macroinvertebrates to relate tissue concentrations to sediment concentrations.
- To evaluate the critical sediment concentrations that appear to result in bioaccumulation in benthic organisms and potential food-web transfer of mercury.

**Sampling Locations and Frequency** – Benthic macroinvertebrate community composition was evaluated at 15 stations in Onondaga Lake (Figure 2-18) and at two stations at the reference lake (i.e., Otisco Lake) (Figure 2-19). Benthic macroinvertebrate tissues (amphipods, chironomids, and oligochaetes) were evaluated at 15 stations in Onondaga Lake (Figure 2-18) and at two stations at Otisco Lake (Figure 2-19).

Eight of the Onondaga Lake stations for tissue sampling differ from stations for community analysis (and toxicity testing). The water depths and coordinates of these stations are presented in Table 2-9. Sampling was conducted from July to August 2000, in conjunction with the sampling of surficial sediments for the determination of the chemical composition and substance distribution and sediment toxicity. At every station at which benthic macroinvertebrates were collected, surficial sediments were also collected for evaluation of chemical concentrations.

**Field Collection Methods** – Samples were collected from either a 23-ft (7-m) pontoon boat or a 28-ft (8.5-m) pontoon boat, both of which were equipped with A-frames, winches, davits, and pulley assemblies. Stations were initially located on the basis of the target water depths and positioned along the shoreline, as identified in the work plan (Exponent, 2000). A buoy was used to mark each station prior to sampling and the position of each station was documented prior to sample collection using a differential GPS with an absolute accuracy of  $\pm 6.5$  ft ( $\pm 2$  m) and a repeatable accuracy of  $\pm 3.3$  ( $\pm 1$  m).

Sampling to determine bioaccumulation of chemicals in benthic organisms and to characterize the benthic community was completed by collecting the surface sediment (i.e., 0 to 0.5 ft [0 to 0.15 m]) using either a stainless-steel, modified Ekman dredge, or stainless-steel Klein dredge as described in the work plan. Each sediment sample, consisting of sediment and the overlying water, was strained through a stainless-steel sieve (600  $\mu$ m) to isolate benthic organisms. Fine sediments were removed by agitating the sieve and running a gentle stream of water over the sediments. Retained material collected for bioaccumulation analysis (i.e., amphipods, chironomids, and oligochaetes) was transferred upon collection to the shore processing area, sorted by species, weighed, and held at 4°C prior to testing. Five separate grab samples were collected at each station for benthic community analysis. These samples were transferred to an appropriate sample container and were preserved with 10 percent formalin with Rose Bengal stain (125 mg/L) in the field for later sorting and identification in a taxonomic laboratory. A replicate sample for benthic community analysis consisted of one Ekman dredge or one-quarter the volume from the Klein dredge. The sediment in the Klein dredge was sectioned using stainless-steel plates. Detailed sampling procedures for the processing of macroinvertebrate samples are provided in the work plan.

**Modifications to the Work Plan** – The following modifications were made to the work plan:

- Although every effort was made (e.g., extended periods of time at each station and multiple sediment grabs at each station), only limited numbers of benthic macroinvertebrates could be collected.
- Although every effort was made (e.g., extended periods of time at each station and multiple sediment grabs at each station), it was not possible to obtain amphipods, chironomids, and oligochaetes for bioaccumulation analyses at every station.
- After repeated attempts, the full penetration of 0 to 15 cm could not be obtained at all stations due to a hard layer of sediment encountered at approximately 8 to 12 cm (see Table 2-9).

### 2.8.3.3 Sediment Toxicity

The objective of the sediment toxicity study element was to assess chronic toxicity to benthic organisms.

The toxicity tests were the amphipod test using *Hyalella azteca* and the chironomid test using *Chironomus tentans*. The test endpoints included all endpoints specified in USEPA Test Method 100.4 (USEPA, 2000) for *Hyalella azteca* and were through pupation and emergence only, as specified in USEPA Test Method 100.5 (USEPA, 2000). These species are considered surrogate species selected to represent both epibenthic (*H. azteca*) and infaunal (*C. tentans*) macroinvertebrates.

