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October 11, 2013

Mr. Gary Priscott
Project Manager
New York State Department of Environmental Conservation
1679 NY Route 11
Kirkwood, NY 13795

Re: Broadway Complex Site, Owego, Tioga County, New York
VCA Index # A7-0407-0001, Site # V00290-7

Dear Mr. Priscott:

Enclosed please find the Remedial Alternatives Report for the Broadway Complex Site located in the Town of Owego, Tioga County, New York. The remedial alternatives evaluation and preparation of this report was completed by Groundwater Sciences, P.C. on behalf of IBM Corporation (IBM). The remedial alternatives evaluation has been completed in response to a New York State Department of Environmental Conservation (NYSDEC) request sent to IBM in a letter dated April 23, 2013.

Should you have any questions, please contact Dean Chartrand of IBM at 703-257-2583.

Very truly yours,

GROUDNWATER SCIENCES, P.C.

Matthew T. Luckman, P.E.
Associate

GROUNDWATER SCIENCES CORPORATION

Robert C. Watson, P.G.
Vice President

Enclosure

cc: Harry Warner, NYSDEC – Syracuse
Julia Kenney, NYSDOH – Albany
Perry Walter, Sanmina-SCI Corporation
Dean Chartrand, IBM Corporation

REMEDIAL ALTERNATIVES REPORT FOR THE BROADWAY COMPLEX SITE

1200 TAYLOR ROAD
OWEGO, TIOGA COUNTY, NEW YORK

Voluntary Cleanup Agreement Index # A7-0407-0001
Site # V00290-7

Prepared for:

IBM Corporation
Manassas, Virginia

October 11, 2013

Prepared by:

Groundwater Sciences, P.C.

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P.E. Certification
Remedial Alternatives Evaluation
Broadway Complex Site, Town of Owego
Tioga County, New York

Voluntary Cleanup Agreement Index #A7-0407-0001
Site #V00290-7

October 11, 2013

I certify that I have reviewed the Remedial Alternatives Report for the Broadway Complex Site in the Town of Owego, Tioga County, New York pursuant to Voluntary Cleanup Agreement Index #A7-0407-0001, Site # V00290-7. This report is dated October 11, 2013 and was prepared by Groundwater Sciences Corporation and Groundwater Sciences, P.C. for IBM Corporation. I certify that I have reviewed all tables, figures, plates, and appendices. To the best of my knowledge, all information contained in this report is complete and accurate.

I certify that all portions of this report have been prepared in accordance with good engineering practices and all work has been performed under my direct supervision.

No alterations to the information contained in this report may be made unless made in accordance with 145-Subsection 7209 of New York State Education Law.

STATE OF NEW YORK
MATTHEW T. LUCKMAN
076619-1
LICENSED PROFESSIONAL ENGINEER

Signature: Matthew Luckman Date: 10/11/2013

Name: Matthew T. Luckman

License No: 076619

State: New York

Table of Contents

Tables

Figures

Plates

Appendices

1 INTRODUCTION

This Remedial Alternatives Report (RAR) has been prepared by Groundwater Sciences, P.C. (GSPC) at the request of the International Business Machines Corporation (IBM) for the former IBM leased property known as the Broadway Complex Site (the "Site") currently owned and operated by Sanmina-SCI and located in the Town of Owego, Tioga County, New York. Tioga County tax map records indicate the Tioga County Industrial Development Agency (IDA) holds a nominal title to the property as part of IDA's Payment-In-Lieu-Of-Taxes (PILOT) program. The Site is subject to a Voluntary Cleanup Agreement (VCA), Index #A7-0407-0001, Site #V00290-7, between IBM and the New York State Department of Environmental Conservation (hereinafter referred to as NYSDEC or the Department).

The Site has been extensively investigated via field explorations and testing performed in 1997 through 1999 and 2008 through 2010. Results of these investigations identified the presence of chlorinated volatile organic compounds (CVOCs) in soil and groundwater that have been attributed, in part, to a former 10,000-gallon septic tank. Specifically, the findings of these field investigations indicated the presence of a small CVOC groundwater plume attributed to the former septic tank that commingles in the area of the former septic tank with a much broader CVOC groundwater plume present across much of the Site that also extends to a greater depth. The results of the supplemental field investigations and testing were summarized in a September 30, 2010 report entitled "*Supplemental Site Investigation Report for the Broadway Complex, 1200 Taylor Road, Owego, Tioga County, New York*" (SSI report) prepared by Groundwater Sciences Corporation (GSC) on behalf of IBM. The SSI report was revised on April 29, 2011 to incorporate comments from NYSDEC and the New York State Department of Health (NYSDOH), collectively referred to hereinafter as the Agencies.

Based on NYSDEC's review of the SSI report and information for the Site and adjacent properties operated by Sanmina-SCI and Lockheed Martin, NYSDEC requested that IBM complete an evaluation of potential remedial alternatives focused on the small portion of the Site with a CVOC groundwater plume attributed to the former septic tank. The CVOCs attributed to the former septic tank include trichloroethene (TCE) and its degradation products cis-1,2-dischloroethene (c12DCE), and vinyl chloride (hereinafter referred to as "TCE-series"). NYSDEC's request was sent to IBM in a letter dated April 23, 2013. The scope of the remedial alternatives evaluation was discussed and agreed upon by NYSDEC and IBM during a project status meeting on May 14, 2013. GSPC performed the evaluation of potential remedial alternatives and prepared this report under a contract for services with IBM. Our work and this report are subject to the limitations provided in Appendix A.

1.1 Purpose and Objectives

This report is intended to summarize the findings and conclusions of an evaluation of remedial alternatives to address the CVOC contamination attributed to the former septic tank at the Broadway Complex Site. The evaluation was performed in accordance with Chapter 4 of NYSDEC *DER-10 Technical Guidance for Site Investigation and Remediation* (NYSDEC, May 2010). In accordance with the VCA, we understand the results of this remedial alternatives evaluation are intended to support the Department's Determination of Need for Remediation and development of an agency decision document.

1.2 Organization of Report

In accordance with Chapter 4.4, subdivision (c) (3) of the NYSDEC DER-10 guidance, the remainder of this report is presented in six additional sections. Section 2 provides a description of the Site and a discussion of relevant history for the Site and the nearby Sanmina-SCI and Lockheed Martin facilities. Section 3 provides a summary of the scope and findings of the SSI, including the findings of the qualitative human health exposure assessment. Section 4 identifies applicable remedial goals and remedial action objectives. Section 5 describes the results of screening of remedial technologies and the development and analysis of remedial alternatives. Section 6 presents the recommended remedy, including the information that supports the remedy selection. References are provided in Section 7.

2 SITE DESCRIPTION AND HISTORY

This section provides a description of pertinent background information including: a description of the Site; a summary of relevant Site history for the former septic tank; and a summary of relevant corrective action history for facilities near the Site.

2.1 Site Description

The Broadway Complex Site is located at 1200 Taylor Road (County Route 606) in the Town of Owego, Tioga County (Tax Map Identifier Number 129.07-1-10). The Site consists of a portion of the property currently occupied by Sanmina-SCI Corporation (formerly Hadco). The Site is used by Sanmina-SCI to manufacture printed circuit boards and related operations. Figure 2-1 shows the location of the Site on a portion of the USGS 7-½ minute Apalachin, NY topographic quadrangle map.

As shown on the Aerial Site Map provided as Figure 2-2, the Broadway Complex Site is bounded on the west and north by other portions of the Sanmina-SCI property, on the east by Broadway Avenue, Barnes Creek, and the Lockheed Martin manufacturing facility, and on the south by wooded undeveloped property. A Site Map showing the Broadway Complex Site, comprised of the Broadway Building and parking lot area, within the larger Sanmina-SCI property is provided as Figure 2-3. As shown on this figure, the Site consists of an approximately 60,000 square foot building (Broadway Building or Former IBM Building 911) with adjacent lawn and asphalt-paved portions of the Sanmina-SCI property to the east and west, and a roughly two-acre parking lot to the south.

2.2 Site History

A description of IBM's historical Site operations and information concerning the discovery and removal of the former septic tank are provided in the following subsections.

2.2.1 IBM Historical Site Use

IBM began leasing the Broadway Complex Site in November 1956 for engineering and manufacturing purposes. From November 1956 to 1987, IBM leased the Site from Owego Enterprises. From 1987 to 1994, IBM leased the Site from Gordon D. and Jean Teeter. IBM ceased leasing the Site in 1994. In 1995, Hadco Corporation purchased the Broadway Complex Site property from the Teeters. In 2000, Sanmina-SCI purchased the property from Hadco Corporation. Tioga County tax map records indicate that in 2003 the Tioga County IDA received a nominal title to the property as part of the Tioga County IDA's PILOT program.

During IBM's occupation, the Broadway Building on the Site was known as Building 911. Available records indicate that activities at this former IBM facility included, but may not have been limited to, the following operations: offices, carpentry shop, model shop, harness assembly and test, carriage assembly and test, card sorter assembly and test, HIMACS assembly and test, photo lab, reprographic area, paint shop, parts cleaning, semi-coating, develop, etch and strip lines, durographic process, Mark 48 testing and Page prep and coat.

2.2.2 Former Septic Tank

During IBM's initial year of occupancy between November 1956 and June 1957, sanitary wastes were reportedly directed to a septic tank located near the southeast corner of the Broadway Building while construction of the nearby Town of Owego wastewater treatment plant was being completed (The connection with the town sewer line reportedly occurred in June 1957). Prior to the connection to the municipal sanitary sewer, IBM shared use of the septic tank with Mutual Design, which owned and occupied a facility to the north. The area of the former Mutual Design building is located within the area of the large Sanmina-SCI building north of the Site. The approximate locations of the former septic tank and the 6-inch sanitary pipeline used by Mutual Design to direct wastes to the septic tank are shown on Figure 2-3.

The former septic tank was discovered by IBM in late 1988 during a shallow excavation associated with installation of a sanitary sewer monitoring station. In April 1989 the tank was uncovered and determined to be constructed of steel with an estimated capacity of 10,000-gallons. Sounding of the tank indicated it contained about 20 inches of dried sludge material. Sampling and analysis of the sludge material in April 1989 indicated the presence of CVOCs in the form of TCE at a concentration of 19,000 micrograms per kilogram (µg/kg) and c12DCE at a concentration of 270 µg/kg.

The former septic tank was removed in May 1989. Groundwater was reportedly observed entering through "pinhole" leaks in the bottom of the tank during removal of the tank contents. A discharge pipe from the tank was identified, but no information was available regarding the potential location of an associated leachfield. The tank and associated bedding material were estimated to extend to a depth of about 12 feet below ground surface (bgs). The soil excavation at the time of the tank removal was estimated to be about 26 feet wide (east-west), 46 feet long (north-south), and about 14 feet deep.

The drummed tank contents (assumed to be sludge mixed with groundwater that entered the tank) and samples of the undisturbed soil beneath and around the tank were collected and submitted to two separate analytical laboratories for volatile organic compounds (VOCs), metals, and other inorganic parameter analyses. Results of the analyses indicated the predominant constituent in the soil samples and tank sludges consisted of TCE and its transformation products, total 1,2-dichloroethene and vinyl chloride. Other VOCs detected in one or more samples were 1,1,1-trichloroethane (TCA), tetrachloroethene (PCE), methylene chloride, and toluene.

2.3 Off-Site Corrective Action

Off-Site corrective action or remedial measures in the form of groundwater extraction and treatment are currently being implemented at the Sanmina-SCI property (former Robintech/Compudyne, Inc. site) at locations north, west, and southwest of the Broadway Complex Site and at the Lockheed Martin facility (former IBM Owego facility) at locations east and southeast of the Site. Brief overviews of investigations and ongoing corrective action or remedial measures for these two neighboring off-Site facilities are provided in the following subsections.

2.3.1 Former Robintech/Compudyne Site

The former Robintech/Compudyne site includes off-Site portions of the Sanmina-SCI property to the north, west, and southwest. In 1956, this property was initially developed and owned by the

Owego Development Company or Owego Enterprises. Between 1956 and 1970 the property was leased to Mutual Design. Between 1970 and 1979 the property was owned and operated by Robintech Inc. which expanded the developed portion of the property in 1975 and 1977. In 1979, the property was sold to Hadco Corporation which owned and operated the facility until its sale to Sanmina-SCI in 2000.

The presence of TCE, TCA, and their transformation products in soil and groundwater beneath a portion of the Site has been attributed to an upgradient source or sources located beneath the portion of the building complex north of the Site. Potential source areas for these CVOCs believed to be associated with former operations by Mutual Design and/or Robintech, Inc. include a former chemical storage area, a former leach field area, and a former wastewater treatment facility. The approximate locations of these potential sources are shown on Figure 2-3.

A Remedial Investigation (RI) and a Feasibility Study (FS) were completed by Blasland, Bouck & Lee (BBL) on behalf of Hadco Corporation between 1991 and 1994. The RI was conducted in two phases and included soil and groundwater investigations focused on the potential CVOC source areas currently beneath the main Sanmina-SCI manufacturing building and groundwater plume areas located to the southwest. Overall, the results of the RI suggest the former chemical storage area is the primary source for the CVOCs. Sampling and analysis of soil for VOCs in the area of the former chemical storage area identified the presence of TCE, TCA, methylene chloride, 1,1-dichloroethene (11DCE), PCE, toluene, and total xylenes.

The principal VOCs detected in groundwater near the former chemical storage area include TCE, TCA, and DCE and several aromatic hydrocarbons, including toluene, ethylbenzene, and xylenes. Groundwater monitoring in the area of the former chemical storage area at the time of the RI detected the presence of TCE at concentrations up to nearly 50 percent of its solubility suggesting the presence of TCE as a separate phase liquid, in which form it is typically referred to as a dense non-aqueous phase liquid (DNAPL). The ratio between TCE and its degradation products to TCA and its degradation products for historical groundwater samples collected in the former chemical storage area is generally on the order of 10 to 1.

On the basis of the FS, the selected remedy consisted of groundwater recovery, on-site groundwater treatment, and discharge to the Town of Owego Publicly-Owned Treatment Works (POTW). In

March 1995, NYSDEC issued a Record of Decision (ROD) describing the selected remedy for the former Robintech/Compudyne site. Corrective measures specified in the ROD are shown on Figure 2-4 and included:

- An iterative groundwater extraction scenario near the former chemical source area with groundwater recovery from shallow recovery well RW-4 followed by subsequent groundwater recovery from deep overburden extraction well RW-5;
- Groundwater extraction from downgradient deep overburden recovery well RW-3; and
- Groundwater extraction from deep overburden/bedrock interface recovery well RW-6 located along the southern property line.

As shown on Figure 2-4, well RW-3 is located about 300 feet west of the former septic tank and well RW-6 is located about 800 feet southwest of the former septic tank. Groundwater recovery operations at recovery well location RW-3 began as an interim remedial measure in October 1993. Groundwater recovery operations at well locations RW-4 and RW-6 began in April 1997. In 1998, the combined groundwater recovery rate of these three wells was estimated to be about 33 gallons per minute (gpm). As of October 2006, the combined recovery rate for these three wells was reported to be about 21 to 26 gpm.

A sub-slab depressurization system for the Broadway Building was designed and installed by Environmental Resources Management (ERM) in 2005. The sub-slab depressurization system is reportedly operated and maintained by Sanmina-SCI and includes one depressurization point (sub-slab vapor extraction point) near the southeast corner of the building and two depressurization points near the north side of the building (ERM, March 2006).

2.3.2 Former IBM Owego Facility

The Lockheed Martin manufacturing facility east of the Site was initially developed by IBM as a manufacturing facility in the 1950s. In 1978, IBM began a voluntary investigation and cleanup program to assess the groundwater quality underlying the property. Various investigations were subsequently completed, including identification of Solid Waste Management Units (SWMUs) and assessments of groundwater, surface water, soil, and indoor air. Corrective action requirements were addressed by IBM under a 6 NYCRR Part 373 Hazardous Waste Management Permit (Part 373 permit).

