APPENDIX D: PART A

GROUNDWATER FLOW TO ONONDAGA LAKE

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SECTION DA.1

INTRODUCTION

This technical paper describes groundwater flow in the vicinity of Onondaga Lake and the magnitude of groundwater discharge to the lake. As part of the Onondaga Lake Feasibility Study (FS), eight Sediment Management Units (SMUs) were defined within the lake. Groundwater flux (the groundwater discharge per unit area of sediment) to each of these SMUs has been evaluated and described in this paper. The locations of the SMUs are identified on Figure DA.1.

One of the tools used in the analysis of groundwater flow to Onondaga Lake was a numerical three-dimensional model developed to simulate groundwater flow beneath and in the vicinity of the southwestern part of Onondaga Lake. Due to the complexity of the model, this appendix has been split into two parts: Groundwater Flow to Onondaga Lake (Part A) and Groundwater Model Documentation (Part B). The first part of this appendix describes the background information pertaining to Onondaga Lake and the various methods used to evaluate groundwater discharge to the lake. The detailed information regarding the groundwater model has been presented in second part of this appendix.

The analyses conducted in this appendix integrate the available information on groundwater conditions in the vicinity of the lake to provide the best possible estimates of groundwater fluxes, which provide a potential pathway for contaminant migration to the lake. Groundwater flux through lake sediments can remobilize and transport contaminants in the sediments. The estimates of groundwater flux described in this appendix have been used in the evaluation of the long-term effectiveness of remedial alternatives described in the Onondaga Lake FS.

SECTION DA.2

GROUNDWATER SETTING

Onondaga Lake overlies a deep, northwest-trending glacial trough in the Vernon Shale, the bedrock formation beneath and in the vicinity of the lake. A schematic cross section through the southeastern end of the lake, which illustrates the trough, is shown on Figure DA.2. The lake lies at the northern end of the trough. The trough averages about 300 feet (ft; 91 meters) deep along the axis of the lake and is filled primarily with unconsolidated, fine-grained sediments. The thickness of the unconsolidated sediments decreases rapidly away from Onondaga Lake, except in the valleys of the main tributaries, which are also underlain by unconsolidated sediments.

The thickness and characteristics of the unconsolidated sediments beneath the lake have been investigated by the United States Geological Survey (USGS) (Kappel, 2004b). The USGS has advanced three deep borings along the approximate centerline of the trough: one located southwest of the lake near the mouth of Onondaga Creek on Spencer Street (Spencer Street), one located in the center of the lake on the saddle between the northwest and southeast basins of the lake (Saddle site), and one located to the northwest of the lake outlet (Outlet site). The locations of the borings have been identified on Figure DA.1. In addition, the USGS has advanced one boring to bedrock about 400 ft (122m) off shore from the western shoreline of the lake northwest of the mouth of Ninemile Creek (West Trail site), and one boring to bedrock approximately 325 ft (99m) off-shore from the eastern shoreline northwest of the mouth of Ley Creek (Parkway site). The stratigraphic sequences observed in the borings are similar:

- Surficial sediments described as gray, marly silt with fine sand and shells;
- Gray clayey marl, gray-brown clayey silty marl (marl unit);
- Brown-gray clay, gray-brown silty clay (silt and clay unit);
- Gray-brown silt with sand layers (silt and fine sand unit);
- Hard sand (sand and gravel unit);
- Red Vernon till, dense with stones (till unit); and
- Green, red, and gray Vernon Shale (bedrock).

The boring at the saddle encountered about 25 ft (7.6 m) of marly sediments, 83 ft (24.4 m) of clay and silty clay, and 76 ft (23.2 m) of silt with sand layers. This boring terminated in a silt and fine sand unit due to difficult drilling conditions.

A large number of borings have been advanced along the western shoreline of the lake from the mouth of Ninemile Creek to mouth of Onondaga Creek as part of various investigation activities conducted in this area. The stratigraphic sequence along the shoreline is similar to that observed in the center of the lake, except that the surface unit is fill along much of this shoreline, and units are much thinner than in the center of the lake. Much of the fill along this portion of the shoreline is wastebeds composed primarily of ionic wastes from the Solvay process.

Four geologic cross sections have been developed in the area between the mouth of Ninemile Creek and the mouth of Harbor Brook. The sections are oriented perpendicular to the shoreline and are shown on Figures DA.3a and DA.3b with their locations posted on Figure DA.1. These sections show that the unconsolidated deposits thin rapidly landward of Onondaga Lake, and that the thickness of the geologic units is quite variable. A short distance southwest of the shoreline, the primary geologic units are till overlying bedrock. Cross sections B-B’ and C-C’ show a fine sand and silt unit of limited aerial extent between the marl unit and the silt and clay unit. The sand and gravel unit above the till is quite variable in thickness and grain size. The maximum thickness of the sand and gravel unit (which is absent in some areas) varies from a thickness of about 3 ft (0.9 m) at cross section D-D’ to a thickness of about 30 ft (9.1 m) at cross section B-B’. The unit varies in grain size from medium-to-coarse sand to sand and gravel.

SECTION DA.3

GROUNDWATER FLOW

Regional groundwater flow in both the bedrock and the unconsolidated sediments is toward the valleys of the major tributaries and toward the lake (Winkley, 1989). Groundwater discharge areas include seven major tributaries: Nine Mile Creek, Geddes Brook, Harbor Brook, Bloody Brook, Onondaga Creek, Saw Mill Creek, and Ley Creek. Groundwater flow toward the lake is believed to originate primarily as precipitation that infiltrates into the unconsolidated sediments bordering the lake. Because the unconsolidated sediments are restricted to a relatively narrow band on either side of the lake, the total recharge area is relatively small, and as a result recharge to and discharge from the unconsolidated sediments is relatively small.

Most of the groundwater in the unconsolidated sediments that flows toward the lake discharges to creeks and drains on the shoreline and in near-shore areas. This occurs in part because of the thickening wedge of fine-grained, low-permeability materials beneath the lake and because of sodium chloride brines in the unconsolidated sediments beneath the lake.

Regional groundwater flow patterns are illustrated on Figure DA.4. A water table map of the area adjacent to the lake from Onondaga Creek to Ninemile Creek is shown on Figure DA.5. The water table map was developed using average groundwater elevations based on available data collected from sites over the past 15 years. Some sites have multiple rounds of elevation measurements over many years, while others have only one or two rounds of data. The water levels indicate that shallow groundwater flow is toward the lake as well as toward other surface water bodies, including Ninemile Creek, Geddes Brook, Tributary 5A, Harbor Brook, and Onondaga Creek. Groundwater mounds exist beneath the wastebeds in this area, with groundwater flow outward from the center of the mounds.

The majority of bedrock groundwater originates from infiltration in the upland areas where the bedrock subcrops. Some bedrock groundwater flows toward the lake, where it discharges after moving upward through the overlying unconsolidated sediments. Groundwater flow through the bedrock is estimated to be small because the Vernon Shale has low permeability, with most flow occurring through widely spaced fractures. Winkley (1989) and Kantrowitz (1970) noted that the Vernon Shale most likely has a relatively low hydraulic conductivity on a regional scale. Winkley noted that locally the hydraulic conductivity of the Vernon Shale approaches 4×10^{-4} cm/sec (1.1 ft/day), and that the median yield from wells in the Vernon Shale is 12 gpm.

The presence of natural sodium chloride brines in the unconsolidated sediments and bedrock beneath the lake complicates the understanding of local groundwater flow conditions. These brines are believed to have originated from the dissolution of halite chips within the unconsolidated sediments that were scoured by glacial activity from halite beds in the Salina Group (Kappel, 2004b), a bedrock unit that overlies the Vernon Shale. The brines currently beneath the lake are relatively stagnant and likely formed during the last period of glaciation. USGS wells screened in the sodium chloride brines are the deep well at Spencer Street (screened ~ 300 feet below lake level) and the deep and shallow wells at the Outlet site (screened ~150 feet and ~110 feet below lake level, respectively; Kappel, 2004a). Wells that are screened in the sodium chloride brines along the western shoreline include DW-102 near the mouth of Ninemile Creek (screened ~90 feet below lake level) and HB-20D near the mouth of Harbor Brook (screened ~ 130 feet below lake level). The chloride concentrations in each of these wells exceed 100,000 milligrams per liter (mg/L). The origin of the brines is discussed in more detail by the USGS (USGS, 2000).

In the past, discharge of brines at salt springs was reported to have occurred around much of the shoreline of the southern basin of the lake (USGS, 2000). These discharges likely occurred where the fine-grained units thinned along the shoreline. The discharge of brines has ceased due to extraction of brines from wells along the southern shoreline of the lake from the early 1800s through the early 1900s. There are no known salt springs around the southern end of the lake today. The so-called Gale Springs along the northwestern shore is a flowing well with a chloride concentration of about 6,700 mg/L. However, there are salt springs in Onondaga Creek southeast of the lake (Kappel, 2004b).

From 1797 through 1917, over 11.5 million tons of finished salt were produced from the springs and wells along the southern shoreline of the lake (USGS, 2000). This represents the salt content from the constant production of 500 gallons per minute (gpm) of brine with a chloride concentration of 60,000 mg/L over this period. The production of these brines undoubtedly decreased groundwater pressures in the more permeable zones beneath the lake, and it is possible that the pressures have not re-established themselves to predevelopment levels.

In addition to the sodium chloride brines, there are mixed cation brines in the bedrock. These brines formed by the dissolution of evaporate beds within the Vernon Shale and overlying bedrock units. These brines are enriched in calcium, magnesium, and bromide relative to the sodium chloride brines. Water quality results from a groundwater sample collected by the USGS from the bedrock at the West Trail site indicate that the groundwater at this location is a mixed cation brine. The chloride concentration of the groundwater at this location is about 58,000 mg/L, the calcium concentration is 12,000 mg/L, the sodium concentration is 22,000 mg/L, the magnesium concentration is 1,400 mg/L, and the bromide concentration is 430 mg/L. These mixed cation brines have a composition similar to Appalachian providence brines as exemplified by the Bass Island brine (Kappel, 2004b).

In addition to natural brines, some brines in groundwater result from seepage from the wastebeds. These brines are comprised primarily of sodium, calcium and chloride. Monitoring well SP-4C, which is completed in the sand and gravel unit beneath Wastebed A in the Willis/Semet area, contains this type of brine. The composition of water from this well is 13,000 mg/L sodium, 21,000 mg/L calcium, and 64,000 mg/L chloride. The wastebed brines typically have sodium to calcium ratios that are 2:1 or less, whereas the natural sodium chloride brines have sodium to calcium rations of greater than 10:1. The mixed cation brines have sodium to calcium ratios that are similar to the wastebed brines.

The chemical composition of the four brine types are compared on the following table based on water quality data collected by the USGS (Kappel 2004a). For ease of comparison among the various water types, concentrations reported as mg/L have been normalized such that the total concentration of the major cations and anions totals 100.

	Sodium-Chloride Brine (Spencer Street Deep Well)	Mixed Cation Brine (West Trail Bedrock Well)	Bass Island Brine	Wastebed Leachate
Calcium	1.45	12	15	21
Magnesium	0.22	1.46	1.85	0.02
Sodium	36	23	20	16
Potassium	0.22	1.25	1.15	0.63
Chloride	58	60	62	62
Sulfate	3.43	1.25	0.06	0.43
Bromide	0.04	0.45	0.52	0.04
Total	100	100	100	100
Sodium/Calcium ratio	25	1.8	1.4	0.8

The mixing of relatively fresh groundwater, natural sodium chloride brines, natural mixed cation brines, and brines from the wastebeds have created a wide variety of groundwater quality types in the vicinity of Onondaga Lake. The distribution of groundwater quality provides information on groundwater migration and origin, as discussed in a later section.

SECTION DA.4

ONONDAGA LAKE

Onondaga Lake, oriented along a northwest-southeast axis, is approximately 4.5 miles long and 1 mile wide. The lake has a mean depth of 36 ft (11 m) and a maximum depth of 65 ft (19.8 m), which occurs in the southern basin. The average lake level during the past 20 years has been 362.9 ft (110.6 m), based on records from the USGS gauge on Onondaga Lake at Liverpool, New York. The surface area of the lake at this elevation is approximately 4.5 square miles, and the volume is approximately 34,600 million gallons.

Surface water inflow to the lake and surface water outflow from the lake average about 470 cubic feet per second (cfs; 211,000 gpm) based on average flows for 1998 to 2002 (EcoLogic *et al*., 2003). The groundwater component of the lake water budget is small, estimated to be less than 0.5 percent of the surface water inflows. Precipitation on the lake and evaporation from the lake are approximately equal; therefore, the net of precipitation and evaporation is small. The average residence time of water in the lake is approximately 100 days.

Groundwater discharge to the lake occurs primarily in the littoral zone. The spatial pattern of groundwater seepage to lakes and the factors that affect these patterns have been investigated and described in papers by Winter (1976), Guyonnet (1991), and Genereux and Bandopadhyay (2001). Other notable research includes McBride and Pfannkuch (1975), Pfannkuch and Winter (1984), Cherkauer and Zager (1989), and Shaw and Prepas (1990). A general observation in the research is that groundwater discharge exhibits an approximately exponential decrease with distance from the shoreline (see Attachment DA.2). Evaluation of many lines of evidence indicates that, this is most likely the case in Onondaga Lake.

SECTION DA.5

METHODS USED TO ESTIMATE GROUNDWATER DISCHARGE TO THE LAKE

This section describes direct estimates of groundwater discharge to creeks and drains in the vicinity of Onondaga Lake and five indirect methods that have been used to estimate groundwater discharge to Onondaga Lake. As noted in the previous section, groundwater discharge to the lake is a very small percentage of the water budget of the lake; therefore, lake water balance calculations cannot provide a reliable estimate of groundwater discharge to the lake.

In an effort to measure discharge to the lake, an upwelling study was conducted near the mouth of Ninemile Creek and in the southwest corner of the lake near SMUs 1, 2, and 7. However, this study only provided an indirect estimate of groundwater discharge due to the lack of reliable hydraulic conductivity data (Parsons, 2003b). Groundwater discharge can be calculated from hydraulic gradients measured in this study and estimated hydraulic conductivities, but because the latter are poorly known, the calculated flows have a large uncertainty associated with them.

The lake is not the only regional groundwater discharge location, as most of the groundwater flowing toward the lake in the unconsolidated sediments and in the bedrock discharges to creeks and drains in the vicinity of the lake. The amount of groundwater discharge to some of these surface water features has been measured and/or estimated. Direct estimates of groundwater discharge to ditches and drains in the southwest portion of the lake are described below, followed by a discussion of the five indirect methods used to estimate groundwater discharge to the lake

DA.5.1 DIRECT ESTIMATES OF GROUNDWATER DISCHARGE

DA.5.1.1 I-690 Underdrain

A drain system under I-690 in the Willis/Semet area is approximately 2,000 ft long and has two outfalls: Outfall 40 and Outfall 41. Periodic monitoring of these drains between December 1999 to 2002, indicates that the groundwater discharge to the drain ranges from 4 to 9 gpm (O'Brien & Gere, 2002b). The groundwater component of flow from these outfalls is estimated to be about 5 gpm.

DA.5.1.2 Harbor Brook

The USGS maintains two gauging stations on Harbor Brook: one is located 0.5 miles upstream of the mouth, and the other is located 2.6 miles upstream of the mouth. The average stream flow gain between the two stations, based on the USGS data for water years 1971 through 2001, is 1,200 gpm, but the groundwater component of this gain based on a base flow analysis is estimated to be only about 135 gpm. The upstream stations is referred to as "Harbor Brook at

Syracuse” station number 04240100 and the downstream stations is referred to as “Harbor Brook at Hiawatha Blvd at Syracuse” station number 0420105.

DA.5.1.3 Geddes Brook and West Flume

The flow of Geddes Brook downstream of the mouth of the West Flume has been measured on a number of occasions (Blasland, Bouck & Lee, Inc. [BBL], 2000). The estimated base flow at this location is about 1,350 gpm. The base flow of the West Flume is estimated to be about 180 gpm.

DA.5.1.4 Ninemile Creek

The USGS maintains a gauging station 0.7 miles upstream of the mouth of Ninemile Creek. The estimated base flow at this station, based on daily flow data from 1970 through 2002, is greater than 23,000 gpm. This large base flow reflects the large drainage basin of this creek upstream of the gauging station, approximately 115 square miles.

This study used several independent methods to estimate groundwater discharge into the lake and groundwater discharge through the lake bottom sediments. In discussing groundwater discharge, this paper uses a variety of units, depending upon the context:

- Gallons per minute are used in the context of a water balance. For example, the total discharge to Onondaga Lake is less than 1,000 gallons per minute.
- Gallons per day per foot of shoreline is used in the context of groundwater discharge to the lake. For example, the groundwater discharge to the lake in the Harbor Brook area is 10 gallons per day per foot of shoreline. This unit normalizes discharge to length of shoreline, which allows easy comparison among discharge rates at various locations along the shoreline.
- Centimeters per year (cm/year) is used to describe the rate of groundwater discharge through the lake bottom sediments per unit area. For example, the groundwater discharge through the sediment in the profundal zone is estimated to be 0.04 cm/year. Groundwater discharge per unit area of sediment is referred to in this paper as groundwater flux.

DA.5.2 INDIRECT METHODS USED TO ESTIMATE GROUNDWATER DISCHARGE

The methods used to indirectly estimate groundwater discharge to Onondaga Lake are described in detail in the following sections.

DA.5.2.1 Chloride Concentrations in Sediment Pore Water

Chloride concentration changes with depth in profundal zone sediments were used to estimate an upward groundwater flux of 0.04 cm/year through the sediment in the profundal zone. This flux is the most reliable of the profundal fluxes estimated by the indirect methods and is used as the best estimate of the groundwater flux to the profundal zone. The method used to estimate the upward groundwater flux is described in detail in Section DA.6.

DA.5.2.2 Chloride Balance for the Lake

An upper bound on groundwater flux of 1.1 cm/year into the profundal zone was estimated using a lake-chloride balance. Groundwater water discharge to the profundal zone was assumed to be the source of most of the chloride in the lake that cannot be attributed to other sources, and the groundwater flux consist with the excess chloride load in the lake was calculated. The use of this method to calculate an upper bound estimate of groundwater flux to the lake is described in Section DA.7.

DA.5.2.3 Darcy's Law

Darcy's law states that volumetric flow rate in a porous medium is a function of flow area, elevation, fluid pressure, and a proportionality constant. Shallow groundwater flow toward Onondaga Lake along three areas of the lake shore where water level data are available (SMUs 1, 2 and 6) was estimated using Darcy's law, measured water levels, and estimated hydraulic conductivities. The estimated groundwater discharges to the lake shore in these three areas range from 4 gallons per day per foot of shoreline to 8 gallons per day per foot of shoreline. A similar approach was used in the remedial investigation (RI) for estimating groundwater discharge to the lake. The use of Darcy's Law to estimate groundwater discharge to the lake is described in Section DA.8.

DA.5.2.4 Water Balance

The groundwater flow into the lake was estimated based on the basin area and the estimated recharge rate. The size of the groundwater basin for the lake was estimated from topographic maps. The estimates of groundwater flow using this method ranged from 1.8 gallons per day per foot of shoreline to 38 gallons per day per foot of shoreline. These estimates are only as reliable as the accuracy of the basin delineation and of the recharge estimate. The use of the water balance method to calculate groundwater discharge to Onondaga Lake is described in Section DA.9.

DA.5.2.5 Water Chemistry

Major ion chemistry of groundwater was used as a tracer to provide information on groundwater discharge areas and groundwater flow rates. This method indicates that groundwater flow from the upland areas toward the lake is small, and that groundwater discharge is focused in a narrow zone along the shoreline. This indirect method of estimating groundwater discharge to the lake is described in Section DA.10.

DA.5.2.6 Three-dimensional Groundwater Model

A three-dimensional (3-D) model of the groundwater system was used to estimate groundwater discharge to the southwestern portion of the lake. This method provides the most reliable estimates total groundwater discharge to the lake, as it integrates all available information on the groundwater system. The calculated groundwater discharge to Onondaga Lake with the 3-D groundwater model averages 10 gallons per day per foot of shoreline. An overview of the groundwater model results are described in Section DA.11 and the groundwater model is discussed in detail in Part B of this appendix.

SECTION DA.6

CHLORIDE CONCENTRATIONS IN SEDIMENT PORE WATER

Chloride concentrations in sediment pore water in the profundal zone typically increase linearly with depth in the upper few meters of sediment. In a core from the southern basin (Station S51), chloride concentrations increased from relatively low concentrations in the lake (<500 mg/L) linearly to 42,000 mg/L at a depth of 5 meters (TAMS, 2002). This profile is shown on Figure DA.6. Similar linear profiles were observed in 36 of 42 cores collected in the profundal zone, most of which only sampled the upper one meter of sediment (TAMS, 2002). The profiles for these samples are shown on Figure DA.7 and sampling locations are shown on Figure DA.8. The linear chloride profiles indicate that the distribution of chloride in sediments is controlled by upward diffusion from natural brines beneath the lake. If the upward groundwater flux was significant, the profile would not be linear. Analyses of the linear chloride profiles described in TAMS (2002) determined that the upward groundwater flux is on the order of 0.04 centimeters per year (cm/year) or less. Larger groundwater fluxes are inconsistent with the observed profiles. The chloride profiles in the six cores that were non linear did not exhibit the profile that would occur if upward groundwater velocity was significant; rather, the profiles suggest inhomogeneities within the sediment profile.

The pore water chloride concentrations estimated at the maximum depth of each of the sediment borings is shown on Figure DA.8. Within the profundal zone, pore water chloride concentrations at an approximate depth of 1 m are typically greater than 8,000 mg/L. These data strongly suggest that the profundal zone is underlain by brine, as the chloride depth profile shown on Figure DA.6 indicates that a chloride concentration of 8,000 mg/L at 1 m is equivalent to a chloride concentration of 40,000 mg/L at 5 meters depth.

The upward diffusive flux of chloride to the lake from the profundal zone was estimated based on the concentration profiles shown on Figure DA.7 and using the following equation:

$$F = \omega D \frac{\partial C}{\partial z} AK \qquad (1)$$

where: F = diffusive flux (metric tons/year)

ω = coefficient related to tortuoisty (dimensionless), defined as porosity/(1-ln(porosity^2) [0.57 calculated from a porosity of 0.81] (Boudreau 1996)

D = effective diffusion coefficient for chloride in a sodium-chloride brine [$1.5\text{x}10^{-9}\text{m}^2$/sec] (Felmy and Weare, 1991)

$\partial C/\partial z$ = chloride gradient in sediments [8381 mg/l/m]

A = area of profundal zone [$7\text{x}10^6$ square meters],

K = units conversion factor [31.5 sec-metric tons/year-mg].

The calculated diffusive flux to the profundal zone, using the parameter values listed above, is approximately 1,600 metric tons of chloride per year. Additional diffusive flux occurs to the littoral zone. The median chloride gradient in the littoral zone, based on samples collected at 24 locations in the littoral zone, is 2080 mg/l/meter. The diffusive flux to the littoral zone calculated with this chloride gradient is about 280 metric tons per year. Therefore, the total diffusive flux to the lake is on the order of 1,900 metric tons per year.

Effler and others (1990) calculated a diffusive flux of 3200 metric tons of chloride per year for Onondaga Lake. This study likely overestimated the diffusive flux because porosity, rather than a term related to tortuosity was used in equation 1, and the chloride gradient calculated for the profundal zone was used for the entire lake area (12×10^6 square meters).

SECTION DA.7

CHLORIDE BALANCE FOR ONONDAGA LAKE

Groundwater beneath and discharging to Onondaga Lake, as described in previous sections of the report, has very high chloride concentrations relative to those in the lake. As a result, a chloride balance for the lake can be used to provide an estimate of groundwater discharge to the lake as small changes in groundwater discharge rates have a significant impact on the total chloride input to the lake.

Chloride concentrations are measured bimonthly in surface water samples from Onondaga Lake, all major tributaries, and the Onondaga County Metropolitan Wastewater Treatment Plant outfall. A chloride mass balance is calculated on an annual basis for the lake and reported in the Onondaga Lake Monitoring Program Annual Report. Over the five-year period from 1998 to 2002, the chloride load in the outflow from the lake exceeded the calculated inflow by seven percent, or about 12,000 metric tons per year (EcoLogic, 2003). The excess chloride load was fairly consistent from year to year, and as chloride is expected to be conservative within the lake system, the excess load is assumed to be the result of inflows not accounted for in the mass balance.

The excess chloride load is attributable to three main factors: diffusive flux of chloride into the lake, which was estimated in Section DA.6 to be about 1,900 metric tons per year or about 16 percent of the excess chloride load, groundwater discharge to the lake, and surface water inflow from ungauged tributaries. Groundwater discharge to the lake includes seepage from Wastebeds B and 1 through 8, which are located along the shoreline of the lake, groundwater discharge to the littoral zone, and groundwater discharge to the profundal zone. None of these groundwater discharges have been measured at this time. An upper bound estimate of the groundwater discharge to the profundal zone, as described below, was estimated based on the assumption that much of the excess chloride load is attributable to groundwater discharge to the profundal zone.

Assuming that forty percent of the excess load is contributed by groundwater discharge to the littoral zone, seepage from the wastebeds and ungauged surface water inflow, an upper bound estimate of the chloride load attributable to groundwater discharge to the profundal zone is 6,000 metric tons per year. Available data suggest that the profundal zone of the lake is underlain by natural brines with an average concentration of chlorides greater than 75,000 mg/L. The discharge of 40 gpm of groundwater with a chloride concentration of 75,000 mg/L is equivalent to an excess chloride load of 6,000 metric tons per year. Therefore, 40 gpm is an upper bound estimate of the groundwater discharge to the profundal zone. A total discharge of 40 gpm equates to an average groundwater flux of 1.1 cm/year over the 75 million square ft of the profundal zone.

The wastebeds have been identified as a possible source of chloride loading to the lake, based on the observed chloride loading from Wastebeds 10 to 15 adjacent to Ninemile Creek. The total chloride loading from Ninemile Creek to Onondaga Lake during the period 1998 to 2002 is calculated to be about 49,000 metric tons (Ecologic, 2003). Based on chloride data collected at various locations along the creek in 1998, it is calculated that over 90 percent of the chloride load is the result of groundwater discharge to the creek as it flows past the wastebeds (Parsons, 2003a), as chloride concentrations increase from about 50 mg/L upstream of the waste beds to about 900 mg/L at the mouth of creek. Most of the increase in chloride loading occurs as the creek flows past Wastebeds 9 to 15 (80 percent of the total increase in July 1998 and 90 percent of the total increase in September 1998), with only a minor increase in chloride loading as the creek flows past Wastebeds 1 to 8 in the lower portion of the creek (Parsons, 2003c). Leaching from wastebeds declines with time; it is reported that leaching from Wastebeds 9 to 15 has decreased by 24 percent over the eight-year period 1989 to 1997. These are the youngest wastebeds, used from 1944 to 1986. Since Wastebeds 1 to 8 along the lake shore are much older than Wastebeds 10 to 15, it is not surprising that the chloride loading through seepage from Wastebeds 1 to 8 is small. However, it should be noted that the chloride flux is not monitored along the Onondaga Lake shoreline of Wastebeds 1 through 8.

SECTION DA.8

GROUNDWATER FLOW ESTIMATED USING DARCY'S LAW

Groundwater flow toward Onondaga Lake in three areas of the lake shore was estimated based on measured water levels and estimated hydraulic conductivities using Darcy's Law. These three areas are the Hiawatha Boulevard site located just west of Onondaga Creek on the Lake shore adjacent to SMU 6, the Harbor Brook area adjacent to SMU 1, and Willis/Semet Area adjacent to SMU 2. The estimated groundwater fluxes to the lake shore in these three areas are 2.4 gallons per day per foot of shoreline, 4.0 gallons per day per foot of shoreline, and 8.0 gallons per day per foot of shoreline, respectively. The assumptions used in making these calculations are described below.

DA.8.1 HIAWATHA BOULEVARD SITE

Shallow groundwater flow toward Onondaga Lake at the Hiawatha Boulevard site was estimated based on water level measurements taken on March 25, 2003, and hydraulic conductivity estimates from slug tests conducted on the 47 monitoring wells located at the site (Arcadis, 2003). At this site, the permeable sediments were classified as shallow to a depth of about 15 ft (4.6 m), and deep to a depth of 30 ft (9.1 m). The deeper borings penetrated low permeability silts and clays. The parameters used in estimating flow were the following:

- Shallow
  - Hydraulic gradient = 0.0027
  - Hydraulic conductivity = 9 ft (2.7 m) per day
  - Saturated thickness = 7.5 ft (2.2 m)
- Deep
  - Hydraulic gradient = 0.0015
  - Hydraulic conductivity = 6 ft (1.8 m) per day
  - Saturated thickness = 15 ft (4.6 m)

The total estimated groundwater flow toward Onondaga Lake based on the parameters listed above is 2.4 gallons per day per foot of shoreline.

DA.8.2 HARBOR BROOK SITE (WASTEBED B)

Shallow groundwater flow in the vicinity of Wastebed B in the Harbor Brook area was estimated on the basis of the stratigraphy and water levels at monitoring wells WA-8S and HB-05S. At this location, Solvay waste materials overlie marl, which in turn overlies the silt and clay unit. Most groundwater flow is through the Solvay waste material and the fill, since they are more permeable than the underlying materials. The parameters used in estimating flow are the following:

- Hydraulic gradient = 0.03
- Hydraulic conductivity = 1 ft (0.3 m per day)
- Saturated thickness = 18 ft (5.5 m)

The total estimated groundwater flow toward the lake based on the parameters listed above is 4.0 gallons per day per foot of shoreline.

DA.8.3 WILLIS/SEMET SITE

Shallow groundwater flow toward Onondaga Lake in the Willis/Semet area was estimated based on the stratigraphy and water levels at monitoring wells SP-4A and SP-7A. At monitoring well SP-7A, Solvay waste and marl overlie the silt and clay unit. However, at SP-7A, the marl is underlain by 7 ft (2.1 m) of fine sand and silt that overlie the silt and clay unit. The parameters used in estimating flow are the following:

- Hydraulic gradient = 0.03
- Hydraulic conductivity = 1 ft (0.3 m) per day
- Saturated thickness = 37 ft (11.3 m)

The total estimated groundwater flow toward the lake based on the parameters listed above is 8 gallons per day per foot of shoreline.

In the Willis/Semet area, a very permeable sand and gravel exists along the lake shore at a depth of approximately 70 to 100 feet below lake level. Aquifer tests indicate that the transmissivity of this unit is on the order of 3,500 ft^2 per day. Groundwater flow in the unit toward the lake is estimated to be negligible, as the gradient in this unit is very small. The method used to calculate the flow toward the lake is described below.

The gradient in an aquifer unit with variable density and a sloping base is a function of the change in equivalent freshwater heads with distance, the slope of the aquifer unit, and the change in density with distance in the aquifer unit. This relationship is discussed in Attachment DA.1, in which equation 3 is the governing equation for flow in an aquifer unit with variable density and a sloping base. The gradient toward the lake in the sand and gravel unit near the lakeshore in the Willis/Semet area was estimated using equation 3, based on equivalent fresh water heads, densities, and mid-screen elevations for four sets of wells along the lakeshore (WA-7D and WA-2D, SP-6C and OW-11/WA-1D, SP-7C and OW-6D, and SP-8C and OW-5D). The water levels, densities, and mid-screen elevations used in this calculation are those listed in Table DB.4. The average calculated gradient from these four sets of wells is -0.0007 ft/ft, with the gradient oriented landward. This is a very small gradient, and since the measured densities have an error bar associated with them, the gradient is effectively zero.

Water levels in the sand and gravel unit along the lake shore at OW-6 are approximately 6.5 feet higher than the lake level. This indicates that there is a potential for upward groundwater flow, and in fact, uncapped wells in the sand and gravel unit along the lakeshore are observed to flow during certain parts of the year. The amount of upward groundwater flow within SMU 2 from the sand and gravel unit to overlying units was estimated using the groundwater model described in Section 11. The calculated groundwater flow is less than 10 gpm for the entire SMU.

SECTION DA.9

GROUNDWATER BASIN METHOD

Groundwater discharge in a groundwater system that has relatively constant average water levels is by definition equal to groundwater recharge. Therefore, groundwater discharge can be estimated if the groundwater recharge is known. Applying this concept to Onondaga Lake requires the definition of the groundwater basin of the lake and recharge rates within the groundwater basin. Groundwater discharge is then defined as the basin area multiplied by the recharge rate.

Shallow groundwater levels in the vicinity of the lake are primarily controlled by topography; therefore, an estimate of the groundwater basin was developed based on topography. Groundwater flow in the bedrock is also thought to be primarily controlled by topography, but data are not available to fully verify this assumption. The shallow groundwater basin for Onondaga Lake is shown on Figure DA.9. The northwestern end of the lake was assumed to be an area where surface water is flowing out of the lake into the groundwater system based on topography and elevations of Seneca River. The groundwater basin was subdivided into 13 sub-basins for estimating groundwater discharge to the various SMUs.

The groundwater recharge rate was specified as 6 inches (15 cm) per year, except along Onondaga Creek adjacent to SMU 6 and SMU 7. In this area, the recharge rate was specified as 2 inches (5 cm) per year due to the amount of paved areas and the Carousel Mall property, which contains a groundwater dewatering system. Winkley (1989) estimated that 6 inches (15 cm) per year is the average groundwater recharge rate for Onondaga County.

The estimated groundwater discharge rates per foot of shoreline calculated by this method for the littoral SMUs are the following:

SMU	Sub-basin	Discharge Rate (gallons/ft/day)
1	F	11
2	F	11
3	F	11
4	D	25
	E	8.2
5	A	29
	B	29
	C	38
6	G	3.1
7	H	1.8

SECTION DA.10

GROUNDWATER CHEMISTRY

Groundwater chemistry along the shoreline is variable. Deeper groundwater is generally a sodium-chloride brine, but in places it is a sodium-calcium-chloride brine. Shallow groundwater typically has a total dissolved solids (TDS) concentration of less than 5,000 mg/L, except along the lake shore in the Harbor Brook area. The relatively low TDS concentrations in 28 shallow groundwater wells in this area reflect recent recharge to the groundwater from precipitation. This section describes the groundwater chemistry in two cross sections along the lake shore area (Harbor Brook and Willis/Semet). This section also describes the information gained about groundwater flow from the distribution of water quality in the cross sections. In addition, the section discusses the variations in groundwater quality in shallow sediment pore water along the six transects monitored as part of the upwelling investigation.

DA.10.1 WILLIS/SEMET SECTION

The concentrations of TDS, chloride, sodium, and calcium in hydrogeologic cross sections A-A’, B-B’, and C-C’ in the Willis/Semet area are shown on Figures DA.10a and DA.10b. Similar water-quality patterns are shown on each of the cross sections; the discussion that follows focuses primarily on the patterns observed in cross section B-B’. Groundwater quality in this area has been affected by seepage from Wastebed A, which was used prior to 1926. Water infiltrating into the groundwater beneath the wastebed likely had a quality similar to wastebed overflow. Effler reported that wastebed overflow has sodium concentrations in the range of 11,000 to 13,100 mg/L, calcium concentrations in the range of 20,000 to 26,000 mg/L, and chloride concentrations in the range of 53,000 to 63,000 mg/L, based on three samples from other wastebeds collected between 1969 and 1974 (Effler 1996).

In cross section B-B’, groundwater in the intermediate and deep completions at monitoring well triplet SP-4 originated as seepage from the overlying wastebed, whereas groundwater quality in the water-table well reflects recent recharge of precipitation. In the intermediate well, SP-4B, the groundwater contains 11,000 mg/L sodium, 18,600 mg/L calcium, and 51,000 mg/L chloride and has a TDS concentration of 81,200 mg/L. The sodium to calcium ratio in this water (0.6:1) is almost identical to that reported for wastebed overflow in Effler (1996). This water is a calcium-chloride water that differs significantly in chemical composition from the natural brines. Groundwater in the deep well at this location, SP-4C, which is partially completed in the sand and gravel unit, contains 12,800 mg/L of sodium, 24,200 mg/L of calcium and has a TDS concentration of 102,000 mg/L, with a similar sodium to calcium ratio as reported in SP-4B. This indicates that this groundwater represents seepage from the wastebed. Water of a similar quality occurs at TW-1 (adjacent to OW-6) in the sand and gravel zone approximately 800 ft (243 m) to the northeast of SP-4C on the lake shore. This indicates that there has been some movement of groundwater from beneath the wastebeds toward the lake in the sand and gravel unit. The excavations for the Semet Residue Ponds may have enhanced migration of seepage from the wastebeds to the sand and gravel unit as the ponds were excavated 20 to 30 ft (6.1 to 9.1 m) into the Solvay wastes, and the strong acidity of the liquids wastes placed in the ponds resulted in high potential to react with and degrade the underlying Solvay waste materials.

The average rate of groundwater movement in the sand and gravel unit from Wastebed A toward the lake required to explain the observed water chemistry along the lake shore in this unit is approximately 10 ft (3 m) per year. This is a relatively slow velocity, and velocities in this unit today are estimated to be smaller than 10 ft (3 m) per year. The migration of water from beneath this wastebed to the lake was likely the result of much higher water levels beneath the wastebed when it was active (Labuz 2004), as well as lower water levels in the sand and gravel unit in the first part of the 20th century as the result of the salt production activities around the lake. During the period of active use of the wastebed prior to 1926, water levels were likely at or above the surface, as liquids would have been impounded in the area of the wastebed. These conditions created much larger velocities in the sand and gravel in the past than are presently estimated based on measured water level data and hydraulic conductivity data.

Benzene is detected at OW-6 and most other monitoring wells along the lake shore that penetrate relatively thick sand and gravel deposits at concentrations in the range of 1 to 10 mg/L, but benzene is detected at concentrations of less than 0.12 mg/L at wells SP-7C and SP-4C, landward where the sand and gravel unit is very thin. The source of the benzene is unknown, but is currently being investigated.

Shallow groundwater in monitoring wells located along cross section B-B' differs significantly in quality from deeper groundwater. In the water table completion at SP-4, the TDS concentration is only 1,110 mg/L, which is significantly less than the concentration in the intermediate zone. The water table well closer to the lake (SP-7A) has a TDS concentration of 1,680 mg/L, and the well on the far side of Tributary 5A (SP-2A) has a TDS concentration of 741 mg/L. Groundwater flow in the shallow zone is toward both the lake and Tributary 5A due to a groundwater mound that exists between the two. A similar groundwater mound is shown on cross section A-A' and also exists in cross section C-C'.

DA.10.2 HARBOR BROOK SECTION

The concentrations of TDS, chloride, sodium, and calcium in hydrogeologic cross section D-D' in the Harbor Brook area are shown on Figure DA.10b. In viewing this cross-section it is important to note that the section has a significant bend between HB-12S/I/D and HB-13 as shown on Figure DA.1. TDS concentrations range from 368 mg/L in monitoring well HB-14S to 114,000 mg/L in monitoring well HB-16D. In the fill material, the TDS concentration is 5,710 mg/L in HB-2S near the lake shore and 6,490 mg/L approximately 1,600 ft southwest of the lake along the railroad tracks in monitoring well HB-09S (refer to Figure DA.10b, cross section D-D'). However, between these two locations, the TDS concentrations are less than 1,000 mg/L. Precipitation that infiltrates into the fill flows (both to the northeast toward the lake and to the southwest toward the ditches along the railroad tracks) indicates that TDS increases as the groundwater flows toward the lake and toward the ditches.

In the sand and gravel unit, the TDS concentrations are highest near the lake shore and decrease toward the southeast. Concentrations are 114,000 mg/L at 400 ft from the lake shore at HB-16D and 12,700 mg/L at 850 ft southwest of the lake shore at HB-13D. Since the sand and gravel unit is not a source of high TDS, these data show that groundwater flow from the upland area toward the lake is insignificant in this unit. If there were significant groundwater flow toward the lake, TDS concentrations adjacent to the lake shore would reflect the low TDS concentrations observed upgradient and to the southwest of the lake shore. This is supported by the sodium/calcium ratio in HB-16D (18:1), which reflects the presence of natural brine.

DA.10.3 UPWELLING TRANSECTS

Six sampling transects were established as part of the groundwater upwelling investigation conducted in 2003 (Parsons, 2003b). One transect was located off shore from SMU 4 near the mouth of Ninemile Creek, one was at the boundary between SMU 1 and SMU 2, two were located off shore from SMU 1, one was located at the boundary between SMU 1 and SMU 7, and one was located off shore from SMU 7 (Figure DA.11). Each transect consisted of either three or four sampling locations at various distances from the shore (~0 to 1000 ft [304 m]). At each sampling location, a groundwater sampling pump was installed to sample pore water at approximately 4.5 ft (1.2 m) below the water-sediment interface. Groundwater samples were collected from these sampling ports in April 2003 and analyzed for sodium, calcium, chloride, and other constituents. Selected water quality data from the transects are listed in the table on the next page.

WATER QUALITY DATA
UPWELLING INVESTIGATION

Transect	Location	Distance from Shore (ft)	Water Depth (ft)	Sodium (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Ratio of Sodium to Calcium
TR01	A	25	0.8	26,640	7,280	47,000	3.7
	B	538	3.1	2,930	400	2,930	7.3
	C	1,011	5.0	1,130	112	1,130	10.1
TR02	A	25	6.5	10,550	2,000 (J)	18,600	5.3 (J)
	B	173	14.6	3,400	600	6,100	5.7
	C	569	17.4	1,100	234	1,860	4.7
TR03	A	34	0.98	12,100	9,120	40,800	1.3
	B	221	2.5	1,140	347	1,900	3.3
	C	393	2.6	1,680	262	2,700	6.4
	D	676	15.5	1,350	364	1,720	3.7
TR04	A	25	1.55	3,890	2,320	11,200	1.7
	B	468	3.8	1,730	248	2,760	7.0
	C	824	9.0	1,880	132	1,560	14.2
	D	1,004	15.5	1,500	475	1,920	3.2
TR05	A	25	1.9	6,920	5,590	22,400	1.2
	B	461	5.2	1,510	727	2,550	2.1
	C	615	6.4	1,650	88	1,800	18.8
	D	790	7.4	1,480	104	1,720	14.2
TR06	A	25	1.2	5,680	2,280	14,500	2.5
	B	637	5.3	1,850	225	2,900	8.2
	C	907	8.85	1,760	257	2,120	6.8
Lake near TR01A		5	1	149	158	450 (est.)	0.9
Lake near TR03A		5	1	216	128	450 (est.)	1.7

At all of the transects, water quality in the near shore sampling point, which was located approximately 25 ft (7.6 m) from shore (Location A), differs markedly from water quality in the sampling points further off shore. For example, at TR01A, the chloride concentration was 47,000 mg/L, whereas chloride concentrations in TR01B and TR01C were 2,930 mg/L and 1,130 mg/L, respectively. A similar marked decrease in chloride concentrations was reported at all of the other transects, though chloride concentrations were lower in the near-shore samples at the other transects.

At all transects, the pore water is a sodium-calcium chloride or a sodium-calcium-chloride-sulfate type water. The ratio of sodium to calcium in each of the transects is lowest at the sampling location 25 ft (7.6 m) from the shoreline. At all sampling points, the concentration of sodium and chloride are significantly higher than concentrations in the lake water.

These observations are explained by groundwater with relatively high calcium, sodium, and chloride concentrations discharging in the near-shore environment with little groundwater discharge occurring further offshore. The groundwater discharge that does occur offshore is a sodium-chloride groundwater that differs significantly in water quality from the groundwater discharging in the near-shore environment.

SECTION DA.11

GROUNDWATER FLOW MODEL

A 3-D groundwater flow has been developed and calibrated for the southwestern portion of Onondaga Lake and vicinity. This model, which incorporates a rigorous representation of the brines beneath the lake, is described in detail in Part B of this appendix. The groundwater flow model was used to estimate groundwater flux through the lake bottom sediments to Onondaga Lake in the SMUs that border the southwestern margin of the lake, both under current conditions and during operation of a hydraulic containment system along the shoreline of SMU 1 and SMU 2. The potential also exists for a hydraulic containment system along SMU 7, but the final decision will be based on design information. Best estimates of groundwater flux as well as reasonable upper bound estimates of groundwater flux were calculated. The computer program SEAWAT-2000 was used to simulate groundwater flux (Langevin et al., 2003), and the computer program PEST was used for model calibration (Doherty, 2002).

DA.11.1 CURRENT CONDITIONS

The total groundwater discharge calculated using the calibrated groundwater flow model to Onondaga Lake is approximately 150 gpm. Most discharge, approximately 137 gpm, occurs to the littoral zone. Groundwater discharge to the profundal zone is 13 gpm. This discharge to the profundal zone is equal to an average groundwater flux through the sediment of 1.0 cm/year, which is the upper bound estimate of groundwater discharge to the profundal zone.

The groundwater discharge to the littoral area is equal to an average discharge rate of 10 gallons per day per foot of shoreline. Calculated average groundwater fluxes through the sediments in SMU 1, SMU 2, SMU 3, SMU 6 (southwestern portion), and SMU 7 are listed below.

Distance from Shore (ft)	Groundwater Darcy Flux (cm/year)				
	SMU 1	SMU 2	SMU 3	SMU 6	SMU 7
20	300	60	700	70	100
60	60	40	90	40	60
100	30	30	30	20	30
140	20	20	20	10	20
220	10	10	7	3	5
300	10	10	4	<2	2
420	8	8	<2	<2	<2
500	5	6	<2	<2	<2

DA.11.2 HYDRAULIC CONTAINMENT SYSTEM

A hydraulic containment system has been proposed for the shoreline along SMU 1 and SMU 2, which border the southwestern margin of the lake (Figure DA.12). The potential exists for extension of this wall along SMU 7 to ensure cap effectiveness in this area. However, the need for a wall in this area will be based on predesign data. The containment system will be designed to reduce upward groundwater velocities in the sediment to negligible levels (less than 2 cm/yr), and if necessary, to contain contaminated groundwater.

In anticipation of the potential inclusion of a barrier wall along SMU 7, a simulation of the wall was conducted with the groundwater model. The preliminary results indicate that upwelling velocities can be reduced to negligible levels (less than 2 cm/yr) in SMU 7. One associated impact to the lake as a result of the SMU 7 barrier wall would be a decrease in the upwelling velocities in SMU 6. Therefore, the current velocities identified for SMU 6 would be conservative if the decision is made to install a barrier wall along SMU 7. If the predesign data indicate a wall is necessary in this area, additional model simulations will be conducted at that time.

The simulated containment system consisted of the following components:

- A barrier wall along the lake shore adjacent to SMU 1 and SMU 2. The hydraulic characteristic (hydraulic conductivity divided by thickness) of the barrier wall was specified as 3.3×10^{-7} centimeters per foot (cm/ft). The barrier was specified as penetrating model layers 1, 2, and 3.

- A shallow groundwater collection system landward of the barrier wall along its entire length. This shallow system was simulated as a drain specified as having its invert in layer 2, except adjacent to a portion of the causeway in the Willis/Semet area, where the drain invert was specified in layer 3 in the locations where a fine sand unit occurs beneath the marl (model columns 65 to 96). The water level in the drain was specified at an elevation of 358.9 ft (109.4 m) above mean sea level MSL, which is 4 ft (1.2 m) below lake level.

- An extraction well at the location of TW-1. The production rate of this well was specified as 10 gallons per minute.

In addition, it was assumed that the East Flume would be abandoned.

The groundwater model was used to calculate groundwater flux through the sediments with the hydraulic containment system in place. This analysis indicates that calculated upward fluxes of groundwater through the sediments adjacent to SMU 1 and SMU 2 will be negligible with the hydraulic containment system in place: less than 0.8 inches (2 cm) per year. The simulated flow to the drain is approximately 75 gallons per minute.

The hydraulic containment system is currently being designed, and the final design may differ from the simulated system described above. The final design may include additional extraction wells in the sand and gravel unit and the total extraction rate from the sand and gravel unit may be as large as 50 gpm. Additional extraction from the sand and gravel unit would further decrease the upward flux from the sand and gravel unit to overlying units.

DA.11.3 ESTIMATED REASONABLE UPPER BOUND FOR LAKE BOTTOM FLUXES

The groundwater fluxes described in Section DA.11.1 were calculated using the calibrated groundwater model. As with any groundwater model, there is some uncertainty associated with the calculated fluxes due to simplifications in representing the groundwater system in the numerical model. An estimate of the uncertainty was calculated using the computer programs SEAWAT-2000 and PEST, these programs were also used to calculate reasonable upper bound estimates of the lake bottom fluxes. The procedure used to estimate the upper bound estimates of fluxes and the parameter values associated with these fluxes are described in Part B of this Appendix.

A set of model parameter values that produces a reasonable upper bound estimate of lake bottom fluxes in a given SMU will generally produce estimates of lake bottom fluxes in the other SMUs are less than the reasonable upper bound estimate. Therefore, four sets of lake bottom fluxes were calculated: one that produces a reasonable upper bound estimate for SMU 1, one that produces a reasonable upper bound estimate for SMU 2, one that produces a reasonable upper bound estimate for SMU 3, and one that produces a reasonable upper bound estimate for SMU 7. Since site conditions are very similar along the shore for SMUs 6 and 7, the upper bound estimates for SMU 7 are assumed to correspond to SMU 6 as well. These calculated lake bottom fluxes are listed on Table DA.1.

SECTION DA.12

GROUNDWATER FLUX TO ONONDAGA LAKE

The preceding sections of this paper have described various methods of estimating groundwater discharge to Onondaga Lake, which produce similar but not identical estimates of groundwater discharge to the littoral zone of the lake. There is a hierarchy of methods, in order of accuracy of results: 1) 3-D groundwater for those areas within the main part of the model domain, 2) Darcy's law, and 3) the groundwater basin method.

Groundwater discharges, expressed as a rate in gallons per minute per foot of shoreline, were converted in a flux through the sediment for methods 2 and 3 listed above by using an exponential relationship developed from the calculated fluxes to the sediment in the groundwater model. Calculated fluxes from five transects in the model were averaged to produce a relationship between groundwater discharge per foot of shoreline and flux through the sediments. This relationship was then scaled to calculate the flux for a specified groundwater discharge rate.

The best estimates of groundwater flux in each of the SMUs following installation of the hydraulic containment system, as a function of distance from shore, are summarized in the table below. The velocities on this table represent the best estimates, based on the many lines of evidence considered in the analyses and described in this report.

Distance from Shore (ft)	Groundwater Darcy Flux (cm/year)						
	SMU 1	**SMU 2**	**SMU 3**	**SMU 4**	**SMU 5**	**SMU 6**	**SMU 7***
20	<2	<2	700	300	600	70	100
60	<2	<2	90	100	300	40	60
100	<2	<2	30	70	200	20	30
140	<2	<2	20	40	90	10	20
220	<2	<2	7	20	30	3	5
300	<2	<2	4	6	10	<2	2
420	<2	<2	<2	<2	4	<2	<2
500	<2	<2	<2	<2	<2	<2	<2

*Note: These values represent groundwater flux to the lake with no hydraulic containment system in place. A preliminary simulation of a barrier wall along SMU 7 conducted with the groundwater model indicates that the upwelling velocities can be reduced to negligible levels (< 2 cm/yr). However, details regarding the need for a barrier wall along this area will be determined based upon predesign data.

SECTION DA.13

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APPENDIX D: PART A

TABLES

TABLE DA.1

Lake Bottom Fluxes – Calibrated Model and Upper Bound Estimates

SMU	Distance from Shore	Sediment Fluxes (cm/year)				
		Calibrated Model	Simulation 1	Simulation 2	Simulation 3	Simulation 4
1	20	300	1000	300	600	300
	60	60	100	60	70	60
	100	30	40	30	30	30
	140	20	20	20	10	20
	220	10	20	10	10	9
	300	10	20	6	10	6
	420	8	<2	4	<2	4
	500	5	<2	3	<2	2
2	20	60	7	100	10	60
	60	40	2	90	4	40
	100	30	2	80	3	30
	140	20	2	70	3	20
	220	10	2	70	3	10
	300	10	2	60	3	10
	420	8	2	50	3	8
	500	6	2	40	3	6
3	20	700	900	200	1000	600
	60	90	100	40	100	80
	100	30	40	20	40	30
	140	20	20	10	20	20
	220	7	8	6	8	8
	300	4	4	4	4	5
	420	<2	<2	2	2	2
	500	<2	<2	<2	<2	<2
6	20	70	20	100	10	300
	60	40	2	50	2	100
	100	20	<2	30	<2	80
	140	10	<2	20	<2	40
	220	3	<2	5	<2	10
	300	<2	<2	2	<2	6
	420	<2	<2	<2	<2	<2
	500	<2	<2	<2	<2	<2
7	20	100	10	200	20	200
	60	60	2	100	3	100
	100	30	<2	60	<2	60
	140	20	<2	30	<2	30
	220	5	<2	10	<2	10
	300	2	<2	5	<2	5
	420	<2	<2	<2	<2	<2
	500	<2	<2	<2	<2	<2

TABLE DA.1 (Continued)

Lake Bottom Fluxes – Calibrated Model and Upper Bound Estimates

Notes: The four simulations conducted for the sensitivity analysis of the groundwater model indicate the highest velocities calculated for SMUs 1, 2, 3 and 7 consistent with a reasonably well calibrated model. The simulation numbers correspond to the respective SMUs as noted below:

Simulation 1: SMU 1 Highest Potential Velocities
Simulation 2: SMU 2 Highest Potential Velocities
Simulation 3: SMU 3 Highest Potential Velocities
Simulation 4: SMU 7 Highest Potential Velocities
Fluxes for SMU 1 and SMU 2 are without the hydraulic containment system in place.

Fluxes for SMU3, SMU6, and SMU7 are with the hydraulic containment system in place.
The potential exists for a containment system along SMU 7. Based on preliminary model runs, the calculated velocities in this SMU would be <2 cm/yr with a barrier wall in place.

APPENDIX D: PART A

FIGURES

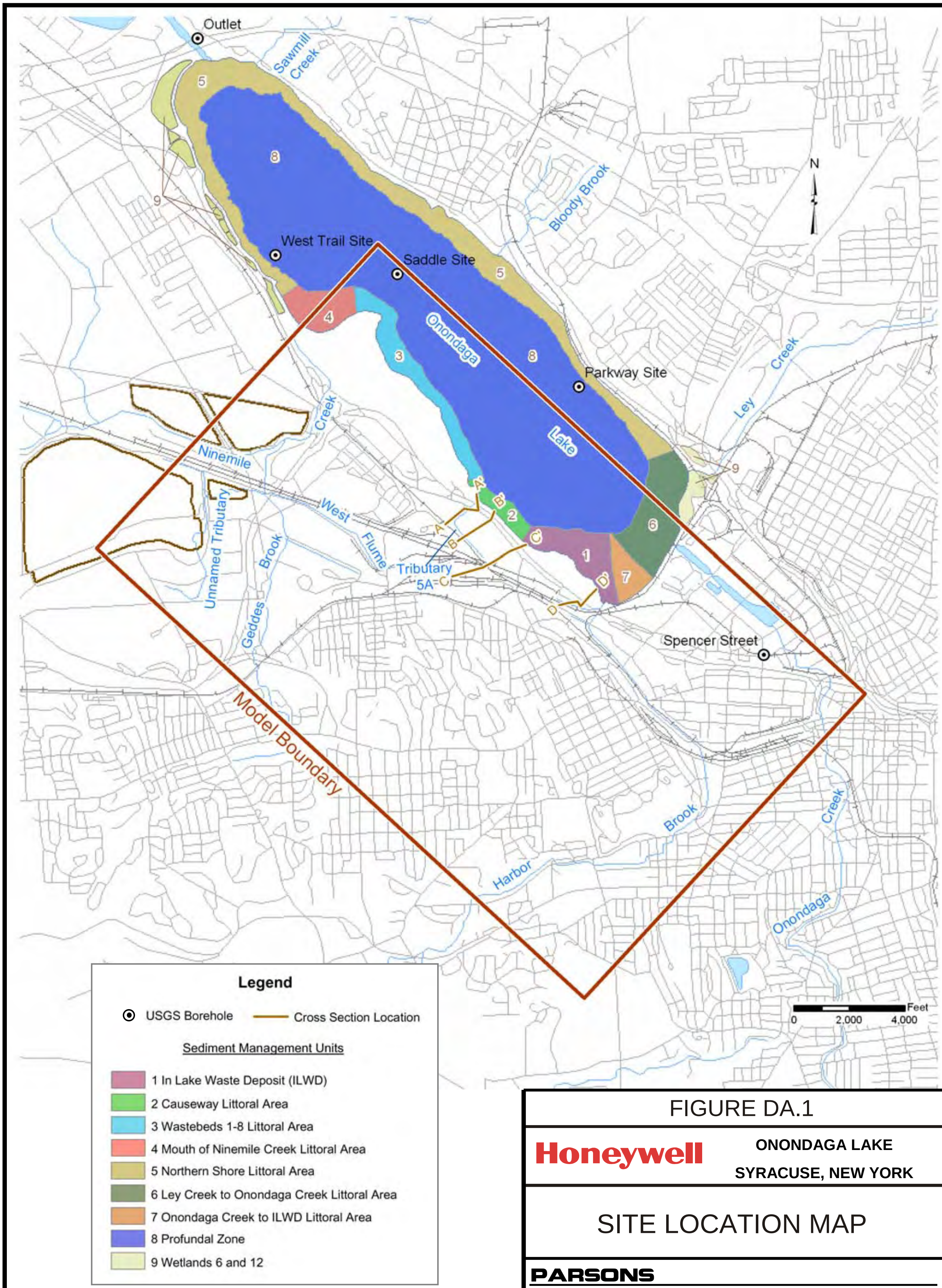

FIGURE DA.1

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

SITE LOCATION MAP

PARSONS

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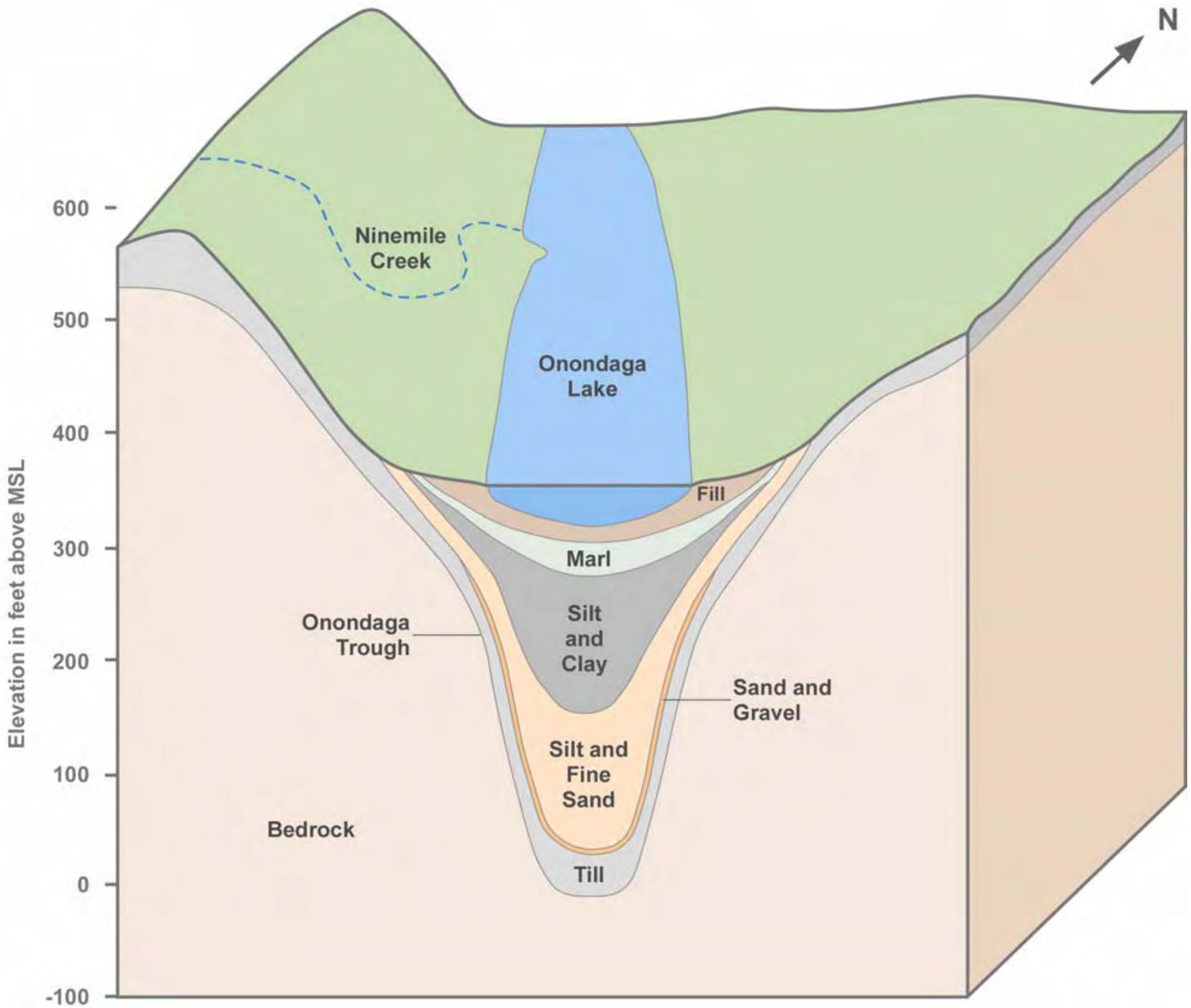

FIGURE DA.2

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

SCHEMATIC BLOCK DIAGRAM OF ONONDAGA LAKE AREA

PARSONS

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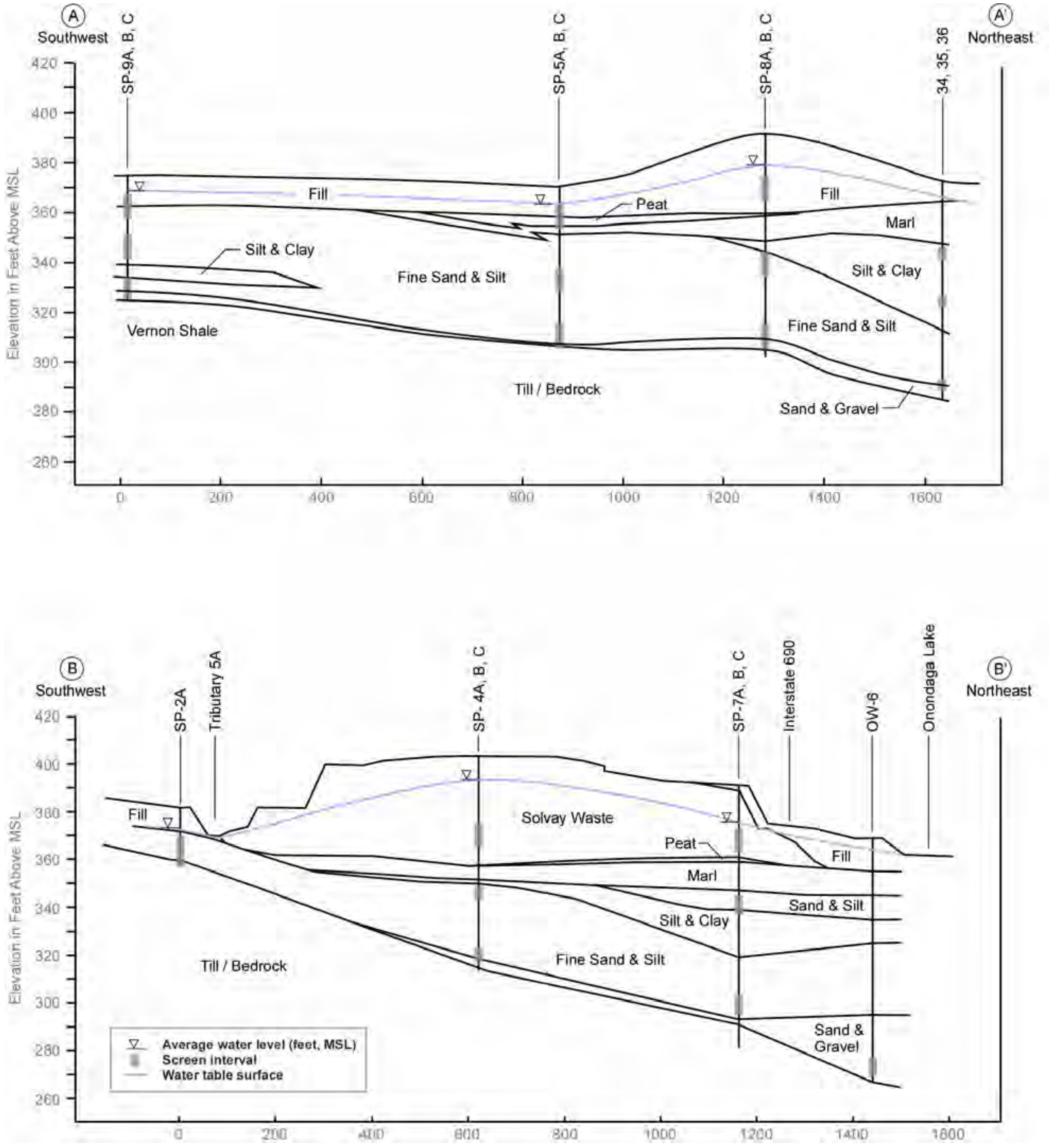

Note: See Figure DA.1 for cross-section locations.

