

5. NATURE AND EXTENT OF CONTAMINATION

This chapter presents and interprets the results of investigations designed to identify the nature and extent of contamination at the site. Those investigations include the assessment of contaminant distribution in:

- Lake sediment.
- Tributary sediment.
- Wetlands sediment.
- Dredged material.
- Sediment porewater.
- Lake water.
- Tributary water.
- Groundwater.
- Biological tissue.

In addition to measuring contaminant levels, other measurements were made to develop an understanding of the factors affecting the distribution, transport, bioaccumulation, and fate of the classes of chemical parameters of interest (CPOIs) in the lake system, including:

- Mercury and other metals.
- Benzene, toluene, ethylbenzene, and xylenes (BTEX).
- Chlorinated benzenes.
- Polycyclic aromatic hydrocarbons (PAHs).
- Polychlorinated biphenyls (PCBs).
- Polychlorinated dibenzo-*p*-dioxins and furans (PCDD/PCDFs).

The CPOIs were identified in Chapter 1, Section 1.6 as those elements or compounds selected as:

- Contaminants of potential concern (COPCs; see Chapter 1, Table 1-3) in the Onondaga Lake Human Health Risk Assessment (HHRA) (TAMS, 2002b).
- Contaminants of concern and stressors of concern (COCs/SOCs) (see Chapter 1, Tables 1-4 and 1-5) in the Onondaga Lake Baseline Ecological Risk Assessment (BERA) (TAMS, 2002a).

Where data are available, the distribution of chemical parameters is discussed in this chapter not only for the specific media in which a CPOI was identified as being of interest, but for additional media as well, in order to more fully depict the fate of and transport process affecting or governing the CPOIs. The other stressors defined in Chapter 6, Section 6.1 of the BERA, and presented in Chapter 1, Table 1-4 (e.g., calcium carbonate, oncolites, chloride, nitrogen, depleted dissolved oxygen [DO]) of this RI are discussed here only for the media in which they were identified as being of interest.

The data discussed in this chapter are derived primarily from the remedial investigation (RI) data reports prepared by Honeywell (PTI, 1993a,c,d, 1994a,b, 1996a, 1997) and from Appendices A through D of this RI for the four most recent investigations (i.e., the supplemental lake water sampling conducted in 1999, the Phase 2A and Phase 2B investigations conducted in 2000 and 2001, and the supplemental Wetland SYW-6 sediment investigation conducted in 2002). These investigations are summarized in Chapter 2 of this RI.

This chapter is organized into 11 main sections. The first section discusses the data quality assessment. The following nine sections characterize the nature and extent of contamination in lake sediment, tributary sediment, wetland sediment, dredged material, sediment porewater, lake water, tributary water, groundwater, and biological tissue. The final section summarizes the nature and extent of contamination for each medium.

Historical Data

Studies conducted prior to 1992, when this RI began, are summarized in the Onondaga Lake Remedial Investigation/Feasibility Study (RI/FS) Work Plan (PTI, 1991c). While pre-1992 data are limited in comparison to the RI data presented in this report, some information on historic conditions in the lake is useful for the purposes of this RI. A study conducted in 1970, and referenced by USEPA (1973), reported a maximum mercury concentration of 122.9 mg/kg in surface sediments. However, the location of this sample was unknown, and “surface sediments” was undefined. A sediment investigation by NYSDEC in 1986 and 1987 (NYSDEC, 1989) found mercury concentrations in surficial (i.e., 0 to 3 inches) sediments to be generally less than 0.5 mg/kg in nearshore areas and up to 50 mg/kg in the deep (9 m contours) sediments of the northern and southern basins. The maximum mercury concentration of 85 mg/kg was from a station located in the southern part of the lake, northwest of the mouth of Harbor Brook.

Historical (pre-1992) mercury concentrations for fish tissue, as reported by NYSDEC prior to 1992 (Sloan et al., 1987), were summarized in the Onondaga Lake RI/FS Work Plan (PTI, 1991c). In 1970, all fishing was banned from Onondaga Lake due to mercury contamination in the fish. At the time mercury levels in most of the 13 species analyzed were greater than 1 mg/kg, the US Food and Drug Administration (US FDA) action limit (Sloan et al., 1987). A followup study in 1985 and 1986 found that mercury levels in ten species were below 1 ppm, but that smallmouth bass (*Micropterus dolomieu*) and walleye (*Stizostedion vitreum*) still had levels exceeding 1 mg/kg. The mean mercury concentration in walleye declined from approximately 4.8 mg/kg in 1973 to less than 2 mg/kg in 1979, but remained above the US FDA limit through the 1980s. In 1986 the ban on fishing was lifted, but the fishery remained a catch-and-release fishery with an advisory to eat no fish. The current fish consumption advisory, starting in 1999, recommends consumption of no walleye caught in Onondaga Lake and to restrict the consumption of all other fish species from the lake to not more than once per month. In addition, women of childbearing age, infants, and children under the age of 15 should not eat any fish species from the lake (NYSDOH, 1999, 2002).

Another comprehensive source of pre-RI data is *Limnological and Engineering Analysis of a Polluted Urban Lake* (Effler, 1996). In this book, Effler (1996) has compiled decades of monitoring data and

modeling results on hydrodynamics and transport, chemistry, biology, and optics (water clarity) in Onondaga Lake. Where applicable, data from Effler (1996) are compared to RI data in this report. Other studies that are referenced in this RI are presented in Table 1-2.

5.1 Data Quality Assessment

Over 150,000 data points were collected during the RI. The chemical analysis data were reported as acceptable by the laboratories, with the exception of a limited number of results that were rejected during the quality assurance review process. Additionally, some of the results were qualified as estimates (marked with a “J” qualifying flag) during the quality assurance reviews. As noted in USEPA (1989): “The J-qualifier is placed on CLP data to provide important information about an analysis to a data user or decision-maker, not to indicate low confidence in the analysis.” Also noted in USEPA (1989): “The J-qualifier is a quantitative qualifier and can mean one or more of several things: 1) the target analyte is definitely present, 2) the sample was difficult to analyze, 3) the value may lie near the low end of the linear range of the instrument, and 4) the value should nearly always be seriously considered in decision-making.” Results qualified as estimates were still considered to have an acceptable degree of uncertainty for use in the RI. Further, the overall data set was considered adequate to support the analyses performed in and the objectives of this RI.

Complete quality assurance reports are provided in appendices to the RI data reports (PTI, 1993a,c,d, 1996a, 1997). For the four most recent investigations, quality assurance reports are attached as appendices to this report (Appendix A for the 1999 [Appendix A4] and 2001 [Appendix A6] supplemental lake water sampling, Appendices B through D for the 2000 Phase 2A investigation, and Appendix B3 for the 2002 supplemental Wetland SYW-6 sediment sampling). With the exception of the NYSDEC fish data used in the risk assessments, data from other sources used in this RI (see Table 1-2) were not subjected to additional data quality review by Honeywell and/or NYSDEC.

An assessment of the 1992 porewater results suggests that the sampling procedures were not implemented properly; therefore, the results of the 1992 porewater study are suspect. This is further discussed in Section 5.6.

5.2 Lake Sediment Characterization

This section summarizes the measured occurrence of CPOIs in Onondaga Lake sediments, including inorganic and organic compounds and stressors (calcium carbonate and oncolites) of interest. A geostatistical assessment of mercury in sediments is presented in Appendix I of this RI. Onondaga Lake is a complex environment where both natural and anthropogenic processes influence the distribution of contaminants.

Natural Processes Affecting CPOI Distribution

The sediments of Onondaga Lake are divided into two zones: the littoral zone (out to 9 m water depth, typically the depth of the thermocline) and the profundal zone (beyond 9 m water depth). Since the littoral zone sediments are covered by shallow, oxygenated water, they are subject to disturbance by wind-driven resuspension and bioturbation. Auer et al. (1996) described the profundal sediments as relatively undisturbed and reflective of sediment focusing (where fine-grained sediment and associated contaminants are resuspended from the littoral zone and deposited in the profundal zone). Because of the lake's depth and formation of an anoxic hypolimnion, the profundal sediments are not subject to wind-driven resuspension or bioturbation, but can be entrained in gas bubbles due to ebullition and transported to the water column.

The influx of suspended sediments from the tributaries also affects contaminant distribution in the lake bottom sediments. The tributaries form deltas of varying size and lateral extent, which physically impact the morphology of the lake bottom and, subsequently, the contaminant distribution. In addition, some of the tributaries are sources of contamination. Ninemile Creek and Onondaga Creek represent the two largest tributary inputs of water and suspended solids to Onondaga Lake.

In summary, sediment focusing, wind-driven resuspension, tributary flow, bioturbation, and gas ebullition are among the most important natural processes that influence the distribution of contaminants in the lake bottom sediments.

Anthropogenic Processes Affecting CPOI Distribution

Onondaga Lake is an urban lake that is surrounded by industrial, commercial, and recreational areas. Most of the northern half of the lake is surrounded by park land, while commercial and industrial areas are concentrated around the southern end. Onondaga Lake has been influenced by anthropogenic activities for over 200 years (Effler and Harnett, 1996). The varied nature and extent of these activities also influence the distribution of the CPOIs.

The historical discharge of waste into Onondaga Lake is probably the largest anthropogenic influence on contaminant distribution. The East Flume, one of the most significant discharge locations (see Chapter 4, Section 4.5.1), is an excavated drainage ditch that received releases from Honeywell's plant sites. Historical discharges into the lake in this area formed a large delta (on the order of 3 million cubic meters) of combined waste, referred to as the Honeywell in-lake waste deposit throughout this report (see Chapter 4, Section 4.5).

An example of the effect of the historical discharge of waste on the spread of contaminants is the "halo effect" observed for mercury and PCBs in the area of the East Flume (see Sections 5.2.1.1 and 5.2.2.11). The halo describes the area wherein sediments with higher concentrations surround sediments with relatively lower concentrations. A likely cause of the halo effect is a combination of the history of usage of various chemicals and the ensuing industrial discharge. Honeywell used or produced several of the major CPOIs

(low molecular weight PAHs, chlorinated benzenes, BTEX) from at least as early as 1918, but did not begin using PCBs or mercury until the 1940s or possibly the late 1930s. Based on historical aerial photographs obtained from Cornell University's Institute for Resource Information Systems (see Chapter 4, Figures 4-6 through 4-12) (D. Ayers, pers. comm., 2001), it was found that by 1938, Honeywell had already been discharging into Onondaga Lake near the western edge of Wastebed B, and by 1951 the discharge point had been moved east such that it was close to the midpoint of the wastebed's shoreline (see Figure 5-1).

Prior to the 1940s, a mound of Honeywell waste had formed near the point of discharge, extending along the lakeshore to the southeast. The predominant current in Onondaga Lake is counterclockwise, so the wastes were likely carried along the shore (southeast) away from the East Flume. These wastes presumably contained many organic CPOIs but not mercury or PCBs, since they were not yet in use. When Honeywell began using mercury and PCBs sometime in the 1940s, the deposition of subsequent waste materials discharged in this area may have occurred at the edges of the existing mound, forming a semicircle of mercury- and PCB-contaminated sediments. The exact location of the semicircle would have depended upon the then-existent bathymetry and the location of the point of discharge. As will be seen in the contaminant distribution maps (discussed below and presented in Figures 5-2 through 5-27) contaminants such as dichlorobenzenes do not exhibit a halo pattern, as they were discharged continuously well before 1938.

Other areas of inflow to the lake that have similar local variability include the mouth of Tributary 5A and the Ninemile Creek delta. As will be seen in Section 5.2.1.1, mercury concentrations are quite low close to Tributary 5A, but increase dramatically farther into the lake. The distribution of mercury contamination at the Ninemile Creek delta reflects the discharge of mercury from Honeywell facilities as well as dredging by Honeywell and Onondaga County in the late 1960s (USEPA, 1973).

Development of Contaminant Maps

For each contaminant or group of contaminants, a description of the distribution in sediment is provided, along with contaminant distribution maps, in Figures 5-2 through 5-27. The concentration contour plots depict representative concentrations at ten sediment depth intervals: 0 to 0.02 meters (m), 0 to 0.3 m, 0.3 to 1 m, 1 to 2 m, 2 to 3 m, 3 to 4 m, 4 to 5 m, 5 to 6 m, 6 to 7 m, and 7 to 8 m. These intervals were selected to provide higher resolution of the near-surface sediments, while also identifying the deeper spatial distribution of contaminants to the maximum depth sampled of 8 m.

The contaminant distribution maps include both 1992 and 2000 data from the RI. When the sample depth intervals did not match the depth intervals selected for mapping, the following assumptions were made at each station:

- If only part of a mapped depth interval was sampled at a particular station, then the concentration measured in the analyzed section was assumed to represent the station's concentration for the entire interval.

- If two or more samples were analyzed from an interval, the concentration for that interval was estimated as the length-weighted average of the measurements.
- If no material from an interval was sampled, then the concentration in the interval was not estimated (i.e., no vertical interpolation was used); the exception to this is mercury, for which a simple depositional model was applied to estimate deeper sediment segments, as explained below.

The importance and spatial extent of mercury contamination in the lake is reflected in the large number of sampling locations analyzed for mercury. As reflected in the various sampling programs, the depth of mercury contamination is not the same everywhere, with deeper mercury contamination within the sediments found in the southwestern nearshore area of the lake. In other areas, mercury contamination is generally limited to shallow (<1 m) sediments. Thus, sampling in these areas is generally limited to shallower depths.

This knowledge of the vertical extent of mercury was reflected on the contour maps by assuming mercury contamination in all areas of the lake, generally following the conceptual statement that mercury contamination in the sediments is vertically continuous with the sediments. That is, one or more layers of recent mercury-contaminated sediment overlie cleaner sediment beneath. Thus, once a clean layer of sediment is found within a core, all deeper layers can be assumed to be clean.

This “depositional” model was applied to stations that were not sampled all the way down to 8 m. For these stations, the depositional model assumed that if the mercury concentration decreased below background levels at the lowest observed depth, it remained uncontaminated at greater depths, even though no samples were collected beyond the station’s lowest observed depth. Based on this assumption, a station-by-station evaluation was performed, and the mercury concentrations were projected to greater depth in stations where the depositional model was applicable.

For the purpose of mapping the contaminants, organic CPOIs, including dichlorobenzenes, trichlorobenzenes, PAHs, PCBs, and PCDD/PCDFs, were summed as follows:

- **Dichlorobenzenes:** 1,2-, 1,3-, and 1,4-dichlorobenzenes were summed using only detected values. In cases where all three analytes were not detected, the minimum detection limit reported for a single analyte was used as the concentration for the sample.
- **Trichlorobenzenes:** From 0 to 2 m, 1,2,3-, 1,3,5-, and 1,2,4-trichlorobenzenes were summed using only detected values. In cases where all three analytes were not detected, the minimum detection limit was used, in the same manner as for dichlorobenzene. Below 2 m, the maps represent only 1,2,4-trichlorobenzene because it was the only trichlorobenzene analyte reported.

- **PAHs:** PAHs were divided into low molecular weight PAHs (LPAHs) (i.e., fluorene, naphthalene, and 2-methylnaphthalene) and high molecular weight PAHs (HPAHs) (i.e., acenaphthene, acenaphthylene, anthracene, benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, indeno[1,2,3-c,d]pyrene, phenanthrene, and pyrene), based on the results of the principal components analysis (PCA) (see Appendix I). Individual analytes for both LPAHs and HPAHs were summed using only detected values. In cases where all analytes were not detected, the minimum detection limit for a single PAH was used.
- **PCBs:** The method used for summing Aroclors to obtain the total PCB concentration is consistent with that used in the Onondaga Lake HHRA (TAMS, 2002b). When two or more Aroclors were detected, only the detections were summed. When only one Aroclor was detected, it was combined with half the detection limit of one other Aroclor. When all the Aroclors were non-detects, the average of two Aroclors were taken, using half the detection limit for both (typically, they all had the same detection limit). PCBs were further divided into low (less than Aroclor 1254) and high (greater than Aroclor 1254) molecular weight Aroclors, and maps were produced for each group. Of the low molecular weight PCBs, only Aroclors 1242 and 1248 were detected.
- **PCDD/PCDFs:** PCDD/PCDFs were presented in terms of toxicity equivalent (TEQ) concentrations. The TEQ approach, developed to facilitate risk assessment, generates a single toxicity value for a mixture of compounds based on the relative risk of individual constituents. Specifically, concentrations of each PCDD/PCDF congener are multiplied by their toxicity equivalence factor (TEF), which is an estimate of a PCDD/PCDF congener's toxicity relative to the most toxic congener within that chemical group (i.e., 2,3,7,8-tetrachlorodibenzo-*p*-dioxin [2,3,7,8-TCDD]), to yield compound-specific TEQ concentrations. The individual TEQ concentrations were summed, producing a single TEQ concentration that approximates the toxicity of all PCDD/PCDFs in the mixture relative to 2,3,7,8-TCDD. The TEFs used here are World Health Organization (WHO) values taken from Van den Berg et al. (1998).