In March 2010, the Part 373 permit was renewed (NYSDEC Permit No. 7-4930-00095/00005). As indicated in the current Part 373 permit, the approved final remedy for corrective action at the facility consists of hydraulic containment, collection, and treatment of contaminated groundwater and a semi-annual groundwater monitoring program to evaluate the effectiveness of the corrective action remedy. Groundwater recovery operations at the former IBM Owego facility that are closest to the Site include operation of groundwater extraction wells 404 and 405 (Figure 2-4). These two groundwater extraction wells each have two separate screen intervals within the till/bedrock interface and overburden comprised of ice-contact deposits or outwash. The combined groundwater extraction rate for wells 404 and 405 typically ranges between about 150 and 250 gpm. As shown on Figure 2-4, extraction wells 405 and 404 are located about 1,000 feet and 1,500 feet southeast of the former septic tank location, respectively.

3 SUMMARY OF SITE INVESTIGATIONS AND QHHEA

This section provides an overview of the scope and a summary of the findings of Site investigation activities and the findings of the qualitative human health exposure assessment (QHHEA).

3.1 Scope of Site Investigations

Several Site investigations were completed between 1997 and 1999 and between 2008 and 2010. The investigations were conducted in an iterative manner whereby the results of initial field activities were used to refine/develop the scope of subsequent field activities. Specific investigation activities included:

- Multiple phases of subsurface utility review activities.
- A soil reconnaissance survey consisting of thirty-six soil sampling probes.
- Two soil borings near the southeastern corner of the Broadway Building in the area of a six-inch sanitary sewer line that was connected to the former septic tank.
- Five soil borings with monitoring well installations (911-1 through 911-5) that were located on the basis of the soil reconnaissance survey.
- Forty-seven direct-push Membrane Interface Probes (MIPs) to screen for the presence of VOCs above and below the water table.
- Nine groundwater sampling probes and three soil sampling probes to supplement the screening-level data from the MIPs.
- Twenty-two soil borings with twenty monitoring well installations (911-6 through 911-25) located on the basis of the MIPs and supplemental sampling probe data. The two soil borings that did not have monitoring well installations were designated 911-4A and 911-5A.
- Location and elevation surveys of the above-listed field explorations.
- Development and hydraulic testing of newly installed monitoring wells.

- Measurement of surface water levels in Barnes Creek and groundwater levels in on-Site and accessible off-Site monitoring wells.

- Collection and analysis of soil samples for VOCs, semi-volatile organic compounds (SVOCs), and metals.

- Collection and analysis of groundwater samples for VOCs, SVOCs, metals, inorganic and transformation indicator parameters, and microbial populations. The scope of the groundwater monitoring included collection of groundwater samples from Site monitoring wells 911-1 through 911-25, an existing Site monitoring well designated BMW-1, and three Former IBM Owego facility monitoring wells.

Details regarding the scope and methods of these above-listed investigation activities are provided in the April 29, 2011 SSI report. Locations of Site monitoring wells and soil borings 911-4A and 911-5A are shown on the exploration location maps provided on Figure 3-1. The maps on Figure 3-1 subdivide shallow monitoring wells with screened intervals that span the water table from monitoring wells with deeper screened intervals. On-Site and off-Site groundwater monitoring wells that were sampled as part of the SSI are highlighted on Figure 3-2.

3.2 Physical Data Analysis and Interpretation

This section summarizes the analysis and interpretation of physical data concerning Site geology and hydrogeology described in the SSI report.

3.2.1 Site Geology

The soil profile at the Site consists of a downward sequence of soil fill, a complex assemblage of interbedded fine- and coarse-textured sediments, and glacial till. The interbedded sequence of fine- and coarse-textured sediments includes silt & clay, fine sand & silt, and sand or sand & gravel soils. This Site stratum is believed to consist of alluvium deposited by post-glacial and late-glacial streams and erosion of glacial sediments on the valley wall north of the Site. The lower portion of the fine- and coarse-textured sediments generally consists of sand or sand & gravel suggesting the lower portion of these interbedded sediments may consist of coarse textured alluvium or “kame” ice-contact sand and gravel deposited between glacial ice and the northern wall of the Susquehanna

River Valley. Two geologic cross-sections prepared without vertical exaggeration that extend through the area of the former septic tank are depicted on Plate 3-1. Cross-Section A-A' is oriented northeast to southwest, parallel to the general direction of groundwater flow in shallow alluvium, while Cross-Section B-B' is oriented west to east, roughly perpendicular to the direction of groundwater flow. Descriptions of the characteristics and extent of the soil fill, alluvium, and glacial till strata are provided in the following subsections.

3.2.1.1 Soil Fill

Soil fill is present throughout the area of the Site. The thickness of soil fill encountered beneath the Site outside the area of the former septic tank excavation typically ranges from about 2 to 6 feet. As shown on the two cross-sections, the thickness of soil fill encountered in the area of the former septic tank is about 14 feet. In general, the soil fill consists of brown to grayish brown, very loose to medium dense, sand and gravel with lesser amounts of silt, and trace clay. Much of this Site stratum is believed to consist of reworked alluvium or glacial till soils.

3.2.1.2 Post-Glacial and Late-Glacial Alluvium

Soils inferred to consist of alluvium have been encountered beneath soil fill throughout the area of the Site. The total thickness of alluvium encountered is typically about 40 feet, ranging from about 26 feet beneath the former septic tank (911-12) to greater than 56 feet near the loading dock for the Broadway Building (911-25). These soils can be subdivided into the following three general soil types:

- Medium to very stiff, brown to gray, silty clay, silt & clay, or clayey silt with or without trace fine sand;
- Loose to medium dense, brown to gray, fine sand & silt, trace clay;
- Medium dense to very dense, brown to brownish-gray, poorly to well-sorted sand or sand & gravel with little to trace amounts of silt & clay.

Contacts between the silt & clay and fine sand & silt, and sand or sand and gravel soils were commonly gradational. As shown on the two cross-sections on Plate 3-1, the alluvium encountered directly beneath the soil backfill of the former tank excavation consists of about ten feet of silt and clay. Based on other nearby soil borings these fine-grained sediments beneath the former septic tank are inferred to thin to the north and pinch out to the east, west, and south. Similar fine-grained silt and clay soils interbedded with fine sand and silt and lesser sand or sand and gravel were also encountered in the upper twenty feet of alluvium west of the former septic tank. Coarser sand and sand & gravel alluvial soils were generally encountered east of the former septic tank location and in the lower portion of the alluvial soils south and west of the former septic tank.

Nine samples of alluvium collected in the area of the former septic tank were analyzed for total organic carbon (TOC) and converted to fraction of organic carbon (foc) values. Overall, the foc values for five samples of shallow alluvium and four samples of deep alluvium ranged from 0.04 to 0.179 percent, with a mean value of 0.078 percent. The average foc value for the shallow alluvium was 0.098 percent, about twice the deep alluvium average of 0.054 percent. Five samples of alluvium collected in the area of the former septic tank were analyzed for permanganate natural oxidant demand (PNOD). The PNOD results range from 3.1 to 9.2 grams per kilogram (g/kg), with an average value of 4.8 g/kg. On the basis of the PNOD results, the natural oxidant demand of the alluvial soils is ranked as being “low.” According to Carus Corporation a “low” ranking is applied to values less than 10 g/kg.

3.2.1.3 Glacial Till

Glacial till soils were encountered in five of the SSI soil borings. The glacial till stratum encountered at the Site consists of a very dense, brown to gray, poorly-sorted heterogeneous mixture of gravel, sand, silt, and clay. The contact between the bottom of the alluvium and top of the glacial till was relatively abrupt based on an increase in soil density and percentage of silt and clay. The depth to the top of glacial till ranged from 39 to 49 feet bgs, corresponding to elevations ranging from about 789 feet above mean sea level (amsl) east of the former septic tank, to 798 feet amsl beneath the former septic tank. Soil boring 911-25 terminated at a depth of 53 feet bgs without encountering glacial till suggesting the till surface elevation is less than 775 feet amsl near the rear southern entrance to the Broadway Building. The glacial till surface elevations are included in the physical data summary table provided in Appendix B.1.

Regionally, the glacial till encountered by off-Site investigations on the Sanmina-SCI property and Lockheed Martin property indicate the surface of glacial till generally slopes from northeast to southwest towards the center of the Susquehanna River valley. As depicted on Figure 3-3, the surface of glacial till beneath the area of the former septic tank generally forms a broad southwesterly plunging ridge with side slopes that dip to the west and to the southeast. The general southwesterly plunge of the glacial till ridge is shown on Cross-Section A-A' (Plate 3-1). The general slope of the till surface on the eastern and western flanks of this localized ridge in the till surface is depicted on Cross-Section B-B' (Plate 3-1).

3.2.2 Site Hydrogeology

An overview of the Site-specific hydrogeology of the alluvium, which is the principal water-transmitting unit in the area of the former septic tank, is provided in the following subsections.

3.2.2.1 Groundwater Levels and Flow Directions

Groundwater and surface water level elevation data collected as part of the SSI are provided in Appendix B.2. March 22, 2010 groundwater level elevation contour maps for wells that screen shallow and deep alluvium are depicted on Figure 3-4. The "Shallow Wells – Alluvium" contour map is based on wells that screen across the water table while the "Deep Wells – Alluvium" depicts potentiometric level contours for wells that screen alluvium between elevations of about 790 to 810 feet amsl. The relative vertical positions of these screened intervals can be seen in the cross sections on Plate 3-1. The water level contour map for the Site shallow wells indicates groundwater flow directions near the water table are generally from the northeast to southwest, from beneath the area of the Broadway Building and former septic tank towards the parking lot south of the Broadway Building.

A comparison of the water table elevations with surface water elevations at the three staff gauge locations suggests a slight groundwater mound in the area of Barnes Creek that is believed to be due to surface water exfiltration from Barnes Creek. The slight mound in surface water elevations as compared to water table elevations is also depicted on the two cross-sections on Plate 3-1. A similar pattern of mounding for this segment of Barnes Creek was observed in September and October 2009.

The potentiometric surface elevation contour map for the deep alluvium wells suggests the groundwater flow direction in the lower portion of the alluvium is southerly rather than southwesterly with less apparent hydraulic effects due to exfiltration from Barnes Creek (Figure 3-4). This southerly direction of groundwater flow in the deeper overburden at the Site is consistent with the overall area wide pattern of potentiometric elevations and apparent groundwater flow directions inferred from water level monitoring of deep overburden and bedrock monitoring wells at the Lockheed Martin property located east of the Site. Groundwater elevation contour maps depicting results of first and second quarter 2010 monitoring at the Lockheed Martin property (former IBM Owego facility)[1] are provided in Appendix D as Figures 3 and 4. A comparison with the March 22, 2010 groundwater elevation contour maps depicted on Figure 3-4 with the groundwater elevation contours maps in Appendix D (data recorded on April 2, 2010) suggests a portion of the off-Site groundwater flow extends in a southerly and southeasterly direction towards IBM groundwater extraction wells 405 and 404. In aggregate, the potentiometric elevation data for the Site and the western portion of the Lockheed Martin property suggests that exfiltration from Barnes Creek only influences shallow groundwater flow directions but does not limit groundwater flow at depth beneath the Site from extending off-Site beneath the creek in a southeasterly direction.

3.2.2.2 Hydraulic Properties

Hydraulic conductivity values estimated based on slug tests performed in Site monitoring wells are summarized in Appendix B.3. Results of the slug tests for wells that screen the shallow portion of the alluvium yield hydraulic conductivity estimates ranging from 2 to 79 feet per day (ft/day) with a median value of 7.7 ft/day. Results of the slug tests for wells that screen the deep portion are similar, with hydraulic conductivity estimates ranging from 1.8 to 27 feet per day (ft/day) and a median value of 8.2 ft/day. Overall, the median hydraulic conductivity estimated based on slug tests of all twenty-five wells is 7.7 ft/day or 2.7×10^{-3} centimeters per second (cm/sec). Applying a range in saturated thickness of the alluvium of 30 to 60 feet yields a range of **transmissivity** values of about 230 to 460 ft^2/day. Transmissivity values in the area of the investigation are inferred to be

[1] Groundwater Sciences Corporation, August 30, 2010, 2010 Semiannual Data Report, Groundwater Monitoring Program, Former IBM Facility, Owego, New York, prepared for IBM Corporate Environmental Affairs.

lowest in the area of the glacial till ridge underlying the former septic tank with higher transmissivity values both east and west of the former tank area. **Porosity** is expected to vary based primarily upon fines content and density. Based upon experience with similar geologic material, and a review of published data, GSC estimates the porosity of the alluvium to be on the order of 0.3.

3.2.2.3 Hydraulic Gradients and Seepage Velocities

Based on water level elevation data and contours depicted on Figure 3-4, lateral hydraulic gradients in the alluvium were calculated to range from about 0.02 to 0.04 feet per foot (ft/ft), while vertical hydraulic gradients in the area of the former septic tank are typically upward. Using measured values of hydraulic conductivity (median value of 7.7 ft/day), inferred hydraulic gradients and porosity typical for alluvial soils, the horizontal seepage velocity in the alluvium is estimated to be 0.5 to 1 ft/day.

3.3 Nature and Extent of Contamination

An overview of the findings of the SSI regarding the nature and extent of soil and groundwater contamination is provided in the following subsections.

3.3.1 Soil Chemistry

Overall, the results of the soil quality sampling indicate the constituents of potential concern in the area of the former septic tank consist of VOCs in the form of TCE and to a lesser extent c12DCE. In aggregate, the VOC quality data collected as part of the SSI along with MIP ECD data and VOC soil data collected in April 2008 indicate the remaining VOC presence in soil in the area of the former septic tank consists of fairly discrete and localized residual CVOC mass diffused into and sorbed onto alluvial soils at depths ranging from slightly below the water table (14 ft bgs) to near the top of glacial till (about 40 ft bgs). Results of soil sample analyses for VOCs are summarized in Appendix C.1.

3.3.2 Groundwater Chemistry

Groundwater monitoring completed as part of the SSI included three rounds of sampling and analysis for VOCs and one round of sampling and analysis for SVOCs, metals, inorganic and transformation indicator parameters and microbial populations. A summary of the SSI findings regarding groundwater geochemistry that are relevant to development and screening of potential remedial alternatives is provided in the following subsections.

3.3.2.1 Volatile Organic Compounds

Results of groundwater sampling and analysis for VOCs performed as part of the SSI are summarized in Appendix C.2. As described in the SSI report, the constituents of potential concern in Site groundwater consist of VOCs, including TCE and its degradation products (TCE-series), and to a lesser extent TCA and its degradation products, 1,1-dichloroethene and 1,1-dichloroethane (hereinafter referred to as TCA-series). In order to account for the apparent variable degree of degradation across the Site, the TCE and TCA concentrations have been "normalized" to their respective series concentrations to account for their degradation products. These TCE-series and TCA-series concentrations are included in the table in Appendix C.2. TCE-series isoconcentration contour maps for shallow and deep alluvium based on March 2010 sampling results are provided as Figure 3-5. TCA-series isoconcentration contour maps for shallow and deep alluvium based on March 2010 sampling results are provided as Figure 3-6. The March 2010 TCE-series and TCA-series concentrations are also posted on the two cross-sections depicted on Plate 3-2. In aggregate, the lateral and vertical distribution of CVOCs in groundwater indicates the presence of a narrow TCE-series groundwater plume in the area of the former septic tank, superimposed on a wider and deeper combined TCE-series and TCA-series groundwater plume centered on the area of the rear southern entrance to the Broadway Building.

The north-south orientation of the long axis and declining concentrations in a southerly direction of the TCE-series and TCA-series plumes in the deeper overburden at the Site is consistent with the overall area wide pattern of TCE-series and TCA-series concentrations. This pattern is also consistent with the apparent plume migration pathways inferred from groundwater sampling of deep overburden and bedrock monitoring wells at the Lockheed Martin property located east of the Site. TCE-series and TCA-series isoconcentration contour maps based on results of first and second quarter 2010 monitoring at the Lockheed Martin property are provided in Appendix D as Figures 5 through 8. A comparison with the isoconcentration contour maps depicted on Figures 3-5 and 3-6 with the isoconcentration contour maps in Appendix D suggests a portion of the off-Site groundwater flow extends in a southerly and southeasterly direction towards IBM groundwater extraction wells 405 and 404. In aggregate, the TCE-series and TCA-series concentration data for the Site and the western portion of the Lockheed Martin property suggests that exfiltration from Barnes Creeks only influences shallow groundwater chemistry but does not limit the TCE-series and TCA-series plumes at depth from extending beneath the creek in a southeasterly direction.