FIGURE DA.3a

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

REPRESENTATIVE GEOLOGIC CROSS-SECTIONS SOUTHWESTERN SHORE LINE OF ONONDAGA LAKE

PARSONS

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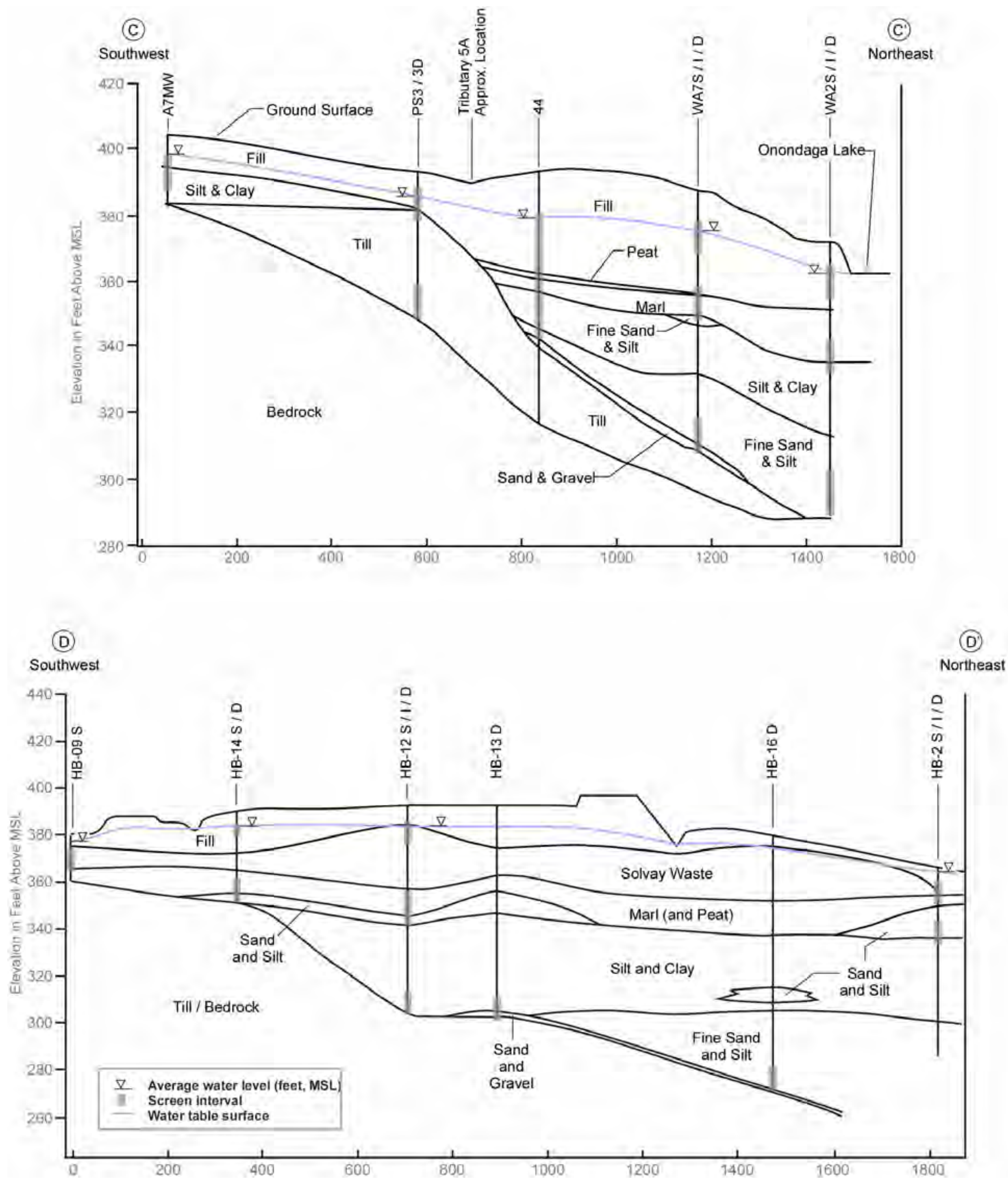

Notes:
See Figure DA.1 for cross-section locations.
Cross section C-C' is from the Willis/Semet Pre-Design Investigation Report.

FIGURE DA.3b

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

REPRESENTATIVE GEOLOGIC CROSS-SECTIONS SOUTHWESTERN SHORE LINE OF ONONDAGA LAKE

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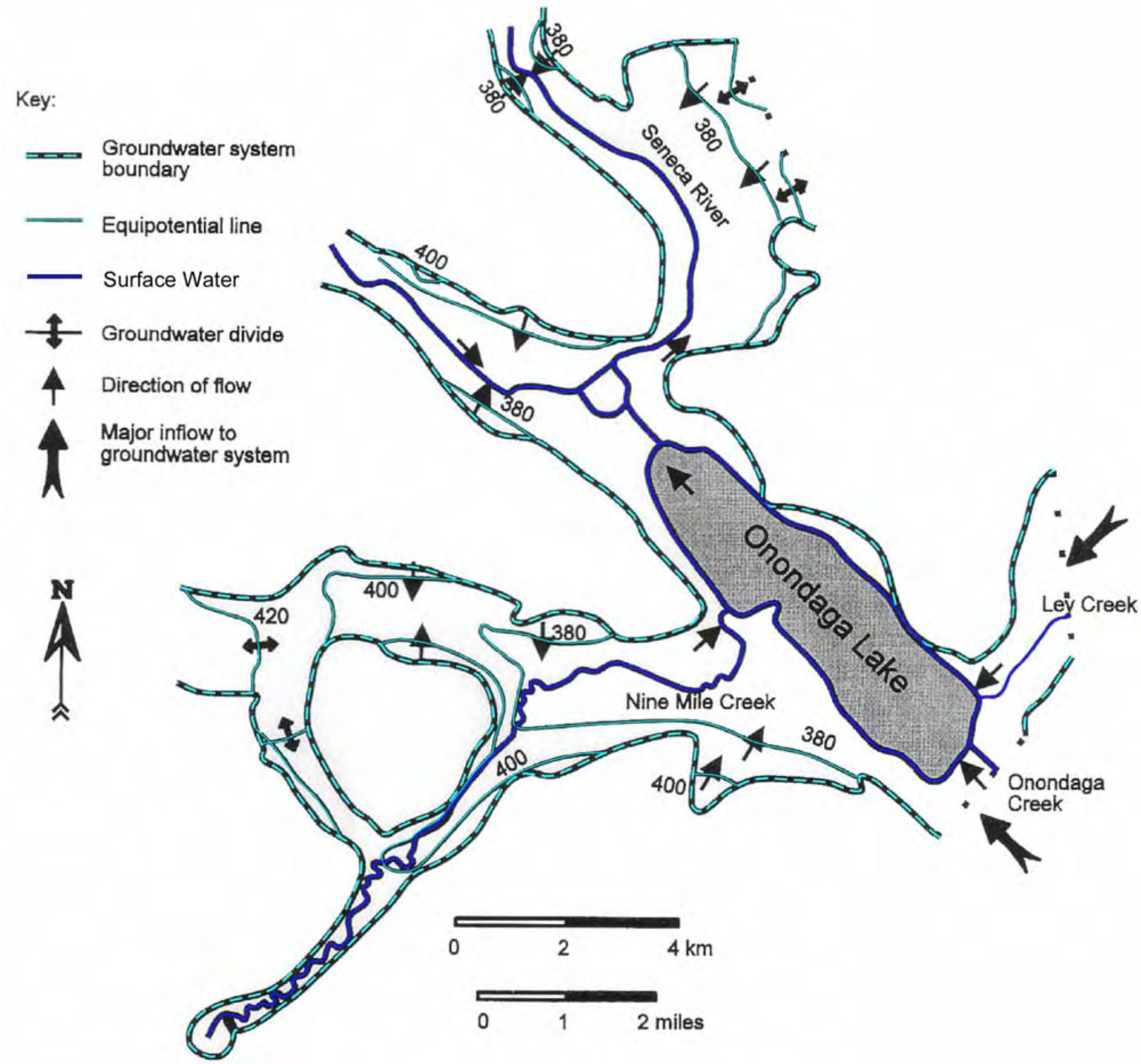

Source: Effler, 1996

FIGURE DA.4

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

REGIONAL GROUNDWATER FLOW

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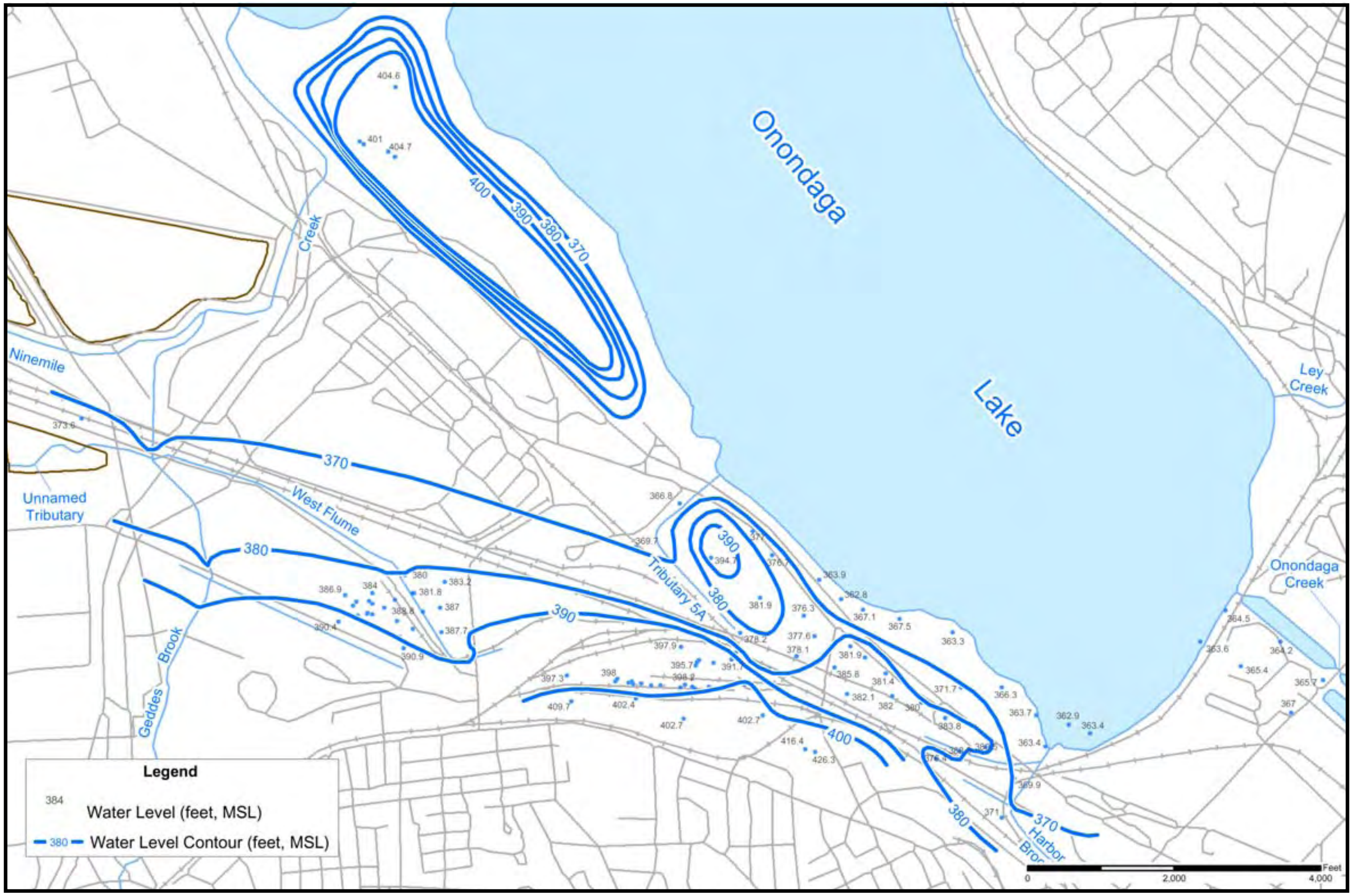

FIGURE DA.5

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

WATER TABLE MAP

PARSONS

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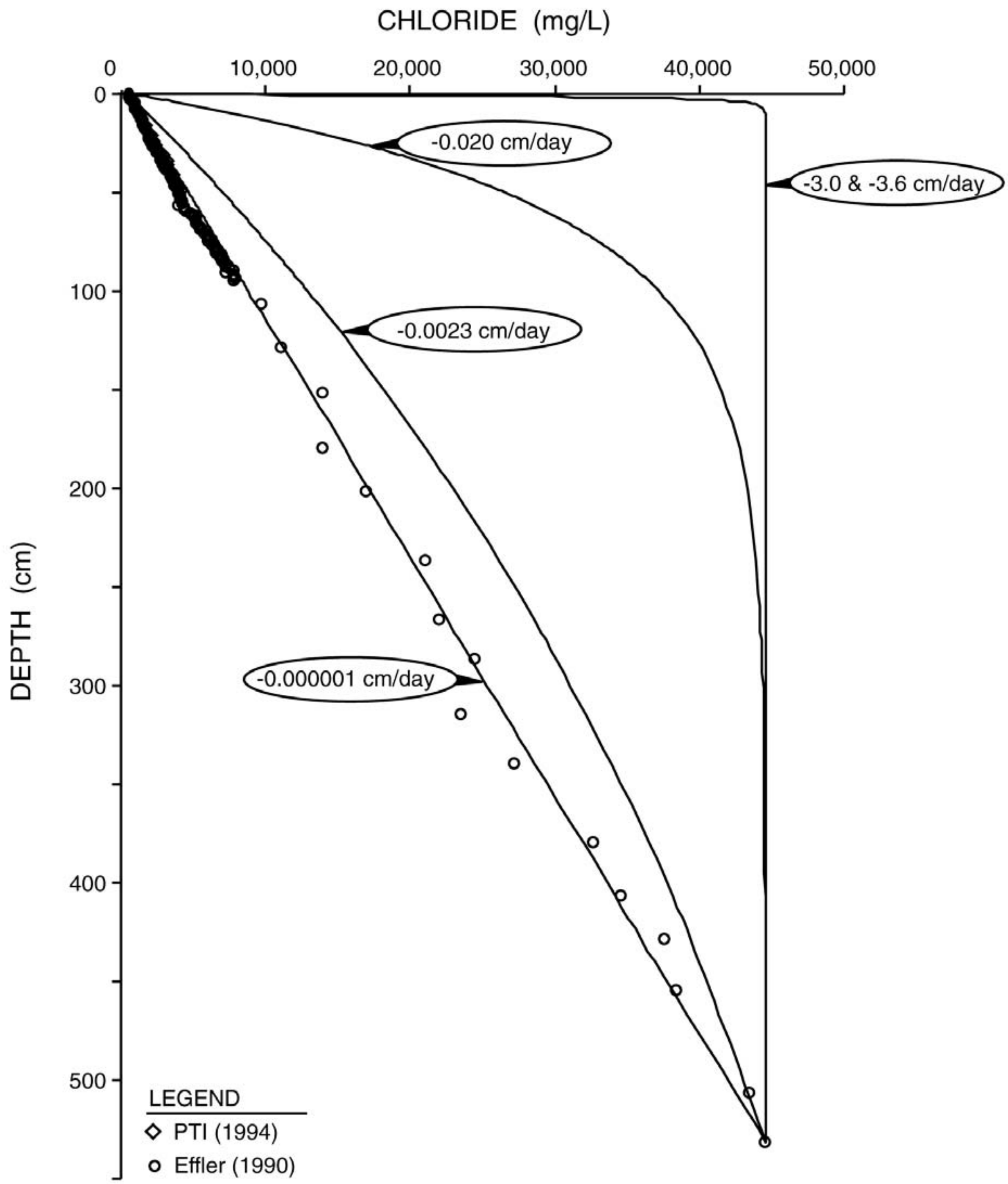

Source: Exponent, 2001

FIGURE DA.6

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

MEASURED AND CALCULATED SEDIMENT POREWATER CHLORIDE CONCENTRATIONS

PARSONS

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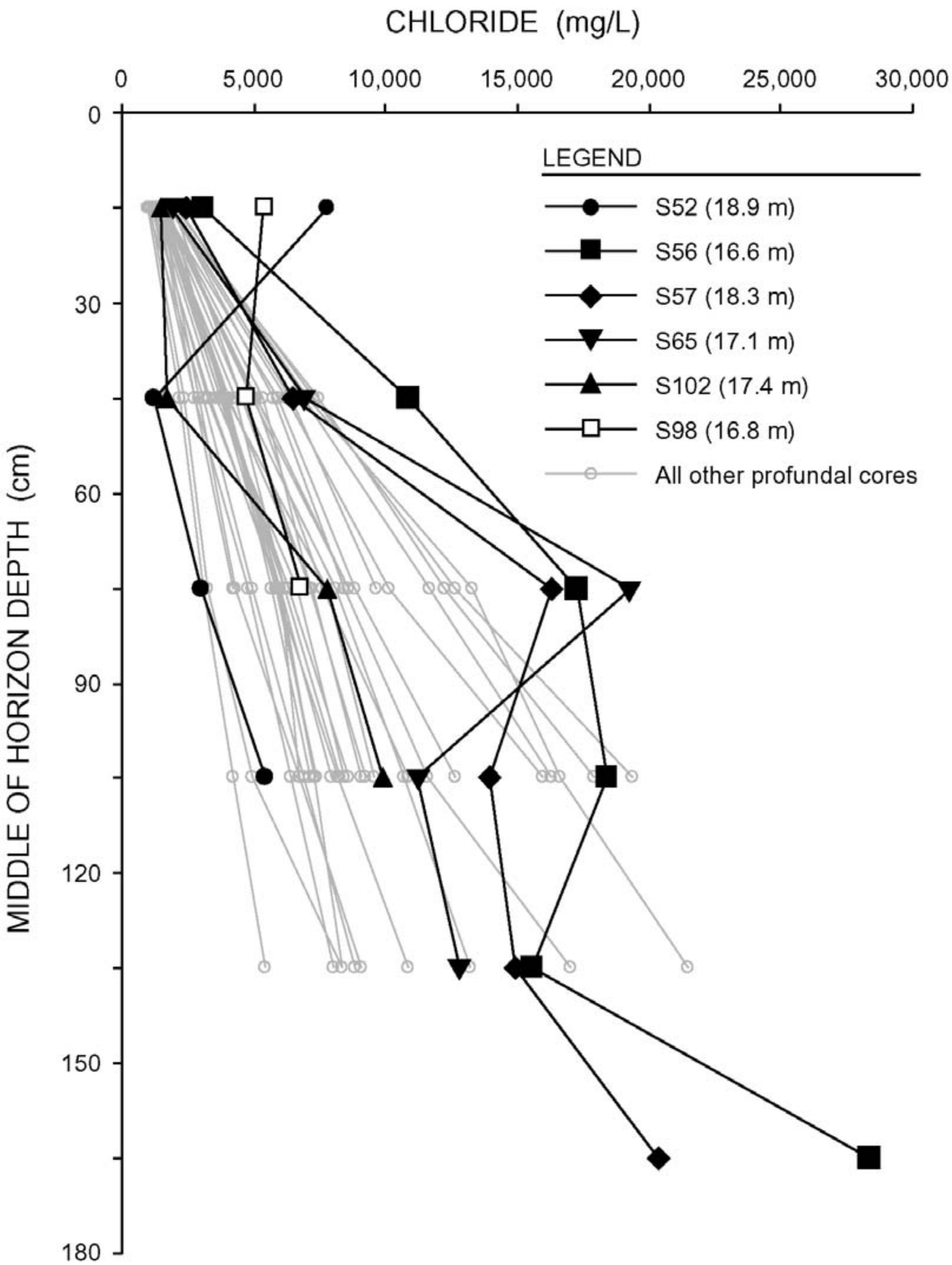

Source: Exponent, 2001

FIGURE DA.7

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

ESTIMATED CHLORIDE CONCENTRATIONS IN POREWATER IN ONONDAGA LAKE

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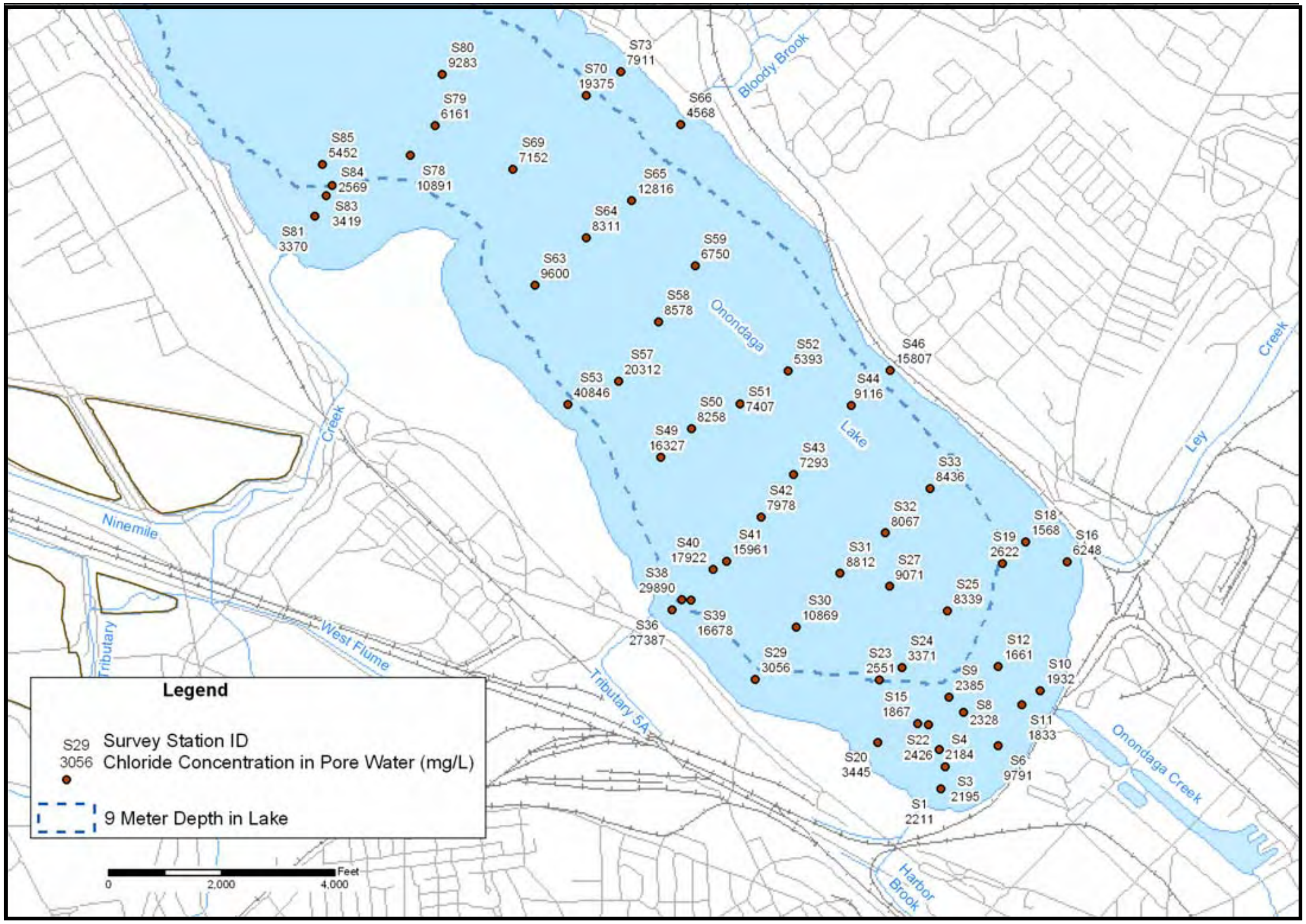

FIGURE DA.8

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

SEDIMENT SAMPLING LOCATIONS AND CHLORIDE CONCENTRATIONS IN PORE WATER

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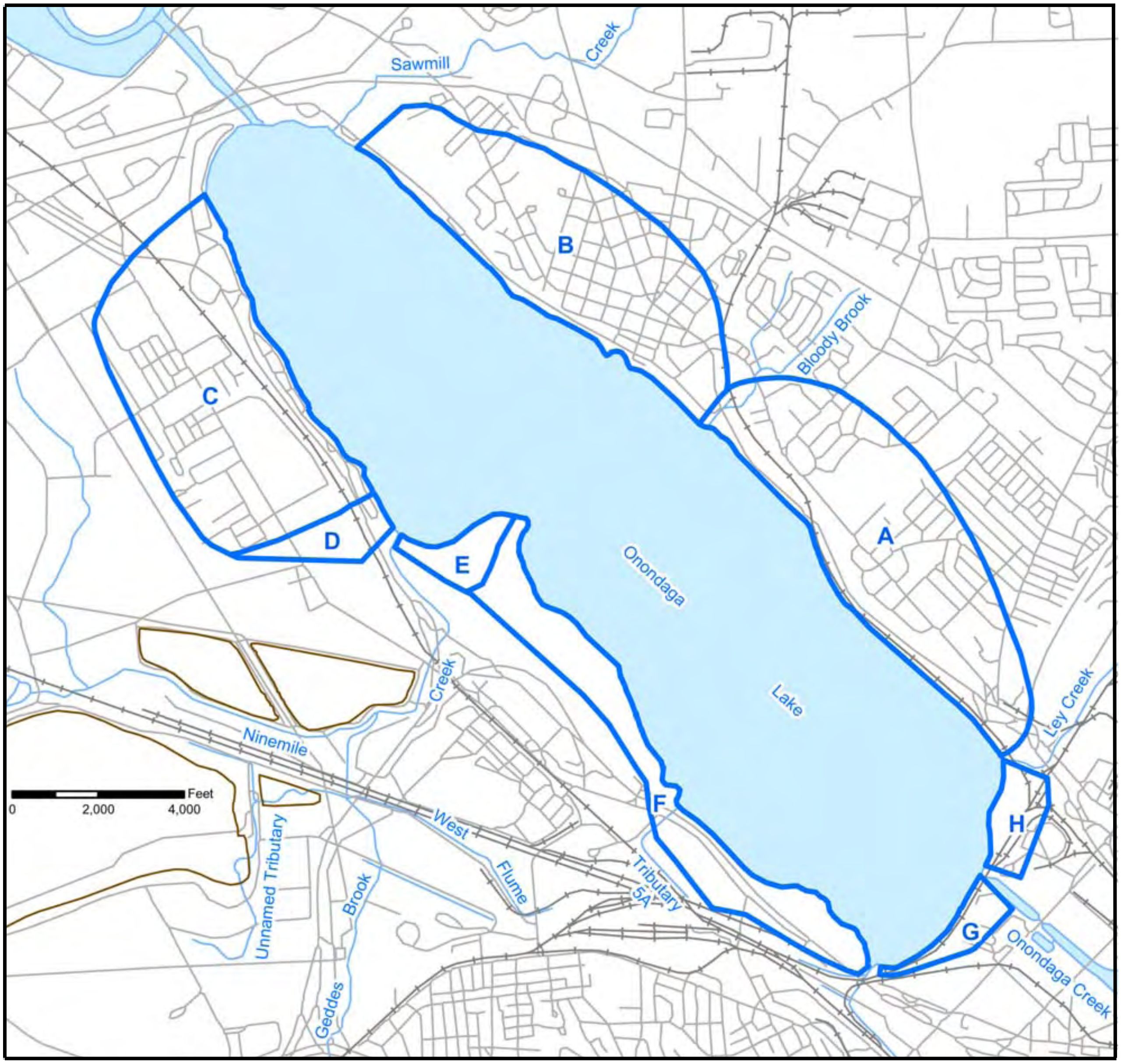

FIGURE DA.9

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

ONONDAGA LAKE
GROUNDWATER BASIN

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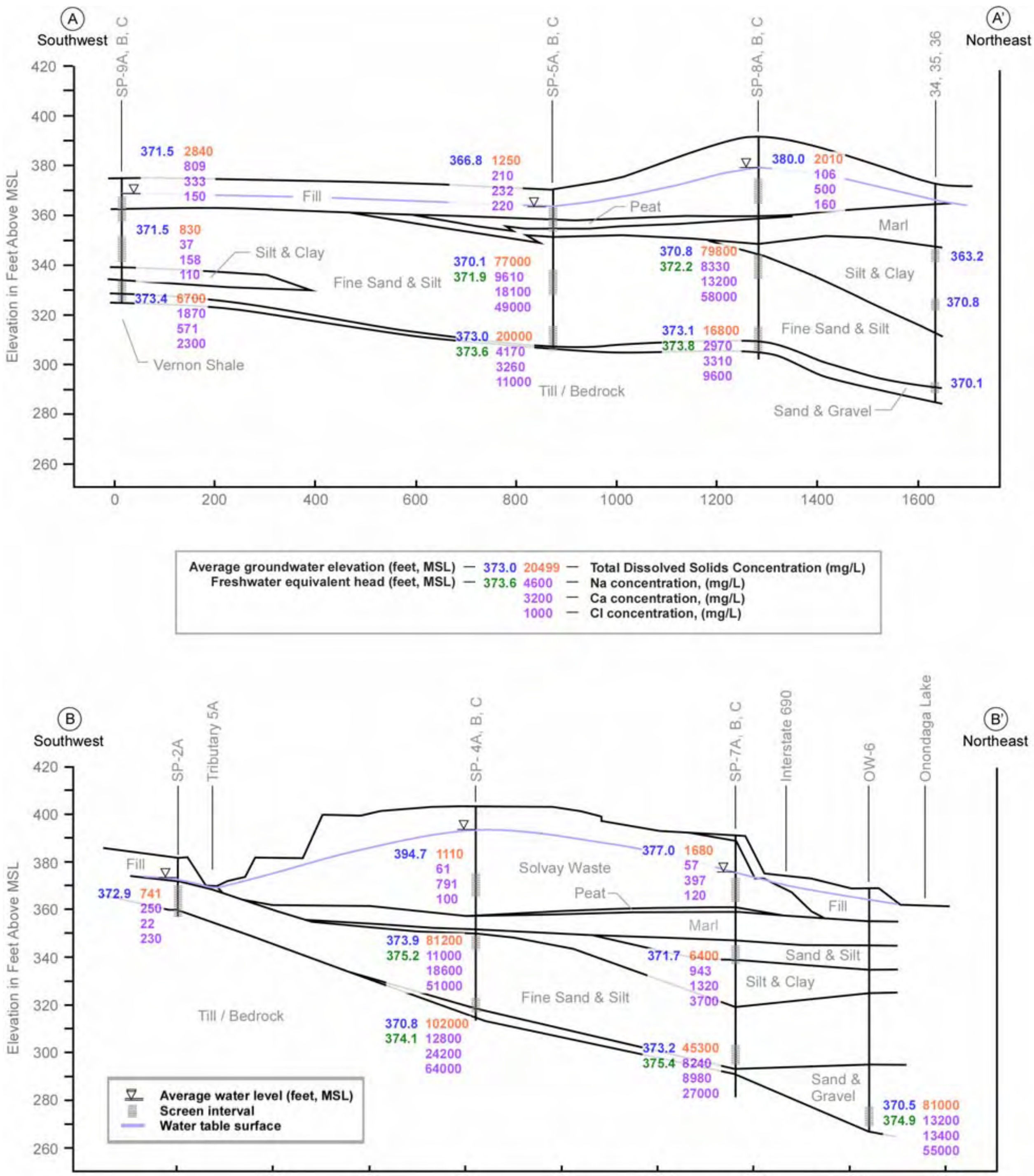

FIGURE DA.10a

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

REPRESENTATIVE HYDROGEOLOGIC CROSS-SECTIONS WITH WATER QUALITY DATA

PARSONS

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Note: *Water-quality data from samples collected March 1991, except for OW-6 which is from sample TW-1 collected January 2002. See Figure DA.1 for cross-section locations.*

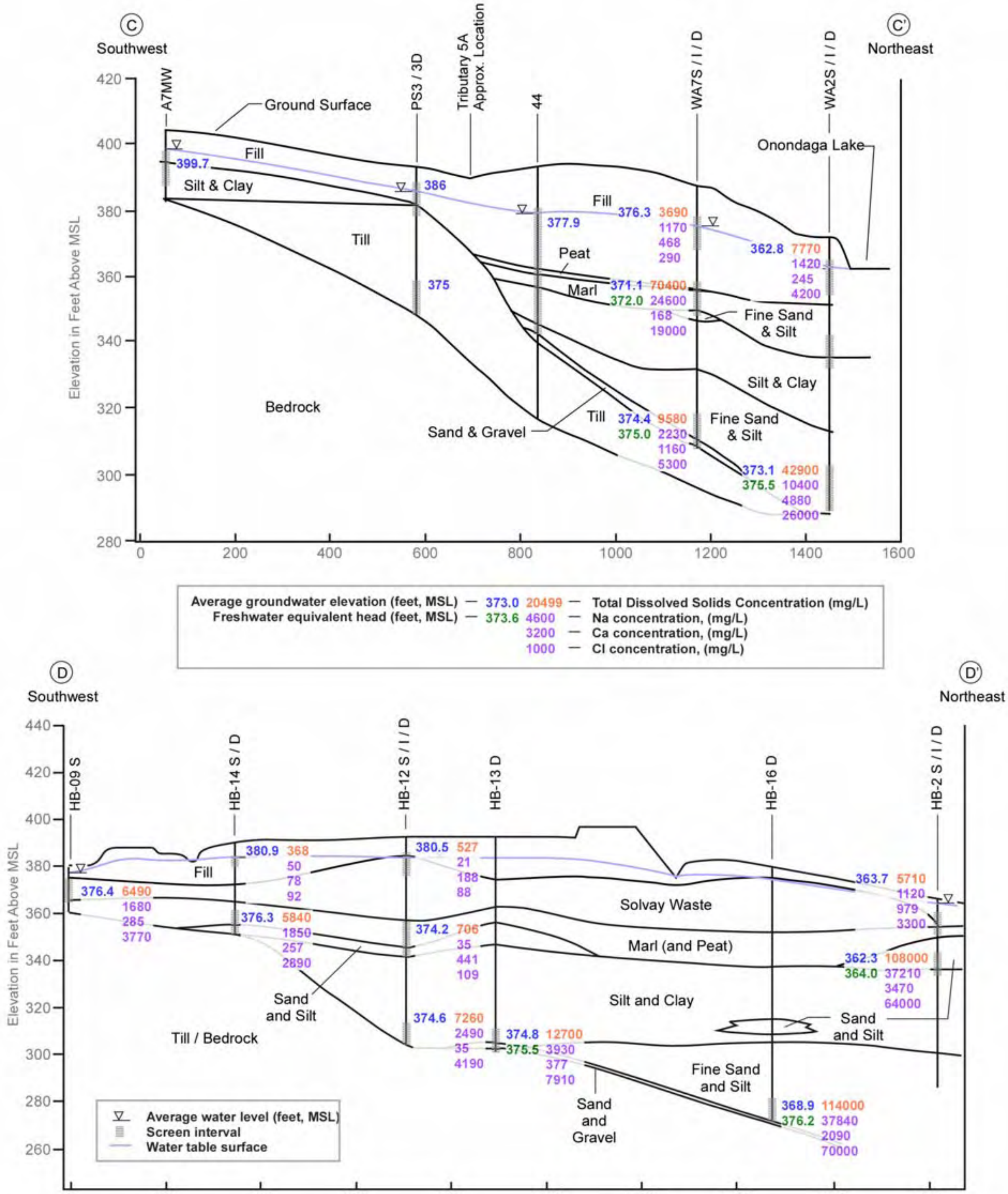

FIGURE DA.10b

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

REPRESENTATIVE HYDROGEOLOGIC CROSS-SECTIONS WITH WATER QUALITY DATA

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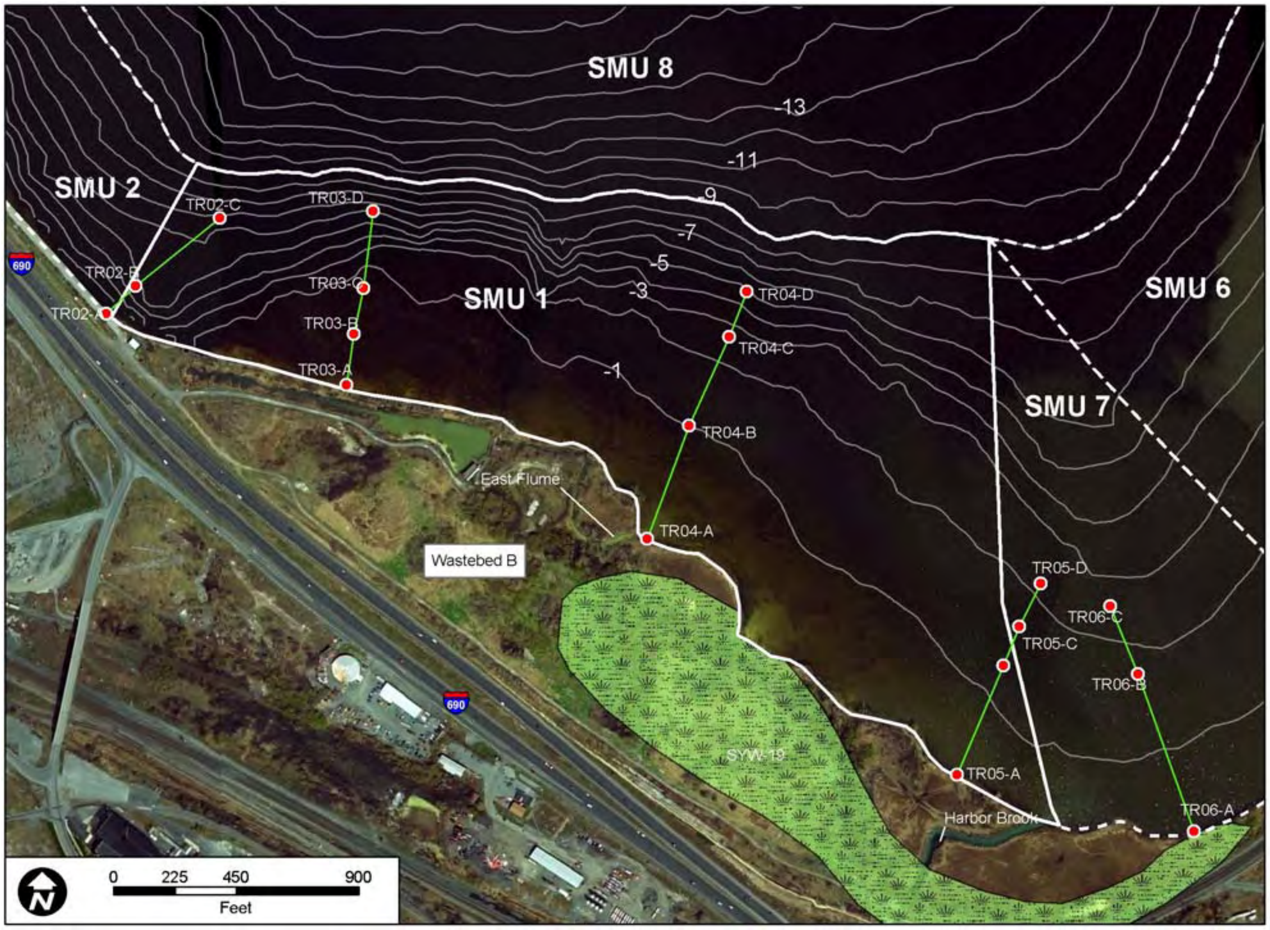
Note: *Water-quality data for Harbor Brook wells from samples collected May 2000, data for WA-7 and WA-2 monitoring wells from samples collected March 1992.*
See Figure DA.1 for cross-section locations.



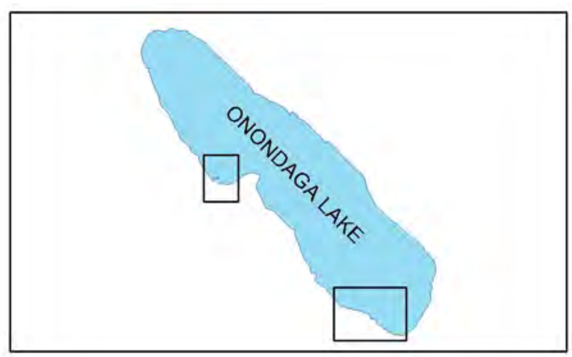


FIGURE DA.11

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

UPWELLING TRANSECT LOCATIONS

PARSONS
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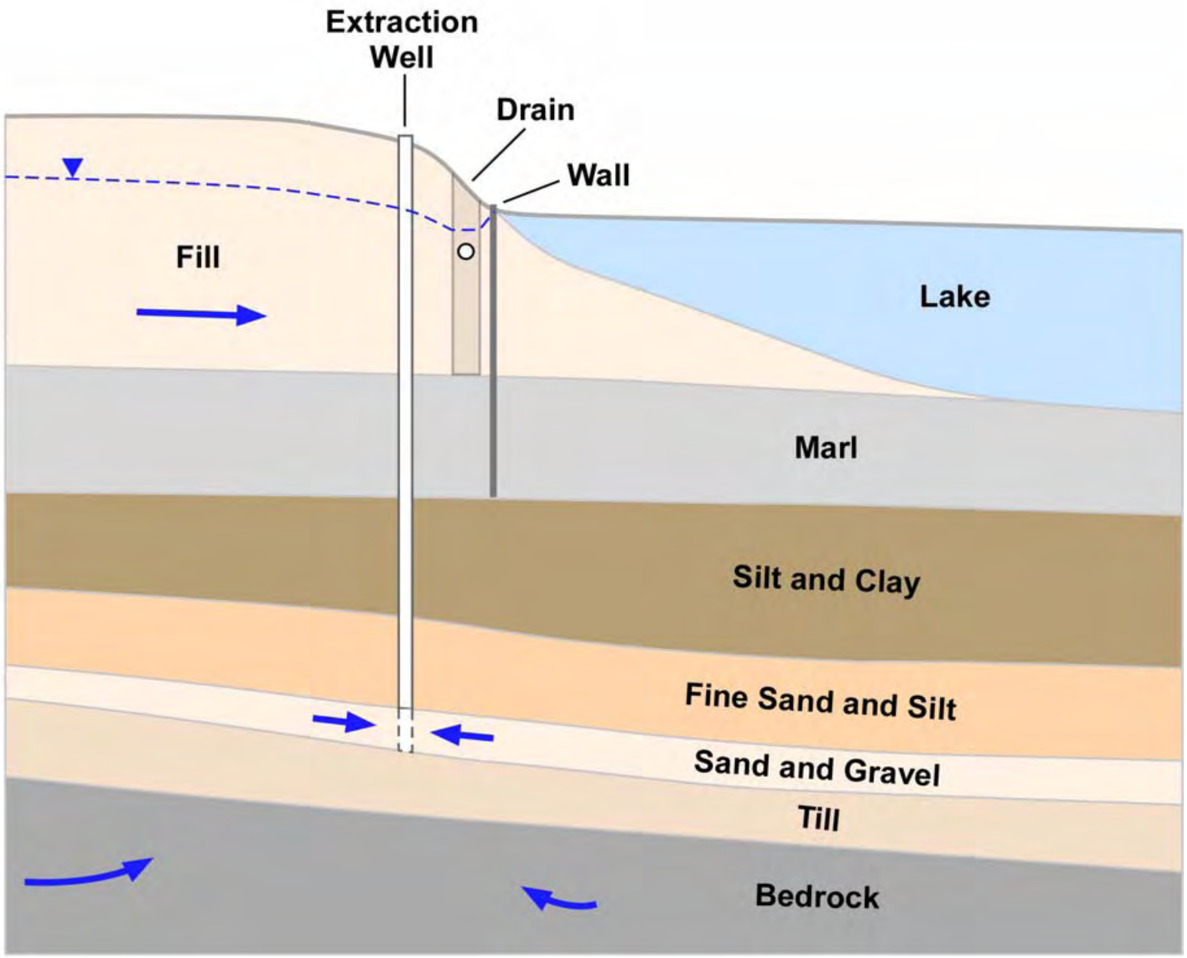

Not to Scale

FIGURE DA.12

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

SCHEMATIC OF GROUNDWATER CONTAINMENT SYSTEM

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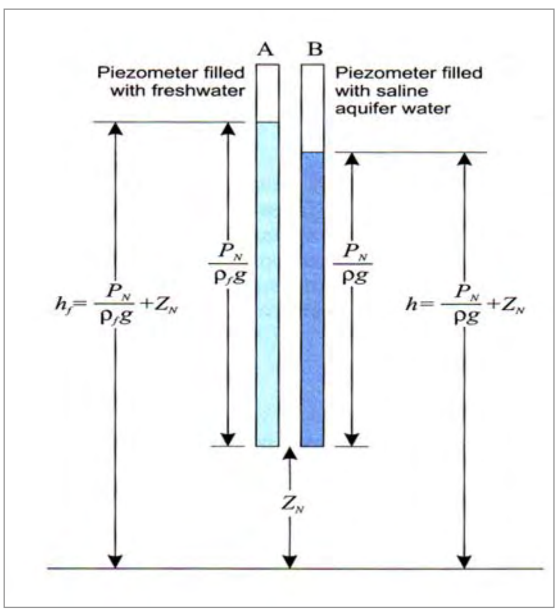
ATTACHMENT DA.1

EQUIVALENT FRESHWATER HEADS

ATTACHMENT DA.1

EQUIVALENT FRESHWATER HEADS

Groundwater head is conventionally measured by recording the depth to water and then calculating the head (water level) by subtracting the depth to water from a reference elevation. In this method, the casing of the well acts as a pressure gauge in which the measured water column in the well is equal to the pressure (P) in the aquifer at the base of the well (assumes well has an infinitesimally small screen) divided by the density of the water (ρ) in the well and the gravitational constant (g); $Water\ column = \frac{P}{\rho g}$. The height of the water column is a function of the density of the water and thus the groundwater head calculated by the conventional method of water level measurements is a function of the density of the water in the well column. The true head or potential is *not* a function of the density of the water column in the well, and for the purposes of expressing head using a common reference, the concept of equivalent freshwater head was introduced. This concept is illustrated in the figure below, where h_f is equivalent freshwater head, h is measured head, ρ_f is freshwater density, and ρ is density of water in the well column.



The equations of groundwater flow can be formulated in terms of measured head, but the results include cumbersome expressions involving density and its derivatives. The equations of groundwater flow in terms of freshwater head are similar to those conventionally used in programs such as MODFLOW.

GROUNDWATER FLOW EQUATIONS

In a horizontally stratified aquifer, in which it is assumed that the hydraulic conductivity and viscosity are not functions of density, Darcy's law can be written as follows:

$$q_x = -K_x \left(\frac{\partial h_f}{\partial x} \right) \quad (1)$$

for horizontal flow; and

$$q_z = -K_z\left(\frac{\partial h_f}{\partial z} + \left(\frac{\rho - \rho_f}{\rho_f}\right)\right) \tag{2}$$

for vertical flow, where K is hydraulic conductivity and q is Darcy groundwater velocity.

It is important to note that Darcy's law for horizontal flow is identical to the form of Darcy's law in MODFLOW, but that Darcy's law for vertical flow is not identical to the form of Darcy's law in MODFLOW; an extra density term has been added. As a result, in a groundwater system with variable density, converting heads at monitoring points and then using MODFLOW to solve the groundwater flow equations will not produce a correct solution unless the system being modeled is in a one-layer horizontal system.

An examination of the equations for Darcy's Law in terms of equivalent freshwater head will indicate that in a horizontally stratified aquifer, vertical flow is approximately equivalent to the gradient calculated from measured heads multiplied by hydraulic conductivity (the density term in equation for vertical flow is equal to the correction term for converting measured head to equivalent freshwater head). Therefore, in a horizontally stratified aquifer with multiple layers, use of MODFLOW with equivalent freshwater heads will result in a correct calculation of horizontal flow but an incorrect calculation of vertical flow.

In an aquifer with dipping units, the principal axes of permeability are not oriented with the x-, y-, and z-coordinate systems, but rather are typically oriented with respect to the dip of the aquifer units. In this situation, Darcy's law for flow parallel to the dip of the aquifer unit, can be written as:

$$q_\alpha = -K_\alpha\left(\frac{\partial h_f}{\partial \alpha} + \left(\frac{\rho - \rho_f}{\rho}\right)\frac{\partial z}{\partial \alpha}\right) \tag{3}$$

where α represents principal direction of permeability oriented parallel to the dip of the aquifer. The term within the brackets can be thought of as the hydraulic gradient, but in this case it consists of two components: 1) a pressure component due to the change in equivalent freshwater head, and 2) a gravitational component due to the slope of the aquifer unit ($\partial z/\partial \alpha$). This equation assumes that the hydraulic conductivity and viscosity are not functions of density.

Equation 3 can be used to estimate the magnitude of groundwater flow in the aquifer units along the shore of Onondaga Lake where the aquifer units are dipping towards the lake and the density is increasing towards the lake. Equation 3, and similar equations for directions orthogonal to α, are incorporated in the computer code SEAWAT-2000, which is a modified version of MODFLOW-2000. Though SEAWAT-2000 uses equivalent freshwater heads in its internal calculations, for ease of comparison with measured water levels, input and output to SEAWAT-2000 is expressed in terms of measured water levels.

Equivalent freshwater heads have been calculated for all monitoring wells with water level data. The procedures used to estimate density and calculated equivalent freshwater heads are described below. The calculated freshwater heads are listed on Table B-3 in Appendix D: Part B.

Groundwater elevations were calculated in three steps: 1) long-term average groundwater elevations were calculated, 2) the density for each well was calculated, and 3) the equivalent freshwater head was calculated.

AVERAGE GROUNDWATER ELEVATION

- Groundwater elevations have been collected intermittently for the Semet, Willis, Ballfield, and Harbor Brook sites starting on February 2, 1991. Because the length of the water level data record for each well is limited by the installation date of the well, the Ballfield and Harbor Brook wells have shorter records than the Semet and Willis wells.
- There was some concern that the short records of some wells might affect the accuracy of the calculated long-term averages for recently installed wells. To address this concern, the long-term averages were compared to averages for just 2003 at wells where the records included both data sets. The long-term and 2003 averages were similar, indicating that the 2003 water level averages are representative of long-term averages. Therefore, the use of 2003 data to represent long-term averages is justified for recently installed wells.
- Average groundwater elevations for each well were calculated based on the full groundwater elevation record for each well.

DENSITY CALCULATION

- The density of the water in each well was calculated by one of three methods: based on TDS, based on water level and pressure measurements, or based on density calculated for wells immediately adjacent. The TDS method was the preferred method. If TDS data were not available, then the water level pressure method was used. If data were not available for either of the previous methods, then the density was estimated based on adjacent wells in similar geologic materials.
- The density based on TDS (total anion and cation concentrations) was calculated using the following formula:

$$\text{Density (g/cm}^{3)} = (0.000687 * \text{TDS Conc.} + 998.4575) / 1000 \qquad (4)$$

  Source: De Marsily, G. 1986. Quantitative Hydrogeology: Groundwater Hydrology for Engineers. San Diego, California: Academic Press.
  Note for some wells the total major anion and cation concentration was used to represent TDS.

- The density based on water level pressure was calculated by measuring both the water pressure (with a pressure transducer) within the screen interval and the height of the water column above the pressure transducer. The density is calculated by the following formula:

$$\text{Density (g/cm}^3\text{)} = \text{pressure head / water column height} \qquad (5)$$

These density measurements were conducted twice on a number of wells, with relatively good duplication of results. The density measurements were also collected at the top and middle of the water column to evaluate the consistency of density of the water within the well.

- Density estimates based on TDS calculations were judged somewhat more reliable than the pressure measurements. Therefore, density based on TDS calculations was the first choice in methods. Density was calculated by TDS for 76 wells. For those 18 wells without TDS data, density was estimated by water level pressure measurements. Density of adjacent wells was used for 15 wells. The attached table identifies which method was used to estimate the water density in the well.

EQUIVALENT FRESHWATER HEAD CALCULATION

- The Equivalent Freshwater Head (EFH) was calculated using the full water level averages and the calculated densities.
- The EFH is calculated using the following formula:

$$\text{EFH} = \text{Density} * \text{Water Level} + (1 - \text{Density}) * \text{Screen Depth} \qquad (6)$$

Where: Density = Density as calculated above,

Water Level = Full, long term average of water level elevation, and

Screen Depth = Elevation of screen midpoint.

ATTACHMENT DA.2

GROUNDWATER DISCHARGE TO LAKES

S.S. PAPADOPULOS & ASSOCIATES, INC.
Environmental & Water-Resource Consultants

Memorandum

Date: April 23, 2004

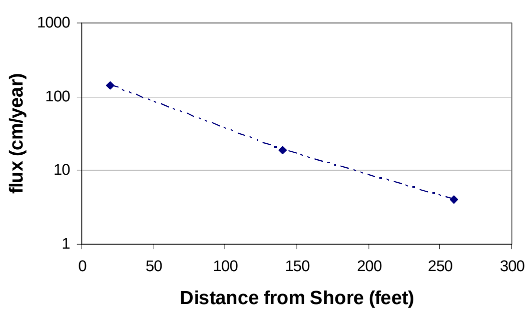
From: Charles Andrews

For: Onondaga Lake Feasibility Study

Subject: **Groundwater Discharge to Lakes**

The spatial pattern of groundwater seepage to lakes has been investigated by a number of researchers. Attached to this memorandum are copies of papers by Winter (1976), Guyonnet (1991), and Genereux and Bandopadhyay (2001) that describe spatial patterns of seepage to lakes and the factors that affect the spatial patterns. Other notable research include McBride and Pfannkuch (1975), Pfannkuch and Winter (1984), Cherkauer and Zager (1989) and Shaw and Prepas (1990). A general observation in the research that has been conducted is that discharge exhibits an approximately exponential decrease with distance from the shoreline.

The 3-D groundwater flow model used in the draft FS (Parsons 2003, Appendix D) for estimating groundwater flux to Onondaga Lake calculated an exponential decrease in groundwater flux with distance from the shore. The calculated exponential decrease at SMU 1 is shown on Table D-1 of the FS and is illustrated in graphic form below.



This model has been updated to incorporate recently collected information, to incorporate comments of NYSDEC on the representation of hydrostratigraphic units, and to incorporate a rigorous representation of the density effects of the brines beneath the lake. These changes had little effect on the spatial pattern of groundwater discharge to the lake, and therefore, the revised model also calculates an approximately exponential decrease in groundwater discharge with distance from the shoreline. Below is a list of references that document this issue at other locations.

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References

Cherkauer, D and Zager 1989. Groundwater interaction with a kettle-hole lake: relation of observations to digital simulations. Journal of Hydrology v109, pp 167-184.

Genereux, D. and I. Bandopadhyay 2001. Numerical investigation of lake bed seepage patterns: effects of porous medium and lake properties. Journal of Hydrology, v241, pp 286-303.

Guyonnet, D., 1991. Numerical modeling of effects of small-scale sedimentary variations on ground water discharge into lakes. Limnology and Oceanography, v36(4), pp 787-796.

McBride, M and H. Pfannkuch 1975. The distribution of seepage within lake beds. U.S. Geological Survey Journal of Research, v3, pp 505-512.

Parsons, 2003. Onondaga Lake Feasibility Study Report. Prepared by Honeywell, Morristown, New Jersey.

Pfannkuch, H. and T.Winter, 1984. Effect of anisotropy and groundwater system geometry on seepage through lake beds: 1. Analog and dimensional analysis. Journal of Hydrology, v75, pp 213-237.

Shwa, R.D. and E.Prepas, 1990. Groundwater-lake interactions: 1. Accuracy of seepage meter estimates of lake seepage and 2. Near shore seepage patterns and the contribution of groundwater to lakes in central Alberta. Journal of Hydrology, v119, pp 105-136.

Winter, T.C., 1976, Numerical simulation analysis of the interaction of lakes and ground water. U.S. Geological Survey Professional Paper 1001, 1976.

APPENDIX D

PART B

GROUNDWATER MODEL DOCUMENTATION

APPENDIX D - PART B:

GROUNDWATER MODEL DOCUMENTATION

Prepared For:

HONEYWELL

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Prepared By:

Guy Swenson, CPG
O'Brien & Gere

Charles B. Andrews, Ph.D.
S. S. Papadopulos and Associates, Inc.

November 2004

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SECTION DB.1

INTRODUCTION

Honeywell International, Inc. (Honeywell) has developed a groundwater flow computer model to simulate groundwater flow beneath and in the vicinity of the southwestern part of Onondaga Lake. This model was developed to facilitate the understanding of groundwater flow and to assist in the evaluation of remedial approaches for Onondaga Lake and Honeywell sites adjacent to the lake. This portion of the appendix presents the objectives, a description, and documentation for the Honeywell groundwater model.

The locations of the Honeywell sites located in the vicinity of Onondaga Lake are shown on Figure DB.1. Figure DB.1 also shows the area encompassed by the Honeywell groundwater model, and Figure DB.2 presents the ground surface topography of the model area. Pertinent surface water features are also shown on Figures DB.1 and DB.2.

SECTION DB.2

OBJECTIVES

The objectives of the Honeywell groundwater model are to:

- Evaluate groundwater discharge to Onondaga Lake;
- Represent groundwater flow to the lake and flow associated with other Honeywell sites;
- Facilitate the evaluation of remedial options for the lake and other Honeywell sites;
- Predict the effectiveness of groundwater remedial alternatives; and
- Predict groundwater discharge to Onondaga Lake following upland remediation.

The Honeywell groundwater model was originally developed by Blasland, Bouck & Lee, Inc. (BBL) in 2000 and documented in an August 2000 model report (BBL, 2000). Since BBL developed the original model, additional hydrogeologic data for the model area have been collected and included in two revisions by O'Brien & Gere Engineers, Inc. (OBG). Following the first model revision, which incorporated data from the Semet Ponds and Willis Avenue sites, OBG prepared a report documenting the model (OBG, 2002a). Additional model revisions incorporated data from the Harbor Brook and Ballfield sites. This version of the model was presented as Appendix D in the Draft Onondaga Lake Feasibility Study (Parsons, 2003b).

S.S. Papadopulos & Associates, Inc. (SSP&A) and OBG recently revised the model to the current version described in this appendix. The recent revisions that were made to the Honeywell groundwater model are as follows:

- A three-dimensional (3-D) representation of density variations in groundwater was developed and incorporated into the model analyses.
- The SEAWAT-2000 computer code was used to simulate groundwater flow (Langevin *et al.*, 2003). This computer code, rather than MODFLOW-2000, was used so that the effects of variable density in the groundwater could be rigorously represented.
- The computer program PEST was used to perform the model calibration (Doherty, 2002). The hydraulic conductivity in each of the zones represented in the model was re-estimated during the calibration process.
- The representation of the model layers was revised to more closely represent available boring log and well data. In addition, recent geologic data from the U.S. Geological Survey (USGS) borings in Onondaga Lake were incorporated to provide a better representation of the geologic units beneath the lake.
- To improve the efficiency of SEAWAT-2000 simulations, the representation of Onondaga Lake in the model was changed from constant-head-type boundary

condition to river-type boundary condition and creeks in the upland areas of the model were converted to drain-type boundary conditions. In addition, the location and elevation of boundary conditions were reviewed and modified as appropriate from earlier versions of the model.

- The coordinate system used by the model was converted to UTM Zone 18N, NAD83, feet. This coordinate system is the system used in most of the RI/FS work.

SECTION DB.3

MODEL CONSTRUCTION

The computer program SEAWAT-2000 was used to simulate groundwater flow in this revision of the model (Langevin *et al*., 2003). This program is designed to simulate variable-density, transient groundwater flow in porous media. It is a modified version of MODFLOW-2000 (Harbaugh *et al*, 2000), which solves the equations for variable-density flow in porous media as described in Part A of this appendix. The program internally uses equivalent freshwater heads, but input heads and output heads from the program are heads as measured in monitoring wells. The data requirements for SEAWAT-2000 are identical to those for MODFLOW-2000, with the additional requirement that an initial density distribution be specified for the model domain.

The current version of the Honeywell groundwater model builds upon the existing regional groundwater flow model developed by BBL. The model was originally developed using the USGS modular, 3-D, finite-difference groundwater flow code (MODFLOW) (McDonald and Harbaugh, 1988). The groundwater particle tracking code called MODPATH (Pollock, 1989) was used to illustrate groundwater flow pathlines.

In MODFLOW and SEAWAT-2000, the differential equations that describe groundwater flow are solved through the iterative, finite-difference approach. The 3-D groundwater flow system is represented by a 3-D grid of discrete, rectilinear cells. These rectilinear cells are used to mathematically represent the hydrogeology of the site. Each 3-D cell represents a single set of hydrogeologic parameters. The geometry and hydrogeologic characteristics of cells vary throughout the model domain; however, each cell has uniform hydraulic characteristics. All of the electronic files used to run the groundwater model are located on a CD in Attachment DB.1.