The contaminant distribution maps were generated using ArcView™ Spatial Analyst, based on a deterministic approach called the Inverse Distance Weighted (IDW) interpolation. The IDW assumes that each measured concentration has a local influence that diminishes with distance. The end result is a series of color-filled contour maps outlining the extent of contamination and detailing the location of hot spots.

The IDW interpolator requires a search neighborhood and power value. The search neighborhood restricts how far and where to look for the measured concentrations used in prediction, while the power value

influences the weighting of the measured location's concentration on the prediction location's concentration. Weights assigned to each measured concentration are proportional to the inverse distance raised to the power value. A circular search neighborhood of a 500 m radius and a power of 6 were applied to each map surface. In addition, the 9 m contour boundary was used to separate the interpolation of the shallow epilimnetic or littoral sediments from the deeper hypolimnetic or profundal sediments. The search neighborhood selected was appropriate for the sample density and distribution in the deep (water depth equal to or greater than 9 m) portion of the northern basin and part of the deep portion of the southern lake basin. The deep portion referred to in the southern basin was the portion closer to the central part of the lake, away from the lakeshore.

At water depths of up to 2 m, the distribution of sample points in the nearshore southern basin is considerably more dense and clustered than the rest of the lake. The input data in this nearshore southern basin may provide greater detail than the search neighborhood is able to resolve, and, as a result, the search neighborhood does not always provide accurate resolution of contaminant trends or features in this area. However, at the scale of the maps, exceedances of screening criteria are generally clear and accurately represented, even with the large search neighborhood selected. Because of the large search neighborhood and the limited sample distribution at depth, large areas of contamination are interpolated, with a corresponding degree of uncertainty. It is important to note that a geostatistical analysis (i.e., kriging) is required to accurately determine the volume of sediment to be remediated in the FS. This was demonstrated for mercury in Appendix I of this RI, in which areas with high probabilities of exceeding a site-specific probable effect concentration were delineated.

Concentrations reported as non-detects added some degree of complexity to the contouring process. It cannot be automatically inferred that a non-detect indicates no contamination. The standard approach used in risk assessment is to use one-half the detection limit as the sample concentration. This approach is problematic because if a high detection limit is reported for a sample in a relatively clean area, half the detection limit might result in a concentration indicating significant contamination. In general, this was a minor issue for metal CPOIs, but was an important concern for organic CPOIs because of the higher number of non-detect values and the high detection limits associated with the organic concentrations. In this analysis, non-detects for metals and organic CPOIs were evaluated as follows:

- For metal CPOIs, non-detects were first compared to background concentrations, which were established as twice the mean CPOI concentration at Otisco Lake (Appendix G, Table G1-1). If one-half of the detection limit was consistent with the background concentrations, then the concentration used in map generation was one-half of the detection limit. Non-detect values that were higher than background were flagged and assessed spatially. In the spatial assessment, maps of each metal CPOI were produced without the flagged non-detects. The values interpolated at the locations of the flagged non-detects were compared to the non-detect reported level. In cases where the interpolated value was consistent with (i.e., less than or equal to) the detection limit, the non-detect value was considered consistent with the resulting map and the map was not revised to include the non-

detect value. The flagged samples were used only when they added information to the map; that is, when the interpolated value was greater than the non-detect level. In this instance, the map was reinterpolated using the flagged non-detect results at one-half of the detection limit.

- The mapping analysis for non-detect organic CPOIs was more involved. Non-detect organic values were first compared to the most-conservative NYSDEC screening criterion. Samples whose detection limits exceeded twice the state screening criterion were flagged. Clusters of non-detects mostly were detected in the northern basin and in the southeastern area of the lake in deeper sediments. In cases where a non-detect with a very high detection limit was detected within a cluster of other non-detects, the high non-detect sample point was not used in contouring. In cases where a non-detect was surrounded by detections, it was only retained in the contouring (at one-half of the detection limit) if it was consistent with the surrounding data and added information to the map (i.e., if the non-detect level was not substantially higher than the surrounding detections).

After integrating the reported values and the non-detect results, the contours of each map were developed using Spatial Analyst. Based on the large range of values and the typical log-normal nature of contaminant data, contour intervals, or bins, were selected at either half- or one-log step. The number of bins for each map was limited to about eight, and in cases where more bins were required at the half-log step interval, a full log step interval was used instead. When applicable, the half-log or log step contour intervals were further split to reflect the NYSDEC risk-based sediment screening criteria, which include lowest effect level (LEL) and severe effect level (SEL) criteria for metal CPOIs (NYSDEC, 1999). Likewise, human health bioaccumulation (HHB), wildlife bioaccumulation (WB), acute toxicities for benthic aquatic life (ATBAL), and chronic toxicities for benthic aquatic life (CTBAL) criteria based on organic carbon content were applied to organic CPOIs (NYSDEC, 1999).

For those NYSDEC sediment screening criteria expressed in terms of organic content, the value given for each criterion is based on the average organic carbon content (5 percent) measured in Onondaga Lake sediment samples. Because the organic carbon content varies with location (0.1 to 46.3 percent), the organic CPOI maps must be interpreted with caution from a risk-based perspective. Specifically, the organic carbon-based criteria shown on the maps represent a general guide to those areas exceeding NYSDEC screening criteria. However, these contours should not be considered exact for the purposes of identifying areas that present unacceptable risks.

NYSDEC sediment criteria have been used as a screening tool to identify areas affected by various contaminants. Site-specific risks are discussed at length in the BERA and HHRA (TAMS 2002a,b). While many of the NYSDEC screening criteria are not generally applied to sediments at depth, they are used here to assist in describing contaminant concentrations. For comparison, sediment metal concentrations from Otisco Lake are presented in Appendix G1, Table G1-1. Summary results (by sediment core interval) of

screening against appropriate sediment criteria and/or standards are provided in Appendix G2, Tables G2-1 through G2-7.

In addition to the sediment contour maps, cross sections along four transects were generated to further illustrate the spatial distribution of mercury, chlorobenzene, xylenes, and LPAHs in Onondaga Lake sediments. The location of each transect (see Figure 5-1) was selected to illustrate vertical and horizontal CPOIs concentrations near Honeywell source areas, as follows:

- Cross section A-A' is perpendicular to the shoreline and extends northeastward from Wastebed B to near Ley Creek.
- Cross section B-B' starts near the Willis Avenue Plant site and extends eastward through the southern basin, terminating near Ley Creek.
- Cross section C-C' starts alongside Wastebeds 1 through 8 and extends approximately parallel to the southwest lakeshore, crossing sediments near the mouths of Tributary 5A, the East Flume, and Harbor Brook.
- Cross section D-D' extends from the mouth of Ninemile Creek, through the northern basin, and to the eastern shoreline. Only mercury is shown for this cross section.

The methods used to illustrate sediment concentrations in the cross sections are consistent with the contour plots discussed above. Specifically, contour intervals correspond to the same concentration ranges, with the same color shading used on cross sections and contaminant maps. The cross sections were generated by aligning the contaminant maps, showing the 0 to 8 m sediment depth, vertically, and slicing through this alignment along the selected transect. The resulting data set is displayed with a vertical exaggeration of ten. It should be noted that because of the scale of the cross section (i.e., up to 8 m deep), the 0 to 2 cm layer is not visible in the cross sections.

Tables containing summary statistics, including the maximum detected concentration for each analyte, are provided for each depth interval and for each investigation (see Appendix G1). The lake sediment data from the 0 to 8 m depth intervals that were collected by Honeywell/Exponent during the Phase 2A investigation in 2000 are summarized in Appendix G1, Tables G1-2 through G1-12. Lake sediment data summary statistics for data collected by Honeywell/PTI in 1992 are presented in Appendix G1, Tables G1-13 through G1-20. Appendix G1, Table G1-21 summarizes lake stratigraphy data collected by Honeywell/PTI in 1992 from depth intervals ranging between 0 and 3 m.

5.2.1 Mercury and Other Metals

Metal levels in the lake generally conform to a single pattern of contamination, reflecting their association with sediment and sediment deposition. In nearly all cases, the surface sediments (0 to 0.02 m) exceed

NYSDEC LEL and sometimes SEL screening criteria. Maximum concentrations are found in the 0 to 1 m interval, with deeper layers gradually becoming less contaminated. Typically, sediments in the 0 to 1 m interval exceed NYSDEC LEL criteria. The pelagic sediments (beyond 9 m of water depth) are generally more contaminated than littoral sediments, with two notable exceptions: the areas of the Ninemile Creek delta and the littoral zone between Tributary 5A and Ley Creek have significantly higher and deeper contamination than any other areas of the lake, reflecting the proximity of these areas to the main metal discharge locations. In particular, the in-lake waste deposit off the East Flume generally contain the highest concentrations of metals. As might be expected, the least-contaminated sediments in the lake are those of the littoral zone along the northern edge of the lake, as they are farthest from the known discharge locations.

5.2.1.1 Mercury

Mercury in surface sediments (0 to 0.02 m) exceeds the SEL screening criterion of 1.3 mg/kg throughout most of Onondaga Lake, with concentrations exceeding 10 mg/kg in the area of the two known sources of mercury in the lake; namely, the Ninemile Creek delta and the Honeywell in-lake waste deposit between Tributary 5A and Harbor Brook (see Figures 5-2 and 5-3). From 0 to 1 m depth, much of the deep basins and the two source areas have mercury concentrations above 10 mg/kg. Below 2 m depth, mercury concentrations have fallen from the highs seen in the 0 to 1 m interval. Most of the lake has low concentrations of mercury (<0.1 mg/kg), with the two source areas now clearly standing out with concentrations above 31 mg/kg. The elevated mercury concentrations (exceeding the SEL of 1.3 mg/kg) in the Ninemile Creek delta decrease to levels at or below the LEL (0.15 mg/kg) at a depth of 6 m, but the concentrations in the Honeywell in-lake waste deposit continue to be above the LEL to the bottom of the cores at 8 m. As shown in the cross sections, large volumes of mercury-contaminated sediments exist along the shoreline near Harbor Brook (Section A) and Ninemile Creek (Section D) to a distance over 500 m into the lake.

The pattern of mercury contamination around East Flume shows a halo effect, which is likely due to the history of mercury discharge from the Honeywell facilities. The distributions of mercury in the sediment layers from 0 to 2 m are consistent with the mercury geostatistical analysis results presented in Appendix I, which present the probability of exceeding the site-specific probable effect concentration (PEC) of 2.2 mg/kg derived in the BERA. The geostatistical analysis suggests that, in the profundal zone, much of the sediments in the 0 to 0.3 m (see Appendix I, Figure I-9) and 0.3 to 0.6 m (see Appendix I, Figure I-10) intervals are highly contaminated relative to the PEC, with the exception of areas off of Ninemile Creek and Bloody Brook, which are likely affected by the deltas from those streams. Below 0.6 m (see Appendix I, Figures I-11 and I-12), areas of contamination relative to the PEC are limited to the southern basin, especially between Harbor Brook and Ley Creek, along with some areas in the Ninemile Creek delta. In the littoral zone, sediments were contaminated relative to the PEC in three areas: the mouth of Harbor Brook, the vicinity of the former loading dock or causeway, and the mouth of Ninemile Creek.

5.2.1.2 Cadmium

Cadmium in surface sediments (0 to 0.02 m) exceeds the LEL criterion of 0.6 mg/kg throughout most of the lake (see Figure 5-4). From 0 to 1 m depth, much of the deep basin sediments have concentrations above the cadmium SEL concentration of 9 mg/kg, with even higher concentrations in the area of Ley Creek. By 2 m depth, most of the lake has lower concentrations of cadmium, although several areas, including the Ninemile Creek delta, the Honeywell in-lake waste deposit, and especially the area near Ley Creek, are still elevated above the LEL. By 3 m depth, the elevated concentrations near the mouth of Ley Creek are not present, and only the Ninemile Creek delta, the area around the Honeywell in-lake waste deposit, and the mouth of Onondaga Creek still contain concentrations above 1 mg/kg. Below 4 m, only the Ninemile Creek delta and the Honeywell in-lake waste deposit contain cadmium concentrations above 1 mg/kg.

5.2.1.3 Chromium

Chromium in surface sediments (0 to 0.02 m) exceeds the LEL criterion of 26 mg/kg throughout most of the lake, with concentrations above the SEL of 110 mg/kg in the areas near Tributary 5A, which receives discharges from the Crucible Materials Corporation, and alongside the Honeywell plant sites (see Figure 5-5). From 0 to 1 m depth, much of the deep basins and the littoral zone near the mouth of Ley Creek exceed the SEL, with the areas near the Crucible and Honeywell plant sites exceeding 1,000 mg/kg. From 1 to 2 m depth, most of the lake has low concentrations of chromium (<26 mg/kg). In contrast, the areas in front of the plant sites now clearly stand out, with concentrations above 1,000 mg/kg. Similarly, the mouths of Ninemile and Ley Creeks have concentrations ranging from 31.6 to 316 mg/kg. Below 2 m depth, there are generally only data for the littoral zone. This is not a significant limitation for the pelagic sediments, since these areas have already dropped below the chromium LEL in the overlying 1 to 2 m layer. At 3 m depth, concentrations greater than 1,000 mg/kg are not present, and chromium concentrations above 32 mg/kg are centered around the Ninemile Creek delta and the Honeywell in-lake waste deposit. Chromium concentrations remain above the LEL at locations within these two source areas at depths of at least 6 to 8 m.

5.2.1.4 Copper

Copper in surface sediments (0 to 0.02 m) exceeds the LEL criterion of 16 mg/kg throughout most of the lake (see Figure 5-6). From 0 to 1 m depth, much of the deep basins have concentrations above the SEL of 110 mg/kg, with even higher concentrations in some areas of the southern part of the lake. Below a sediment depth of 2 m, most of the lake has lower concentrations of copper, although several areas are still elevated above the LEL, including the Ninemile Creek delta and the southern shoreline portion of the lake. Below 2 m, there are generally only data for the littoral zone. As discussed for chromium, this is not a significant limitation in the pelagic areas, as discussed for chromium. By 3 m depth, the elevated concentrations in the Ninemile Creek delta, the area around the in-lake waste deposit, and the mouth of Onondaga Creek, continue to exceed the LEL. Below 5 m depth, only the Ninemile Creek delta and the Honeywell in-lake waste deposit still contain copper concentrations above the LEL.

5.2.1.5 Lead

Lead concentrations in surface sediments (0 to 0.02 m) exceeds the LEL criterion of 31 mg/kg throughout most of the lake (see Figure 5-7). From 0 to 1 m, much of the deep basins and the littoral zone in the Ninemile Creek delta and the southern portion of the lake have lead concentrations above the SEL of 110 mg/kg, with the areas near the Crucible Materials Corporation and Honeywell plants exceeding 1,000 mg/kg. Below a sediment depth of 2 m, most of the lake still has concentrations of lead above the LEL of 31 mg/kg, with some areas in the southern basin also exceeding the SEL. At 3 m depth, concentrations exceeding 1,000 mg/kg no longer occur, but lead concentrations above the LEL remain in the Ninemile Creek delta and the Honeywell in-lake waste deposit down to 7 and 8 m.

5.2.1.6 Nickel

Nickel in surface sediments (0 to 0.02 m) exceeds the LEL criterion of 16 mg/kg throughout most of the lake, with concentrations above the SEL of 50 mg/kg in the areas near the Crucible Materials Corporation and Honeywell lakeshore area sites (see Figure 5-8). From 0 to 1 m depth, much of the deep basins and the littoral zone near the mouth of Ley Creek have nickel concentrations above 50 mg/kg, while the areas near the Crucible and Honeywell plant sites exceed 300 mg/kg. From 1 to 2 m depth, most of the lake has nickel concentrations above the LEL, with the area near the plant sites exceeding 300 mg/kg and a portion of the southern area of the lake above the SEL of 50 mg/kg. Below a sediment depth of 3 m, concentrations above 300 mg/kg are absent, but nickel concentrations above the LEL remain in the Ninemile Creek delta and the Honeywell in-lake waste deposit to a depth of at least 8 m.