An analysis of molar ratios between the TCE-series and TCA-series constituents completed as part of the SSI resulted in the following conclusions:

- As shown on Figure 3-7 and Plate 3-2, the high ratio of TCE-series/TCA-series in shallow groundwater near the septic tank and the rapid decline of that ratio with distance from the septic tank confirm that two plumes, a large plume from the sources being remediated by Sanmina-SCI and a much smaller plume from the septic tank release, commingle within a small footprint close to the former septic tank beyond which the effects of releases from the septic tank cannot be discerned from the overall impact of releases unassociated with historical use of the septic tank.

- The impact of releases from the septic tank are even less pronounced in the deeper alluvium as shown by the vertical attenuation of higher TCE-series/TCA-series ratios on Plate 2 and the limited increase in this ratio in deeper monitoring wells shown on Figure 3-7;

- The small TCE plume that originates from the former septic tank area is a *de minimus* contributor to the overall CVOC flux in groundwater that extends off-Site; and

- The larger plume has a similar CVOC signature to groundwater north of the Site near a former chemical storage area operated historically by Robintech, Inc. and currently being remediated by Sanmina-SCI.

Results of historical and/or recent groundwater elevation monitoring suggest the CVOC plume that extends off-Site is contained by IBM off-Site extraction wells 405 and 404 on the Lockheed Martin property, and possibly off-Site extraction well RW-6 on the Sanmina-SCI property. A review of groundwater elevation and VOC concentration data collected over a period of about fifteen years indicates the CVOC plume that extends off-Site is stable without evidence of a significant increasing or decreasing trend.

3.3.2.2 Inorganic and Transformation Indicator Parameters

Results of analysis and field screening of March 2010 groundwater samples for inorganic and transformation indicator parameters are tabulated in Appendix C.3. In aggregate, the major cations and anions identified in Site groundwater are indicative of general groundwater quality conditions possibly reflecting impacts from road deicing salts and regional use of fertilizers with an abundance of sodium, chloride, calcium, alkalinity (bicarbonate), and nitrate and sulfate. The overall lateral and vertical nature and extent of these major cations and anions, and field screening parameters such as temperature, dissolved oxygen, and pH are indicative of dilution due to exfiltration from Barnes Creek.

The water quality data does not suggest significant biodegradation is occurring in the area of the former septic tank or other portions of the Site. In general, degradation of TCE and TCA by reductive dechlorination initially requires consumption of oxygen, denitrification of nitrate, and consumption of iron before sulfate reducing bacteria become prevalent and anaerobic conditions develop allowing CVOC reductive dechlorination. Although the presence of TCE and TCA degradation products suggests some isolated reductive dechlorination has occurred at least in areas upgradient of the parking lot located south of the Broadway Building (such as beneath the Broadway Building), the overall aerobic groundwater quality conditions and elevated nitrate would generally inhibit growth of CVOC degrading bacteria. Specific findings of the SSI that indicate biodegradation by reductive dechlorination is limited in the area of the former septic tank include the following:

- Dissolved oxygen concentrations greater than 1 mg/L for shallow monitoring wells throughout the area of the former septic tank and for some of the deep monitoring wells (See Figure 3-8).

- Nitrate concentrations greater than 1 mg/L for all of the wells sampled (See Figure 3-9).

- Sulfate concentrations greater than 50 µg/L in deep alluvium monitoring wells in the area of the former septic tank (See Figure 3-10).

- Dissolved methane concentrations only in a few shallow and deep alluvium wells that suggest reductive dechlorination is occurring only:

    - Upgradient of the Broadway building parking lot beneath the Broadway Building or in locations further to the north, and

    - In isolated finer-textured zones within shallow and deep alluvium where localized anaerobic conditions exist that have not been eliminated by the flow of oxygenated groundwater from Barnes Creek.

3.3.2.3 Microbial Analyses

Groundwater samples were collected from nine monitoring wells to assess the presence of dechlorinating bacteria as an initial screening of enhanced biodegradation as a remedial alternative. The groundwater samples were analyzed for populations (census) of *dehalococcoides spp* (chlorinated ethene dechlorinating bacteria), populations of *dehalobacter spp* (chlorinated ethane dechlorinating bacteria), and *dehalococcoides spp* functional genes (strains known to degrade certain TCE-series compounds). Results of the microbial analyses are tabulated in Appendix C.4.

In general, populations of dechlorinating bacteria around 10,000 cells per milliliter (cell/ml) or greater are thought to represent conditions of efficient reductive dechlorination. The populations of *dehalococcoides spp* and *dehalobacter spp* detected in the nine groundwater samples suggest reductive dechlorination of TCE-series compounds and TCA-series compounds is severely to moderately limited in the area of the former septic tank. The data suggest some dechlorinating bacteria may be present in fine-textured, oxygen reduced zones within the alluvium but the presence of oxygen-rich groundwater due to exfiltration from Barnes Creek has limited the development of greater populations of the CVOC reducing bacteria.

3.4 Fate and Transport Mechanisms

Contaminants of potential concern identified at the Site include TCE, TCA, and their related breakdown products c12DCE, vinyl chloride, 1,1-DCA, and 1,1-DCE. As separate phase liquids, these contaminants are considered to be dense non-aqueous phase liquids (DNAPLs), meaning that they are only slightly soluble in water, and, if present in sufficient quantities, may sink through the water column due to a higher specific gravity than water. Once dissolved in groundwater, these substances will migrate with flowing groundwater by the process of advection at a velocity equal to or less than the velocity of groundwater, depending on the effect of processes that may retard their movement. An analysis of fate and transport mechanisms indicates aqueous diffusion, sorption, and sorption-retarded intragranular aqueous diffusion are likely to be the primary groundwater plume attenuation mechanisms at the Site. These mechanisms are reversible and, as such, will tend to slow the rate that groundwater concentrations will decline over time in response to remediation and limit the effectiveness of some remedial technologies. A detailed discussion of these mechanisms along with a conceptual model of the possible sequence of events and fate and transport mechanisms associated with the release of CVOCs from the former septic tank is provided in the SSI report.

3.5 Qualitative Human Health Exposure Assessment (QHHEA)

A Qualitative Human Health Exposure Assessment for the former septic tank area was completed as part of the SSI. The former septic tank area includes asphalt-paved parking and roadway areas and a small grassed area between the parking lot and Broadway Avenue. The wider and deeper CVOC plume identified at the Site was not the subject of the QHHEA since it relates to a source or sources located outside of the former septic tank area.

The purpose of the QHHEA was to characterize potential public health and environmental exposures due to contamination in the area of the former septic tank. The assessment was performed in consideration of the available information regarding the chemical character of soil, aqueous, and vapor media and our understanding of human activity at and near the former septic tank. IBM does not own the property or operate the manufacturing facility located at the Site and therefore does not have control over current and future Site operations and uses. However, based on IBM's understanding of Sanmina-SCI operations an attempt was made to evaluate possible human activity in the area of the former septic tank.

The QHHEA included a review of the following five elements:

- **Contaminant Source:** The constituents of potential concern consist of CVOCs, including TCE and to a lesser extent its degradation product c12DCE. Other CVOCs identified in the area of the former septic tank that are believed to be sourced from areas upgradient of the former septic tank area include PCE, TCA, and TCA degradation products 11DCE and 11DCA. In aggregate, the results of multi-phased Site investigations indicate the mass of these constituents are present in soil and groundwater at depths of 14 feet or greater below the ground surface.

- **Potential Contaminant Release and Transport Mechanisms:** Potential contaminant release and transport mechanisms include partitioning from soil to groundwater or soil pore water, groundwater plume migration, and volatilization from the water table to the vadose zone.

- **Potential Point of Exposure:** Given the exterior location of the former septic tank area on the Site the potential exposure points include contact with soil, groundwater, and/or CVOC vapors associated with construction-related human activities such as groundwater extraction (dewatering) and deep (greater than 14 feet) soil excavation.

- **Potential Route of Exposure:** Potential routes of exposure include ingestion of soil and groundwater, dermal contact with soil and groundwater, and inhalation of vapors volatilized from contaminated soil and groundwater.

- **Potential Receptor Population:** Potential human receptors in the area of the former septic tank are limited to on-Site construction workers.

Overall, the only potentially complete exposure pathway identified in the area of the former septic tank based on IBM's understanding of Site conditions consists of contact with soil and groundwater by on-Site construction workers during deep (greater than 14 feet bgs) excavation activities. A summary table that provides an overview of the current and potential exposures for the area of the former septic tank and associated groundwater plume is provided below.

Environmental Media & Exposure Route	Human Exposure Assessment
Direct Contact with Surface Soils (and incidental ingestion)	• Incomplete exposure pathway as CVOC presence is not located at the ground surface.
Direct Contact with Subsurface Soils (and incidental ingestion)	• On-Site construction workers could come into contact with subsurface soils if work involves deep (greater than 14 feet bgs) soil excavation.
Direct Contact with Groundwater	• On-Site construction workers could come into contact with groundwater if work involves dewatering as part of deep (greater than 14 feet bgs) soil excavation.
Ingestion of Groundwater	• Incidental ingestion of groundwater by on-Site construction workers in deep excavations would be a complete exposure pathway. • Contaminated groundwater is not being used for drinking water, as the area is served by a public water supply. • There are no known domestic water supply wells in the area of the former septic tank and associated plume.
Inhalation of Vapors	• Exposure to vapors volatilized from soil and/or groundwater in deep excavations would be a complete pathway for on-Site construction workers. • Soil vapor intrusion into occupied structures is not a complete pathway since there are no structures overlying the former septic tank and associated plume. • Exfiltration of Barnes Creek likely would limit the potential for soil vapor intrusion if a structure was constructed in the former septic tank area in the future.

4 REMEDIAL GOALS AND REMEDIAL ACTION OBJECTIVES

In accordance with former Voluntary Cleanup Program (VCP) guidance (NYSDEC, 2002), the "goal of the remedy selection process in the VCP is to remediate the site to a level that is protective of public health and the environment under the conditions of the site's Contemplated Use." The VCA between IBM and NYSDEC defines the "Contemplated Use" for the Site as "Restricted Residential", which allows residential uses such as homes, apartments, mobile home parks, dormitories, schools, and day-care facilities but engineering and/or institutional controls are required for the use to be protective. For the purposes of this remedial alternatives analysis the contemplated use is "Restricted Residential," even though the Site property and surrounding properties are currently mapped by the Town of Owego as being within an "Industrial Zoning District" rather than a residential zoning district.

According to Chapter 4 of NYSDEC DER-10 guidance, remedial goals are statutory or regulatory remedial action goals for remedial actions undertaken pursuant to applicable NYSDEC programs, including the VCP. Remedial action objections (RAOs) are media-specific goals developed for the protection of public health and the environment based on contaminant-specific Standards, Criteria and Guidelines (SCGs) to address contamination identified at a site. Based on the results of the SSI, the SCGs and RAOs pertain to saturated soil and groundwater in the area of the former septic tank associated with the small TCE-series groundwater plume that commingles with a much broader and deeper TCE-series and TCA-series groundwater plume present across much of the Site (as defined by the shaded areas on Plate 3-2).

4.1 Identification of Standards, Criteria and Guidelines

SCGs are defined in New York State and federal environmental laws, regulations and guidance. Standards and criteria are requirements that are promulgated under New York State or federal law, while guidelines are non-promulgated criteria or guidance that are not legally binding, but should, as appropriate, be considered in the development of the remedial approach. SCGs are generally divided into three categories: chemical-specific, location-specific, and action-specific. Chemical-specific SCGs provide guidance on acceptable or permissible contaminant concentrations in soil, air, and water. Location-specific SCGs govern activities in critical environments such as floodplains, wetlands, endangered species habitats, or historically significant areas. No location-specific SCGs have been determined to be applicable to the implementation of alternatives evaluated in this report. Action-specific SCGs are technology- or activity-based requirements. SCGs in the chemical and action specific categories that may apply to the evaluation of remedial alternatives at the Broadway Complex Site have been identified in the two following subsections.

4.1.1 Chemical Specific SCGs

This subsection lists the chemical-specific SCGs that apply to the evaluation of the alternatives described in this report. Results of the SSI determined the constituents of potential concern associated with the former septic tank are limited to TCE and its related breakdown products c12DCE and vinyl chloride. Although a portion of the TCE-series compounds in the area of the former septic tank appear to be sourced from off-Site areas to the north, the evaluation of remedial alternatives will include review of technologies that may address the presence of these three TCE-series constituents, regardless of their source.

Sampling of vadose zone and saturated zone soils in the area of the former septic tank did not identify TCE-series concentrations above Part 375-6.8(b) Restricted Use Soil Cleanup Objectives for sites with a contemplated use of "Restricted Residential." Therefore, the attainment of cleanup goals for soil to protect groundwater will be based on the attainment of groundwater quality standards as listed below, which is a more direct determination of the remedial goal that saturated soil has been remediated to levels that are protective of groundwater.

New York State Drinking Water Standards were promulgated in the New York Code of Rules and Regulations (NYCRR) Title 10 Chapter I (State Sanitary Code) Subpart 5-1. The applicable standard for the former septic tank related COPCs is 5 µg/L for TCE and c12-DCE, and 2 µg/L for vinyl chloride.

New York State Groundwater Standards were promulgated by NYSDEC at 10NYCRR §703.5 and are legally enforceable. The aquifer underlying the site has been designated a Class GA groundwater, which is defined as: "*The best usage of Class GA waters is as source of potable water supply. Class GA waters are fresh groundwaters found in the saturated zone of unconsolidated deposits and consolidated rock or bedrock.*" Therefore, the Class GA groundwater standards for the former septic tank related COPCs are intended to protect human health through the use of the groundwater as a drinking water supply and are equivalent to the drinking water standards of 5 µg/L for TCE and c12-DCE, and 2 µg/L for vinyl chloride.

New York State Water Guidance Values are provided in the Division of Water Technical and Operational Guidance Series (TOGS 1.1.1), which describes ambient groundwater quality standards, guidance values, and groundwater effluent limitations. For the former septic tank related COPCs the groundwater standards listed in TOGS 1.1.1 for Class GA waters are identical to those listed in 10NYCRR §703.5.

4.1.2 Activity Specific SCGs

This subsection provides a list of SCGs that may apply to the evaluation of the remedial alternatives described in this report. To the extent that any of these requirements applies to an action to be taken as part of a particular alternative, an appropriate discussion will be included in the analysis of the alternatives in the event that one or more of these SCGs will not be met.

6 NYCRR Part 257 – Air Quality Standards

Air Guide 1 – Guidelines for the Control of Toxic Ambient Air Contaminants

6 NYCRR Part 371 – Identification and Listing of Hazardous Wastes (November 1998)

6 NYCRR Part 372 - Hazardous Waste Manifest System and Related Standards for Generators,

Transporters and Facilities (November 1998)

6 NYCRR Part 375 – Environmental Remediation Programs (December 2006)

6 NYCRR Part 376 - Land Disposal Restrictions

6 NYCRR Part 750 through 758 - Implementation of NPDES Program in NYS (“SPDES Regulations”)

TAGM 3028 - "Contained-In" Criteria for Environmental Media: Soil Action Levels (August 1997)

TOGS 2.1.2 - Underground Injection/Recirculation (UIR) at Groundwater Remediation Sites

CP-43 - Groundwater Monitoring Well Decommissioning Policy (November 2009)

CP-51 – Soil Cleanup Guidance (October 2010)

NYSDEC Sampling Guidelines and Protocols (March 1991)

DER-10 – Technical Guidance for Site Investigation and Remediation (May 2010)

DER-15 – Presumptive/ Proven Remedial Technologies (February 2007)

DER-31 – Green Remediation (January 2011)

DER-33 – Institutional Controls: A Guide to Drafting and Recording Institutional Controls (December 2010)

29 CFR Part 1910.120 - Hazardous Waste Operations and Emergency Response

40 CFR Part 144 - Underground Injection Control Program

OSWER Directive 9200.4-17 – Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (November 1997)

4.2 Remedial Action Objectives

Based on the SCGs listed above, the following remedial action objectives developed for the protection of public health and the environment will apply to the selection and implementation of a remedial action alternative for the Site.