DB.3.1 MODEL DOMAIN

The groundwater model domain encompasses an area of approximately 13 square miles surrounding the southwest shoreline of Onondaga Lake (Figure DB.1). The model grid dimensions are 24,000 feet (ft) (7315 meters [m]) in the northwest-southeast direction and 15,000 ft (4572 m) in the northeast-southwest direction. The model domain is approximately centered at the Semet Ponds and Willis Avenue sites and extends outward to the locations of regional surface-water features and a regional groundwater flow divide. The model domain is bounded to the north by the approximate centerline of Onondaga Lake and the New York State Barge Canal. The model is bounded to the south by an interpreted regional groundwater divide that crosses a topographic high area. The Barge Canal and Onondaga Creek form the model boundary to the southeast, and Ninemile Creek and Geddes Brook form the model boundary to the west.

The model grid coordinate system is UTM Zone 18N (in ft) NAD83, and the elevation datum is NGVD88 ft. This coordinate system is used in most of the RI/FS work at the Honeywell sites adjacent to Onondaga Lake. The original model coordinate system was offset about 737 ft (225 m) to the west and 117 ft (36 m) to the south from the current coordinates. The model grid is rectilinear in plan view and rotated with respect to the geographical coordinates, such that the columns are oriented northeast to southwest and the rows are oriented northwest to southeast (Figure DB.1). The grid was rotated so that the rows are approximately parallel to the southwest shoreline of Onondaga Lake and groundwater flow along the shoreline is approximately parallel to the grid columns.

The rectilinear, 3-D, block-centered finite difference model grid consists of 123 non-uniformly spaced rows and 246 non-uniformly spaced columns (30,258 cells per layer). The spacing of cells in the vicinity of the Semet and Willis sites is 40 ft by 40 ft (12.2 m by 12.2 m) in plan view. The cell sizes extending outward from Semet and Willis sites were gradually increased with a magnification factor less than 1.5 from cell to cell. At the periphery of the model, the grid cell size coarsens to approximately 800 ft by 800 ft (244 m by 244 m) in plan view.

The ground surface elevation within the model domain is based on the USGS 1/24,000 digital elevation model (DEM) for the Syracuse West quadrangle. This DEM consists of an array of elevations for ground positions at regularly spaced intervals (100 ft by 100 ft [30.5 m by 30.5 m]), based on Universal Transverse Mercator (UTM) projection. The lake bottom elevations were developed by subtracting the lake depth from a specified lake level of 363 ft (110.6 m). The top of layer 1 was defined as the ground surface in all areas outside Onondaga Lake and the lake bottom under the lake.

The model grid represents seven hydrogeologic units with nine model layers. The layers have variable thickness, with thickness defined by the geologic logs from 216 borings. These model layers along the Onondaga Lake shore and under the lake, from the top to the bottom, are generally characterized as:

1. Fill,
2. Fill
3. Marl,
4. Silt and clay,
5. Silt and fine sand,
6. Sand and gravel,
7. Till,
8. Bedrock, and
9. Bedrock.

Away from the lake, many of these layers pinch out, and the model layers represent bedrock. The top and bottom elevations of these units at the 221 boring locations are listed on Table DB.1. The locations of the borings are shown on Figure DB.3. Boring logs used in the definition of the model layers are included in Attachment DB.2.

Each model grid layer is continuous throughout the model domain. Since the hydrogeologic units, with the exception of the bedrock, are not continuous over the model domain, model layers typically represent more than one hydrogeologic unit. The only model layers that represent constant hydrogeologic units throughout the subject model domain are the bottom two layers (Layers 8 and 9), which represent the bedrock. To account for the variable thickness and discontinuous nature of the unconsolidated hydrogeologic layers, the model layers were digitally processed as follows:

- The top of model Layer 1 was defined as land surface, except beneath the lake, where it was specified as the top of the sediments.
- A structure contour map was developed for the base of the fill using the boring log data. The elevations of the base of the fill at each boring location were contoured using the kriging routine in Surfer® (Golden Software, 2002). This contoured surface was then used to define the base of model Layer 2 in areas where fill exists. In areas where fill does not exist, beneath the lake and in the uplands areas, the base of model Layer 2 was defined as described below. Beneath the lake where model Layers 1 and 2 represent sediments above the marl, the base of Layer 2 was specified at 20 ft (6.1 m) below the bottom of the lake except in areas where fill thickness is defined on the basis of boring data. In upland areas where model Layers 1 and 2 represent undifferentiated till and bedrock, the base of Layer 2 was defined as 378 ft (115.2 m) above mean sea level (MSL). This elevation was chosen to so that the water table was everywhere above the base of the layer to ensure model stability. The structure contour map of the base of Layer 2, which is by definition also the top of model Layer 3, is shown on Figure DB.4.
- The top of model Layer 2 was specified as 5 ft (1.5 m) above the base of model Layer 2. The thickness of this model layer was arbitrarily specified to retain compatibility with previous model versions. The thickness of model Layers 1 and 2 are shown on Figures DB.5 and DB.6, respectively.
- The elevation of the top of model Layer 4 was calculated by subtracting the thickness of the marl unit and the thickness of the underlying fine sand where it exists in the Willis and Semet areas from the top of model Layer 3. The thickness of this unit throughout the model domain was specified by kriging the thickness data from the boring logs using the program Surfer®. In areas where the unit does not exist, the top of model Layer 4 was specified as one 1 ft (0.3 m) below the top of model Layer 3. The thickness of model Layer 3 is shown on Figure DB.7. In areas where peat overlies the marl, the peat was included in the thickness of model Layer 3.
- The elevation of the top of model Layer 5 was calculated by subtracting the thickness of the silt and clay unit from the top of model Layer 4. The thickness of the unit throughout the model domain was specified by kriging the thickness data from the boring logs using the program Surfer. In areas where the silt and clay unit does not exist, the top of model Layer 5 was specified as 1 ft (0.3 m) below the top of model Layer 4. The thickness of model Layer 4 is shown on Figure DB.8.

- The elevation of the top of model Layer 6 was calculated by subtracting the thickness of the silt and fine sand unit from the top of model Layer 5. The thickness of the unit throughout the model domain was specified by kriging the thickness data from the boring logs using the program Surfer®. In areas where the silt and fine sand unit does not exist, the top of model Layer 6 was specified as 1 ft (0.3 m) below the top of model Layer 5. The thickness of model Layer 5 is shown on Figure DB.9.

- The elevation of the top of model Layer 7 was calculated by subtracting the thickness of sands and gravels above the till from the top of model Layer 6. The thickness of sand and gravel throughout the model domain was specified by kriging the thickness data from the boring logs using the program Surfer®. In areas where the sand and gravel unit does not exist, the top of model Layer 7 was specified as 1 ft (0.3 m) below the top of model Layer 6. The thickness of model Layer 6 is shown on Figure DB.10.

- The elevation of the top of model Layer 8 was calculated by subtracting the thickness of till from the top of model Layer 7. The thickness of till throughout the model domain was specified by kriging the thickness data from the boring logs using the program Surfer®. In areas where the till unit does not exist, the top of model Layer 8 was specified as 1 ft (0.3 m) below the top of model Layer 7. In areas where the base of the till is higher than 374 ft (114.0 m) MSL, the top of model Layer 8 was specified as 374 ft (114.0 m) above MSL. The thickness of model Layer 7 is shown on Figure DB.11.

- The top of model Layer 9 was specified as 5 ft (1.5 m) below the top of model Layer 8, and the base of model Layer 9 was specified as 95 ft (29 m) below the top of Layer 9.

After the elevations of each of the model layers had been specified using the procedures described above, the elevations of the top of the hydrogeologic units as determined from the logs were compared with the elevations of the top of the layers in the model to ensure that the model accurately represented the structure of the hydrogeologic units. The results of this comparison are shown on Table DB.2. In addition, cross-section profiles of the model structure were prepared and compared to geologic cross sections. Two of the model cross sections that were prepared are shown on Figure DB.12. These cross section sections depict similar sections to those shown on the geologic cross sections shown on Figure DA.3 of this Appendix.

DB.3.2 HYDRAULIC PROPERTIES

Estimates of hydraulic conductivity of the hydrogeologic units have been derived from *in situ* hydraulic conductivity tests, laboratory permeability tests, specific capacity tests, and pumping tests conducted at various locations within the model domain. These properties provided the basis for the hydraulic conductivity values assigned to the layers in the model. Hydraulic conductivity zones in the model were developed based on the available geologic information and hydraulic conductivity data (Attachment DB.3). During the model calibration process, the assigned hydraulic conductivity values were adjusted to improve the model calibration. Table DB.3 presents the range of hydraulic conductivity values specified in the model and the range of values derived from testing. The measured and model-calibrated hydraulic conductivities are described below by model layer.

The fill unit (Layers 1 and 2) is characterized by significant heterogeneity in both horizontal and vertical hydraulic conductivities. Measured horizontal conductivities range from 0.01 feet per day (ft/day) to 230 ft/day (Table DB.3). Measured vertical hydraulic conductivities for the fill range from 0.006 ft/day to 0.06 ft/day. Calibrated model horizontal hydraulic conductivities for Layers 1 and 2 range from 0.05 ft/day to 50 ft/day, and the calibrated vertical hydraulic conductivities range from 0.0014 ft/day to 5 ft/day. The Layer 1 and 2 distributions of horizontal and vertical hydraulic conductivities in the calibrated model are presented on Figures DB.13 and DB.14.

Layer 3 generally comprises the marl hydrogeologic unit adjacent to and beneath Onondaga Lake. Away from the lake, this layer represents other hydrogeologic units. The measured horizontal conductivities of this layer are generally less than the fill unit and range from 0.019 ft/day to 7.52 ft/day (Table DB.3). Measured vertical hydraulic conductivity of the marl ranges from 0.0003 ft/day to 0.0022 ft/day. Calibrated model horizontal hydraulic conductivities for Layer 3 range from 0.0015 ft/day to 50 ft/day, and the vertical hydraulic conductivities range from 0.00015 ft/day to 5 ft/day. The calibrated model hydraulic conductivity for the marl is 0.019 ft/day horizontal and 0.0019 ft/day vertical. The distributions of Layer 3 horizontal and vertical hydraulic conductivities in the calibrated model are presented on Figure DB.15. In the Willis Avenue and Semet Ponds areas, the sands that occur beneath the marl in localized areas along the lake shore are included in model Layer 3. A horizontal hydraulic conductivity of 5 ft/day and a vertical hydraulic conductivity of 0.01 ft/day were specified for this layer where the sands exist along the lake shore.

Layer 4 represents the silt and clay unit present under Onondaga Lake and along the lakeshore area. In areas that are further away from the lake, this layer represents different hydrogeologic units. The measured horizontal conductivities of this layer range from 0.0003 ft/day to 0.18 ft/day (Table DB.3). Measured vertical hydraulic conductivities of the silt and clay range from 0.0001 ft/day to 0.0007 ft/day. Calibrated model horizontal hydraulic conductivities for Layer 4 range from 0.06 ft/day to 50 ft/day, and the vertical hydraulic conductivities range from 0.0006 ft/day to 5 ft/day. The distributions of Layer 4 horizontal and vertical hydraulic conductivities in the calibrated model are presented on Figure DB.16.

There has been limited hydraulic testing of the fine sand and silt unit that comprises Layer 5 under Onondaga Lake and along the lakeshore. In areas that are further away from the lake, this layer represents different hydrogeologic units. The measured hydraulic conductivities of the silt and fine-grained sand unit range between 0.07 ft/day and 5.4 ft/day (Table DB.3). The measured vertical hydraulic conductivities of the silt and fine sand unit range from 0.0004 ft/day to 0.022 ft/day. Calibrated model horizontal hydraulic conductivities for Layer 5 range from 1.2 ft/day to 40 ft/day, and the vertical hydraulic conductivities range from 0.12 ft/day to 4 ft/day. The distributions of Layer 5 horizontal and vertical hydraulic conductivities in the calibrated model are presented on Figure DB.17.

Ranges of hydraulic conductivity values for the basal sand and basal sand and gravel units along the lakeshore were identified as 0.13 ft/day to 1,073 ft/day (Table DB.3). The thickness and grain size of these units varies significantly, and these ranges of values are likely a reflection of that variability. This hydrogeologic unit is represented by Layer 6 in the model. In areas that are further away from the lake, this layer represents different hydrogeologic units. Calibrated model horizontal hydraulic conductivities for Layer 6 range from 1.2 ft/day to 1000 ft/day, and the vertical hydraulic conductivities range from 0.12 ft/day to 100 ft/day. The calibrated model horizontal and vertical hydraulic conductivity for the sand and gravel unit ranges from 10 ft/day to 1000 ft/day and 1 to 100 ft/day, respectively. The distributions of Layer 6 horizontal and vertical hydraulic conductivities in the model are presented on Figure DB.18. In the Willis Avenue and Semet Ponds areas, the sand and gravel unit along the lake shore was likely formed as channel deposits in a glacial stream, as these deposits are very coarse grained, have a high hydraulic conductivity, and have a limited width. The channel deposits are specified as occurring along the lake shore and extending beneath the Semet Ponds in the vicinity of monitoring well MW-20.

Limited hydraulic conductivity information is available for Layer 7, which is made of the till. The measured hydraulic conductivity of the till ranges between 0.055 ft/day and 8.8 ft/day (Table DB.3). There have been no measurements of the vertical hydraulic conductivity in this unit. Calibrated model horizontal hydraulic conductivity for that portion of Layer 7 that represents the till was 0.05 ft/day, and the vertical hydraulic conductivity was 0.005 ft/day. The distributions of Layer 7 horizontal and vertical hydraulic conductivities in the model are presented on Figure DB.19.

Limited hydraulic conductivity information is available for Layers 8 and 9, which are comprised of the bedrock. The measured hydraulic conductivity of the bedrock ranges between 0.00003 ft/day and 1.13 ft/day (Table DB.3). There have been no measurements of the vertical hydraulic conductivity within the bedrock. The calibrated model horizontal hydraulic conductivity for Layers 8 and 9 was 1.2 ft/day, and the vertical hydraulic conductivity was 0.12 ft/day. Layers 8 and 9 represent the bedrock throughout the entire model domain.

DB.3.3 BOUNDARY CONDITIONS

Boundary conditions in the model include Onondaga Lake, Ninemile Creek, Geddes Brook, the New York State Barge Canal, and Onondaga Creek (Figure DB.1). In addition, a no-flow boundary was specified as the southern boundary for the model to represent the topographic divide that was interpreted by Winkley (1989) as a groundwater divide. Boundaries internal to the model domain (Tributary 5A, Harbor Brook, the West Flume, the East Flume, I-690 underdrains and ditches) were also specified in the model. The following subsections describe the hydraulic boundaries incorporated in the model.

Onondaga Lake was treated as a river-type boundary condition in Layer 1 to improve the efficiency of the simulation with SEAWAT-2000 (Figure DB.20). A surface water elevation of 362.9 ft (110.6 m) above MSL was assigned to the lake boundary cells. This surface water elevation represents the average lake elevation from 1991 through 2003.

Ninemile Creek is represented as a drain-type boundary in the model (Figure DB.21). For the entire section of creek in the model, the drain elevation is 362.9 ft above MSL, which is the same as the lake elevation. Observations at the USGS gauging station 04240300 (Ninemile Creek at Lakeland, New York) indicate that lake elevations above 362 ft (110.6 m) above MSL cause Ninemile Creek to back up past the gauging station. Attachment DB.4 presents supporting data for this model boundary.

Geddes Brook is represented as a drain-type boundary in the model (Figure DB.21). The assigned drain elevations are based on the USGS 1:24,000 topographic map of the area and range from 363 ft (110.6 m) above MSL at the confluence with Ninemile Creek to 408 ft (124.4 m) above MSL at the upstream end of the brook in the model domain. The base flow of Geddes Brook within the model domain is estimated to be 0.5 to 1.7 cubic ft per second (cfs). The base flow was estimated as follows: Low flow for Geddes Brook is estimated to be about 3 to 7 cfs (Figure 3-13, Ninemile Creek RI). Approximately 30 percent of Geddes Brook is within the model domain (6,000 ft [1829 m] out of a total of 21,000 ft [6401 m] of stream length from Figure G-4, Ninemile Creek RI). Assuming that the brook gains water from groundwater discharge at a constant rate along its entire length, the discharge into the brook within the model domain is 30 percent of the total flow and ranges from 0.9 to 2.1 cfs. Additionally, inflow from the West Flume into Geddes Brook is 0.4 cfs, thereby decreasing the range of groundwater discharge to Geddes Brook within the model domain to 0.5 to 1.7 cfs.

The Barge Canal was treated as a river-type boundary condition with the surface water elevation of 362.9 ft (110.6 m) above MSL (Figure DB.20). The surface water elevation is assumed to be the same as the lake elevation, since the canal is directly connected to the lake.

Onondaga Creek is represented as a drain-type boundary in the appropriate layers based on elevation (Figure DB.21). The drain elevations were based on the linear interpolation of creek elevations from the Barge Canal to the Spencer Street USGS gauging station and past the station to the upstream edge of the model domain. The creek water elevation at the upstream edge of the model was specified as 369.5 ft (112.6 m) above MSL. The Spencer Street gauging station water elevation was estimated to be approximately 365 ft (111.2 m) above MSL, based on average low water level at the station between February 2002 and February 2004. The gauging station is approximately 950 ft (290 m) from the barge canal. The edge of the model area is approximately 1960 ft (598 m) upstream from the gauging station.

Tributary 5A is a relatively shallow drainage ditch located southwest of the Semet Ponds site, which perennially contains water at an elevation below that of the surrounding groundwater table. This tributary was simulated as a drain-type boundary in the model (Figure DB.21). The assigned model water levels in Tributary 5A (365.9 ft to 376.2 ft [111.5 m to 114.7 m] above MSL) were based on data collected by OBG (1991).

Harbor Brook is represented by both river-type and drain-type boundaries. Between Onondaga Lake and monitoring well HB-4 the brook is modeled as a river-type boundary with a surface water elevation of 362.9 (110.6 m) ft above MSL (Figure DB.20). This portion of the brook is an open channel directly connected to the lake. The remainder of Harbor Brook is represented as a drain-type boundary (Figure DB.21). Between well HB-4 and the Hiawatha USGS gauging station, the drain elevation is based on a linear interpolation between the downstream elevation of 362.9 ft (110.6 m) above MSL and an upstream elevation of 367 ft (111.9 m) above MSL. The elevation of 367 ft (111.9 m) above MSL is the average low water level recorded at the Hiawatha gauging station between February 2002 and February 2004. Drain elevations between the Hiawatha gauging station and the edge of the model domain were estimated based on a linear interpolation between the Hiawatha and Syracuse gauging stations. The drain elevation at the Syracuse station was specified as 391 (119.2 m) ft above MSL. This elevation is based on the average low water level at the Syracuse gauging station between February 2002 and February 2004. Base flow data were developed for that portion of Harbor Brook that occurs within the model domain. These data, which are summarized below, were used for model calibration. These data indicate that base flow gain within the model domain is at least 0.16 cfs.

Harbor Brook Flow Data Based on USGS Gauging from 1970 to 2001

Downstream (Hiawatha Station) Flow (cfs)	Average Difference in Flow between the Hiawatha and Syracuse Stations (cfs)	Average Difference in Flow Adjusted to Model Domain (cfs)
< 5	0.5	0.4
< 4	0.3	0.24
< 3	0.2	0.16

The highway I-690 underdrains are a subsurface drainage system located under highway I-690 along the lakeshore adjacent to the Semet Ponds, Willis Avenue, and Harbor Brook sites. These underdrains, reportedly installed to drain groundwater from low areas of I-690 as well as to convey storm water, were represented by drain-type boundaries (Figure DB.21). The drain elevations were based on drawings provided by the New York State Department of Transportation (NYSDOT). For the drains located adjacent to the Semet Ponds and Willis Avenue sites, the west drain elevations ranged from 366.4 to 368.6 ft (111.7 m to 112.3 m) above MSL and the east drain elevations ranged from 366.6 to 370.7 ft (111.7 m to 113 m) above MSL. The combined base water flow from these drains is between 770 and 1,733 cubic feet per day (ft^3/day) (December 2000 to March 2003 OBG data). For the drains located adjacent to the Harbor Brook site the west drain elevations ranged from 385.4 to 394.1 ft (117.5 to 120.1 m) above MSL and the east drain elevations ranged from 385.4 to 396.6 ft (117.5 to 120.9 m) above MSL. No flow information is available for the Harbor Brook I-690 drains.

The East Flume was modeled as a river-type boundary condition with a surface water elevation of 367.3 ft (111.9 m) above MSL (Figure DB.20). The water level in the East Flume is higher than the lake due to a small dam located near the lake end of the flume. Water elevation for the East Flume was based on data collected on September 3, 1998. Other water levels collected on this date for the lake (362.6 ft [110.5 m] above MSL) and monitoring well WA-3S (366.8 ft (111.8 m) above MSL) were close to long-term average levels. Consequently, this single date was considered representative of the long-term average East Flume water levels.

The West Flume was represented as a drain-type boundary in the model (Figure DB.21). The drain elevation is 365 ft (111.2 m) above MSL adjacent to Geddes Brook and 385 ft (117.3 m) above MSL at the highest upstream location in the model domain. Elevations were based on stream elevations from the topographic map and stream gage data from the LCP Bridge Street RI/FS. In August 1994, a flow of 0.4 cfs was measured in the West Flume near it junction with Geddes Brook. For this model, this flow was assumed to represent average groundwater discharge to the West Flume

Ditches are present at various locations within the Harbor Brook site. These ditches provide limited groundwater drainage. The prominent ditches were represented in the model as drain-type boundaries (Figure DB.21). The drain elevations used to represent the ditches were estimated based on site topographic maps.

The 30-year (1961 to 1990) average annual precipitation at Syracuse is 38.93 inches (98.88 cm) according to the National Oceanic and Atmospheric Administration (NOAA) (BBL, 2000). Average monthly precipitation is relatively consistent, ranging from 2.15 inches (5.46 cm) in February to 3.81 inches (9.68 cm) in July. Considering the balancing effect of evapotranspiration, it was assumed that the yearly average groundwater recharge rates within the model domain would be relatively consistent throughout the year. Calibrated recharge rates in the model range from 1 to 5 inches (2 to 13 cm) per year, which represents approximately 3 to 13 percent of precipitation. This range of recharge percentages is considered reasonable, based on the variety of surface materials, topography, and urbanization in the model area. Low-to-moderate recharge values are considered reasonable, considering that much of the domain is either steep upland areas underlain by dense till or heavily developed lowland areas. These factors are expected to limit the percentage of precipitation that recharges the groundwater flow system over the majority of the model domain. The distribution of recharge rates in the model is shown on Figure DB.22.

Groundwater inflow into the model domain from the extension of the glacial trough to the southeast of Onondaga Lake was simulated with constant heads placed along the southeast edge of the model domain beneath the deepest portion of the trough in model layers 5 through 9.

DB.3.4 GROUNDWATER DENSITY DISTRIBUTION

Groundwater total dissolved solids (TDS) concentrations in the model domain range from about 400 mg/L in monitoring well HB-14S to almost 194,000 mg/L in monitoring well HB-20D. The range in TDS concentrations is caused by the presence of both naturally occurring salt brine and leachate from the Solvay waste deposits. Because of the TDS concentrations, groundwater density varies significantly (from 1.00 to 1.13) within the model domain (Table DB.4). The density of groundwater influences groundwater flow, and therefore a rigorous representation of the groundwater density distribution was incorporated in the Honeywell groundwater model. Groundwater density was measured at numerous wells within the model domain, and density was also calculated based on the TDS or total anion and cation data available for wells.

The available groundwater density data were contoured, and the density distribution was incorporated in the model. Figures DB.23 to DB.28 present the density distributions specified for each model layer.

DB.3.5 SOURCES AND SINKS

No active pumping wells were incorporated in the model. The pumping test completed at test well TW-1 was simulated as part of the calibration process, but no pumping was simulated for the steady state simulation of existing conditions.

SECTION DB.4

MODEL CALIBRATION

DB.4.1 SELECTION OF CALIBRATION TARGETS AND GOALS

Model calibration is the process in which a computer model is adjusted to improve the accuracy of the model and to demonstrate that the model is reasonably representative of observed site conditions. The overall purpose for model calibration is to increase the reliability of the model. The calibration process adjusts the model input parameters such that the model output reasonably correlates with the existing site data. A model that reasonably correlates with site data can be considered to provide a good representation of actual site conditions. The extent of calibration necessary for a model is guided by the objectives of the modeling effort, the complexity of the site, and the level of understanding of the site hydrogeology.

The groundwater model was calibrated using the automated computer program "PEST – Model Independent Parameter Estimation" (Doherty, 2002). A groundwater model is deemed calibrated when the difference between model outputs and field observations, referred to as calibration targets, has been reduced to a minimum in the weighted least squares sense (i.e., the sum of squared differences between model outputs and measurements, termed the objective function or phi [Φ]). Model calibration is an iterative process that seeks to reduce phi by determining the sensitivity of the model parameters to the calibration data. When the calibration process can no longer reduce phi (i.e., $\Phi = \Phi_{min}$), the parameters are considered optimal with respect to the measured data set and may be used to make predictions under conditions comparable to the calibration conditions. The computer program PEST automates the procedure of determining the minimum value of phi.

The first step in the model calibration process is the identification of measured hydrologic data that can be used as calibration targets. Three sets of formal calibration targets were identified: water levels in monitoring wells, drain and creek flows, and drawdowns during the aquifer test of TW-1. An estimate of average water levels in 188 monitoring wells located within the model area were developed and used as calibration targets. Water levels in the monitoring wells are from various periods of time but because annual water level fluctuations in most wells are small, they provide a reasonable estimate of water level conditions in the model area. Stream flow targets included measured flow in the I-690 under drains and base flow in Harbor Brook. The calibration targets, with the exception of the aquifer test drawdowns, are listed in Part B of this appendix. The aquifer test drawdowns are described in Section DB.4.9. These water level targets were assumed to represent average groundwater conditions. An analysis of seasonal changes in hydraulic gradients indicated that the changes were small and that groundwater flow conditions could be adequately represented using steady-state assumptions. An analysis of water level data indicates that the average range in water levels at a monitoring wells is 2.3 feet over the period of record.

The second step in the model calibration process is the selection of model parameters that can be varied in the model calibration process. Thirty-six zones were defined in the nine model layers, and hydraulic conductivity was estimated for each of these zones.

The third step in the model calibration process is the identification of conditioning information on model parameters. Two types of conditioning information were identified: estimates of aquifer hydraulic conductivity (from aquifer tests conducted in the Willis/Semet area and slug-tests) and geologic information. The aquifer test and slug test estimates of hydraulic conductivity were incorporated in the calibration process as a constraint on the estimated hydraulic conductivities. The known geologic information was incorporated into the calibration processes by the use of the geologic zones.

The fourth step in the calibration process is automated calibration using the computer program PEST. The result of this step is the calibrated groundwater model.

DB.4.2 AVERAGE GROUNDWATER ELEVATIONS

Groundwater elevation data for the monitoring wells in the model domain have been collected over a period of many years. The duration and frequency of measurement vary between each of the upland sites. Table DB.5 presents the groundwater elevations at 188 wells used during the model calibration (Figure DB.29). Supporting data for this table are included in Attachment DB.4. For some sites, groundwater elevation data are available for only one date. At other sites, long-term averages were used where extensive data were available. A comparison of the average groundwater elevations and the simulated groundwater elevations at the completion of calibration is presented on Table DB.5. Figure DB.30 provides graphic presentations of the results of model calibration. Figure DB.30 presents the average measured water table elevation, and DB.31 presents the simulated shallow (Layer 2) groundwater elevations. Figure DB.32 presents the average measured deep groundwater elevations, and DB.33 presents the simulated deep (Layer 6) groundwater elevations. Monitoring wells not used as calibration targets and a summary of all boring locations are listed on Table DB.6.

DB.4.3 I-690 UNDERDRAIN

The discharge from the I-690 underdrain adjacent to the Semet Ponds and Willis Avenue sites was periodically measured from 1999 to 2002 (O'Brien & Gere, 2002b). The mean base discharge is estimated to be between 770 and 1,733 ft^3/day (December 2000 to March 2003; OBG data). For model calibration, it was assumed that this base flow represents groundwater discharge to the underdrain. The model-simulated discharge to the underdrain is 1400 ft^3/day (7.4 gallons per minute [gpm]). The simulated discharge rate is within the range of measured discharges.

DB.4.4 HARBOR BROOK

Two USGS streamflow gauging stations (USGS 0420105 and USGS 04240100) are located on Harbor Brook upstream from where it discharges to Onondaga Lake. Daily streamflow data, for the years 1970 to 2001, from the upstream station was subtracted from the streamflow of the downstream station. The resulting flow rate represented the increase in flow for the stretch of the brook between the stations. It was assumed that the lower resultant flows represented baseflow, which was groundwater discharge to the brook. This baseflow was adjusted to reflect that portion of the brook stretch between the stations that was simulated in the model. The estimated increase in base flow within the model domain from Harbor Brook is 0.16 to 0.4 cfs. For model calibration, it was assumed that this base flow represents groundwater discharge to Harbor Brook. The model simulated discharge to Harbor Brook of 0.4 cfs (173 gpm). The simulated discharge rates are effectively the same, indicating that the model provides a good representation of shallow groundwater discharge to Harbor Brook.

DB.4.5 WEST FLUME

The estimated groundwater discharge in the West Flume is 0.4 cfs. This estimate was based on an analysis of measured flows in the flume as reported by Parsons (2003a) For model calibration, it was assumed that this flow represents groundwater discharge to the West Flume. The model-simulated discharge to the West Flume is 0.4 cfs (172 gpm). The simulated discharge rates are effectively the same, indicating that the model provides a good representation of shallow groundwater discharge to the West Flume.

DB.4.6 GEDDES BROOK

The estimated groundwater discharge within the model domain to Geddes Brook is 0.5 cfs to 1.7 cfs. The base flow of Geddes Brook where it discharges into Ninemile Creek is estimated to be between 3 and 7 cfs (Figure 3-13, TAMS and YEC,2003.). Approximately 30% of Geddes Brook is within the model domain (6,000 ft out of a total of 21,000 ft of stream length. Assuming that the brook gains water from groundwater discharge at a constant rate along its entire length, the discharge into the brook within the model domain is 30% of the total discharge. The flow of Geddes Brook also includes the flow of the West Flume. Adjusting the total base flow of Geddes Brook for the fraction within the model area and the discharge of the West Flume, the groundwater discharge to Geddes Brook within the model domain is estimated to be between 0.5 and 1.7 cfs. For model calibration, it was assumed that this flow represents groundwater discharge to Geddes Brook. The model simulated discharge to Geddes Brook of 0.3 cfs (131 gpm).

DB.4.7 CALIBRATION SUMMARY

Quantitative evaluation of the model calibration consisted of examining the residuals between the 188 measured water levels from the monitoring wells and the residuals from the two flow targets. The residual is defined as the target minus the calculated water level or flow. The calculated water levels and residuals are listed on Table DB.5.

The automated calibration process minimized the sum of the square of the residuals for the 188 monitoring wells to 2162 square feet (ft^2). To quantify the model error for the water levels in the calibrated model with easier-to-understand metrics, three statistics were calculated for the residuals: the mean of the residuals, the mean of the absolute value of the residuals, and the standard deviation of the residuals. The mean of the residuals was -0.1 ft (-0.03 m), the mean of the absolute value of the residuals was 3.1 ft (0.9 m), and the standard deviation of the residuals was 4.4 ft (1.3 m). The near-zero value of the mean residuals demonstrates that there is no systematic bias in the calibration. The absolute mean residual of 3.1 ft (0.9 m) is considered acceptable, since the observed water-level measurements applied as calibration targets have a total range of 83 ft (25.3 m). The standard deviation of 4.4 ft (1.3 m) is also acceptable given the range of water-level values, the complexity of near surface materials, and the large variations in groundwater density. A plot showing the correspondence between measured and calculated water levels and a histogram of residuals is shown on Figure DB.34. Plots showing a comparison between observed and calculated water levels at selected well clusters are shown on Figure DB.35 to illustrate the correspondence between observed and calculated water levels in vertical profiles.

DB.4.8 SENSITIVITY ANALYSIS

Model calibration is a process of determining the sensitivity of model results to changes in model parameters and using this information in an iterative manner to produce a model that produces a good correspondence between observed and calculated values. The parameter estimation program used in this study, PEST, calculates sensitivities to parameters during model calibration and uses these sensitivities in its search for optimal solutions. The sensitivities to parameters are calculated by the method of perturbation: a base run of the model is made and the sum of squares of the residuals is computed, then one of the parameters is changed by a fractional amount, the model is rerun, and the sum of squares of the residuals is recomputed. The difference in the sum of squares of the residuals between the two runs is a measure of the sensitivity to that parameter. The PEST program works by computing sensitivity to each parameter and then uses the information on the sensitivities to adjust parameter values to minimize the sum of squares of the residuals.

The sensitivity of model results to the value of hydraulic conductivity in the defined 35 hydraulic conductivity zones was computed using PEST. The calculated sensitivities indicated that model results are very sensitive to the parameters in 10 of the zones. The parameters to which the model is most sensitive and the relative sensitivity of the model results to these parameters are listed on the next page.

RELATIVE SENSITIVITY OF GROUNDWATER MODEL

Parameter	Relative Sensitivity
Hydraulic Conductivity – Layer 5: Beneath the lake	1.0
Hydraulic Conductivity – Layers 1 and 2: LCP area	.90
Hydraulic Conductivity – Layer 3: Beneath the lake	.80
Hydraulic Conductivity – Layer 6: Beneath the lake	.74
Hydraulic Conductivity – Layers 1 and 2: Willis Avenue area	.69
Hydraulic Conductivity – Layer 4: Beneath the lake	.67
Hydraulic Conductivity – Layer 1: At the Semet Ponds	.57
Hydraulic Conductivity – Layer 3: In Willis-Semet area where fine sand unit overlies the silt and clay unit	.57
Hydraulic Conductivity – Layer 3: Beneath the lake	.40
Hydraulic Conductivity – Layer 3: LCP area	.38

The relative sensitivity is a measure of the change that occurs in the computed sum of squares of the residuals for a fractional change in the value of the parameter. A larger relative sensitivity indicates that a fractional change in the given parameter will result in a larger change in model outputs. Therefore, the relative sensitivities are a useful measure of the effect different model parameters have on model results.

DB.4.9 TW-1 PUMPING TEST

A pumping test was performed on a test well (TW-1) located along the shore of Onondaga Lake north of the Semet Ponds site (OBG, 2002). This test well was screened in the basal medium sand and sand and gravel unit. Groundwater drawdown during the test was monitored in observation wells installed in the basal sand and gravel, medium sand, and the silt and fine sand units. This pumping test was simulated as part of the model calibration. Figure DB.35 presents the results of the calibration to the pumping test at selected monitoring wells. For the transient model run, a specific storage value of $3x10^{-4}$ was specified for model layers 2 through 5. In model Layer 1, a specific yield of 0.1 was specified, and in Layers 6, 7, 8, and 9, a specific storage of 1×10^{-6} was specified. Observed drawdown in the basal sand and gravel unit ranged from 1.66 ft (0.5 m) in OW-6, located 60 ft (18.3 m) from the pumping well, to 0.49 ft (0.14 m) in SP-7C, which is located about 340 ft (103.6 m) from the pumping well. Drawdown was also observed in the silt and fine sand unit overlying the basal sand and gravel (OW-2 and OW-7).

The model calculated drawdowns were similar to the observed drawdowns, as illustrated on Figure DB-35a for monitoring wells OW-4, OW-5, OW-6, OW-11, SP-7C, and WA-1D completed in the sand and gravel unit; monitoring well OW-2 completed in the silt and fine sand unit; and OW-7 completed in the silt and clay unit.

The sensitivity of the calculated drawdown to changes in three model parameters was investigated. The parameters varied in this analysis were hydraulic conductivity near TW-1 in the sand and gravel aquifer, storage coefficient in layers 4 and 5, and the vertical hydraulic conductivity of layer 5. The parameters used in the base simulation and the three sensitivity runs are listed below:

Simulation	**Hydraulic Conductivity near TW-1**	**Storage Coefficient in Layers 4 and 5**	**Vertical Hydraulic Conductivity in Layer 5**
Base	1000 ft/day	3E-4	0.22
Sensitivity 1	1000 ft/day	3E-4	0.14
Sensitivity 2	1000 ft/day	1E-4	0.22
Sensitivity 3	500 ft/day	3E-4	0.22

The calculated drawdowns for the three sensitivity simulations are shown on Figures Db.35b, DB.35c, and DB.35d. A review of the figures indicates that the drawdowns are relatively sensitive to changes in these three model parameters.

DB.4.10 CALCULATION OF LAKE BOTTOM FLUXES

The groundwater flux from the sediment to the lake was calculated for every lake node. The results of these analyses are described in Part A of this appendix. The sediment flux values described in Part A for SMUs 1, 2, 3, 6, and 7 were developed from a subset of the nodes within the lake in each of these SMUs. The nodes were chosen to represent typical conditions within the SMU. The nodes used for each SMU are listed below according to model column number and row number.

SMU 1

The following nodes were used to analyze fluxes in SMU 1 for developing the tables:

- Nodes between columns 148 and 154 and between rows 11 and 21,
- Nodes between columns 174 and 179 and between rows 11 and 21, and
- Nodes between columns 161 and 165 and between rows 10 and 20.

SMU 2

The nodes used to analyze fluxes in SMU 2 for developing the tables were all the nodes between columns 64 and 83 and between rows 24 and 36.

SMU 3

The nodes used to analyze fluxes in SMU 3 for developing the tables were all the nodes between columns 6 and 11 and between rows 2 and 12.

SMU6

The nodes used to analyze fluxes in SMU 6 for developing the tables were all the nodes between columns 198 and 216 and between rows 3 and 7.

SMU 7

The nodes used to analyze fluxes in SMU 7 for developing the tables are listed below by column and row in the format (column, row):

(216,9), (215,10), (215,11), (214,12), (213,13), (211,14), (210,12), (206,16),

(205,17), (215,9), (214,10), (214,11), (213,12), (211,13), (210,14), (201,17),

(204,16), (215,8), (214,8), (214,9), (213,10), (213,11), (212,12), (210,13),

(209,14), (205,15), (203,16), (201,17), (213,9), (213,10), (212,11), (211,12),

(208,14), (204,15), (202,16), (199,17), (213,8), (213,9), (213,10), (212,11),

(211,12), (208,14), (204,15), (202,16), (211,9), (210,10), (210,11), (209,12),

(204,14), (201,15), (198,16), (209,9), (208,10), (208,11), (207,12), (205,13),

(200,14), (197,15), (206,9), (206,10), (201,12), (198,13), (194,14), (204,9), (203,10),

(202,11), (201,12), (198,13), (194,14)

DB.4.11 REASONABLE UPPER BOUND ESTIMATE OF LAKE BOTTOM FLUXES

The computer programs SEAWAT-2000 and PEST were used to calculate reasonable upper bound estimates of the lake bottom fluxes. The procedure used to estimate the upper bound estimates of fluxes and the parameter values associated with these fluxes are described in this section.

In using PEST to calibrate the groundwater model based on SEAWAT-2000, the groundwater model was deemed to be calibrated when the difference between model outputs and field observations, referred to as calibration targets, were reduced to a minimum using a weighted least squares analysis (i.e., the sum of squared differences between model outputs and measurements, termed the objective function or Φ). In the calibrated groundwater model, the value of Φ was 2162, as described in Section DB.4.7.

For estimating reasonable upper bounds, it was assumed that the model is reasonably calibrated if Φ is less than 2500, an increase in Φ of about 16 percent from value in the calibrated model. This range was deemed to be a reasonable range for uncertainty associated with model calibration. The computer program PEST was used to calculate parameter values that produced a Φ of approximately 2500 and maximized the flux for a given SMU. In simple other words, the program PEST was asked to calculate the parameter values that maximize the calculated fluxes in SMU 1, for example, with the constraint that Φ could not be greater than 2500. As part of this process, fluxes were also calculated for the other SMUs with the parameter values that produce the maximum fluxes in SMU 1, but only the fluxes in SMU 1 represent reasonable upper bounds.

Four analyses were conducted in this manner using PEST, all with the constraint that Φ is less than 2500. The analyses differed only in the SMU for which the fluxes were maximized subject to the constraint: SMUs 1, 2, 3, and 7, respectively. No analysis was conducted to maximize fluxes in SMU 6, as the parameters that control the fluxes in SMUs 6 and 7 are similar; therefore, the analysis that produced the reasonable upper bound for fluxes in SMU 7 also produced reasonable upper bound estimates for fluxes in SMU 6. The parameter set in the calibrated groundwater model and the parameter sets calculated for each of the analyses are listed on Table DB.6. In addition, an estimate of the acceptable range of parameter values has been included on Table DB.6. The parameter zones on Table DB.6 are listed by the zone number assigned by the Groundwater Vistas program. For ease of reference, the zones are listed by the order used in the program.

Calculated lake bottom fluxes are presented in Part A of this appendix on Table DA.1 for the calibrated model and the four analyses described above. Much of the variation in the fluxes in the calibrated model and in the four upper bound analyses is a result of uncertainty in the recharge estimate. For example, the recharge rate south of the lake was specified as having an acceptable range of 0.5 inches per year to 2.0 inches per year. In the calibrated model, the recharge rate is 1 inch per year in this zone, and in the upper bound estimate for SMU 7 the recharge rate is 2 inches per year. The doubling of the recharge rate, alone, accounts for an approximate doubling of the calculated lake bottom fluxes in SMU 6 and SMU 7.

A set of model parameters that produces a Φ of 2500 would generally be considered to be less well calibrated than a model with a set of parameters that produces a Φ of 2160. In the uncertainty analyses, parameters that were determined to be insensitive to the model output were fixed.

SECTION DB.5

SUMMARY AND CONCLUSIONS

Honeywell developed a groundwater flow computer model to simulate groundwater flow beneath and in the vicinity of the southwestern part of Onondaga Lake. This model was developed to facilitate the understanding of groundwater flow and to assist in the evaluation of remedial approaches for Onondaga Lake and other Honeywell sites adjacent to the lake. The successful calibration of this model demonstrates that the model provides a reasonable representation of site groundwater flow and that the model is capable of addressing the model objectives.

SECTION DB.6

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APPENDIX D: PART B

TABLES

TABLE DB.1
GEOLOGIC DATA

	UTM Coordinates (NAD 83 ft)		Elevation (feet)							
Well/Boring ID	X-coordinate (ft)	Y-coordinate (ft)	Ground Elevation	Base of Fill	Bottom of Marl	Top of Silt and Clay	Top of Silt and Fine Sand	Top of Sand and Gravel	Top of Till	Top of Bedrock
493	1316739	15649010	389	369	-	-	369	-	-	317
494	1316842	15649104	394	362	-	-	362	317	312	307
495	1316946	15649234	419	364	-	-	364	-	317	302
#1	1315297	15646684	383	-	-	-	383	-	333	-
#10	1316007	15647301	381	-	-	-	381	-	346	-
#11	1315355	15644696	412	-	-	-	-	-	-	412
#12	1315348	15645131	403	392	-	-	392	-	387	382
#13	1315414	15645265	389	-	-	-	389	-	378	364
#3	1315395	15646822	384	377	-	-	377	347	337	-
#5	1315489	15646910	385	-	-	385	378	353	343	-
#7	1315647	15647068	381	374	-	-	374	360	344	-
#8	1315784	15646946	382	375	-	-	375	355	340	-
A-10MW	1318407	15644380	420	413	-	-	413	405	396	-
A-11B	1318488	15644250	420	416	-	-	-	416	401	-
A-12MW	1319120	15644610	411	390	389	-	389	-	377	-
A-13MW	1319499	15644233	429	417	-	-	417	401	-	399
A-15MW	1319772	15644439	432	424	-	-	-	-	424	-
A-16B	1319270	15645118	391	378	-	378	-	-	-	369
A-18MW	1319235	15645323	388	381	-	381	-	358	354	353
A-1MW	1316588	15644852	415	409	-	-	-	-	-	409
A-2MW	1317495	15644926	409	403	-	-	-	-	403	397
A-3MW	1317638	15644577	428	410	-	-	-	-	-	410
A-7MW	1317692	15645106	404	394	-	394	-	-	-	382
B-10	1314649	15652909	422	359	-	-	-	-	-	-
B-11	1314996	15653016	378	360	354	-	-	-	-	-
B-1C	1313613	15652985	426	362	-	-	-	-	-	-
B-2	1313752	15652157	427	362	-	-	-	-	-	-
B-3	1313680	15651884	399	368	-	368	350	-	-	-
B-4	1313876	15652854	426	361	349	-	-	-	-	-
B-5	1313228	15653204	425	360	359	-	-	-	-	-
B-6	1312860	15653457	387	360	-	-	-	-	-	-
B-7	1314042	15653107	428	362	346	-	-	-	-	-
B-76-1	1321503	15646776	363	301	299	299	-	-	-	-
B-76-2	1321495	15646494	363	313	-	313	-	-	-	-
B-76-3	1321480	15645939	375	338	329	329	313	301	300	-

TABLE DB.1
GEOLOGIC DATA

	UTM Coordinates (NAD 83 ft)		Elevation (feet)							
Well/Boring ID	X-coordinate (ft)	Y-coordinate (ft)	Ground Elevation	Base of Fill	Bottom of Marl	Top of Silt and Clay	Top of Silt and Fine Sand	Top of Sand and Gravel	Top of Till	Top of Bedrock
B-76-4	1321464	15645825	382	362	352	352	334	-	324	-
B-76-8	1320924	15646152	370	352	-	-	-	-	-	-
B-8	1314251	15653456	425	363	-	-	-	-	-	-
B-85-2	1312987	15652796	411	357	344	-	344	-	-	-
B-9	1314574	15653903	410	361	355	-	-	-	-	-
BFMW-01D	1320393	15645633	402	359	349	-	349	-	333	-
BFMW-02	1320609	15645496	402	359	349	-	349	-	-	343
BFMW-03I	1320874	15645255	407	360	350	-	-	-	350	-
BFMW-04D	1321357	15644887	401	360	349	349	-	342	337	-
BFMW-05I	1320955	15644971	400	361	357	-	-	-	357	-
BFMW-06I	1320158	15645353	405	362	354	354	-	-	351	-
BFMW-07S	1320364	15644994	387	373	-	-	-	-	373	-
BG-1	1315686	15645392	435	430	-	-	-	-	-	430
BG-2	1317729	15645039	440	436	-	-	-	-	-	436
Boring 19	1317753	15646385	405	394	-	-	-	-	-	394
CB-10* (B-10)	1313854	15647325	377	375	-	375	-	-	-	-
CB-11* (B-11)	1314331	15647168	377	375	-	375	368	-	-	-
CB-12* (B-12)	1314886	15646909	384	379	-	379	-	-	-	-
CB-13* (B-13)	1315367	15646801	384	383	-	383	-	-	-	-
CB-19* (B-19)	1317335	15646328	381	379	-	379	-	-	371	-
CB-20* (B-20)	1317816	15646184	380	375	-	-	-	-	375	371
CB-21* (B-21)	1318229	15646319	377	375	-	-	-	-	375	366
CB-22* (B-22)	1317751	15646788	382	367	363	-	-	-	-	-
CB-3* (B-3)	1310334	15648485	378	363	362	362	-	-	-	-
CB-4* (B-4)	1310714	15648355	378	369	368	368	-	-	-	-
CB-5* (B-5)	1311159	15648176	374	369	-	369	-	-	-	-
CB-6* (B-6)	1311853	15647975	375	369	-	369	-	-	-	-
CB-7* (B-7)	1312384	15647791	376	372	-	372	-	-	-	-
CB-8* (B-8)	1312974	15647652	375	371	-	371	-	-	-	-
CB-9* (B-9)	1313400	15647498	375	-	371	371	-	-	-	-
CM-107	1313946	15653467	424	362	-	-	-	-	-	-
CM-108	1313477	15653663	425	360	-	-	-	-	-	-
CM-109	1313301	15652637	427	363	-	-	-	-	-	-
CM-201	1314163	15653312	428	360	-	-	-	-	-	-
DAF-10	1323871	15643320	391	354	-	-	-	-	-	-

TABLE DB.1
GEOLOGIC DATA

Well/Boring ID	UTM Coordinates (NAD 83 ft) X-coordinate (ft)	Y-coordinate (ft)	Elevation (feet) Ground Elevation	Base of Fill	Bottom of Marl	Top of Silt and Clay	Top of Silt and Fine Sand	Top of Sand and Gravel	Top of Till	Top of Bedrock
DAF-2	1323791	15643457	375	356	320	320	280	-	268	-
DAF-3	1324533	15642997	373	367	297	297	272	-	257	-
DAF-31	1317779	15648188	365	356	349	349	-	-	324	-
DAF-34	1316996	15649158	395	379	-	379	374	-	-	-
DH-6	1315565	15646998	384	378	-	-	378	343	338	-
DH-9	1315814	15647168	381	-	-	-	381	354	344	-
DNF-1	1323711	15643300	370	355	329	329	283	280	278	-
DW-101	1315967	15651354	431	362	354	-	354	311	-	300
DW-102	1314345	15654047	410	-	347	-	347	-	-	-
DW-103	1313007	15652892	425	359	349	349	313	270	-	-
GP-05	1322277	15645048	379	351	350	-	-	-	-	-
GP-06	1322622	15644903	378	347	-	-	-	-	-	-
GP-07	1322766	15644805	378	350	-	-	-	-	-	-
GP-08	1320878	15645782	388	354	-	-	-	-	-	-
GP-09	1321040	15645631	386	356	354	-	-	-	-	-
GP-13	1321866	15645023	380	356	352	346	-	-	-	-
GP-14	1322007	15644872	381	357	-	-	-	-	-	-
GP-18	1322867	15644406	379	351	-	-	-	-	-	-
GP-19	1323030	15644238	369	357	-	-	357	-	-	-
GP-25	1322524	15643685	370	361	355	355	-	-	-	-
GP-26	1322610	15643735	377	358	350	350	-	-	-	-
GP-27	1322233	15643799	375	363	361	-	-	-	361	-
GP-28	1321984	15643907	376	360	-	-	-	-	360	-
GP-29	1321743	15643995	376	363	362	-	-	-	362	-
GP-30	1321957	15643741	379	-	-	-	379	370	366	-
GP-32	1322422	15644105	385	358	349	341	-	-	-	-
GP-34	1322189	15644105	392	355	348	348	-	-	-	-
GP-35	1321900	15644215	390	365	355	-	355	-	351	-
GP-36	1321695	15644261	390	359	353	353	-	-	-	-
GP-38	1321275	15644435	382	372	-	372	-	-	371	-
GP-39	1321202	15644646	385	362	-	-	-	-	362	-
H-2	1317881	15645240	399	391	-	-	-	-	391	-
H-5	1316892	15645387	406	391	-	-	391	-	387	-
H-8MW	1316501	15645223	405	392	-	-	392	-	-	357
HB-01D	1321804	15645833	368	320	-	320	282	-	277	-

TABLE DB.1
GEOLOGIC DATA

	UTM Coordinates (NAD 83 ft)		Elevation (feet)							
Well/Boring ID	X-coordinate (ft)	Y-coordinate (ft)	Ground Elevation	Base of Fill	Bottom of Marl	Top of Silt and Clay	Top of Silt and Fine Sand	Top of Sand and Gravel	Top of Till	Top of Bedrock
HB-02D	1322941	15644724	366	354	350	336	300	-	286	-
HB-03S	1321079	15646012	370	354	-	-	-	-	-	-
HB-04D	1323068	15644269	368	352	336	336	280	272	271	-
HB-05D	1322461	15645081	378	326	-	326	294	276	274	-
HB-06S	1323380	15644574	363	337	-	-	-	-	-	-
HB-07S	1322466	15643304	372	367	-	-	-	-	367	-
HB-08D	1322640	15643838	377	363	355	355	-	-	313	309
HB-09S	1321576	15644115	380	362	360	-	-	-	360	-
HB-10	1321395	15644807	393	358	350	-	-	-	-	-
HB-11I	1321704	15644652	395	359	350	350	-	333	331	-
HB-12D	1322260	15644263	392	356	346	341	-	-	304	-
HB-13D	1322342	15644091	390	362	356	346	-	306	304	-
HB-16D	1322683	15644485	379	351	337	337	305	275	272	-
HB-17D	1322045	15644405	394	357	349	339	-	319	-	-
HB-20D	1323671	15644449	364	343	327	327	242	238	230	-
HB-21I	1322892	15643754	378	359	343	-	-	-	-	-
INC-1	1313164	15652716	425	363	-	363	345	-	-	-
INC-2	1313734	15652231	425	361	351	342	325	-	-	-
L-11	1310267	15645378	436	429	-	-	-	-	429	-
L-12	1310266	15646110	425	419	-	-	-	-	419	-
L-128	1312971	15651197	368	-	-	-	368	-	299	-
L-150	1313097	15651123	367	-	355	-	355	-	303	286
L-152	1313347	15650928	372	-	-	372	362	-	321	283
L-2	1310123	15642282	497	-	-	-	-	-	497	-
L-51	1311199	15648151	373	-	-	-	373	-	330	293
L-64	1311749	15648948	368	-	-	368	334	-	304	288
L-67	1311928	15648855	369	-	-	369	350	309	300	289
L-74	1312171	15649562	367	365	-	365	347	305	-	-
L-91	1312588	15649966	369	-	-	369	360	-	312	305
LP-1	1316321	15649111	389	373	368	-	368	320	316	308
LP-2	1316270	15649056	385	368	-	-	368	328	<305	-
MS-104.1	1314197	15652372	427	360	349	-	-	-	-	-
MS-105.1	1313632	15652508	426	361	350	-	-	-	-	-
MS-106	1313706	15653371	427	363	350	-	-	-	-	-
MW-104	1318299	15645568	402	391	-	-	-	-	391	-

TABLE DB.1
GEOLOGIC DATA

	UTM Coordinates (NAD 83 ft)		Elevation (feet)							
Well/Boring ID	X-coordinate (ft)	Y-coordinate (ft)	Ground Elevation	Base of Fill	Bottom of Marl	Top of Silt and Clay	Top of Silt and Fine Sand	Top of Sand and Gravel	Top of Till	Top of Bedrock
MW-107	1318539	15645418	397	393	-	-	-	-	393	-
MW-108	1318668	15645453	397	391	-	-	-	-	391	-
MW-3AR	1313864	15646054	392	388	-	388	-	-	-	-
MW-5A	1313665	15646186	392	388	-	388	-	-	-	-
MW-6A	1313669	15646285	390	388	-	388	-	-	-	-
OW-11	1319433	15647243	370	356	346	324	308	280	259	-
OW-4	1318951	15647664	370	351	345	344	332	306	288	-
OW-5	1318738	15647815	372	353	345	345	335	306	300	-
OW-6	1319190	15647469	370	356	346	335	325	296	268	-
PP-1* (TH-1)	1314953	15648019	375	371	-	371	368	360	352	-
R-13	1318801	15644481	412	406	-	-	406	-	381	-
R-14MW	1318519	15644501	412	408	-	-	408	-	396	-
R-2	1318774	15645151	394	387	-	-	387	-	385	-
R-8MW	1318921	15644919	405	378	-	-	378	-	372	-
SP-2A	1317916	15646424	381	369	-	-	369	-	358	-
SP-3C	1319189	15646312	388	360	351	351	340	316	314	-
SP-4C	1318542	15646822	404	359	352	352	350	319	-	314
SP-5C	1318072	15647581	374	362	356	-	356	312	311	309
SP-6C	1319374	15646848	392	361	355	332	311	291	287	-
SP-7C	1319058	15647178	392	364	349	340	320	293	292	-
SP-8C	1318633	15647515	395	360	348	348	345	313	306	-
SP-9C	1317467	15646979	376	364	-	364	335	330	-	326
SS-1* (TH-1)	1313694	15648474	375	370	-	370	-	-	357	341
TB-1	1318571	15646029	387	365	-	-	-	-	365	-
TB-10	1318011	15647433	390	362	357	357	353	-	-	-
TB-11	1318391	15647599	396	360	351	351	-	-	-	-
TB-12	1318155	15647541	392	360	353	-	353	-	-	-
TB-13	1318664	15647488	396	362	352	352	-	-	-	-
TB-14	1318686	15647445	397	363	350	350	-	-	-	-
TB-15	1318697	15647501	390	362	348	-	-	-	-	-
TB-2	1318630	15646087	402	368	-	-	368	-	-	-
TB-3	1318442	15646238	403	368	-	368	-	-	360	-
TB-4	1318392	15646189	383	366	-	-	-	-	366	351
TB-5	1318151	15646398	384	368	-	-	368	340	-	-
TB-7	1317744	15646930	381	366	-	366	361	-	-	329

TABLE DB.1
GEOLOGIC DATA

	UTM Coordinates (NAD 83 ft)		Elevation (feet)							
Well/Boring ID	X-coordinate (ft)	Y-coordinate (ft)	Ground Elevation	Base of Fill	Bottom of Marl	Top of Silt and Clay	Top of Silt and Fine Sand	Top of Sand and Gravel	Top of Till	Top of Bedrock
TB-9	1317884	15647305	387	361	360	-	360	-	-	-
TH-100	1318576	15647960	370	344	-	344	340	-	-	-
TH-301	1325276	15644456	374	354	-	-	-	-	-	-
TH-302	1325298	15644551	374	360	-	-	-	-	-	-
TH-304	1325789	15645493	372	358	-	-	-	-	-	-
TH-305	1325740	15645243	371	357	333	333	241	-	-	-
TH-307	1325827	15644342	374	360	-	-	-	-	-	-
TH-308	1326019	15645101	375	361	-	-	-	-	-	-
TH-311	1326816	15645235	374	366	350	-	350	-	-	-
TH-312	1325172	15644930	372	358	-	-	-	-	-	-
TH-313	1325601	15645306	371	357	-	-	-	-	-	-
TH-314	1325847	15645982	370	360	-	-	-	-	-	-
TH-315	1326148	15645277	374	360	-	-	-	-	-	-
TH-316	1325264	15644763	373	357	-	-	-	-	-	-
TH-318	1325428	15645350	371	358	-	-	-	-	-	-
TH-325	1326166	15645457	373	356	-	-	-	-	-	-
TH-328	1326116	15644584	375	360	347	-	-	-	-	-
TH-330	1325199	15645315	376	367	-	-	-	-	-	-
TH-333	1324758	15644606	377	347	-	-	-	-	-	-
TH-334	1324838	15644746	379	359	-	-	-	-	-	-
TH-337	1325010	15644275	372	357	-	-	-	-	-	-
TH-7A	1307065	15646378	446	-	-	-	-	-	443	430
TH-8A	1308124	15646380	436	-	-	-	-	-	434	411
USGS Lake Saddle	1316051	15655925	307**	288***	283	283	168	-	-	-
USGS Spencer St.	1329092	15642449	378	364	-	-	233	-	23	3
USGS West Trail	1311532	15655779	341**	328***	313	313	278	-	261	237
W5	1313665	15646186	393	384	-	-	-	-	-	-
W6	1313818	15646344	390	386	-	385	-	-	-	-
W7	1313740	15646205	391	387	-	387	-	-	-	-
WA-1D	1319979	15646551	370	354	332	332	308	280	-	264
WA-2D	1320281	15646276	371	353	335	335	315	-	-	289
WA-3D	1320542	15646132	370	354	346	346	323	-	-	307
WA-4D	1320074	15645680	400	362	351	351	340	-	331	-
WA-5D	1319662	15645500	394	363	356	-	356	-	344	-
WA-6D	1318925	15645839	399	366	364	364	363	355	353	-

TABLE DB.1
GEOLOGIC DATA

	UTM Coordinates (NAD 83 ft)		Elevation (feet)							
Well/Boring ID	X-coordinate (ft)	Y-coordinate (ft)	Ground Elevation	Base of Fill	Bottom of Marl	Top of Silt and Clay	Top of Silt and Fine Sand	Top of Sand and Gravel	Top of Till	Top of Bedrock
WA-7D	1319757	15646058	388	360	349	346	332	-	310	-
WA-8D	1321911	15645079	380	356	343	336	319	306	303	-
WB-10U	1311061	15649997	377	374	361	-	361	-	-	-
WB-11U	1309364	15649992	378	373	-	373	357	-	-	-
WB-5R	1308027	15650347	386	374	-	374	364	333	265	252
WB-7L	1309603	15649964	378	371	-	371	358	319	311	275
WB-9U	1312188	15650388	375	367	-	367	365	-	-	-

Notes: - This geologic layer is not present on the boring log.
* These boring IDs were changed to avoid confusion with other boring of the same ID. The former boring names are listed in parentheses after the revised name.
** Elevation is the top of lake sediments based on boring log.
*** Elevation is the base of the lake sediements based on boring log.