5.2.1.7 Zinc

Zinc in surface sediments (0 to 0.02 m) exceeds the LEL criterion of 120 mg/kg throughout the deep basins of the lake and the littoral zone at the southern end (see Figure 5-9). From 0 to 1 m, much of the deep basins and the littoral zone near the mouth of Ley Creek and the areas near the Crucible Materials Corporation and Honeywell lakeshore area sites have zinc concentrations above the SEL of 270 mg/kg. By 2 to 3 m depth, the area of the lake with zinc concentrations above the LEL decreased, but concentrations above the SEL exist at the delta of Ninemile Creek and in the area between Harbor Brook and Ley Creek. Below 3 m, the zinc concentrations remain above the SEL in the Ninemile Creek delta and in the vicinity of Harbor Brook to a depth of at least 6 m.

5.2.2 Organic Contaminants

Organic contaminants in the lake generally follow one of two contaminant patterns. For the shorter-lived, lower molecular weight organic compounds, sediment contamination is generally limited to the southern basin littoral area, focused around the in-lake waste deposit and the shoreline area of the Honeywell sites. These compounds include the BTEX group and the chlorinated benzenes.

Higher molecular weight compounds, specifically the PCBs, tend to be more widely distributed in the lake, with large areas of the southern deep basin showing significant contamination. As for the lighter of these compounds, PCB contamination is highest in the southern littoral zone. PAHs and PCDD/PCDFs also fall into this category, but the data set for these compounds is less extensive. For PAHs, the data available exhibit patterns similar to those observed for PCBs, with maximum concentrations in the southern basin littoral zone and lower, but significant, concentrations elsewhere in the lake. For PCDD/PCDFs, the data are limited to the littoral zone, but even this data set shows maximum concentrations associated with the in-lake waste deposit and the Honeywell shoreline area.

In many ways, the distribution of the higher molecular weight contaminants is similar to that of the metals. Metals and high molecular weight organic contaminants have two centers: the Ninemile Creek delta and the southern littoral zone. The lighter molecular weight compounds generally have only one major center of contamination, at the southern littoral zone. Note that elevated levels of some organics (e.g., PCBs) extend around the southern basin perimeter to Ley Creek.

On the maps for organic contaminants, a concentration contour has been derived based on the NYSDEC sediment screening criteria and assuming a constant organic carbon content of 5 percent. These values are only approximate, since the absolute concentration criteria vary with the organic carbon content of the sediment. For this reason, the criteria are not specifically discussed in this text for all CPOIs.

Also evident in several figures for the organic compounds is the less extensive sample coverage at depths greater than 2 m. This is an artifact of the various sampling programs. Deeper cores were generally limited to areas of suspected deep contamination. In nearly all instances, this data limitation does not affect the interpretation of lake contamination because, in most instances, the contamination in the 1 to 2 m layer is already at or close to background levels. Based on cores collected for this investigation as well as others, it is reasonable to assume that subsequent, unsampled layers are also at or below concentrations seen in the overlying layers.

5.2.2.1 Benzene

In the surface sediments (0 to 0.02 m), the highest concentrations (100 to >1,000 µg/kg) for benzene are centered on the littoral zone in an area extending from Harbor Brook to Solvay Wastebeds 1 through 8, with concentrations decreasing rapidly to levels less than 100 µg/kg throughout the rest of the lake at this depth interval (see Figure 5-10). From 0 to 2 m depth, this pattern is even more pronounced, with higher peak concentrations (>10,000 µg/kg). By 4 m, concentrations exceeding the NYSDEC chronic toxicity value at 5 percent organic carbon of 1,400 µg/kg are centered only on the in-lake waste deposit, and extend to the bottom of the cores at 8 m. However, deep cores were not performed along the shoreline of Wastebeds 1 through 8, where contamination extended to the bottom (1 to 2 m) of available cores. The pattern of sediment contamination observed for benzene is typical of the compounds in the BTEX group.

5.2.2.2 Ethylbenzene

In the surface sediments (0 to 0.02 m), the highest concentrations (100 to >1,200 µg/kg) of ethylbenzene are centered on the littoral zone in the Honeywell in-lake waste deposit and near Wastebeds 1 through 8, with concentrations lower than 10 µg/kg throughout the rest of the lake at this depth interval (see Figure 5-11), similar to the distribution observed for benzene. From 0 to 2 m, this pattern is even more pronounced, and between 2 to 3 m, concentrations exceeding 100 µg/kg of ethylbenzene appear in the Ninemile Creek delta. Below 4 m, the concentrations exceeding the NYSDEC chronic toxicity value at 5 percent organic carbon of 1,200 µg/kg are centered only on the in-lake waste deposit, and extend to the bottom of the cores at 8 m.

5.2.2.3 Toluene

In the surface sediments (0 to 0.02 m), the highest concentrations (100 to >2,500 µg/kg) of toluene are centered on the littoral zone in the Honeywell in-lake waste deposit and near Wastebeds 1 through 8, with concentrations generally less than 1,000 µg/kg throughout the rest of the lake at this depth interval (see Figure 5-12). From 0 to 2 m depth, this pattern is even more pronounced, with higher peak concentrations (>12,000 µg/kg). Below 4 m, concentrations exceeding the NYSDEC chronic toxicity value at 5 percent organic carbon of 2,450 µg/kg are centered only on the in-lake waste deposit and the Honeywell lakeshore sites, and extend to the bottom of the cores at 8 m.

5.2.2.4 Xylenes

In the surface sediments (0 to 0.02 m), the highest concentrations (100 to >100,000 µg/kg) of xylenes are centered on the littoral zone in the Honeywell in-lake waste deposit and near Wastebeds 1 through 8, with concentrations less than 100 µg/kg throughout the rest of the lake at this depth interval (see Figures 5-13). From 0 to 2 m depth, this pattern is even more pronounced in the southwestern corner of the lake, and concentrations above 1,000 µg/kg of xylenes also appear in the Ninemile Creek delta. Evident in the maps for ethylbenzene, toluene, and xylenes is the continued presence of elevated concentrations in the deep basin sediments near the highly contaminated southern basin littoral zone. Although no data are available in this area below a sediment depth of 2 m, it is observed that the littoral zone contamination gradually decreases below this depth. This would suggest that the concentrations of these contaminants would similarly decrease in the unsampled deep sediments in this area. Below 4 m depth, the concentrations exceeding the NYSDEC chronic toxicity value at 5 percent organic carbon of 4,600 µg/kg of xylenes are centered only on the in-lake waste deposit, and extend to near the bottom of the cores at 7 m.

The vertical distribution of xylenes is also represented in the cross sections presented in Figure 5-14. Evident in each cross section is the thick sequence of contaminated sediment associated with the Honeywell shoreline area and the in-lake waste material. Also evident are the underlying uncontaminated sediments of the lake in the areas outside the littoral zone, indicating the relative shallow sediment depth of contamination in these areas (e.g., the areas near Sections A' and B').

5.2.2.5 Chlorobenzene

In the surface sediments (0 to 0.02 m), the highest concentrations ($>10,000$ $\mu\text{g/kg}$) of chlorobenzene are located in an area in front of the Honeywell lakeshore sites (Willis, Semet, and Wastebed B/Harbor Brook) and in the in-lake waste deposit, with concentrations decreasing rapidly to less than the NYSDEC chronic toxicity value of 175 $\mu\text{g/kg}$ throughout the rest of this depth interval (see Figures 5-15 and 5-16). In fact, the remainder of the lake is below the NYSDEC benthic aquatic life acute toxicity value at 5 percent organic carbon of $1,730$ $\mu\text{g/kg}$ at all depths, and most sediment depths are below the benthic aquatic life chronic value at 5 percent organic carbon of 175 $\mu\text{g/kg}$. From 0 to 2 m depth, portions of the areas in front of the Honeywell sites and in the in-lake waste deposit have concentrations exceeding $100,000$ $\mu\text{g/kg}$. Below 2 m, there are generally data only from the littoral zone, and concentrations exceeding the benthic aquatic life acute toxicity value at 5 percent organic carbon are centered only on the in-lake waste deposit, and extend to the bottom of the cores at 8 m (see also Sections A and C in Figure 5-16).

5.2.2.6 Dichlorobenzenes

In the surface sediments (0 to 0.02 m), the highest concentrations of dichlorobenzenes ($>10,000$ $\mu\text{g/kg}$) are located in the area of the Honeywell in-lake waste deposit, with concentrations decreasing rapidly to less than 100 $\mu\text{g/kg}$ throughout the rest of the lake (with the exception of the area of the Honeywell lakeshore sites and Wastebeds 1 through 8) in this depth interval (see Figure 5-17). From 0 to 3 m depth, the elevated concentrations are still prevalent throughout the southwest portion of the lake, and exceed NYSDEC's benthic aquatic life acute toxicity screening value at 5 percent organic carbon of $6,000$ $\mu\text{g/kg}$. Below 3 m depth, the concentrations greater than $1,000$ $\mu\text{g/kg}$ continue to be centered on the in-lake Honeywell deposit, and extend to a depth of 7 m.

5.2.2.7 Trichlorobenzenes

In the surface sediments (0 to 0.02 m), concentrations of trichlorobenzenes are lower than the NYSDEC benthic aquatic life chronic toxicity value at 5 percent organic carbon of $4,550$ $\mu\text{g/kg}$, with values between 100 and $4,550$ $\mu\text{g/kg}$ in the area of the Honeywell in-lake waste deposit, while concentrations are less than 100 $\mu\text{g/kg}$ throughout the rest of the lake in this surface interval (Figure 5-18). From 0 to 3 m depth, the areas with concentrations between 100 and $4,550$ $\mu\text{g/kg}$ expand into the deep southern basin and to Ley Creek in the littoral zone, with concentrations exceeding the NYSDEC benthic aquatic life acute toxicity value at 5 percent organic carbon of $45,500$ $\mu\text{g/kg}$ at discrete locations. Below 3 m, concentrations are less than $4,550$ $\mu\text{g/kg}$.

5.2.2.8 Hexachlorobenzene

In the surface sediments (0 to 0.02 m), the hexachlorobenzene concentrations above $1,000$ $\mu\text{g/kg}$ are centered on the Honeywell in-lake waste deposit near the East Flume, with the majority of the lake at this depth interval having concentrations below 100 $\mu\text{g/kg}$ (see Figure 5-19). From 0 to 3 m depth, concentrations above the NYSDEC wildlife bioaccumulation value at 5 percent organic carbon of 600

µg/kg are still centered on the same locations in the southwest corner the lake. Concentrations in areas of the deep southern basin and southern littoral zone are above the NYSDEC human health bioaccumulation value at 5 percent organic carbon of 7.5 µg/kg. Unlike the other chlorinated benzenes, elevated concentrations (100 to over 1,000 µg/kg) of hexachlorobenzene are also found in the Ninemile Creek delta from 0 to 3 m depth. Below 5 m depth, the elevated concentrations are not present, but portions of the area of the Honeywell in-lake waste deposit continue to exceed the NYSDEC human health bioaccumulation value.

5.2.2.9 Low Molecular Weight Polycyclic Aromatic Hydrocarbons

For the sediment intervals 0 to 0.02 m and 0 to 2 m, LPAHs (i.e., the sum of naphthalene, 2-methylnaphthalene, and fluorene) are found at the highest concentrations in the southern portion of the lake (see Figure 5-20). High concentrations (10,000 to >100,000 µg/kg) are found in both littoral and deep basin (pelagic) sediments, although the high concentrations occur most frequently in the littoral sediments between Harbor Brook and Solvay Wastebeds 1 through 8. Below 2 m there are generally data only from the littoral zone, and the elevated concentrations down to 8 m continue the pattern of being centered on the area in front of the Honeywell properties.

The vertical distribution of LPAHs is illustrated in the lake sediment cross sections shown in Figure 5-21. High concentrations (>100,000 µg/kg) are observed to the maximum coring depth of 8 m in the littoral sediments near the Honeywell shoreline and the in-lake waste deposit (see Section C). In the deeper sediments of the lake (middle portion of Section B), core results do not define the depth of LPAH contamination. However, Section A does establish this depth and can be used to infer a similar vertical extent (i.e., 4 to 6 m or less) for the sediments in Section B.

5.2.2.10 High Molecular Weight Polycyclic Aromatic Hydrocarbons

As is true for LPAHs, the HPAHs are found at high concentrations (10,000 to >100,000 µg/kg) throughout much of the southern basin for both the 0 to 0.02 m and the 0 to 2 m sediment intervals (see Figure 5-22). However, the highest concentrations occur off the Oil City shoreline region, as well as the Honeywell shoreline area. From 2 to 6 m, both areas remain as centers of contamination. Only below 6 m does the Oil City shoreline area drop to non-detect levels. As observed for LPAHs, the Honeywell shoreline area and the in-lake waste deposit show elevated HPAH contamination to the maximum coring depth of 8 m.

5.2.2.11 Polychlorinated Biphenyls

The patterns observed in the total, low, and high molecular weight PCBs are similar. In the surface sediments (0 to 0.02 m), concentrations exceeding 3,000 µg/kg of total PCBs are centered on the Honeywell in-lake waste deposit. In addition, concentrations exceeding 316 µg/kg of total PCBs are centered on an area extending along the Honeywell lakeshore sites to across the lake to the mouth of Ley Creek, with concentrations less than 316 µg/kg throughout the rest of the lake at this depth interval (see Figures 5-23 through 5-25). From 0 to 1 m depth, this pattern is continued in the southern portion of the

lake; in addition, total PCB concentrations above 300 µg/kg extend across much of the deep basin areas and in the Ninemile Creek delta. Between 2 and 5 m, the elevated total PCB concentrations (>300 µg/kg) are centered on the Ninemile Creek delta and the in-lake waste deposit. From below 5 m to the bottom of the cores at 8 m, only the in-lake waste deposit continues to have elevated total PCB concentrations (>300 µg/kg).

5.2.2.12 PCDD/PCDFs

The number of samples analyzed for PCDD/PCDFs was much more limited than for the other CPOIs (see Figures 5-26 and 5-27). Sampling for PCDD/PCDFs was only performed in 2000, and consisted of just 14 cores of varying depths. TEQs are calculated for fish, birds, and humans/mammals to depths of 2 m, below which there are very few data points. The NYSDEC wildlife bioaccumulation screening criterion at 5 percent organic carbon of 10 ng/kg (NYSDEC, 1999) is exceeded at various locations at all depths, as shown on Figure 5-26. The highest concentrations (>1,000 ng/kg bird TEQ) exist near the East Flume, at depths of 0.15 to 1 m. The human health bioaccumulation screening criterion at 5 percent organic carbon of 500 ng/kg (NYSDEC, 1999) is exceeded in the depth interval of 0.15 to 0.3 m in one station near the East Flume (Figure 5-27).

5.2.3 Toxicity Characteristic Leaching Procedure Results

A limited number of Toxicity Characteristic Leaching Procedure (TCLP) analyses were conducted during the Phase 2A investigation by Honeywell/Exponent in 2000 to assess the landfill requirements for possible lake sediment disposal. The results are presented in Appendix G1, Table G1-22. Of the 21 samples analyzed at three coring locations (S309, S312, and S315), only one analyte in one sample exceeded the maximum regulatory limit; specifically, in the 0.15 to 0.3 m depth interval at Station S312 in the in-lake waste deposit near the East Flume, 1,4-dichlorobenzene exceeded the maximum regulatory limit (MRL). The concentration of 1,4-dichlorobenzene in the TCLP extract was 8.6 mg/L, and the MRL for this compound is 7.5 mg/L, indicating that these sediments are a hazardous waste. As shown in Figure 5-17, this area of the lake contains concentrations of dichlorobenzenes above 10,000 µg/kg, from the surface down to 3 m. Benzene and chlorobenzene were also detected in extracts of the three TCLP cores, but at concentrations below the respective MRLs.