**Sampling Locations and Frequency** – Surface sediment (i.e., 0 to 15 cm) was collected at 15 stations in Onondaga Lake (Figure 2-18) and at two stations at the reference lake (i.e., Otisco Lake) (Figure 2-19). The water depths and coordinates of these stations are presented in Table 2-9. Sampling was conducted in August 2000 in conjunction with the sampling of surficial sediments for the determination of the chemical composition and substance distribution and the sampling of benthic macroinvertebrate assemblages. Sediments for toxicity testing were collected as subsamples from the homogenized samples of surficial sediments collected for chemical analyses as part of the sediment chemistry study of the substance distribution study.

**Field Collection Methods** – Surface sediments sampled for toxicity testing were collected using either a stainless-steel, modified Ekman dredge or a stainless-steel Klein dredge, as described in the work plan. Samples were collected from a 28-ft (8.5-m) pontoon boat, which was equipped with A-frame, winch, davit, and pulley assembly. Stations were initially located on the basis of the target water depths and positioned along the shoreline, as identified in the work plan (Exponent, 2000). A buoy was used to mark each station prior to sampling and the position of each station was documented prior to sample collection using a differential GPS with an absolute accuracy of  $\pm 6.5$  ft ( $\pm 2$  m) and a repeatable accuracy of  $\pm 3.3$  ( $\pm 1$  m).

All sample compositing equipment was constructed of stainless steel and was decontaminated prior to sampling according to the procedures described in the work plan. Large indigenous organisms and large debris were removed in the field using decontaminated stainless-steel forceps and spoons. The sediments used for toxicity testing were placed in chemically cleaned glass jars with TFE-lined lids and held at 4°C prior to testing.

**Modifications to the Work Plan** – The following modifications were made to the work plan:

- In addition to using forceps, large indigenous organisms and large debris were also removed in the field using decontaminated stainless-steel spoons.
- After repeated attempts, the full penetration of 0 to 15 cm could not be obtained at all stations due to a hard layer of sediment encountered at approximately 8 to 12 cm (see Table 2-9).



## **2.9 Phase 2B Supplemental Water Sampling (2001)**

Based on historic aerial photographs and data obtained prior to and during the RI, it is believed that Honeywell may have historically disposed of large quantities of Solvay wastes and other chemical wastes directly into Onondaga Lake in the 1930s, 1940s, and 1950s. These aerial photographs are presented and discussed in Chapter 4.

The water sampling conducted in 1999 during the fall turnover investigation and water collected just above the sediment surface (“overlying water”) during the 2000 sediment porewater investigation indicated that mercury concentrations in this area were significantly higher than concentrations elsewhere in the lake. In December 2001, NYSDEC and TAMS undertook a supplemental water sampling program to document the release (or lack of release) of mercury from an area of Honeywell waste deposits in the southern corner of Onondaga Lake, as described in the work plan (TAMS, 2001).

The mechanisms of release from this waste could include diffusion, bioturbation, groundwater advection, and wave-induced resuspension, with resuspension likely to be a major mechanism of release. While several of these mechanisms might be assessed on a small scale (e.g., flux boxes), resuspension required that a large-scale, in-situ sampling program be conducted that would measure the combined effects of all these mechanisms, yet concentrate on resuspension. The results of the sampling were used to estimate the potential advective flux of resuspended sediments, as discussed in Chapter 6.

### **2.9.1 Sampling Location and Frequency**

This sampling was conducted on two separate days: a calm day (December 4, 2001) and a day with stronger northwest winds (December 18, 2001) generating waves in the southern corner of the lake, so as to provide two different resuspension conditions. Wind, environmental, and underwater conditions were monitored daily utilizing UFI’s Remote Underwater Sampling Station (RUSS) instrumentation. As shown in Figure 2-20, water samples were collected from eight stations along a transect extending from the shoreline in the middle of the waste mass in the East Flume and Harbor Brook area, to the “Baby RUSS” monitoring buoy (Station W64, installed by UFI for NYSDEC/TAMS), to the “Big RUSS” in the deep-basin southern station (historic Station W1, where the “Big RUSS” is located as part of an ongoing monitoring program), and then to a single location on the far side of the lake. There were two additional stations in the area of the waste mass (Stations W67 and W68).

### **2.9.2 Field Collection Methods**

The investigation was conducted by TAMS for NYSDEC using a boat equipped for sampling. On board the boat, which was operated by UFI, was a peristaltic pump, a GPS unit, a depth finder, and a Hydrolab unit.