TABLE DB.2
MODEL REPRESENTATION OF GEOLOGIC UNITS

	Model Location		Difference between Observed and Modeled Unit Tops (ft)					
Well ID	**Row**	**Column**	**Layer 3**	**Layer 4**	**Layer 5**	**Layer 6**	**Layer 7**	**Layer 8**
493	51	16	4	-	-3	-	-	-3
494	48	16	6	-	-1	-2	-1	-1
495	44	16	7	-	0	-	0	1
#1	105	20	-	-	-7	-	-6	-
#10	95	21	-	-	-11	-	-12	-
#11	112	48	-	0	0	0	0	0
#12	111	40	0	0	0	0	0	0
#13	110	39	-	-	-13	-	-12	-10
#3	104	19	6	-	-2	-5	-3	-
#5	103	20	-	-8	-6	-8	-8	-
#7	101	20	6	-	-1	-8	-5	-
#8	101	21	6	-	-1	-3	-2	-
A-10MW	102	109	0	0	0	0	0	0
A-11B	102	113	0	0	0	0	0	0
A-12MW	92	118	-	-	-	-	-	-
A-13MW	92	132	-	0	0	0	0	0
A-15MW	84	133	0	0	0	0	0	0
A-16B	80	112	5	-1	-	-	-	-2
A-18MW	77	108	-	-	-	-	-	-
A-1MW	108	68	-	0	0	0	0	0
A-2MW	104	83	0	0	0	0	0	0
A-3MW	105	91	-	0	0	0	0	0
A-7MW	101	84	-	0	0	0	0	0
B-10	18	4	5	-	-	-	-	-
B-11	14	4	4	-	-	-	-	-
B-1C	31	3	5	-	-	-	-	-
B-2	44	4	7	-	-	-	-	-
B-3	50	4	5	-2	13	-	-	-
B-4	29	3	6	-	-	-	-	-
B-5	34	2	5	-	-	-	-	-
B-6	35	2	5	-	-	-	-	-
B-7	22	3	5	-	-	-	-	-

TABLE DB.2
MODEL REPRESENTATION OF GEOLOGIC UNITS

	Model Location		Difference between Observed and Modeled Unit Tops (ft)					
Well ID	Row	Column	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8
B-76-1	16	125	38	0	-	-	-	-
B-76-2	19	130	32	0	-	-	-	-
B-76-3	27	139	5	0	-1	-1	-1	-
B-76-4	30	141	4	-1	-1	-	-1	-
B-76-8	33	125	4	-	-	-	-	-
B-8	16	3	5	-	-	-	-	-
B-85-2	45	2	7	-	-19	-	-	-
B-9	11	3	4	-	-	-	-	-
BFMW-01D	51	124	5	-	-2	-	-2	-
BFMW-02	50	130	5	-	-1	-	-	-2
BFMW-03I	50	139	5	-	-	-	-3	-
BFMW-04D	49	155	5	0	-	0	1	-
BFMW-05I	54	146	5	-	-	-	-3	-
BFMW-06I	60	125	5	1	-	-	-2	-
BFMW-07SS	64	135	6	-	-	-	-3	-
BG-1	109	42	-	0	0	0	0	0
BG-2	101	85	-	0	0	0	0	0
Boring 19	71	1	-	0	0	0	0	0
CB-10* (B-10)	108	11	0	-2	-	-	-	-
CB-11* (B-11)	107	13	1	-1	-2	-	-	-
CB-12* (B-12)	106	16	-	-	-	-	-	-
CB-13* (B-13)	104	19	-	-	-	-	-	-
CB-19* (B-19)	90	56	-	-	-	-	-	-
CB-20* (B-20)	85	68	5	-	-	-	-4	-4
CB-21* (B-21)	75	73	3	-	-	-	-9	-9
CB-22* (B-22)	75	56	5	-	-	-	-	-
CB-3* (B-3)	114	4	7	4	-	-	-	-
CB-4* (B-4)	113	4	1	-4	-	-	-	-
CB-5* (B-5)	113	5	5	-1	-	-	-	-
CB-6* (B-6)	112	6	1	-1	-	-	-	-
CB-7* (B-7)	111	7	0	-2	-	-	-	-
CB-8* (B-8)	110	9	2	0	-	-	-	-

TABLE DB.2
MODEL REPRESENTATION OF GEOLOGIC UNITS

	Model Location		Difference between Observed and Modeled Unit Tops (ft)					
Well ID	Row	Column	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8
CB-9* (B-9)	109	10	-	-1	-	-	-	-
CM-107	19	3	4	-	-	-	-	-
CM-108	21	2	4	-	-	-	-	-
CM-109	43	3	5	-	-	-	-	-
CM-201	18	3	6	-	-	-	-	-
DAF-10	35	224	5	-	-	-	-	-
DAF-2	34	222	5	1	0	-	1	-
DAF-3	30	230	4	38	0	-	0	-
DAF-31	49	33	5	0	-	-	0	-
DAF-34	44	16	-	-	-	-	-	-
DH-6	102	20	5	-	-4	2	-2	-
DH-9	98	20	-	-	-10	-10	-9	-
DNF-1	38	223	5	0	0	0	0	-
DW-101	22	8	5	-	-1	-1	-	-1
DW-102	12	3	-	-	-3	-	-	-
DW-103	43	2	5	1	9	9	-	-
GP-05	30	169	3	-	-	-	-	-
GP-06	27	178	5	-	-	-	-	-
GP-07	26	182	5	-	-	-	-	-
GP-08	40	131	5	-	-	-	-	-
GP-09	40	136	5	-	-	-	-	-
GP-13	38	162	5	0	-	-	-	-
GP-14	38	167	5	-	-	-	-	-
GP-18	32	190	5	-	-	-	-	-
GP-19	32	196	3	-	-23	-	-	-
GP-25	51	196	5	1	-	-	-	-
GP-26	49	197	6	1	-	-	-	-
GP-27	54	189	5	-	-	-	-4	-
GP-28	56	183	5	-	-	-	-5	-
GP-29	59	177	5	-	-	-	-3	-
GP-30	60	185	-	-	-17	-17	-16	-
GP-32	45	187	5	0	-	-	-	-

TABLE DB.2
MODEL REPRESENTATION OF GEOLOGIC UNITS

	Model Location		Difference between Observed and Modeled Unit Tops (ft)					
Well ID	Row	Column	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8
GP-34	49	183	6	0	-	-	-	-
GP-35	52	176	4	-	-1	-	-1	-
GP-36	54	171	5	0	-	-	-	-
GP-38	58	161	4	-3	-	-	-5	-
GP-39	56	156	6	-	-	-	-3	-
H-2	99	85	0	0	0	0	0	0
H-5	104	64	0	0	0	0	0	0
H-8MW	107	60	-	-	-	-	-	-
HB-01D	24	147	7	0	1	-	1	-
HB-02D	25	186	4	13	13	-	12	-
HB-03S	33	130	5	-	-	-	-	-
HB-04D	31	197	5	2	6	7	7	-
HB-05D	26	172	7	0	-1	-1	-1	-
HB-06S	21	197	13	-	-	-	-	-
HB-07S	59	202	5	-	-	-	-5	-
HB-08D	46	196	4	-1	-	-	0	0
HB-09S	59	172	5	-	-	-	-3	-
HB-10	50	157	6	-	-	-	-	-
HB-11I	47	165	5	0	-	0	0	-
HB-12D	45	182	5	0	-	-	-1	-
HB-13D	47	186	4	0	-	3	3	-
HB-16D	34	186	5	1	1	3	3	-
HB-17D	46	175	5	1	-	1	-	-
HB-20D	19	205	8	0	1	0	0	-
HB-21I	44	202	5	-	-	-	-	-
INC-1	44	3	4	-8	-5	-	-	-
INC-2	43	4	7	9	15	-	-	-
L-11	119	8	0	0	0	0	0	0
L-12	118	7	0	0	0	0	0	0
L-128	75	4	-	-	-12	-	-4	-
L-150	74	4	-	-	1	-	-7	-7
L-152	74	5	-	-11	-10	-	-9	-5

TABLE DB.2
MODEL REPRESENTATION OF GEOLOGIC UNITS

	Model Location		Difference between Observed and Modeled Unit Tops (ft)					
Well ID	**Row**	**Column**	**Layer 3**	**Layer 4**	**Layer 5**	**Layer 6**	**Layer 7**	**Layer 8**
L-2	123	14	0	0	0	0	0	0
L-51	113	5	-	-	-24	-	-23	-22
L-64	109	5	-	-4	0	-	-6	-4
L-67	109	5	-	-5	-15	-7	-1	-4
L-74	105	5	2	-1	0	1	-	-
L-91	100	5	-	-4	-5	-	-3	-5
LP-1	57	14	4	-	-1	1	-4	-4
LP-2	58	14	6	-	-2	-4	1	-
MS-104.1	33	4	5	-	-	-	-	-
MS-105.1	40	3	6	-	-	-	-	-
MS-106	23	3	4	-	-	-	-	-
MW-104	88	87	0	0	0	0	0	0
MW-107	87	94	0	0	0	0	0	0
MW-108	84	96	0	0	0	0	0	0
MW-3AR	112	15	-	-	-	-	-	-
MW-5A	112	14	-	-	-	-	-	-
MW-6A	112	14	-	-	-	-	-	-
OW-11	38	79	4	0	-1	-1	-1	-
OW-4	38	63	5	-2	-2	-2	-2	-
OW-5	39	57	4	-1	-1	-1	-2	-
OW-6	38	71	4	0	-1	-1	0	-
PP-1* (TH-1)	98	13	3	-1	-1	-2	-2	-
R-13	98	114	0	0	0	0	0	0
R-14MW	100	109	0	0	0	0	0	0
R-2	88	103	0	0	0	0	0	0
R-8MW	89	109	5	-	-2	-	-2	-
SP-2A	79	65	7	-	0	-	0	-
SP-3C	59	91	5	-1	-1	-1	-1	-
SP-4C	61	70	5	0	0	0	-	0
SP-5C	55	49	5	-	-2	-1	-2	-2
SP-6C	46	85	5	0	0	-1	-1	-
SP-7C	46	73	5	0	2	2	1	-

TABLE DB.2
MODEL REPRESENTATION OF GEOLOGIC UNITS

	Model Location		Difference between Observed and Modeled Unit Tops (ft)					
Well ID	**Row**	**Column**	**Layer 3**	**Layer 4**	**Layer 5**	**Layer 6**	**Layer 7**	**Layer 8**
SP-8C	47	60	6	1	1	1	1	-
SP-9C	76	48	5	-1	0	-1	-	0
SS-1* (TH-1)	103	9	1	-1	-	-	-2	-2
TB-1	75	84	6	-	-	-	-3	-
TB-10	59	50	5	0	1	-	-	-
TB-11	49	54	5	0	-	-	-	-
TB-12	54	51	5	-	-1	-	-	-
TB-13	47	61	5	-1	-	-	-	-
TB-14	47	62	5	1	-	-	-	-
TB-15	46	61	5	-	-	-	-	-
TB-2	73	84	5	-	-3	-	-	-
TB-3	73	78	5	-1	-	-	-1	-
TB-4	75	78	6	-	-	-	-4	-3
TB-5	75	70	5	-	-2	1	-	-
TB-7	72	54	5	-1	-1	-	-	-1
TB-9	63	50	5	-	-1	-	-	-
TH-100	39	51	5	-9	-9	-	-	-
TH-301	9	227	7	-	-	-	-	-
TH-302	9	227	2	-	-	-	-	-
TH-304	4	224	5	-	-	-	-	-
TH-305	5	225	5	0	-1	-	-	-
TH-307	8	231	5	-	-	-	-	-
TH-308	5	228	5	-	-	-	-	-
TH-311	3	231	4	-		-	-	-
TH-312	8	223	4	-	-	-	-	-
TH-313	5	223	5	-	-	-	-	-
TH-314	3	219	1	-	-	-	-	-
TH-315	4	228	5	-	-	-	-	-
TH-316	8	225	5	-	-	-	-	-
TH-318	6	221	2	-	-	-	-	-
TH-325	3	227	7	-	-	-	-	-
TH-328	6	231	5	-	-	-	-	-

TABLE DB.2
MODEL REPRESENTATION OF GEOLOGIC UNITS

	Model Location		Difference between Observed and Modeled Unit Tops (ft)					
Well ID	Row	Column	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8
TH-330	6	218	-12	-	-	-	-	-
TH-333	11	221	5	-	-	-	-	-
TH-334	10	221	0	-	-	-	-	-
TH-337	11	226	4	-	-	-	-	-
TH-7A	121	2	0	0	0	0	0	0
TH-8A	120	3	0	0	0	0	0	0
USGS Lake Saddle	1	2	-	-6	-6	-	-	-
USGS Spencer St.	4	242	5	-	0	-	0	1
USGS West Trail	outside model area		0	0	0	0	0	0
W5	112	14	-	-	-	-	-	-
W6	111	14	-	-	-	-	-	-
W7	112	14	-	-	-	-	-	-
WA-1D	42	101	5	0	1	1	-	2
WA-2D	41	111	4	-1	-1	-	-	-2
WA-3D	40	118	5	-1	0	-	-	-1
WA-4D	56	118	5	0	1	-	1	-
WA-5D	66	113	5	-	-1	-	-1	-
WA-6D	72	94	5	0	-1	-1	-1	-
WA-7D	54	105	5	0	-1	-	-1	-
WA-8D	36	162	5	2	2	2	2	-
WB-10U	108	3	5	-	-2	-	-	-
WB-11U	113	1	5	-1	1	-	-	-
WB-5R	outside model area		0	0	0	0	0	0
WB-7L	112	2	5	-3	-2	-2	-1	0
WB-9U	100	4	5	-1	-3	-	-	-

Notes: * These boring ids were changed to avoid confusion with other boring of the same id.
The former boring names are listed in parentheses after the revised name.
- Not Applicable

TABLE DB.3
HYDRAULIC CONDUCTIVITY VALUES

Layer	Model Hydraulic Conductivity Values	
	K_h (ft/day)	K_v (ft/day)
1 + 2	0.15 - 50	0.0015 - 5
3	0.002 - 50	0.0002 - 4
4	0.06 - 40	0.0006 - 4
5	1.2 - 40	0.12 - 4
6	1.2 - 1000	0.12 - 100
7	0.05 - 1.2	0.005 - 0.12
8 + 9	1.2	0.12

Unit	Model Hydraulic Conductivity Values		Measured Hydraulic Conductivity Values	
	K_h (ft/day)	K_v (ft/day)	K_h (ft/day)	K_v (ft/day)
Fill	0.15 - 50	0.0015 - 5	0.028 - 230	0.006 - 0.06
Marl	0.002 - 5	0.0002 - 0.01	0.003 - 9.07	0.0003 - 0.022
Silt and Clay	0.06 - 0.14	0.0006 - 0.0014	0.0003 - 0.54	0.0001 - 0.0096
Fine Sand and Silt	1.6 - 28	0.16 - 0.22	0.02 - 5.4	0.0004 - 0.022
Sand and Gravel	10 - 1000	1 - 100	0.099 - 1073	NA
Till	0.05	0.005	0.056 - 250	NA
Bedrock	1.2	0.12	0.00003 - 1.13	NA

Notes: K_h : Horizontal hydraulic conductivity
K_v : Vertical hydraulic conductivity

TABLE DB.4
CALCULATED DENSITIES AT SELECTED MONITORING WELLS

Well ID	Ground water Zone	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Midpoint Screen Elevation (ft)	Average Ground Water Elevation (ft)	Density	Fresh Water Equivalent Head Elevation (ft)	Difference Avg. Groundwater Elevation and Fresh Water Equivalent Elevation
Average Ground Water elevations from monitoring 1991 through 2003.										
BFMW-01D	D	Ballfield	401.8	403.5	353.8 - 343.8	348.8	374.5	1.07	376.3	1.8
BFMW-01I	I	Ballfield	401.8	404.1	357.8 - 347.8	352.8	377.3	1.01	377.5	0.2
BFMW-01S	S	Ballfield	401.8	404.3	389.8 - 379.8	384.8	381.9	1.00	381.9	0.0
BFMW-02	S	Ballfield	402.4	404.9	396.4 - 386.4	391.4	386.0	1.00	386.0	0.0
BFMW-03I	I	Ballfield	406.9	409.4	358.9 - 348.9	353.9	376.7	1.08	378.5	1.8
BFMW-03S	S	Ballfield	407.0	409.4	389.5 - 379.5	384.5	381.4	1.00	381.4	0.0
BFMW-04D	D	Ballfield	400.9	400.4	350.3 - 340.3	345.3	374.5	1.07	376.6	2.0
BFMW-04I	I	Ballfield	401.3	400.8	359.2 - 349.2	354.2	376.9	1.00	376.9	0.0
BFMW-04S	S	Ballfield	401.2	400.9	389.2 - 379.2	384.2	380.0	1.00	380.0	0.0
BFMW-05I	I	Ballfield	400.1	400.0	361.1 - 356.1	358.6	380.7	1.07	382.2	1.5
BFMW-05S	S	Ballfield	400.0	399.7	384.0 - 374.0.	379.0	382.0	1.00	382.0	0.0
BFMW-06I	I	Ballfield	405.2	407.8	363.2 - 353.2	358.2	378.2	1.06	379.4	1.2
BFMW-06S	S	Ballfield	405.3	408.0	393.3 - 383.3	388.3	385.8	1.00	385.8	0.0
BFMW-07S	S	Ballfield	387.2	389.6	383.5 - 373.5	378.5	382.1	1.00	382.1	0.0
HB-01D	D	Lakeshore	368.3	370.9	281.9 - 276.9	279.4	370.2	1.05	374.7	4.5
HB-01S	S	Lakeshore	368.4	371.1	363.4 - 358.4	360.9	363.3	1.00	363.3	0.0
HB-02I	I	Lakeshore	365.4	367.4	343.4 - 333.4	338.4	362.3	1.07	364.0	1.7
HB-02S	S	Lakeshore	365.5	367.4	361.5 - 351.5	356.5	363.7	1.00	363.7	0.0
HB-03S	S	Lakeshore	369.7	372.0	364.7 - 354.7	359.7	367.5	1.00	367.5	0.0
HB-04D	D	Lakeshore	368.4	370.3	280.4 - 270.4	275.4	372.7	1.04	376.6	3.9
HB-04S	S	Lakeshore	367.8	370.3	359.8 - 349.8	354.8	363.3	1.01	363.4	0.1
HB-05D	D	Lakeshore	378.0	379.7	280.0 - 270.0	275.0	369.5	1.08	377.0	7.6
HB-05I	I	Lakeshore	377.9	380.2	333.9 - 323.9	328.9	364.9	1.04	366.3	1.4
HB-05S	S	Lakeshore	377.5	379.7	370.5 - 360.5	365.5	366.3	1.00	366.3	0.0
HB-06S	S	Lakeshore	363.4	365.7	360.4 - 350.4	355.4	362.7	1.03	362.9	0.2
HB-07S	S	Harbor Brook	371.9	374.6	368.9 - 363.9	366.4	371.0	1.00	371.0	0.0
HB-08D	D	Harbor Brook	376.9	379.2	318.9 - 308.9	313.9	374.3	1.02	375.5	1.2
HB-08I	I	Harbor Brook	376.4	378.9	364.4 - 354.4	359.4	369.8	1.00	369.8	0.0
HB-08S	S	Harbor Brook	376.2	378.8	371.2 - 366.2	368.7	369.9	1.00	369.9	0.0
HB-09S	S	Harbor Brook	379.8	382.1	374.8 - 364.8	369.8	376.4	1.00	376.4	0.0
HB-11I	I	Harbor Brook	394.5	394.1	359.5 - 349.5	354.5	375.7	1.00	375.7	0.0
HB-11S	S	Harbor Brook	394.5	394.2	390.5 - 380.5	385.5	383.8	1.00	383.8	0.0
HB-12D	D	Harbor Brook	392.0	394.0	314.0 - 304.0	309.0	374.6	1.00	374.6	0.0
HB-12I	I	Harbor Brook	392.0	394.4	352.0 - 342.0	349.5	374.2	1.00	374.2	0.0
HB-12S	S	Harbor Brook	392.0	394.4	386.0 - 376.0	381.0	380.5	1.00	380.5	0.0
HB-13D	D	Harbor Brook	389.5	391.1	313.5 - 303.5	308.5	374.8	1.01	375.5	0.7
HB-14D	D	Harbor Brook	390.3	390.0	362.3 - 352.3	357.3	376.3	1.00	376.3	0.0

TABLE DB.4
CALCULATED DENSITIES AT SELECTED MONITORING WELLS

Well ID	Ground water Zone	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Midpoint Screen Elevation (ft)	Average Ground Water Elevation (ft)	Density	Fresh Water Equivalent Head Elevation (ft)	Difference Avg. Groundwater Elevation and Fresh Water Equivalent Elevation
HB-14S	S	Harbor Brook	390.5	390.0	383.5 - 378.5	381.0	380.9	1.00	380.9	0.0
HB-16D	D	Lakeshore	378.8	380.4	281.8 - 271.8	276.8	368.9	1.08	376.2	7.4
HB-17D	D	Lakeshore	394.3	394.0	327.3 - 317.3	322.3	376.2	1.00	376.2	0.0
HB-20D	D	Lakeshore	363.5	365.2	238.5 - 228.5	233.5	363.5	1.13	380.4	16.9
HB-20I	I	Lakeshore	363.5	365.1	335.5 - 325.5	330.5	363.0	1.05	364.7	1.6
HB-20S	S	Lakeshore	363.5	365.0	359.5 - 349.5	354.5	363.3	1.01	363.4	0.1
OW-10	I	Lakeshore	370.1	371.8	356.1 - 346.1	351.1	363.7	1.04	364.2	0.5
OW-11	D	Lakeshore	370.4	371.6	269.4 - 259.4	264.4	370.7	1.05	376.1	5.3
OW-2	D	Lakeshore	370.1	371.9	316.1 - 306.1	311.1	371.6	1.04	374.1	2.4
OW-4	D	Lakeshore	369.7	371.0	297.7 - 287.7	292.7	370.6	1.04	373.7	3.1
OW-5	D	Lakeshore	371.7	372.6	309.7 - 299.7	304.7	371.3	1.04	373.7	2.3
OW-6	D	Lakeshore	370.0	371.4	278.0 - 268.0	273.0	370.5	1.05	374.9	4.4
OW-7	D	Lakeshore	370.2	371.8	306.2 - 296.2	301.2	370.7	1.07	375.5	4.9
SP-3A	S	Semet Ponds	388.2	390.3	374.2 - 364.2	369.2	381.9	1.00	381.9	0.0
SP-3B	I	Semet Ponds	388.2	389.7	354.2 - 344.2	349.2	377.4	1.01	377.7	0.3
SP-3C	D	Semet Ponds	388.4	390.1	322.4 - 312.4	317.4	372.9	1.00	372.9	0.0
SP-4A	S	Semet Ponds	403.6	405.5	375.6 - 365.6	370.6	394.7	1.00	394.7	0.0
SP-4B	I	Semet Ponds	403.7	405.6	351.7 - 341.7	346.7	373.9	1.05	375.2	1.4
SP-4C	D	Semet Ponds	404.1	405.9	328.1 - 318.1	323.1	370.8	1.07	374.1	3.3
SP-5A	S	Semet Ponds	373.4	375.1	365.4 - 355.4	360.4	366.8	1.00	366.8	0.0
SP-5B	I	Semet Ponds	373.5	375.2	339.5 - 329.5	334.5	370.1	1.05	371.9	1.8
SP-5C	D	Semet Ponds	373.6	375.4	319.6 - 309.6	314.6	373.0	1.01	373.6	0.6
SP-6A	S	Semet Ponds	391.8	393.5	371.8 - 361.8	366.8	376.7	1.00	376.7	0.0
SP-6B	I	Semet Ponds	392.2	394.0	344.2 - 334.2	339.2	371.7	1.00	371.7	0.0
SP-6C	D	Semet Ponds	392.1	393.9	296.1 - 286.1	291.1	370.8	1.02	372.4	1.6
SP-7A	S	Semet Ponds	391.4	393.1	375.4 - 365.4	370.4	377.0	1.00	377.0	0.0
SP-7B	I	Semet Ponds	391.6	393.4	347.6 - 337.6	342.6	371.7	1.00	371.7	0.0
SP-7C	D	Semet Ponds	391.7	393.4	303.7 - 293.7	298.7	373.2	1.03	375.4	2.2
SP-8A	S	Semet Ponds	395.7	397.8	377.7 - 367.7	372.7	380.0	1.00	380.0	0.0
SP-8B	I	Semet Ponds	395.7	397.7	347.7 - 337.7	342.7	370.8	1.05	372.2	1.4
SP-8C	D	Semet Ponds	395.4	397.5	317.4 - 307.4	312.4	373.1	1.01	373.8	0.6
SP-9A	S	Semet Ponds	375.6	377.5	369.6 - 359.6	364.6	369.7	1.00	369.7	0.0
SP-9B	I	Semet Ponds	375.3	377.5	351.3 - 341.3	346.3	371.5	1.00	371.5	0.0
SP-9C	D	Semet Ponds	375.5	377.2	333.5 - 323.5	328.5	373.4	1.00	373.4	0.0
WA-1D	D	Lakeshore	370.1	373.4	273.5 - 263.5	268.5	370.3	1.04	374.3	4.1
WA-1S	S	Lakeshore	369.5	371.2	363.0 - 353.0	358.0	363.9	1.00	363.9	0.0
WA-2D	D	Lakeshore	371.2	375.6	297.7 - 287.7	292.7	373.1	1.03	375.5	2.4
WA-2S	S	Lakeshore	371.0	372.8	363.0 - 353.0	358.0	362.8	1.00	362.8	0.0

TABLE DB.4
CALCULATED DENSITIES AT SELECTED MONITORING WELLS

Well ID	Ground water Zone	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Midpoint Screen Elevation (ft)	Average Ground Water Elevation (ft)	Density	Fresh Water Equivalent Head Elevation (ft)	Difference Avg. Groundwater Elevation and Fresh Water Equivalent Elevation
WA-3D	D	Lakeshore	370.4	374.8	316.9 - 306.9	311.9	373.2	1.02	374.4	1.2
WA-3S	S	Lakeshore	370.1	372.0	367.1 - 357.1	362.1	367.1	1.00	367.1	0.0
WA-8D	D	Lakeshore	380.3	382.5	310.3 - 300.3	305.3	372.5	1.03	374.6	2.0
WA-8I	I	Lakeshore	380.3	382.3	350.3 - 340.3	345.3	371.3	1.01	371.6	0.3
WA-8S	S	Lakeshore	380.5	382.7	371.5 - 361.5	366.5	371.7	1.00	371.7	0.0
WA-3I	I	Lakeshore	370.5	372.6	350.5-340.5	345.5	366.9	1.01	367.1	0.2
WA-4D	D	Willis Avenue	400.2	402.5	340.2 - 330.2	335.2	375.3	1.03	376.5	1.2
WA-4I	I	Willis Avenue	399.5	401.1	359.5 - 349.5	354.5	375.8	1.00	375.8	0.0
WA-4S	S	Willis Avenue	400.6	402.3	377.6 - 367.6	372.6	377.6	1.00	377.6	0.0
WA-5D	D	Willis Avenue	394.0	395.8	354.0 - 344.0	349.0	376.7	1.02	377.2	0.6
WA-5I	I	Willis Avenue	394.0	395.7	368.0 - 358.0	363.0	377.9	1.00	377.9	0.0
WA-5S	S	Willis Avenue	393.9	395.8	381.9 - 371.9	376.9	378.1	1.00	378.1	0.0
WA-6D	D	Willis Avenue	398.6	400.0	362.6 - 352.6	357.6	376.9	1.00	376.9	0.0
WA-6S	S	Willis Avenue	399.4	401.1	382.9 - 372.9	377.9	378.2	1.00	378.2	0.0
WA-7D	D	Willis Avenue	387.7	389.4	317.7 - 307.7	312.7	374.4	1.01	375.0	0.6
WA-7I	I	Willis Avenue	387.4	389.2	357.4 - 347.4	352.4	371.1	1.05	372.0	0.9
WA-7S	S	Willis Avenue	387.8	389.7	377.8 - 367.8	372.8	376.3	1.00	376.3	0.0
Wastebeds (WBs) 1-8: Fresh Water Equivalent Heads, BBL, 2000										
CM-201	S	WBs 1-8	428.2	NA	403.2 - 379.2	391.2	404.5	1.01	404.6	0.1
DW-101	D	WBs 1-8	431.0	433.2	309 - 299	304.0	372.5	1.07	377.3	4.8
DW-102	D	WBs 1-8	410.2	412.8	282 - 272	277.0	372.0	1.12	382.9	10.9
DW-103	D	WBs 1-8	424.9	NA	267.9 - 262.9	265.4	373.9	1.06	380.2	6.3
MS-104.1	D	WBs 1-8	426.8	NA	352.8 - 347.8	350.3	377.8	1.09	380.2	2.4
MS-104.2	S	WBs 1-8	426.8	NA	373.8 - 363.8	368.8	405.2	1.13	410.0	4.8
MS-104.4	S	WBs 1-8	426.8	428.5	393.8 -383.8	388.8	404.6	1.01	404.7	0.1
MS-105.1	D	WBs 1-8	425.8	NA	359.3 - 354.3	356.8	390.0	1.03	390.9	0.9
MS-105.2	S	WBs 1-8	425.8	NA	371.8 - 361.8	366.8	399.9	1.03	401.0	1.1
MS-105.4	S	WBs 1-8	425.8	NA	392.3 - 382.3	387.3	401.0	1.00	401.0	0.0
Wastebeds (WBs) 9-15: Fresh Water Equivalent Heads										
WB-7L	D	WBs 9-15	377.5	379.7	305.5 - 300.5	303.0	370.3	1.03	372.4	2.1
WB-7U	D	WBs 9-15	377.5	380.3	329.5 - 324.5	327.0	371.0	1.03	372.2	1.2

Notes: - Not available
(WBs) - Wastebeds
(S,I,D) - Shallow, intermediate and deep ground water zones

TABLE DB.5
MEASURED AND CALCULATED GROUNDWATER LEVELS

Well ID	Groundwater Zone (S,I,D)	Site/Location	UTM Coordinates (NAD 83 ft)		Model Location			Water Levels		
			X(UTM)	Y(UTM)	Layer	Row	Column	Average Groundwater Elevation (ft)	Calculated Groundwater Elevation (ft)	Residual
A-12MW	S	Main Plant	1319120	15644610	1	92	118	402.7	399.6	3.1
A-14MW	S	Main Plant	1319795	15644239	1	87	137	416.4	400.7	15.7
A-15MW	S	Main Plant	1319772	15644439	1	84	133	426.3	397.9	28.4
A-18MW	S	Main Plant	1319235	15645323	2	77	108	378.2	383.2	-5.0
A-1MW	S	Main Plant	1316588	15644852	1	108	68	409.7	405.0	4.7
A-2MW	S	Main Plant	1317495	15644926	1	104	83	402.4	403.6	-1.2
A-6MW	S	Main Plant	1318138	15644654	1	101	99	402.7	404.6	-1.9
A-7MW	S	Main Plant	1317692	15645106	1	101	84	399.7	400.6	-0.9
AW-2	S	LCP	1313893	15646215	2	112	15	389.4	385.6	3.8
AW-3	S	LCP	1313895	15646077	2	112	15	389.5	387.2	2.3
BFMW-01D	D	Ballfield	1320393	15645633	5	51	124	374.5	377.9	-3.3
BFMW-01I	I	Ballfield	1320397	15645643	3	51	124	377.3	377.6	-0.2
BFMW-01S	S	Ballfield	1320395	15645639	1	51	124	381.9	378.3	3.7
BFMW-02	S	Ballfield	1320609	15645496	1	50	130	386.0	380.3	5.8
BFMW-03I	I	Ballfield	1320874	15645255	3	50	139	376.7	379.9	-3.1
BFMW-03S	S	Ballfield	1320870	15645259	1	50	139	381.4	382.0	-0.6
BFMW-04D	D	Ballfield	1321357	15644887	4	49	155	374.5	378.4	-3.8
BFMW-04I	I	Ballfield	1321361	15644888	3	49	155	376.9	379.9	-3.0
BFMW-04S	S	Ballfield	1321357	15644892	1	49	154	380.0	381.6	-1.7
BFMW-05I	I	Ballfield	1320955	15644971	3	54	146	380.7	381.0	-0.2
BFMW-05S	S	Ballfield	1320955	15644969	1	54	146	382.1	383.2	-1.1
BFMW-06I	I	Ballfield	1320158	15645353	3	60	125	378.2	379.5	-1.2
BFMW-06S	S	Ballfield	1320165	15645352	1	60	125	385.8	379.8	6.1
BFMW-07S	S	Ballfield	1320364	15644994	1	64	135	382.1	383.2	-1.0
C-1	S	Main Plant	1318291	15645062	1	96	95	400.5	398.0	2.5
C-11	S	Main Plant	1317452	15645123	1	103	79	399.7	401.3	-1.6
C-12	S	Main Plant	1317385	15645147	1	103	77	397.9	401.2	-3.3
C-13	S	Main Plant	1317432	15645163	1	102	78	395.1	400.8	-5.7
C-14	S	Main Plant	1317562	15645138	1	102	81	396.2	400.7	-4.5
C-15	S	Main Plant	1317203	15645159	1	104	74	397.7	401.4	-3.7
C-2	S	Main Plant	1318086	15645083	1	98	91	399.8	399.0	0.9
C-3	S	Main Plant	1318254	15645093	1	96	94	401.1	397.8	3.3
C-5	S	Main Plant	1318156	15645115	1	97	92	398.2	398.1	0.1
CM-201	S	WB 1-8	1314163	15653312	1	18	3	404.5	406.4	-1.8
DW-101	D	WB 1-8	1315967	15651354	6	22	8	372.5	370.2	2.3
DW-102	D	WB 1-8	1314345	15654047	5	12	3	372.0	365.2	6.9

TABLE DB.5
MEASURED AND CALCULATED GROUNDWATER LEVELS

Well ID	Groundwater Zone (S,I,D)	Site/Location	UTM Coordinates (NAD 83 ft)		Model Location			Water Levels		
			X(UTM)	Y(UTM)	Layer	Row	Column	Average Groundwater Elevation (ft)	Calculated Groundwater Elevation (ft)	Residual
DW-103	D	WB 1-8	1313007	15652892	6	43	2	373.9	367.9	6.1
H-10MW	S	Main Plant	1317230	15645192	1	103	74	398.0	401.0	-3.0
H-8MW	S	Main Plant	1316501	15645223	1	107	60	397.3	400.2	-2.9
HB-01D	D	Lakeshore	1321804	15645833	6	24	147	370.2	372.3	-2.1
HB-01S	S	Lakeshore	1321808	15645832	1	24	147	363.3	364.0	-0.8
HB-02I	I	Lakeshore	1322941	15644724	3	25	186	362.3	364.6	-2.2
HB-02S	S	Lakeshore	1322937	15644720	2	25	186	363.7	364.9	-1.1
HB-03S	S	Lakeshore	1321079	15646012	1	33	130	367.5	367.5	0.0
HB-04D	D	Lakeshore	1323068	15644269	6	31	197	372.7	373.7	-1.1
HB-04S	S	Lakeshore	1323076	15644274	2	31	197	363.3	364.7	-0.8
HB-05D	D	Lakeshore	1322461	15645081	6	26	172	369.5	369.9	-0.4
HB-05I	I	Lakeshore	1322461	15645094	3	26	171	364.9	368.5	-3.7
HB-05S	S	Lakeshore	1322460	15645090	1	26	171	366.3	365.0	1.3
HB-06S	S	Lakeshore	1323380	15644574	2	21	197	362.7	363.4	-0.4
HB-07S	S	Harbor Brook	1322466	15643304	1	59	202	371.0	367.8	3.2
HB-08D	D	Harbor Brook	1322640	15643838	6	46	196	374.3	376.5	-2.3
HB-08I	I	Harbor Brook	1322646	15643837	3	46	196	369.8	369.1	0.7
HB-08S	S	Harbor Brook	1322641	15643846	2	46	196	369.9	368.6	1.3
HB-09S	S	Harbor Brook	1321576	15644115	1	59	172	376.4	381.5	-5.2
HB-11I	I	Harbor Brook	1321704	15644652	3	47	165	375.7	378.5	-2.9
HB-11S	S	Harbor Brook	1321704	15644652	1	47	165	383.8	379.0	4.8
HB-12D	D	Harbor Brook	1322260	15644263	4	45	182	374.6	377.6	-3.0
HB-12I	I	Harbor Brook	1322260	15644263	3	45	182	374.2	373.7	0.5
HB-12S	S	Harbor Brook	1322260	15644263	1	45	182	380.6	373.6	6.9
HB-13D	D	Harbor Brook	1322342	15644091	5	47	186	374.8	377.8	-3.0
HB-14D	D	Harbor Brook	1321900	15644215	5	52	176	376.3	379.3	-3.0
HB-14S	S	Harbor Brook	1321901	15644216	1	52	176	380.9	377.7	3.2
HB-16D	D	Lakeshore	1322683	15644485	6	34	186	368.9	370.0	-1.0
HB-17D	D	Lakeshore	1322045	15644405	4	46	175	376.2	376.8	-0.6
HB-20D	D	Lakeshore	1323671	15644449	6	19	205	363.5	363.5	0.0
HB-20I	I	Lakeshore	1323676	15644448	3	19	205	363.0	363.2	0.1
HB-20S	S	Lakeshore	1323681	15644447	2	19	205	363.3	363.7	-0.2
HMW-11D	I	Hiawatha MGP	1326814	15645073	3	3	232	366.1	364.9	1.2
HMW-11S	S	Hiawatha MGP	1326853	15645174	2	3	232	365.7	364.3	1.4
HMW-14D	I	Hiawatha MGP	1325593	15646213	3	3	210	364.3	362.7	1.6
HMW-14S	S	Hiawatha MGP	1325525	15646129	2	3	210	364.5	362.9	1.6

TABLE DB.5
MEASURED AND CALCULATED GROUNDWATER LEVELS

Well ID	Groundwater Zone (S,I,D)	Site/Location	UTM Coordinates (NAD 83 ft)		Model Location			Water Levels		
			X(UTM)	Y(UTM)	Layer	Row	Column	Average Groundwater Elevation (ft)	Calculated Groundwater Elevation (ft)	Residual
HMW-15D	I	Hiawatha MGP	1325235	15645764	3	5	211	364.4	362.7	1.7
HMW-15S	S	Hiawatha MGP	1325180	15645700	2	5	211	363.6	362.9	0.7
HMW-18D	I	Hiawatha MGP	1326215	15645639	3	3	226	365.2	363.7	1.6
HMW-18S	S	Hiawatha MGP	1326276	15645704	2	3	226	364.2	363.7	0.6
HMW-4D	I	Hiawatha MGP	1325655	15645287	3	5	224	365.4	364.6	1.0
HMW-4S	S	Hiawatha MGP	1325728	15645370	2	5	224	365.4	364.7	0.9
HMW-6D	I	Hiawatha MGP	1326435	15644624	3	5	232	366.2	367.9	-1.5
HMW-6S	S	Hiawatha MGP	1326421	15644737	2	5	232	367.0	367.5	-0.3
HR-1	S	Main Plant	1317819	15645111	1	100	86	396.5	400.0	-3.5
MS-104.1	I	WB 1-8	1314197	15652372	3	33	4	377.8	380.4	-2.5
MS-104.2	S	WB 1-8	1314197	15652372	2	33	4	405.2	399.3	6.0
MS-104.4	S	WB 1-8	1314197	15652372	1	33	4	404.6	405.5	-0.8
MS-105.1	I	WB 1-8	1313632	15652508	3	40	3	390.0	393.3	-3.3
MS-105.2	S	WB 1-8	1313632	15652508	2	40	3	399.9	395.7	4.2
MS-105.4	S	WB 1-8	1313632	15652508	1	40	3	401.0	401.1	-0.1
MW-104	S	Main Plant	1318299	15645568	1	88	87	397.9	390.0	7.9
MW-105	S	Main Plant	1318346	15645450	1	89	90	399.4	391.6	7.9
MW-106	S	Main Plant	1318322	15645423	1	90	90	398.6	392.2	6.4
MW-107	S	Main Plant	1318539	15645418	1	87	94	391.7	390.3	1.4
MW-108	S	Main Plant	1318668	15645453	1	84	96	391.3	388.2	3.1
MW-11D	D	LCP	1314728	15646533	4	108	17	376.9	379.0	-2.1
MW-12D	D	LCP	1314416	15646333	5	110	17	374.2	379.6	-5.4
MW-12S	S	LCP	1314416	15646333	2	110	17	383.5	379.7	3.8
MW-13D	D	LCP	1314794	15646143	5	109	20	374.6	380.2	-5.6
MW-13S	S	LCP	1314794	15646143	1	109	20	387.0	379.9	7.1
MW-14D	D	LCP	1314663	15645634	3	111	22	376.1	388.0	-11.9
MW-14S	S	LCP	1314663	15645634	1	111	22	388.7	388.2	0.5
MW-15D	D	LCP	1314297	15645584	4	112	20	376.5	390.8	-14.3
MW-15S	S	LCP	1314297	15645584	1	112	20	390.9	390.9	0.0
MW-16D	D	LCP	1314481	15645899	5	111	19	375.5	385.6	-10.1
MW-16S	S	LCP	1314481	15645899	2	111	19	389.8	385.7	4.1
MW-17D	D	LCP	1314253	15646054	5	111	17	377.8	385.5	-7.7
MW-17S	S	LCP	1314253	15646054	2	111	17	388.8	385.7	3.1
MW-18D	D	LCP	1314581	15646108	4	110	19	374.1	380.5	-6.4
MW-18S	S	LCP	1314580	15646113	2	110	19	387.1	380.1	7.0
MW-19D	D	LCP	1314239	15646255	4	111	16	374.3	382.6	-8.3

TABLE DB.5
MEASURED AND CALCULATED GROUNDWATER LEVELS

Well ID	Groundwater Zone (S,I,D)	Site/Location	UTM Coordinates (NAD 83 ft)		Model Location			Water Levels		
			X(UTM)	Y(UTM)	Layer	Row	Column	Average Groundwater Elevation (ft)	Calculated Groundwater Elevation (ft)	Residual
MW-19S	S	LCP	1314239	15646255	2	111	16	387.1	382.8	4.3
MW-21S	S	LCP	1314835	15645829	2	110	22	387.7	381.8	5.9
MW-23S	S	LCP	1314361	15645748	1	112	19	389.9	388.8	1.2
MW-24D	D	LCP	1313974	15646427	7	111	14	374.5	382.8	-8.3
MW-24S	S	LCP	1313974	15646427	2	111	14	384.0	382.2	1.8
MW-25S	S	LCP	1314055	15646168	2	111	16	388.4	385.4	3.0
MW-28D	D	LCP	1314274	15646747	4	109	14	373.5	374.4	-0.9
MW-29D	D	LCP	1314330	15646580	5	109	15	373.9	376.0	-2.1
MW-29S	S	LCP	1314330	15646580	2	109	15	380.0	375.9	4.1
MW-32S	S	LCP	1314837	15646452	2	108	18	383.2	380.2	3.0
MW-4	S	WB 9-15	1309928	15648732	2	114	3	373.7	377.1	-3.4
MW-5A	S	LCP	1313665	15646186	2	112	14	389.1	386.8	2.3
MW-8D	D	LCP	1313675	15645905	5	113	15	378.9	389.3	-10.4
MW-9D/AW-1	D	LCP	1314102	15646177	5	111	16	378.1	384.9	-6.8
OW-10	I	Lakeshore	1319179	15647479	3	38	71	363.7	366.7	-0.3
OW-11	D	Lakeshore	1319433	15647243	6	38	79	370.7	372.2	-1.2
OW-2	D	Lakeshore	1319170	15647492	5	38	70	371.6	372.2	-0.5
OW-4	D	Lakeshore	1318951	15647664	6	38	63	370.6	372.7	-2.0
OW-5	D	Lakeshore	1318738	15647815	6	39	57	371.3	372.8	-1.3
OW-6	D	Lakeshore	1319190	15647469	6	38	71	370.5	372.0	-1.4
OW-7	D	Lakeshore	1319421	15647256	5	38	79	370.7	371.2	-0.5
P-1	S	LCP	1313825	15646091	2	112	15	390.2	387.3	2.9
P-12	S	LCP	1314466	15646366	1	109	17	381.9	378.1	3.8
P-2	S	LCP	1313822	15646082	2	112	15	390.2	387.4	2.8
PS-1	S	Main Plant	1318304	15645374	1	92	90	395.7	393.2	2.6
PS-2	S	Main Plant	1318391	15645556	1	87	89	392.3	389.3	3.0
PS-3D	S	Main Plant	1318787	15645458	1	82	98	375.0	386.6	-11.5
PS-3S	S	Main Plant	1318785	15645459	1	82	98	386.0	386.6	-0.5
R-3MW	S	Main Plant	1318480	15645091	1	94	98	396.1	396.3	-0.2
R-6MW	S	Main Plant	1318474	15645059	1	94	99	397.2	396.9	0.4
R-8MW	S	Main Plant	1318921	15644919	1	89	109	400.6	395.9	4.7
SP-3A	S	Semet Ponds	1319177	15646314	1	59	90	381.9	382.6	-0.9
SP-3B	I	Semet Ponds	1319182	15646297	4	60	91	377.4	377.6	-0.2
SP-3C	D	Semet Ponds	1319189	15646312	6	59	91	372.9	376.9	-3.9
SP-4A	S	Semet Ponds	1318513	15646846	1	61	69	394.7	391.1	3.2
SP-4B	I	Semet Ponds	1318542	15646851	4	60	70	373.9	375.1	-1.3

TABLE DB.5
MEASURED AND CALCULATED GROUNDWATER LEVELS

Well ID	Groundwater Zone (S,I,D)	Site/Location	UTM Coordinates (NAD 83 ft)		Model Location			Water Levels		
			X(UTM)	Y(UTM)	Layer	Row	Column	Average Groundwater Elevation (ft)	Calculated Groundwater Elevation (ft)	Residual
SP-4C	D	Semet Ponds	1318542	15646822	6	61	70	370.8	371.4	-0.6
SP-5A	S	Semet Ponds	1318079	15647584	2	55	49	366.8	368.4	-1.5
SP-5B	I	Semet Ponds	1318079	15647574	5	55	49	370.1	372.2	-2.0
SP-5C	D	Semet Ponds	1318072	15647581	6	55	49	373.0	374.4	-1.3
SP-6A	S	Semet Ponds	1319350	15646843	1	47	85	376.7	378.0	2.3
SP-6B	I	Semet Ponds	1319355	15646859	4	46	84	371.7	374.0	-1.2
SP-6C	D	Semet Ponds	1319374	15646848	6	46	85	370.8	375.2	-4.2
SP-7A	S	Semet Ponds	1319078	15647191	1	45	74	377.0	377.2	0.5
SP-7B	I	Semet Ponds	1319060	15647200	4	45	73	371.7	373.2	-1.5
SP-7C	D	Semet Ponds	1319058	15647178	6	46	73	373.2	373.6	-0.3
SP-8A	S	Semet Ponds	1318654	15647511	1	46	60	380.0	379.0	5.3
SP-8B	I	Semet Ponds	1318613	15647518	4	47	60	370.8	372.6	-1.4
SP-8C	D	Semet Ponds	1318633	15647515	6	47	60	373.2	374.5	-1.2
SP-9A	S	Semet Ponds	1317485	15646990	1	76	48	369.8	372.9	-3.1
SP-9B	I	Semet Ponds	1317462	15646996	4	76	47	371.5	373.0	-1.5
SP-9C	D	Semet Ponds	1317467	15646979	5	76	48	373.4	373.0	0.4
W1	S	LCP	1313678	15646247	2	112	14	387.5	386.1	1.4
W2	S	LCP	1313435	15645978	2	113	14	390.4	389.3	1.1
W3	S	LCP	1313518	15646338	1	112	13	386.9	385.7	1.2
W5	S	LCP	1313665	15646186	2	112	14	389.7	386.8	2.9
W6	S	LCP	1313818	15646344	2	111	14	388.2	384.4	3.8
WA-1D	D	Lakeshore	1319979	15646551	6	42	101	370.3	373.3	-2.9
WA-1S	S	Lakeshore	1319994	15646535	2	42	102	363.9	365.2	-0.9
WA-2D	D	Lakeshore	1320281	15646276	5	41	111	373.1	376.6	-3.4
WA-2S	S	Lakeshore	1320276	15646281	1	41	111	362.8	366.2	-3.1
WA-3D	D	Lakeshore	1320542	15646132	6	40	118	373.2	375.2	-2.0
WA-3I	I	Lakeshore	1320576	15646135	3	39	119	366.9	367.9	-0.8
WA-3S	S	Lakeshore	1320509	15646136	2	40	118	367.1	367.4	0.0
WA-4D	D	Willis Avenue	1320074	15645680	5	56	118	375.3	378.2	-2.8
WA-4I	I	Willis Avenue	1320055	15645674	3	56	117	375.8	377.5	-1.6
WA-4S	S	Willis Avenue	1320094	15645690	1	55	118	377.6	376.9	0.9
WA-5D	D	Willis Avenue	1319662	15645500	5	66	113	376.7	379.4	-2.7
WA-5I	I	Willis Avenue	1319654	15645507	3	66	113	377.9	379.1	-1.1
WA-5S	S	Willis Avenue	1319665	15645509	1	66	113	378.1	379.1	-0.9
WA-6D	D	Willis Avenue	1318925	15645839	5	72	94	376.9	378.4	-1.4
WA-6S	S	Willis Avenue	1318915	15645852	1	72	93	378.2	379.4	-1.4

TABLE DB.5
MEASURED AND CALCULATED GROUNDWATER LEVELS

Well ID	Groundwater Zone (S,I,D)	Site/Location	UTM Coordinates (NAD 83 ft)		Model Location			Water Levels		
			X(UTM)	Y(UTM)	Layer	Row	Column	Average Groundwater Elevation (ft)	Calculated Groundwater Elevation (ft)	Residual
WA-7D	D	Willis Avenue	1319757	15646058	6	54	105	374.4	376.9	-2.4
WA-7I	I	Willis Avenue	1319774	15646065	3	54	105	371.1	374.0	-2.6
WA-7S	S	Willis Avenue	1319766	15646077	1	54	105	376.3	374.5	2.2
WA-8D	D	Lakeshore	1321911	15645079	6	36	162	372.6	375.1	-2.5
WA-8I	I	Lakeshore	1321922	15645081	3	36	162	371.3	372.2	-0.9
WA-8S	S	Lakeshore	1321913	15645093	1	35	161	371.7	371.9	-0.2
WB-7L	D	WBs 9-15	1309603	15649964	6	112	2	370.3	370.7	-0.4
WB-7U	D	WBs 9-15	1309604	15649953	5	112	2	371.0	367.9	3.1

Notes:
UTM Coordinates (NAD 83 ft) : Universal Transverse Mercator (UTM) presented in NAD-83 feet)
WBs : Wastebeds
S,I,D : Shallow, intermediate and deep ground water zones.
Elevation datum NGVD 1988

TABLE DB.6
MONITORING WELL AND SOIL BORING SUMMARY

Well/Boring ID		UTM Coordinates (NAD 83 ft)		Well/Boring Use in Model			Notes
	Date Installed	X(UTM)	Y(UTM)	Development of Layer Pics (Tables DB.1 and DB.2)	Density (Table DB.4)	Ground Water Calibration (Table DB.5)	
493	1969	1316739	15649010	Yes	No	No	Boring only, no well installed
494	1969	1316842	15649104	Yes	No	No	Boring only, no well installed
495	1969	1316946	15649234	Yes	No	No	Boring only, no well installed
#1	1968	1315297	15646684	Yes	No	No	Boring only, no well installed
#10	1968	1316007	15647301	Yes	No	No	Boring only, no well installed
#11	1969	1315355	15644696	Yes	No	No	Boring only, no well installed
#12	1969	1315348	15645131	Yes	No	No	Boring only, no well installed
#13	1969	1315414	15645265	Yes	No	No	Boring only, no well installed
#3	1968	1315395	15646822	Yes	No	No	Boring only, no well installed
#5	1969	1315489	15646910	Yes	No	No	Boring only, no well installed
#7	1968	1315647	15647068	Yes	No	No	Boring only, no well installed
#8	1968	1315784	15646946	Yes	No	No	Boring only, no well installed
A-10MW	1990	1318407	15644380	Yes	No	No	Not used for GW calibration due to proximity to other similar wells
A-11B	1990	1318488	15644250	Yes	No	No	Boring only, no well installed
A-12MW	1990	1319120	15644610	Yes	No	Yes	No density correction
A-13MW	1990	1319499	15644233	Yes	No	No	Not used for GW calibration due to proximity to other similar wells
A-14MW	1990	1319795	15644239	No	No	Yes	Not used for layer pic selections because of minimal vertical profile and proximity of similar wells
A-15MW	1990	1319772	15644439	Yes	No	Yes	No density correction
A-16B	1990	1319270	15645118	Yes	No	No	Boring only, no well installed
A-18MW	1990	1319235	15645323	Yes	No	Yes	No density correction
A-1MW	1990	1316588	15644852	Yes	No	Yes	No density correction
A-2MW	1990	1317495	15644926	Yes	No	Yes	No density correction
A-3MW	1990	1317638	15644577	Yes	No	No	Not used for GW calibration due to proximity to other similar wells
A-6MW	1990	1318138	15644654	No	No	Yes	Not used for layer pic selections because of minimal vertical profile and proximity of similar wells
A-7MW	1990	1317692	15645106	Yes	No	Yes	No density correction
AW-2	1990	1313893	15646215	No	No	Yes	No boring log available
AW-3	1990	1313895	15646077	No	No	Yes	No boring log available
B-10	1981	1314649	15652909	Yes	No	No	Boring only, no well installed
B-11	1981	1314996	15653016	Yes	No	No	Boring only, no well installed
B-1C	1981	1313613	15652985	Yes	No	No	Boring only, no well installed
B-2	1981	1313752	15652157	Yes	No	No	Boring only, no well installed
B-3	1981	1313680	15651884	Yes	No	No	Boring only, no well installed
B-4	1981	1313876	15652854	Yes	No	No	Boring only, no well installed
B-5	1981	1313228	15653204	Yes	No	No	Boring only, no well installed
B-6	1981	1312860	15653457	Yes	No	No	Boring only, no well installed
B-7	1981	1314042	15653107	Yes	No	No	Boring only, no well installed
B-76-1	1976	1321503	15646776	Yes	No	No	Boring only, no well installed
B-76-2	1976	1321495	15646494	Yes	No	No	Boring only, no well installed
B-76-3	1976	1321480	15645939	Yes	No	No	Boring only, no well installed
B-76-4	1976	1321464	15645825	Yes	No	No	Boring only, no well installed
B-76-8	1976	1320924	15646152	Yes	No	No	Boring only, no well installed
B-8	1981	1314251	15653456	Yes	No	No	Boring only, no well installed
B-85-2	1985	1312987	15652796	Yes	No	No	Boring only, no well installed
B-9	1981	1314574	15653903	Yes	No	No	Boring only, no well installed

TABLE DB.6
MONITORING WELL AND SOIL BORING SUMMARY

Well/Boring ID	Date Installed	UTM Coordinates (NAD 83 ft)		Well/Boring Use in Model			Notes
		X(UTM)	Y(UTM)	Development of Layer Pics (Tables DB.1 and DB.2)	Density (Table DB.4)	Ground Water Calibration (Table DB.5)	
BFMW-01D	2003	1320393	15645633	Yes	Yes	Yes	
BFMW-01I	2001	1320397	15645643	No	Yes	Yes	Not used for layer pics because BFMW-01D is deepest well in well cluster
BFMW-01S	2001	1320395	15645639	No	Yes	Yes	Not used for layer pics because BFMW-01D is deepest well in well cluster
BFMW-02	2001	1320609	15645496	Yes	Yes	Yes	
BFMW-03I	2001	1320874	15645255	Yes	Yes	Yes	
BFMW-03S	2001	1320870	15645259	No	Yes	Yes	Not used for layer pics because BFMW-03D is deepest well in well cluster
BFMW-04D	2002	1321357	15644887	Yes	Yes	Yes	
BFMW-04I	2002	1321361	15644888	No	Yes	Yes	Not used for layer pics because BFMW-04D is deepest well in well cluster
BFMW-04S	2002	1321357	15644892	No	Yes	Yes	Not used for layer pics because BFMW-04D is deepest well in well cluster
BFMW-05I	2001	1320955	15644971	Yes	Yes	Yes	
BFMW-05S	2001	1320955	15644969	No	Yes	Yes	Not used for layer pics because BFMW-05D is deepest well in well cluster
BFMW-06I	2001	1320158	15645353	Yes	Yes	Yes	
BFMW-06S	2001	1320165	15645352	No	Yes	Yes	Not used for layer pics because BFMW-06D is deepest well in well cluster
BFMW-07S	2002	1320364	15644994	Yes	Yes	Yes	
BG-1	1986	1315686	15645392	Yes	No	No	Boring only, no well installed
BG-2	1986	1317729	15645039	Yes	No	No	Boring only, no well installed
Boring 19	1986	1317753	15646385	Yes	No	No	Boring only, no well installed
C-1	1985	1318291	15645062	No	No	Yes	Not used for layer pics, geology represented by nearby borings, log not available
C-11	1985	1317452	15645123	No	No	Yes	Not used for layer pics, geology represented by nearby borings
C-12	1985	1317385	15645147	No	No	Yes	Not used for layer pics, geology represented by nearby borings
C-13	1985	1317432	15645163	No	No	Yes	Not used for layer pics, geology represented by nearby borings
C-14	1985	1317562	15645138	No	No	Yes	Not used for layer pics, geology represented by nearby borings
C-15	1985	1317203	15645159	No	No	Yes	Not used for layer pics, geology represented by nearby borings
C-2	1985	1318086	15645083	No	No	Yes	Not used for layer pics, geology represented by nearby borings
C-3	1985	1318254	15645093	No	No	Yes	Not used for layer pics, geology represented by nearby borings
C-5	1985	1318156	15645115	No	No	Yes	Not used for layer pics, geology represented by nearby borings
CB-10* (B-10)	1970	1313854	15647325	Yes	No	No	Boring only, no well installed
CB-11* (B-11)	1970	1314331	15647168	Yes	No	No	Boring only, no well installed
CB-12* (B-12)	1970	1314886	15646909	Yes	No	No	Boring only, no well installed
CB-13* (B-13)	1970	1315367	15646801	Yes	No	No	Boring only, no well installed
CB-19* (B-19)	1970	1317335	15646328	Yes	No	No	Boring only, no well installed
CB-20* (B-20)	1970	1317816	15646184	Yes	No	No	Boring only, no well installed
CB-21* (B-21)	1971	1318229	15646319	Yes	No	No	Boring only, no well installed
CB-22* (B-22)	1971	1317751	15646788	Yes	No	No	Boring only, no well installed
CB-3* (B-3)	1971	1310334	15648485	Yes	No	No	Boring only, no well installed
CB-4* (B-4)	1971	1310714	15648355	Yes	No	No	Boring only, no well installed
CB-5* (B-5)	1970	1311159	15648176	Yes	No	No	Boring only, no well installed
CB-6* (B-6)	1970	1311853	15647975	Yes	No	No	Boring only, no well installed
CB-7* (B-7)	1970	1312384	15647791	Yes	No	No	Boring only, no well installed
CB-8* (B-8)	1970	1312974	15647652	Yes	No	No	Boring only, no well installed
CB-9* (B-9)	1970	1313400	15647498	Yes	No	No	Boring only, no well installed
CM-107	1982	1313946	15653467	Yes	No	No	Not used for GW calibration due to large open interval
CM-108	1982	1313477	15653663	Yes	No	No	Not used for GW calibration due to large open interval
CM-109	1982	1313301	15652637	Yes	No	No	Not used for GW calibration due to large open interval

TABLE DB.6
MONITORING WELL AND SOIL BORING SUMMARY

Well/Boring ID	Date Installed	UTM Coordinates (NAD 83 ft)		Well/Boring Use in Model			Notes
		X(UTM)	Y(UTM)	Development of Layer Pics (Tables DB.1 and DB.2)	Density (Table DB.4)	Ground Water Calibration (Table DB.5)	
CM-201	1981	1314163	15653312	Yes	Yes	Yes	
DAF-10	1975	1323871	15643320	Yes	No	No	Boring only, no well installed
DAF-2	1975	1323791	15643457	Yes	No	No	Boring only, no well installed
DAF-3	1975	1324533	15642997	Yes	No	No	Boring only, no well installed
DAF-31	1975	1317779	15648188	Yes	No	No	Boring only, no well installed
DAF-34	1975	1316996	15649158	Yes	No	No	Boring only, no well installed
DH-6	1968	1315565	15646998	Yes	No	No	Boring only, no well installed
DH-9	1968	1315814	15647168	Yes	No	No	Boring only, no well installed
DNF-1	1974	1323711	15643300	Yes	No	No	Boring only, no well installed
DW-101	1982	1315967	15651354	Yes	Yes	Yes	
DW-102	1982	1314345	15654047	Yes	Yes	Yes	
DW-103	1982	1313007	15652892	Yes	Yes	Yes	
GP-05	2000	1322277	15645048	Yes	No	No	Boring only, no well installed
GP-06	2000	1322622	15644903	Yes	No	No	Boring only, no well installed
GP-07	2000	1322766	15644805	Yes	No	No	Boring only, no well installed
GP-08	2000	1320878	15645782	Yes	No	No	Boring only, no well installed
GP-09	2000	1321040	15645631	Yes	No	No	Boring only, no well installed
GP-13	2000	1321866	15645023	Yes	No	No	Boring only, no well installed
GP-14	2000	1322007	15644872	Yes	No	No	Boring only, no well installed
GP-18	2000	1322867	15644406	Yes	No	No	Boring only, no well installed
GP-19	2000	1323030	15644238	Yes	No	No	Boring only, no well installed
GP-25	2001	1322524	15643685	Yes	No	No	Boring only, no well installed
GP-26	2001	1322610	15643735	Yes	No	No	Boring only, no well installed
GP-27	2001	1322233	15643799	Yes	No	No	Boring only, no well installed
GP-28	2001	1321984	15643907	Yes	No	No	Boring only, no well installed
GP-29	2001	1321743	15643995	Yes	No	No	Boring only, no well installed
GP-30	2001	1321957	15643741	Yes	No	No	Boring only, no well installed
GP-32	2001	1322422	15644105	Yes	No	No	Boring only, no well installed
GP-34	2001	1322189	15644105	Yes	No	No	Boring only, no well installed
GP-35	2001	1321901	15644215	Yes	No	No	Well was installed and renamed HB-14D
GP-36	2001	1321695	15644261	Yes	No	No	Boring only, no well installed
GP-38	2001	1321275	15644435	Yes	No	No	Boring only, no well installed
GP-39	2001	1321202	15644646	Yes	No	No	Boring only, no well installed
H-10MW	1987	1317230	15645192	No	No	Yes	Not used for layer pics due to proximity of other locations
H-2	1987	1317881	15645240	Yes	No	No	Boring only, no well installed
H-5	1987	1316892	15645387	Yes	No	No	Not used for GW calibration due to close proximity to H-8MW
H-8MW	1987	1316501	15645223	Yes	No	Yes	No density correction
HB-01D	2000	1321804	15645833	Yes	Yes	Yes	
HB-01S	2000	1321808	15645832	No	Yes	Yes	Not used for layer pics because HB-01D is deepest well in well cluster
HB-02D	2000	1322941	15644724	Yes	No	No	No deep well installed
HB-02I	2000	1322941	15644724	No	Yes	Yes	Not used for layer pics because HB-02D is deepest boring in well cluster [See log HB-2I(S)]
HB-02S	2000	1322937	15644720	No	Yes	Yes	Not used for layer pics because HB-02D is deepest boring in well cluster [See log HB-2I(S)]
HB-03S	2000	1321079	15646012	Yes	Yes	Yes	
HB-04D	2003	1323068	15644269	Yes	Yes	Yes	