Public Health

- Prevent ingestion/direct contact of residential human receptors with groundwater having TCE-series concentrations exceeding applicable NYSDOH Drinking Water Standards.

- Prevent ingestion/direct contact/inhalation of soil, groundwater, and vapors containing TCE-series constituents by on-Site construction workers during deep (greater than 14 feet bgs) excavation activities in the area of the former septic tank.

Environmental Protection

- Restore groundwater in the former septic tank area to applicable New York State Groundwater Standards for TCE-series constituents.

5 DEVELOPMENT AND ANALYSIS OF ALTERNATIVES

The purpose of this section is to document the development and screening of remedial alternatives that would address RAOs for the various environmental media in the area of the former septic tank. Tables 5-1 and 5-2 present the results of this process as described in the following three subsections. Consistent with EPA's guidance on performing an RI/FS (USEPA, 1988), the screening of alternatives has been performed on the level of individual technologies since all alternatives that might include a given technology might be screened out on the basis of that technology alone.

5.1 Screening of Remedial Technologies

Remedial technologies were initially screened for proven overall effectiveness at other TCE-series sites and potential application for addressing the limited TCE-series presence in the saturated alluvium in the area of the former septic tank. Results of this preliminary screening step identified the following six remedial technologies for further consideration:

1. No Further Action/Institutional Controls
2. *In-Situ* Chemical Oxidation (ISCO)
3. *In-Situ* Chemical Reduction (ISCR)
4. Enhanced Bioremediation
5. *In-Situ* Thermal Treatment
6. Excavation

Table 5-1 provides a summary of the results of screening of six remedial technologies listed above. As indicated in the table, the technologies were screened relative to their implementability in the former septic tank area of the Site and their apparent short-term and long-term effectiveness. As indicated in the table, all six technologies were determined to be feasible or potentially feasible at the Site. However, based on short-term and/or long-term effectiveness issues three of the technologies were excluded from further consideration as summarized below.

1. Enhanced Bioremediation – Treatment of soil and groundwater by addition of amendments for enhanced biodegradation of CVOCs (TCE-series and TCA-series constituents) by reductive dechlorination.

    a. Limited short-term effectiveness in reduction of TCE-series and TCA-series constituents in hydrogeologic settings with natural oxidizing conditions (water table aquifer). Exfiltration of oxygenated water from Barnes Creek would further limit ability of this technology at and near the water table.

    b. Presence of electron acceptors, such as dissolved oxygen, nitrate, iron, and manganese would limit potential for reductive dechlorination.

    c. Populations of dechlorinating bacteria in groundwater in the area of the former septic tank are severely to moderately limited.

    d. Duration of injection of amendments and long-term effectiveness is uncertain.

2. *In-Situ* Thermal Treatment – *In-Situ* treatment via thermal conductive heating below the water table with multi-phase extraction of groundwater and soil vapor.

    a. Large footprint that would disrupt Site operations.

    b. Dewatering would pull higher concentration TCE-series and TCA-series mass from the northwest and west towards the thermal treatment zone in the former septic tank area.

    c. Need to relocate subsurface utilities that would be damaged during thermal treatment operations would disrupt Site operations.

    d. Heat would likely damage root systems and kill trees in the active remediation area.

3. Excavation – Physical removal of soil to depths of 20 to 30 feet bgs, with sheet piling and dewatering of groundwater. Off-Site disposal of soil to landfill and off-Site treatment of groundwater.

a. Sheet piling installation is close proximity to Broadway Building could damage the building foundation.

b. Large excavation footprint would disrupt Site operations.

c. Dewatering would pull higher concentration CVOC mass from the northwest and west towards the excavation in the former septic tank area.

d. Potential for worker exposure to noise and vapor emissions.

e. Increased truck traffic associated with removal of soil, removal of water, and placement of clean fill.

As indicated on Table 5-1, the three other remedial technologies were retained for development and screening as separate remedial alternatives.

5.2 Development and Analysis of Remedial Alternatives

This section assembles the three remaining technologies into remedial alternatives, evaluates those alternatives with respect to the six criteria in NYSDEC DER-10 section 4.2, and compares the alternatives in accordance with NYSDEC DER-10 subdivision 4.2(b).

5.2.1 Development of Remedial Alternatives

The three possible remedial alternatives that were developed using the three technologies retained for further evaluation include the following:

- **No Further Action/Institutional Controls** – Deed restrictions placed on the Broadway Complex Site property by the property owner that would mitigate potential exposures to TCE-series constituents in soil and groundwater in the area of the former septic tank. IBM does not own the property and therefore does not have control over implementation of this remedial alternative. However, IBM understands that on May 16, 2013, NYSDEC requested that Sanmina-SCI place such deed restrictions on the Broadway Complex Site property and the larger adjacent Sanmina-SCI property to address similar potential exposure pathways to the CVOC presence currently remediated by Sanmina-SCI.

- ***In-Situ* Chemical Oxidation (ISCO) –** Treatment of TCE-series constituents in soil and groundwater by direct injection of chemical oxidants, such as permanganate or peroxide. This alternative would include multiple injections of permanganate or peroxide using a combination of hydraulically-driven injection points and wells. Injection would target the former septic tank area with TCE-series to TCA-series ratios greater than 25 near the water table (shallow alluvium) and greater than 10 in the lower portion of the alluvium (deep alluvium). The chemical oxidants would destroy the TCE-series constituents.

- ***In-Situ* Chemical Reduction (ISCR) -** Treatment of TCE-series constituents in soil and groundwater by direct injection of chemical reducing agents, such as micro-scale Zero Valent Iron (ZVI), within a reducing substrate, such as emulsified oil. This alternative would include multiple injections of ZVI and emulsified oil or another substrate using a combination of hydraulically-driven injection points and wells. Injection would target the former septic tank area with TCE-series to TCA-series ratios greater than 25 near the water table (shallow alluvium) and greater than 10 in the lower portion of the alluvium (deep alluvium). This alternative would transform TCE, c12DCE, and vinyl chloride to ethene.

5.2.2 Detailed Analysis of Remedial Alternatives

Results of a detailed analysis of the three possible remedial alternatives developed for the former septic tank area of the Site are summarized in Table 5-2. The analysis includes screening of each remedial alternative relative to six criteria set forth in NYSDEC DER-10 section 4.2, including:

- Overall Protection of Human Health and the Environment
- Compliance with New York State Standards, Criteria & Guidance
- Short-Term Effectiveness & Impacts
- Long-Term Effectiveness & Permanence
- Reduction of Toxicity, Mobility, or Volume
- Implementability

A discussion of the findings of the detailed analysis of the three possible remedial alternatives relative to the six above-listed screening criteria is provided in the following subsections.

5.2.2.1 No Further Action (NFA) with Institutional Controls

As indicated in Table 5-2, the NFA with Institutional Controls alternative would meet the overall goal of protection of public health and the environment by mitigating potential exposure pathways via the use of deed restrictions on the Site that would be put in place by the property owner.

This alternative screens relatively low in its ability to meet applicable SCGs for groundwater as it does not include active Site remediation activities that could reduce TCE-series concentrations in groundwater in the area of the former septic tank. The timeframe for concentrations for TCE-series constituents to decline to applicable NYS Part 703 groundwater standards is unchanged under this remedial alternative.

The short-term effectiveness of this alternative is high. Implementation of this proposed remedy would result in no short-term risks to the community, workers, and the environment as there would be no active remediation activities and disruption to Site operations. This proposed remedy would achieve the RAOs for protection of public health upon its implementation by mitigating exposure of human receptors to unacceptable levels of COPCs in soil and groundwater.

The long-term effectiveness of this alternative is high as it would effectively mitigate potential exposure pathways to TCE-series presence in soil and groundwater in the area of the former septic tank. The restrictions would remain on the deed for the property in the case of a change in property ownership. This alternative does not reduce the toxicity, mobility, or volume of the TCE-series constituents in the area of the former septic tank.

This alternative is technically and administratively feasible. Use of deed restrictions is a common and effective institutional control for mitigating potential exposure pathways and unacceptable risk to human health and the environment. NYSDEC has requested that Sanmina-SCI place a deed restriction on the Broadway Complex Site property to address the larger and broader on-Site CVOC groundwater plume Sanmina-SCI is currently remediating.

5.2.2.2 *In-Situ* Chemical Oxidation (ISCO)

As indicated in Table 5-2, ISCO screens low in its ability to meet the overall goal of protection of public health and the environment. Implementation of this alternative would be unlikely to eliminate potential exposure pathways to TCE-series constituents in the former septic tank area during construction activities that require excavation beneath the water table and/or Site activities that require management of untreated groundwater.

ISCO screens relatively low in its ability to meet applicable SCGs for groundwater. This alternative would be expected to reduce concentrations of TCE-series constituents in groundwater but it is not expected to achieve the 99% reductions for TCE and greater than 80% reductions in c12DCE necessary to meet applicable NYS Part 703 groundwater standard of 5 µg/L. Application of this technology in similar hydrogeologic settings at other sites suggests short-term reductions could approach 75 to 90% but long-term reductions are commonly much less due to rebound effects as mass partitions back into groundwater from aquifer solids.

The short-term effectiveness of this alternative is considered to be moderate to high. Disruptions to Site operations during installation of injection points, chemical oxidant injections, and groundwater monitoring activities should be minimal as the activities should be short in duration and limited to the former septic tank area of the Site. The work area would be barricaded to control access to the ISCO treatment area. A Site-specific Health and Safety Plan would be in place to protect remediation workers from physical, chemical, and biological hazards during implementation of this alternative. This proposed remedy would be unlikely to achieve the overall RAO within its first two years of implementation. Given the potential for rebound in concentrations of TCE-series constituents, attainment of the RAOs using this alternative could take more than a decade to achieve.

The long-term effectiveness of ISCO to eliminate potential exposure pathways to TCE-series presence in former septic tank area is low given:

1. Potential rebound effects due to diffusion of TCE-series constituents from finer textured alluvial soils; and

2. Recontamination of the TCE-series groundwater plume in the ISCO treatment zone due to a source or sources of CVOCs north of the former septic tank area.

Application of ISCO could initially reduce the mass of TCE-series constituents in the former septic tank area as high as 75 to 90%. However, concentrations of TCE-series constituents would be expected to rebound. The net decline in TCE-series mass is anticipated to be no more than an order of magnitude (about 90%). However, due to the rebound expected from secondary sourcing, that 90% decline in the overall volume of TCE-series compounds in groundwater would be temporary, ultimately resulting in only a slight reduction in the volume of TCE-series constituents present. The reduction in toxicity, mobility, and volume of TCE-series constituents under this alternative is anticipated to be similar to the NFA with Institutional Controls alternative due to recontamination of the ISCO treatment zone due to a source or sources of CVOCs north of the former septic tank area.

This alternative is technically and administratively feasible. Injection of chemical oxidants via hydraulically-driven injection points and wells into alluvial soils in the area of the former septic tank is feasible. Testing of alluvial soils suggests natural oxidant demand is “low” and should not inhibit the implementation of this technology. Potential technical limitations to the implementation of this alternative include difficulties in the ability to deliver chemical oxidants uniformly in the saturated alluvium and difficulties in maintaining concentrations of chemical oxidants at and near the water table due to dilution effects from exfiltration of water from nearby Barnes Creek. There should be no restrictions in obtaining an Underground Injection Control (UIC) program permit to inject the chemical oxidants. Concerns of Site workers would be addressed through the Site’s community participation plan and direct contacts with Site owners and occupants.

5.2.2.3 *In-Situ* Chemical Reduction (ISCR)

As indicated in Table 5-2, ISCR screens low in its ability to meet the overall RAO of protection of public health and the environment. Implementation of this alternative would be unlikely to eliminate potential exposure pathways to TCE-series constituents in the former septic tank area during construction activities that require excavation beneath the water table and/or Site activities that require use of untreated groundwater.

ISCR screens relatively low in its ability to meet applicable SCGs for groundwater. This alternative would be expected to reduce concentrations of TCE-series constituents in groundwater but it is not expected to achieve the 99% reductions for TCE and greater than 80% reductions in c12DCE necessary to meet applicable NYS Part 703 groundwater standard of 5 µg/L. Application of this technology in similar hydrogeologic settings at other sites has been shown to have less rebound potential than ISCO but at this Site the potential rebound would be expected to be similar due to the presence of an upgradient source or sources of TCE.

The short-term effectiveness of this alternative is considered to be moderate to high. Disruptions to Site operations during installation of injection points, chemical reducing agent and oil substrate injections, and groundwater monitoring activities should be minimal as the activities should be short in duration and limited to the former septic tank area of the Site. The work area would be barricaded to control access to the ISCR treatment area. A Site-specific Health and Safety Plan would be in place to protect remediation workers from physical, chemical, and biological hazards during implementation of this alternative. This proposed remedy would be unlikely to achieve the overall RAO within its first two years of implementation. Given the potential for rebound in concentrations of TCE-series constituents, attainment of the RAOs using this alternative could take more than a decade to achieve.

The long-term effectiveness of ISCR to eliminate potential exposure pathways to TCE-series presence in former septic tank area is low given:

1. Difficulties in developing and maintaining reducing conditions;

2. Potential rebound effects due to back diffusion of TCE-series constituents from finer textured alluvial soils, such as silt and clay; and

3. Recontamination of the TCE-series groundwater plume in the ISCR treatment zone due to a source or sources north of the former septic tank area.

Application of ISCR could initially reduce the mass of TCE-series constituents in the former septic tank area as high as 75 to 90%. However, concentrations of TCE-series constituents would be expected to rebound. The net decline in TCE-series mass is anticipated to be no more than an order of magnitude (about 90%). However, due to the rebound expected from secondary sourcing, that 90% decline in the overall volume of TCE-series compounds in groundwater would be temporary, ultimately resulting in only a slight reduction in the volume of TCE-series constituents present. The reduction in toxicity, mobility, and volume of TCE-series constituents under this alternative is anticipated to be similar to the NFA with Institutional Controls alternative due to recontamination of the ISCR treatment zone due to a source or sources of CVOCs north of the former septic tank area.

This alternative is technically and administratively feasible. Injection of chemical reducing agents using an oil substrate via hydraulically-driven injection points and wells into alluvial soils in the area of the former septic tank is feasible. Potential technical limitations to the implementation of this alternative include difficulties in the ability to deliver reducing agents and emulsified oil uniformly in the saturated alluvium and difficulties in maintaining concentrations of chemical reducing agents at and near the water table due to dilution effects from exfiltration of water from nearby Barnes Creek. There should be no restrictions in obtaining a UIC program permit to inject the chemical reducing agents and emulsified oil. Concerns of Site workers would be addressed through the Site's community participation plan and direct contacts with Site owners and occupants.

5.3 Comparative Analysis of Alternatives

Of the three possible remedial alternatives only NFA with Institutional Controls is able to achieve the overall goal for protection of public health and the environment. All three alternatives are believed to be unlikely to achieve New York State SCGs for groundwater in the short-term. However, achieving SCGs for groundwater in the area of the former septic tank is currently impractical due to CVOC mass flux from an upgradient source or sources that would limit the long-term effectiveness of the remedial alternatives.

The short-term effectiveness of the NFA with Institutional Controls alternative is higher relative to ISCO and ISCR because it does not include remedial construction activities that could result in limited disruption of Site operations in the former septic tank area and possible remediation worker exposure to noise and chemicals.

The long-term effectiveness of NFA with institutional controls is rated high as it would effectively mitigate potential exposure pathways to TCE-series constituents while the long-term effectiveness of ISCO and ISCR is rated low given the potential for rebound of TCE-series concentrations in groundwater due to effects of back diffusion of TCE-series constituents from finer textured alluvial soils and continued CVOC mass flux from an upgradient source or sources.