Based on a review of Honeywell's core logs from the Phase 2A investigation in 2000, it is noted that many locations in the southwest area of the lake contain sediments impacted by petroleum wastes. The locations at which "sheens" or "visible oil" were noted in the 2000 core logs at various depths are shown in Figure 5-28. The locations are concentrated along the shore, near the Willis Avenue site and between the East Flume and Harbor Brook near the Wastebed B/Harbor Brook site. As noted in Chapter 4, a dense non aqueous phase liquid (DNAPL) plume containing chlorinated benzenes exists along the lakeshore at the Willis Avenue site, and a DNAPL plume containing naphthalene as a major constituent exists at the Wastebed B/Harbor Brook site. Significant quantities of DNAPLs were also observed in sediments of the lower reaches of Harbor Brook near the lake. The approximate extent of these DNAPL plumes, based on available data from the subsites, is also shown on Figure 5-28. In addition, sheens and/or DNAPL have

been observed at many of the locations (Figure 5-28) where vibrating-wire piezometers were recently (October and November 2002) installed by Honeywell (Parsons, 2002b).

The presence of an oily sheen in the lake sediments indicates that the contamination in this area of the lake is not being buried. Since the contamination is non-aqueous, it is unlikely that its presence is due to natural limnological processes (i.e., it was not transported there by the lake waters or the tributaries). Therefore, the contamination is either part of a DNAPL plume or it was disposed of directly in the lake or its vicinity. As discussed in Chapter 4, Section 4.5, based on a review of historic reports, aerial photographs, and physical and chemical data, this area of the lake contains historic waste deposits from Honeywell. Thus, a combination of the DNAPL plumes from the Honeywell lakeshore areas and the in-lake waste deposit serves to significantly impact the sediments in this area of the lake. The contaminants in this area are in contact with the overlying water and the potential for release to the water column is considerable. A further discussion of the fate and transport of contaminants from this area is provided in Chapter 6. The fact that the sediments in this area represent a waste material is an issue which must be considered in the FS.

5.2.4 Calcium Carbonate and Oncolites

The concentrations of calcium carbonate and oncolites in the surface sediments (0 to 2 cm) of Onondaga Lake in 1992, as determined by Honeywell/PTI, are presented in Figure 5-29. Oncolite quantities were estimated by determining the volume retained by a sieve with mesh size of 2 mm (i.e., gravel size) for the sieved fraction of all 0.06-m² benthic macroinvertebrate samples. The following distributions of calcium carbonate and oncolites were found:

- **Calcium carbonate** – Concentrations of calcium carbonate in surface sediment were generally less than 60 percent by weight throughout most of the deeper parts of the lake, and greater than 60 percent by weight throughout most of the nearshore zone. The highest calcium concentrations (>80 percent by weight) were found in the nearshore zone off Ley Creek and Tributary 5A, along much of the northwestern and northeastern shorelines, and at several stations off the eastern and western shorelines.
- **Oncolites** – Oncolite distribution was determined only for the nearshore zone. In general, the distribution of oncolites closely corresponded to the distribution of calcium carbonate. The lowest concentrations (<100 mL/0.06 m²) were detected between Tributary 5A and Ley Creek and along sections of the eastern and western shorelines. The highest concentrations (>300 mL/0.06 m²) were detected along most of the northwestern and northeastern shorelines and in small areas off Ley Creek and Tributary 5A.

5.3 Tributary Sediment Characterization

This section summarizes the measured occurrence of contaminants (i.e., mercury and other metals, BTEX, chlorinated benzenes, PAHs, PCBs, and PCDD/PCDFs) in tributary sediments, based on data from the following sources:

- East Flume and West Flume sediment data collected by Honeywell/PTI from 1992 to 1994 (PTI, 1996a).
- West Flume sediment data collected by Honeywell 1995 for the LCP Bridge Street RI (NYSDEC/TAMS, 1998c).
- Ninemile Creek, Geddes Brook, Harbor Brook, Ley Creek, Bloody Brook, and Sawmill Creek data collected by NYSDEC from 1996 to 1998 (NYSDEC/TAMS, 2001).
- Tributary 5A and East Flume sediment data collected in 1991 and 1998 by Honeywell as part of the Willis Avenue RI (O'Brien & Gere, 2002e).
- Geddes Brook and Ninemile Creek sediment data collected in 1998 and 2001 by Honeywell as part of the Geddes Brook/Ninemile Creek RI (NYSDEC/TAMS, 2001).

Appendix G1, Tables G1-23 through G1-54 contain summary statistics for the tributary sediment data. The results of the comparisons of the data against appropriate sediment criteria and/or standards (i.e., screening) are provided in Appendix G2, Tables G2-8 and G2-9.

The presence of a contaminant in tributary sediment is an indicator of the potential importance of the tributary as a conduit of that contaminant to the lake. Sediments serve as an integrator of tributary contaminant concentrations and loads over time. However, the heterogeneous and temporary nature of sediment deposition in tributaries limits the absolute translation of sediment concentrations into loads. Nonetheless, it can be generally inferred that tributaries with higher sediment concentrations have had higher contaminant concentrations in the water column. When coupled with tributary flow, the results can be used to provide a relative measure of the importance of the tributary to contaminant transport to the lake. Note that the occurrence of higher concentrations in one tributary versus another does not necessarily implicate the more contaminated tributary as the greater source; rather, both flow and concentration must be considered in this regard. A more thorough discussion of recent (1992 to present) tributary loads can be found in Chapter 6 of this report.

5.3.1 Mercury and Other Metals

The maximum total mercury concentrations detected in sediment in each sampled tributary were as follows:

- West Flume: 131 mg/kg.
- Ninemile Creek: 118 mg/kg.
- Geddes Brook: 88.9 mg/kg.
- Harbor Brook: 35.7 mg/kg.
- East Flume: 7.5 mg/kg.
- Tributary 5A: 1.3 mg/kg.
- Onondaga Creek: 1.2 mg/kg.
- Ley Creek: 0.52 mg/kg.

The maximum concentrations of methylmercury were highest in the West Flume (53 µg/kg) and Ninemile Creek (20 µg/kg).

The maximum concentrations of antimony (38.5 mg/kg), lead (4,100 mg/kg), and vanadium (925 mg/kg) were detected in Tributary 5A. The maximum concentrations of cadmium (594 mg/kg), chromium (6,290 mg/kg), copper (1,170 mg/kg), cyanide (22.5 mg/kg), nickel (1,460 mg/kg), and zinc (5,050 mg/kg) were detected in Ley Creek. The maximum detected concentrations of arsenic (101 mg/kg) and thallium (33 mg/kg) were detected in Ninemile Creek and Geddes Brook, respectively.

5.3.2 Benzene, Toluene, Ethylbenzene, and Xylenes

Benzene was detected in sediments in all tributaries except for the West Flume, Bloody Brook, and Sawmill Creek. Detected benzene concentrations ranged from 2 µg/kg in a sample collected from Ley Creek to a maximum detected concentration of 25,000 µg/kg in Tributary 5A sediments. Maximum toluene and ethylbenzene concentrations were highest in Tributary 5A (9,400 µg/kg) and Harbor Brook (3,200 µg/kg), respectively. Maximum concentrations of total xylenes were highest in the East Flume (15,000 µg/kg), Tributary 5A (10,000 µg/kg), and Harbor Brook (10,000 µg/kg).

5.3.3 Chlorinated Benzenes

Chlorobenzene was not detected in the West Flume, Onondaga Creek, Bloody Brook, or Sawmill Creek. The highest detection of chlorobenzene (460,000 µg/kg) was measured in a sample collected from the East Flume. Detected chlorobenzene concentrations in the other tributaries ranged between 2 and 36,000 µg/kg.

Dichlorobenzenes were detected in nearly all tributaries. Only Bloody Brook and Sawmill Creek sediments were non-detect for dichlorobenzenes. The highest concentration (1,272,000 µg/kg) of the sum of detected dichlorobenzenes was measured in a sediment sample collected from the East Flume. The sum of detected dichlorobenzenes in the other tributaries ranged from 2 to 76,000 µg/kg.

Trichlorobenzenes were found in sediments from only three tributaries: the East Flume, Geddes Brook, and Ninemile Creek. Detection of the sum of trichlorobenzenes ranged from 5 to 18,700 µg/kg, with the highest concentration detected in the East Flume.

1,2,3,4-Tetrachlorobenzene was detected in the East Flume at concentrations ranging from 28 to 240 µg/kg. Hexachlorobenzene was detected in Geddes Brook, Ninemile Creek, the West Flume, and the East Flume at concentrations ranging from 3.1 to 160,000 µg/kg, with the highest concentration detected in Geddes Brook.

5.3.4 Polycyclic Aromatic Hydrocarbons

PAHs were detected in all tributaries. The highest detected LPAH concentrations were in Harbor Brook (990,000 µg/kg) and the East Flume (224,500 µg/kg). Maximum detected HPAHs were highest in the East Flume (6,760,000 µg/kg), followed by Harbor Brook (793,700 µg/kg).

5.3.5 Polychlorinated Biphenyls

PCBs were detected in all tributaries. Detected concentrations of total PCBs ranged from 5 µg/kg in Ninemile Creek to 237,400 µg/kg in Old Ley Creek (a branch of Ley Creek).

5.3.6 PCDD/PCDFs

Samples collected in the East Flume, Geddes Brook, and Ninemile Creek were analyzed for PCDD/PCDFs. TEQ concentrations for mammal receptors were calculated from World Health Organization (WHO) TEFs (Van den Berg et al., 1998), as described in Section 5.2. Maximum mammalian TEQ concentrations were 734, 218, 71, and 62 ng/kg for the East Flume, Geddes Brook, Ninemile Creek, and Ley Creek, respectively.

5.4 Wetland Sediment Characterization

In order to determine the nature and extent of contamination in the wetlands around Onondaga Lake, sediment cores from four New York State wetlands were collected and analyzed by Honeywell/Exponent in 2000 during Phase 2A of the Onondaga Lake investigation. These wetlands include:

- Two northern wetlands:
 - Wetland SYW-6 (Stations S375 through S378), located at the north end of the lake.
 - Wetland SYW-10 (Stations S379 through S382), located at the mouth of Ninemile Creek.

- Two southern wetlands:
 - Wetland SYW-19 (Stations S383 through S386), located at the mouths of the East Flume and Harbor Brook.
 - Wetland SYW-12 (Stations S387 through S390), located between the mouths of Ley Creek and Onondaga Creek.

The four stations in each wetland were sampled at two depth intervals (0 to 15 cm and 15 to 30 cm) and analyzed for Target Analyte List (TAL) inorganics and Target Compound List (TCL) organic compounds. In 2002, supplemental sediment sampling was performed by NYSDEC/TAMS in Wetland SYW-6 at the same depth intervals in five locations (Stations SYW6-1 through SYW6-5) surrounding the 2000 Station S375. These samples were analyzed for TAL inorganics and semivolatile organic compounds (SVOCs).

In the wetlands, 30 analytes were identified as CPOIs in the BERA and/or HHRA (see Chapter 1, Section 1.6). Summary statistics are presented in Appendix G, Tables G1-55 through G1-60, and Figures 5-30 through 5-96 present the distribution of CPOIs in wetlands with the concentrations for non-detect results depicted as one-half of the detection limit, and duplicate samples averaged. The results of screening the wetland data against appropriate sediment criteria are summarized in Appendix G2, Tables G2-10 through G2-13.

The appropriate screening standards were included in the figures depicting concentrations of total mercury and other metals (Figures 5-30 through 5-56). In the case of organic compounds (Figures 5-57 through 5-96), since screening criteria are available as organic carbon-normalized concentrations, two figures were presented for most compounds: the first depicting the concentrations in dry weight, and the second showing the organic carbon-normalized concentrations and the appropriate screening criteria. Organic CPOIs with less than three detected concentrations in the 2002 supplemental Wetland SYW-6 samples were not plotted, but the concentrations are summarized in Appendix G1, Tables G1-59 and G1-60. Due to the extensive contamination in Wetland SYW-19 (as described below), this wetland area is undergoing further investigation as part of the Preliminary Site Assessment (PSA) and RI for the Wastebed B/Harbor Brook site. In addition, Wetland SYW-10, which is evaluated in this RI, is being evaluated further as part of the Geddes Brook/Ninemile Creek RI/FS.

5.4.1 Mercury and Other Metals

Total mercury and 13 other metal CPOIs were detected within the wetlands (Figures 5-30 through 5-56). Detections of total mercury ranged from 0.054 to 60.2 mg/kg, with the maximum concentration occurring in the 15 to 30 cm interval at Station S385 in SYW-19, between the East Flume and Harbor Brook (Figure 5-30). Average total mercury concentrations in the surface and deep wetland sediment layers were 6.3 and 6.9 mg/kg, respectively. Total mercury concentrations in Wetland SYW-19 were significantly higher than values reported for the other wetland stations. In 2000, about 90 percent of the detected total mercury concentrations exceeded the NYSDEC LEL of 0.15 mg/kg, and 53 percent exceeded the SEL of 1.3 mg/kg. In the 2002 sampling results, all samples exceeded the LEL, while only samples from Station

SYW6-3 exceeded the SEL (Figure 5-31). Concentrations of the other 13 detected metals are summarized as follows:

- Aluminum concentrations ranged from 1,870 to 15,100 mg/kg (Figures 5-32 and 5-33), with the concentration at the 15 to 30 cm depth of Station S390 in Wetland SYW-12 exceeding the maximum value of 13,700 mg/kg detected at Otisco Lake.
- Concentrations of antimony were generally lower than the LEL of 2 mg/kg (Figures 5-34 and 5-35), with the exception of the concentrations (10 mg/kg, 6 mg/kg, and 2.2 mg/kg) in the 15 to 30 cm layers in Station S380 in Wetland SYW-10 and Station S385 in Wetland SYW-19, and the 0 to 15 cm layer of Station SYW6-3, respectively.
- Concentrations of arsenic ranged from 1.3 to 18.4 mg/kg (Figures 5-36 and 5-37), with the concentrations of nine samples exceeding the LEL of 6 mg/kg. The maximum arsenic concentration was detected in the 0 to 15 cm layer at Station S379 in Wetland SYW-10.
- Concentrations of barium ranged from 31 to 655 mg/kg (Figures 5-38 and 5-39), with eight samples exceeding the maximum concentration of 189 mg/kg that was reported for Otisco Lake.
- Cadmium ranged from 0.14 to 80.4 mg/kg (Figures 5-40 and 5-41), with the most elevated concentration occurring in the 15 to 30 cm layer of Station S390 in Wetland SYW-12. About 81 percent of cadmium concentrations exceeded the LEL of 0.6 mg/kg.
- Chromium concentrations ranged from 6.2 to 594 mg/kg (Figures 5-42 and 5-43), with 26 and five samples exceeding the LEL and SEL, respectively. The highest chromium concentrations occur in Wetland SYW-12.
- Concentrations of copper ranged from 8 to 517 mg/kg (Figures 5-44 and 5-45), with 35 and five samples out of a total of 42 samples exceeding the LEL and SEL, respectively. However, only three samples had copper concentrations higher than the maximum value of 158 mg/kg observed at Otisco Lake.
- Cyanide levels ranged from 1.4 to 5.4 mg/kg (Figure 5-46), with the maximum concentration occurring at Station S376 (0 to 15 cm) in Wetland SYW-6.
- Concentrations of iron ranged from 3,250 to 32,400 mg/kg (Figures 5-47 and 5-48), with four samples exceeding the LEL of 20,000 mg/kg.

- Lead concentrations ranged from 12 to 376 mg/kg (Figures 5-49 and 5-50), with the maximum concentration occurring at Station S385 (15 to 30 cm) in Wetland SYW-19. The lead LEL and SEL were exceeded in 31 and 14 samples out of a total of 42 samples, respectively.
- Selenium concentrations ranged from 0.64 to 4.1 mg/kg (Figures 5-51 and 5-52), with the maximum concentration occurring at Station S389 in Wetland SYW-12, exceeding the maximum detected concentration of 3.2 mg/kg observed at Otisco Lake.
- Thallium detected concentrations ranged from 0.71 to 3.2 mg/kg (Figures 5-53 and 5-54), with the maximum concentration occurring at Station S379 (0 to 15 cm) in Wetland SYW-10.
- Concentrations of zinc ranged from 22.5 to 866 mg/kg (Figures 5-55 and 5-56), with the maximum concentration detected at Station S390 (15 to 30 cm) in SYW-12. Twenty-nine values were higher than the maximum concentration of 84 mg/kg observed at Otisco Lake. Zinc concentrations exceeded the LEL and SEL levels in 20 and four samples, respectively.