TABLE DB.6
MONITORING WELL AND SOIL BORING SUMMARY

Well/Boring ID		UTM Coordinates (NAD 83 ft)		Well/Boring Use in Model			Notes
	Date Installed	X(UTM)	Y(UTM)	Development of Layer Pics (Tables DB.1 and DB.2)	Density (Table DB.4)	Ground Water Calibration (Table DB.5)	
HB-04S	2003	1323076	15644274	No	Yes	Yes	Not used for layer pics because HB-04D is deepest well in well cluster [See log HB-4I(S)]
HB-05D	2000	1322461	15645081	Yes	Yes	Yes	
HB-05I	2000	1322461	15645094	No	Yes	Yes	Not used for layer pics because HB-05D is deepest well in well cluster [See log HB-5I(S)]
HB-05S	2000	1322460	15645090	No	Yes	Yes	Not used for layer pics because HB-05D is deepest well in well cluster [See log HB-5I(S)]
HB-06S	2000	1323380	15644574	Yes	Yes	Yes	
HB-07S	2001	1322466	15643304	Yes	Yes	Yes	
HB-08D	2001	1322640	15643838	Yes	Yes	Yes	
HB-08I	2001	1322646	15643837	No	Yes	Yes	Not used for layer pics because HB-08D is deepest well in well cluster [See log HB-8IS)]
HB-08S	2001	1322641	15643846	No	Yes	Yes	Not used for layer pics because HB-08D is deepest well in well cluster [See log HB-8IS)]
HB-09S	2001	1321576	15644115	Yes	Yes	Yes	
HB-10	2001	1321395	15644807	Yes	No	No	Boring only, no well installed
HB-11I	2001	1321704	15644652	Yes	Yes	Yes	
HB-11S	2001	1321704	15644652	No	Yes	Yes	Not used for layer pics because HB-11I is deepest well in well cluster
HB-12D	2001	1322260	15644263	Yes	Yes	Yes	
HB-12I	2001	1322260	15644263	No	Yes	Yes	Not used for layer pics because HB-12D is deepest well in well cluster
HB-12S	2001	1322260	15644263	No	Yes	Yes	Not used for layer pics because HB-12D is deepest well in well cluster
HB-13D	2001	1322342	15644091	Yes	Yes	Yes	
HB-14D	2001	1321900	15644215	No	Yes	Yes	Not used for layer pics because stratigraphy was noted in GP-35 at this location.
HB-14S	2001	1321901	15644216	No	Yes	Yes	Not used for layer pics because stratigraphy was noted in GP-35 at this location.
HB-16D	2003	1322683	15644485	Yes	Yes	Yes	
HB-17D	2003	1322045	15644405	Yes	Yes	Yes	
HB-20D	2002	1323671	15644449	Yes	Yes	Yes	
HB-20I	2002	1323676	15644448	No	Yes	Yes	Not used for layer pics because HB-20D is deepest well in well cluster
HB-20S	2002	1323681	15644447	No	Yes	Yes	Not used for layer pics because HB-20D is deepest well in well cluster
HB-21I	2003	1322892	15643754	Yes	No	No	Not used for ground water calibration due to lack of adequete ground water elevation data
HMW-11D	unknown	1326814	15645073	No	No	Yes	Not used for layer pics because of large number of borings in close proximity, log not available
HMW-11S	unknown	1326853	15645174	No	No	Yes	Not used for layer pics because of large number of borings in close proximity, log not available
HMW-14D	2001	1325593	15646213	No	No	Yes	Not used for layer pics because of large number of borings in close proximity.
HMW-14S	2001	1325525	15646129	No	No	Yes	Not used for layer pics because of large number of borings in close proximity.
HMW-15D	2001	1325235	15645764	No	No	Yes	Not used for layer pics because of large number of borings in close proximity.
HMW-15S	2001	1325180	15645700	No	No	Yes	Not used for layer pics because of large number of borings in close proximity.
HMW-18D	unknown	1326215	15645639	No	No	Yes	Not used for layer pics because of large number of borings in close proximity, log not available
HMW-18S	unknown	1326276	15645704	No	No	Yes	Not used for layer pics because of large number of borings in close proximity, log not available
HMW-4D	unknown	1325655	15645287	No	No	Yes	Not used for layer pics because of large number of borings in close proximity, log not available
HMW-4S	unknown	1325728	15645370	No	No	Yes	Not used for layer pics because of large number of borings in close proximity, log not available
HMW-6D	unknown	1326435	15644624	No	No	Yes	Not used for layer pics because of large number of borings in close proximity, log not available
HMW-6S	unknown	1326421	15644737	No	No	Yes	Not used for layer pics because of large number of borings in close proximity, log not available
HR-1	1992	1317819	15645111	No	No	Yes	Not used for layer pic selections because of proximity to similar wells
INC-1	1985	1313164	15652716	Yes	No	No	Boring only, no well installed
INC-2	1985	1313734	15652231	Yes	No	No	Boring only, no well installed
L-11	1964	1310267	15645378	Yes	No	No	Boring only, no well installed
L-12	1964	1310266	15646110	Yes	No	No	Boring only, no well installed
L-128	1965	1312971	15651197	Yes	No	No	Boring only, no well installed
L-150	1965	1313097	15651123	Yes	No	No	Boring only, no well installed

TABLE DB.6
MONITORING WELL AND SOIL BORING SUMMARY

Well/Boring ID	Date Installed	UTM Coordinates (NAD 83 ft) X(UTM)	Y(UTM)	Well/Boring Use in Model: Development of Layer Pics (Tables DB.1 and DB.2)	Density (Table DB.4)	Ground Water Calibration (Table DB.5)	Notes
L-152	1965	1313347	15650928	Yes	No	No	Boring only, no well installed
L-2	1965	1310123	15642282	Yes	No	No	Boring only, no well installed
L-51	1965	1311199	15648151	Yes	No	No	Boring only, no well installed
L-64	1965	1311749	15648948	Yes	No	No	Boring only, no well installed
L-67	1965	1311928	15648855	Yes	No	No	Boring only, no well installed
L-74	1965	1312171	15649562	Yes	No	No	Boring only, no well installed
L-91	1965	1312588	15649966	Yes	No	No	Boring only, no well installed
LP-1	1965	1316321	15649111	Yes	No	No	Boring only, no well installed
LP-2	1965	1316270	15649056	Yes	No	No	Boring only, no well installed
MS-104.1	1982	1314197	15652372	Yes	Yes	Yes	See MS-104 boring log
MS-104.2	1982	1314197	15652372	No	Yes	Yes	Not used for layer pics because MS-104.1 is deepest well in well cluster (See MS-104 log)
MS-104.4	1982	1314197	15652372	No	Yes	Yes	Not used for layer pics because MS-104.1 is deepest well in well cluster (See MS-104 log)
MS-105.1	1982	1313632	15652508	Yes	Yes	Yes	See MS-105 boring log
MS-105.2	1982	1313632	15652508	No	Yes	Yes	Not used for layer pics because MS-105.1 is deepest well in well cluster (See MS-105 log)
MS-105.4	1982	1313632	15652508	No	Yes	Yes	Not used for layer pics because MS-105.1 is deepest well in well cluster (See MS-105 log)
MS-106	1982	1313706	15653371	Yes	No	No	Not used for GW calibration due to proximity to other similar wells
MW-104	1985	1318299	15645568	Yes	No	Yes	
MW-105	1985	1318346	15645450	No	No	Yes	Not used for layer pic selections because of minimal vertical profile and proximity of similar wells
MW-106	1985	1318322	15645423	No	No	Yes	Not used for layer pic selections because of minimal vertical profile and proximity of similar wells
MW-107	1985	1318539	15645418	Yes	No	Yes	No density correction
MW-108	1985	1318668	15645453	Yes	No	Yes	No density correction
MW-11D	1989	1314728	15646533	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-12D	1989	1314416	15646333	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-12S	1989	1314416	15646333	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-13D	1989	1314794	15646143	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-13S	1989	1314794	15646143	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-14D	1989	1314663	15645634	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-14S	1989	1314663	15645634	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-15D	1989	1314297	15645584	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-15S	1989	1314297	15645584	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-16D	1989	1314481	15645899	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-16S	1989	1314481	15645899	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-17D	1989	1314253	15646054	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-17S	1989	1314253	15646054	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-18D	1995	1314581	15646108	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-18S	1995	1314580	15646113	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-19D	1995	1314239	15646255	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-19S	1995	1314239	15646255	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-21S	1995	1314835	15645829	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-23S	1995	1314361	15645748	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-24D	1995	1313974	15646427	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-24S	1995	1313974	15646427	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-25S	1995	1314055	15646168	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-28D	1995	1314274	15646747	No	No	Yes	Not used for layer pics, geology represented by nearby borings

TABLE DB.6
MONITORING WELL AND SOIL BORING SUMMARY

Well/Boring ID		UTM Coordinates (NAD 83 ft)		Well/Boring Use in Model			Notes
	Date Installed	X(UTM)	Y(UTM)	Development of Layer Pics (Tables DB.1 and DB.2)	Density (Table DB.4)	Ground Water Calibration (Table DB.5)	
MW-29D	1995	1314330	15646580	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-29S	1995	1314330	15646580	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-32S	1995	1314837	15646452	No	No	Yes	Not used for layer pics, geology represented by nearby borings
MW-3AR	1989	1313864	15646054	Yes	No	No	Not used for GW calibration due to proximity to other similar wells
MW-4	1985	1309928	15648732	No	No	Yes	Not used for layer pics because of lack of a good boring log
MW-5A	1989	1313665	15646186	Yes	No	Yes	No density correction
MW-6A	1989	1313669	15646285	Yes	No	No	Not used for GW calibration due to proximity to other similar wells
MW-8D	1989	1313675	15645905	No	No	Yes	No boring log available
MW-9D/AW-1	1986	1314102	15646177	No	No	Yes	No boring log available
OW-10	2001	1319179	15647479	No	Yes	Yes	Not used for layer pics because of close proximity to deep well OW-6
OW-11	2001	1319433	15647243	Yes	Yes	Yes	
OW-2	2001	1319170	15647492	No	Yes	Yes	Not used for layer pics because of close proximity to deep well OW-6
OW-4	2001	1318951	15647664	Yes	Yes	Yes	
OW-5	2001	1318738	15647815	Yes	Yes	Yes	
OW-6	2001	1319190	15647469	Yes	Yes	Yes	
OW-7	2001	1319421	15647256	No	Yes	Yes	Not used for layer pics because of close proximity to deep well OW-11
P-1	1965	1313825	15646091	No	No	Yes	Not used for layer pics; geology represented by nearby borings, no log available
P-12	1964	1314466	15646366	No	No	Yes	Not used for layer pics; geology represented by nearby borings, no log available
P-2	1965	1313822	15646082	No	No	Yes	Not used for layer pics; geology represented by nearby borings, no log available
PP-1* (TH-1)	1978	1314953	15648019	Yes	No	No	Boring only, no well installed
PS-1	1992	1318304	15645374	No	No	Yes	Not used for layer pics because of close proximity to other wells in area
PS-2	1992	1318391	15645556	No	No	Yes	Not used for layer pics because of close proximity to other wells in area
PS-3D	1992	1318787	15645458	No	No	Yes	Not used for layer pics because of close proximity to other wells in area, log not available
PS-3S	1992	1318785	15645459	No	No	Yes	Not used for layer pics because of close proximity to other wells in area (See PS-3 boring log)
R-13	1987	1318801	15644481	Yes	No	No	Boring only, no well installed
R-14MW	1987	1318519	15644501	Yes	No	No	Not used for GW calibration due to proximity to other similar wells
R-2	1987	1318774	15645151	Yes	No	No	Boring only, no well installed
R-3MW	1987	1318480	15645091	No	No	Yes	Not used for layer pics because of close proximity to other wells in area
R-6MW	1987	1318474	15645059	No	No	Yes	Not used for layer pics because of close proximity to other wells in area
R-8MW	1987	1318921	15644919	Yes	No	Yes	No density correction
SP-2A	1991	1317916	15646424	Yes	No	No	Well destroyed
SP-3A	1990	1319177	15646314	No	Yes	Yes	Not used for layer pics because SP-3C is deepest well in well cluster
SP-3B	1990	1319182	15646297	No	Yes	Yes	Not used for layer pics because SP-3C is deepest well in well cluster
SP-3C	1990	1319189	15646312	Yes	Yes	Yes	
SP-4A	1991	1318513	15646846	No	Yes	Yes	Not used for layer pics because SP-4C is deepest well in well cluster
SP-4B	1991	1318542	15646851	No	Yes	Yes	Not used for layer pics because SP-4C is deepest well in well cluster
SP-4C	1991	1318542	15646822	Yes	Yes	Yes	
SP-5A	1991	1318079	15647584	No	Yes	Yes	Not used for layer pics because SP-5C is deepest well in well cluster
SP-5B	1991	1318079	15647574	No	Yes	Yes	Not used for layer pics because SP-5C is deepest well in well cluster
SP-5C	1991	1318072	15647581	Yes	Yes	Yes	
SP-6A	1990	1319350	15646843	No	Yes	Yes	Not used for layer pics because SP-6C is deepest well in well cluster
SP-6B	1990	1319355	15646859	No	Yes	Yes	Not used for layer pics because SP-6C is deepest well in well cluster
SP-6C	1990	1319374	15646848	Yes	Yes	Yes	
SP-7A	1990	1319078	15647191	No	Yes	Yes	Not used for layer pics because SP-7C is deepest well in well cluster

TABLE DB.6
MONITORING WELL AND SOIL BORING SUMMARY

Well/Boring ID	Date Installed	UTM Coordinates (NAD 83 ft) X(UTM)	UTM Coordinates (NAD 83 ft) Y(UTM)	Well/Boring Use in Model: Development of Layer Pics (Tables DB.1 and DB.2)	Well/Boring Use in Model: Density (Table DB.4)	Well/Boring Use in Model: Ground Water Calibration (Table DB.5)	Notes
SP-7B	1990	1319060	15647200	No	Yes	Yes	Not used for layer pics because SP-7C is deepest well in well cluster
SP-7C	1990	1319058	15647178	Yes	Yes	Yes	
SP-8A	1990	1318654	15647511	No	Yes	Yes	Not used for layer pics because SP-8C is deepest well in well cluster
SP-8B	1990	1318613	15647518	No	Yes	Yes	Not used for layer pics because SP-8C is deepest well in well cluster
SP-8C	1990	1318633	15647515	Yes	Yes	Yes	
SP-9A	1991	1317485	15646990	No	Yes	Yes	Not used for layer pics because SP-9C is deepest well in well cluster
SP-9B	1991	1317462	15646996	No	Yes	Yes	Not used for layer pics because SP-9C is deepest well in well cluster
SP-9C	1991	1317467	15646979	Yes	Yes	Yes	
SS-1* (TH-1)	1978	1313694	15648474	Yes	No	No	Boring only, no well installed
TB-1	1979	1318571	15646029	Yes	No	No	Boring only, no well installed
TB-10	1979	1318011	15647433	Yes	No	No	Boring only, no well installed
TB-11	1979	1318391	15647599	Yes	No	No	Boring only, no well installed
TB-12	1979	1318155	15647541	Yes	No	No	Boring only, no well installed
TB-13	1979	1318664	15647488	Yes	No	No	Boring only, no well installed
TB-14	1979	1318686	15647445	Yes	No	No	Boring only, no well installed
TB-15	1979	1318697	15647501	Yes	No	No	Boring only, no well installed
TB-2	1979	1318630	15646087	Yes	No	No	Boring only, no well installed
TB-3	1979	1318442	15646238	Yes	No	No	Boring only, no well installed
TB-4	1979	1318392	15646189	Yes	No	No	Boring only, no well installed
TB-5	1979	1318151	15646398	Yes	No	No	Boring only, no well installed
TB-7	1979	1317744	15646930	Yes	No	No	Boring only, no well installed
TB-9	1979	1317884	15647305	Yes	No	No	Boring only, no well installed
TH-100	1975	1318576	15647960	Yes	No	No	Boring only, no well installed
TH-301	1970	1325276	15644456	Yes	No	No	Boring only, no well installed
TH-302	1970	1325298	15644551	Yes	No	No	Boring only, no well installed
TH-304	1970	1325789	15645493	Yes	No	No	Boring only, no well installed
TH-305	1970	1325740	15645243	Yes	No	No	Boring only, no well installed
TH-307	1970	1325827	15644342	Yes	No	No	Boring only, no well installed
TH-308	1970	1326019	15645101	Yes	No	No	Boring only, no well installed
TH-311	1970	1326816	15645235	Yes	No	No	Boring only, no well installed
TH-312	1970	1325172	15644930	Yes	No	No	Boring only, no well installed
TH-313	1970	1325601	15645306	Yes	No	No	Boring only, no well installed
TH-314	1970	1325847	15645982	Yes	No	No	Boring only, no well installed
TH-315	1970	1326148	15645277	Yes	No	No	Boring only, no well installed
TH-316	1970	1325264	15644763	Yes	No	No	Boring only, no well installed
TH-318	1970	1325428	15645350	Yes	No	No	Boring only, no well installed
TH-325	1970	1326166	15645457	Yes	No	No	Boring only, no well installed
TH-328	1970	1326116	15644584	Yes	No	No	Boring only, no well installed
TH-330	1971	1325199	15645315	Yes	No	No	Boring only, no well installed
TH-333	1971	1324758	15644606	Yes	No	No	Boring only, no well installed
TH-334	1971	1324838	15644746	Yes	No	No	Boring only, no well installed
TH-337	1971	1325010	15644275	Yes	No	No	Boring only, no well installed
TH-7A	1972	1307065	15646378	Yes	No	No	Boring only, no well installed
TH-8A	1972	1308124	15646380	Yes	No	No	Boring only, no well installed

TABLE DB.6
MONITORING WELL AND SOIL BORING SUMMARY

Well/Boring ID	Date Installed	UTM Coordinates (NAD 83 ft)		Well/Boring Use in Model			Notes
		X(UTM)	Y(UTM)	Development of Layer Pics (Tables DB.1 and DB.2)	Density (Table DB.4)	Ground Water Calibration (Table DB.5)	
USGS Lake Saddle	2003	1316051	15655925	Yes	No	No	Boring logs by verbal communication
USGS Spencer St.	2002	1329092	15642449	Yes	No	No	Boring logs by verbal communication
USGS West Trail	2003	1311532	15655779	Yes	No	No	Boring logs by verbal communication
W1	1989	1313678	15646247	No	No	Yes	Not used for layer pics, geology represented by nearby borings
W2	1989	1313435	15645978	No	No	Yes	Not used for layer pics, geology represented by nearby borings
W3	1989	1313518	15646338	No	No	Yes	Not used for layer pics, geology represented by nearby borings
W5	1989	1313665	15646186	Yes	No	Yes	No density correction
W6	1989	1313818	15646344	Yes	No	Yes	No density correction
W7	1989	1313740	15646205	Yes	No	No	Not used for GW calibration due to proximity to other similar wells
WA-1D	1992	1319979	15646551	Yes	Yes	Yes	
WA-1S	1992	1319994	15646535	No	Yes	Yes	Not used for layer pics because WA-1D is deepest well in well cluster
WA-2D	1992	1320281	15646276	Yes	Yes	Yes	
WA-2S	1992	1320276	15646281	No	Yes	Yes	Not used for layer pics because WA-2D is deepest well in well cluster
WA-3D	1992	1320542	15646132	Yes	Yes	Yes	
WA-3I	1992	1320576	15646135	No	Yes	Yes	Not used for layer pics because WA-3D is deepest well in well cluster
WA-3S	1992	1320509	15646136	No	Yes	Yes	Not used for layer pics because WA-3D is deepest well in well cluster
WA-4D	1992	1320074	15645680	Yes	Yes	Yes	
WA-4I	1992	1320055	15645674	No	Yes	Yes	Not used for layer pics because WA-4D is deepest well in well cluster
WA-4S	1992	1320094	15645690	No	Yes	Yes	Not used for layer pics because WA-4D is deepest well in well cluster
WA-5D	1992	1319662	15645500	Yes	Yes	Yes	
WA-5I	1992	1319654	15645507	No	Yes	Yes	Not used for layer pics because WA-5D is deepest well in well cluster
WA-5S	1992	1319665	15645509	No	Yes	Yes	Not used for layer pics because WA-5D is deepest well in well cluster
WA-6D	1992	1318925	15645839	Yes	Yes	Yes	
WA-6S	1992	1318915	15645852	No	Yes	Yes	Not used for layer pics because WA-6D is deepest well in well cluster
WA-7D	1992	1319757	15646058	Yes	Yes	Yes	
WA-7I	1992	1319774	15646065	No	Yes	Yes	Not used for layer pics because WA-7D is deepest well in well cluster
WA-7S	1992	1319766	15646077	No	Yes	Yes	Not used for layer pics because WA-7D is deepest well in well cluster
WA-8D	1994	1321911	15645079	Yes	Yes	Yes	
WA-8I	1994	1321922	15645081	No	Yes	Yes	Not used for layer pics because WA-8D is deepest well in well cluster
WA-8S	1994	1321913	15645093	No	Yes	Yes	Not used for layer pics because WA-8D is deepest well in well cluster
WB-10U	1998	1311061	15649997	Yes	No	No	Well not used for ground water calibration due to lack of adequete ground water data
WB-11U	1998	1309364	15649992	Yes	No	No	Well not used for ground water calibration due to lack of adequete ground water data
WB-5R	1994	1308027	15650347	Yes	No	No	Not used for ground water calibration because well outside model area
WB-7L	1987	1309603	15649964	Yes	Yes	Yes	
WB-7U	1987	1309604	15649953	No	Yes	Yes	Not used for layer pics because WB-7L is deepest well in well cluster
WB-9U	1998	1312188	15650388	Yes	No	No	Well not used for ground water calibration due to lack of adequete ground water data

Notes: * These boring IDs were changed to avoid confusion with other boring of the same ID.
The former boring names are listed in parentheses after the revised name.

TABLE DB.7
PARAMETERS IN GROUNDWATER MODEL

Zone	Layer	Description of Approximate Location	Parameter	Acceptable Range of Parameter Values	Simulation 1 Draft FS	Simulation 2 Revised Model	Parameter Values Estimated in Analysis of Sediment Flux Uncertainty (K_h -- ft/day or Recharge -- in/yr)				Ratio of K_H to K_V
							Sim 3 (SMU1)	Sim 4 (SMU2)	Sim 5 (SMU3)	Sim 6 (SMU7)	
1	4	Silt and clay in upland areas	K_H ft/d	0.01-1	0.45	0.14	0.53	0.8	0.002	0.16	100
2	1	Semet tar pit	K_H ft/d	?	0.15	0.15	0.15	0.15	0.15	0.15	100
3	1,2	Harbor Brook area west of Highway	K_H ft/d	0.1-10	0.34	2	1.9	2.0	2.0	2.0	100
4	3	Marl beneath lake	K_H ft/d	0.01-0.1	0.02	0.02	0.02	0.008	0.008	0.01	10
5	1,2	Fairgrounds area	K_H ft/d	1-50	11	11	11	11	11	11	100
6	3	Fairgrounds area	K_H ft/d	1-50	20	20	20	20	20	20	1000
7	1,2	Lake sediment	K_H ft/d	0.1-20	20	20	0.07	20	0.12	20	100
8	7	Till	K_H ft/d	0.01-10	0.05	0.05	0.03	0.05	0.05	0.05	10
9	All	Bedrock	K_H ft/d	0.1-10	1.2	1.2	0.97	1.2	0.55	1.2	10
10	5	Sand and silt under lake	K_H ft/d	1-28	28	28	26.8	28	5.9	28	127
11	1,2	Waste beds at Harbor Brook	K_H ft/d	0.1-5	0.8	1.8	4	1.8	1.8	1.8	100
12	1,2	Waste beds at Willis	K_H ft/d	0.1-5	1.2	0.6	0.59	4.0	0.59	0.59	100
13	1,2,3	Ninemile Creek Area	K_H ft/d	1-50	1.4	1.4					10

TABLE DB.7 (CONTINUED)
PARAMETERS IN GROUNDWATER MODEL

Zone	Layer	Description of Approximate Location	Parameter	Acceptable Range of Parameter Values	Simulation 1 Draft FS	Simulation 2 Revised Model	Parameter Values Estimated in Analysis of Sediment Flux Uncertainty (K_h -- ft/day or Recharge -- in/yr)				Ratio of K_H to K_V
							Sim 3 (SMU1)	Sim 4 (SMU2)	Sim 5 (SMU3)	Sim 6 (SMU7)	
14	3	Harbor Book area	K_H ft/d	0.001-0.1	0.002	0.002	0.001	0.002	0.002	0.002	10
15	1,2	In Lake Waste Deposit	K_H ft/d	0.1-20	20	20	50	20	20	20	10
16	5	Ninemile Creek area	K_H ft/d	1-50	1.6	1.6	1.6	1.6	1.6	1.6	10
17	1,2	Wastebeds 1 through 15	K_H ft/d	0.1-5	0.8	0.4	0.43	0.43	2.2	0.43	100
18	1	Between Harbor Brook and Willis/Semet	K_H ft/d	1-50	17	13	16	1.0	13	13	100
19	3	South of Lake	K_H ft/d	1-50	50	50	50	50	48	50	10
20	5	South of Lake	K_H ft/d	1-50	28	28	50	8.2	6.8	50	10
21	6	Sand and gravel under lake	K_H ft/d	10-200	100	100	100	100	100	100	10
22	6	Sand and gravel at TW-1	K_H ft/d	100-1000	850	1000	1000	1000	1000	1000	10
23	6	Sand and gravel west of Harbor Brook	K_H ft/d	10-200	20	20	20	20	20	20	10
24	3	Beneath bed of Harbor Brook	K_H ft/d	1-50	40	40	40	40	40	40	10

TABLE DB.7 (CONTINUED)
PARAMETERS IN GROUNDWATER MODEL

Zone	Layer	Description of Approximate Location	Parameter	Acceptable Range of Parameter Values	Simulation 1 Draft FS	Simulation 2 Revised Model	Parameter Values Estimated in Analysis of Sediment Flux Uncertainty (K_h -- ft/day or Recharge -- in/yr)				Ratio of K_H to K_V
25	3	Hiawatha Site area	K_H ft/d	0.1-5	1	1	1.5	1	1	1	10
26	1,2	Hiawatha Site area	K_H ft/d	5-20	12	12	20	20	12	20	10
27	4	Ninemile Creek area	K_H ft/d	1-50	5	5	5	5	5	5	10
28	6	Ninemile Creek area	K_H ft/d	1-50	10	10	10	10	10	10	10
29	3,4,5	Near subcrop of bedrock west of Willis/Semet	K_H ft/d	1-50	40	40	40	40	40	40	10
30	5	Near subcrop of bedrock west of Harbor Brook	K_H ft/d	1-50	20	20	20	20	20	20	10
31	3	Near subcrop of bedrock west of Willis	K_H ft/d	1-50	1.4	1.4	1.4	1.4	1.4	1.4	10
32	1,2	Beneath Tributary 5A	K_H ft/d	1-50	50	50	50	50	50	50	10
33	6	Sand and gravel beneath Semet/Willis	K_H ft/d	10-200	100	100	100	100	100	100	10
34	4	Silt and clay beneath lake	K_H ft/d	0.01-1	0.06	0.06	0.06	0.06	0.12	0.06	100
35	3	Marl with fine sand	K_H ft/d	1-50	5	5	49	50	50	5	400

TABLE DB.7 (CONTINUED)
PARAMETERS IN GROUNDWATER MODEL

Zone	Layer	Description of Approximate Location	Parameter	Acceptable Range of Parameter Values	Simulation 1 Draft FS	Simulation 2 Revised Model	Parameter Values Estimated in Analysis of Sediment Flux Uncertainty (K_h -- ft/day or Recharge -- in/yr)				Ratio of K_H to K_V
36	4	Fairgrounds area	K_H ft/d	1-50	27 ft/d	27 ft/d	27 ft/d	27 ft/d	27 ft/d	27 ft/d	10
R2	1	South end of lake	R in/yr	0.5-2	1	1	0.4	2	.4	2	NA
R3	1	Bedrock	R in/yr	2-6	3	3	2.4	2.9	1.1	3	NA
R4	1	Waste beds	R in/yr	3-7	Variable	6	7	7	7	6.4	NA
R5	1	Alluvial areas west of lake	R in/yr	3-7	5	5	4.6	5.3	6.5	4.9	NA

Notes:
Sim - Simulation
NA – Not Applicable
? – Acceptable range for this location has not been defined.

APPENDIX D: PART B

FIGURES

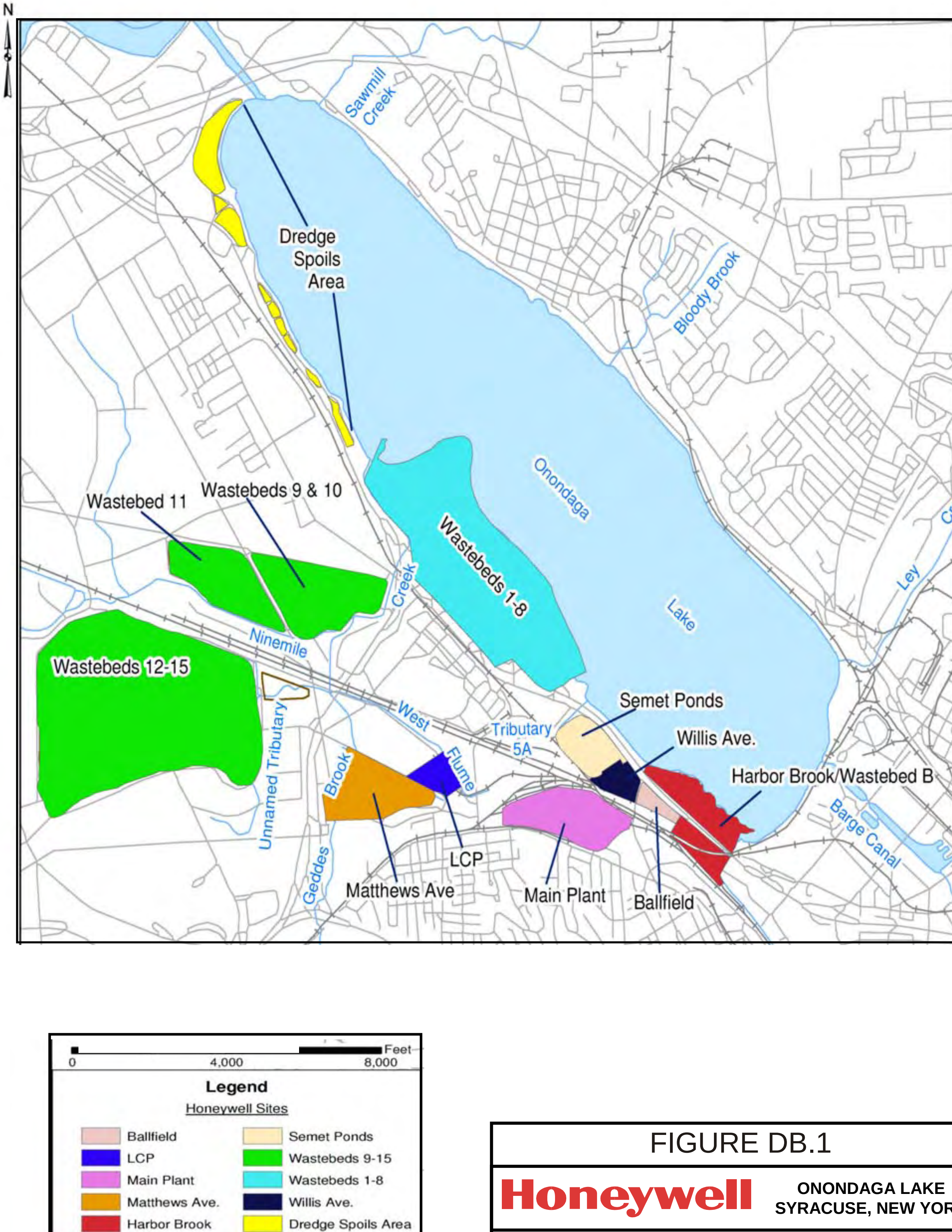

FIGURE DB.1

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

SITE LOCATION MAP

PARSONS

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

FIGURE DB.2

Honeywell

Onondaga Lake
Syracuse, New York

SURFACE TOPOGRAPHY

PARSONS
290 ELWOOD DAVIS ROAD, SUITE 312, LIVERPOOL, NY 13088 PHONE: (315) 451-9560

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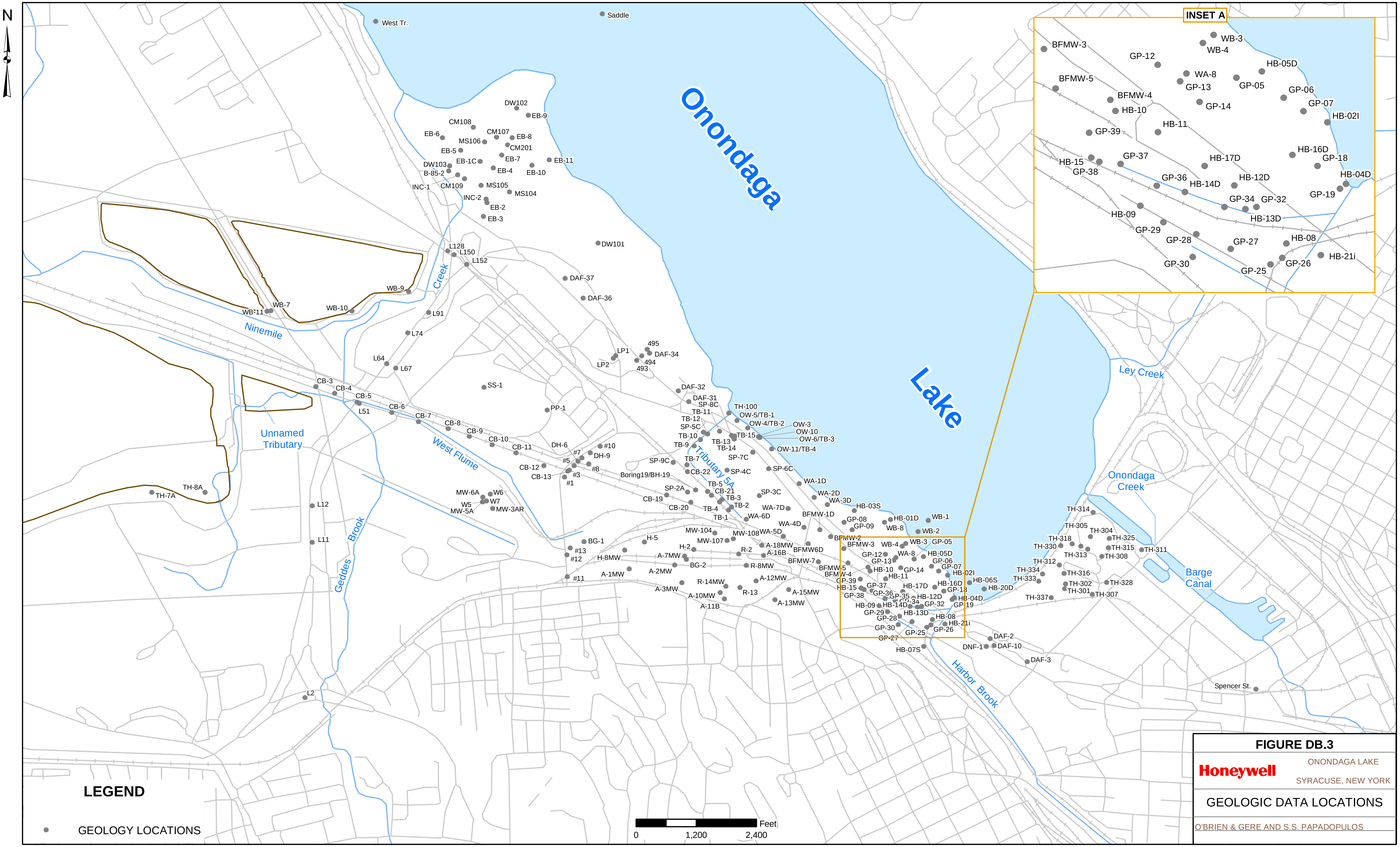

FIGURE DB.3

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

GEOLOGIC DATA LOCATIONS

O'BRIEN & GERE AND S.S. PAPADOPULOS

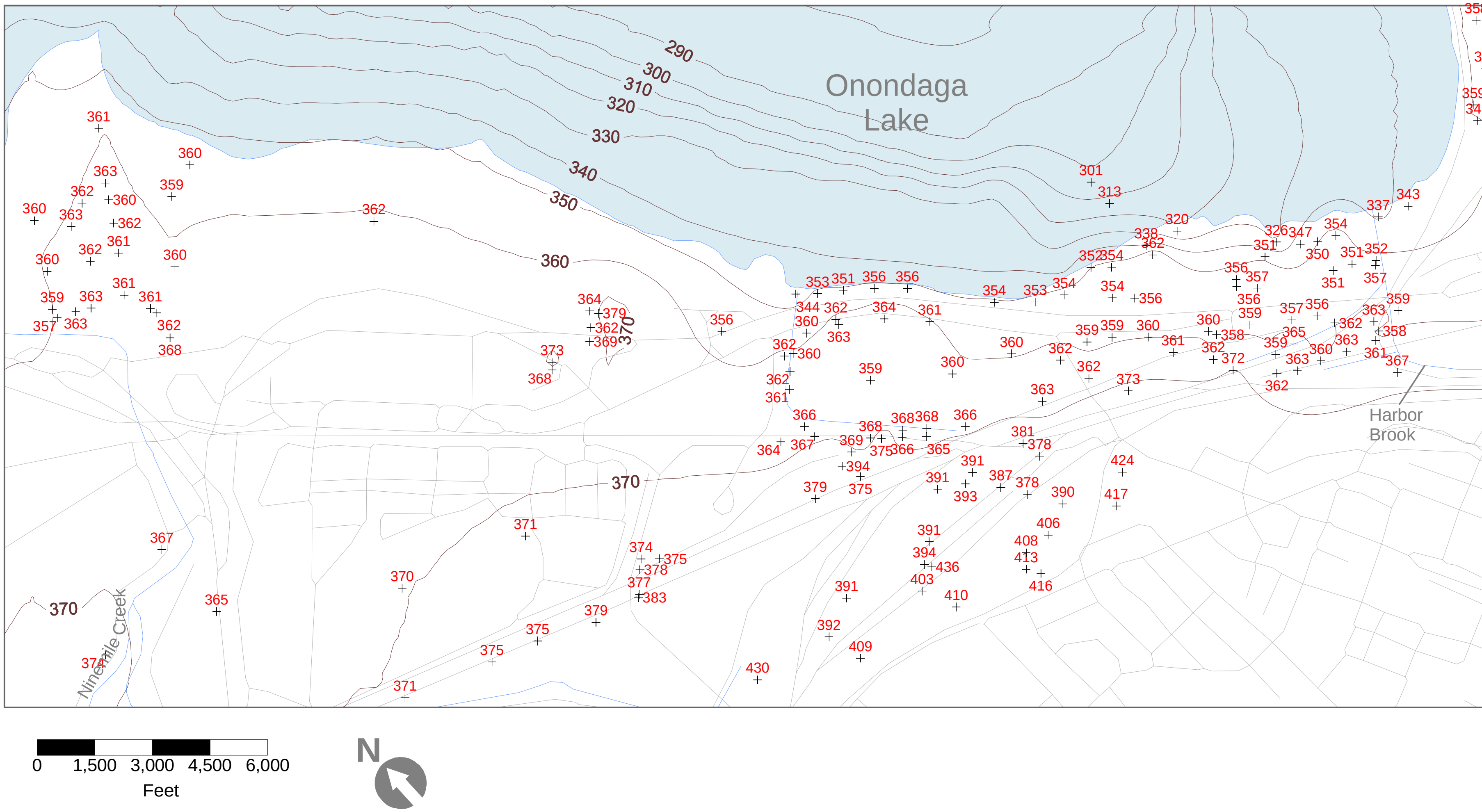

FIGURE DB.4

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

STRUCTURE CONTOUR MAP OF TOP OF MODEL LAYER 3

PARSONS

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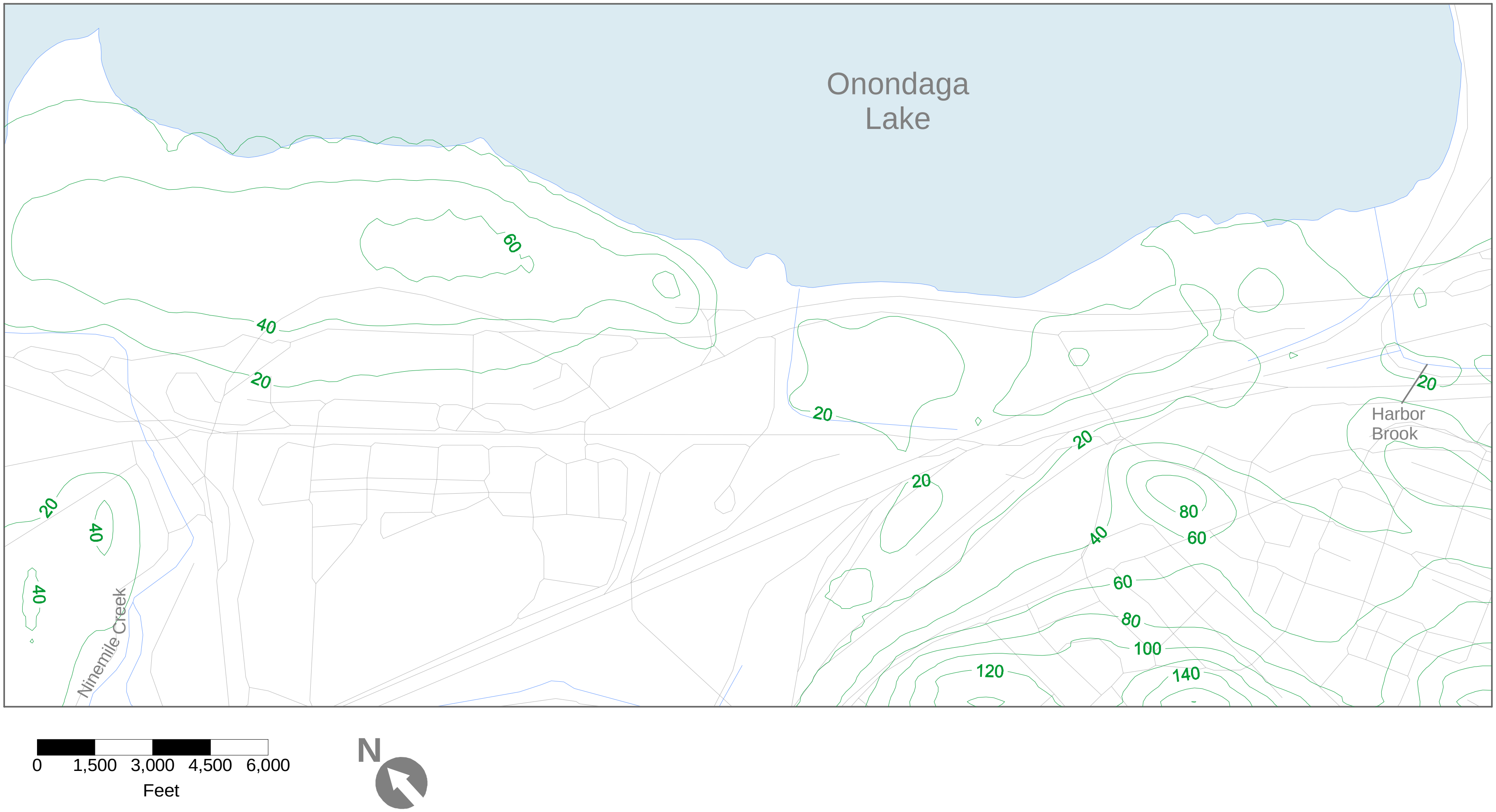

FIGURE DB.5

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

THICKNESS OF MODEL LAYER 1

PARSONS

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

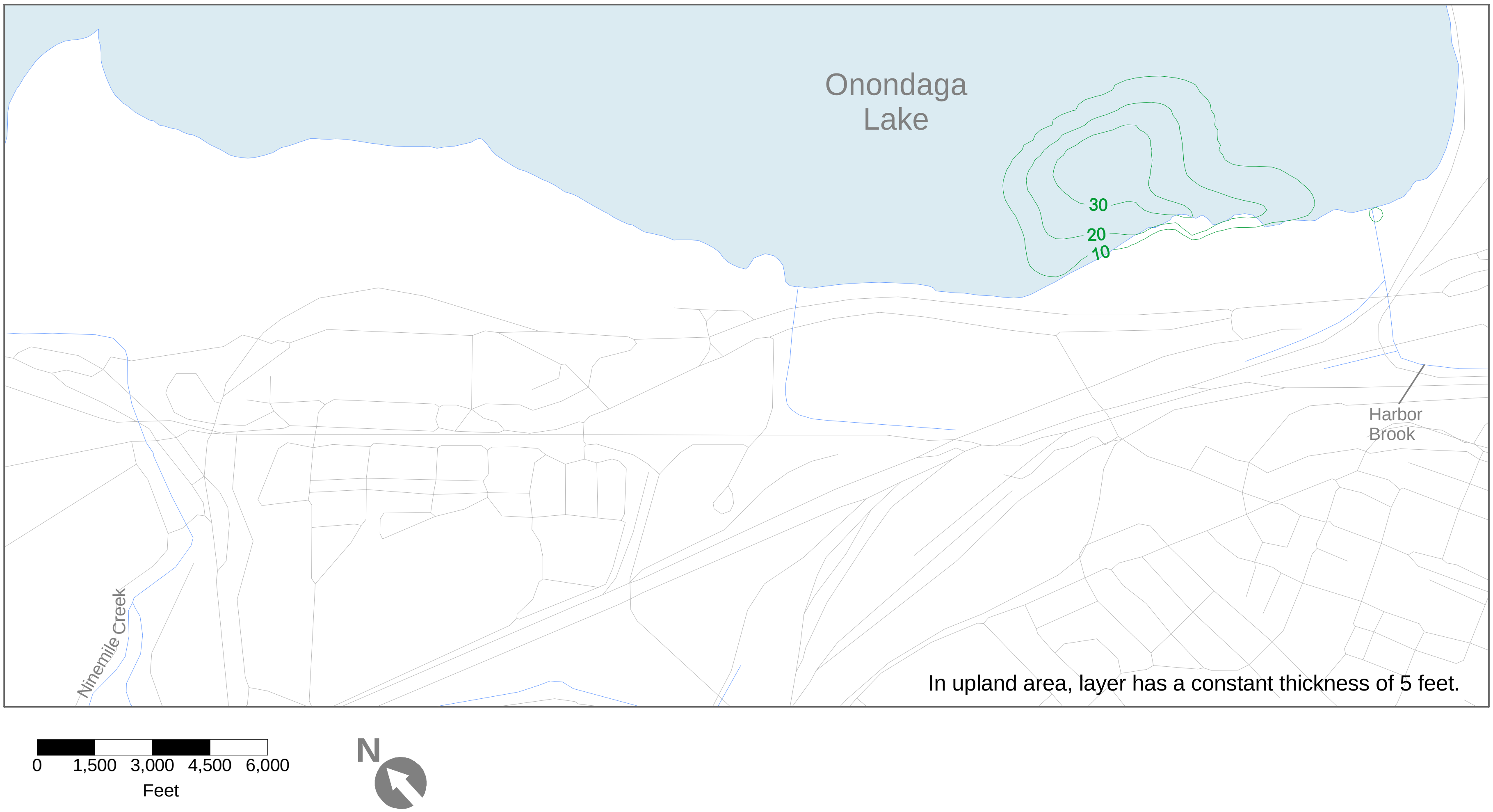

FIGURE DB.6

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

THICKNESS OF MODEL LAYER 2

PARSONS

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

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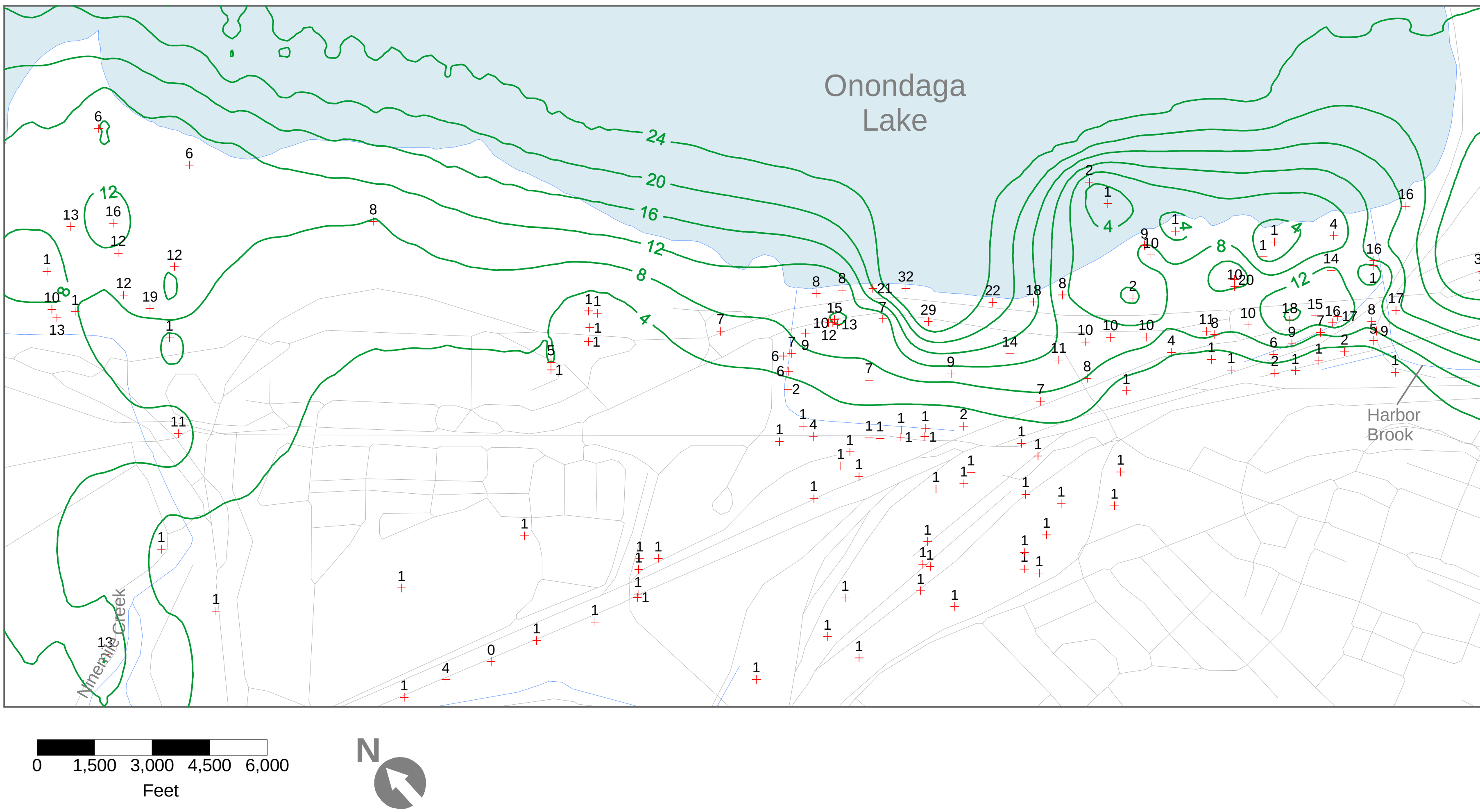

FIGURE DB.7

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

THICKNESS OF MODEL LAYER 3

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

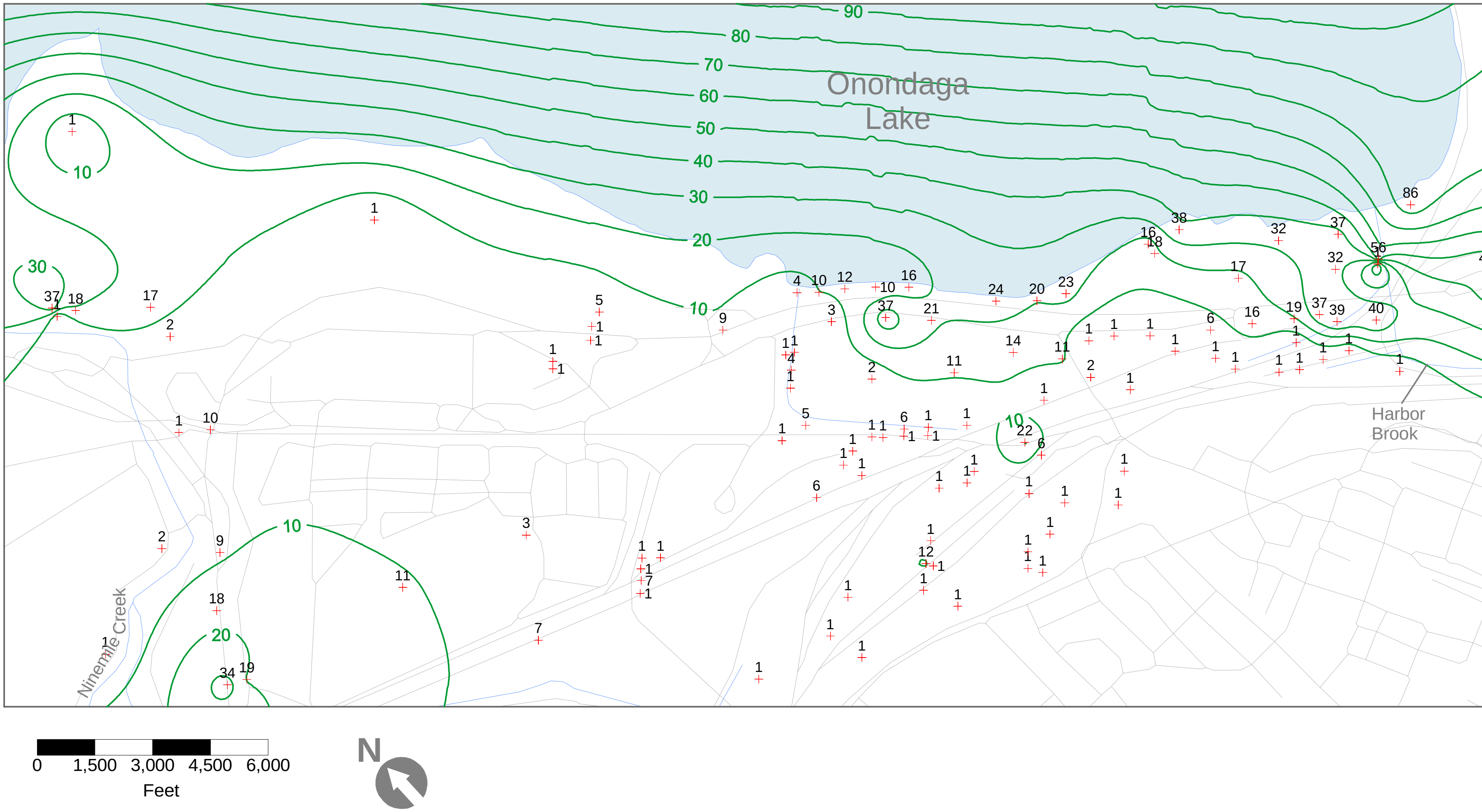

FIGURE DB.8

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

THICKNESS OF MODEL LAYER 4

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

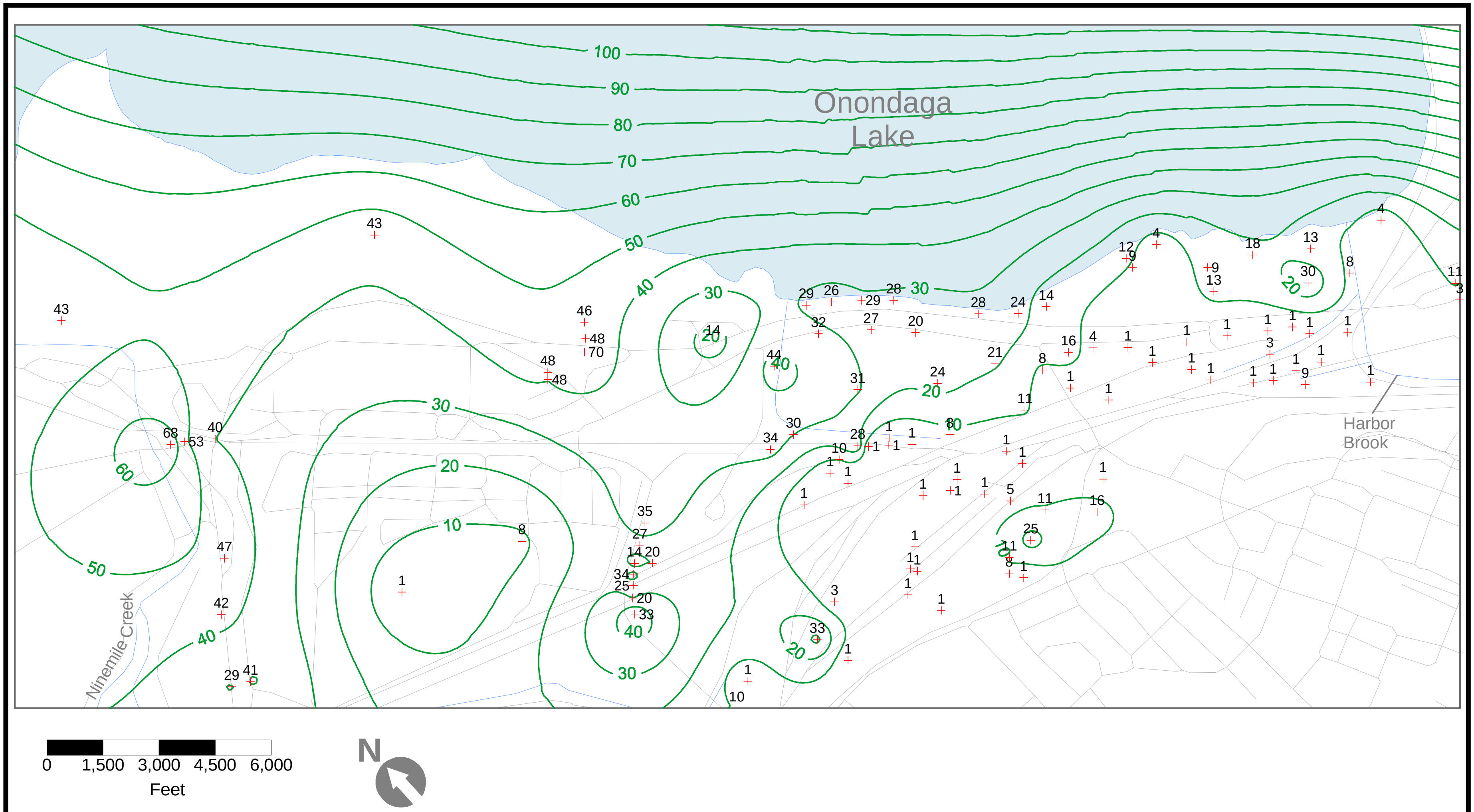

FIGURE DB.9

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

THICKNESS OF MODEL LAYER 5

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

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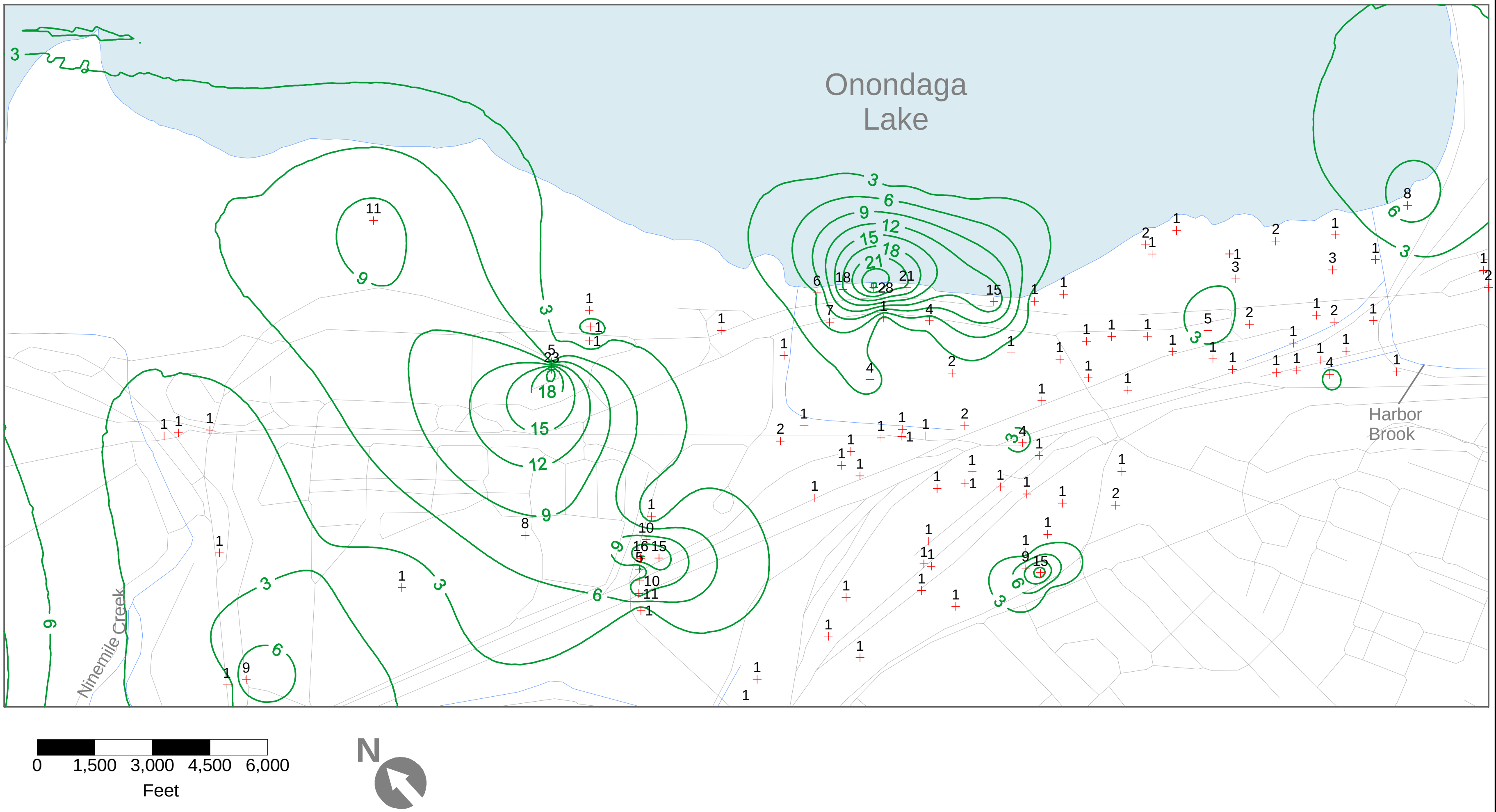

FIGURE DB.10

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

THICKNESS OF MODEL LAYER 6

PARSONS

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

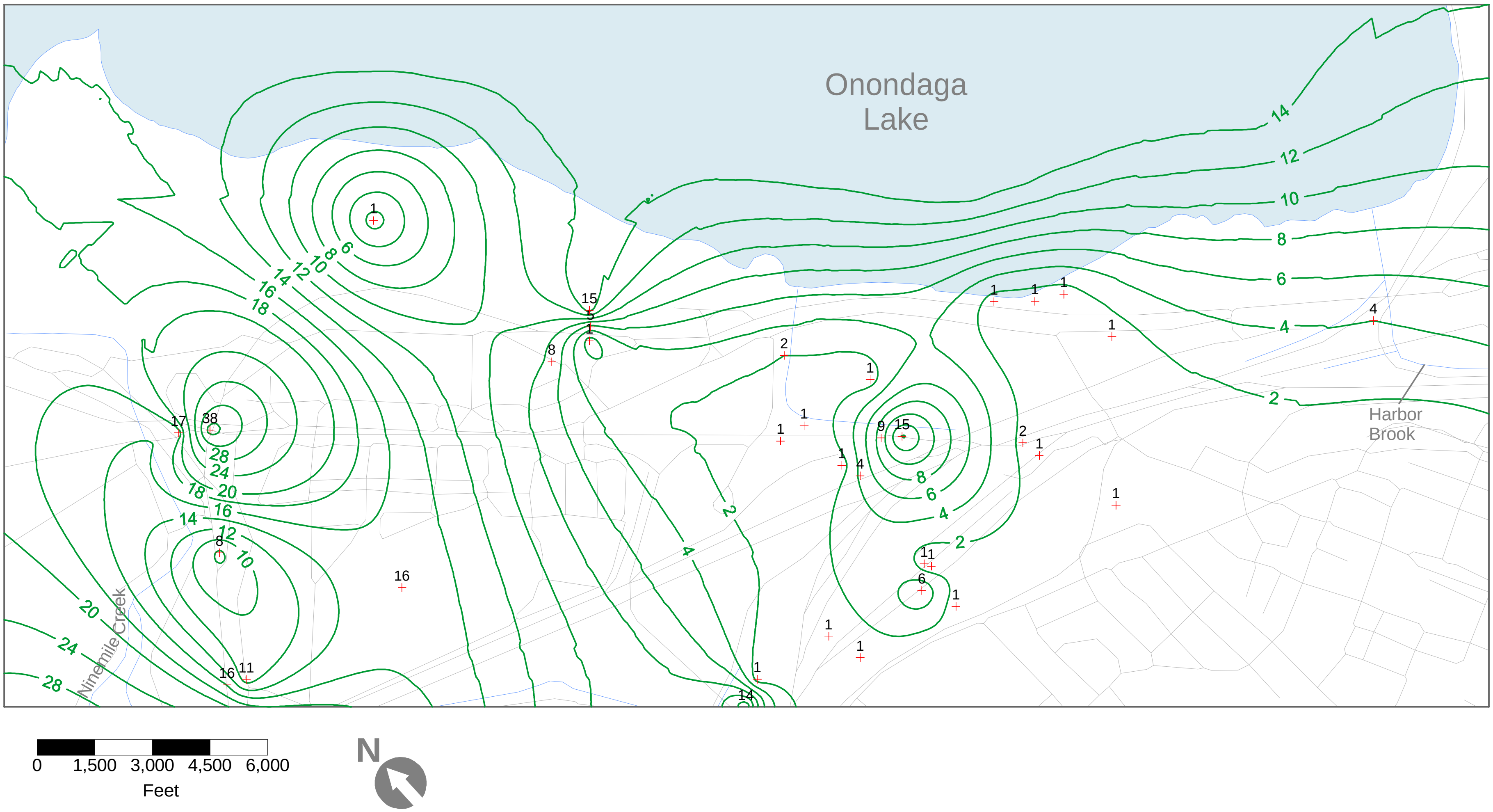

FIGURE DB.11

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

THICKNESS OF MODEL LAYER 7

PARSONS

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

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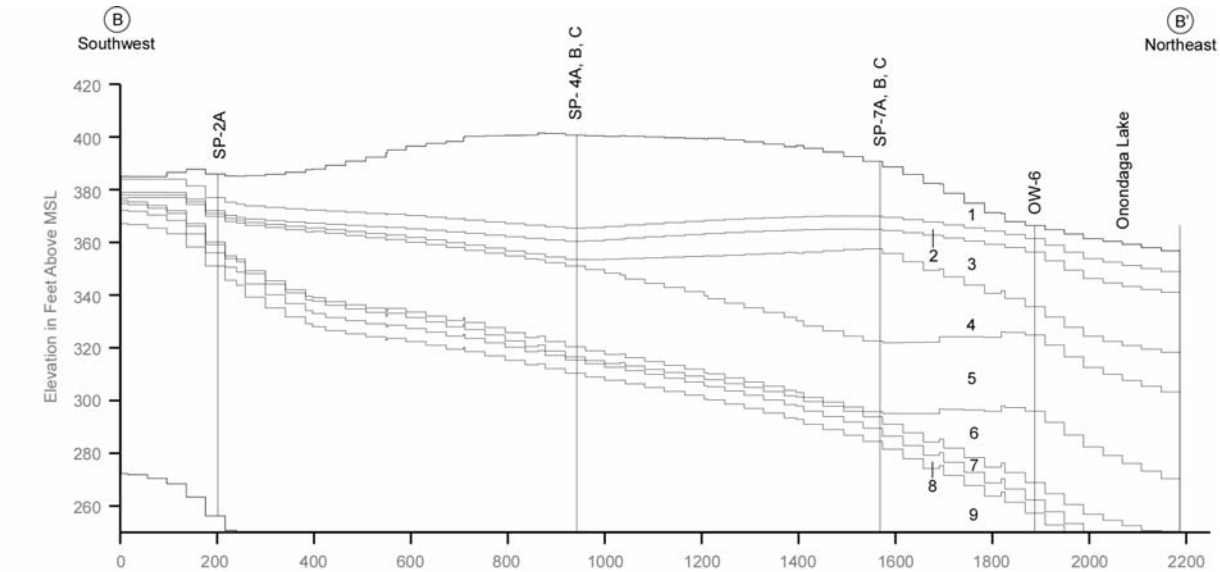

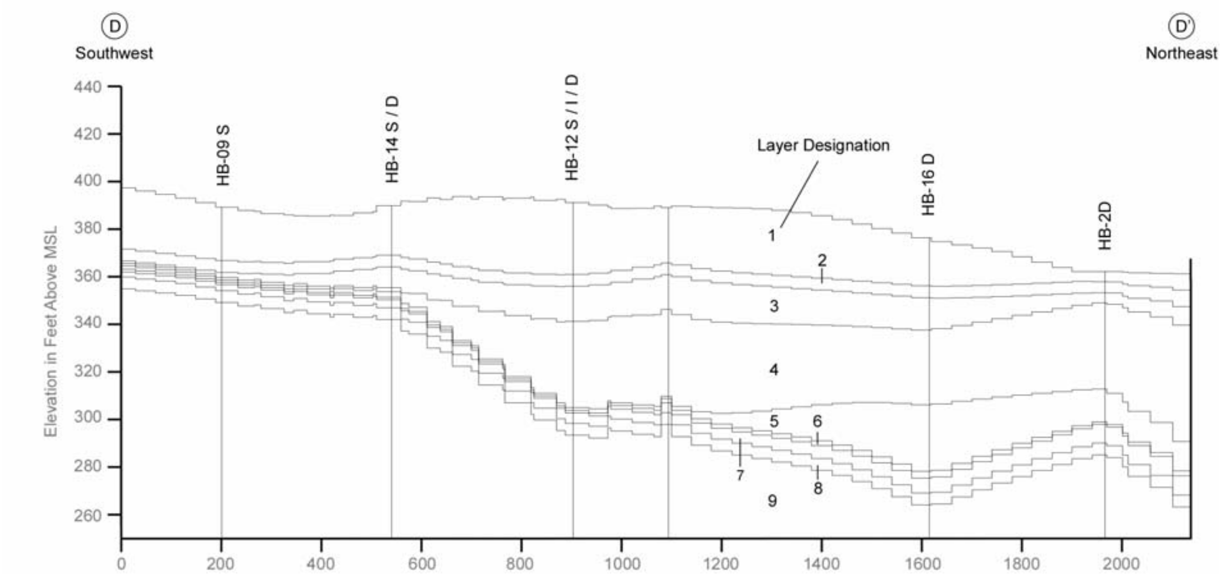

See Figure DA.1 for cross-section locations.