Implementation of the ISCO and ISCR alternatives would be expected to provide some initial reduction in the volume of TCE-series constituents in groundwater, however, the long-term reductions that would occur are anticipated to be similar to the NFA with Institutional Controls alternative due to recontamination of the ISCO or ISCR treatment zones due to a source or sources of CVOCs north of the former septic tank area.

All three alternatives are expected to be technically and administratively feasible. Although groundwater and soil conditions in the area of the former septic tank generally favor chemical oxidation over chemical reduction as a potential remedial alternative.

6 RECOMMENDED REMEDY

The purpose of this section is to identify the recommended remedial alternative, provide the justification for that selection and present the proposed institutional controls associated with the selected remedy.

6.1 Identification and Justification of Selected Remedy

Based on the detailed and comparative analyses of remedial alternatives presented in the preceding section, No Further Action (NFA) with Institutional Controls has been selected as the recommended remedy. The justification for this selection is as follows:

1. NFA with Institutional Controls is the only alternative that would meet the RAO of preventing ingestion/direct contact of residential human receptors with groundwater having TCE-series concentrations exceeding applicable NYSDOH Drinking Water Standards.

2. NFA with Institutional Controls is the only alternative that would meet the RAO of preventing ingestion/direct contact/inhalation of soil, groundwater, and vapors containing TCE-series constituents by on-Site construction workers during deep (greater than 14 feet) excavation activities in the area of the former septic tank.

3. NFA with Institutional Controls rates the highest of the three alternatives for both short-term and long-term effectiveness.

4. The rate of reduction in toxicity, mobility, and volume of TCE-series constituents in groundwater in the area of the former septic tank should not be significantly different for the NFA with Institutional Controls alternative as compared to the ISCO and ISCR alternatives due to continued CVOC mass flux entering the former septic tank area from an upgradient source or sources.

6.2 Proposed Institutional Controls

The proposed institutional controls associated with the NFA with Institutional Controls remedy would include deed restrictions placed on the Broadway Complex Site property by the property owner that would mitigate potential exposures to TCE-series constituents in soil and groundwater in the area of the former septic tank. IBM does not own the property and therefore does not have control over implementation of this remedial alternative. However, IBM understands that NYSDEC has requested that Sanmina-SCI place such deed restrictions on the Broadway Complex Site property and the larger adjacent Sanmina-SCI property to address similar potential exposure pathways to the CVOC presence currently remediated by Sanmina-SCI. If implemented, the deed restrictions would be deemed a covenant that would run with the land and would be binding upon future owners of the Site.

7 REFERENCES

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TABLE 5-1
SCREENING OF REMEDIAL TECHNOLOGIES
Remedial Alternatives Report
Broadway Complex Site, Owego, New York

POTENTIALLY APPLICABLE TECHNOLOGY	IMPLEMENTABILITY RELATIVE TO SITE HYDROGEOLOGIC CONDITIONS	EFFECTIVENESS in Protecting Human Health and Environment		POTENTIAL APPLICATION TO Broadway Complex Site
		Short-term (Includes Potential Impacts to Workers and Community)	**Long-term (Effectiveness at Meeting Remedial Action Objectives)**	
No Further Action (NFA) with Institutional Controls Deed restrictions placed on the Broadway Complex Site property by the property owner that would mitigate potential exposures toTCE-series constituents in soil and groundwater in the area of the former septic tank.	**Feasible** Deed restrictions would mitigate potential exposure pathways to CVOC presence in soil and groundwater in the former septic tank area regardless of Site hydrogeologic conditions.	**High –** The area of the Site is served by public water. Deed restrictions would not include active remediation activities that could disrupt Site operations.	**High -** Deed restrictions would mitigate potential exposure pathways to CVOC presence in soil and groundwater in the area of the former septic tank. TCE-series groundwater plume from former septic tank area is a *de minimus* contributor to the overall stable or shrinking CVOC groundwater plume that is captured by off-Site groundwater extraction wells.	**Retain for further consideration** as a separate remedial alternative due to high short-term and long-term effectiveness.
***In Situ* Chemical Oxidation (ISCO)** Treatment of soil and groundwater by direct injection of chemical oxidants, such as permanganate or peroxide.	**Potentially Feasible** Potential limitations in the ability to deliver chemical oxidants uniformly in the former septic tank area. Testing of alluvial soils suggests natural oxidant demand is "low" and should not inhibit the application of this technology. Exfiltration of water from nearby Barnes Creek would likely limit effectiveness of this technology at and near the water table where COPC concentrations are higher.	**High -** Proven method for short-term reduction in TCE-series concentrations in similar hydrogeologic settings. Technology is relatively ineffective at short-term reduction of TCA-series concentrations. Limited access in area of former septic tank for drilling of injection probes due to presence of numerous subsurface utilities. Potential issues/concerns related to workers handling chemicals and public perception of chemical injection. The number and duration of oxidant injections is uncertain.	**Low –**Ability to mitigate potential exposure pathways to TCE-series presence in former septic tank area is low given: 1) potential rebound effects due to diffusion of TCE-series constituents from finer textured alluvial soils, such as silt and clay; and 2) recontamination of the TCE-series portion of the CVOC groundwater plume in the ISCO treatment zone due to a source or sources north of the former septic tank area.	**Retain for further consideration** as a separate remedial alternative due to high short-term effectiveness in reducing TCE-series mass.
***In Situ* Chemical Reduction (ISCR)** Treatment of soil and groundwater by direct injection of chemical reducing agents, such as micro-scale Zero Valent Iron (ZVI) within a reducing substrate, such as emulsified oil.	**Potentially Feasible** Potential limitations in the ability to deliver chemical reducing agent and substrate uniformly in the former septic tank area. Technology requires adding and maintaining sufficient chemical reducing agents and substrates to convert the alluvial aquifer from oxidizing to reducing conditions. Exfiltration of oxygenated water from nearby Barnes Creek would likely limit effectiveness of this technology at and near the water table.	**Moderate –** Some proven effectiveness in converting portions of aquifers from oxidizing to reducing conditions to allow destruction of TCE-series constituents using ZVI. Limited access in area of former septic tank for drilling of injection probes due to presence of numerous subsurface utilities. Potential issues/concerns limited to workers handling chemicals and public perception of chemical injection. The number and duration of reducing agent injections is uncertain.	**Low -** Ability to mitigate potential exposure pathways pathways to TCE-series presence in former septic tank area is low given: 1) difficulties in developing and maintaining reducing conditions; 2) potential rebound effects due to diffusion of TCE-series constituents from finer textured alluvial soils, such as silt and clay; and 3) recontamination of the TCE-series groundwater plume in the ISCR treatment zone due to a source or sources north of the former septic tank area.	**Retain for further consideration** as a separate remedial alternative due to moderate short-term effectiveness in removing TCE-series mass.
Enhanced Bioremediation Treatment of soil and groundwater by addition of amendments for enhanced biodegradation of CVOCs by reductive dechlorination.	**Potentially Feasible** Potential limitations in the ability to deliver biological amendments uniformly in the former septic tank area. Natural attenuation via reductive dechlorination appears to be severely limited in the area of the former septic tank. Technology requires adding and maintaining sufficient amendments to convert the alluvial aquifer from oxidizing to reducing conditions. Exfiltration of oxygenated water from nearby Barnes Creek would likely limit effectiveness of this technology at and near the water table.	**Low –**Limited effectiveness in reduction of TCE-series constituents in hydrogeologic settings with natural oxidizing conditions. Presence of electron acceptors, such as dissolved oxygen, nitrate, iron, and manganese would further limit potential for reductive dechlorination. Limited access in area of former septic tank for drilling of injection probes due to presence of numerous subsurface utilities. The number and duration of biological amendment injections is uncertain.	**Low -** Ability to mitigate potential exposure pathways pathways to TCE-series presence in former septic tank area is low given: 1) difficulties in developing and maintaining reducing conditions; 2) potential rebound effects due to diffusion of TCE-series constituents from finer textured alluvial soils, such as silt and clay; and 3) recontamination of the TCE-series groundwater plume in the enhanced biodegradation treatment zone due to a source or sources north of the former septic tank area.	**Exclude from further consideration** due to low short-term and long-term effectiveness.

TABLE 5-1
SCREENING OF REMEDIAL TECHNOLOGIES
Remedial Alternatives Report
Broadway Complex Site, Owego, New York

POTENTIALLY APPLICABLE TECHNOLOGY	**IMPLEMENTABILITY RELATIVE TO SITE HYDROGEOLOGIC CONDITIONS**	**EFFECTIVENESS in Protecting Human Health and Environment**		**POTENTIAL APPLICATION TO Broadway Complex Site**
		Short-term (Includes Potential Impacts to Workers and Community)	**Long-term (Effectiveness at Meeting Remedial Action Objectives)**	
Excavation Physical removal of soil to depths of 20 to 30 feet bgs with sheet piling/dewatering. Off-Site soil disposal to landfill. Off-Site water treatment.	**Feasible** The majority of TCE mass in soil is below a depth of 14 feet bgs. Excavation would require sheet pilings and dewatering as excavation would advance 10 to 20 feet below the water table.	**Low –** Requires sheet piling and excavation around numerous subsurface utilities (water, sewer, electric). Sheet piling installation could damage foundation structure of nearby Broadway Building. Large excavation footprint would disrupt site operations. Dewatering would pull higher concentration TCE-series and TCA-series mass from the northwest and west towards the former septic tank area. Potential for worker exposure to noise and vapor emissions. Increased truck traffic.	**Low -** Proven method for long-term reduction in TCE-series concentrations in soil and groundwater. Removal of soil would eliminate potential for rebound via diffusion. However, ability to eliminate potential exposure pathways pathways to TCE-series presence in former septic tank area is low due to the expected recontamination of the TCE-series groundwater plume in the area of the excavation due to a source or sources north of the former septic tank area.	**Exclude from further consideration** due to numerous short-term effectiveness concerns and low long-term effectiveness.
***In-Situ* Thermal Treatment** *In-situ* treatment via thermal conductive heating below the water table with multi-phase extraction.	**Potentially Feasible** the former septic tank area is accessible for likely spacing of heater/SVE wells and multi-phase extraction wells targeting TCE-series presence in alluvial soil and groundwater between 11 and 35 feet bgs. Closely-spaced multi-phase extraction wells would be required to limit potential short-circuiting of steam and CVOC vapors towards the Broadway Building. Groundwater extraction in area upgradient of treatment zone may be required in order to maintain elevated temperatures necessary for steam generation.	**Low -** Technology reported to be equally effective in removing mass in fine and coarse-grained soils. Thermal treatment operations require a large footprint outside of the treatment zone that would disrupt site operations. Frequent soil vapor monitoring would be required adjacent to Broadway Building to confirm containment via SVE of resultant soil vapors generated during heating. Dewatering would pull higher concentration TCE-series and TCA-series mass from the northwest and west towards the thermal treatment zone in the former septic tank area. Subsurface utilities would need to be relocated outside of the thermal treatment zone area which would disrupt Site operations. Heat would likely damage root systems and kill trees adjacent to active remediation area.	**Low** - Technology reportedly has been effective in significantly reducing TCE-series concentrations in soil and groundwater in similar hydrogeologic settings. However, ability to eliminate potential exposure pathways pathways to TCE-series presence in former septic tank area is low due to the expected recontamination of the TCE-series groundwater plume in the thermal treatment zone due to a source or sources north of the former septic tank area.	**Exclude from further consideration** due to numerous short-term effectiveness concerns and low long-term effectiveness.

NOTE: This table is intended to summarize results of screening of remedial technologies with potential application to the Broadway Complex Site. Each technology is screened relative to Site-specific hydrogeologic conditions and potential short-term and long-term effectiveness. See the report text for additional details.

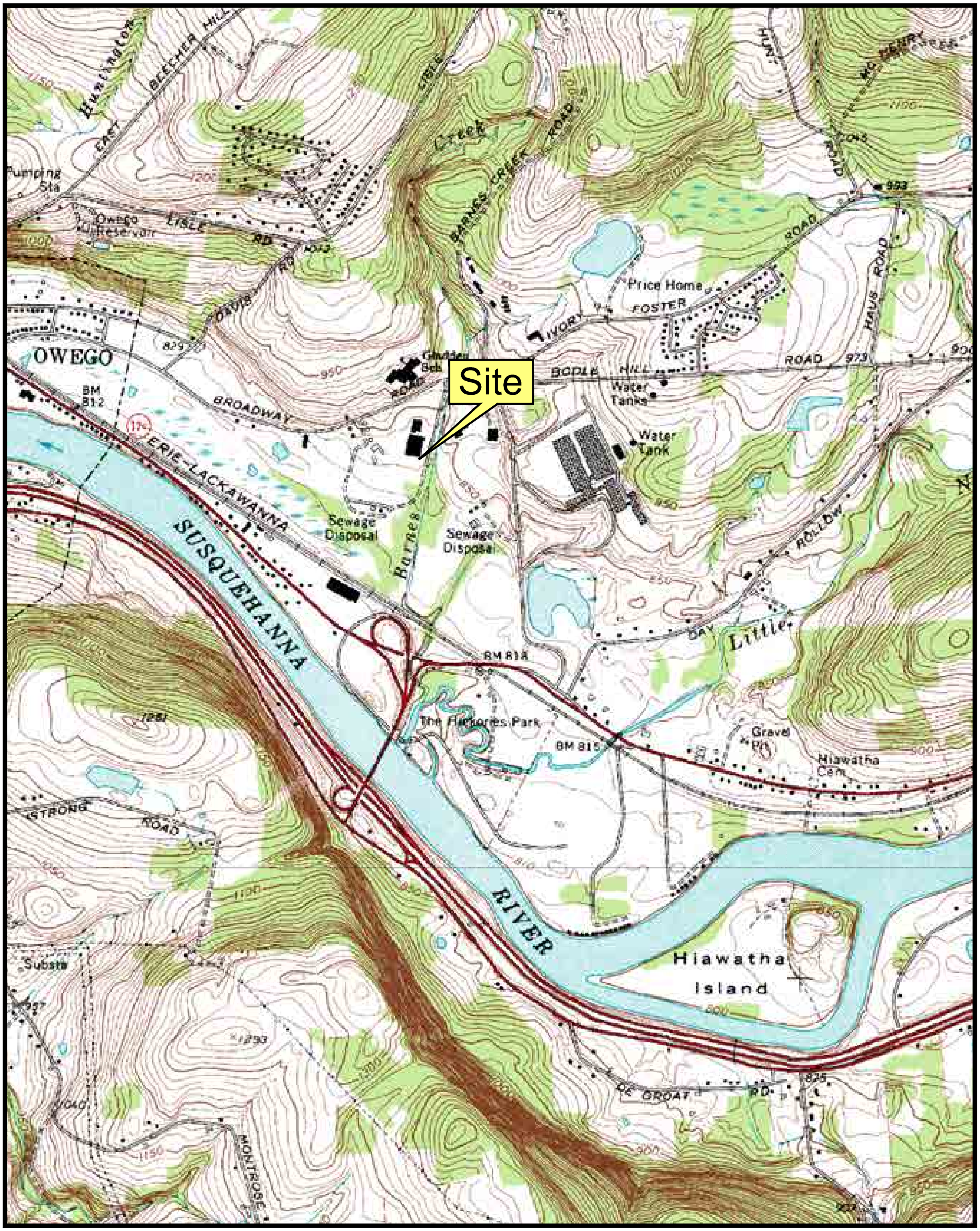
TABLE 5-2
DEVELOPMENT AND ANALYSIS OF REMEDIAL ALTERNATIVES
Remedial Alternatives Report
Broadway Complex Site, Owego, New York