5.4.2 Chlorinated Benzenes and Phenol

Dichlorobenzenes were detected in the wetlands around Onondaga Lake (Figures 5-57 through 5-59), with concentrations as follows: 1,2-dichlorobenzene (450 to 5,800 µg/kg), 1,3-dichlorobenzene (62 to 6,200 µg/kg), and 1,4-dichlorobenzene (54 to 11,000 µg/kg). The maximum detections of dichlorobenzenes were at Stations S383, S384, and S385 in Wetland SYW-19. When the concentrations of the sum of dichlorobenzenes are normalized by their respective organic carbon content, values in Wetland SYW-19 exceeded the NYSDEC acute and chronic toxicity criteria (Figure 5-60).

Concentrations of 1,2,4-trichlorobenzene, which was detected mainly in Wetland SYW-19, ranged from 160 to 18,000 µg/kg, with the concentration in the 15 to 30 cm interval of Station S385 exceeding the NYSDEC chronic value (Figure 5-61). Hexachlorobenzene concentrations ranged from 61 to 6,900 µg/kg, with Stations S383 and S385 in Wetland SYW-19 having the highest values (Figures 5-62 and 5-63). Concentrations of phenol (Figure 5-64) and the sum of unchlorinated phenols (Figure 5-65) were also highest in Wetland SYW-19, where values generally exceeded the NYSDEC chronic value.

5.4.3 Polycyclic Aromatic Hydrocarbons

The two LPAH CPOIs detected in the 2000 wetland sampling and their range of concentrations were naphthalene (52 to 5,100 µg/kg; Figure 5-66) and 2-methylnaphthalene (320 to 1,300 µg/kg; Figure 5-67). In the 2002 Wetland SYW-6 supplemental sampling, naphthalene and 2-methylnaphthalene were each detected once at 7,600 µg/kg and 5,600 µg/kg, respectively, in the 15 to 30 cm interval at Station SYW6-3

(Appendix G1, Table G1-60), with the naphthalene value exceeding the NYSDEC ATBAL. Although the highest concentration of naphthalene and 2-methylnaphthalene occurs in the deep interval at Station SYW6-3, area-wide LPAH concentrations in Wetland SYW-19 were higher than values in other wetlands sampled in 2000 and 2002, including Wetland SYW-6.

The HPAH CPOIs and their range of detected concentrations (Figures 5-68 through 5-84) were:

- Acenaphthylene: 78 to 7,500 µg/kg.
- Benz(a)anthracene: 74 to 49,000 µg/kg.
- Benzo(a)pyrene: 91 to 48,000 µg/kg.
- Benzo(b)fluoranthene: 77 to 59,000 µg/kg.
- Benzo(g,h,i)perylene: 76 to 28,000 µg/kg.
- Benzo(k)fluoranthene: 86 to 22,000 µg/kg.
- Dibenzo(a,h)anthracene: 64 to 7,900 µg/kg.
- Indeno(1,2,3-cd)pyrene: 90 to 28,000 µg/kg.
- Phenanthrene: 60 to 63,000 µg/kg.

The maximum concentration for the individual HPAH CPOIs occurred in the 15 to 30 cm interval of Station SYW6-3 in Wetland SYW-6, although Wetland SYW-19 had higher concentrations of HPAHs relative to the other wetlands in the 2000 samples, including Wetland SYW-6. Similar to the individual PAHs, the maximum concentration for the sum of PAH CPOIs occurred in the 15 to 30 cm interval of Station SYW6-3, but overall, values were higher in Wetland SYW-19, between the East Flume and Harbor Brook (Figures 5-85 and 5-86). The organic carbon-normalized concentrations of benz(a)anthracene (Figures 5-70 and 5-71) and phenanthrene (Figures 5-83 and 5-84) indicate that 11 and three samples exceeded the NYSDEC chronic toxicity values for these two HPAHs, respectively.

5.4.4 Polychlorinated Biphenyls and Pesticides

PCB concentrations in the wetlands around Onondaga Lake were highest at multiple stations in Wetland SYW-19 and one station (Station S390) in Wetland SYW-12 (Figures 5-87 through 5-90). Three PCB Aroclors identified as CPOIs were detected in the wetlands sediment: Aroclor 1242 (13.7 to 1,130 µg/kg), Aroclor 1254 (14.3 to 750 µg/kg), and Aroclor 1260 (11.7 to 576 µg/kg). Organic carbon-normalized concentration plots in these figures indicate that the NYSDEC wildlife bioaccumulation value was exceeded in six samples for Aroclor 1242, nine samples for Aroclor 1254, and nine samples for Aroclor 1260. Total PCBs ranged from 100 to 1,870 µg/kg, with many stations exceeding the wildlife criterion and only Station S385 (15 to 30 cm) in Wetland SYW-19 exceeding the chronic toxicity value.

Concentrations of the pesticide aldrin (3.35 to 49.6 µg/kg) were significantly higher in Wetland SYW-19 than in the other wetlands (Figure 5-91), with the highest concentration at Station S385. Detected concentrations of dieldrin (1.42 to 38.5 µg/kg) were also highest in Wetland SYW-19 (Figure 5-92). The organic carbon-normalized sum of aldrin and dieldrin did not exceed the wildlife bioaccumulation criterion at any station (Figure 5-93).

5.4.5 PCDD/PCDFs

The TEQ concentrations of PCDD/PCDFs were calculated based on WHO TEFs (Van den Berg et al., 1998). PCDD/PCDFs were detected in all wetlands sampled, with TEQ concentrations ranging from 0.14 to 549 ng/kg for PCDDs only (Figure 5-94) and 0.17 to 577 ng/kg for PCDFs only (Figure 5-95). Total PCDD/PCDF TEQ concentrations (Figure 5-96) were higher in the Harbor Brook wetland area (Wetland SYW-19) than in the other wetland areas, and the values in this wetland exceeded the wildlife bioaccumulation criterion. PCDD/PCDFs were not analyzed in Wetland SYW-12.

5.5 Dredged Material Characterization

Surface and subsurface soil samples were collected in 2000 from the dredged material disposal basins (Basins 1 through 4) located north of the mouth of Ninemile Creek, along the shoreline, in order to characterize the nature and extent of contamination. With the possible exception of Basin 4, these basins contain material dredged from the Ninemile Creek delta from 1966 to 1968. Eight sampling stations in the four basin areas were sampled at surface (0 to 60 cm) and subsurface (>60 cm) intervals and analyzed for inorganics, SVOCs, PCBs, and PCDD/PCDFs. Soil samples were collected at the surface in the fill covering the dredge spoils, as well as in the spoils at different depths down to the native soils at the approximate elevation of the lake. Summary statistics of all samples are presented in Appendix G1, Table G1-61. Results of screening against NYSDEC Technical and Administrative Guidance Memorandum (TAGM) #4046 (NYSDEC, 2002) soil cleanup objectives are summarized in Appendix G2, Tables G2-14 and G2-15.

5.5.1 Mercury and Other Metals

Total mercury and 15 other metal CPOIs were detected within the dredged material basins (Figures 5-97 through 5-112). Detections of total mercury ranged from 0.05 to 98.8 mg/kg, with maximum concentrations occurring in Basins 1 through 3 at subsurface intervals (Figure 5-97). About 68 percent of the samples exceeded the upper end of NYSDEC TAGM #4046 background values (0.2 mg/kg), while 92 percent of the samples exceeded the NYSDEC recommended soil cleanup objective (0.1 mg/kg). For other metals, the following is noted:

- Aluminum concentrations ranged from 1,010 to 23,300 mg/kg (Figure 5-98), and the maximum concentration was detected at greater than 250 cm below the surface at Station S437 in Basin 1.
- Detected concentrations of antimony ranged from 0.24 to 1.30 mg/kg (Figure 5-99), with the highest concentration occurring below 200 cm at Station S439 in Basin 2.
- Concentrations of arsenic ranged from 0.62 to 13.3 mg/kg (Figure 5-100), with the maximum concentration detected below 200 cm at Station S438 in Basin 2.

About 39 percent of the samples exceeded the NYSDEC recommended soil cleanup objective of 7.5 mg/kg.

- Barium concentrations ranged from 49.1 to 227 mg/kg (Figure 5-101), and were generally between 50 to 100 mg/kg, with the exception of the maximum concentration, which was between 250 and 300 cm at Station S440 in Basin 3.
- Cadmium concentrations ranged from 0.07 to 4.3 mg/kg (Figure 5-102), with the highest concentration detected in the 230 to 250 cm depth interval at Station S439 in Basin 2. Only 13 percent of the cadmium concentrations exceeded the recommended soil cleanup objective of 1 mg/kg.
- Chromium concentrations ranged from 2.8 to 61.6 mg/kg (Figure 5-103). The maximum chromium concentration, which was detected at Station S439 in Basin 2, exceeded the upper end of NYSDEC background values (40 mg/kg). About 84 percent of the chromium concentrations exceeded the recommended soil cleanup objective of 10 mg/kg.
- Copper concentrations ranged from 1.80 to 61.6 mg/kg (Figure 5-104), and about 47 percent of the values were higher than the recommended cleanup objective of 25 mg/kg. Concentrations greater than 60 mg/kg occurred at Stations S439 and S441 in Basins 2 and 3, respectively.
- Nine out of 44 samples had detected concentrations of cyanide (Figure 5-105), with levels ranging from 0.9 to 1.4 mg/kg. Higher subsurface concentrations (>1 mg/kg) were detected at Stations S437, S440, and S441 in Basins 1 and 3.
- Iron concentrations ranged from 1,330 to 29,600 mg/kg (Figure 5-106), with the maximum concentration occurring just above 300 cm at Station S437 in Basin 1. Over 90 percent of the iron concentrations exceeded the recommended soil cleanup objective of 2,000 mg/kg.
- Lead concentrations ranged from 2.50 to 157 mg/kg (Figure 5-107), with the maximum concentration detected below 220 cm at Station S439 in Basin 2.
- Manganese concentrations ranged from 106 to 440 mg/kg (Figure 5-108), with the maximum concentration detected at Station S443 in Basin 4.
- Nickel concentrations ranged from 1.8 to 64.6 mg/kg (Figure 5-109), with the highest values in the 60 to 150 cm and 230 to 250 cm intervals at Stations S438 and S439 in Basin 2, respectively. About 78 percent of the samples exceeded the recommended soil cleanup objective of 13 mg/kg.

- Concentrations of selenium ranged from 0.49 to 2.10 mg/kg (Figure 5-110). The maximum value, which was detected at Station S437 in Basin 1 in the 250 to 300 cm depth interval, exceeded the recommended soil cleanup objective of 2 mg/kg.
- Thallium was detected only in the subsurface interval of 60 to 120 cm at Station S436 in Basin 1, at a concentration of 0.75 mg/kg (Figure 5-111).
- Concentrations of zinc ranged from 12.1 to 186 mg/kg (Figure 5-112), with the highest value detected below 200 cm at Station S349 in Basin 2. Only two samples had concentrations lower than the recommended soil cleanup objective of 20 mg/kg.

5.5.2 Chlorinated Benzenes

Detections of dichlorobenzenes ranged from 51 to 97 µg/kg for 1,2-dichlorobenzene (Figure 5-113) and 79 to 130 µg/kg for 1,3-dichlorobenzene (Figure 5-114), with maximum concentrations in Basins 3 and 1, respectively. The maximum concentration of the sum of dichlorobenzenes (Figure 5-115) was detected in the subsurface depth interval (190 to 230 cm) of Basin 3. Hexachlorobenzene detections ranged from 55 to 620 µg/kg, with the maximum concentration at Station S438 in Basin 2 (Figure 5-116). Hexachlorobenzene concentrations in the 50 to 150 cm depth interval at Station S438 in Basin 2 and in the 100 to 150 cm depth interval at Station S440 in Basin 3 exceeded the recommended soil cleanup objective of 410 µg/kg.

5.5.3 Polycyclic Aromatic Hydrocarbons

A total of nine PAH CPOIs were detected in the dredge spoil basins. Detections of naphthalene ranged from 85 to 18,000 µg/kg (Appendix G1, Table G1-61), with the maximum concentration occurring at Station S436 in Basin 1 at the 120 to 180 cm interval; however, naphthalene was not detected (<56 µg/kg) in a duplicate sample collected at the same interval at Station S436, bringing the estimated station average to 9,014 µg/kg (Figure 5-117). Detections of the other PAHs, as depicted in Figures 5-118 through 5-125, include:

- Benz(a)anthracene: 47 to 22,000 µg/kg.
- Benzo(a)pyrene: 44 to 23,000 µg/kg.
- Benzo(b)fluoranthene: 53 to 20,000 µg/kg.
- Benzo(g,h,i)perylene: 51 to 11,000 µg/kg.
- Benzo(k)fluoranthene: 56 to 20,000 µg/kg.
- Dibenz(a,h)anthracene: 46 to 5,200 µg/kg.
- Indeno(1,2,3-cd)pyrene: 47 to 11,000 µg/kg.
- Phenanthrene: 50 to 14,000 µg/kg.

The maximum concentrations of each of these PAHs occurred at a depth of 180 to 240 cm at Station S443 in Basin 4. Maximum concentrations of the sum of PAHs were detected in Basin 4 at concentrations of 50,000 to 208,000 µg/kg, at intervals greater than 180 cm below the surface (Figure 5-126). The elevated levels of PAHs at Basin 4, as compared to the elevated levels of mercury and chlorinated benzenes at Basins 1 through 3, suggest that the source of the fill at Basin 4 was not dredge spoils from the Ninemile Creek delta.

5.5.4 Polychlorinated Biphenyls

The concentration ranges of the four PCB Aroclors that were detected in the dredge spoil basins, as shown in Figures 5-127 through 5-130, were as follows:

- Aroclor 1242: 17 to 193 µg/kg.
- Aroclor 1254: 10.6 to 289 µg/kg.
- Aroclor 1260: 14 to 126 µg/kg.
- Aroclor 1268: 53.7 to 487 µg/kg.

The estimated total PCB concentrations in the dredge spoils were highest at Station S440 in Basin 3, and were greater in subsurface soils than in surface soils (Figure 5-131). PCB concentrations were much greater in Basins 1 through 3 than in Basin 4.

5.5.5 PCDD/PCDFs

PCDD/PCDFs were analyzed in only one of the two borings at each of the four basins. PCDD TEQ concentrations (less than 10 ng/kg) were significantly less than the NYSDEC soil cleanup objective to protect groundwater quality of 60 µg/kg (Figure 5-132). Compared to PCDD TEQs, PCDF TEQs were relatively higher in Basins 1 through 3 (Figure 5-133). The total PCDD/PCDFs TEQ concentrations (up to 69 ng/kg) were highest in the subsurface depth interval (90 to 130 cm) of Station S440 in Basin 3 (Figure 5-134).

5.6 Sediment Porewater Characterization

Sediment cores were collected at four locations in the lake in 1992 and seven locations in 2000. The samples from 1992 were collected in August and November, and sectioned at 2 cm intervals to a total depth of 10 cm. Three of the 1992 cores (Stations S4, S73, and S83) were from sediments above the thermocline, and one (Station S90) was from below the thermocline. The August samples were analyzed for total mercury, methylmercury, and stressors (ammonia, chloride, and sulfides) in porewater and solids. Only the stressors were analyzed in the November samples. The chloride profiles from both the August and November 1992 porewater samples are strikingly different throughout the length of the cores. The August concentrations are consistently and substantially lower, which could indicate a rapid mechanism for movement through the sediments; however, it most likely indicates that the lake water and porewater were allowed to mix during collection of the August samples, which would invalidate the samples. Because of

the significant change in chloride concentrations, certainly the August, and possibly the November, results from 1992 are suspect and unusable. Even if the porewater data from November 1992 are usable, the lack of mercury analyses on those samples limits their value.

The samples from 2000 were sectioned at 4 cm intervals for the top 8 cm. In addition, one 4 cm interval was collected at depths ranging from 30 to 120 cm. These samples were analyzed for total mercury, methylmercury, iron, manganese, and stressors in porewater and solids. Four of the 2000 cores (Stations S305, S344, S402, and S405) were from sediments above the thermocline, and three (Stations S303, S354, and S355) were from below the thermocline. Three replicate cores were collected at each of the seven stations. Figures 5-135 through 5-141 show the distribution of total mercury and methylmercury, iron, manganese, and sulfide in porewater from the seven stations sampled in 2000, as well as the dissolved concentrations in overlying water. The resolution of porewater measurements affects the accuracy of porewater diffusion estimates. As will be seen in Chapter 6, the lack of detailed information on porewater concentrations near the sediment-water interface (i.e., less than 4 cm) limits the accuracy of the interfacial contaminant gradient.