FIGURE DB.12

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

MODEL LAYER
CROSS SECTIONS

PARSONS

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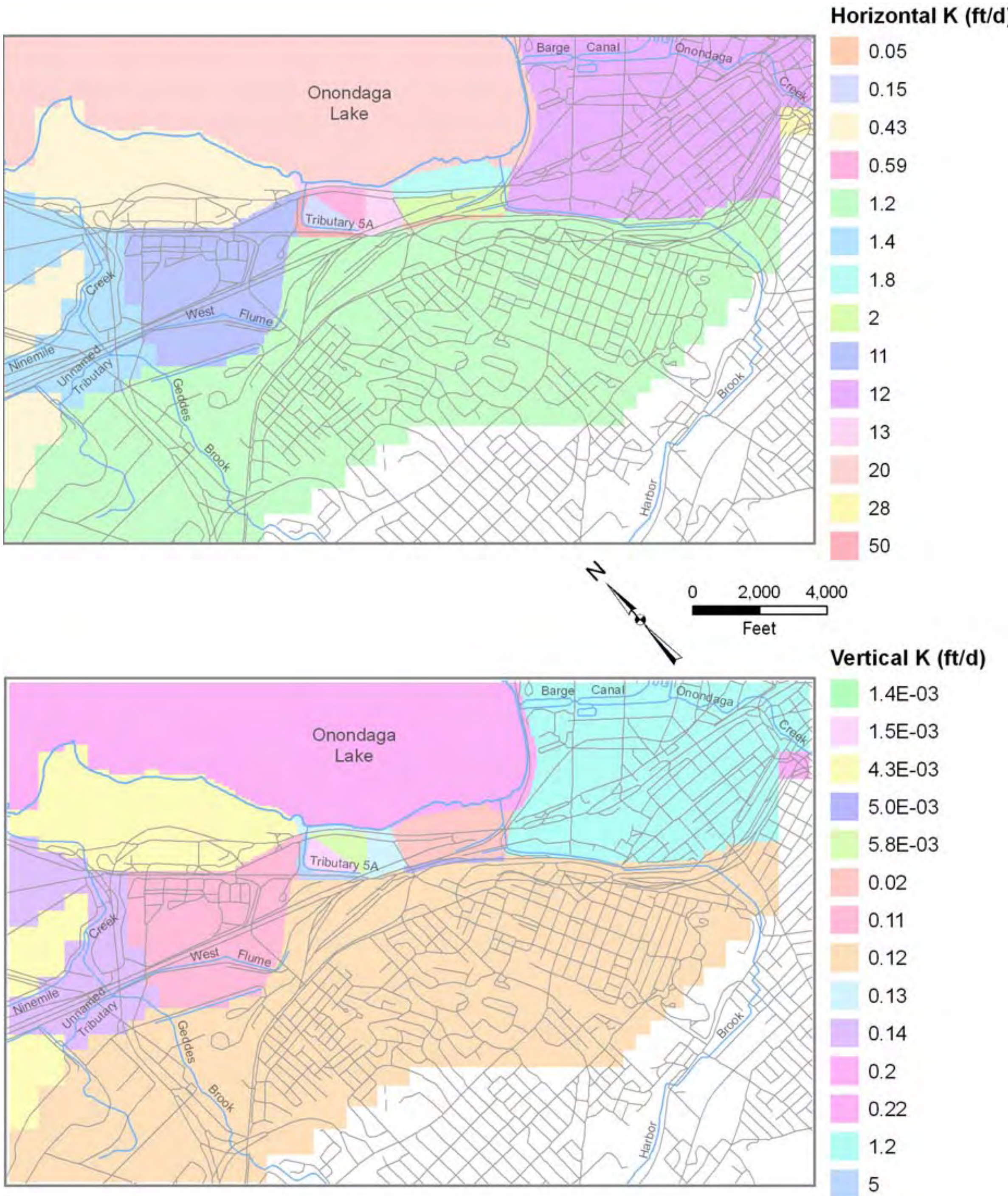

FIGURE DB.13

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

SITE HYDRAULIC CONDUCTIVITY
IN MODEL LAYER 1

PARSONS

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

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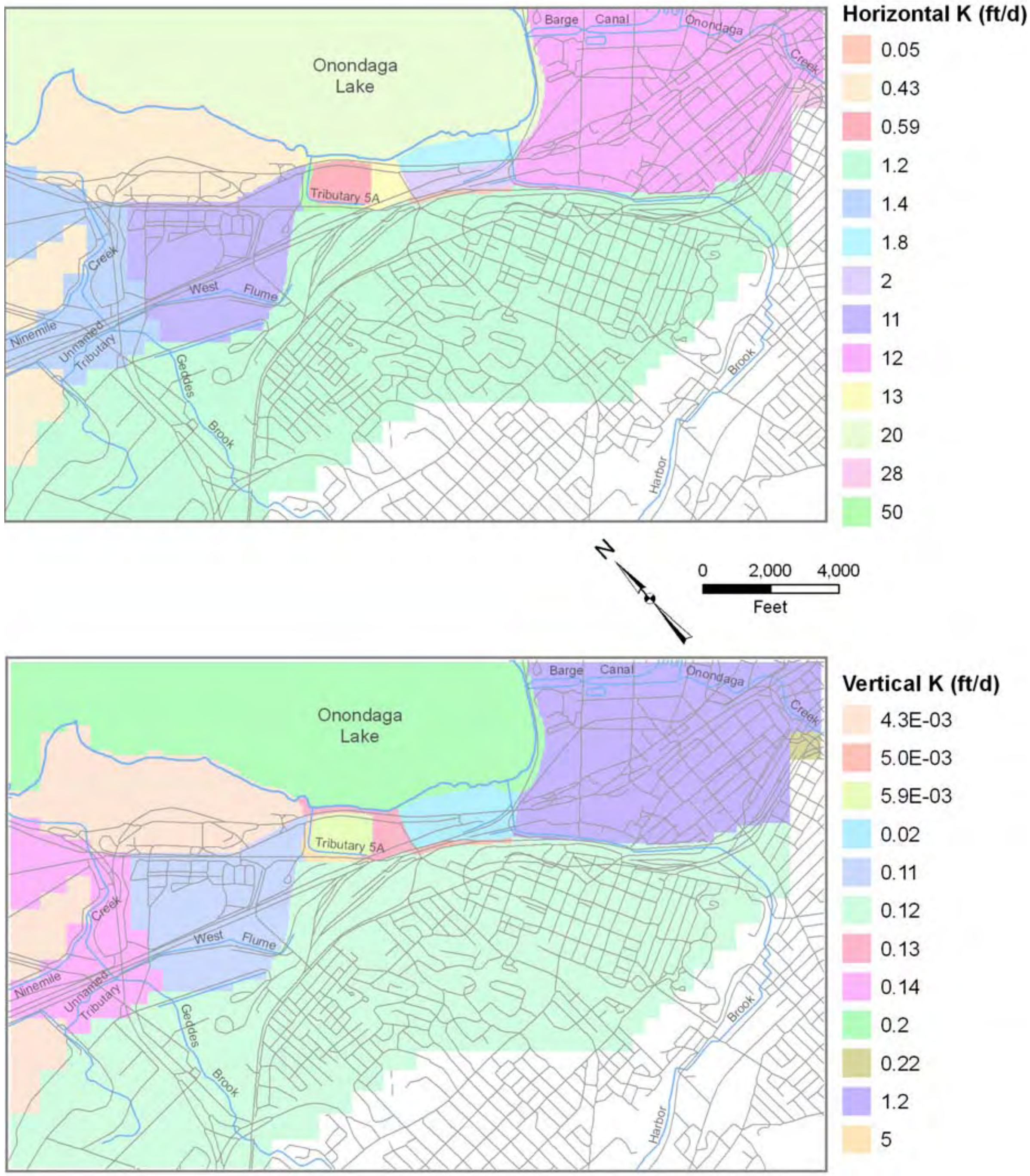


FIGURE DB.14

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

SITE HYDRAULIC CONDUCTIVITY
IN MODEL LAYER 2

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

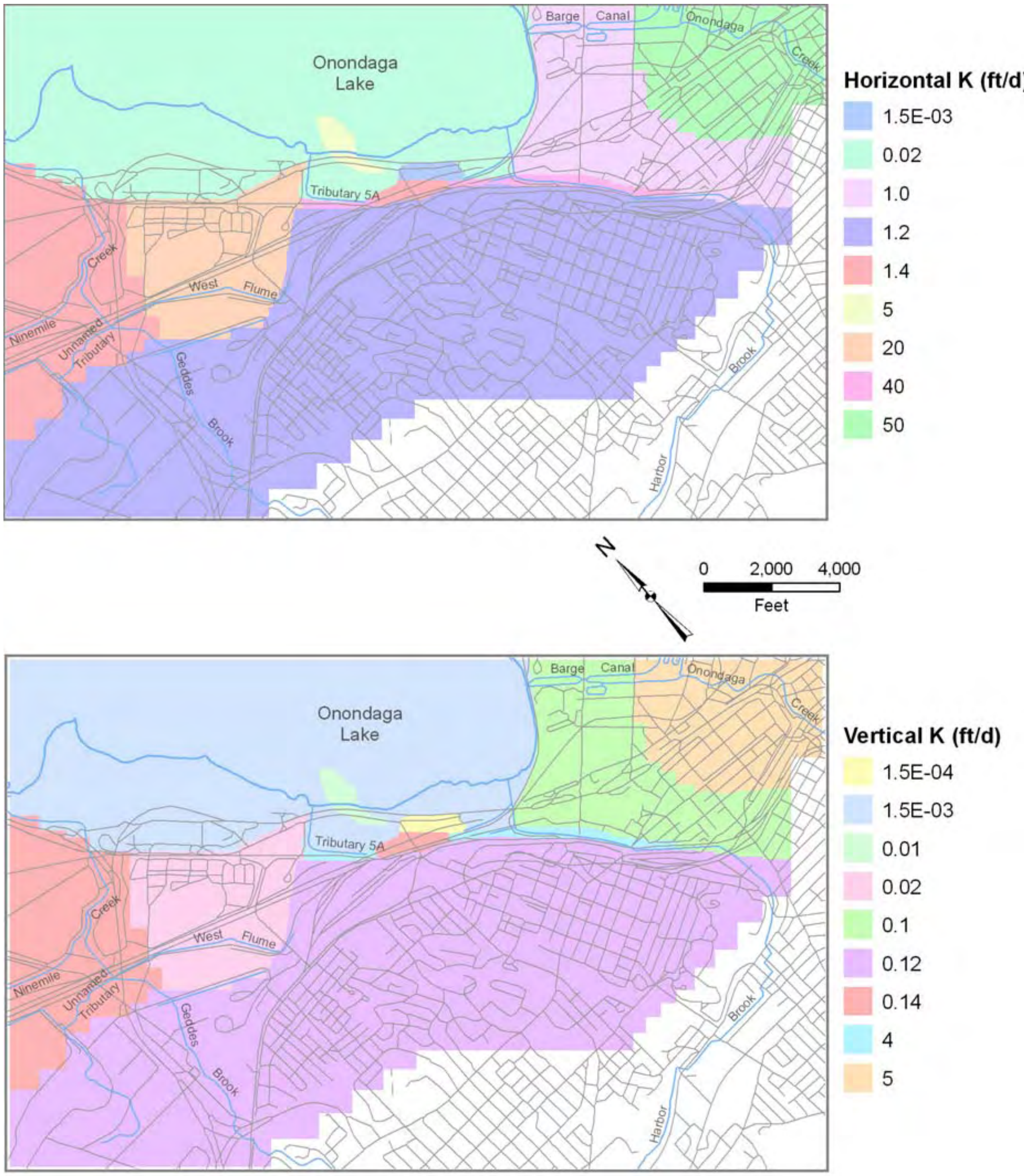


FIGURE DB.15

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

SITE HYDRAULIC CONDUCTIVITY
IN MODEL LAYER 3

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

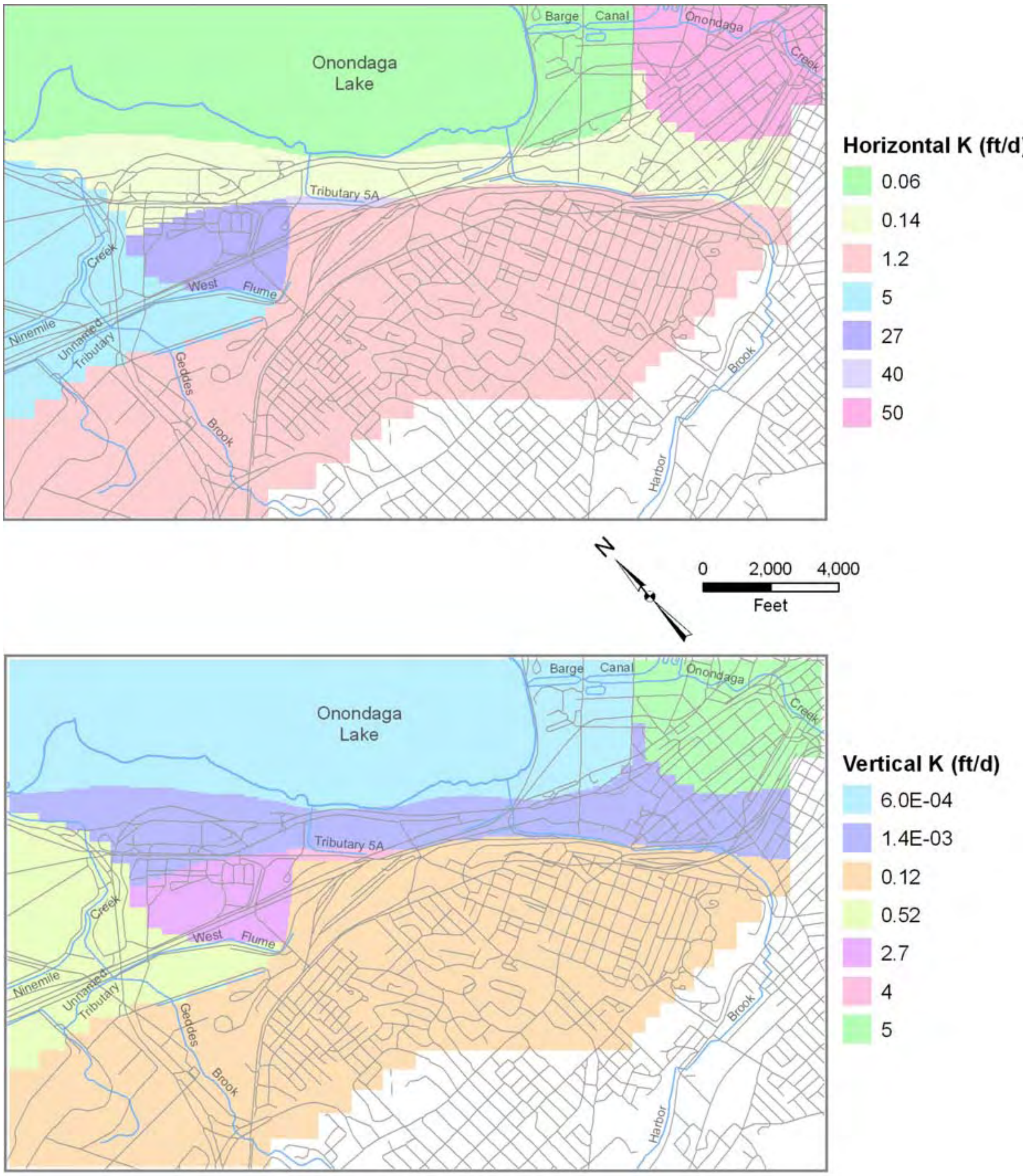


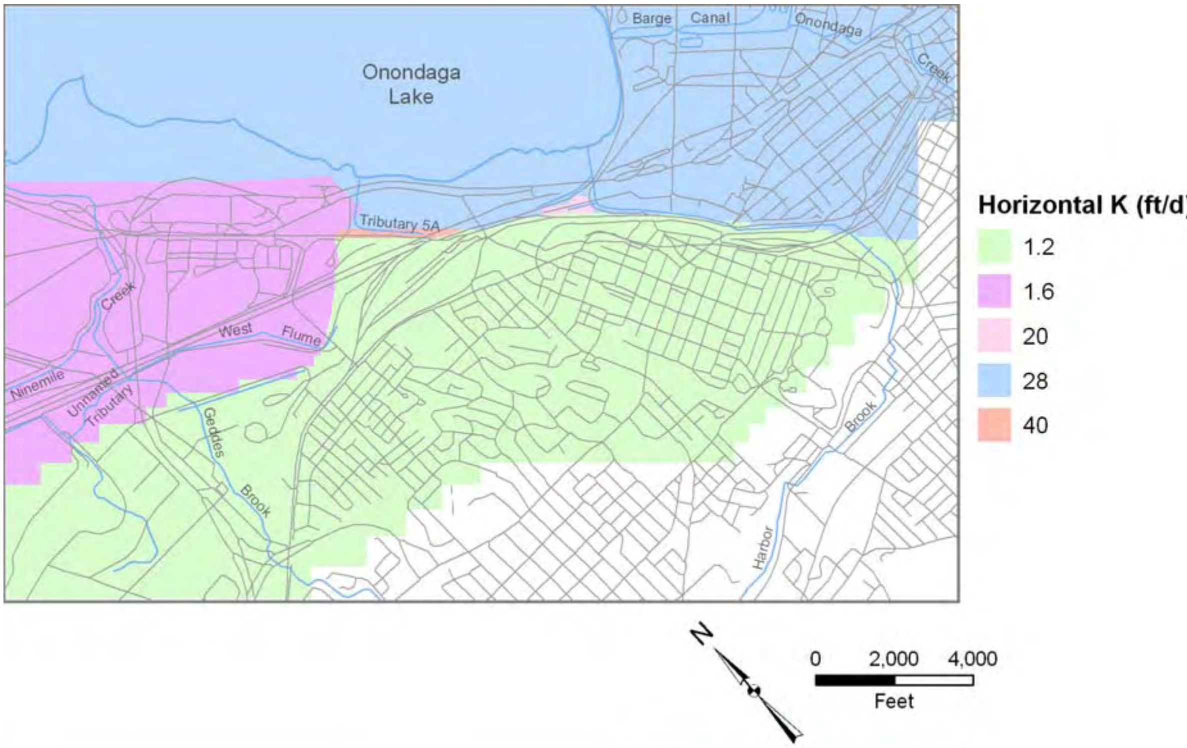
FIGURE DB.16

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

SITE HYDRAULIC CONDUCTIVITY
IN MODEL LAYER 4

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



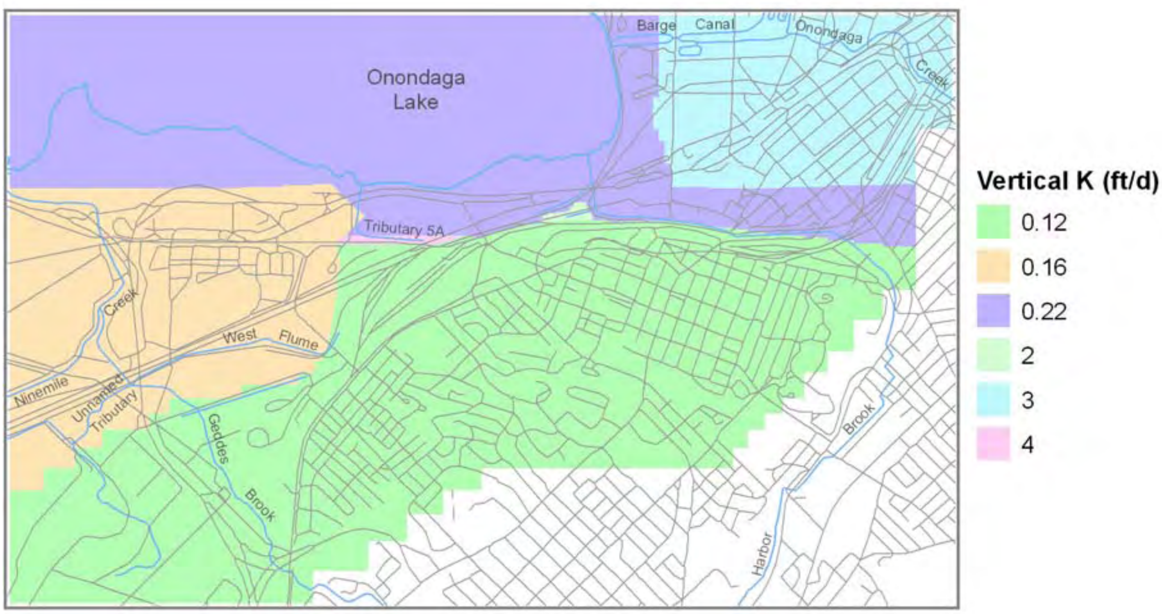


FIGURE DB.17

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

SITE HYDRAULIC CONDUCTIVITY IN MODEL LAYER 5

PARSONS

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

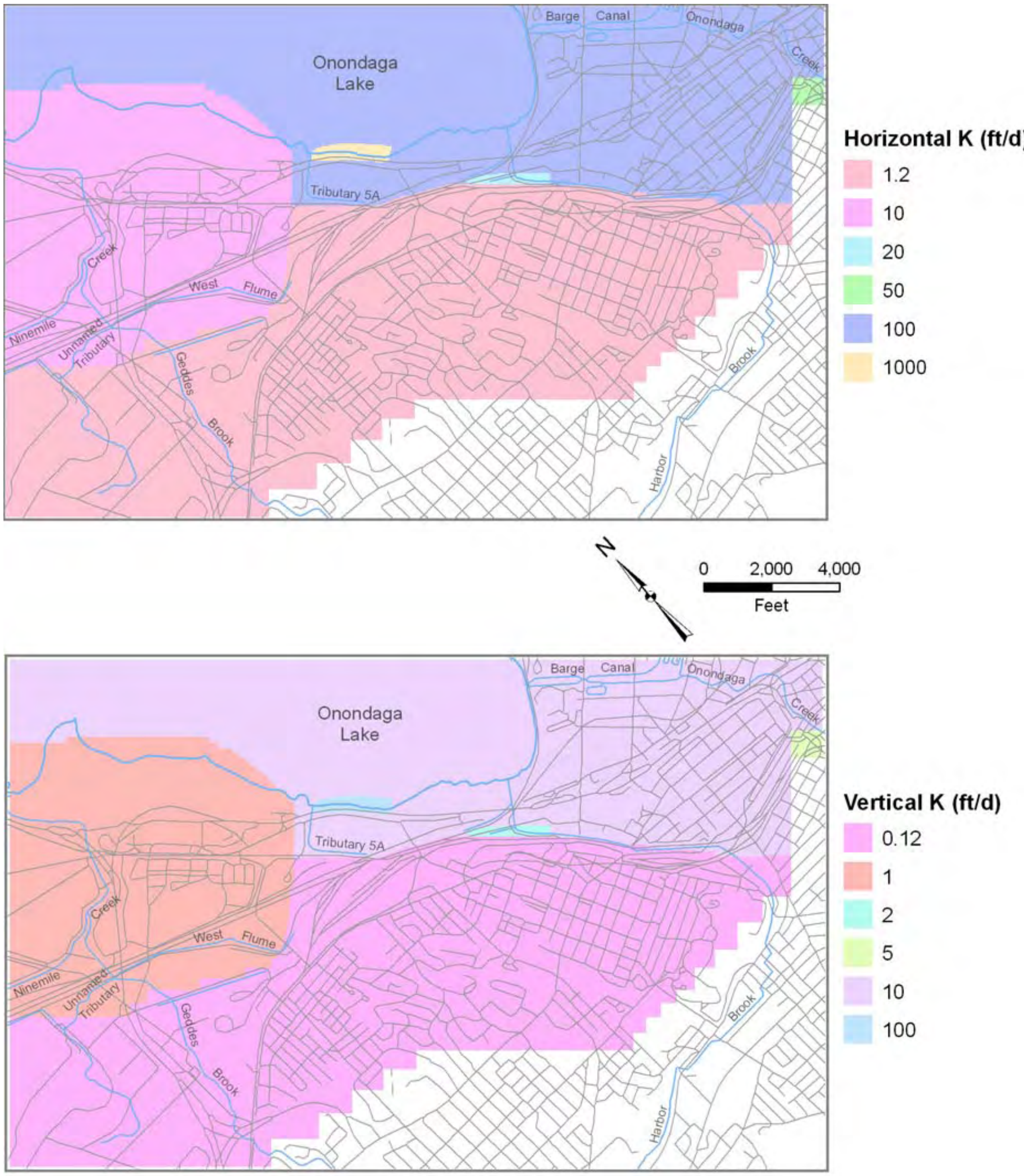


FIGURE DB.18

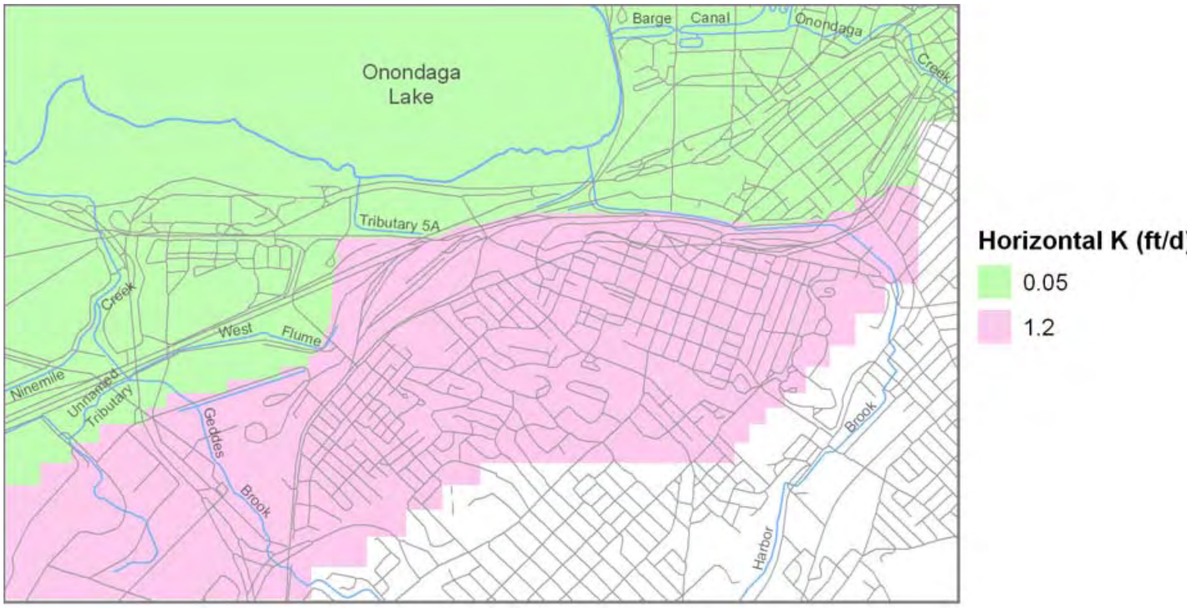
Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

SITE HYDRAULIC CONDUCTIVITY
IN MODEL LAYER 6

PARSONS

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



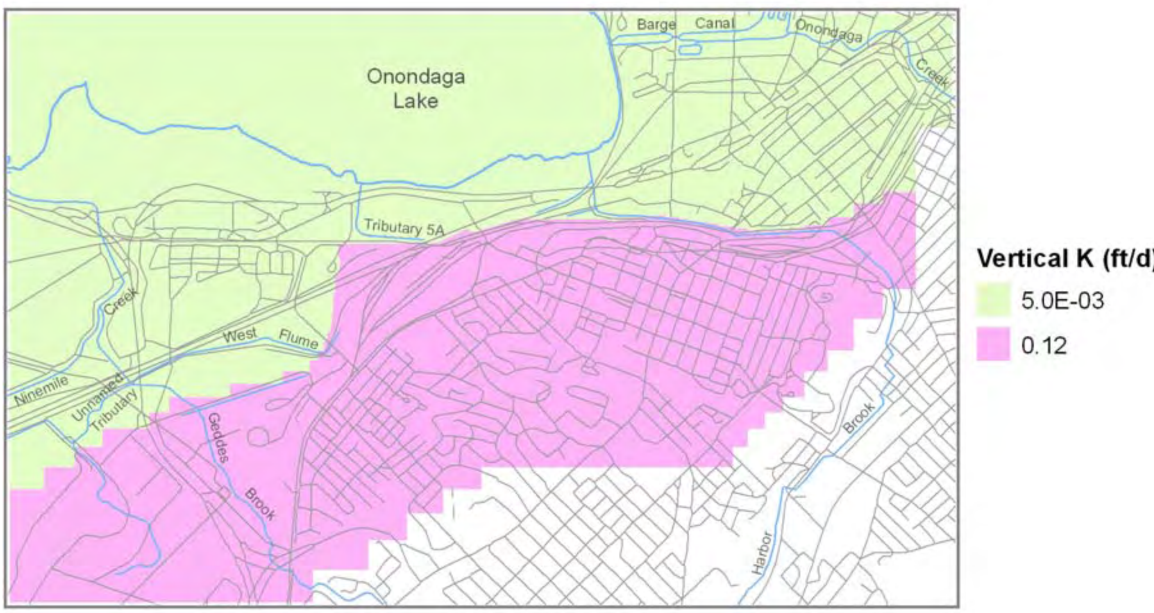


FIGURE DB.19

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

SITE HYDRAULIC CONDUCTIVITY
IN MODEL LAYER 7

PARSONS

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

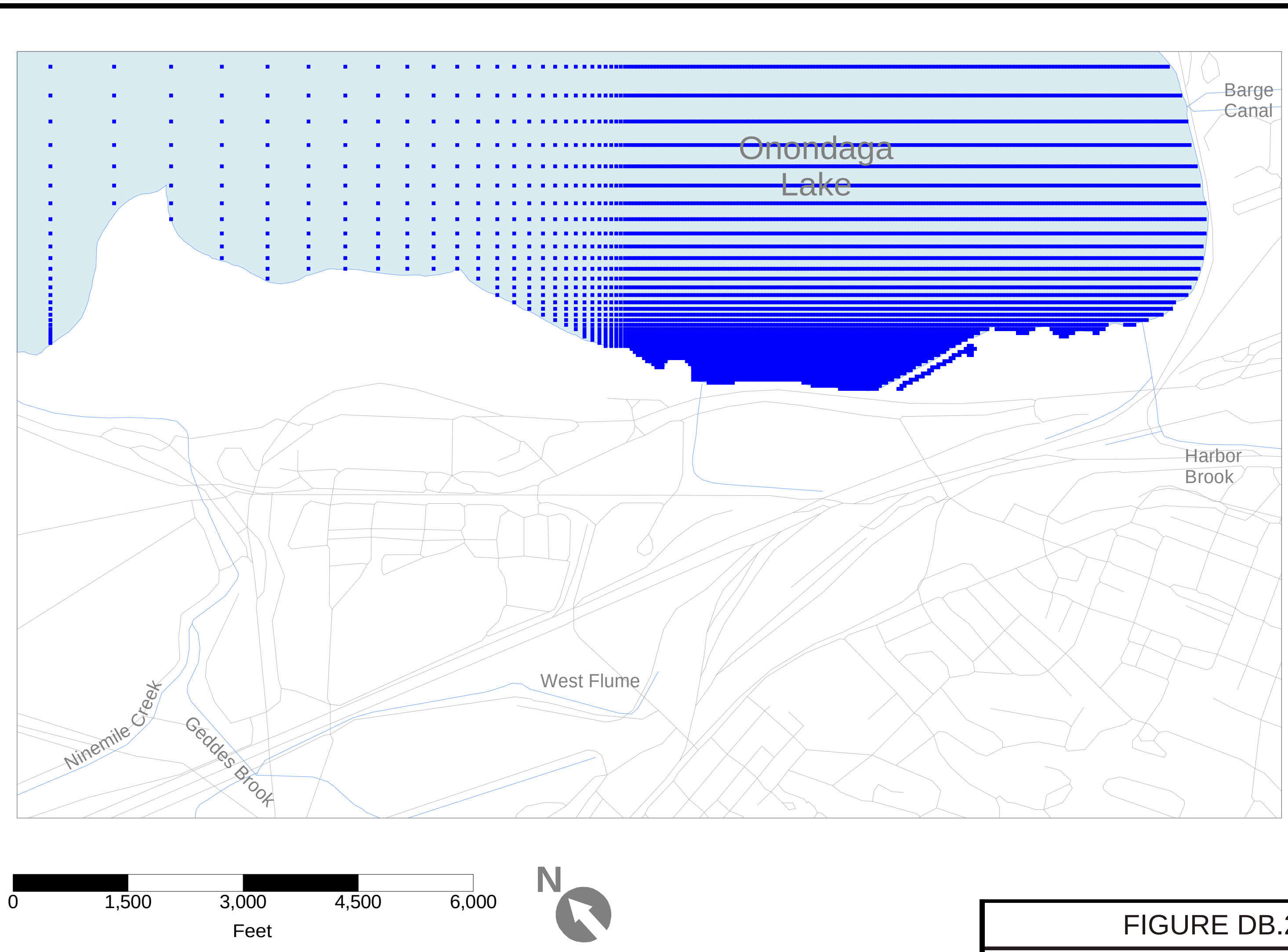


FIGURE DB.20

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

LOCATION OF RIVER TYPE BOUNDARY CONDITIONS

PARSONS

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

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FIGURE DB.21

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

LOCATION OF DRAIN TYPE BOUNDARY CONDITIONS

PARSONS

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

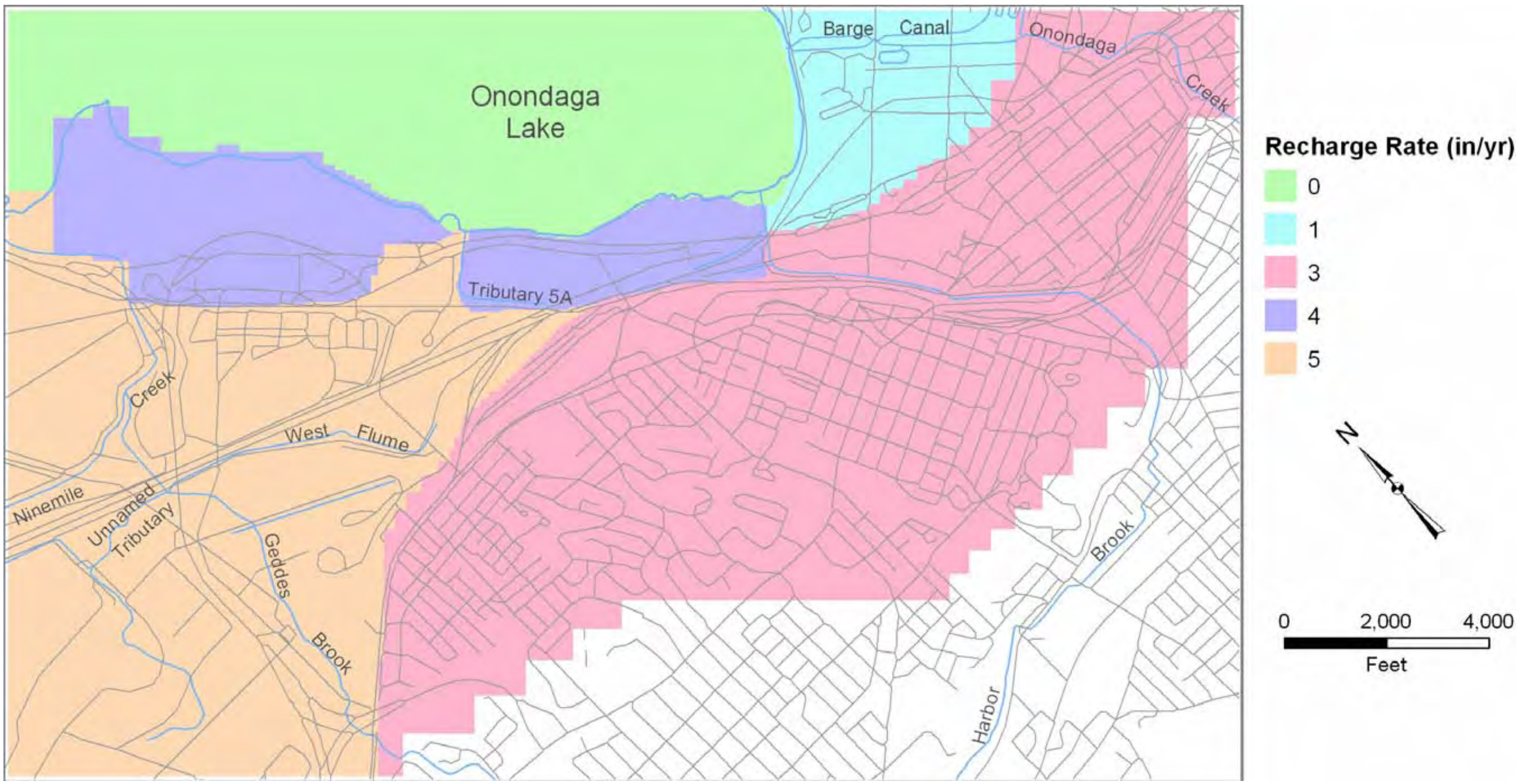

FIGURE DB.22

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

RECHARGE RATES IN MODEL

PARSONS

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

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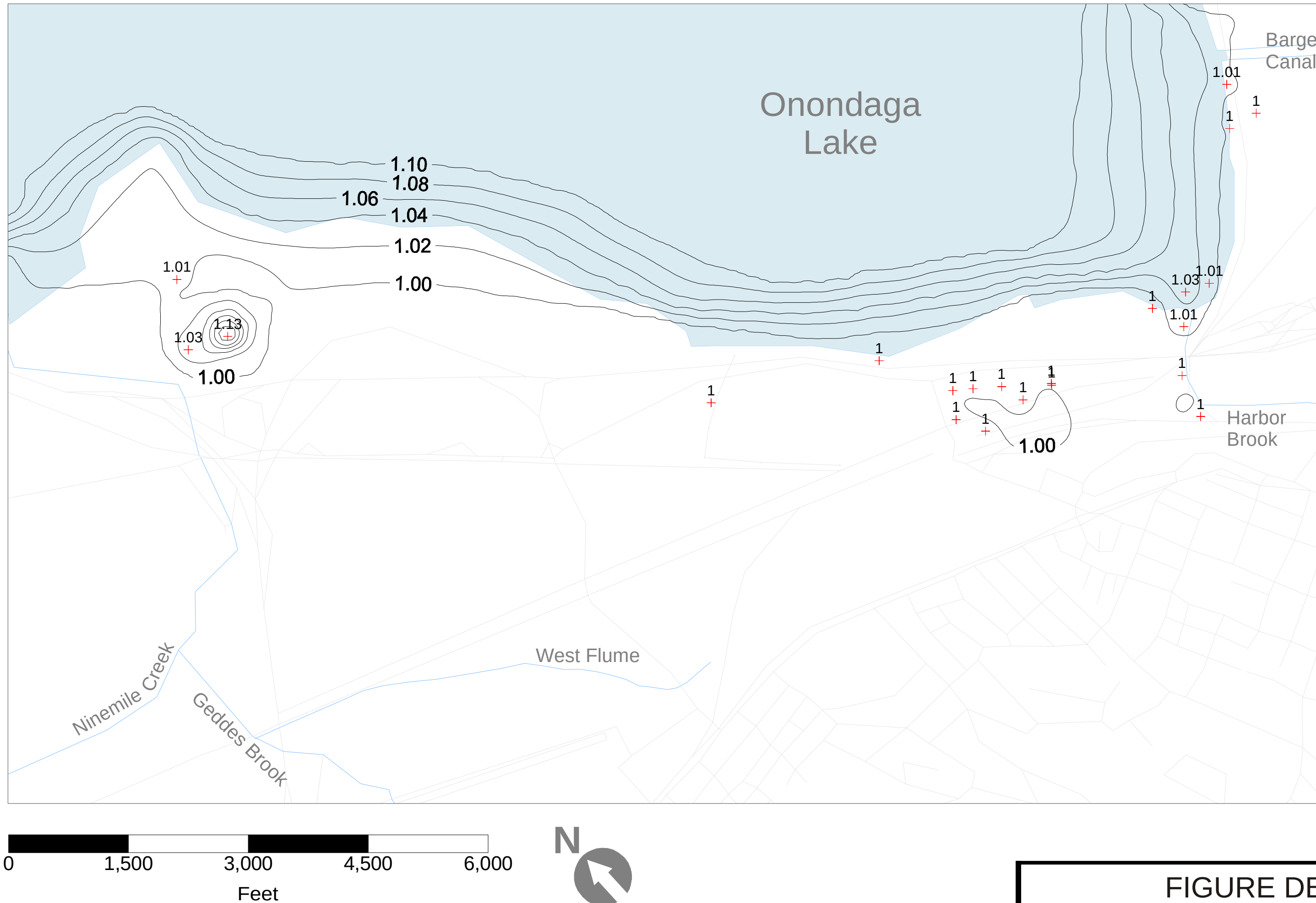

FIGURE DB.23

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

DENSITY DISTRIBUTION IN MODEL LAYER 2

PARSONS

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

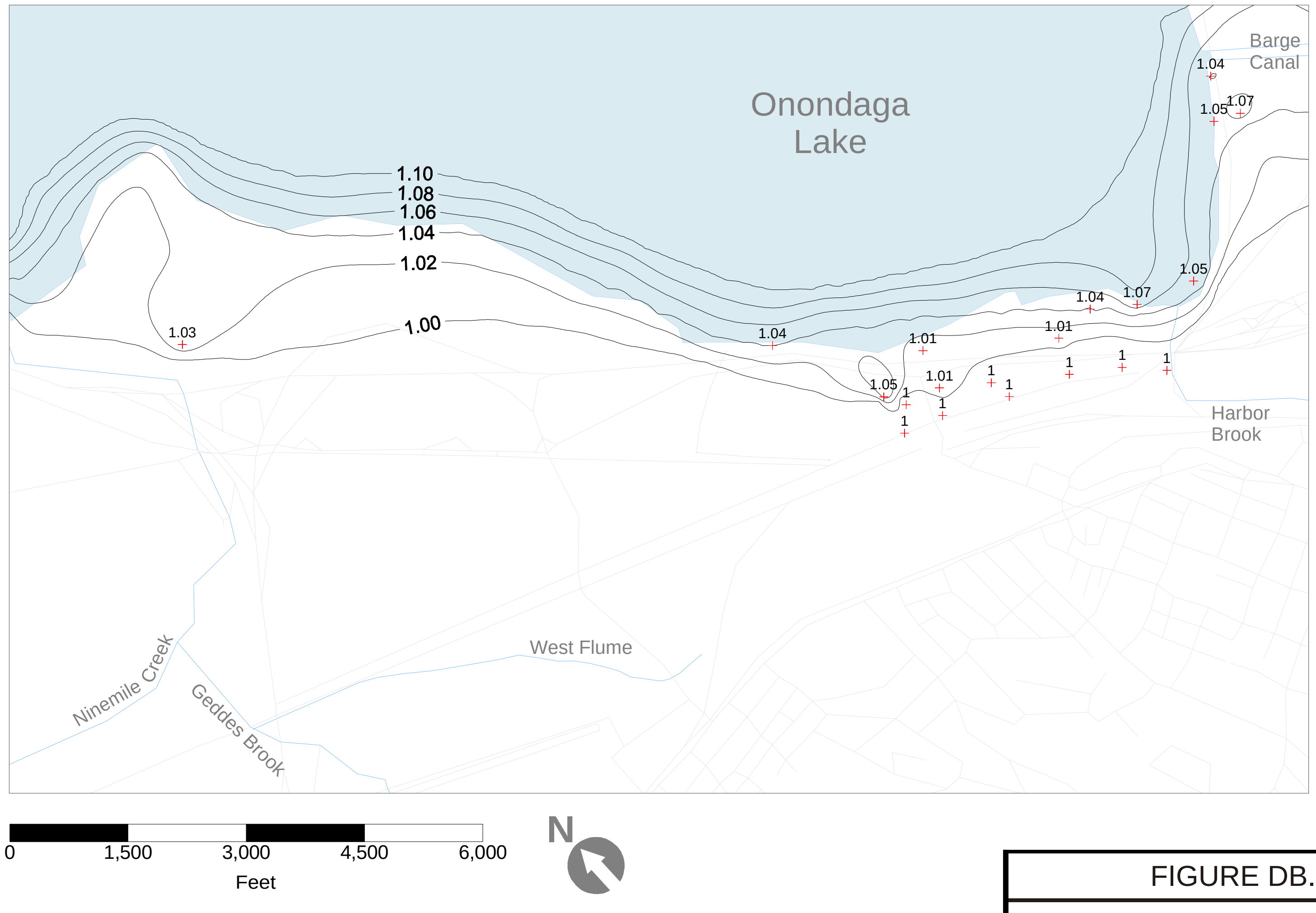

FIGURE DB.24

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

DENSITY DISTRIBUTION IN MODEL LAYER 3

PARSONS

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

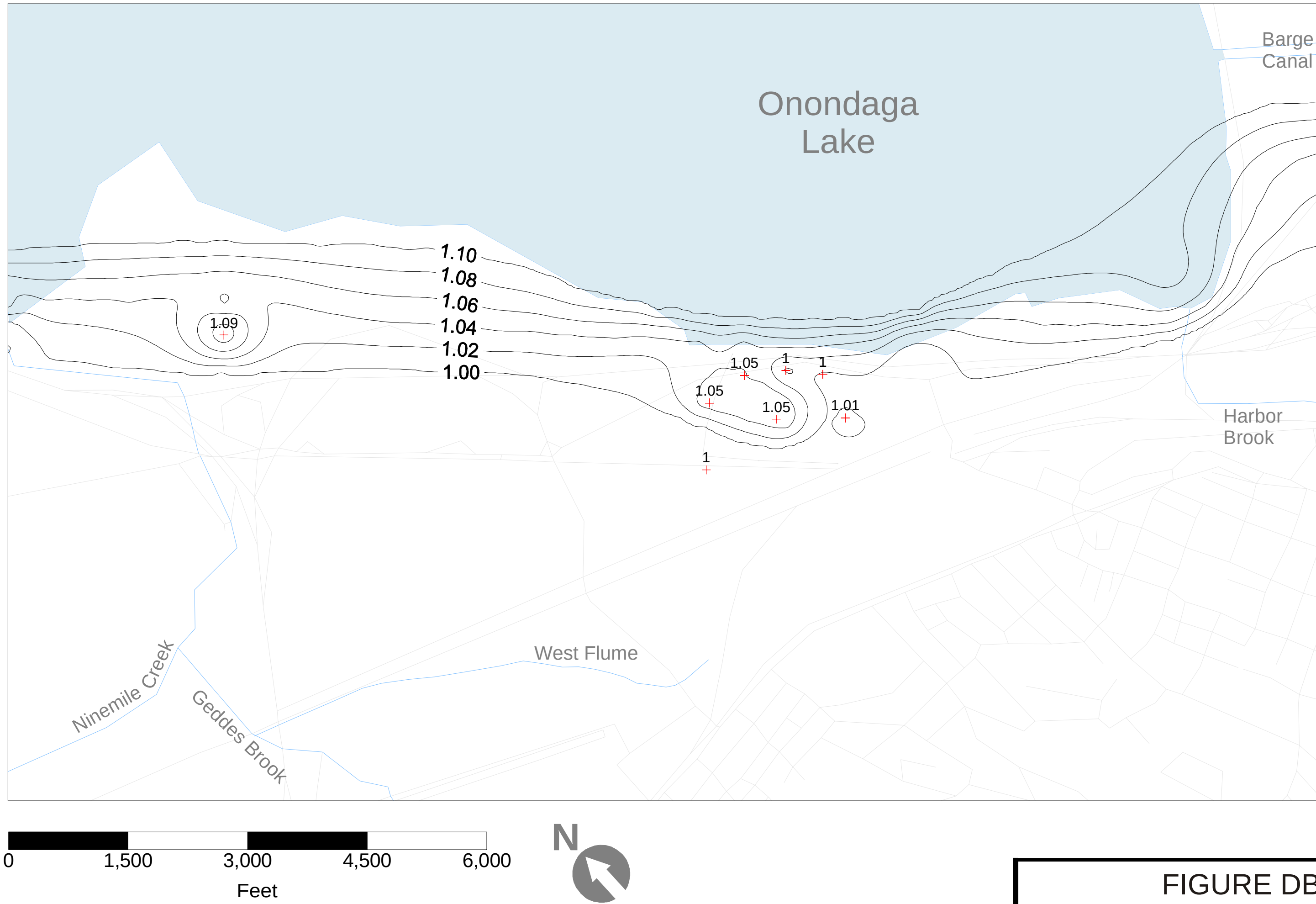

FIGURE DB.25

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

DENSITY DISTRIBUTION IN
MODEL LAYER 4

PARSONS

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

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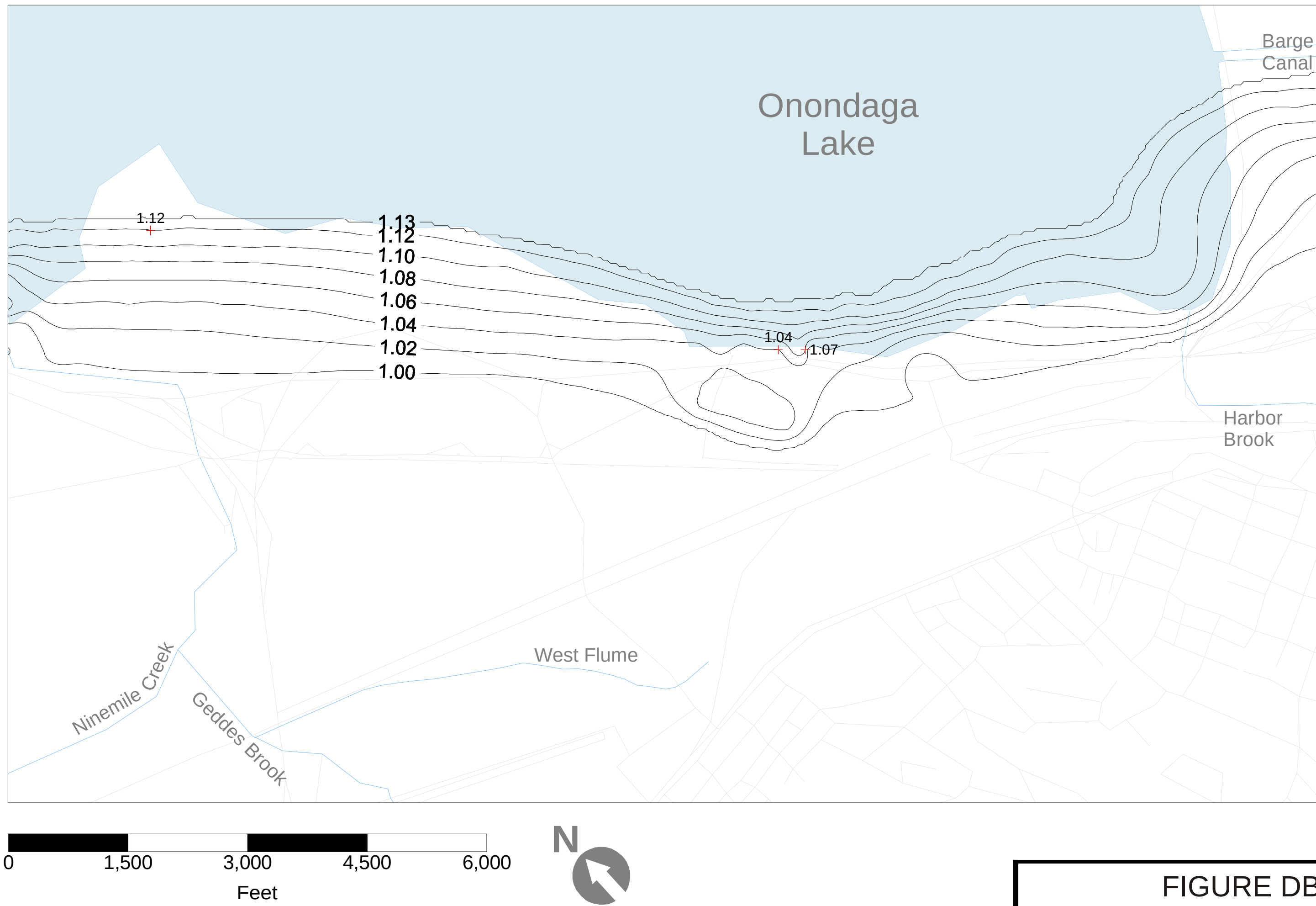