REMEDIAL ALTERNATIVE	Protection of Human Health and the Environment	Compliance with New York State SCGs	Short-Term Effectiveness & Impacts	Long-Term Effectiveness and Permanence	Reduction in Toxicity, Mobility, or Volume	Implementability
No Further Action (NFA) with Institutional Controls Deed restrictions placed on the Broadway Complex Site property by the property owner that would mitigate potential exposures to TCE-series constituents in soil and groundwater in the area of the former septic tank.	**High** Would meet the overall goal of protection of public health and the environment by mitigating potential exposure pathways via the use of a deed restriction on the Site property. The deed restriction would mitigate the potential for construction worker exposure and eliminate the potential use of groundwater without treatment.	**Low** Concentrations of TCE and c12DCE in groundwater that are above New York State Part 703 groundwater standards would likely remain that way due to no active remediation activities. Results of the SSI indicate the TCE-series presence in groundwater at the Site is stable or shrinking but the timeframe to attain groundwater quality standards is uncertain.	**High** This alternative does not include active remediation activities that could disrupt Site operations. The Site and surrounding region is served by public water.	**High** Deed restrictions would mitigate potential exposure pathways to TCE-series presence in soil and groundwater in the area of the former septic tank. The restrictions would remain on the deed for the property in the case of a change in property ownership.	**Low** This alternative does not reduce the toxicity, mobility, or volume of the TCE-series constituents in the area of the former septic tank.	***Technical Feasibility***- Use of deed restrictions is a common and effective institutional control at mitigating potential exposure pathways and unacceptable risk to public health and the environment. ***Administrative Feasibility***- NYSDEC has requested that Sanmina-SCI place a deed restriction on the Broadway Complex Site property. The deed restriction would also be protective of the larger and broader on-Site CVOC groundwater plume Sanmina-SCI is currently remediating.
***In Situ* Chemical Oxidation (ISCO)** Treatment of soil and groundwater by direct injection of chemical oxidants, such as permanganate or peroxide. This alternative would include multiple injections of permanganate or peroxide using a combination of hydraulically-driven injection points and wells. Injection would target septic tank area with TCE-series to TCA-series ratios greater than 25 near the water table (shallow alluvium) and greater than 10 in the lower portion of the alluvium (deep alluvium). The chemical oxidants would destroy the TCE-series constituents.	**Low** This alternative is unlikely to attain the overall goal of protection of public health and the environment. TCE-series mass in groundwater above applicable SCGs would likely remain after implementation of this remedial alternative due to short-term and long-term effectiveness issues.	**Low** It is unlikely that ISCO would reduce TCE-series groundwater concentrations in the area of the former septic tank to levels below applicable NYS Part 703 groundwater standards. Concentrations of TCE in groundwater in the area of the former septic tank would need to be reduced by over 99% and concentrations of c12DCE would need to be reduced by over 80% to meet the NYS Part 703 standard of 5 µg/L. Application of this technology in similar hydrogeologic settings at other sites suggests short-term reductions could approach 75 to 90% but long-term reductions are commonly much less due to rebound effects as mass partitions from aquifer solids. The presence of an upgradient source or sources of TCE would also result in recontamination of the ISCO treatment zone regardless of the initial effectiveness of this remedial alternative.	**Moderate-High** Proven method for short-term reduction in TCE-series concentrations in similar hydrogeologic settings. Limited access in area of former septic tank for drilling of injection probes due to presence of numerous subsurface utilities. Possible worker exposure to noise during installation of injection points. Potential issues/concerns related to workers handling chemicals and public perception of chemical injection.	**Low** Ability to mitigate potential exposure pathways to TCE-series presence in former septic tank area is low given: 1) Potential rebound effects due to back diffusion of TCE-series constituents from finer textured alluvial soils; and 2) Recontamination of the TCE-series groundwater plume in the ISCO treatment zone due to a source or sources north of the former septic tank area.	**Low** Application of ISCO could initially reduce the mass of TCE-series constituents in the former septic tank area as high as 75 to 90%. However, concentrations of TCE-series constituents would be expected to rebound. The net decline in TCE-series mass is anticipated to be no more than an order of magnitude (about 90%). However, the initial decline in the overall volume of TCE-series is anticipated to rebound in the ISCO treatment zone due to a source or sources north of the former septic tank area.	***Technical Feasibility***- Injection of chemical oxidants via hydraulically-driven injection points and wells into alluvial soils in the area of the former septic tank is feasible. Potential limitations in the ability to deliver chemical oxidants uniformly in the former septic tank area. Testing of alluvial soils suggests natural oxidant demand is “low” and should not inhibit the implementation of this technology. Exfiltration of water from nearby Barnes Creek would likely limit effectiveness of this technology at and near the water table. ***Administrative Feasibility***- There should be no restrictions in obtaining an Underground Injection Control (UIC) program permit to inject the chemical oxidants. Concerns of local residents would be addressed through the Site’s community participation plan and direct contacts with nearby property owners and occupants.

TABLE 5-2
DEVELOPMENT AND ANALYSIS OF REMEDIAL ALTERNATIVES
Remedial Alternatives Report
Broadway Complex Site, Owego, New York

REMEDIAL ALTERNATIVE	Protection of Human Health and the Environment	Compliance with New York State SCGs	Short-Term Effectiveness & Impacts	Long-Term Effectiveness and Permanence	Reduction in Toxicity, Mobility, or Volume	Implementability
***In Situ* Chemical Reduction (ISCR)** Treatment of soil and groundwater by direct injection of chemical reducing agents, such as micro-scale Zero Valent Iron (ZVI) within a reducing substrate, such as emulsified oil. This alternative would include multiple injections of ZVI and emulsified oil or another substrate using a combination of hydraulically-driven injection points and wells. Injection would target septic tank area with TCE-series to TCA-series ratios greater than 25 near the water table (shallow alluvium) and greater than 10 in the lower portion of the alluvium (deep alluvium). The chemical reducing agents would destroy the TCE-series constituents. The reducing agents would also destroy TCA-series constituents in groundwater sourced to the north of the treatment zone.	**Low** This alternative is unlikely to attain the overall goal of protection of public health and the environment. TCE-series mass in groundwater above applicable SCGs would likely remain after implementation of this remedial alternative due to short-term and long-term effectiveness issues.	**Low** It is unlikely that ISCR would reduce TCE-series groundwater concentrations in the area of the former septic tank to levels below applicable NYS Part 703 groundwater standards. Concentrations of TCE in groundwater in the area of the former septic tank would need to be reduced by over 99% and concentrations of c12DCE would need to be reduced by over 80% to meet the NYS part 703 standard of 5 µg/L. In general, application of ISCR at other similar hydrogeoligc settings has been shown to have less rebound potential than ISCO but at this Site the potential rebound would be expected to be similar due to the presence of an upgradient source or sources of TCE.	**Moderate to High** Some proven effectiveness in converting portions of aquifers from oxidizing to reducing conditions to allow destruction of TCE-series constituents using ZVI. Limited access in area of former septic tank for drilling of injection probes due to presence of numerous subsurface utilities. Possible worker exposure to noise during installation of injection points. Potential issues/concerns limited to workers handling chemicals and public perception of chemical injection.	**Low** Ability to mitigate potential exposure pathways to TCE-series presence in former septic tank area is low given: 1) Difficulties in developing and maintaining reducing conditions; 2) Potential rebound effects due to back diffusion of TCE-series constituents from finer textured alluvial soils, such as silt and clay; and 3) Recontamination of the TCE-series groundwater plume in the ISCR treatment zone due to a source or sources north of the former septic tank area.	**Low** Application of this technology has significant long-term effectiveness issues in developing and maintaining reducing conditions due to the nearby exfiltration of oxygenated water from Barnes Creek. These limitations make projections of groundwater concentration declines difficult. The net decline in TCE-series mass is anticipated to be no more than an order of magnitude (about 90%). However, the initial decline in the overall volume of TCE-series is anticipated to rebound in the ISCR treatment zone due to a source or sources north of the former septic tank area.	***Technical Feasibility*** Injection of chemical reducing agents via hydraulically-driven injection points and wells into alluvial soils in the area of the former septic tank is feasible. Potential limitations in the ability to deliver reducing agents and emulsified oil uniformly in the former septic tank area. Exfiltration of water from nearby Barnes Creek would likely limit effectiveness of this technology at and near the water table. ***Administrative Feasibility*** There should be no restrictions in obtaining an Underground Injection Control (UIC) program permit to inject the chemical reducing agents and substrate.

NOTE: This table is intended to summarize an analysis of three possible remedial alternatives developed for the Broadway Complex Site against the six evaluation criteria set forth in section 4.2 of NYSDEC DER-10. See the text of the report for a narrative description of each alternative and presentation of individual and comparative analyses.



Portion of the Apalachin, NY
7.5-minute USGS Quadrangle
(2000)

Scale
0 1000' 2000'

NORTH

Figure 2-1

Corporate Environmental Affairs

Site Location Map

GROUNDWATER SCIENCES CORPORATION

29003-013-B1 / 9-6-2013

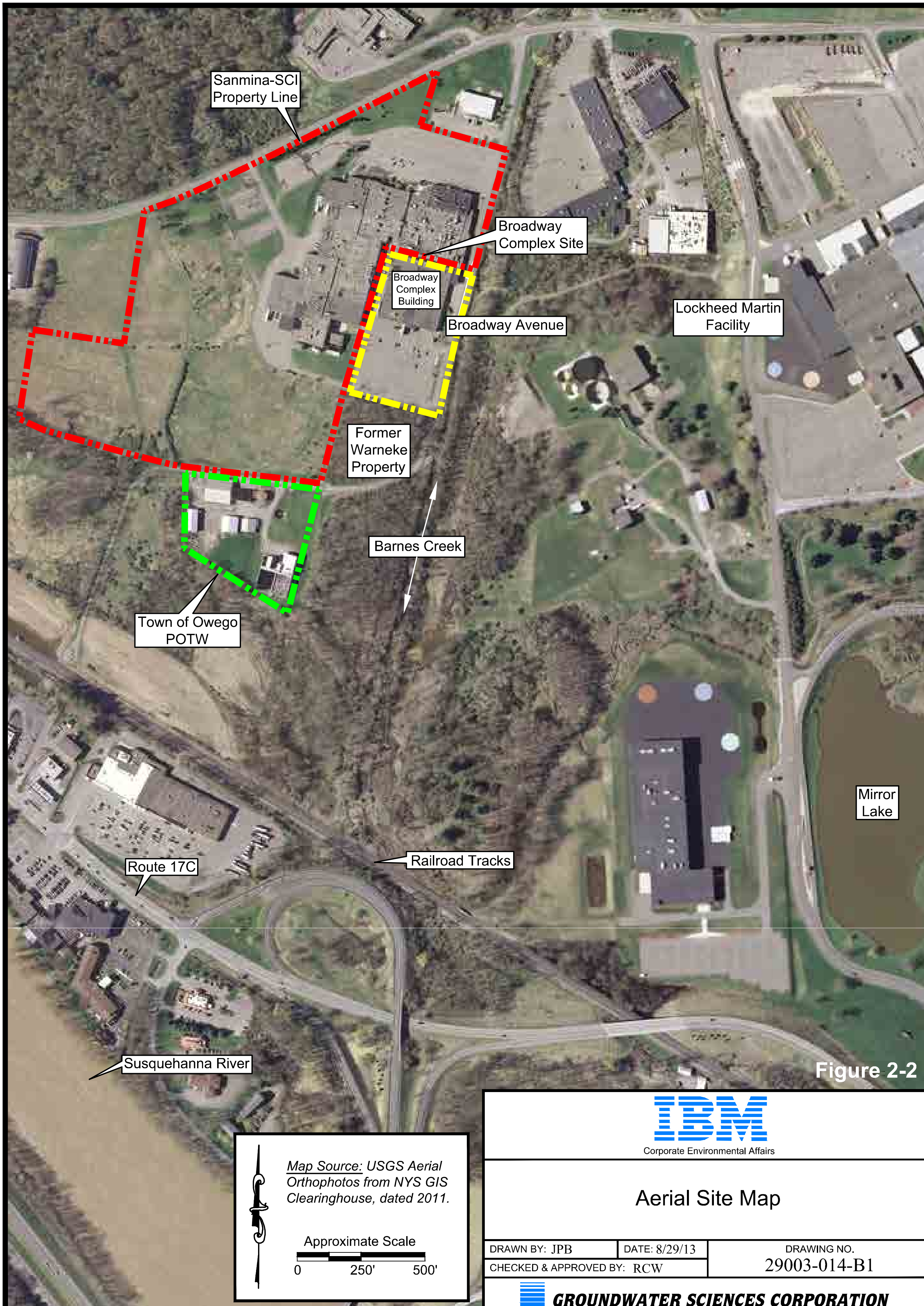


Figure 2-2

IBM
Corporate Environmental Affairs

Aerial Site Map

DRAWN BY: JPB	DATE: 8/29/13	DRAWING NO.
CHECKED & APPROVED BY: RCW		29003-014-B1

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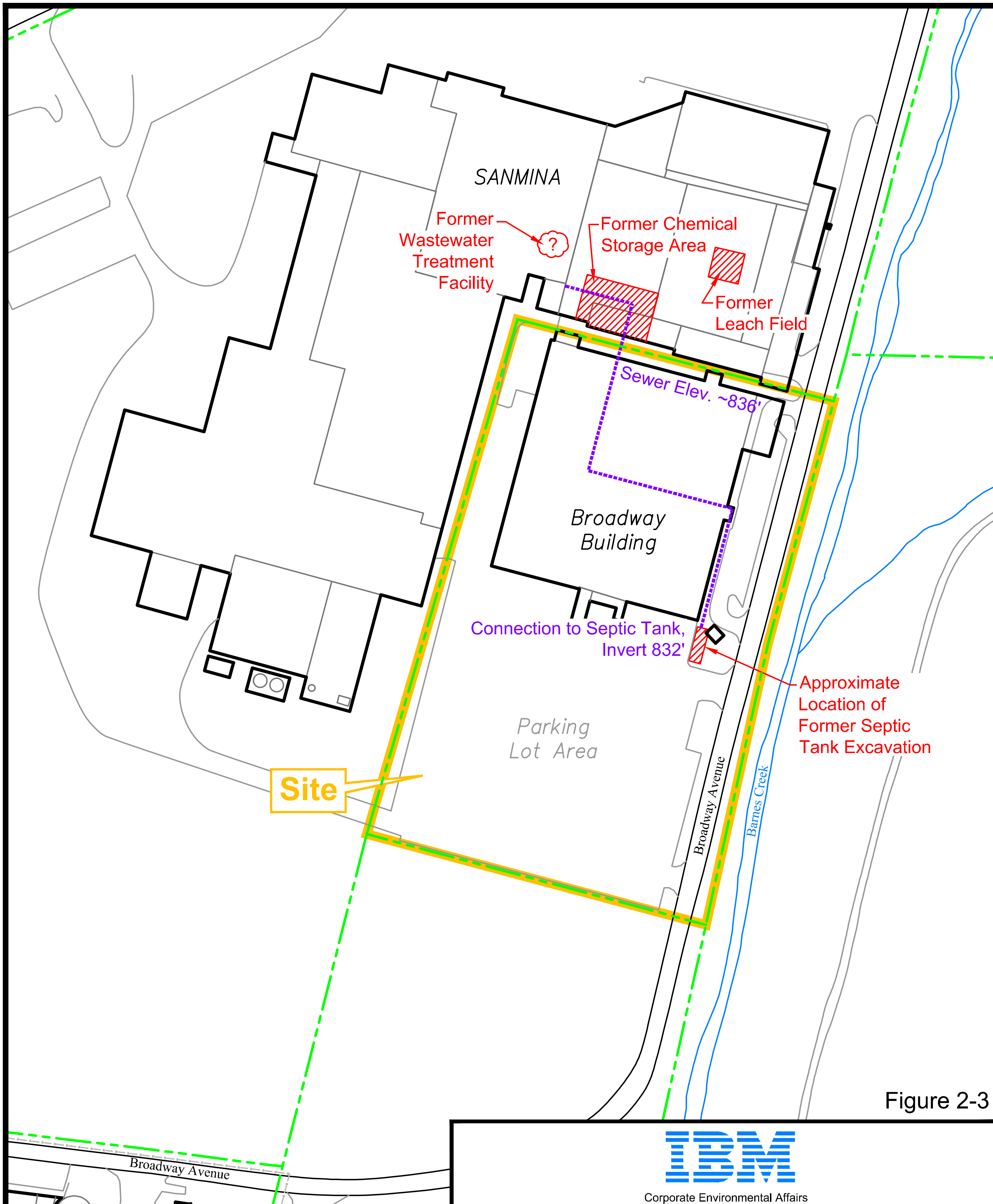

Figure 2-3

LEGEND

- Property Line (approx.)
- Fence
- Railroad
- Former 6" Sanitary Sewer Line

Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).