5.6.1 Mercury and Other Metals

At all stations, the porewater concentrations of dissolved total mercury and methylmercury in the 0 to 4 cm interval were higher than in the overlying water. The highest concentrations of dissolved total mercury (up to 49,000 ng/L) and methylmercury (up to 915 ng/L) in porewater occurred at Stations S344 and S402, located offshore of the East Flume in an area that contains Honeywell waste material (Figure 3-9). There was no consistent pattern of mercury and methylmercury concentrations in porewater with depth, probably because other parameters (e.g., porewater pH and sulfide concentration) influence mercury concentration independent of depth. With the exception of Station S402, manganese concentrations in the 0 to 4 cm interval were higher than values in the overlying water. Manganese concentrations were highest at Stations S303, S354 and S355, which are below the thermocline.

5.6.2 Sulfide

Porewater sulfide concentrations were consistently higher than corresponding concentrations in the overlying water. At Stations S303, S305, and S354, sulfide concentrations were higher in the 0 to 4 cm interval relative to the deeper intervals, while at the other stations (S344, S355, S402, and S405), sulfide concentrations in porewater increased with depth of the core.

5.7 Lake Water Characterization

Surface water samples were collected from Onondaga Lake in 1992 by Honeywell/PTI, in 1999 by Honeywell/Exponent, and in 2001 by NYSDEC/TAMS to determine the nature and extent of contamination (Chapter 2, Figures 2-17 and 2-20). Seven depth intervals in the deep basins (Stations W1 and W2) were sampled (0, 3, 6, 9, 12, 15, and 18 m) in 1992 and 1999, and nine nearshore stations (Stations W50 through W58) and the lake outlet (Station W12) were sampled in 1999, for chemical

analysis. In December 2001, ten stations in the southern half of the lake (Stations W1 and W60 through W68) were sampled for total mercury and conventional analytes under both calm and windy conditions. As a result of these studies, 14 analytes were identified as CPOIs in water and are described in their respective contaminant classes below (i.e., mercury and other metals; BTEX; chlorinated benzenes; other organic CPOIs; and other analytes).

The data presented for characterization of other analytes are derived from the Onondaga County monitoring report for 1992 (Stearns & Wheler, 1994). Monitoring data were collected by Onondaga County on a weekly basis in 1992 from the southern basin, and are more comprehensive than the monthly data collected by Honeywell/PTI in 1992. The Honeywell/PTI data (PTI, 1993d) are comparable to the Onondaga County monitoring data.

Summary statistics for the lake water data are presented in Appendix G1, Tables G1-62 and G1-63 for the 1992 data and Appendix G1, Tables G1-64 and G1-65 for the 1999 data. The mercury and total suspended solid (TSS) data from 2001 are presented in Appendix A6. Most of the metal CPOI concentrations in lake water were near or below detection limits, and many of the organic CPOI concentrations in lake water were below detection limits. Salinity was not directly measured during the 1992 field sampling program, but can be estimated from its major components (calcium, chloride, and sodium) (Effler et al., 1996b). A summary of the water data is presented below, while a discussion of the fate and transport of these CPOIs is provided in Chapter 6.

5.7.1 Mercury and Other Metals

Profiles of total mercury, methylmercury, and DO concentrations in the deep basins of Onondaga Lake in 1992 and 1999 are presented in Figures 5-142 through 5-145. The profiles present the variations in mercury and DO from month to month, with DO used as an indicator of the thickness of the oxic and anoxic layers. The concentrations of total mercury and methylmercury in nearshore stations in September and October 1999 are presented in Figures 5-146 through 5-149. Estimates of volume-weighted average total mercury and methylmercury concentrations in water depths above and below 9 m from samples collected in the deep basins in 1992 and 1999 are presented in Figures 5-150 and 5-151. Total mercury concentrations from the two sampling events conducted in December 2001 are presented in Figure 5-152.

In 1992, the total mercury concentrations increased from spring to fall in both the epilimnion and hypolimnion. The increase in the hypolimnion (from 5 to 23 ng/L) was substantially greater than the increase in the epilimnion (from 3 to 7 ng/L). The maximum concentrations during fall of 1999 were 28 ng/L in the hypolimnion and 14 ng/L in the epilimnion. In 1992 and 1999, total mercury concentrations in the hypolimnion declined to levels found in the epilimnion after the fall turnover. The highest concentration of total mercury in nearshore stations sampled in 1999 was found in Station W55 (103 ng/L), followed by Station W53 (26.2 ng/L). Notably, Station W55 is located in the in-lake waste deposit area near the mouth of Harbor Brook, while Station W53 is located near Ninemile Creek.

For methylmercury, the concentrations in the epilimnion varied little over the course of the year, ranging from 0.3 to 1.5 ng/L in 1992 and 0.5 to 2.8 ng/L in 1999. By contrast, concentrations in the hypolimnion increased substantially from spring to fall, rising from 0.7 to 12 ng/L between May and early October 1992. Maximum concentrations in the fall of 1999 were 14 ng/L in the hypolimnion. After fall turnover in 1992 and 1999, methylmercury concentrations in the hypolimnion declined to levels found in the epilimnion (less than 2 ng/L). Methylmercury concentrations in the nearshore stations did not vary with the corresponding total mercury levels, and the values compare well with epilimnion methylmercury levels in the deep basin stations.

In the 2001 sampling program (Figure 5-152), the total mercury concentrations in the southern deep basin (Stations W1 and W61) and on the north shore (Station W60) are about 5 ng/L under calm, low-turbidity conditions. The water overlying the Honeywell in-lake waste deposit contained an average of about 10 ng/L under calm conditions. Under windy conditions, concentrations of total mercury continue to be at about 5 ng/L in the southern deep basin and on the north shore. However, the concentrations in the water overlying the Honeywell in-lake waste deposit doubled to an average of about 20 ng/L, with the highest concentration reaching 49 ng/L. During calm conditions, the area of increased mercury concentrations relative to the southern deep basin and north shore extended from the Honeywell lakeshore to Station W63 at the edge of the in-lake waste deposit at approximately 7 m water depth. Under windier conditions, the area of increased mercury concentrations extended approximately 300 m farther offshore to Station W62 in 15 m of water.

Other inorganic CPOIs (i.e., barium, cadmium, chromium, copper, lead, and manganese) were detected in the southern and northern basins of Onondaga Lake in 1992 and 1999. Profiles for manganese are presented in Figures 5-153 and 5-154 for 1992 and 1999, and concentrations of chromium and manganese in nearshore stations in 1999 are presented in Figure 5-155. In 1992, the maximum concentrations of barium, cadmium, chromium, copper, and lead in Onondaga Lake were 77.2, 2.7, 5.3, 51.2, and 7.8 µg/L, respectively. In 1999, concentrations of chromium ranging from 2.6 to 3.9 µg/L were detected in the nearshore stations. Manganese profiles indicate an increase in the hypolimnion from spring to fall in 1992. Volume-weighted average concentrations of manganese (Figure 5-156) showed no major patterns in the epilimnion with concentrations lower than 150 µg/L, while concentrations in the hypolimnion increased to a maximum of 532 µg/L in October 1992 and decreased to epilimnion levels after turnover. A similar pattern was observed for manganese in 1999.

5.7.2 Benzene, Toluene, Ethylbenzene, and Xylenes

Three CPOIs in this class were detected in Onondaga Lake surface water in 1999 (Appendix G1, Table G1-64). Benzene concentrations of 0.11 µg/L and 6.3 µg/L were detected at Stations W55 (located near the mouth of Harbor Brook) and W50 (located in the Willis Lakeshore Exposure Area), respectively. Toluene was detected at Station W50 at a concentration of 0.16 µg/L. Xylene was detected at Station W55 at a concentration of 0.33 µg/L. Ethylbenzene was not detected in the water samples collected in 1999.

5.7.3 Chlorinated Benzenes

Three chlorinated benzene CPOIs were detected in Onondaga Lake surface water in 1999. 1,2-Dichlorobenzene was detected in three nearshore stations, with the maximum concentration of 3.2 µg/L in 1999 at Station W50 in the Willis Lakeshore Exposure Area (Figure 5-157). 1,4-Dichlorobenzene was detected in all nearshore stations in 1999 (Figure 5-157), with the maximum concentration of 3.4 µg/L found at Station W50 at the Willis Lakeshore Exposure Area. The third CPOI in this class, chlorobenzene, was detected at only two stations in the lake: 0.51 µg/L at Station W55 (located near the mouth of Harbor Brook) and at 12 µg/L at Station W50 (located in the Willis Lakeshore Exposure Area) in 1999.

5.7.4 Other Organic Chemical Parameters of Interest

Chloroform was detected in surface water in 1999 at maximum concentrations of 0.85 µg/L at Station W51 (located near the mouth of Tributary 5A), 0.84 µg/L at Station W50, and 0.59 µg/L at Station W55 (Figure 5-158). Bromodichloromethane was detected in surface water in 1999 at maximum concentrations of 0.24 µg/L at Station W50, 0.22 µg/L at Station W51, and 0.17 µg/L at Station W55 (Figure 5-158).

5.7.5 Stressors

The data discussed in this section were collected for the Onondaga County monitoring program by Stearns & Wheler (1994). These data for chloride, nitrogen and phosphorous, sulfide, DO, and water transparency, rather than the Honeywell RI data, are presented because samples were collected weekly and are, therefore, more comprehensive than the RI samples that were collected monthly. Additional information and data on SOCs are included in the Onondaga Lake BERA (TAMS, 2002a).

5.7.5.1 Chloride

Chloride concentrations in the epilimnion and hypolimnion of Onondaga Lake from April to November 1992 are presented in Figure 5-159. In the epilimnion, chloride concentrations ranged from 419 to 489 mg/L, with only the August value below 457 mg/L. The minimum values of chloride concentrations in the epilimnion were found between late June and mid-September, during the period of thermal stratification. Chloride concentrations in the hypolimnion were generally greater than those found in the epilimnion, ranging from 469 to 520 mg/L. In the hypolimnion, the minimum chloride concentration was found in late May, near the onset of thermal stratification. Concentrations then increased continuously during the period of stratification and reached a maximum value in early October, immediately prior to fall turnover. The mean chloride concentration for all samples collected in Onondaga Lake (i.e., epilimnion and hypolimnion) was 485 mg/L.

5.7.5.2 Nitrogen and Phosphorus

The concentrations of nitrogen and phosphorus in the epilimnion and hypolimnion of the lake from April through November 1992 are presented in Figure 5-160 (ammonia, nitrite, and nitrate) and Figure 5-161

(phosphorus). The most noticeable trends for these substances were the increasing concentrations of ammonia and phosphorous in the hypolimnion during the period of stratification, and the near absence of nitrite and nitrate in the hypolimnion during the same period.

5.7.5.3 Sulfide

The concentrations of sulfide in the hypolimnion of the lake from April through November 1992 are presented in Figure 5-162. At depths of both 14 and 18 m, sulfide concentrations became measurable in early June to mid-July with the onset of stratification, increased substantially throughout the summer to maximum concentrations in late September, and then declined dramatically after fall turnover. Sulfide concentrations were similar in magnitude and followed a similar pattern of increase and decrease in 1999.

Sulfide was analyzed, but not detected, in the water overlying sediment samples from the seven porewater stations in 2000 (Figures 5-135 through 5-141).

5.7.5.4 Dissolved Oxygen

The concentrations of DO in the epilimnion and hypolimnion of the lake and the depth of anoxia in the lake from April through November 1992 are presented in Figure 5-163. In the epilimnion, DO concentrations declined from 14 mg/L in April to 6 mg/L in early October. By contrast, DO concentrations in the hypolimnion rapidly declined from 13 mg/L in April to less than 0.5 mg/L in mid-June after the onset of stratification. Anoxic conditions remained in the hypolimnion until fall turnover. The depth of anoxia became established at 18 m in early June with the onset of stratification, rose to a depth of 9 to 12 m during the period of stratification, and then disappeared after fall turnover.

5.7.5.5 Water Transparency

The Secchi disk depths in Onondaga Lake from April through November 1992 are presented in Figure 5-164. Secchi disk depth generally varied from 1 to 2 m between April and early October, and then increased to almost 6 m by the end of November, following fall turnover.

5.8 Tributary Water and Metro Discharge Characterization

In 1992, surface water samples were collected from nine tributaries in the Onondaga Lake area, as well as at the lake outlet and Metropolitan Syracuse Sewage Treatment Plant (Metro) effluent, in order to determine the nature and extent of contamination and loadings of CPOIs, with the following groups addressed in this section: mercury and other metals, BTEX, chlorinated benzenes, and stressors. The laboratory analysis was performed on the unfiltered surface water samples. Most metal CPOIs (other than mercury) were detected occasionally in tributaries and point sources. Cadmium was detected infrequently, while copper, lead, and zinc were detected frequently. The majority of the metal CPOIs were more frequently detected in Tributary 5A, Geddes Brook, and the East Flume.

Organic CPOIs were occasionally detected in Tributary 5A, the East Flume, Harbor Brook, and Geddes Brook. With the exception of a single detection of toluene in Metro effluent, organic CPOIs were not detected in any other tributaries or point sources. The tributaries and Metro effluent were also sampled for several other stressors (e.g., chloride, ammonia, and DO).

The 1992 surface water data were stratified into three flow regimes: base flow, intermediate flow, and high flow. Base-flow conditions were determined by examination of daily flow records for each tributary, and were generally set to low flows in the late summer and early fall. High-flow conditions were defined as the highest 10 percent of the average daily flows, and intermediate flow was defined as flows between base- and high-flow stages. Summary statistics for the 1992 tributary data for base-, intermediate-, and high-flow conditions are presented in Appendix G1, Tables G1-66 through G1-97, along with the flow rates under each flow condition.

Total mercury data collected in 1992 in the major tributaries by Driscoll (1995) are included in the summary tables. In addition, the 1998 Geddes Brook/Ninemile Creek surface water data collected under base-flow conditions are summarized in Appendix G1, Tables G1-98 through G1-101.

5.8.1 Mercury and Other Metals

Concentrations of total mercury and methylmercury in tributary water and Metro effluent in 1992 are presented for base-, intermediate-, and high-flow conditions in Figures 5-165 and 5-166, respectively. Under base-flow conditions, mean concentrations of total mercury were highest in Geddes Brook (100 ng/L), the East Flume (53 ng/L), in Metro effluent (24 ng/L), and in lower Ninemile Creek (13 ng/L), and were less than 10 ng/L elsewhere in 1992. Mean total mercury concentrations in Ninemile Creek downstream of the Geddes Brook confluence (13 ng/L) were significantly higher than mean concentrations in upper Ninemile Creek (3.8 ng/L) under base-flow conditions in 1992. In 1998, total mercury concentrations in lower Geddes Brook and lower Ninemile Creek averaged 22 and 9 ng/L, respectively. Mean concentrations of methylmercury under base-flow conditions in 1992 were highest in Metro effluent (2.06 ng/L), the East Flume (0.80 ng/L), Geddes Brook (0.46 ng/L), the lake outlet (0.42 ng/L), Harbor Brook (0.39 ng/L), and Onondaga Creek (0.31 ng/L), and were less than 0.3 ng/L elsewhere.

Under intermediate-flow conditions in 1992, mean concentrations of total mercury were highest in Geddes Brook (154 ng/L), the East Flume (96 ng/L), Tributary 5A (36 ng/L), and lower Ninemile Creek (31 ng/L); concentrations were less than 25 ng/L elsewhere. Mean concentrations of methylmercury under intermediate-flow conditions in 1992 were highest in the East Flume (1.56 ng/L), the lake outlet (1.25 ng/L), in Metro effluent (1 ng/L), Harbor Brook (0.61 ng/L), Onondaga Creek (0.54 ng/L), Tributary 5A (0.53 ng/L), and Geddes Brook (0.50 ng/L), and were less than 0.5 ng/L elsewhere.

Under high-flow conditions in 1992, mean concentrations of total mercury were again highest in the East Flume (155 ng/L), Geddes Brook (145 ng/L), Tributary 5A (94 ng/L), Harbor Brook (41 ng/L), in Metro effluent (39 ng/L), and lower Ninemile Creek (27 ng/L); concentrations were less than 20 ng/L elsewhere. A single high-flow total mercury concentration of 47 ng/L was reported for Bloody Brook in 1992. Mean

concentrations of methylmercury under high-flow conditions in 1992 were highest in Harbor Brook (2.36 ng/L), Tributary 5A (1.52 ng/L), the East Flume (1.32 ng/L), in Metro effluent (1.19 ng/L), Geddes Brook (0.99 ng/L), Ley Creek (0.85 ng/L), and the lake outlet (0.71 ng/L). Concentrations were less than 0.5 ng/L elsewhere.