Twelve samples were collected and analyzed for total mercury and TSS at the ten stations on each day, plus a single duplicate and blank. Samples were also collected and analyzed for dissolved and total mercury

at the stations near the RUSS buoys (Stations W1 and W64) on each day, plus a single duplicate. In total, there were 14 total mercury samples and three dissolved mercury samples (including duplicates and a blank) sampled on each day of sampling.

To sample for mercury and TSS, the Teflon® sampling line provided by the laboratory was attached to a peristaltic pump, and the other end secured to the Hydrolab sonde. Each station location was determined using a depth finder, and the boat was anchored. The location was noted by GPS reading, and a profile (a series of readings conducted at each one meter interval) was obtained with the Hydrolab (oxidation-reduction potential [ORP], conductivity, temperature, DO, and pH). The samples were collected during the profiling. An adequate time (approximately two minutes) was allowed to run the pump and flush the sampling line with water from that station. At least two minutes was allowed to flush the disposable filters for the dissolved mercury samples. Care was taken to collect surface water samples upwind of the boat and away from waters that came in contact with the boat or motor.

The sampling was conducted utilizing the clean-hands technique (USEPA Method 1669, SOP 72, Clean-Hands Technique for Water Sampling of Mercury [Exponent, 1998b]). This required two people to conduct the sampling (a “clean-hands” person and a “dirty-hands” person), plus the boat operator.

The samples were analyzed for total mercury (using low-level techniques, USEPA Method 1631, Revision D, 0.1 ng/L detection limit) and TSS at all of the stations, plus dissolved total mercury at the two RUSS stations (Stations W1 and W64). The analyses were conducted by NYSDEC’s contract laboratory (Frontier Geosciences) and data validation was conducted by EQA, Inc. The coordinates of the stations, analytical results, and the validation report are included in Appendix A6.

### **2.9.3 Modifications to the Work Plan**

There were no modifications to the work plan. However, during the first sampling event, the blank was collected a day before the other samples, placed in a TSS bottle, and shipped to the laboratory. Following receipt by the laboratory, the sample was transferred by the laboratory to the appropriate container prior to analysis. This is discussed further in Appendix A6 (QA/QC). Also, the number of Hydrolab readings collected during the second (windy) event was reduced from the number taken during the first (calm) event due to time constraints and evaluation of the purpose and use of the Hydrolab readings from the first event.

## **2.10 Supplemental Wetland SYW-6 Sediment Sampling (2002)**

After examination of the Phase 2A (2000) sediment data from Wetland SYW-6, Station S375 was determined to have elevated mercury concentrations. NYSDEC/TAMS conducted a supplemental sediment sampling program to determine the extent of contamination surrounding this core location.

### **2.10.1 Sampling Location and Frequency**

Five locations were sampled at two depth intervals (0 to 15 and 15 to 30 cm) surrounding Station S375 in May 2002. These five new stations are shown on Figure 2-21.

### **2.10.2 Field Collection Methods**

The investigation was conducted by NYSDEC and TAMS in May 2002 using a hand auger. The position of each station was documented using a differential GPS.

To collect samples, a Lexan tube was augured into the sediment to a target penetration of just greater than 1 ft (0.3 m). Wetland sediments were extruded from the core in two discrete sample intervals: 0 to 0.5 ft (0 to 15 cm) and 0.5 to 1 ft (15 to 30 cm). Both intervals were homogenized before sampling.

All sample compositing equipment was constructed of stainless steel and was decontaminated prior to sampling, consistent with the Phase 2A work plan (Exponent, 2000). The sediments used for chemical analyses were placed in chemically cleaned glass jars with TFE-lined lids and held at 4°C prior to testing.

Ten samples and one duplicate were collected and analyzed for metals, SVOCs, and TOC. The analyses were conducted by Mitkem Corporation and data validation was conducted by Analytical Assurance Associates, both under subcontract to NYSDEC/TAMS. The data and validation report are presented in Appendix B3.

### **2.10.3 Modifications to the Work Plan**

There were no modifications to the work plan. However, one of the stations (SYW6-5) could not be reoccupied for GPS documentation due to increased vegetation, and will be reoccupied at a later date. This station was placed on Figure 2-21, based on the field notes.