Scale

0 150'

IBM

Corporate Environmental Affairs

Broadway Complex Site Map
Owego, New York

DRAWN BY: JPB	DATE: 8/29/13	DRAWING NO. 29003-003-M1
CHECKED & APPROVED BY: RCW		

GROUNDWATER SCIENCES CORPORATION

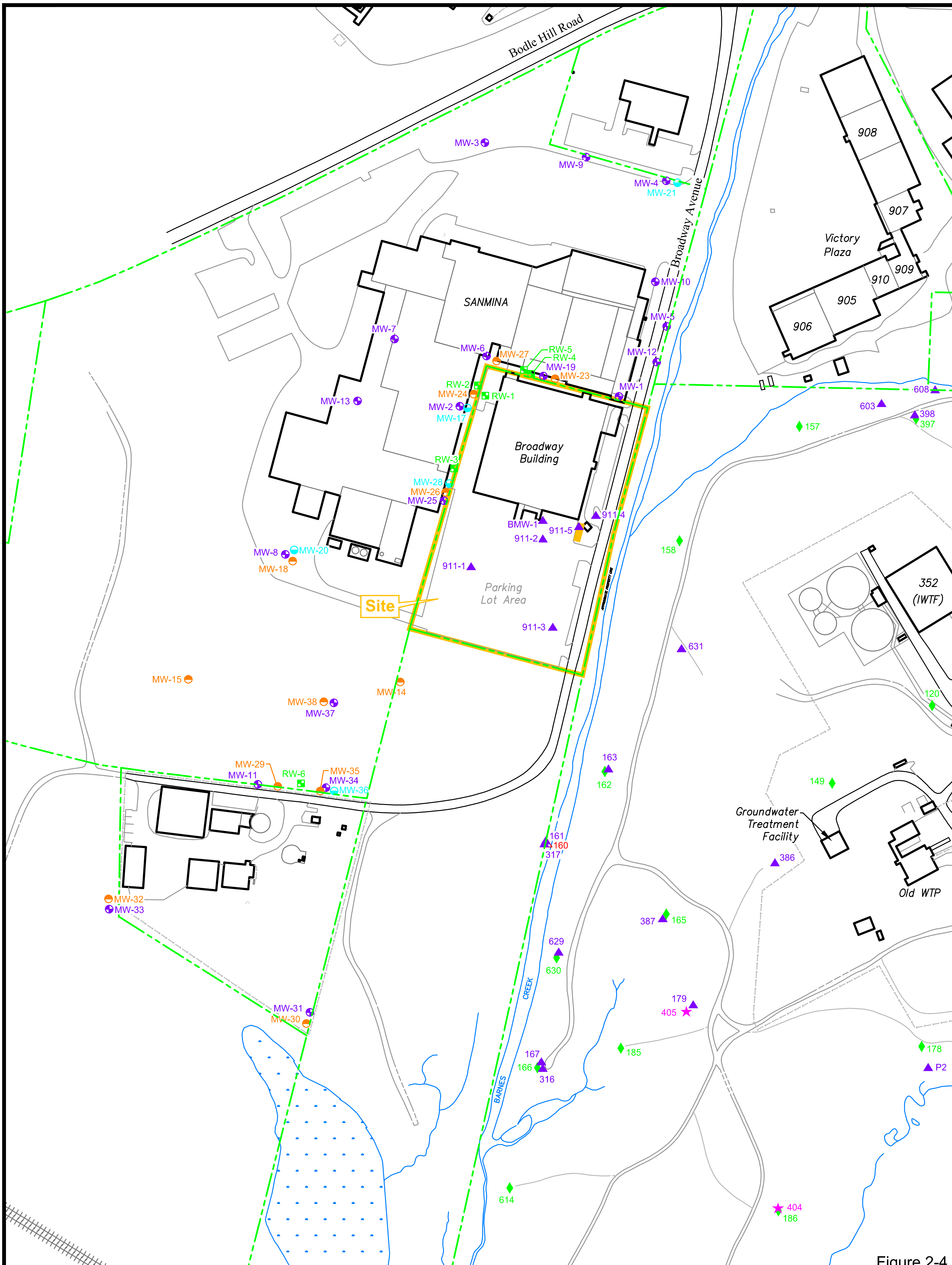

Figure 2-4

LEGEND

Sanmina/Broadway Complex Site:

- Bedrock Monitoring Well
- Deep Overburden Monitoring Well
- Shallow Overburden Monitoring Well
- Recovery Well (various intervals)

Former IBM Owego Site:

- Soil Monitoring Well
- Till Monitoring Well
- Soil/Bedrock Monitoring Well
- Withdrawal Well

- Property Line (approx.)
- Fence
- Railroad
- Approx. Location of Former Septic Tank Excavation

Scale

0 100' 200'

Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).

IBM

Corporate Environmental Affairs

Off-Site Corrective Action

DRAWN BY: JPB	DATE: 8/29/13	DRAWING NO.
CHECKED & APPROVED BY: RCW		29003-015-B1

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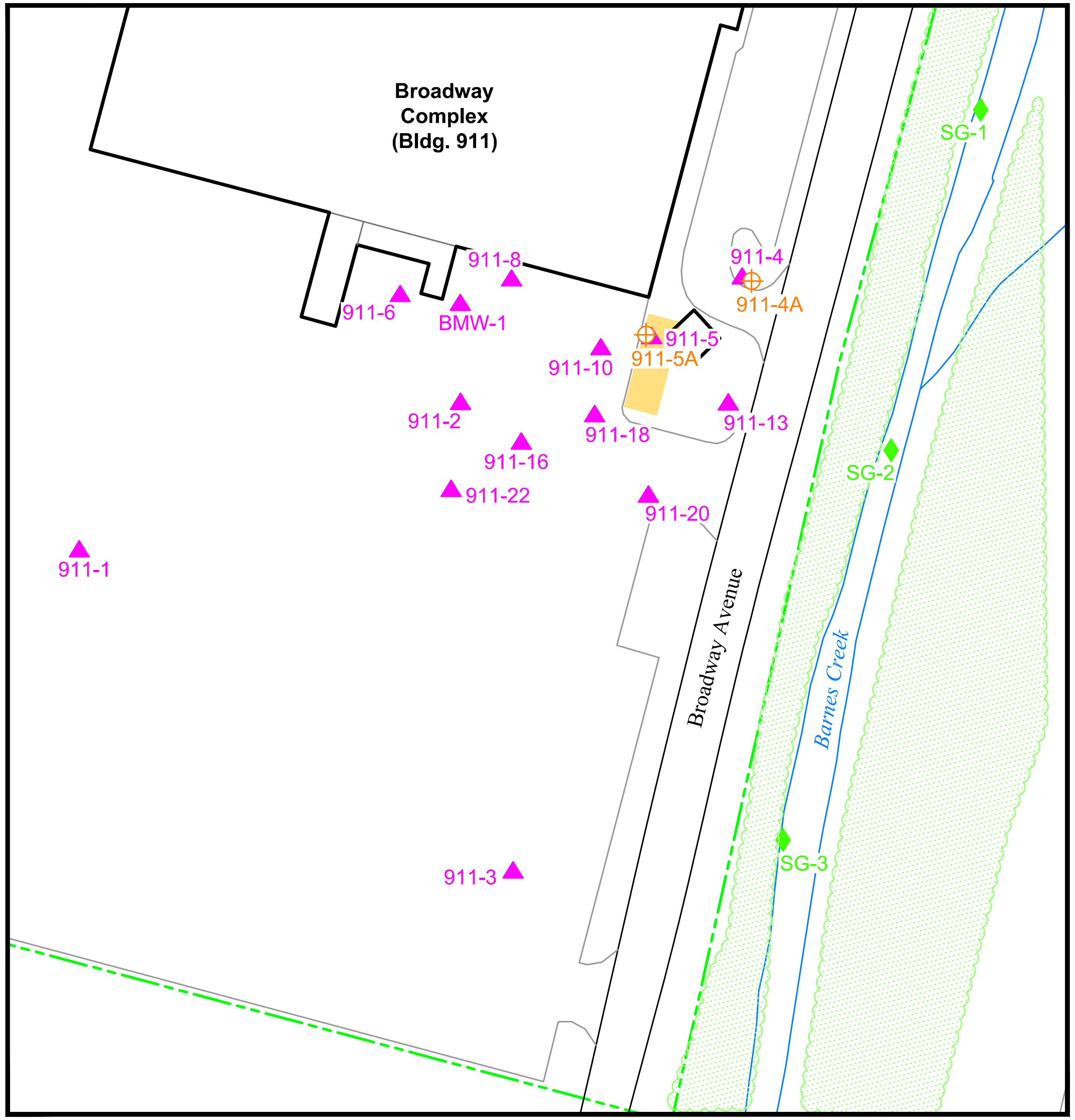
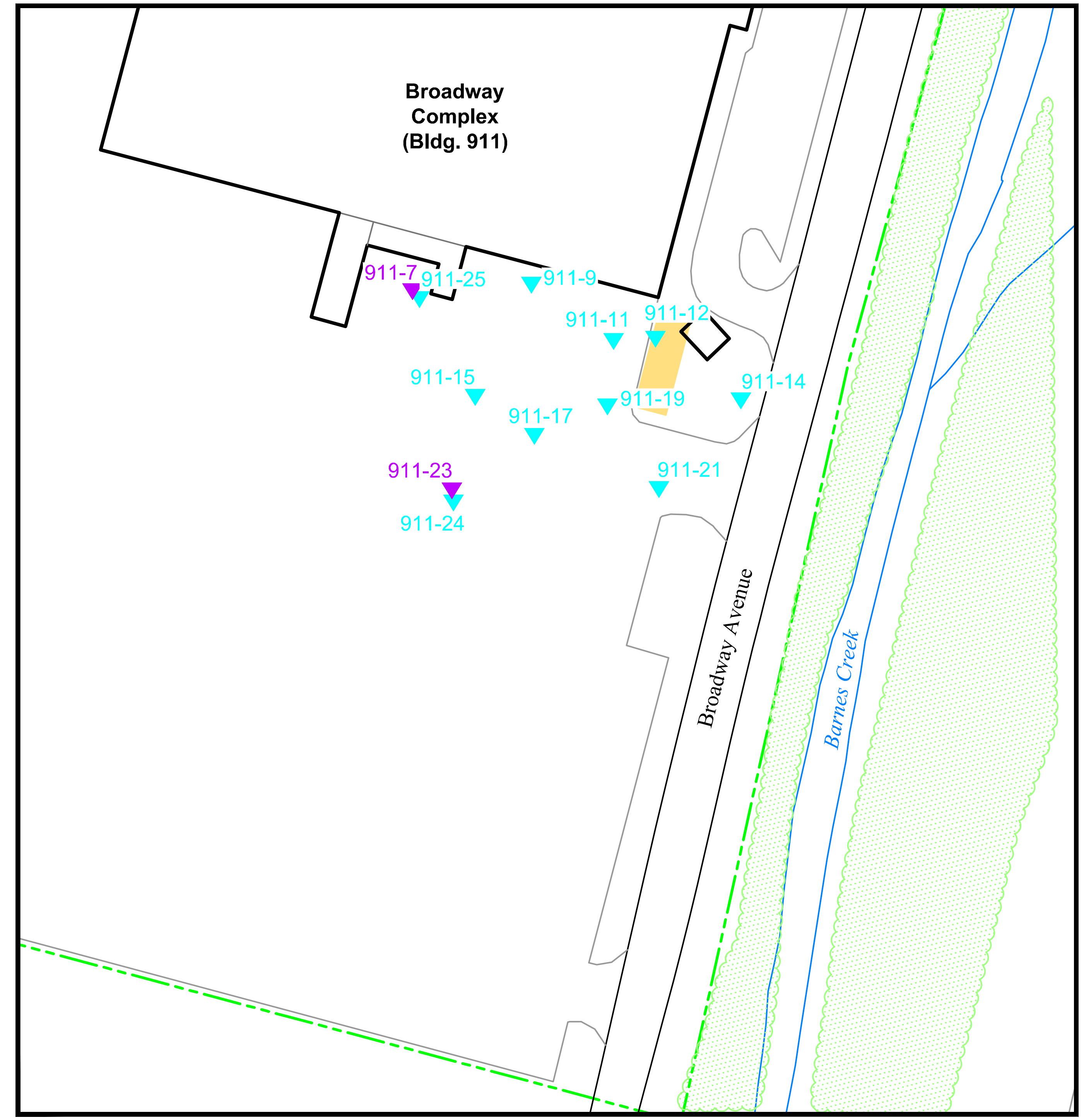


Shallow Wells - Alluvium



Deep Wells - Alluvium

Figure 3-1

LEGEND

- Shallow Groundwater Monitoring Well
- Intermediate Groundwater Monitoring Well
- Deep Groundwater Monitoring Well
- Staff Gauge
- Soil Boring (approx. location)
- Property Line (approx.)
- Approx. Location of Former Septic Tank Excavation

Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).

Scale
0 30' 60'

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Corporate Environmental Affairs

Supplemental Site Investigation
Exploration Location Maps

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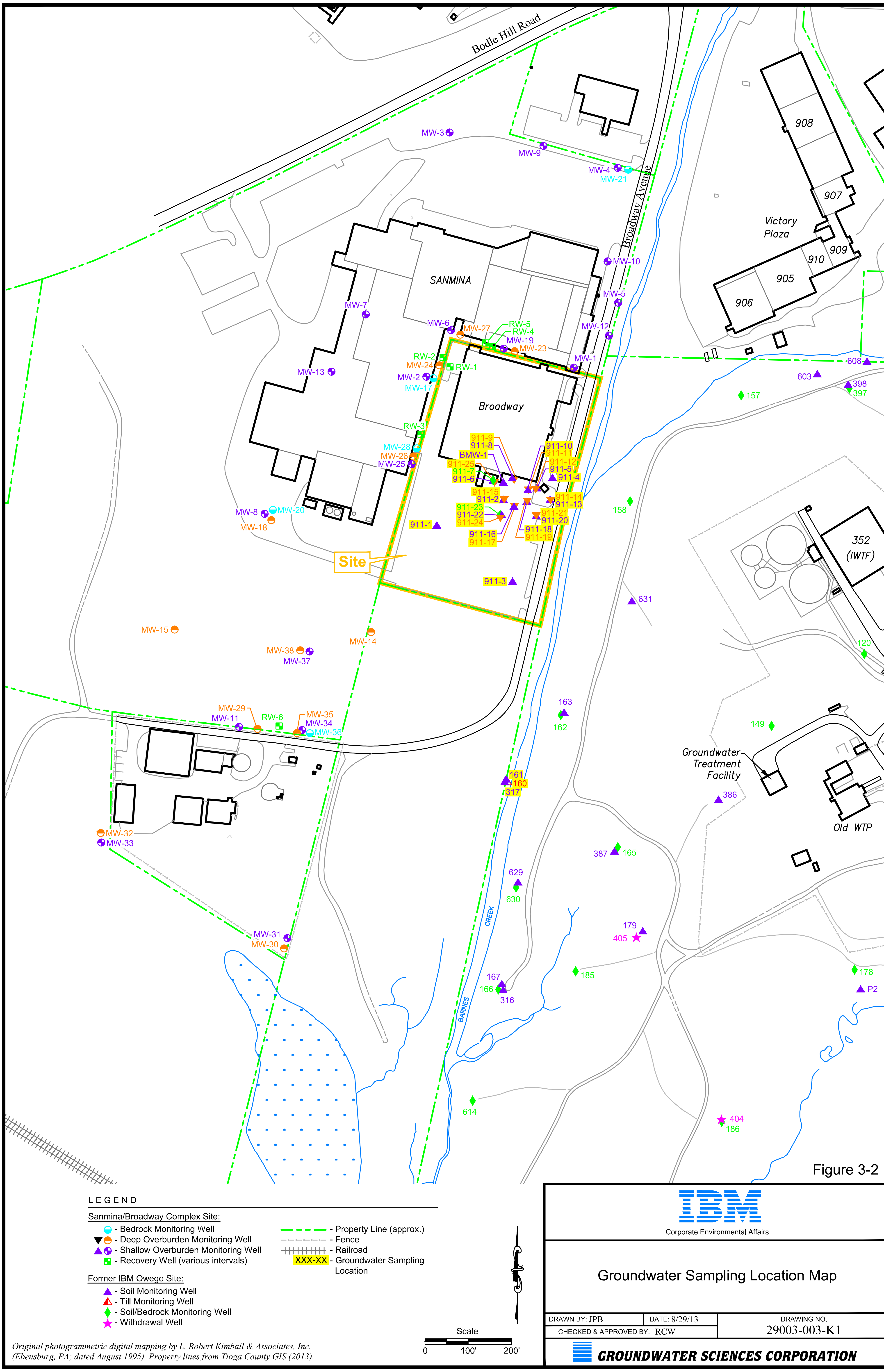
CHECKED & APPROVED BY: RCW		29003-023-A1