Concentrations of metals other than mercury in tributary water, the lake outlet, and Metro effluent in 1992 are presented for the three flow regimes in Appendix G1, Tables G1-66 through G1-97 and mean concentrations are presented in Figures 5-167 through 5-169, respectively. Low-flow sampling results for Geddes Brook and Ninemile Creek in 1998 are summarized in Appendix G1, Tables G1-98 through G1-101. Under base-flow conditions, the following metal CPOIs were detected in 1992:

- **Chromium:** Maximum concentrations of chromium were highest in Tributary 5A (28.3 µg/L), followed by the lake outlet (17.5 µg/L) and the East Flume (10.6 µg/L).
- **Copper:** Maximum concentrations of copper were highest in the East Flume (15.2 µg/L), Metro effluent (12.1 µg/L), Tributary 5A (10.3 µg/L), and Onondaga Creek (6.4 µg/L).
- **Lead:** Lead was detected at eight stations. The maximum concentrations were in the East Flume (10.8 µg/L) and Ley Creek (7.4 µg/L).
- **Nickel:** Nickel was detected at four stations, with concentrations ranging from 18.4 to 115 µg/L in Tributary 5A and 10.7 to 19.4 µg/L in the Metro effluent. Concentrations were detected once each in the lake outlet (10.3 µg/L) and Harbor Brook (9.1 µg/L).
- **Zinc:** Zinc was detected at all stations, except Bloody Brook and Sawmill Creek, with higher values in the East Flume (10.1 to 98 µg/L), the Metro effluent (26.9 to 41.7 µg/L), and Onondaga Creek (7.3 to 51.1 µg/L).

Under intermediate-flow conditions for 1992, the following distributions were found for each metal:

- **Cadmium:** Cadmium was only detected once, in Tributary 5A (2.4 µg/L).
- **Chromium:** Maximum concentrations of chromium were highest in Tributary 5A (119 µg/L) and lower Ninemile Creek (12.1 µg/L).
- **Copper:** Copper was detected in seven tributaries and the lake outlet. Maximum concentrations were highest in Tributary 5A (30.2 µg/L) and Ninemile Creek (19.2 µg/L).

- **Lead:** Maximum lead concentrations were highest in the East Flume (28.3 µg/L) and Ninemile Creek (21.5 µg/L).
- **Nickel:** Nickel concentrations found in Tributary 5A (29.6 to 92.6 µg/L) exceeded the concentrations in other tributaries.
- **Zinc:** Concentrations of zinc in the East Flume ranged from 58.6 to 179 µg/L, with an mean of 126 µg/L. Mean concentrations in all other tributaries and Metro effluent were less than 100 µg/L.

Under high-flow conditions in 1992, the following distributions were found for each metal:

- **Cadmium:** Concentrations of cadmium were detected in upper Ninemile Creek (19 µg/L), Bloody Brook (17.4 µg/L), Tributary 5A (3.2 µg/L), and lower Ninemile Creek (2.1 µg/L).
- **Chromium:** At least one detected value of chromium occurred in all stations except Onondaga Creek, Sawmill Creek, the East Flume, and the lake outlet. The maximum concentrations were highest in Tributary 5A (560 µg/L) and Ley Creek (19.3 µg/L).
- **Copper:** Copper was detected at all stations and the lake outlet. The maximum concentrations were highest in Tributary 5A (125 µg/L), Ley Creek (57.7 µg/L), and Harbor Brook (47.9 µg/L).
- **Lead:** Lead was detected at all stations. Maximum concentrations were highest in Ley Creek (94.5 µg/L), Tributary 5A (54.9 µg/L), Harbor Brook (63 µg/L), and Bloody Brook (43.8 µg/L).
- **Nickel:** The maximum nickel concentration at Tributary 5A (327 µg/L) exceeded the concentrations at all other stations. The tributary with the next highest concentration of nickel was Harbor Brook, with a maximum concentration of 16.5 µg/L.
- **Zinc:** Maximum concentrations of zinc were highest in Tributary 5A (259 µg/L), followed by Bloody Brook (201 µg/L), Harbor Brook (188 µg/L), Ley Creek (182 µg/L), the East Flume (130 µg/L), and Geddes Brook (105 µg/L). Concentrations were less than 100 µg/L at the remaining stations.

5.8.2 Benzene, Toluene, Ethylbenzene, and Xylenes

Under base-flow conditions in 1992, the following detected distributions were found:

- **Benzene:** Benzene was detected in Harbor Brook (1 to 1.7 µg/L), the East Flume (15 µg/L), and Tributary 5A (6.9 to 34 µg/L).
- **Toluene:** Toluene was detected in the Metro effluent (3.1 µg/L), Harbor Brook (1 to 2.6 µg/L), the East Flume (2.5 µg/L), Geddes Brook (5 µg/L), and Tributary 5A (1.1 to 4.2 µg/L).
- **Xylenes:** Xylenes were detected in Harbor Brook (2 to 3.6 µg/L), the East Flume (1.4 µg/L), and Tributary 5A (1.1 to 2.2 µg/L).

With the exception of ethylbenzene, which was detected in Ley Creek at a concentration of 1.7 µg/L, there were no detections of BTEX compounds under intermediate-flow conditions in 1992. Under high-flow conditions in 1992, benzene was only detected in Tributary 5A (60 µg/L), toluene was detected in Tributary 5A (5.1 µg/L) and Harbor Brook (2.1 µg/L), and xylenes were detected in the East Flume (1.6 to 1.8 µg/L), Tributary 5A (1.1 to 2.4 µg/L), and Harbor Brook (1.7 µg/L).

5.8.3 Chlorinated Benzenes

Under base-flow conditions in 1992, chlorobenzene was detected in the East Flume (7.6 µg/L), and in 1998, chlorobenzene was detected in upper Ninemile Creek (1.8 to 2.2 µg/L) and lower Ninemile Creek (1.2 to 1.6 µg/L). In 1992, 1,2-dichlorobenzene (2 to 10 µg/L) and 1,4-dichlorobenzene (4.6 to 14 µg/L) were detected only in the East Flume.

Under intermediate-flow conditions, 1,4-dichlorobenzene (2 to 2.4 µg/L) and 1,2,4-trichlorobenzene (0.9 to 1.1 µg/L) were detected only in the East Flume. Under high-flow conditions, chlorobenzene was not detected in any of the tributaries, dichlorobenzenes were detected in Harbor Brook (1 µg/L of 1,2-dichlorobenzene and 5.3 to 7.2 µg/L of 1,4-dichlorobenzene) and the East Flume (1 to 5.2 µg/L of 1,2-dichlorobenzene and 7.8 to 21 µg/L of 1,4-dichlorobenzene), and trichlorobenzenes were detected only in the East Flume (1.9 to 2.7 µg/L of 1,2,4-trichlorobenzene).

5.8.4 Stressors

5.8.4.1 Calcium

Under base-flow conditions in 1992, calcium concentrations ranged from 79,600 to 580,000 µg/L (Figure 5-170), with mean concentrations greatest in lower Ninemile Creek (518,333 µg/L), followed by Geddes Brook (404,182 µg/L). Under intermediate-flow conditions in 1992, calcium concentrations ranged from

71,400 to 348,000 µg/L, with lower Ninemile Creek and Geddes Brook averaging 301,600 and 304,000 µg/L, respectively.

Calcium concentrations decreased under high-flow conditions in 1992, ranging from 54,200 to 383,000 µg/L. Mean high-flow concentrations at lower Ninemile Creek (253,700 µg/L) and Geddes Brook (230,800 µg/L) are lower than the corresponding values under base flow and intermediate flow conditions.

5.8.4.2 Chloride

Concentrations of chloride under base-flow conditions in 1992 ranged from 46.4 to 1,411 mg/L (Figure 5-171). Mean chloride concentrations were highest in lower Ninemile Creek (1,250 mg/L), Geddes Brook (730 mg/L), and Onondaga Creek (670 mg/L), and were less than 500 mg/L in the remaining stations. Under intermediate-flow conditions in 1992, chloride concentrations in the tributaries ranged from 34.8 to 1,040 mg/L, with mean concentrations greatest in Geddes Brook (682 mg/L) and lower Ninemile Creek (665 mg/L). Under high-flow conditions in 1992, chloride concentrations ranged from 36.4 to 844 mg/L, with the highest mean values occurring in the East Flume (613 mg/L) and lower Ninemile Creek (505 mg/L).

5.8.4.3 Nitrogen

The only nutrient form of nitrogen or phosphorus that was measured in tributaries and Metro effluent in 1992 was ammonia (phosphorus was not measured). Concentrations of ammonia in the tributaries and Metro effluent under the three flow conditions are depicted in Figure 5-172.

Under base-flow conditions in 1992, maximum ammonia concentrations were highest in the Metro effluent (13.6 mg/L), followed by the East Flume (4.2 mg/L), the lake outlet (2.5 mg/L), and Geddes Brook (1.6 mg/L). Concentrations were less than 1 mg/L in the remaining tributaries. Under intermediate-flow conditions, maximum ammonia concentrations were highest in the Metro effluent (21.6 mg/L), followed by the East Flume (5.1 mg/L) and the lake outlet (3 mg/L), and were less than 1 mg/L elsewhere. Under high-flow conditions, maximum ammonia concentrations were also highest in the Metro effluent (14.7 mg/L), followed by the East Flume (5 mg/L) and the lake outlet (3 mg/L), and were 2 mg/L or less in the remaining tributaries.

5.8.4.4 Dissolved Oxygen

Dissolved oxygen concentrations and the percent-oxygen saturation in the tributaries and Metro effluent are presented for base-, intermediate-, and high-flow conditions in 1992 in Figure 5-173. Under base-flow conditions, mean DO concentrations were lowest in the East Flume (5.6 mg/L), and were higher than 7.2 mg/L in the remaining tributaries. Under intermediate-flow conditions, mean DO in the East Flume was 5.9 mg/L, and was higher than 7.4 mg/L elsewhere. Under high-flow conditions, mean DO concentrations were again lowest in the East Flume (5.7 mg/L), and were higher than 8.6 mg/L in the other tributaries sampled. Under each flow regime, the East Flume is approximately 60 percent oxygen saturated.

5.9 Groundwater Characterization

Sampling and analysis of groundwater for this RI focused on a limited number of monitoring wells in the vicinity of Wastebeds 12 through 15, and piezometers offshore of the Semet Residue Ponds and the Willis Avenue sites. Chlorobenzene data for these locations are presented in Chapter 4 of this report. Groundwater characterization for upland areas adjacent to Onondaga Lake was performed in a more comprehensive manner during RIs for the Semet Residue Ponds (O'Brien & Gere, 1991), the Willis Avenue site (O'Brien & Gere, 2002e, currently under NYSDEC review), and the LCP Bridge Street site (NYSDEC/TAMS, 1998c). In addition, groundwater conditions were evaluated in a supplemental site investigation for Wastebeds 9 through 15 (BBL, 1999). Groundwater investigations have also been conducted for the PSAs for Honeywell's Wastebed B/Harbor Brook and Willis Avenue Ballfield sites. Remedial investigations have commenced at both of these sites. Groundwater data are currently not available for the dredge spoils area north of Ninemile Creek. However, as contaminants in the lake are fully characterized, such data are not necessary in order to complete this RI. In addition, the dredge spoils area is being further evaluated as a separate site with its own RI.

A brief description of groundwater characteristics of the upland sites is presented here. Loadings of contaminants from these sites to Onondaga Lake are presented in Chapter 6 of this RI. More comprehensive evaluations of groundwater issues at the Semet Residue Ponds, Willis Avenue, and LCP Bridge Street sites are presented in the RI reports for each site. For Wastebeds 9 through 15, groundwater issues are discussed in the supplemental site investigation report (BBL, 1999). Groundwater results for the Wastebed B/Harbor Brook site are in the RI/FS Work Plan (O'Brien & Gere, 2002a) and the PSA Data Summary Report (O'Brien & Gere, 2000b). Inorganic and organic groundwater constituents that were detected in at least one groundwater sample at the upland sites and exceeded the NYSDEC Class GA groundwater standards are presented in Appendix G1, Tables G1-102 and G1-103. The NYSDEC groundwater standards, the total number of samples, the maximum detected concentration, and the sample corresponding to this maximum concentration are also presented in these tables.

The Semet Residue Ponds and Willis Avenue sites RI reports (O'Brien & Gere, 1991, 2002e) identified groundwater from these areas as a potential pathway for CPOIs to directly enter Onondaga Lake.

In groundwater beneath and downgradient from the Willis Avenue site, metals such as mercury, arsenic, copper, chromium, and lead, among others (Appendix G1, Table G1-102), and organic compounds such as benzene, toluene, xylenes, naphthalene, and chlorinated benzenes (mono-, di-, tri-, and hexachlorobenzene) exceeded NYSDEC Class GA groundwater standards (Appendix G1, Table G1-103) (O'Brien & Gere, 2002e). DNAPL deposits of mercury and chlorinated benzene exist in the groundwater under the Willis Avenue Plant site. In groundwater beneath the Semet Residue Ponds, the organic compounds benzene, toluene, xylenes, and naphthalene, among others, exceeded NYSDEC groundwater standards (Appendix G1, Table G1-103) (O'Brien & Gere, 1991).

The LCP Bridge Street site RI report (NYSDEC/TAMS, 1998c) identified site groundwater as a source of mercury to surface water in the vicinity of the site, with the primary source at the location of the former

mercury cell building where mercury in DNAPL form exists. The extent of the mercury plume was bounded by surface water bodies (the East Ditch, the West Ditch, and the West Flume) in the upper aquifer unit, and was confined to the area near the former Mercury cell building in the lower aquifer unit.

In addition to mercury, the metals arsenic, copper, cadmium, chromium, nickel, and lead were detected in groundwater at the LCP Bridge Street site at concentrations that exceeded NYSDEC Class GA standards (Appendix G1, Table G1-102). Non-mercury CPOIs were detected sporadically and infrequently at the site, and the conclusion was drawn in the RI report that there is no discernable non-mercury plume emanating from the site. However, groundwater data do indicate that a chlorinated volatile organic compound (VOC) plume originates at an upgradient off-site source. NYSDEC Class GA standards were exceeded in at least one on-site groundwater sample for benzene, naphthalene, benz(a)anthracene, chrysene, and hexachlorobenzene. The extent of the plume on-site was determined to be limited and well defined. In addition, Honeywell is conducting an RI at Operable Unit 2 (OU-2) at the LCP Bridge Street site to assess groundwater contaminated with xylenes.

Groundwater sampling in the vicinity of Wastebeds 9 through 15 indicates that CPOIs are present only in the surface aquifer, and that the bedrock groundwater quality is not affected by site-related activities (BBL, 1999). Benzene and chlorobenzene were detected in site wells but appear to be associated with municipal refuse deposited in a canal bed in the vicinity of Wastebed 15, rather than with Solvay Process waste (BBL, 1999). Organic constituents that exceeded NYSDEC Class GA standards in on-site wells include benzene, toluene, chlorobenzene, dichlorobenzenes, and PCBs (Appendix G1, Table G1-103). Metals that exceeded Class GA standards include copper and chromium.

Groundwater sampling at the Wastebed B/Harbor Brook site indicates that this site is a source of mercury, chlorinated benzenes, BTEX, and PAHs, in particular, naphthalene. These and other compounds exceeded the NYSDEC Class GA standards in on-site wells (Appendix G1, Tables G1-102 and G1-103). A DNAPL plume also exists on this site in the Penn-Can area and in lower Harbor Brook. Concentrations of many CPOIs, including mercury, also exceeded NYSDEC standards at the Willis Avenue Ballfield site.

5.10 Biological Tissue Characterization

Biota have been sampled in Onondaga Lake and its tributaries as part of this RI by Honeywell/PTI/Exponent, as well as by NYSDEC for monitoring purposes. The fish, benthic organisms, and plankton data used in this RI are presented in the following section. Further presentation and interpretation of the biota data, along with analysis of ecological exposure, are included in the BERA (TAMS, 2002a).

5.10.1 Fish

Fish were collected from Onondaga Lake and its tributaries by Honeywell in both 1992 and 2000 as part of this RI. Summary statistics for the Honeywell and NYSDEC data for 1992 and 2000 are provided in Appendix G1, Tables G1-104 through G1-106. A summary statistics table is also provided for data

collected by NYSDEC between 1994 and 1999 (Appendix G1, Table G1-107). All fish concentrations are stated on a wet-weight basis. The majority of fish samples were collected on a fillet basis; a limited number of samples were collected on a whole-fish basis.