FIGURE DB.26

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

DENSITY DISTRIBUTION IN MODEL LAYER 5

PARSONS

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

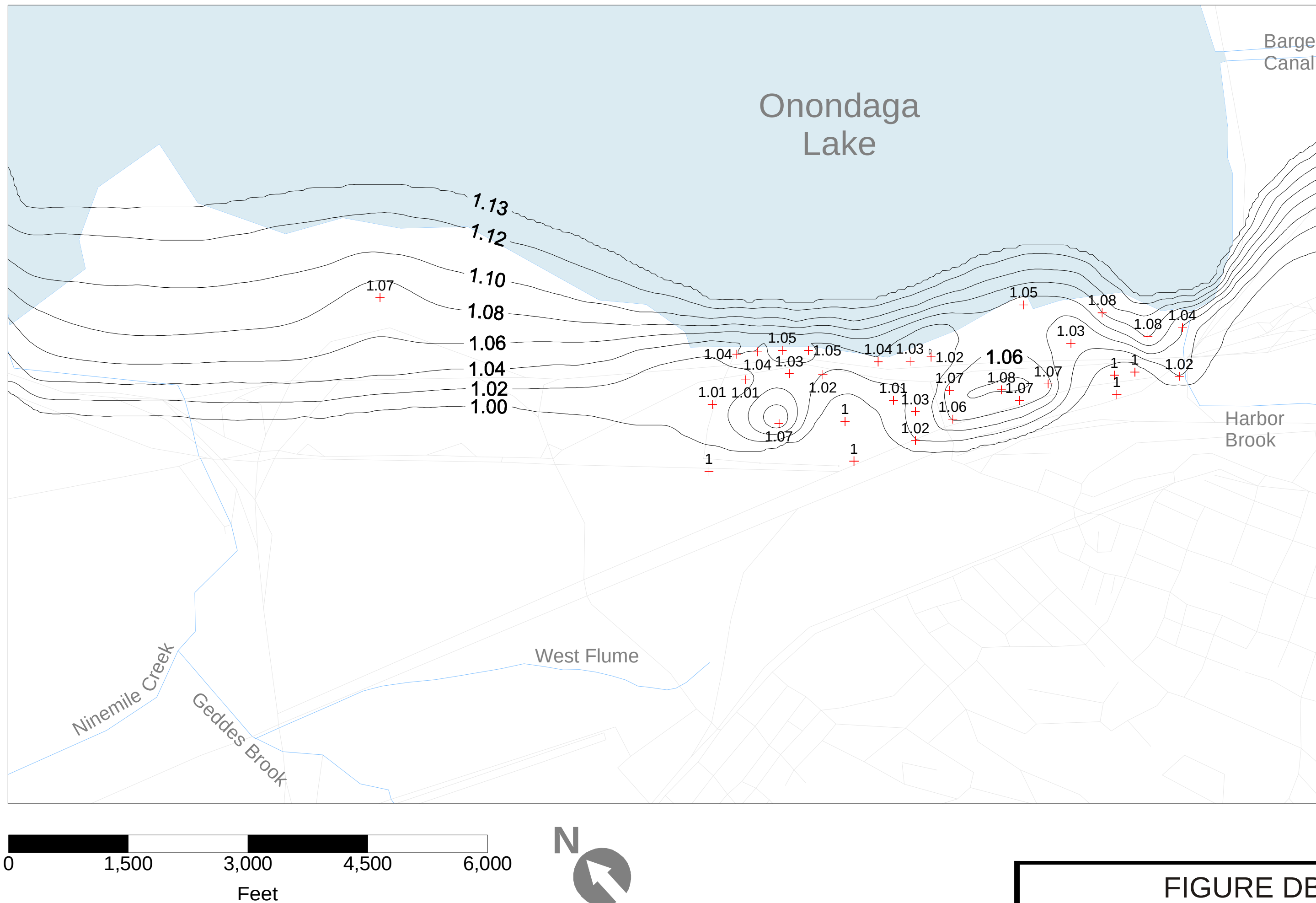

FIGURE DB.27

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

DENSITY DISTRIBUTION IN
MODEL LAYER 6

PARSONS

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

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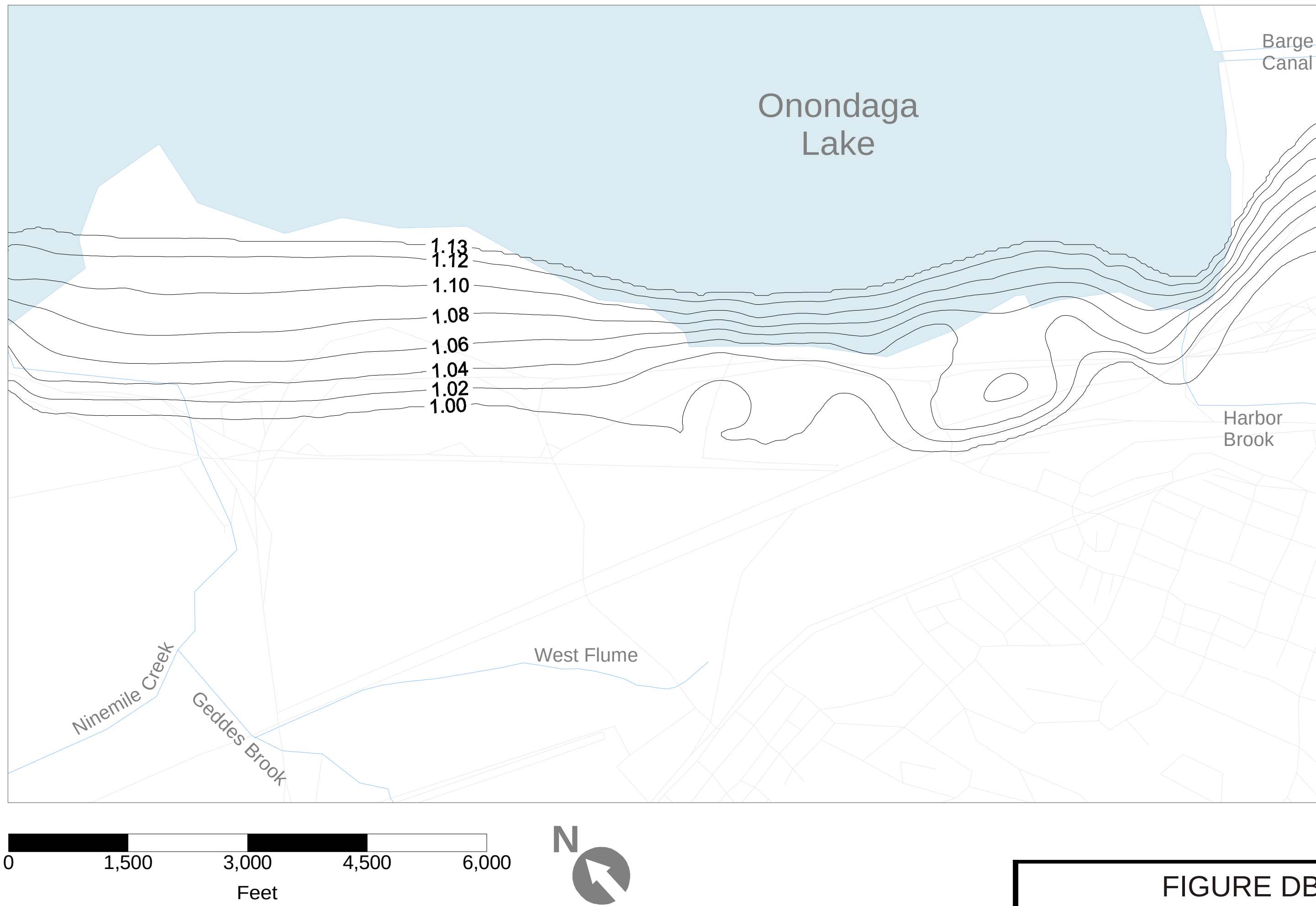

FIGURE DB.28

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

DENSITY DISTRIBUTION IN
MODEL LAYERS 7, 8 and 9

PARSONS

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

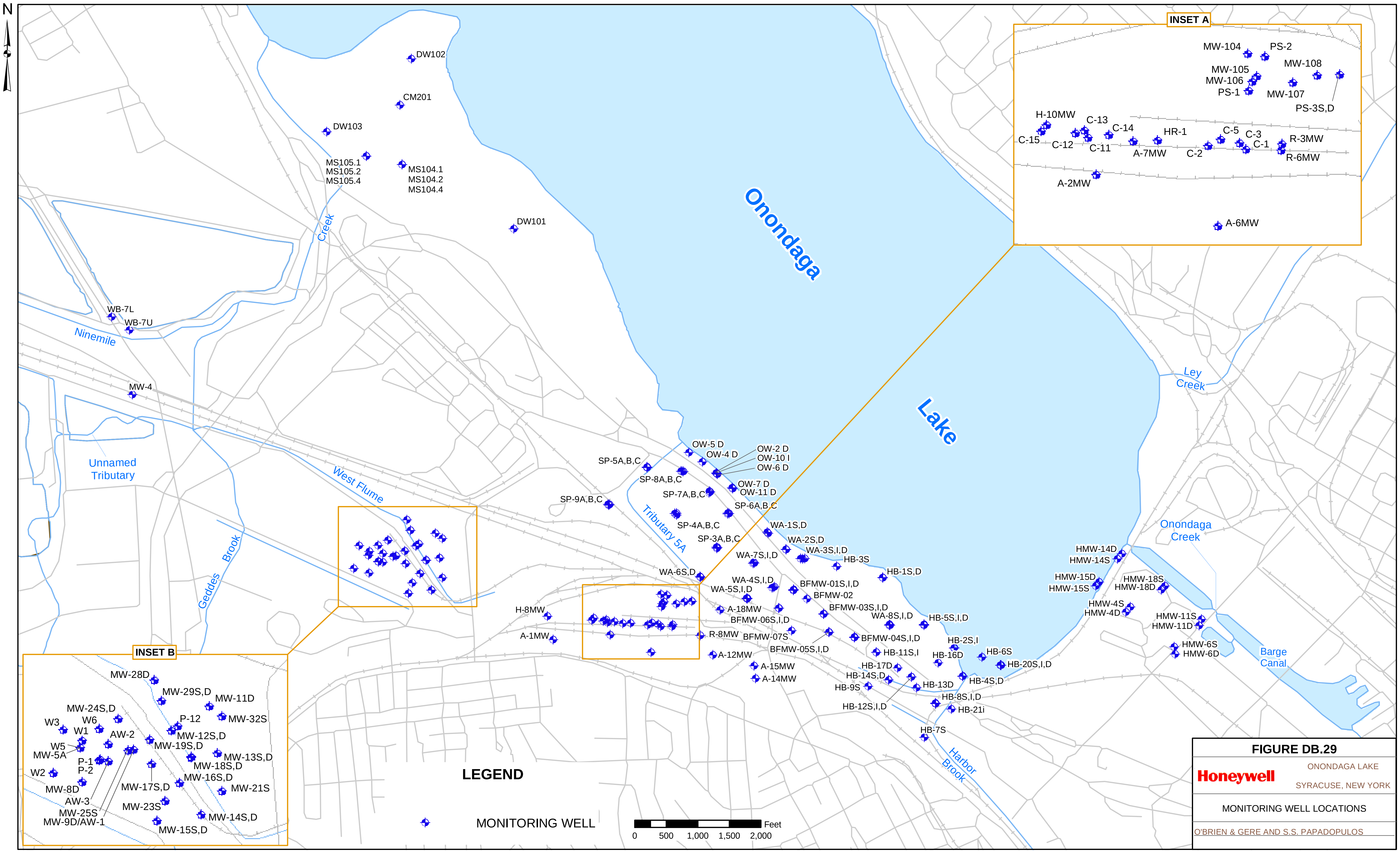

FIGURE DB.29

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

MONITORING WELL LOCATIONS

O'BRIEN & GERE AND S.S. PAPADOPULOS

T:\1163_HONEYWELL\SYRACUSE\LAKE_FS\PLATE DB2-MODEL MW LOCATIONS

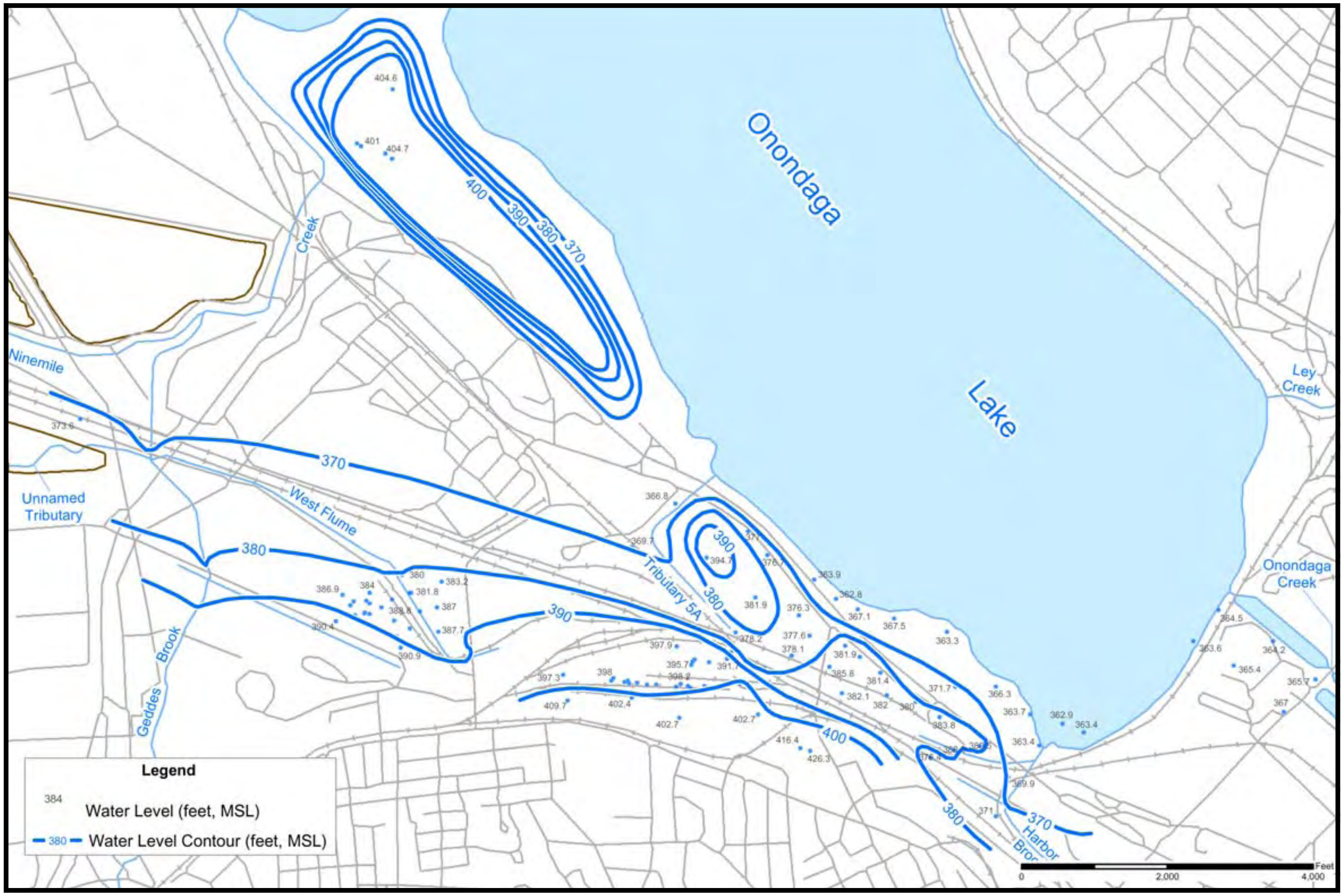

FIGURE DB.30

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

WATER TABLE MAP

PARSONS

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

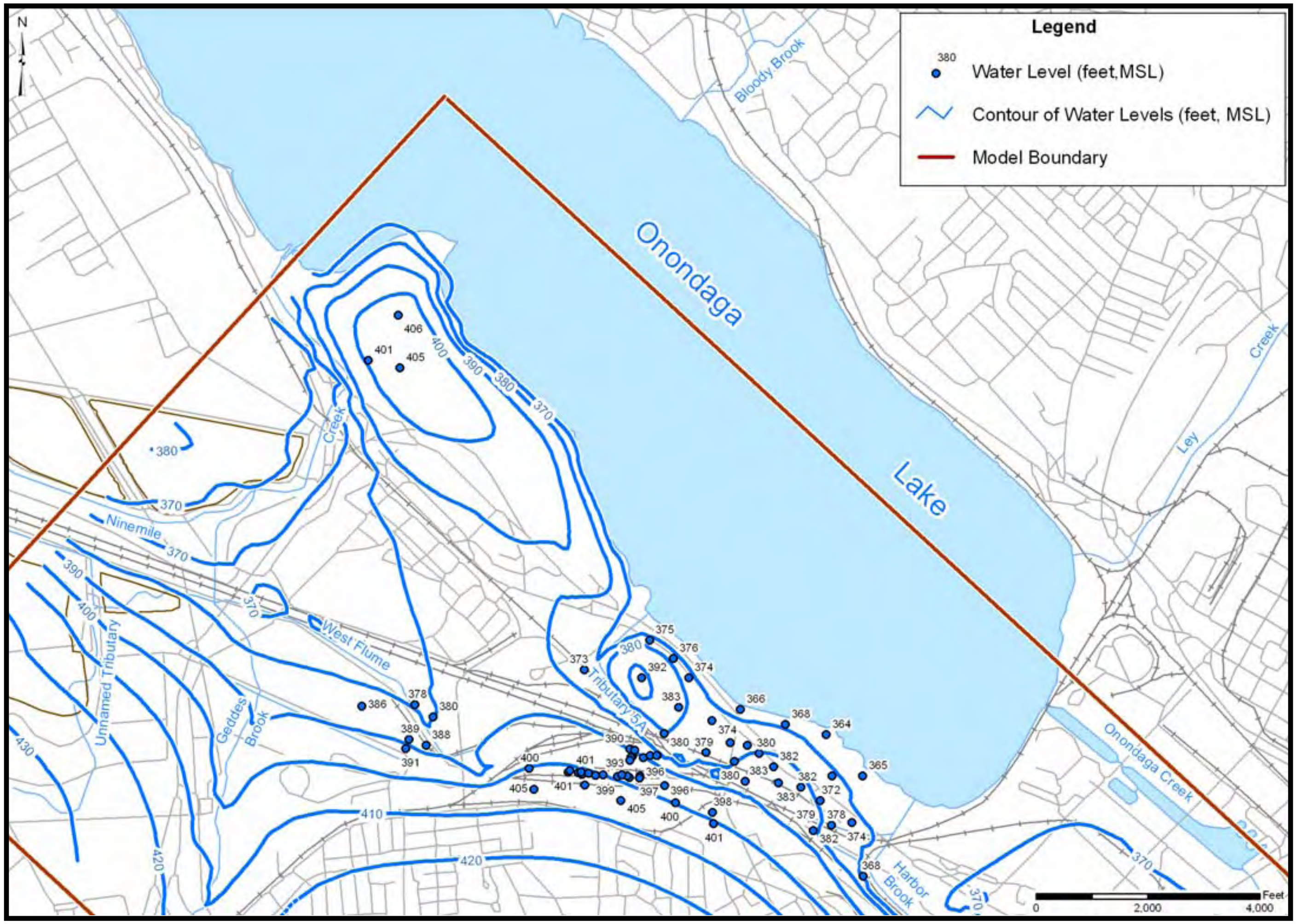

FIGURE DB.31

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

CALCULATED WATER TABLE

PARSONS

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

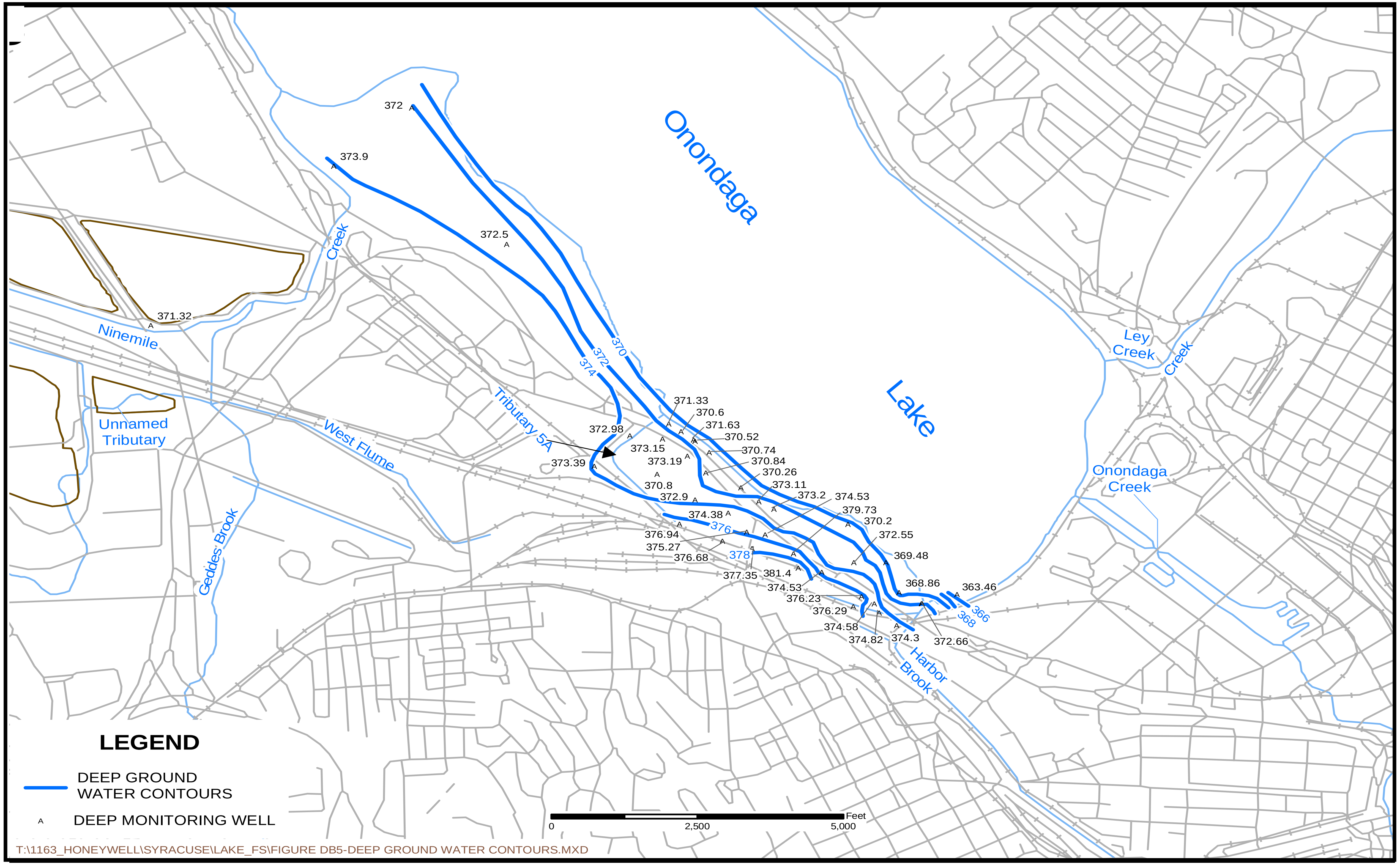

FIGURE DB.32

Honeywell

Onondaga Lake
Syracuse, New York

DEEP GROUNDWATER CONTOURS

PARSONS

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

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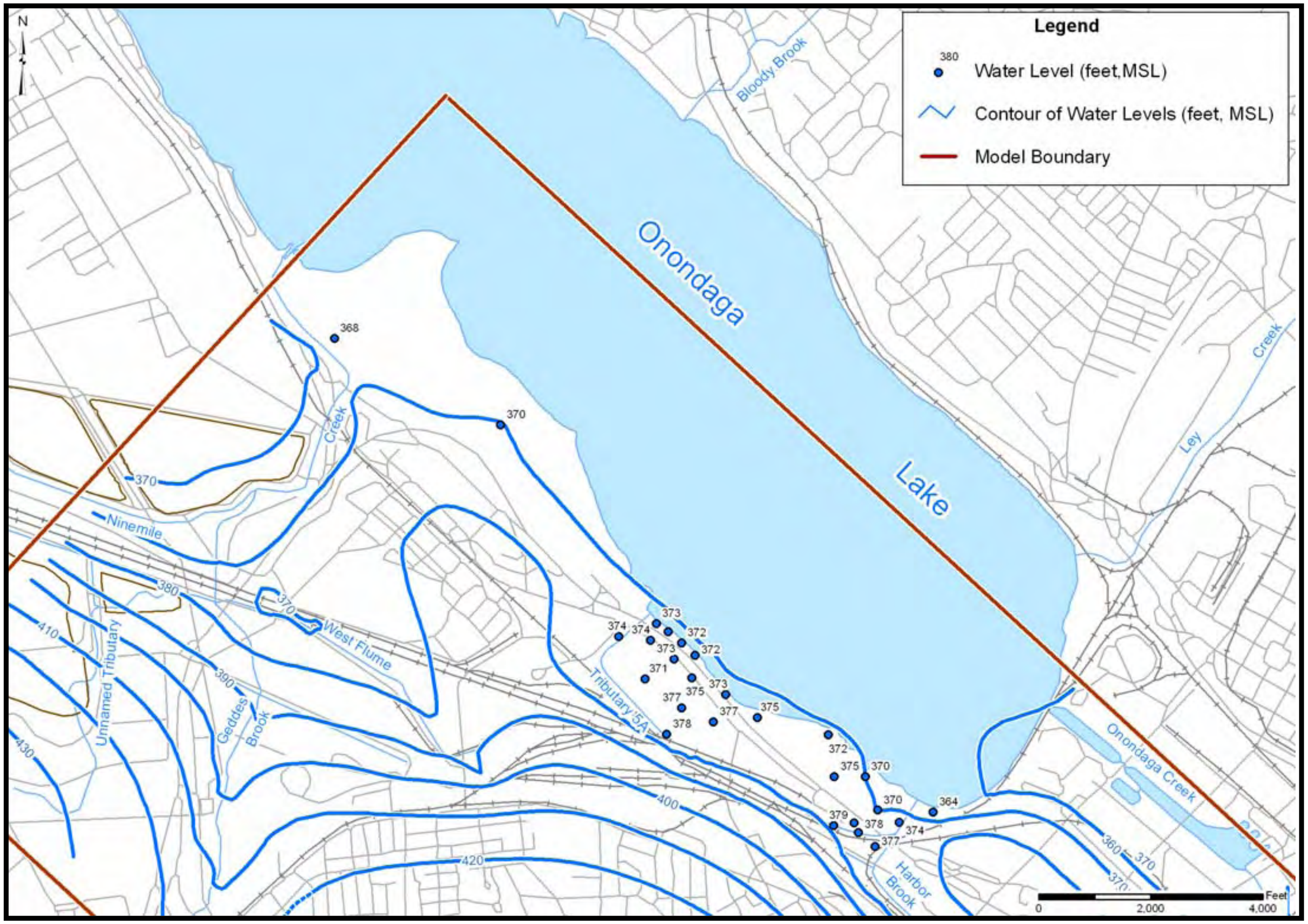

FIGURE DB.33

Honeywell

ONONDAGA LAKE

SYRACUSE, NEW YORK

CALCULATED DEEP WATER LEVELS

PARSONS

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

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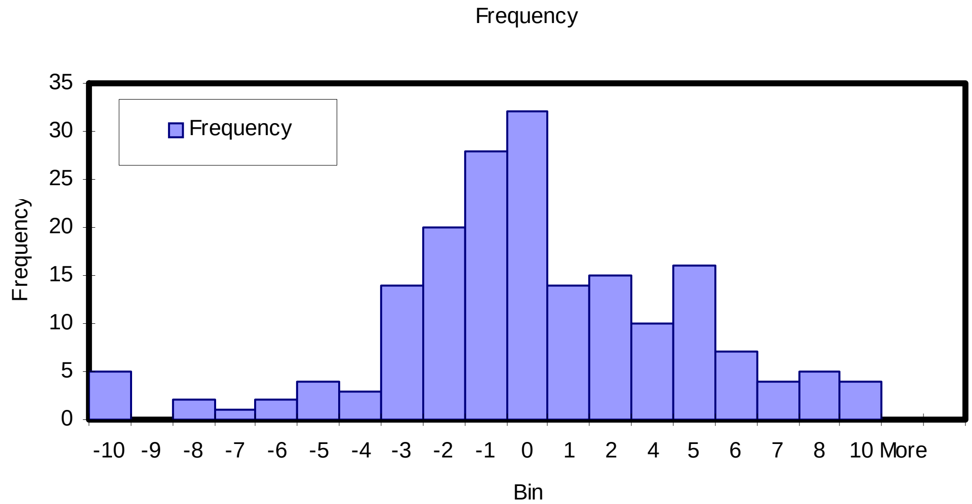
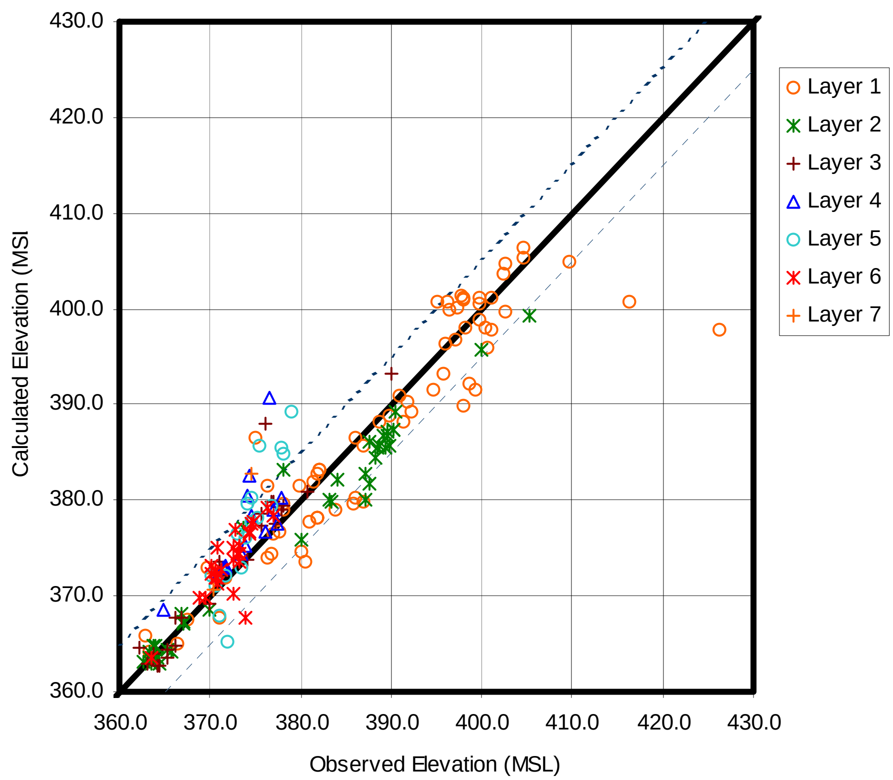


a) Calibration Residual Histogram



b) Observed and Calculated Water Levels

FIGURE DB.34

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

CALIBRATION RESIDUALS

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

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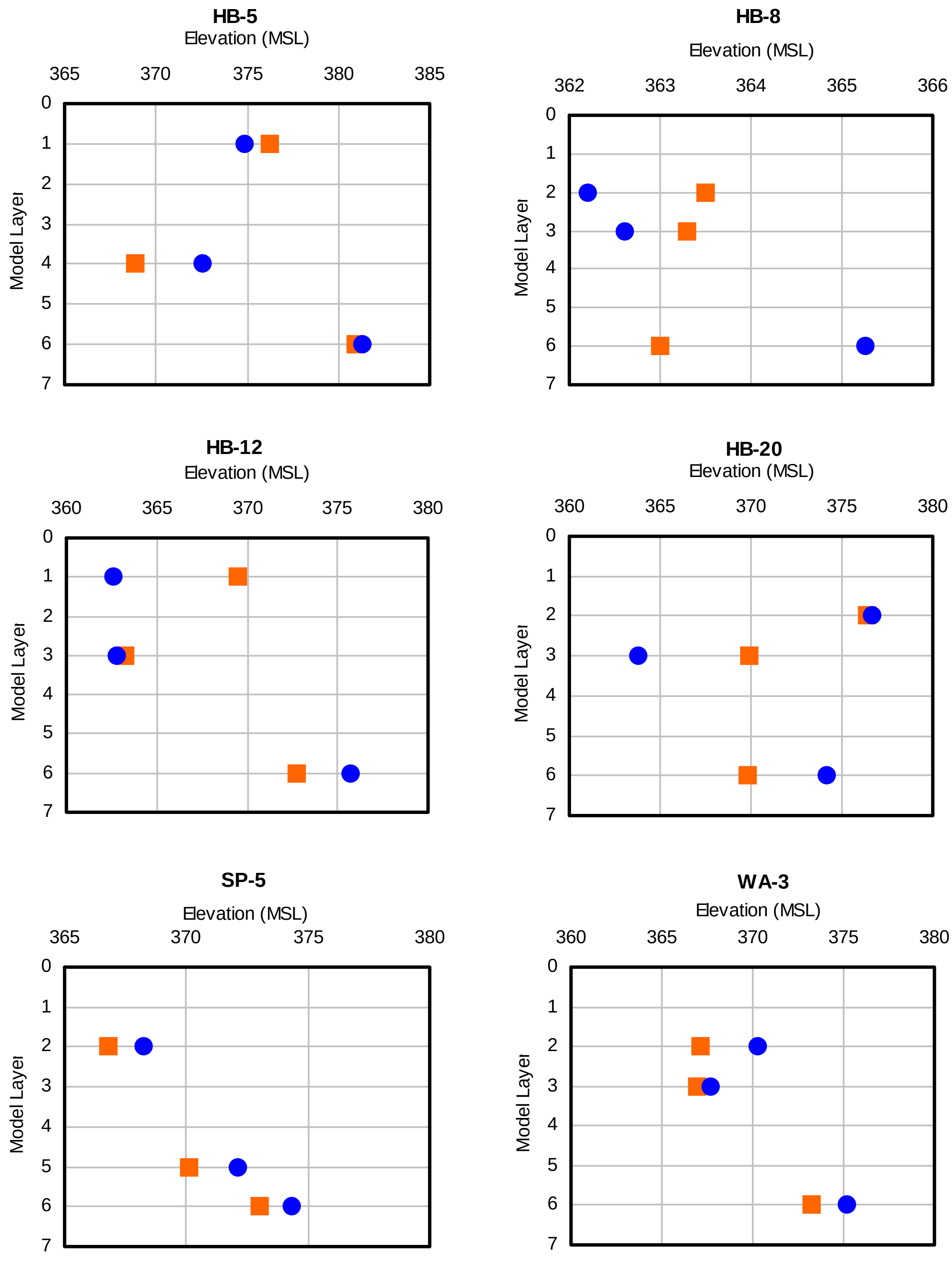


Legend

Calculated

Measured

FIGURE DB.35

Honeywell

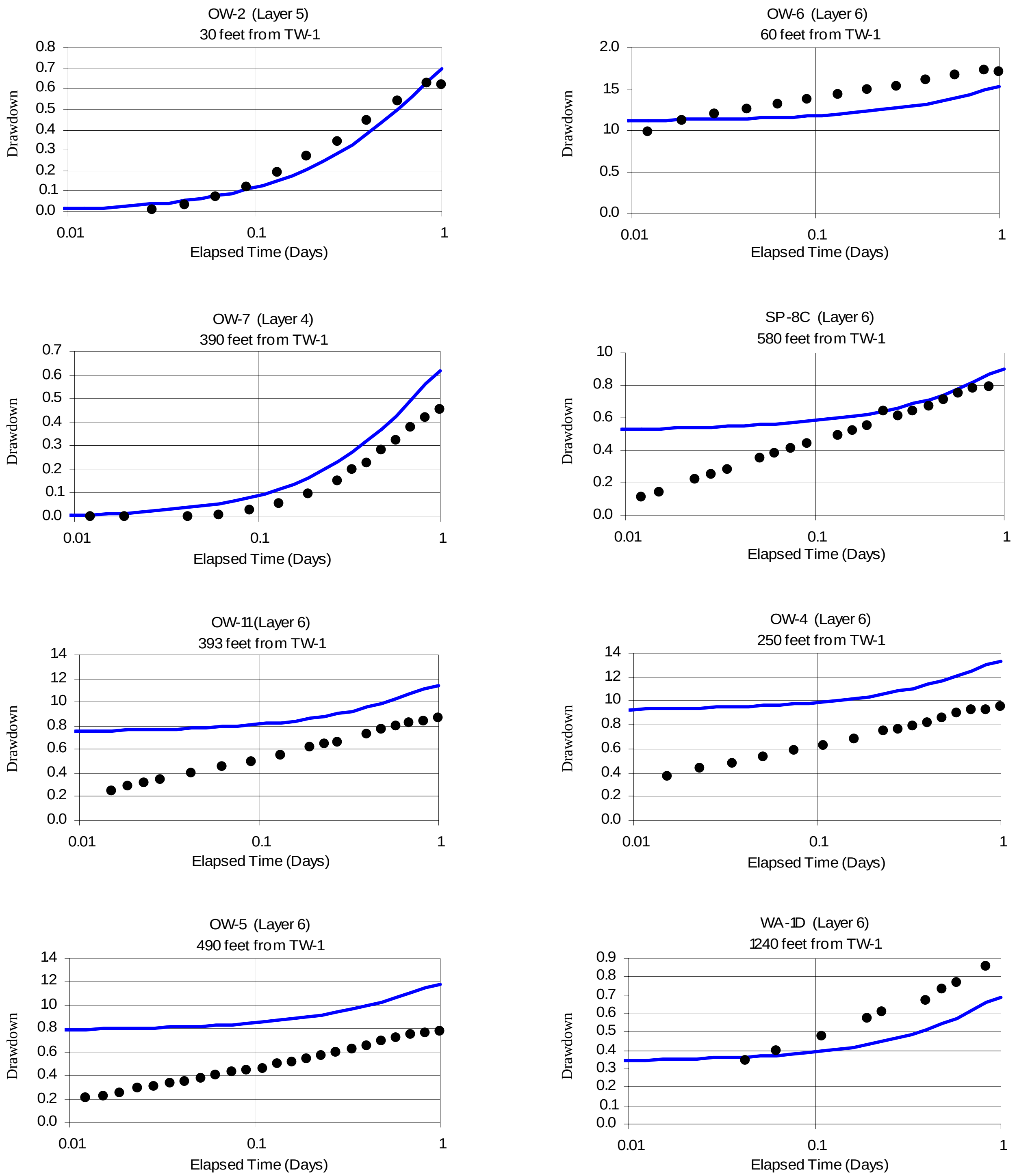
ONONDAGA LAKE

SYRACUSE, NEW YORK

OBSERVED AND CALCULATED WATER LEVELS AT SELECTED WELL CLUSTERS

PARSONS

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



NOTE:
PARAMETER VALUES AS FOLLOWS:

STORAGE COEFFICIENT LAYER 6	1.00E-06
STORAGE COEFFICIENT LAYERS 4,5	3.00E-04
VERTICAL HYDRAULIC CONDUCTIVITY LAYER 5	0.22 ft/day
HORIZONTAL HYDRAULIC CONDUCTIVITY AT TW-1	1000 ft/day

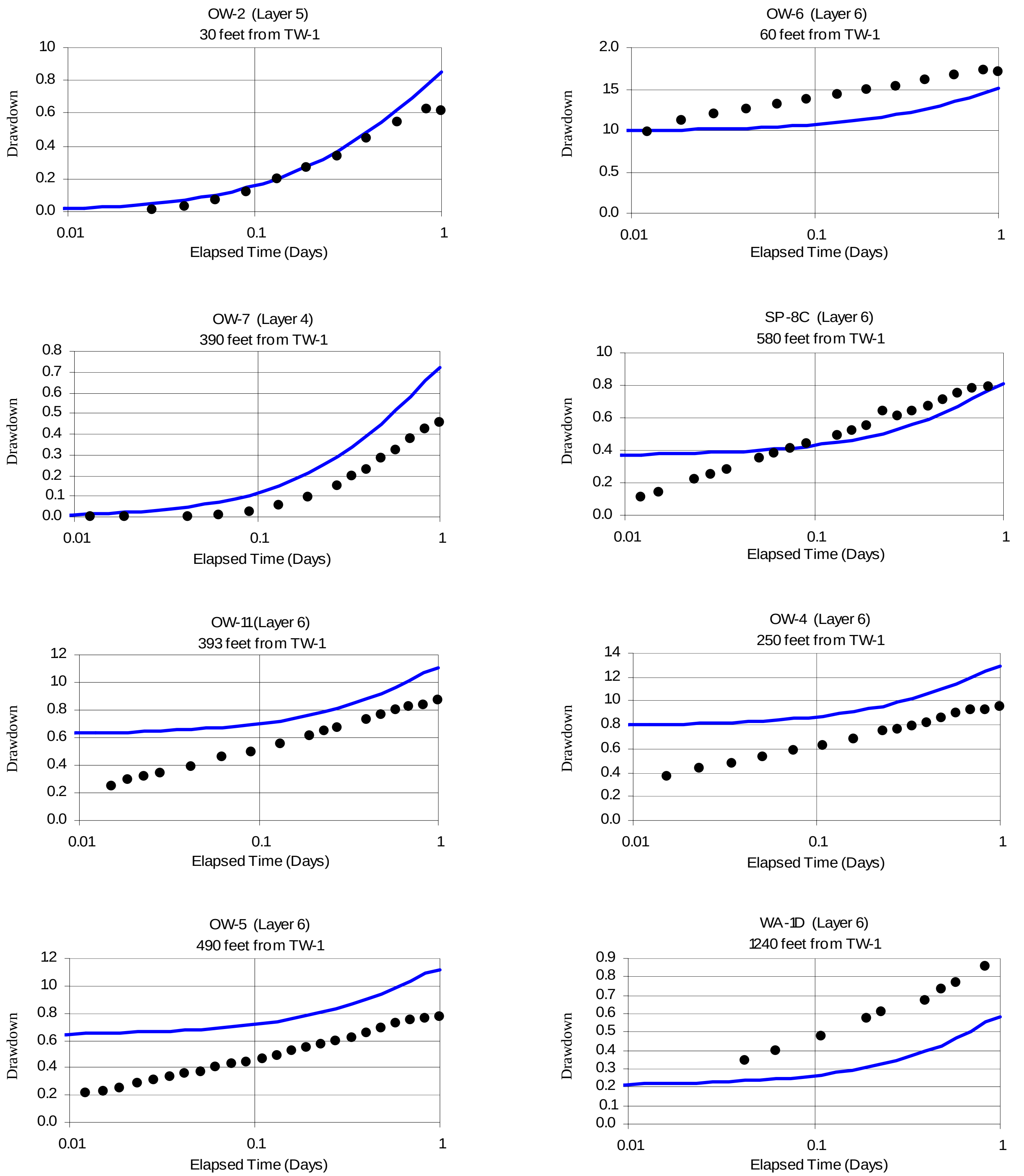
FIGURE DB.36a

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

SIMULATED PUMPING TEST DRAWDOWNS
BASE RUN

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



NOTE:
PARAMETER VALUES AS FOLLOWS:

STORAGE COEFFICIENT LAYER 6	1.00E-06
STORAGE COEFFICIENT LAYERS 4,5	3.00E-04
VERTICAL HYDRAULIC CONDUCTIVITY LAYER 5	0.14 ft/day
HORIZONTAL HYDRAULIC CONDUCTIVITY AT TW-1	1000 ft/day

FIGURE DB.36b

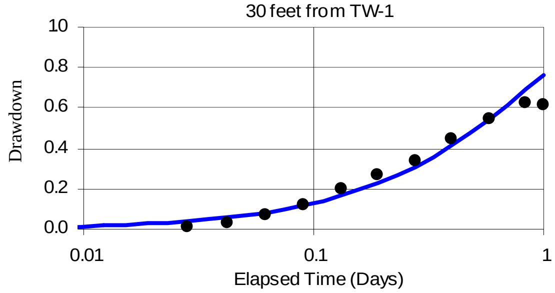
Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

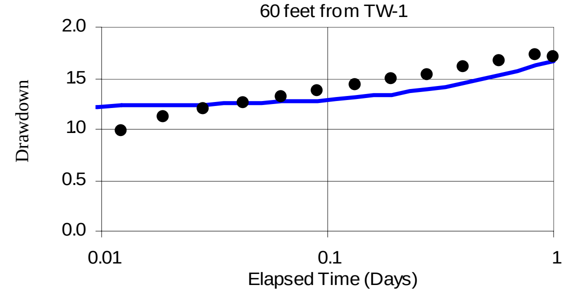
SIMULATED PUMPING TEST DRAWDOWNS
RUN 1

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

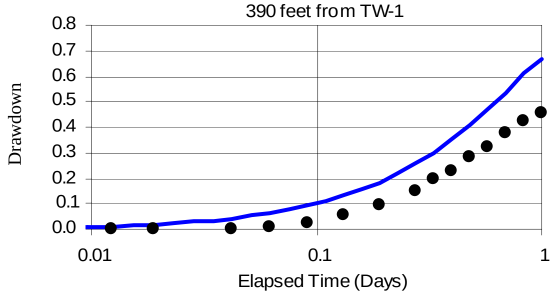
OW-2 (Layer 5)
30 feet from TW-1



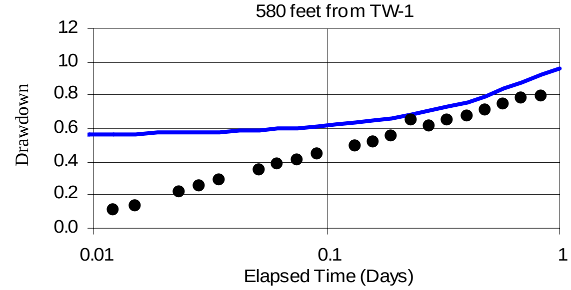
OW-6 (Layer 6)
60 feet from TW-1



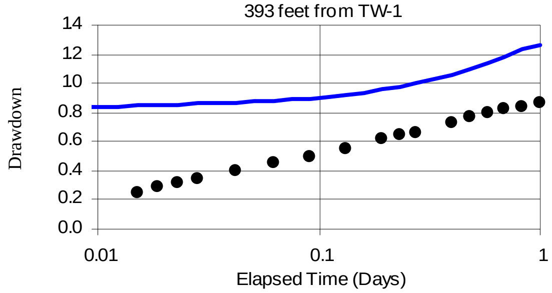
OW-7 (Layer 4)
390 feet from TW-1



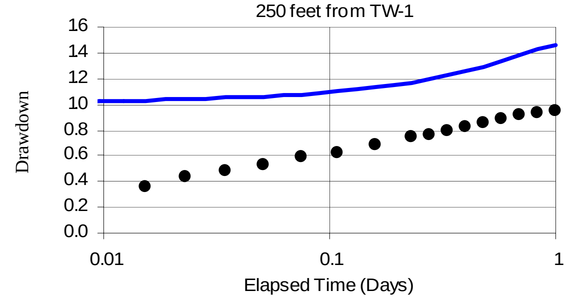
SP-8C (Layer 6)
580 feet from TW-1



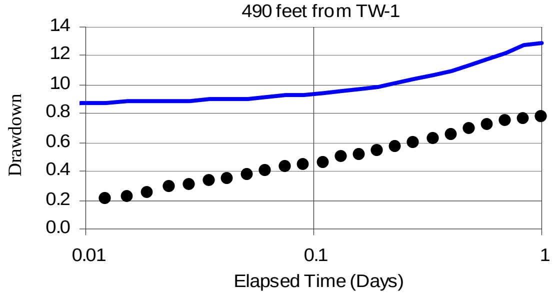
OW-11(Layer 6)
393 feet from TW-1



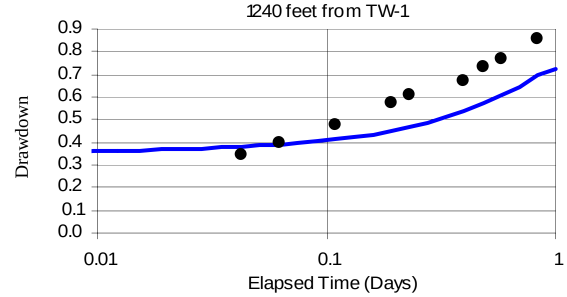
OW-4 (Layer 6)
250 feet from TW-1



OW-5 (Layer 6)
490 feet from TW-1



WA-1D (Layer 6)
1240 feet from TW-1



NOTE:
PARAMETER VALUES AS FOLLOWS:

STORAGE COEFFICIENT LAYER 6	1.00E-06
STORAGE COEFFICIENT LAYERS 4,5	1.00E-04
VERTICAL HYDRAULIC CONDUCTIVITY LAYER 5	0.22 ft/day
HORIZONTAL HYDRAULIC CONDUCTIVITY AT TW-1	1000 ft/day

FIGURE DB.36c

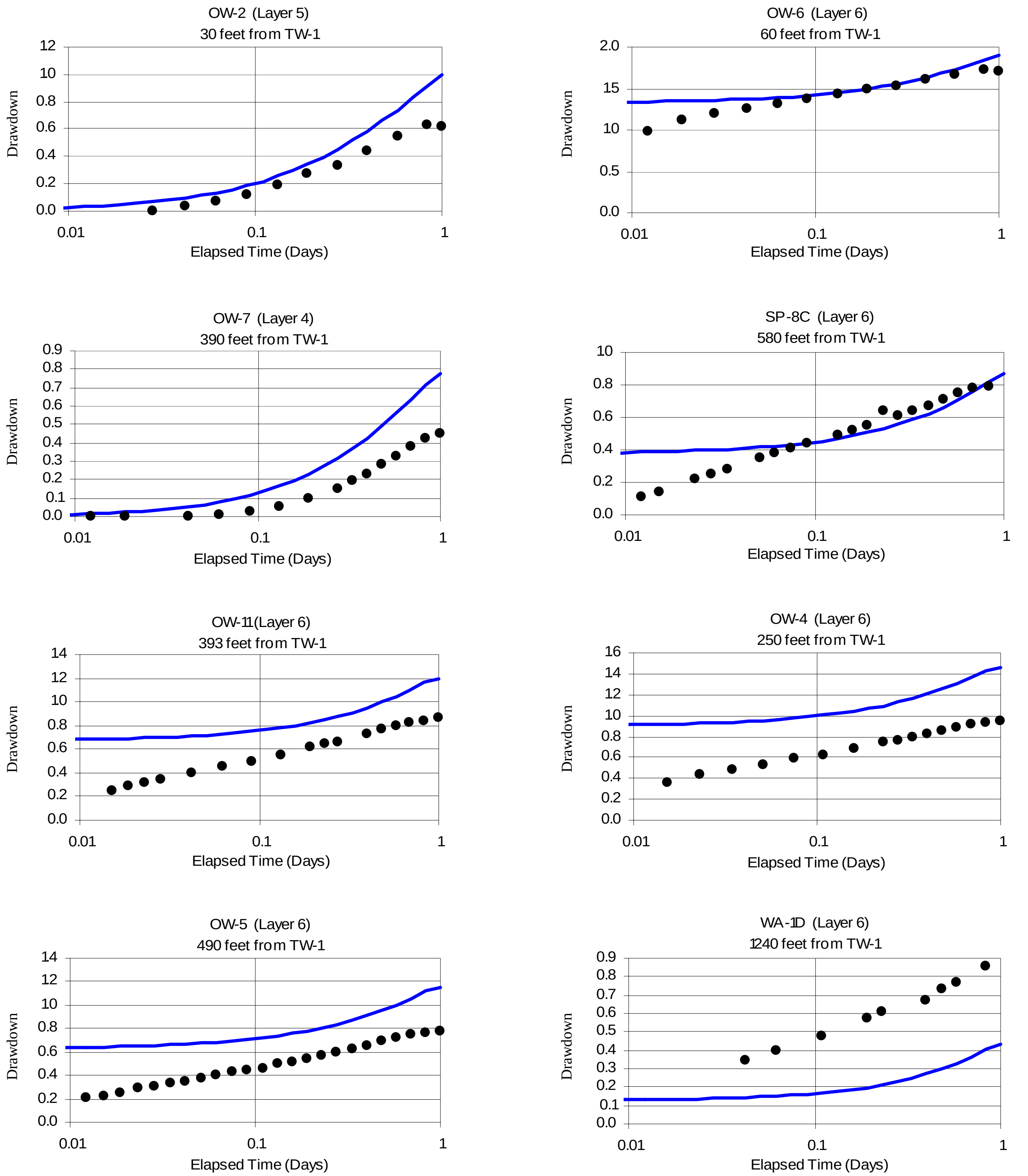
Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

SIMULATED PUMPING TEST DRAWDOWNS
RUN 2

PARSONS

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



NOTE:
PARAMETER VALUES AS FOLLOWS:

STORAGE COEFFICIENT LAYER 6	1.00E-06
STORAGE COEFFICIENT LAYERS 4,5	3.00E-04
VERTICAL HYDRAULIC CONDUCTIVITY LAYER 5	0.22 ft/day
HORIZONTAL HYDRAULIC CONDUCTIVITY AT TW-1	500 ft/day

FIGURE DB.36d

Honeywell

ONONDAGA LAKE
SYRACUSE, NEW YORK

SIMULATED PUMPING TEST DRAWDOWNS
RUN 3

PARSONS

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

APPENDIX D: PART B

ATTACHMENTS

APPENDIX D: PART B

ATTACHMENT DB.1

GROUNDWATER MODEL FILES

Place CD Here

APPENDIX D: PART B

ATTACHMENT DB.2

BORING LOGS

Place CD Here

APPENDIX D: PART B

ATTACHMENT DB.3

HYDRAULIC CONDUCTIVITY DATA

APPENDIX D: PART B

ATTACHMENT DB.4

GROUNDWATER ELEVATION DATA

ATTACHMENT DB.3
VERTICAL HYDRAULIC CONDUCTIVITY DATA

Fill/Waste		
	Ft/Day	Source
	0.023	(Thomsen, 1982) Laboratory Permeability Test
	0.016	SP-3C (O'Brien & Gere, 1991) Laboratory Permeability Test
	0.020	SP-4C (O'Brien & Gere, 1991) Laboratory Permeability Test
	0.023	SP-6B (O'Brien & Gere, 1991) Laboratory Permeability Test
	0.009	SP-8C (O'Brien & Gere, 1991) Laboratory Permeability Test
	0.006	B1C (Thomsen, 1982) Laboratory Permeability Test
	0.057	B1C (Thomsen, 1982) Laboratory Permeability Test
	0.020	MS-105 (Thomsen, 1982) Laboratory Permeability Test
	0.014	MS-105 (Thomsen, 1982) Laboratory Permeability Test
	0.014	MS-106 (Thomsen, 1982) Laboratory Permeability Test
Minimum	0.006	
Maximum	0.06	

Marl		
	Ft/Day	Source
	0.002	Well 49 (Geraghty&Miller, 1982) Laboratory Permeability Test
	0.022	SP-7C (O'Brien & Gere, 1991) Laboratory Permeability Test
	0.0003	SP-4C (O'Brien & Gere, 1991) Laboratory Permeability Test
Minimum	0.0003	
Maximum	0.022	

Silt/Clay		
	Ft/Day	Source
	0.0005	Well 49 (Geraghty&Miller, 1982) Laboratory Permeability Test
	0.0007	(LCP, 1998) Reported Value
	0.0002	(LCP, 1998) Reported Value
	0.0003	(LCP, 1998) Reported Value
	0.0001	29 (Geraghty&Miller, 1980) Laboratory Permeability Test
	0.0012	WA-1D (45-45.3'), (O' Brien & Gere, 2002) Laboratory Permeability Test
	0.0001	WA-2D (51.4-51.7), (O' Brien & Gere, 2002) Laboratory Permeability Test
	0.0096	WA-7D (44.4-44.7'), (O' Brien & Gere, 2002) Laboratory Permeability Test
	0.0020	SP-8C(O'Brien & Gere, 1991) Laboratory Permeability Test
Minimum	0.0001	
Maximum	0.0096	

ATTACHMENT DB.3
VERTICAL HYDRAULIC CONDUCTIVITY DATA

Fine Sand and Silt		
	Ft/Day	Source
	0.0086	WA-4D (68-68.3'), (O' Brien & Gere, 2002) Laboratory Permeability Test
	0.0222	SP-9C (O' Brien & Gere, 1991) Laboratory Permeability Test
	0.0004	SP-6C (O' Brien & Gere, 1991) Laboratory Permeability Test
Minimum	0.0004	
Maximum	0.022	

Notes:

Geraghty and Miller, 1982. Groundwater Quality Conditions at the Former Willis Avenue Plant.

Geraghty and Miller, 1980. Hydrogeologic Investigation.

NYSDEC, TAMS Consultants, Inc. Gradient Corporation, Parsons.(LCP) 1998. New York State Revision of the Remedial Investigation Report LCP Bridge Street Site Solvay, New York. August 1998.

O'Brien & Gere, 1991. Remedial Investigation, Semet Residue Ponds, Geddes, New York

O'Brien & Gere, 2002. Willis Avenue Chlorobenzene Site Remedial Investigation, Geddes, New York

Thomsen Associates (Thomsen). 1982. Phase II Geotechnical Investigations, Crucible Incorporated, Solid Waste Management Facility. Thomsen Associates, Syracuse, New York.

Reported Value - Value is reported in document, but supporting documentation of test method is not available.

ATTACHMENT DB.3
HORIZONTAL HYDRAULIC CONDUCTIVITY DATA

Fill		
	K(Ft/Day)	Source
Fill	70.592	WA-1S (O' Brien & Gere, 2002) Slug Test
	5.585	WA-2S (O' Brien & Gere, 2002) Slug Test
	2.948	WA-5S (O' Brien & Gere, 2002) Slug Test
	5.188	WA-7S (O' Brien & Gere, 2002) Slug Test
	0.992	MW-17S (LCP, 1998) Reported Value
	0.128	MW-11S (LCP, 1998) Reported Value
	0.369	MW-15S (LCP, 1998) Reported Value
	0.207	MW-13S (LCP, 1998) Reported Value
	0.218	MW-14S (LCP, 1998) Reported Value
	5.387	MW-16S(LCP, 1998) Reported Value
	9.639	MW-18S (LCP, 1998) Reported Value
	1.332	MW-19S (LCP, 1998) Reported Value
	229.635	MW-20S (LCP, 1998) Reported Value
	2.617	MW-4S (Arcadis, 2003) Slug Test
	1.491	MW-6S (Arcadis, 2003) Slug Test
	36.720	MW-11S (Arcadis, 2003) Slug Test
	1.452	MW-14S (Arcadis, 2003) Slug Test
	43.582	MW-15S (Arcadis, 2003) Slug Test
	44.759	MW-18S (Arcadis, 2003) Slug Test
	109.565	OW-8 (O'Brien & Gere, 2002b) Pumping Test
	68.936	TW-2 (O'Brien & Gere, 2002b) Pumping Test
	6.000	WA-3S (O'Brien & Gere, 2002b) Pumping Test
	13.766	Well 55 (O'Brien & Gere, 2002b) Pumping Test
	23.900	WA-2S (O'Brien & Gere, 2002b) Pumping Test
	2.32	HB-1S (O'Brien & Gere, 2003) Slug Test
	10.58	HB-2S (O'Brien & Gere, 2003) Slug Test
	5.97	HB-7S (O'Brien & Gere, 2003) Slug Test
	4.25	SP-2A (O'Brien & Gere, 1991) Slug Test
	1.13	SP-9A (O'Brien & Gere, 1991) Slug Test
	23.77	HB-19S (O'Brien & Gere, 2003) Slug Test
	1.54	HB-20S (O'Brien & Gere, 2003) Slug Test
Waste	0.369	SP-3A (O'Brien & Gere, 1991) Slug Test
	0.369	SP-4A (O'Brien & Gere, 1991) Slug Test
	2.720	SP-6A (O'Brien & Gere, 1991) Slug Test
	0.425	SP-7A (O'Brien & Gere, 1991) Slug Test
	0.040	SP-8A (O'Brien & Gere, 1991) Slug Test
	0.312	WB-BU (BBL, 1989) Slug Test
	0.085	OW-56 (Thomsen, 1982) Slug Test
	0.028	OW-101 (Thomsen, 1982) Slug Test
	0.170	OW-102 (Thomsen, 1982) Slug Test
	0.057	S-1C (Thomsen, 1982) Slug Test
	0.170	MS-104.5 (Thomsen, 1982) Slug Test
	0.057	MS-104.4 (Thomsen, 1982) Slug Test
	0.255	MS-104.3 (Thomsen, 1982) Slug Test
	0.085	MS-104.2 (Thomsen, 1982) Slug Test
	0.170	MS-105.5 (Thomsen, 1982) Slug Test

ATTACHMENT DB.3
HORIZONTAL HYDRAULIC CONDUCTIVITY DATA

Fill

	K(Ft/Day)	Source
	0.198	MS-105.4 (Thomsen, 1982) Slug Test
	0.142	MS-105.3 (Thomsen, 1982) Slug Test
	0.851	MS-106.5 (Thomsen, 1982) Slug Test
	0.284	MS-106.4 (Thomsen, 1982) Slug Test
	0.170	MS-106.3 (Thomsen, 1982) Slug Test
	5.54	HB-3S (O'Brien & Gere, 2003) Slug Test
	6.04	HB-4S (O'Brien & Gere, 2003) Slug Test
	0.56	HB-5S (O'Brien & Gere, 2003) Slug Test
	4.48	HB-6S (O'Brien & Gere, 2003) Slug Test
	6.8	WA-8S (O'Brien & Gere, 2003) Slug Test
	0.31	HB-8S (O'Brien & Gere, 2003) Slug Test
	3.12	WA-3S (O' Brien & Gere, 2002) Slug Test
	77.396	WA-4S (O' Brien & Gere, 2002) Slug Test
	1.3	HB-9S (O'Brien & Gere, 2003) Slug Test
	4.57	HB-12S (O'Brien & Gere, 2003) Slug Test
	0.88	HB-18S (O'Brien & Gere, 2003) Slug Test
	2.44	WB-BU (O'Brien & Gere, 2003) Slug Test
	0.09	HB-5I (O'Brien & Gere, 2003) Slug Test
Minimum	0.028	
Maximum	229.635	

Marl

	K(Ft/Day)	Source
	9.072	SP-5A (O'Brien & Gere, 1991) Slug Test
	0.003	Well 49 (Geraghty&Miller, 1982) Laboratory Permeability Test
	0.079	WA-4I (O' Brien & Gere, 2002) Slug Test
	0.329	WA-7I (O' Brien & Gere, 2002) Slug Test
	1.091	WA-3I (O' Brien & Gere, 2002) Slug Test
	0.889	MW-4D(Arcadis, 2003) Slug Test
	7.520	MW-6D(Arcadis, 2003) Slug Test
	2.477	MW-11D(Arcadis, 2003) Slug Test
	2.706	MW-14D(Arcadis, 2003) Slug Test
	1.280	MW-15D(Arcadis, 2003) Slug Test
	0.669	MW-18D(Arcadis, 2003) Slug Test
	0.63	HB-2I (O'Brien & Gere, 2003) Slug Test
	4.65	HB-8I (O'Brien & Gere, 2003) Slug Test
	3.67	WA-8I (O'Brien & Gere, 2003) Slug Test
	1.49	HB-11I (O'Brien & Gere, 2003) Slug Test
	4.34	HB-12I (O'Brien & Gere, 2003) Slug Test
	0.15	HB-20I (O'Brien & Gere, 2003) Slug Test
	0.53	HB-21I (O'Brien & Gere, 2003) Slug Test
	0.205	Marl downgradient Semet Area (O' Brien & Gere, 2002b) Specific Capacity Test
	0.141	Marl downgradient Willis Area (O' Brien & Gere, 2002b) Specific Capacity Test
Minimum	0.003	
Maximum	9.072	

ATTACHMENT DB.3
HORIZONTAL HYDRAULIC CONDUCTIVITY DATA

Silt/Clay		
	K(Ft/Day)	Source
	0.0454	SP-3B (O'Brien & Gere, 1991) Slug Test
	0.5387	SP-4B (O'Brien & Gere, 1991) Slug Test
	0.0190	SP-7B (O'Brien & Gere, 1991) Slug Test
	0.0003	Well 49 (Geraghty&Miller, 1982) Laboratory Permeability Test
	0.1843	(Thomsen, 1982) Slug Test
	0.0227	(Thomsen, 1982) Slug Test
	0.1134	(Thomsen, 1982) Slug Test
	0.0096	MW-21I(LCP, 1998) Reported Value
	0.0082	P-10S(LCP, 1998) Reported Value
	0.0709	P-10N(LCP, 1998) Reported Value
	0.0425	P-12S(LCP, 1998) Reported Value
	0.0142	P-12N(LCP, 1998) Reported Value
	0.0162	P-13S(LCP, 1998) Reported Value
	0.0230	P-13N(LCP, 1998) Reported Value
	0.0003	(Winkley, 1989) Reported Value
	0.1701	(Winkley, 1989) Reported Value
Minimum	0.0003	
Maximum	0.5387	

Fine Sand		
	K(Ft/Day)	Source
	0.30	OW-7 (O' Brien & Gere, 2002b) Specific Capacity Test
	5.40	OW-7 (O' Brien & Gere, 2002b) Pumping Test
	1.16	SP-5B (O'Brien & Gere, 1991) Slug Test
	0.15	SP-6B (O'Brien & Gere, 1991) Slug Test
	0.02	SP-8B (O'Brien & Gere, 1991) Slug Test
	1.39	SP-9B (O'Brien & Gere, 1991) Slug Test
	4.59	Well 49 (Geraghty&Miller, 1982) Laboratory Permeability Test
	3.8	WA-3D (O' Brien & Gere, 2002) Slug Test
	0.071	WA-5D (O' Brien & Gere, 2002) Slug Test
	0.75	HB-12D (O'Brien & Gere, 2003) Slug Test
Minimum	0.018	
Maximum	5.400	

Sand/Gravel		
	K(Ft/Day)	Source
	28.4	(Winkley, 1989) Reported Value
	45.4	WB-5L (BBL, 1995) Slug Test
	17.1	WA-1D(O' Brien & Gere, 2002) Slug Test
	1.4	WA-6D(O' Brien & Gere, 2002) Slug Test
	0.9	(Thomsen, 1982) Reported Value
	5.7	(Thomsen, 1982) Reported Value
	0.1	(LCP, 1998) Reported Value
	2.5	(LCP, 1998) Reported Value

ATTACHMENT DB.3
HORIZONTAL HYDRAULIC CONDUCTIVITY DATA

Sand/Gravel		
	K(Ft/Day)	Source
	9.1	(LCP, 1998) Reported Value
	1.1	(LCP, 1998) Reported Value
	0.6	(LCP, 1998) Reported Value
	1.1	SP-3C (O'Brien & Gere, 1991) Slug Test
	0.4	SP-4C (O'Brien & Gere, 1991) Slug Test
	2.7	SP-5C (O'Brien & Gere, 1991) Slug Test
	0.7	SP-6C (O'Brien & Gere, 1991) Slug Test
	0.1	SP-7C (O'Brien & Gere, 1991) Slug Test
	0.4	SP-8C (O'Brien & Gere, 1991) Slug Test
	9.6	SP-9C (O'Brien & Gere, 1991) Slug Test
	136.1	TW-1 (O' Brien & Gere, 2002b) Pumping Test
	1073.0	OW-4 (O' Brien & Gere, 2002b) Pumping Test
	553.7	WA-1D (O' Brien & Gere, 2002b) Pumping Test
	458.1	Thiem, (O' Brien & Gere, 2002b) Pumping Test
	42.0	HB-1D (O'Brien & Gere, 2003) Slug Test
	5.9	HB-5D (O'Brien & Gere, 2003) Slug Test
	14.6	HB-8D (O'Brien & Gere, 2003) Slug Test
	28.5	WA-8D (O'Brien & Gere, 2003) Slug Test
	0.6	HB-16D (O'Brien & Gere, 2003) Slug Test
	3.9	HB-17D (O'Brien & Gere, 2003) Slug Test
	7.2	HB-20D (O'Brien & Gere, 2003) Slug Test
	11.9	WB-BL (O'Brien & Gere, 2003) Slug Test
Minimum	0.099	
Maximum	1073	

Till		
	K(cm/sec)	Source
	0.737	(BBL, 1989) Slug Test
	0.056	PS-3D(O' Brien & Gere, 2002) Slug Test
	8.8	(Winkley, 1989) Reported Value
	19.1	M-201(82.7-88.6', 5 psi)(O' Brien & Gere, 2003b) Packer Test
	63.2	M-201(82.7-88.6', 10 psi);(O' Brien & Gere, 2003b) Packer Test
	68.0	M-201(82.7-88.6', 15 psi); (O' Brien & Gere, 2003b) Packer Test
	249.5	M-201(82.7-88.6', 20 psi); (O' Brien & Gere, 2003b) Packer Test
	21.0	M-201(84.2-90.1', 5 psi);(O' Brien & Gere, 2003b) Packer Test
	29.2	M-201(84.2-90.1', 10 psi); (O' Brien & Gere, 2003b) Packer Test
	36.6	M-201(84.2-90.1', 15 psi); (O' Brien & Gere, 2003b) Packer Test
	26.9	M-201(84.2-90.1', 20 psi); (O' Brien & Gere, 2003b) Packer Test
	2.3	M-201(79-84.9', 5 psi); (O' Brien & Gere, 2003b) Packer Test
	1.7	M-201(79-84.9', 10 psi); (O' Brien & Gere, 2003b) Packer Test
	1.7	M-201(79-84.9', 15 psi); (O' Brien & Gere, 2003b) Packer Test
	1.4	M-201(79-84.9', 20 psi); (O' Brien & Gere, 2003b) Packer Test
Minimum	0.056	
Maximum	249.480	

ATTACHMENT DB.3
HORIZONTAL HYDRAULIC CONDUCTIVITY DATA

	Bedrock	
	K(cm/sec)	Source
	0.1729	WB-5R (BBL, 1995) Slug Test
	0.0028	(O' Brien & Gere, 2002) Slug Test
	0.00003	(O' Brien & Gere, 2002) Slug Test
	1.134	(Winkley, 1989) Reported Value
	0.0109	M-202(121-126', 15 psi); (O' Brien & Gere, 2003b) Packer Test
	0.0172	M-202(121-126', 30 psi); (O' Brien & Gere, 2003b) Packer Test
	0.0116	M-202(121-126', 45 psi); (O' Brien & Gere, 2003b) Packer Test
Minimum	0.00003	
Maximum	1.134	

Notes:

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Calocerinos & Spina (C&S). 1986. Revised Landfill Closure Plan, Volumes 1 and 2. January 1986. Calocerinos & Spina Consulting Engineers, Liverpool, New York.

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NYSDEC, TAMS Consultants, Inc. Gradient Corporation, Parsons.(LCP) 1998. New York State Revision of the Remedial Investigation Report LCP Bridge Street Site Solvay, New York. August 1998.

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Thomsen Associates (Thomsen). 1982. Phase II Geotechnical Investigations, Crucible Incorporated, Solid Waste Management Facility. Thomsen Associates, Syracuse, New York.

Thomsen. 1982a. Phase I Hydrogeological Investigations, Crucible Incorporated, Solid Waste Management Facility. Thomsen Associates, Syracuse, New York.

Winkley, Steven J., 1989. The Hydrogeology of Onondaga County, New York. Department of Geology, Syracuse University, Syracuse, New York (Thesis).

Reported Value - Value is reported in document, but supporting documentation of test method is not available.

Slug Test - In-situ hydraulic conductivity test.

ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	2/20/91	3/4/91	5/13/91	6/10/91	7/25/91	3/18/92	5/2/92	7/13/92
						ELEVATION (FT)							
						Average ground water elevations from OBG monitoring 1991 thru 2003							
HB-7S	Railroad Area	371.9	374.63	368.9 - 363.9	**371.0**								
HB-8S	Railroad Area	376.2	378.82	371.2 - 366.2	**369.9**								
HB-8I	Railroad Area	376.4	378.93	364.4 - 354.4	**369.8**								
HB-8D	Railroad Area	376.9	379.17	318.9 - 308.9	**374.3**								
HB-9S	Railroad Area	379.8	382.09	374.8 - 364.8	**376.4**								
HB-11S	Penn-Can	394.5	394.21	390.5 - 380.5	**383.8**								
HB-11I	Penn-Can	394.5	394.09	359.5 - 349.5	**375.7**								
HB-12S	Penn-Can	392.0	394.43	386.0 - 376.0	**380.5**								
HB-12I	Penn-Can	392.0	394.35	357.0 - 342.0	**374.2**								
HB-12D	Penn-Can	392.0	393.95	314.0 - 304.0	**374.6**								
HB-13D	Penn-Can	389.5	391.07	313.5 - 303.5	**374.8**								
HB-14S	Penn-Can	390.5	390.04	383.5 - 378.5	**380.9**								
HB-14D	Penn-Can	390.3	389.97	362.3 - 352.3	**376.3**								
OW-1 D	Lakeshore	371.8	373.14	283.8 - 273.8	**372.1**								
OW-2 D	Lakeshore	370.1	371.89	316.1 - 306.1	**371.6**								
OW-3 I	Lakeshore	370.3	371.94	356.3 - 346.3	**363.8**								
OW-4 D	Lakeshore	369.7	371.01	297.7 - 287.7	**370.6**								
OW-5 D	Lakeshore	371.7	372.6	309.7 - 299.7	**371.3**								
OW-6 D	Lakeshore	370.0	371.42	278.0 - 268.0	**370.5**								
OW-7 D	Lakeshore	370.2	371.8	306.2 - 296.2	**370.7**								
OW-8 S	Lakeshore	371.9	373.71	365.9 - 355.9	**364.2**								
OW-9 I	Lakeshore	370.6	372.4	351.6 - 341.6	**364.0**								
OW-10 I	Lakeshore	370.1	371.76	356.1 - 346.1	**363.7**								
OW-11 D	Lakeshore	370.4	371.55	269.4 - 259.4	**370.7**								
TW-1 D	Lakeshore	369.8	371.81	283.8 - 273.8	**370.5**								
TW-2 S	Lakeshore	371.5	373.67	366.5 - 356.5	**364.1**								
TW-3 I	Lakeshore	370.2	372.17	356.2 - 346.2	**363.4**								
HB-1S	Lakeshore	368.4	371.14	363.4 - 358.4	**363.3**								
HB-1D	Lakeshore	368.3	370.92	281.9 - 276.9	**370.2**								
HB-2S	Lakeshore	365.5	367.39	361.5 - 351.5	**363.7**								
HB-2I	Lakeshore	365.4	367.44	343.4 - 333.4	**362.3**								
HB-3S	Lakeshore	369.7	371.95	364.7 - 354.7	**367.5**								
HB-4S	Lakeshore	367.8	370.3	359.8 - 349.8	**363.3**								
HB-4D	Lakeshore	368.4	370.26	280.4 - 270.4	**372.7**								
HB-5S	Lakeshore	377.5	379.69	370.5 - 360.5	**366.3**								

Notes:

NA: Not applicable/not available
(1) - This well was not located during the survey.
(2) - These wells had a water level that exceeded the elevation of the inside casing and could not be accurately measured.
(3) - Unable to access well during this survey.
(4) - Well appears to have been destroyed.

ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	9/22/92	12/15/94	1/4/95	3/8/95	9/18/97	8/15/00	5/8/01	8/27/01	9/27/01	10/29/01
						ELEVATION (FT)									
						Average ground water elevations from OBG monitoring 1991 thru 2003									
HB-7S	Railroad Area	371.9	374.63	368.9 - 363.9	**371.0**							370.5			
HB-8S	Railroad Area	376.2	378.82	371.2 - 366.2	**369.9**							369.5			
HB-8I	Railroad Area	376.4	378.93	364.4 - 354.4	**369.8**							369.4			
HB-8D	Railroad Area	376.9	379.17	318.9 - 308.9	**374.3**										
HB-9S	Railroad Area	379.8	382.09	374.8 - 364.8	**376.4**							375.8			
HB-11S	Penn-Can	394.5	394.21	390.5 - 380.5	**383.8**							388.9			
HB-11I	Penn-Can	394.5	394.09	359.5 - 349.5	**375.7**							377.1			
HB-12S	Penn-Can	392.0	394.43	386.0 - 376.0	**380.5**							379.9			
HB-12I	Penn-Can	392.0	394.35	357.0 - 342.0	**374.2**							374.4			
HB-12D	Penn-Can	392.0	393.95	314.0 - 304.0	**374.6**							374.8			
HB-13D	Penn-Can	389.5	391.07	313.5 - 303.5	**374.8**							374.7			
HB-14S	Penn-Can	390.5	390.04	383.5 - 378.5	**380.9**							379.6			
HB-14D	Penn-Can	390.3	389.97	362.3 - 352.3	**376.3**							376.6			
OW-1 D	Lakeshore	371.8	373.14	283.8 - 273.8	**372.1**										
OW-2 D	Lakeshore	370.1	371.89	316.1 - 306.1	**371.6**										
OW-3 I	Lakeshore	370.3	371.94	356.3 - 346.3	**363.8**										
OW-4 D	Lakeshore	369.7	371.01	297.7 - 287.7	**370.6**										
OW-5 D	Lakeshore	371.7	372.6	309.7 - 299.7	**371.3**										
OW-6 D	Lakeshore	370.0	371.42	278.0 - 268.0	**370.5**										
OW-7 D	Lakeshore	370.2	371.8	306.2 - 296.2	**370.7**										
OW-8 S	Lakeshore	371.9	373.71	365.9 - 355.9	**364.2**										
OW-9 I	Lakeshore	370.6	372.4	351.6 - 341.6	**364.0**										
OW-10 I	Lakeshore	370.1	371.76	356.1 - 346.1	**363.7**										
OW-11 D	Lakeshore	370.4	371.55	269.4 - 259.4	**370.7**										
TW-1 D	Lakeshore	369.8	371.81	283.8 - 273.8	**370.5**										
TW-2 S	Lakeshore	371.5	373.67	366.5 - 356.5	**364.1**										
TW-3 I	Lakeshore	370.2	372.17	356.2 - 346.2	**363.4**										
HB-1S	Lakeshore	368.4	371.14	363.4 - 358.4	**363.3**							362.8			
HB-1D	Lakeshore	368.3	370.92	281.9 - 276.9	**370.2**							370.1			
HB-2S	Lakeshore	365.5	367.39	361.5 - 351.5	**363.7**						362.4	363.4			
HB-2I	Lakeshore	365.4	367.44	343.4 - 333.4	**362.3**						364.5	362.4			
HB-3S	Lakeshore	369.7	371.95	364.7 - 354.7	**367.5**						366.3	367.8			
HB-4S	Lakeshore	367.8	370.3	359.8 - 349.8	**363.3**						362.3	363.3			
HB-4D	Lakeshore	368.4	370.26	280.4 - 270.4	**372.7**										
HB-5S	Lakeshore	377.5	379.69	370.5 - 360.5	**366.3**							371.2			

Notes:
- NA: Not applicable/not available
- (1) - This well was not located during the survey.
- (2) - These wells had a water level that exceeded the elevation of the inside casing and could not be accurately measured.
- (3) - Unable to access well during this survey.
- (4) - Well appears to have been destroyed.

ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	11/20/01	12/5/01	12/26/01	1/23/02	2/14/02	7/15/02	12/16/02	12/27/02	1/4/03
						ELEVATION (FT)								
						Average Ground Water elevations from OBG monitoring 1991 thru 2003								
HB-7S	Railroad Area	371.9	374.63	368.9 - 363.9	**371.0**									
HB-8S	Railroad Area	376.2	378.82	371.2 - 366.2	**369.9**									
HB-8I	Railroad Area	376.4	378.93	364.4 - 354.4	**369.8**									
HB-8D	Railroad Area	376.9	379.17	318.9 - 308.9	**374.3**									
HB-9S	Railroad Area	379.8	382.09	374.8 - 364.8	**376.4**									
HB-11S	Penn-Can	394.5	394.21	390.5 - 380.5	**383.8**									
HB-11I	Penn-Can	394.5	394.09	359.5 - 349.5	**375.7**									
HB-12S	Penn-Can	392.0	394.43	386.0 - 376.0	**380.5**									
HB-12I	Penn-Can	392.0	394.35	357.0 - 342.0	**374.2**									
HB-12D	Penn-Can	392.0	393.95	314.0 - 304.0	**374.6**									
HB-13D	Penn-Can	389.5	391.07	313.5 - 303.5	**374.8**									
HB-14S	Penn-Can	390.5	390.04	383.5 - 378.5	**380.9**									
HB-14D	Penn-Can	390.3	389.97	362.3 - 352.3	**376.3**									
OW-1 D	Lakeshore	371.8	373.14	283.8 - 273.8	**372.1**		371.7				372.1			
OW-2 D	Lakeshore	370.1	371.89	316.1 - 306.1	**371.6**		371.4				371.6			
OW-3 I	Lakeshore	370.3	371.94	356.3 - 346.3	**363.8**		363.6				363.5			
OW-4 D	Lakeshore	369.7	371.01	297.7 - 287.7	**370.6**		370.5				370.6			
OW-5 D	Lakeshore	371.7	372.6	309.7 - 299.7	**371.3**		372.0				371.0			
OW-6 D	Lakeshore	370.0	371.42	278.0 - 268.0	**370.5**		370.6				370.5			
OW-7 D	Lakeshore	370.2	371.8	306.2 - 296.2	**370.7**		370.9				370.7			
OW-8 S	Lakeshore	371.9	373.71	365.9 - 355.9	**364.2**		363.9							
OW-9 I	Lakeshore	370.6	372.4	351.6 - 341.6	**364.0**		364.1				363.9			
OW-10 I	Lakeshore	370.1	371.76	356.1 - 346.1	**363.7**		363.4				363.5			
OW-11 D	Lakeshore	370.4	371.55	269.4 - 259.4	**370.7**		371.2				370.8			
TW-1 D	Lakeshore	369.8	371.81	283.8 - 273.8	**370.5**		370.4				370.4			
TW-2 S	Lakeshore	371.5	373.67	366.5 - 356.5	**364.1**		363.8				363.7			
TW-3 I	Lakeshore	370.2	372.17	356.2 - 346.2	**363.4**		363.6				363.3			
HB-1S	Lakeshore	368.4	371.14	363.4 - 358.4	**363.3**					362.8		364.1	363.7	363.8
HB-1D	Lakeshore	368.3	370.92	281.9 - 276.9	**370.2**					370.0		370.2	370.0	370.3
HB-2S	Lakeshore	365.5	367.39	361.5 - 351.5	**363.7**					363.6		364.1	363.8	364.0
HB-2I	Lakeshore	365.4	367.44	343.4 - 333.4	**362.3**					361.8		352.6	363.0	363.3
HB-3S	Lakeshore	369.7	371.95	364.7 - 354.7	**367.5**									
HB-4S	Lakeshore	367.8	370.3	359.8 - 349.8	**363.3**									
HB-4D	Lakeshore	368.4	370.26	280.4 - 270.4	**372.7**									
HB-5S	Lakeshore	377.5	379.69	370.5 - 360.5	**366.3**					366.5		363.1	363.8	364.5

Notes:
NA: Not applicable/not available
(1) - This well was not located during the survey.
(2) - These wells had a water level that exceeded the elevation of the inside casing and could not be accurately measured.
(3) - Unable to access well during this survey.
(4) - Well appears to have been destroyed.

ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	1/10/03	1/17/03	1/24/03	1/31/03	2/7/03	2/14/03	2/21/03	3/12/03	5/7/03	8/11/03
						ELEVATION (FT)									
						Average Ground Water elevations from OBG monitoring 1991 thru 2003									
HB-7S	Railroad Area	371.9	374.63	368.9 - 363.9	**371.0**								371.1	370.9	371.3
HB-8S	Railroad Area	376.2	378.82	371.2 - 366.2	**369.9**								371.3	370.5	368.4
HB-8I	Railroad Area	376.4	378.93	364.4 - 354.4	**369.8**								370.5	370.0	369.4
HB-8D	Railroad Area	376.9	379.17	318.9 - 308.9	**374.3**								374.5	374.4	374.0
HB-9S	Railroad Area	379.8	382.09	374.8 - 364.8	**376.4**								376.3	376.1	377.3
HB-11S	Penn-Can	394.5	394.21	390.5 - 380.5	**383.8**								NA (1)	381.2	381.2
HB-11I	Penn-Can	394.5	394.09	359.5 - 349.5	**375.7**								376.1	375.3	374.2
HB-12S	Penn-Can	392.0	394.43	386.0 - 376.0	**380.5**								383.0	380.4	378.9
HB-12I	Penn-Can	392.0	394.35	357.0 - 342.0	**374.2**								375.2	374.5	372.7
HB-12D	Penn-Can	392.0	393.95	314.0 - 304.0	**374.6**								375.8	374.0	373.8
HB-13D	Penn-Can	389.5	391.07	313.5 - 303.5	**374.8**								375.1	374.5	374.9
HB-14S	Penn-Can	390.5	390.04	383.5 - 378.5	**380.9**								379.7	383.1	381.4
HB-14D	Penn-Can	390.3	389.97	362.3 - 352.3	**376.3**								376.5	375.4	376.7
OW-1 D	Lakeshore	371.8	373.14	283.8 - 273.8	**372.1**								372.4	372.4	371.8
OW-2 D	Lakeshore	370.1	371.89	316.1 - 306.1	**371.6**								NA (2)	371.9	371.6
OW-3 I	Lakeshore	370.3	371.94	356.3 - 346.3	**363.8**								364.0	363.7	364.0
OW-4 D	Lakeshore	369.7	371.01	297.7 - 287.7	**370.6**								NA (2)	370.9	370.5
OW-5 D	Lakeshore	371.7	372.6	309.7 - 299.7	**371.3**								371.5	371.2	370.9
OW-6 D	Lakeshore	370.0	371.42	278.0 - 268.0	**370.5**								370.9	370.4	370.2
OW-7 D	Lakeshore	370.2	371.8	306.2 - 296.2	**370.7**								371.0	370.6	370.2
OW-8 S	Lakeshore	371.9	373.71	365.9 - 355.9	**364.2**								364.4	364.2	
OW-9 I	Lakeshore	370.6	372.4	351.6 - 341.6	**364.0**										
OW-10 I	Lakeshore	370.1	371.76	356.1 - 346.1	**363.7**								363.9	363.8	364.0
OW-11 D	Lakeshore	370.4	371.55	269.4 - 259.4	**370.7**								371.3	370.5	370.1
TW-1 D	Lakeshore	369.8	371.81	283.8 - 273.8	**370.5**								370.9	370.6	370.3
TW-2 S	Lakeshore	371.5	373.67	366.5 - 356.5	**364.1**								365.3	363.7	
TW-3 I	Lakeshore	370.2	372.17	356.2 - 346.2	**363.4**								362.7	363.6	363.8
HB-1S	Lakeshore	368.4	371.14	363.4 - 358.4	**363.3**	363.9	363.3	363.3	362.8	363.5		363.1	363.4	362.9	363.2
HB-1D	Lakeshore	368.3	370.92	281.9 - 276.9	**370.2**	370.4	370.1	370.2	369.8	370.4		370.2	370.4	370.4	370.2
HB-2S	Lakeshore	365.5	367.39	361.5 - 351.5	**363.7**	364.0	363.8	363.7	363.6	363.9		363.7	364.0	363.9	363.7
HB-2I	Lakeshore	365.4	367.44	343.4 - 333.4	**362.3**	363.1	363.0	362.8	362.9	363.2		363.0	363.3	363.2	362.3
HB-3S	Lakeshore	369.7	371.95	364.7 - 354.7	**367.5**								367.9	367.9	367.7
HB-4S	Lakeshore	367.8	370.3	359.8 - 349.8	**363.3**								363.8	363.6	363.6
HB-4D	Lakeshore	368.4	370.26	280.4 - 270.4	**372.7**								NA (2)	373.4	372.0
HB-5S	Lakeshore	377.5	379.69	370.5 - 360.5	**366.3**	365.0	365.5	365.7	366.0	366.3		366.7	367.4	371.6	365.1

Notes:
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ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	2/20/91	3/4/91	5/13/91	6/10/91	7/25/91	3/18/92	5/2/92	7/13/92
						ELEVATION (FT)							
						Average ground water elevations from OBG monitoring 1991 thru 2003							
HB-5I	Lakeshore	377.9	380.24	333.9 - 323.9	**364.9**								
HB-5D	Lakeshore	378.0	379.68	280.0 - 270.0	**369.5**								
HB-6S	Lakeshore	363.4	365.7	360.4 - 350.4	**362.7**								
HB-16D	Lakeshore	378.8	380.37	281.8 - 271.8	**368.9**								
HB-17D	Lakeshore	394.3	393.99	327.3 - 317.3	**376.2**								
WA-1S	Lakeshore	369.5	371.24	363.0 - 353.0	**363.9**						364.1	364.1	363.5
WA-1I	Lakeshore	368.9	370.7	340.4 - 330.4	**355.3**						364.6	363.4	363.2
WA-1D	Lakeshore	370.1	373.35	273.5 - 263.5	**370.3**						371.2	370.7	370.4
WA-2S	Lakeshore	371.0	372.76	363.0 - 353.0	**362.8**						363.9	363.9	363.4
WA-2D	Lakeshore	371.2	375.64	297.7 - 287.7	**373.1**						373.6	373.0	
WA-3S	Lakeshore	370.1	372	367.1 - 357.1	**367.1**						366.7	366.6	
WA-3I	Lakeshore	370.5	372.56	350.5-340.5	**366.9**						367.0	366.8	
WA-3D	Lakeshore	370.4	374.84	316.9 - 306.9	**373.2**						374.1	373.3	
WA-8S	Lakeshore	380.5	382.66	371.5 - 361.5	**371.7**								
WA-8I	Lakeshore	380.3	382.27	350.3 - 340.3	**371.3**								
WA-8D	Lakeshore	380.3	382.51	310.3 - 300.3	**372.5**								
WB-BU	Lakeshore	382.3	385.2	363.5 - 358.5	**372.6**								
WB-BL	Lakeshore		384		**376.5**								
HB-18S	AOS #1	363.5	365.28	359.5 - 349.5	**363.5**								
HB-19S	AOS #1	363.5	365.39	359.5 - 349.5	**363.2**								
HB-20S	AOS #1	363.5	365.02	359.5 - 349.5	**363.3**								
HB-20I	AOS #1	363.5	365.05	335.5 - 325.5	**363.0**								
HB-20D	AOS #1	363.5	365.19	238.5 - 228.5	**363.5**								
HB-21I	AOS #2	378.0	380.11	358.0 - 348.0	**366.6**								
BFMW-1S	Ballfield	401.8	404.32	389.8 - 379.8	**381.9**								
BFMW-1I	Ballfield	401.8	404.09	357.8 - 347.8	**377.3**								
BFMW-1D	Ballfield	401.8	403.48	353.8 - 343.8	**374.5**								
BFMW-2	Ballfield	402.4	404.93	396.4 - 386.4	**386.0**								
BFMW-3S	Ballfield	407.0	409.37	389.5 - 379.5	**381.4**								
BFMW-3I	Ballfield	406.9	409.35	358.9 - 348.9	**378.2**								
BFMW-3D	Ballfield	406.9	409.35	358.9 - 348.9	**376.2**								
BFMW-4S	Ballfield	401.2	400.92	389.2 - 379.2	**380.0**								
BFMW-4I	Ballfield	401.3	400.76	359.2 - 349.2	**376.9**								
BFMW-4D	Ballfield	400.9	400.44	338.9 - 328.9	**374.5**								

Notes:

NA: Not applicable/not available

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Honeywell

ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	9/22/92	12/15/94	1/4/95	3/8/95	9/18/97	8/15/00	5/8/01	8/27/01	9/27/01	10/29/01
						ELEVATION (FT)									
						Average ground water elevations from OBG monitoring 1991 thru 2003									
HB-5I	Lakeshore	377.9	380.24	333.9 - 323.9	**364.9**							366.1			
HB-5D	Lakeshore	378.0	379.68	280.0 - 270.0	**369.5**										
HB-6S	Lakeshore	363.4	365.7	360.4 - 350.4	**362.7**						361.5	362.6			
HB-16D	Lakeshore	378.8	380.37	281.8 - 271.8	**368.9**										
HB-17D	Lakeshore	394.3	393.99	327.3 - 317.3	**376.2**										
WA-1S	Lakeshore	369.5	371.24	363.0 - 353.0	**363.9**	363.9			364.1	362.4			363.4	364.0	363.6
WA-1I	Lakeshore	368.9	370.7	340.4 - 330.4	**355.3**					362.4				365.3	364.8
WA-1D	Lakeshore	370.1	373.35	273.5 - 263.5	**370.3**	370.4				369.6			369.4	369.9	369.5
WA-2S	Lakeshore	371.0	372.76	363.0 - 353.0	**362.8**	363.8			364.2	361.8			362.1	362.6	362.3
WA-2D	Lakeshore	371.2	375.64	297.7 - 287.7	**373.1**	372.7				371.8			372.6	372.8	372.8
WA-3S	Lakeshore	370.1	372	367.1 - 357.1	**367.1**	366.4			367.2	366.5			366.8	367.3	367.0
WA-3I	Lakeshore	370.5	372.56	350.5-340.5	**366.9**	366.5				366.5			366.3	366.8	366.5
WA-3D	Lakeshore	370.4	374.84	316.9 - 306.9	**373.2**	372.9				372.3			372.5	372.6	372.4
WA-8S	Lakeshore	380.5	382.66	371.5 - 361.5	**371.7**			371.5	372.7			371.8			
WA-8I	Lakeshore	380.3	382.27	350.3 - 340.3	**371.3**			372.0				372.0			
WA-8D	Lakeshore	380.3	382.51	310.3 - 300.3	**372.5**			372.4				372.6			
WB-BU	Lakeshore	382.3	385.2	363.5 - 358.5	**372.6**							373.3			
WB-BL	Lakeshore		384		**376.5**							375.8			
HB-18S	AOS #1	363.5	365.28	359.5 - 349.5	**363.5**										
HB-19S	AOS #1	363.5	365.39	359.5 - 349.5	**363.2**										
HB-20S	AOS #1	363.5	365.02	359.5 - 349.5	**363.3**										
HB-20I	AOS #1	363.5	365.05	335.5 - 325.5	**363.0**										
HB-20D	AOS #1	363.5	365.19	238.5 - 228.5	**363.5**										
HB-21I	AOS #2	378.0	380.11	358.0 - 348.0	**366.6**										
BFMW-1S	Ballfield	401.8	404.32	389.8 - 379.8	**381.9**							378.8			
BFMW-1I	Ballfield	401.8	404.09	357.8 - 347.8	**377.3**							376.9			
BFMW-1D	Ballfield	401.8	403.48	353.8 - 343.8	**374.5**										
BFMW-2	Ballfield	402.4	404.93	396.4 - 386.4	**386.0**										
BFMW-3S	Ballfield	407.0	409.37	389.5 - 379.5	**381.4**							381.0			
BFMW-3I	Ballfield	406.9	409.35	358.9 - 348.9	**378.2**							378.2			
BFMW-3D	Ballfield	406.9	409.35	358.9 - 348.9	**376.2**										
BFMW-4S	Ballfield	401.2	400.92	389.2 - 379.2	**380.0**							381.3			
BFMW-4I	Ballfield	401.3	400.76	359.2 - 349.2	**376.9**							378.2			
BFMW-4D	Ballfield	400.9	400.44	338.9 - 328.9	**374.5**										

Notes:
NA: Not applicable/not available
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ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	11/20/01	12/5/01	12/26/01	1/23/02	2/14/02	7/15/02	12/16/02	12/27/02	1/4/03
						ELEVATION (FT)								
						Average Ground Water elevations from OBG monitoring 1991 thru 2003								
HB-5I	Lakeshore	377.9	380.24	333.9 - 323.9	**364.9**					364.8		363.9	364.1	364.3
HB-5D	Lakeshore	378.0	379.68	280.0 - 270.0	**369.5**									
HB-6S	Lakeshore	363.4	365.7	360.4 - 350.4	**362.7**					362.4		362.9	362.8	363.2
HB-16D	Lakeshore	378.8	380.37	281.8 - 271.8	**368.9**									
HB-17D	Lakeshore	394.3	393.99	327.3 - 317.3	**376.2**									
WA-1S	Lakeshore	369.5	371.24	363.0 - 353.0	**363.9**	363.6	363.7	364.0	363.7		363.7	364.5	364.1	364.4
WA-1I	Lakeshore	368.9	370.7	340.4 - 330.4	**355.3**	264.8	364.6	364.5	364.7		365.6			
WA-1D	Lakeshore	370.1	373.35	273.5 - 263.5	**370.3**	369.5	369.7	370.0	369.7		370.2	370.6	370.3	370.6
WA-2S	Lakeshore	371.0	372.76	363.0 - 353.0	**362.8**	362.2	362.5	362.6	362.2		362.3	363.2	362.9	363.1
WA-2D	Lakeshore	371.2	375.64	297.7 - 287.7	**373.1**	372.9	373.1	373.4	373.2		373.6			
WA-3S	Lakeshore	370.1	372	367.1 - 357.1	**367.1**	366.9	367.0	367.5	367.5	367.2	367.0	367.6	367.3	367.5
WA-3I	Lakeshore	370.5	372.56	350.5-340.5	**366.9**	366.6	366.7	367.5	367.6		367.1			
WA-3D	Lakeshore	370.4	374.84	316.9 - 306.9	**373.2**	372.5	372.7	373.1	372.8	373.2	373.3	373.6	373.4	373.7
WA-8S	Lakeshore	380.5	382.66	371.5 - 361.5	**371.7**					372.7		370.7	371.5	372.0
WA-8I	Lakeshore	380.3	382.27	350.3 - 340.3	**371.3**					371.4		370.8	370.8	371.4
WA-8D	Lakeshore	380.3	382.51	310.3 - 300.3	**372.5**					371.6		372.6	372.5	372.8
WB-BU	Lakeshore	382.3	385.2	363.5 - 358.5	**372.6**									
WB-BL	Lakeshore		384		**376.5**									
HB-18S	AOS #1	363.5	365.28	359.5 - 349.5	**363.5**									
HB-19S	AOS #1	363.5	365.39	359.5 - 349.5	**363.2**									
HB-20S	AOS #1	363.5	365.02	359.5 - 349.5	**363.3**									
HB-20I	AOS #1	363.5	365.05	335.5 - 325.5	**363.0**									
HB-20D	AOS #1	363.5	365.19	238.5 - 228.5	**363.5**									
HB-21I	AOS #2	378.0	380.11	358.0 - 348.0	**366.6**									
BFMW-1S	Ballfield	401.8	404.32	389.8 - 379.8	**381.9**									
BFMW-1I	Ballfield	401.8	404.09	357.8 - 347.8	**377.3**									
BFMW-1D	Ballfield	401.8	403.48	353.8 - 343.8	**374.5**									
BFMW-2	Ballfield	402.4	404.93	396.4 - 386.4	**386.0**									
BFMW-3S	Ballfield	407.0	409.37	389.5 - 379.5	**381.4**									
BFMW-3I	Ballfield	406.9	409.35	358.9 - 348.9	**378.2**									
BFMW-3D	Ballfield	406.9	409.35	358.9 - 348.9	**376.2**									
BFMW-4S	Ballfield	401.2	400.92	389.2 - 379.2	**380.0**									
BFMW-4I	Ballfield	401.3	400.76	359.2 - 349.2	**376.9**									
BFMW-4D	Ballfield	400.9	400.44	338.9 - 328.9	**374.5**									

Notes:

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ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	1/10/03	1/17/03	1/24/03	1/31/03	2/7/03	2/14/03	2/21/03	3/12/03	5/7/03	8/11/03
						ELEVATION (FT)									
						Average Ground Water elevations from OBG monitoring 1991 thru 2003									
HB-5I	Lakeshore	377.9	380.24	333.9 - 323.9	**364.9**	364.5	364.5	364.5	364.4	366.8		364.6	365.1	366.1	364.2
HB-5D	Lakeshore	378.0	379.68	280.0 - 270.0	**369.5**								370.1	370.0	368.4
HB-6S	Lakeshore	363.4	365.7	360.4 - 350.4	**362.7**	363.0	362.9	362.6	362.5	362.9		362.7	363.0	362.8	363.1
HB-16D	Lakeshore	378.8	380.37	281.8 - 271.8	**368.9**								369.8	369.8	367.0
HB-17D	Lakeshore	394.3	393.99	327.3 - 317.3	**376.2**								376.5	376.6	375.6
WA-1S	Lakeshore	369.5	371.24	363.0 - 353.0	**363.9**	364.4	364.1	364.0	363.8	364.3	363.9	363.9	364.1	364.1	364.3
WA-1I	Lakeshore	368.9	370.7	340.4 - 330.4	**355.3**										
WA-1D	Lakeshore	370.1	373.35	273.5 - 263.5	**370.3**	370.6	370.4	370.4	370.1	370.7	370.2	370.4	370.6	371.6	370.2
WA-2S	Lakeshore	371.0	372.76	363.0 - 353.0	**362.8**	363.1	362.7	362.7	362.3	362.9	362.4	362.6	362.8	362.6	362.9
WA-2D	Lakeshore	371.2	375.64	297.7 - 287.7	**373.1**								372.9	374.7	373.6
WA-3S	Lakeshore	370.1	372	367.1 - 357.1	**367.1**	367.5	367.2	367.2	367.1	367.5		367.2	367.5	367.4	367.3
WA-3I	Lakeshore	370.5	372.56	350.5-340.5	**366.9**								367.4	367.4	367.3
WA-3D	Lakeshore	370.4	374.84	316.9 - 306.9	**373.2**	373.7	373.5	373.4	373.2	373.7		373.5	373.7	373.7	373.3
WA-8S	Lakeshore	380.5	382.66	371.5 - 361.5	**371.7**	372.1	371.9	371.6	371.4	371.8		371.6	372.3	372.1	369.7
WA-8I	Lakeshore	380.3	382.27	350.3 - 340.3	**371.3**	371.5	371.3	371.2	371.1	371.5		371.4	371.8	371.7	370.1
WA-8D	Lakeshore	380.3	382.51	310.3 - 300.3	**372.5**	372.8	372.6	372.6	372.3	372.7		372.5	372.9	372.9	372.6
WB-BU	Lakeshore	382.3	385.2	363.5 - 358.5	**372.6**								373.1	372.8	371.3
WB-BL	Lakeshore		384		**376.5**										377.2
HB-18S	AOS #1	363.5	365.28	359.5 - 349.5	**363.5**								363.8	363.4	363.3
HB-19S	AOS #1	363.5	365.39	359.5 - 349.5	**363.2**								363.5	363.1	363.2
HB-20S	AOS #1	363.5	365.02	359.5 - 349.5	**363.3**								363.5	363.3	363.1
HB-20I	AOS #1	363.5	365.05	335.5 - 325.5	**363.0**								363.5	363.4	362.3
HB-20D	AOS #1	363.5	365.19	238.5 - 228.5	**363.5**								364.0	363.9	362.5
HB-21I	AOS #2	378.0	380.11	358.0 - 348.0	**366.6**								366.9	366.6	366.4
BFMW-1S	Ballfield	401.8	404.32	389.8 - 379.8	**381.9**								383.2	383.7	381.9
BFMW-1I	Ballfield	401.8	404.09	357.8 - 347.8	**377.3**								377.4	377.4	377.4
BFMW-1D	Ballfield	401.8	403.48	353.8 - 343.8	**374.5**								374.9	374.3	374.4
BFMW-2	Ballfield	402.4	404.93	396.4 - 386.4	**386.0**								386.0	Dry	Dry
BFMW-3S	Ballfield	407.0	409.37	389.5 - 379.5	**381.4**								381.1	383.8	379.8
BFMW-3I	Ballfield	406.9	409.35	358.9 - 348.9	**378.2**										
BFMW-3D	Ballfield	406.9	409.35	358.9 - 348.9	**376.2**								377.1	377.7	373.8
BFMW-4S	Ballfield	401.2	400.92	389.2 - 379.2	**380.0**								380.5	NA (3)	378.1
BFMW-4I	Ballfield	401.3	400.76	359.2 - 349.2	**376.9**								376.9	NA (3)	375.5
BFMW-4D	Ballfield	400.9	400.44	338.9 - 328.9	**374.5**								375.1	NA (3)	373.9

Notes:
NA: Not applicable/not available
(1) - This well was not located during the survey.
(2) - These wells had a water level that exceeded the elevation of the inside casing and could not be accurately measured.
(3) - Unable to access well during this survey.
(4) - Well appears to have been destroyed.

ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	2/20/91	3/4/91	5/13/91	6/10/91	7/25/91	3/18/92	5/2/92	7/13/92
						ELEVATION (FT)							
						Average ground water elevations from OBG monitoring 1991 thru 2003							
BFMW-5S	Ballfield	400.0	399.74	384.0 - 374.0.	**382.0**								
BFMW-5I	Ballfield	400.1	399.97	361.1 - 356.1	**381.8**								
BFMW-5D	Ballfield	400.1	399.97	361.1 - 351.1	**379.7**								
BFMW-6S	Ballfield	405.3	407.95	393.3 - 383.3	**385.8**								
BFMW-6I	Ballfield	405.2	407.77	363.2 - 353.2	**380.6**								
BFMW-6D	Ballfield	405.2	407.77	363.2 - 353.2	**377.4**								
BFMW-7S	Ballfield	387.2	389.62	383.2 - 373.2	**382.1**								
WA-4S	Willis Avenue	400.6	402.28	377.6 - 367.6	**377.6**						377.7	378.1	377.8
WA-4I	Willis Avenue	399.5	401.14	359.5 - 349.5	**375.8**						375.4	375.9	375.6
WA-4D	Willis Avenue	400.2	402.5	340.2 - 330.2	**375.3**						375.2	375.4	374.9
WA-5S	Willis Avenue	393.9	395.77	381.9 - 371.9	**378.1**						377.9	378.1	377.9
WA-5I	Willis Avenue	394.0	395.73	368.0 - 358.0	**377.9**						377.6	377.9	377.6
WA-5D	Willis Avenue	394.0	395.82	354.0 - 344.0	**376.7**						376.0	376.3	376.0
WA-6S	Willis Avenue	399.4	401.12	382.9 - 372.9	**378.2**						377.3	379.1	378.4
WA-6D	Willis Avenue	398.6	400.04	362.6 - 352.6	**376.9**						377.3	376.7	376.2
WA-7S	Willis Avenue	387.8	389.65	377.8 - 367.8	**376.3**						377.2	378.1	377.3
WA-7I	Willis Avenue	387.4	389.18	357.4 - 347.4	**371.1**						371.0	372.0	371.5
WA-7D	Willis Avenue	387.7	389.44	317.7 - 307.7	**374.4**						374.8	375.2	374.6
SP-2A	Semet Ponds	381.4	383.0	375.4 - 365.4	**372.9**	373.4	373.3	372.7	372.6	372.6		373.1	372.8
SP-3A	Semet Ponds	388.2	390.25	374.2 - 364.2	**381.9**	383.4	383.7	382.8	379.5	378.3	381.9	383.4	382.8
SP-3B	Semet Ponds	388.2	389.71	354.2 - 344.2	**377.4**	377.6	378.2	378.3	376.0	375.8	376.8	378.4	377.8
SP-3C	Semet Ponds	388.4	390.13	322.4 - 312.4	**372.9**	373.3	373.4	372.6	370.6	371.9	373.5	373.8	373.2
SP-4A	Semet Ponds	403.6	405.49	375.6 - 365.6	**394.7**	396.7	396.7	394.4	393.4	393.4	394.6	396.5	395.4
SP-4B	Semet Ponds	403.7	405.62	351.7 - 341.7	**373.9**	374.3	374.3	373.4	371.1	372.4	373.8	374.3	373.9
SP-4C	Semet Ponds	404.1	405.94	328.1 - 318.1	**370.8**	370.1	370.1	369.5	367.4	368.8	370.6	370.9	370.4
SP-5A	Semet Ponds	373.4	375.06	365.4 - 355.4	**366.8**	367.1	367.0	366.9	365.2	366.9		367.0	367.0
SP-5B	Semet Ponds	373.5	375.16	339.5 - 329.5	**370.1**	370.5	370.9	369.9	368.0	369.6		370.9	370.5
SP-5C	Semet Ponds	373.6	375.37	319.6 - 309.6	**373.0**	373.8	374.0	373.0	370.8	372.2		373.7	373.1
SP-6A	Semet Ponds	391.8	393.5	371.8 - 361.8	**376.7**	378.8	379.0	379.3	376.5	375.9	376.5	378.7	377.8
SP-6B	Semet Ponds	392.2	393.98	344.2 - 334.2	**371.7**	372.8	373.2	373.3	370.9	371.1	371.5	373.1	372.5
SP-6C	Semet Ponds	392.1	393.85	296.1 - 286.1	**370.8**	371.2	371.3	370.8	368.7	370.0	371.2	371.4	370.8
SP-7A	Semet Ponds	391.4	393.14	375.4 - 365.4	**377.0**	379.6	379.5	379.7	376.5	375.9	376.2	378.8	377.6
SP-7B	Semet Ponds	391.6	393.43	347.6 - 337.6	**371.7**	374.9	373.2	373.1	370.5	370.9	371.0	372.8	372.2
SP-7C	Semet Ponds	391.7	393.4	303.7 - 293.7	**373.2**	371.9	371.7	371.3	369.2	370.5	371.6	371.8	371.2

Notes:

NA: Not applicable/not available

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(4) - Well appears to have been destroyed.

ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	9/22/92	12/15/94	1/4/95	3/8/95	9/18/97	8/15/00	5/8/01	8/27/01	9/27/01	10/29/01
						ELEVATION (FT)									
						Average ground water elevations from OBG monitoring 1991 thru 2003									
BFMW-5S	Ballfield	400.0	399.74	384.0 - 374.0.	**382.0**							382.5			
BFMW-5I	Ballfield	400.1	399.97	361.1 - 356.1	**381.8**							381.8			
BFMW-5D	Ballfield	400.1	399.97	361.1 - 351.1	**379.7**										
BFMW-6S	Ballfield	405.3	407.95	393.3 - 383.3	**385.8**							386.0			
BFMW-6I	Ballfield	405.2	407.77	363.2 - 353.2	**380.6**							380.6			
BFMW-6D	Ballfield	405.2	407.77	363.2 - 353.2	**377.4**										
BFMW-7S	Ballfield	387.2	389.62	383.2 - 373.2	**382.1**										
WA-4S	Willis Avenue	400.6	402.28	377.6 - 367.6	**377.6**	377.7	374.7		374.7	377.9			377.5	377.7	377.5
WA-4I	Willis Avenue	399.5	401.14	359.5 - 349.5	**375.8**	375.6				375.6			375.4	375.4	375.1
WA-4D	Willis Avenue	400.2	402.5	340.2 - 330.2	**375.3**	375.0				374.5			374.5	374.4	374.0
WA-5S	Willis Avenue	393.9	395.77	381.9 - 371.9	**378.1**	377.9	377.6		377.7	378.1					
WA-5I	Willis Avenue	394.0	395.73	368.0 - 358.0	**377.9**	377.7				377.8					
WA-5D	Willis Avenue	394.0	395.82	354.0 - 344.0	**376.7**	376.3				376.6					
WA-6S	Willis Avenue	399.4	401.12	382.9 - 372.9	**378.2**	378.3	377.8		377.9	377.9					
WA-6D	Willis Avenue	398.6	400.04	362.6 - 352.6	**376.9**	376.4				375.7					
WA-7S	Willis Avenue	387.8	389.65	377.8 - 367.8	**376.3**	377.4	376.3		376.6	375.7			373.4	375.4	375.2
WA-7I	Willis Avenue	387.4	389.18	357.4 - 347.4	**371.1**	371.5							370.4	370.4	370.2
WA-7D	Willis Avenue	387.7	389.44	317.7 - 307.7	**374.4**	374.7				373.8			373.9	373.0	373.7
SP-2A	Semet Ponds	381.4	383.0	375.4 - 365.4	**372.9**	372.8									
SP-3A	Semet Ponds	388.2	390.25	374.2 - 364.2	**381.9**	382.5	382.2		381.8						
SP-3B	Semet Ponds	388.2	389.71	354.2 - 344.2	**377.4**	377.2									
SP-3C	Semet Ponds	388.4	390.13	322.4 - 312.4	**372.9**	373.3									
SP-4A	Semet Ponds	403.6	405.49	375.6 - 365.6	**394.7**	394.8				392.4					
SP-4B	Semet Ponds	403.7	405.62	351.7 - 341.7	**373.9**	373.8				373.5					
SP-4C	Semet Ponds	404.1	405.94	328.1 - 318.1	**370.8**	370.5				371.1					
SP-5A	Semet Ponds	373.4	375.06	365.4 - 355.4	**366.8**	367.0									
SP-5B	Semet Ponds	373.5	375.16	339.5 - 329.5	**370.1**	370.6									
SP-5C	Semet Ponds	373.6	375.37	319.6 - 309.6	**373.0**	373.3									
SP-6A	Semet Ponds	391.8	393.5	371.8 - 361.8	**376.7**	376.8			376.3				375.2	374.8	374.8
SP-6B	Semet Ponds	392.2	393.98	344.2 - 334.2	**371.7**	371.9				371.3			370.7	370.4	370.3
SP-6C	Semet Ponds	392.1	393.85	296.1 - 286.1	**370.8**	371.0				370.2			370.5	370.9	370.4
SP-7A	Semet Ponds	391.4	393.14	375.4 - 365.4	**377.0**	376.7			376.6				375.3	374.8	374.9
SP-7B	Semet Ponds	391.6	393.43	347.6 - 337.6	**371.7**	371.7							370.8	370.8	369.7
SP-7C	Semet Ponds	391.7	393.4	303.7 - 293.7	**373.2**	371.4							374.1	374.0	373.9

Notes:
NA: Not applicable/not available
(1) - This well was not located during the survey.
(2) - These wells had a water level that exceeded the elevation of the inside casing and could not be accurately measured.
(3) - Unable to access well during this survey.
(4) - Well appears to have been destroyed.

ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	11/20/01	12/5/01	12/26/01	1/23/02	2/14/02	7/15/02	12/16/02	12/27/02	1/4/03
						ELEVATION (FT)								
						Average Ground Water elevations from OBG monitoring 1991 thru 2003								
BFMW-5S	Ballfield	400.0	399.74	384.0 - 374.0.	**382.0**									
BFMW-5I	Ballfield	400.1	399.97	361.1 - 356.1	**381.8**									
BFMW-5D	Ballfield	400.1	399.97	361.1 - 351.1	**379.7**									
BFMW-6S	Ballfield	405.3	407.95	393.3 - 383.3	**385.8**									
BFMW-6I	Ballfield	405.2	407.77	363.2 - 353.2	**380.6**									
BFMW-6D	Ballfield	405.2	407.77	363.2 - 353.2	**377.4**									
BFMW-7S	Ballfield	387.2	389.62	383.2 - 373.2	**382.1**									
WA-4S	Willis Avenue	400.6	402.28	377.6 - 367.6	**377.6**	377.4	377.4	377.7	377.7		378.6			
WA-4I	Willis Avenue	399.5	401.14	359.5 - 349.5	**375.8**	375.3	375.1	375.6	375.7		376.5			
WA-4D	Willis Avenue	400.2	402.5	340.2 - 330.2	**375.3**	374.5	374.8	374.7	374.8		375.5			
WA-5S	Willis Avenue	393.9	395.77	381.9 - 371.9	**378.1**		377.5							
WA-5I	Willis Avenue	394.0	395.73	368.0 - 358.0	**377.9**		377.1							
WA-5D	Willis Avenue	394.0	395.82	354.0 - 344.0	**376.7**		377.2							
WA-6S	Willis Avenue	399.4	401.12	382.9 - 372.9	**378.2**		377.6							
WA-6D	Willis Avenue	398.6	400.04	362.6 - 352.6	**376.9**		375.9							
WA-7S	Willis Avenue	387.8	389.65	377.8 - 367.8	**376.3**	375.3	375.3	376.0	376.0		377.1			
WA-7I	Willis Avenue	387.4	389.18	357.4 - 347.4	**371.1**	370.3	370.4	370.7						
WA-7D	Willis Avenue	387.7	389.44	317.7 - 307.7	**374.4**	374.0	374.1	374.5	374.2		374.7			
SP-2A	Semet Ponds	381.4	383.0	375.4 - 365.4	**372.9**									
SP-3A	Semet Ponds	388.2	390.25	374.2 - 364.2	**381.9**		380.0							
SP-3B	Semet Ponds	388.2	389.71	354.2 - 344.2	**377.4**		375.9							
SP-3C	Semet Ponds	388.4	390.13	322.4 - 312.4	**372.9**		372.5							
SP-4A	Semet Ponds	403.6	405.49	375.6 - 365.6	**394.7**		392.5							
SP-4B	Semet Ponds	403.7	405.62	351.7 - 341.7	**373.9**		374.0							
SP-4C	Semet Ponds	404.1	405.94	328.1 - 318.1	**370.8**		372.4							
SP-5A	Semet Ponds	373.4	375.06	365.4 - 355.4	**366.8**									
SP-5B	Semet Ponds	373.5	375.16	339.5 - 329.5	**370.1**									
SP-5C	Semet Ponds	373.6	375.37	319.6 - 309.6	**373.0**									
SP-6A	Semet Ponds	391.8	393.5	371.8 - 361.8	**376.7**	375.0	375.2	375.6	375.8		377.5			
SP-6B	Semet Ponds	392.2	393.98	344.2 - 334.2	**371.7**	370.3	370.4	371.0	371.0		372.6			
SP-6C	Semet Ponds	392.1	393.85	296.1 - 286.1	**370.8**	370.5	370.8	371.1	370.8		371.3			
SP-7A	Semet Ponds	391.4	393.14	375.4 - 365.4	**377.0**	375.1	375.3	375.9	377.0		377.6			
SP-7B	Semet Ponds	391.6	393.43	347.6 - 337.6	**371.7**	370.5	370.7	371.3	371.1		372.3			
SP-7C	Semet Ponds	391.7	393.4	303.7 - 293.7	**373.2**	374.0	374.2	374.7	374.5		375.7			

Notes:

NA: Not applicable/not available

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(3) - Unable to access well during this survey.

(4) - Well appears to have been destroyed.

ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	1/10/03	1/17/03	1/24/03	1/31/03	2/7/03	2/14/03	2/21/03	3/12/03	5/7/03	8/11/03
						ELEVATION (FT)									
						Average Ground Water elevations from OBG monitoring 1991 thru 2003									
BFMW-5S	Ballfield	400.0	399.74	384.0 - 374.0.	**382.0**								381.6	NA (4)	NA (4)
BFMW-5I	Ballfield	400.1	399.97	361.1 - 356.1	**381.8**										
BFMW-5D	Ballfield	400.1	399.97	361.1 - 351.1	**379.7**								379.7	NA (4)	NA (4)
BFMW-6S	Ballfield	405.3	407.95	393.3 - 383.3	**385.8**								385.7	386.0	385.5
BFMW-6I	Ballfield	405.2	407.77	363.2 - 353.2	**380.6**										
BFMW-6D	Ballfield	405.2	407.77	363.2 - 353.2	**377.4**								377.9	377.9	376.3
BFMW-7S	Ballfield	387.2	389.62	383.2 - 373.2	**382.1**								381.9	382.4	NA (1)
WA-4S	Willis Avenue	400.6	402.28	377.6 - 367.6	**377.6**								378.8	379.3	378.7
WA-4I	Willis Avenue	399.5	401.14	359.5 - 349.5	**375.8**								376.6	377.1	376.5
WA-4D	Willis Avenue	400.2	402.5	340.2 - 330.2	**375.3**								380.0	376.4	375.9
WA-5S	Willis Avenue	393.9	395.77	381.9 - 371.9	**378.1**								378.7	379.1	378.1
WA-5I	Willis Avenue	394.0	395.73	368.0 - 358.0	**377.9**								378.3	378.1	378.6
WA-5D	Willis Avenue	394.0	395.82	354.0 - 344.0	**376.7**								377.3	377.5	377.0
WA-6S	Willis Avenue	399.4	401.12	382.9 - 372.9	**378.2**								378.7	378.9	378.4
WA-6D	Willis Avenue	398.6	400.04	362.6 - 352.6	**376.9**								381.5	376.5	376.3
WA-7S	Willis Avenue	387.8	389.65	377.8 - 367.8	**376.3**								377.4	377.7	376.3
WA-7I	Willis Avenue	387.4	389.18	357.4 - 347.4	**371.1**								372.1	372.3	NA (3)
WA-7D	Willis Avenue	387.7	389.44	317.7 - 307.7	**374.4**								375.0	375.1	374.7
SP-2A	Semet Ponds	381.4	383.0	375.4 - 365.4	**372.9**										
SP-3A	Semet Ponds	388.2	390.25	374.2 - 364.2	**381.9**								382.3	382.9	380.5
SP-3B	Semet Ponds	388.2	389.71	354.2 - 344.2	**377.4**								378.3	378.9	377.0
SP-3C	Semet Ponds	388.4	390.13	322.4 - 312.4	**372.9**								373.3	373.3	373.0
SP-4A	Semet Ponds	403.6	405.49	375.6 - 365.6	**394.7**								395.1	396.5	393.9
SP-4B	Semet Ponds	403.7	405.62	351.7 - 341.7	**373.9**								375.1	375.5	374.7
SP-4C	Semet Ponds	404.1	405.94	328.1 - 318.1	**370.8**								373.3	373.2	372.9
SP-5A	Semet Ponds	373.4	375.06	365.4 - 355.4	**366.8**										
SP-5B	Semet Ponds	373.5	375.16	339.5 - 329.5	**370.1**										
SP-5C	Semet Ponds	373.6	375.37	319.6 - 309.6	**373.0**										
SP-6A	Semet Ponds	391.8	393.5	371.8 - 361.8	**376.7**								376.7	378.8	376.3
SP-6B	Semet Ponds	392.2	393.98	344.2 - 334.2	**371.7**								372.0	373.2	371.7
SP-6C	Semet Ponds	392.1	393.85	296.1 - 286.1	**370.8**								371.8	371.6	371.6
SP-7A	Semet Ponds	391.4	393.14	375.4 - 365.4	**377.0**								377.2	379.2	376.6
SP-7B	Semet Ponds	391.6	393.43	347.6 - 337.6	**371.7**								372.2	373.1	371.7
SP-7C	Semet Ponds	391.7	393.4	303.7 - 293.7	**373.2**								375.8	377.2	375.3

Notes:

NA: Not applicable/not available

(1) - This well was not located during the survey.

(2) - These wells had a water level that exceeded the elevation of the inside casing and could not be accurately measured.

(3) - Unable to access well during this survey.

(4) - Well appears to have been destroyed.

ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	2/20/91	3/4/91	5/13/91	6/10/91	7/25/91	3/18/92	5/2/92	7/13/92
						ELEVATION (FT)							
						Average ground water elevations from OBG monitoring 1991 thru 2003							
SP-8A	Semet Ponds	395.7	397.79	377.7 - 367.7	**380.0**	380.8	380.6	380.5	378.1	379.3	380.0	380.3	380.1
SP-8B	Semet Ponds	395.7	397.68	347.7 - 337.7	**370.8**	371.1	371.1	371.2	368.8	370.3	371.3	371.6	371.1
SP-8C	Semet Ponds	395.4	397.46	317.4 - 307.4	**373.1**	373.4	373.4	372.9	370.5	372.1	373.5	373.7	373.1
SP-9A	Semet Ponds	375.6	377.53	369.6 - 359.6	**369.7**	370.2	370.2	369.9	367.9	369.7		370.2	369.9
SP-9B	Semet Ponds	375.3	377.51	351.3 - 341.3	**371.5**	372.0	372.3	371.8	368.5	371.5		372.3	372.0
SP-9C	Semet Ponds	375.5	377.15	333.5 - 323.5	**373.4**	374.2	373.2	373.6	371.6	372.8		374.3	373.7
Tributary 5A	Onondaga Lake	NA	NA	NA	**362.8**								
Harbor Brook	Harbor Brook	NA	NA	NA	**362.8**								
Onodaga Lake*	Liverpool, NY	uncorrected	subtract	0.59 ft	**363.4**	363.7	363.9	363.2	362.6	362.6	363.7	363.7	363.0
Onodaga Lake	Liverpool, NY	corrected			**362.8**	363.1	363.3	362.6	362.0	362.0	363.1	363.1	362.4

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Honeywell

ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	9/22/92	12/15/94	1/4/95	3/8/95	9/18/97	8/15/00	5/8/01	8/27/01	9/27/01	10/29/01
						ELEVATION (FT)									
						Average ground water elevations from OBG monitoring 1991 thru 2003									
SP-8A	Semet Ponds	395.7	397.79	377.7 - 367.7	**380.0**	380.1			380.2				379.9	379.9	379.6
SP-8B	Semet Ponds	395.7	397.68	347.7 - 337.7	**370.8**	371.1							370.5	370.8	370.3
SP-8C	Semet Ponds	395.4	397.46	317.4 - 307.4	**373.1**	373.2							372.8	373.2	372.9
SP-9A	Semet Ponds	375.6	377.53	369.6 - 359.6	**369.7**	370.0									
SP-9B	Semet Ponds	375.3	377.51	351.3 - 341.3	**371.5**	371.9									
SP-9C	Semet Ponds	375.5	377.15	333.5 - 323.5	**373.4**	373.8									
Tributary 5A	Onondaga Lake	NA	NA	NA	**362.8**									362.8	362.5
Harbor Brook	Harbor Brook	NA	NA	NA	**362.8**								363.8		362.5
Onodaga Lake*	Liverpool, NY	uncorrected	subtract	0.59 ft	**363.4**	363.6	363.9	363.1	364.5	362.8	363.4	363.0	363.0	363.3	363.1
Onodaga Lake	Liverpool, NY	corrected			**362.8**	363.0	363.3	362.6	363.9	362.2	362.8	362.4	362.4	362.7	362.5

Notes:

NA: Not applicable/not available

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(4) - Well appears to have been destroyed.

ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	11/20/01	12/5/01	12/26/01	1/23/02	2/14/02	7/15/02	12/16/02	12/27/02	1/4/03
						ELEVATION (FT)								
						Average Ground Water elevations from OBG monitoring 1991 thru 2003								
SP-8A	Semet Ponds	395.7	397.79	377.7 - 367.7	**380.0**	379.0	380.5	380.7	379.6		380.4			
SP-8B	Semet Ponds	395.7	397.68	347.7 - 337.7	**370.8**	370.4	370.6	370.9	370.6		371.1			
SP-8C	Semet Ponds	395.4	397.46	317.4 - 307.4	**373.1**	372.9	373.2	373.5	373.2		373.7			
SP-9A	Semet Ponds	375.6	377.53	369.6 - 359.6	**369.7**									
SP-9B	Semet Ponds	375.3	377.51	351.3 - 341.3	**371.5**									
SP-9C	Semet Ponds	375.5	377.15	333.5 - 323.5	**373.4**									
Tributary 5A	Onondaga Lake	NA	NA	NA	**362.8**	362.4	362.9	362.6	362.2					
Harbor Brook	Harbor Brook	NA	NA	NA	**362.8**	362.4		362.6	362.2					
Onodaga Lake*	Liverpool, NY	uncorrected	subtract	0.59 ft	**363.4**	363.2	363.3	363.3	362.8	363.7	363.0	364.3	363.8	363.8
Onodaga Lake	Liverpool, NY	corrected			**362.8**	362.6	362.8	362.7	362.2	363.1	362.5	363.7	363.2	363.2

Notes:
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ATTACHMENT DB.4
GROUNDWATER ELEVATION DATA
O'BRIEN AND GERE DATA

Well ID	Site/Location	Ground Elevation (ft)	Well Casing Elevation (ft)	Screened Interval Elevation (ft)	Average Ground Water Elevation (ft)	1/10/03	1/17/03	1/24/03	1/31/03	2/7/03	2/14/03	2/21/03	3/12/03	5/7/03	8/11/03
						ELEVATION (FT)									
						Average Ground Water elevations from OBG monitoring 1991 thru 2003									
SP-8A	Semet Ponds	395.7	397.79	377.7 - 367.7	**380.0**								380.7	380.6	379.6
SP-8B	Semet Ponds	395.7	397.68	347.7 - 337.7	**370.8**								371.5	371.4	371.1
SP-8C	Semet Ponds	395.4	397.46	317.4 - 307.4	**373.1**								374.2	374.0	373.7
SP-9A	Semet Ponds	375.6	377.53	369.6 - 359.6	**369.7**										
SP-9B	Semet Ponds	375.3	377.51	351.3 - 341.3	**371.5**										
SP-9C	Semet Ponds	375.5	377.15	333.5 - 323.5	**373.4**										
Tributary 5A	Onondaga Lake	NA	NA	NA	**362.8**								363.0		363.9
Harbor Brook	Harbor Brook	NA	NA	NA	**362.8**								362.9		362.9
Onodaga Lake*	Liverpool, NY	uncorrected	subtract	0.59 ft	**363.4**	364.0	363.5	363.7	362.9	363.6	362.8	363.6	363.6	363.2	363.7
Onodaga Lake	Liverpool, NY	corrected			**362.8**	363.4	362.9	363.1	362.3	363.0	362.2	363.0	363.0	362.6	363.1

Notes:

NA: Not applicable/not available

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