5.10.1.1 Mercury and Other Metals

Methylmercury concentrations in fillets of all fish species sampled by Honeywell/PTI in Onondaga Lake and its tributaries in 1992 ranged from 0.03 to 3.17 mg/kg wet weight (PTI, 1993a). Breakdowns by species as fish fillet and whole-body concentrations are presented by age group on a wet weight and lipid-normalized basis in Appendix G1, Table G1-108. Methylmercury was detected in all fish sampled. The breakdown by species for the 1992 wet-weight fillet data is as follows:

- Bluegill (*Lepomis macrochirus*): 0.05 to 0.92 mg/kg.
- Carp (*Cyprinus carpio*): 0.04 to 0.80 mg/kg.
- Channel catfish (*Ictalurus punctatus*): 0.30 to 1.05 mg/kg.
- Gizzard shad (*Dorosoma cepedianum*): 0.07 to 0.38 mg/kg.
- Smallmouth bass: 0.26 to 1.72 mg/kg.
- Walleye: 0.30 to 3.17 mg/kg.
- White perch (*Morone americana*): 0.20 to 2.04 mg/kg.

Since nearly all of the mercury in fish tissue consists of methylmercury, total mercury rather than methylmercury was analyzed in the samples collected by Honeywell/Exponent in 2000. Mercury concentrations in adult fish sampled in 2000 are presented in Appendix G1, Table G1-109 in the same manner as described above for the 1992 samples. Concentrations in fish fillets of all species sampled in 2000 ranged from 0.23 to 1.89 mg/kg wet weight. Mercury was detected in all fish sampled. The breakdown by species for the 2000 wet-weight fillet data is as follows:

- Bluegill: 0.23 to 0.44 mg/kg.
- Carp: 0.38 to 0.90 mg/kg.
- Channel catfish: 0.54 to 0.66 mg/kg.
- Largemouth bass (*Micropterus salmoides*): 0.30 to 1.89 mg/kg.
- Smallmouth bass: 0.41 to 1.53 mg/kg.

Mercury was detected in juvenile (young-of-year [YOY]) fish sampled in 2000 at the tributary mouths (Appendix G1, Table G1-110) on a wet-weight basis, as follows:

- Bluegill: 0.05 to 0.22 mg/kg.
- Largemouth bass: 0.08 to 0.16 mg/kg.
- Pumpkinseed (*Lepomis gibbosus*): 0.05 to 0.14 mg/kg.

Concentrations of other metals detected in fish (Appendix G1, Tables G1-104 through G1-106) are summarized below:

- In 1992, antimony was detected at estimated concentrations between 1.8 and 2.1 mg/kg. The detection limits were 2.2 and 2.7 mg/kg. Antimony was not detected in any adult or juvenile fish sampled in 2000 (maximum detection limit 0.05 mg/kg). That no antimony was detected in the 2000 samples using a method with a detection limit 50 times lower than the 1992 samples suggests that the 1992 positive results, which were very close to the detection limit, are suspect.
- Cadmium concentrations ranged from 0.01 to 0.03 mg/kg in fish collected in 1992. For samples collected in 2000, concentrations ranged from 0.06 to 0.9 mg/kg for adult fish and from 0.06 to 0.2 mg/kg for juvenile fish.
- Detected chromium concentrations in fish collected in 1992 ranged from 0.6 to 0.73 mg/kg. For samples collected in 2000, concentrations ranged from 1.2 to 14 mg/kg in adult fish. A concentration of 1 mg/kg was found in one juvenile fish.
- Detected lead concentrations ranged from 0.06 to 0.29 mg/kg for fish collected in 1992. Concentrations ranged from 0.02 to 1.9 mg/kg in adult fish and from 0.06 to 1 mg/kg in juvenile fish collected in 2000.
- Selenium was detected in one fish at a concentration of 0.86 mg/kg 1992. Concentrations ranged from 1 to 2.4 mg/kg for adult fish and from 1.1 to 2.6 mg/kg for juvenile fish collected in 2000.
- Zinc was detected in one fish at a concentration of 17 mg/kg in 1992. For adult fish collected in 2000, detected zinc concentrations ranged from 20 to 425 mg/kg and from 81 to 154 mg/kg for juvenile fish.

5.10.1.2 Polychlorinated Biphenyls, Pesticides, and PCDD/PCDFs

While many fish fillets were analyzed for PCBs by Honeywell in 1992, these data will not be included in this RI or the HHRA and BERA (see Appendix A of the HHRA [TAMS, 2002b]). The NYSDEC 1992 to 2000 fish data are considered in the HHRA (TAMS, 2002b), and 1992 PCB data are presented in Appendix G1, Table G1-111.

Concentrations in adult fish in 2000 ranged from 0.09 to 3.4 mg/kg wet weight (fillets and whole bodies; Appendix G1, Table G1-105), and in juvenile fish ranged from 0.14 to 2.4 mg/kg wet weight (Appendix G1, Table G1-106). PCB concentrations in adult fish sampled in 2000 are presented in Appendix G1, Table G1-112 by species, and for all species, mean concentrations of PCBs were higher in whole-body samples than fillets. The PCB concentration breakdown by species on a lipid-normalized wet-weight fillet basis is as follows:

- Bluegill: 13.3 to 16.1 mg/kg.
- Carp: 4.14 to 11.27 mg/kg.
- Channel catfish: 16.4 to 28.4 mg/kg.
- Largemouth bass: 5.28 to 20.02 mg/kg.
- Smallmouth bass: 15.6 to 41 mg/kg.

For pesticides, DDT concentrations (sum of DDT and metabolites) ranged from 20 to 600 µg/kg in fish collected in 1992 (Appendix G1, Table G1-104). For adult fish collected in 2000, detected DDT and metabolites ranged from 5 to 500 µg/kg (Appendix G1, Table G1-105) and from 12 to 87 µg/kg for juvenile fish (Appendix G1, Table G1-106). Chlordane (sum) concentrations ranged from 8.4 to 90 µg/kg for fish collected in 1992. For adult fish collected in 2000, detected chlordane (sum) concentrations ranged from 1.1 to 15 µg/kg. Chlordane (sum) was not detected in juvenile fish (maximum detection limit of 10 µg/kg). Dieldrin concentrations ranged from 5 to 19 µg/kg for fish collected in 1992. For adult fish collected in 2000, detected dieldrin concentrations ranged from 0.012 to 100 µg/kg and from 2.9 to 26 µg/kg in juvenile fish. Heptachlor epoxides (sum of heptachlor and heptachlor epoxide) were detected in one fish at 4 µg/kg in 1992, but were not detected in juvenile fish collected in 2000 (maximum detection limit of 25 µg/kg), though heptachlor epoxide was detected in one adult fish at 7 µg/kg in 2000.

PCDD/PCDF data from fish collected by Honeywell/Exponent in 2000 and by NYSDEC in 1992, 1997, and 1999 are presented in Appendix G1, Table G1-113. TEQs were calculated based on risks to mammals and birds. The TEQs, as follows, are for risks to mammals, although it should be noted that the TEQ calculated for avian risks are higher, and are shown in the respective tables. In 1992, the TEQ concentration ranged from 3.1 to 7.8 ng/kg. The TEQ for adult fish collected by Honeywell/Exponent in 2000 ranged from 0.3 to 79 ng/kg (this maximum value includes concentrations from both fillet and remainder samples from the same fish). The TEQ in adult fish collected by NYSDEC in 1999 ranged from 1 to 46 ng/kg. In juvenile fish collected in 2000, the TEQ ranged from 0.3 to 4.7 ng/kg.

5.10.2 Benthic Macroinvertebrates and Plankton

Mercury and methylmercury were analyzed in benthic macroinvertebrates and phytoplankton collected in Onondaga Lake in 1992. Benthic organisms sampled include chironomids, amphipods, daphnids, and other zooplankton assemblages. Summary statistics are provided in Appendix G1, Table G1-114. Mercury was detected in all benthic samples collected, with concentrations ranging from 23 to 994 µg/kg wet weight. The maximum detected concentration in 1992 was found at Station S04, in the center of the southern basin, in a daphnid sample. Methylmercury was detected in all samples collected, with concentrations ranging from 10 to 390 µg/kg wet weight (PTI, 1993a). The maximum detected concentration was found in a daphnid sample from Station S04. Mercury was detected in all phytoplankton samples collected. Detected mercury and methylmercury concentrations for phytoplankton ranged from 90 to 300 µg/kg and 4.0 to 39 µg/kg wet weight, respectively. The maximum mercury concentration was found at Station S05, in the center of the northern basin and the maximum methylmercury concentration was found at Station S04, in the center of the southern basin.

Methylmercury, total mercury, and PCBs were analyzed in benthic macroinvertebrates collected in Onondaga Lake in 2000. Benthic organisms sampled included chironomids, amphipods, and oligochaetes. Summary statistics are provided in Appendix G1, Table G1-115.

Total mercury was detected in 40 of 41 samples, with concentrations ranging from 28 to 7,470 µg/kg wet weight, and methylmercury was detected in 35 of 41 samples, with concentrations ranging from 3.1 to 355 µg/kg wet weight. The maximum concentrations for both mercury and methylmercury were detected at Station S406 in a chironomid sample, in the in-lake waste area between the East Flume and Harbor Brook. Total mercury concentrations were also very elevated at Station S344 (6,480 µg/kg in an oligochaete and 6,210 µg/kg in a chironomid sample) and at Station S404 (3,700 µg/kg in an oligochaete). These two stations are also in the vicinity of the East Flume and the in-lake waste deposit.

For PCBs, Aroclor 1242 was most frequently detected (five of the seven samples), with concentrations ranging from 49.6 to 195 µg/kg. The maximum detected concentration was found at Station S403 in an amphipod sample. Total PCBs were calculated, and range from 79.4 to 308 µg/kg, with the maximum concentration found (as above) at Station S403 in an amphipod sample.

5.11 Summary

This chapter of the RI documents the nature and extent of contamination in the sediments of Onondaga Lake and its associated tributaries and wetlands; soil from the dredge spoils area; porewater from Onondaga Lake sediments; surface water from Onondaga Lake and tributaries; groundwater from adjacent upland sites; and tissue from Onondaga Lake fish, benthic macroinvertebrates, and plankton. These data, collected between 1992 and 2002, provide a comprehensive basis for understanding the current nature and extent of Honeywell- and non-Honeywell-related contaminants in Onondaga Lake.

Most CPOIs in the sediment are present at elevated concentrations at various locations in the lake. Mercury is generally present throughout the lake at concentrations between 1 and 4 mg/kg in surface sediments (0 to 0.02 m) and over 100 mg/kg in subsurface sediments. For mercury and organic CPOIs (including BTEX, chlorinated benzenes, PAHs, PCBs, and PCDD/PCDFs), the primary area of elevated concentrations is in portions of the southern end of the lake. Highest concentrations were consistently located along the southwestern shoreline of the lake between Tributary 5A and Harbor Brook out to beyond the 9 m bathymetric contour. Organic CPOIs were heterogeneous, with elevated concentrations extending at least 8 m into the sediment in several cases. In addition, a TCLP extract from one of the sediment samples collected in this area exceeded the regulatory limit for dichlorobenzenes.

Mercury was also found at elevated concentrations in sediment near the mouth of Ninemile Creek, to a depth of approximately 5 m. Based on stratigraphic cores, mercury concentrations were elevated at depth (approximately 18 to 45 cm below the sediment surface) in the deep basins of the lake. Mercury concentrations in surface sediments in the deep basins of the lake (i.e., maximum concentration of 3.6 mg/kg in 0 to 2 cm surface grabs in 1992) are lower than they were in 1986 (i.e., maximum concentration of 50 mg/kg in the 0 to 0.075 m interval; NYSDEC, 1989). Limited analysis of Onondaga

Lake sediment for organic substances prior to 1992 prevents comparison of pre-investigation conditions to current conditions.

In tributary sediments, Tributary 5A and Ley Creek contained the highest concentrations of metals, while the East Flume, Tributary 5A, and Harbor Brook had the highest concentrations of organic contaminants. Mercury concentrations were also elevated in Geddes Brook and Ninemile Creek.

In wetland sediments, Wetland SYW-19, which is adjacent to the Wastebed B disposal area, contains elevated concentrations of mercury, lead, chlorinated benzenes, PAHs, PCBs, and PCDD/PCDFs. Wetland SYW-12, at the mouth of Ley Creek, contains the highest concentrations of cadmium and chromium. In Wetland SYW-6 in the northern part of the lake, elevated concentrations of mercury, LPAHs, and HPAHs were detected in the 15 to 30 cm interval of Station SYW6-3.

For the dredge spoils area, mercury concentrations were highest in Basins 1 through 3 (up to approximately 100 mg/kg), indicating the presence of dredged material from the Ninemile Creek delta. Maximum concentrations of PAHs were detected in Basin 4, at intervals greater than 180 cm below the surface. The source of the fill in Basin 4 is not known.

Porewater from Onondaga Lake sediment contained dissolved total mercury and methylmercury. Concentrations were highest at two stations located offshore of the East Flume at concentrations (up to 50,000 ng/L) more than three orders-of-magnitude greater than surface water concentrations.

In lake water, most metals were measured near or below detection limits, with the exception of mercury, which has an extremely low detection limit (i.e., less than 1 ng/L). Mercury concentrations in water varied seasonally with depth in the water column. The highest concentrations of mercury were seen in the littoral zone in the southwest corner of the lake. The highest mercury concentrations in the deep basins of the lake were observed in the hypolimnion during summer stratification. With two exceptions, all of the organic CPOIs were measured below detection limits in lake water. In 1992, one lake water sample (out of 98 total) contained dichlorobenzenes and trichlorobenzenes. In 1999, two samples taken offshore of the East Flume contained benzene and chlorobenzene. Dichlorobenzenes were detected in 1999 at nearly all stations in the lake with the highest concentrations near the East Flume and Harbor Brook.

Unlike lake water, most CPOIs were detected in water from tributaries and Metro effluent. Most metal CPOIs (other than mercury) were detected occasionally. Cadmium was detected infrequently, while copper, lead, and zinc were frequently detected. Tributary 5A and the East Flume are the two tributaries in which the majority of the metal CPOIs were more frequently detected. The East Flume and Geddes Brook contained the highest concentrations of total mercury, while the East Flume and Metro effluent contained the highest concentrations of methylmercury. Organic CPOIs were detected in Tributary 5A (benzene, toluene), East Flume (xylenes, chlorinated benzenes), and Harbor Brook (xylenes). These compounds were found at less than detection limits in all other tributaries and Metro effluent.

Groundwater at sites adjacent to Onondaga Lake contained mercury and organic CPOIs. CPOIs include benzene, toluene, xylenes, and naphthalene at the Semet Residue Ponds; chlorinated benzenes, benzene, toluene, xylenes, naphthalene, and metals (mercury, arsenic, copper, chromium, and lead) at the Willis Avenue site; mercury and other metals at the LCP Bridge Street site; mercury, chlorinated benzenes, BTEX, and PAHs at the Wastebed B/Harbor Brook site; and benzene, toluene, chlorobenzene, dichlorobenzenes, PCBs, copper, and chromium at Wastebeds 9 through 15. DNAPL plumes are present at the Willis Avenue and Wastebed B/Harbor Brook sites.

Methylmercury concentrations in the tissue of all fish species sampled by Honeywell/Exponent in Onondaga Lake and its tributaries in 1992 ranged from 0.03 to 3.17 mg/kg wet weight (PTI, 1993a). In 2000, total mercury concentrations in fish filets ranged from 0.230 to 0.904 mg/kg wet weight. Methylmercury and total mercury concentrations in fish tissue are usually equivalent because total mercury is predominantly (greater than 95 percent) methylmercury in fish tissue (Bloom, 1992). Total PCB concentrations in adult fish tissue of all species of fish sampled by Honeywell/Exponent in Onondaga Lake and its tributaries ranged from 0.020 to 4.70 mg/kg wet weight in 1992 and 0.088 to 1.84 mg/kg wet weight in 2000. PCDD/PCDFs (reported as TEQ with risk to mammals) in adult fish ranged from 1.81 to 79 ng/kg. While pre-investigation data are available for mercury and PCBs in fish tissue, it is difficult to compare these data to the current data because of lack of standardization (i.e., differences in fish species, age, preparation, and laboratory methods).