GROUNDWATER SCIENCES CORPORATION



Bodle Hill Road
Broadway Avenue
SANMINA
Broadway
Victory Plaza
908
907
909
910
905
906
352 (IWTF)
Groundwater Treatment Facility
Old WTP
BARNES CREEK
Site
MW-3
MW-9
MW-4
MW-21
MW-10
MW-5
MW-12
MW-1
MW-7
MW-6
MW-27
RW-5
RW-4
MW-19
MW-23
RW-2
MW-24
RW-1
MW-2
MW-17
MW-13
RW-3
MW-28
MW-26
MW-25
MW-8
MW-20
MW-18
MW-15
MW-38
MW-37
MW-14
MW-29
MW-11
RW-6
MW-35
MW-34
MW-36
MW-32
MW-33
MW-31
MW-30
911-9
911-8
BMW-1
911-25
911-7
911-6
911-10
911-11
911-12
911-5
911-4
911-15
911-2
911-14
911-13
911-23
911-22
911-24
911-21
911-20
911-1
911-16
911-17
911-18
911-19
911-3
608
603
398
397
157
158
631
120
163
162
149
161
160
317
386
387
165
629
630
179
405
185
178
P2
167
166
316
614
404
186
Figure 3-2
LEGEND
Sanmina/Broadway Complex Site:
- Bedrock Monitoring Well
- Deep Overburden Monitoring Well
- Shallow Overburden Monitoring Well
- Recovery Well (various intervals)
- Property Line (approx.)
- Fence
- Railroad
XXX-XX - Groundwater Sampling Location
Former IBM Owego Site:
- Soil Monitoring Well
- Till Monitoring Well
- Soil/Bedrock Monitoring Well
- Withdrawal Well
Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).
Scale
0
100'
200'
IBM
Corporate Environmental Affairs
Groundwater Sampling Location Map
DRAWN BY: JPB
DATE: 8/29/13
DRAWING NO.
29003-003-K1
CHECKED & APPROVED BY: RCW
GROUNDWATER SCIENCES CORPORATION

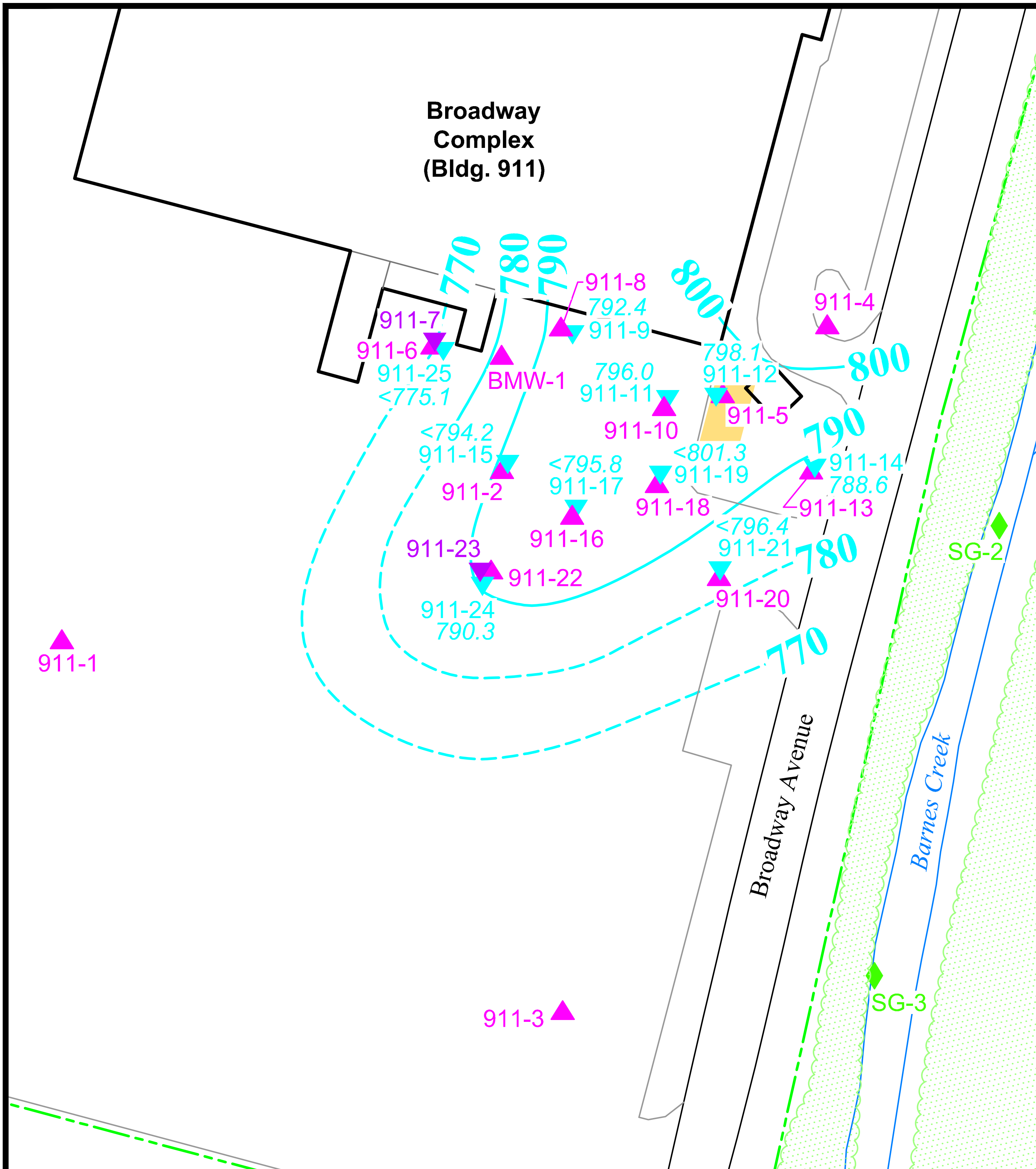


Figure 3-3

LEGEND

- 800 - Glacial Till Surface Elevation Contour (feet) (dashed where inferred)
- *792.4* - Glacial Till Surface Elevation (feet amsl)
- Shallow Groundwater Monitoring Well
- Intermediate Groundwater Monitoring Well
- Deep Groundwater Monitoring Well
- Staff Gauge
- Property Line (approx.)
- Approx. Location of Former Septic Tank Excavation

Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).

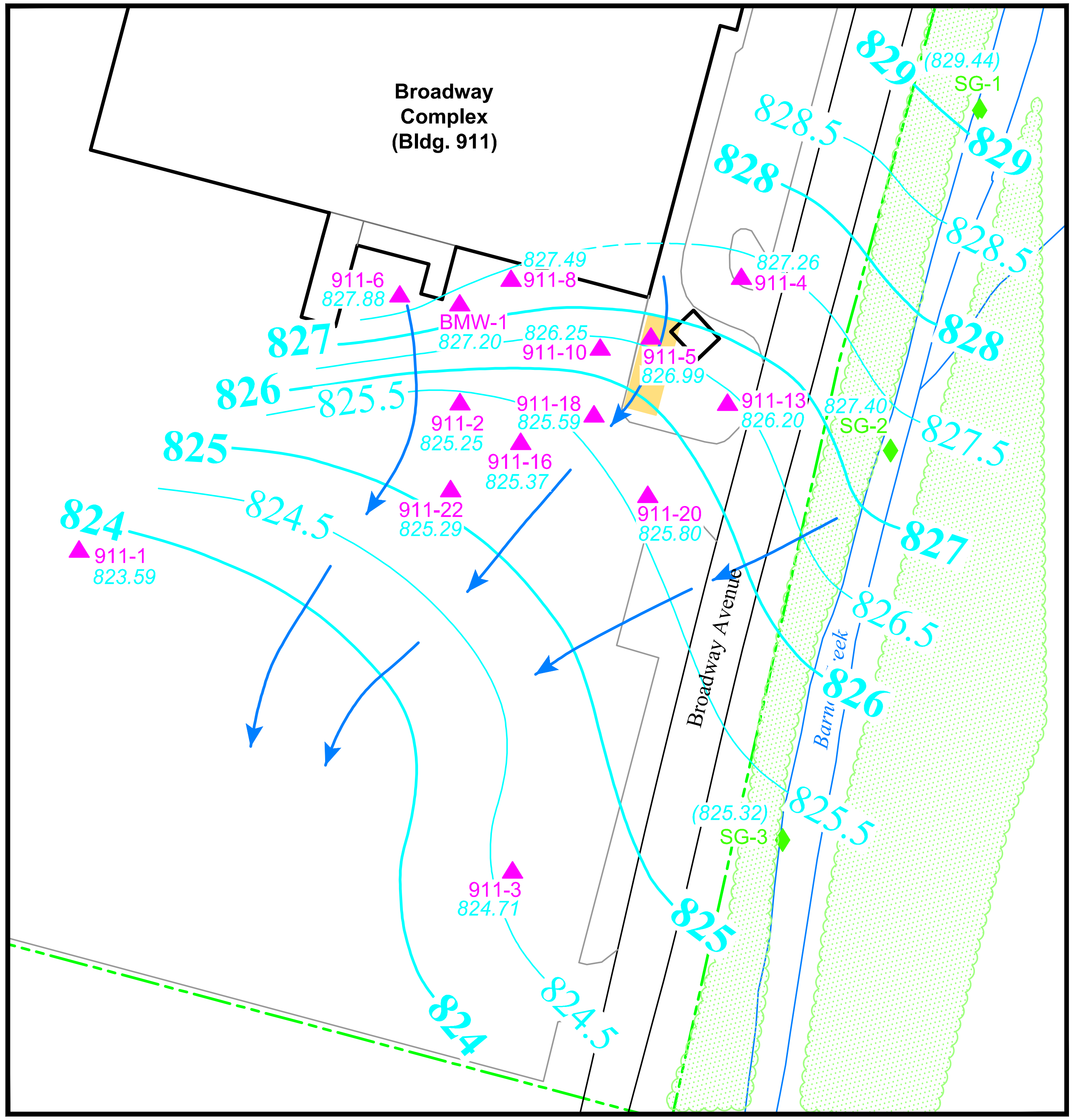
Scale
0 30' 60'

Corporate Environmental Affairs

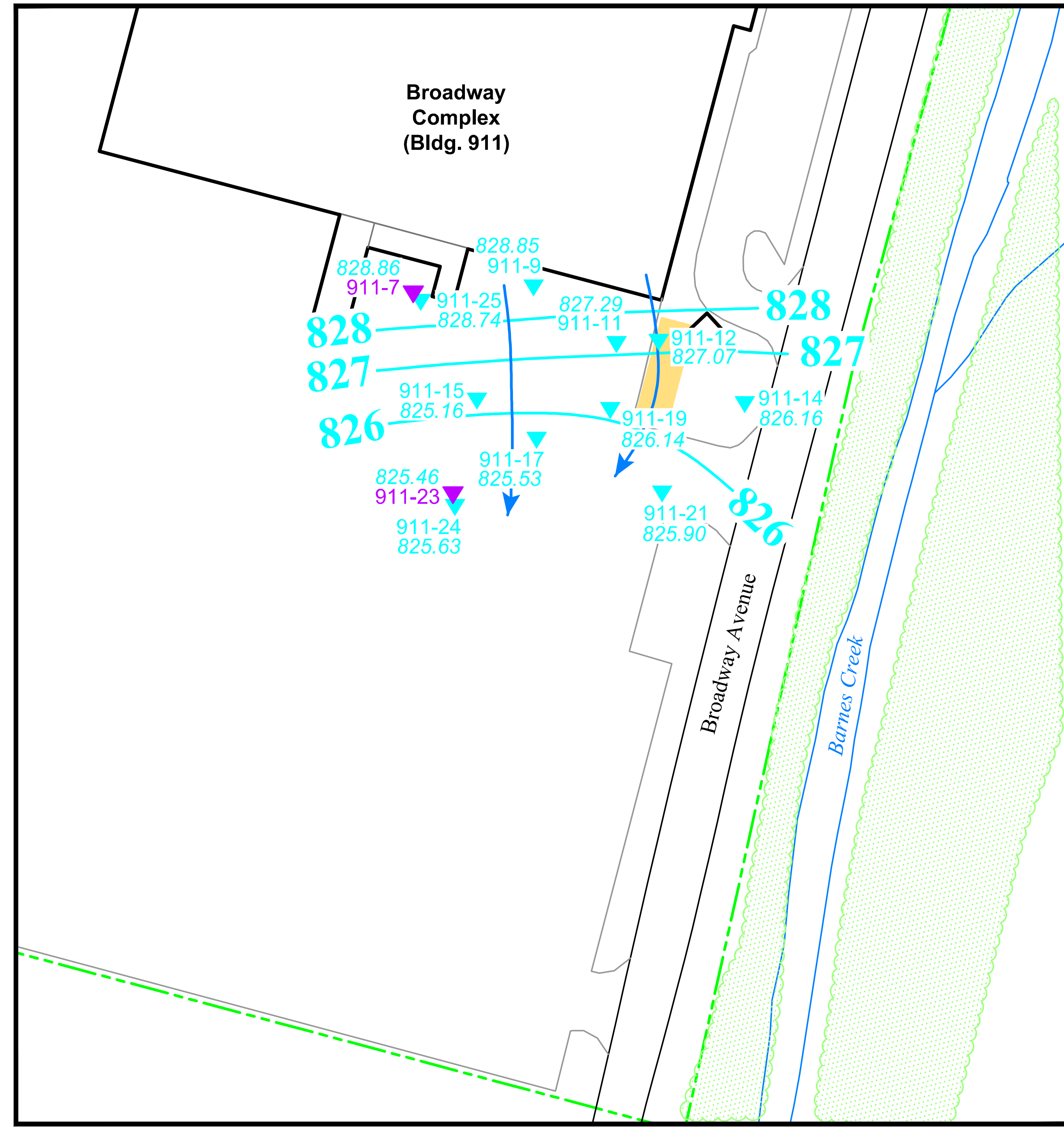
Glacial Till Surface
Elevation Contour Map

DRAWN BY: JPB	DATE: 8/29/13	DRAWING NO.
CHECKED & APPROVED BY: RCW		29003-019-B1

GROUNDWATER SCIENCES CORPORATION



Shallow Wells - Alluvium



Deep Wells - Alluvium

Figure 3-4

LEGEND

- Shallow Groundwater Monitoring Well
- Intermediate Groundwater Monitoring Well
- Deep Groundwater Monitoring Well
- Staff Gauge
- Property Line (approx.)
- Approx. Location of Former Septic Tank Excavation
- (829.44) - Surface Water Elevation (feet amsl)
- 827.26 - Potentiometric Water Level Elevation (feet amsl)
- 824 - Groundwater Elevation Contour (feet)
- Inferred Direction of Groundwater Flow

Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).

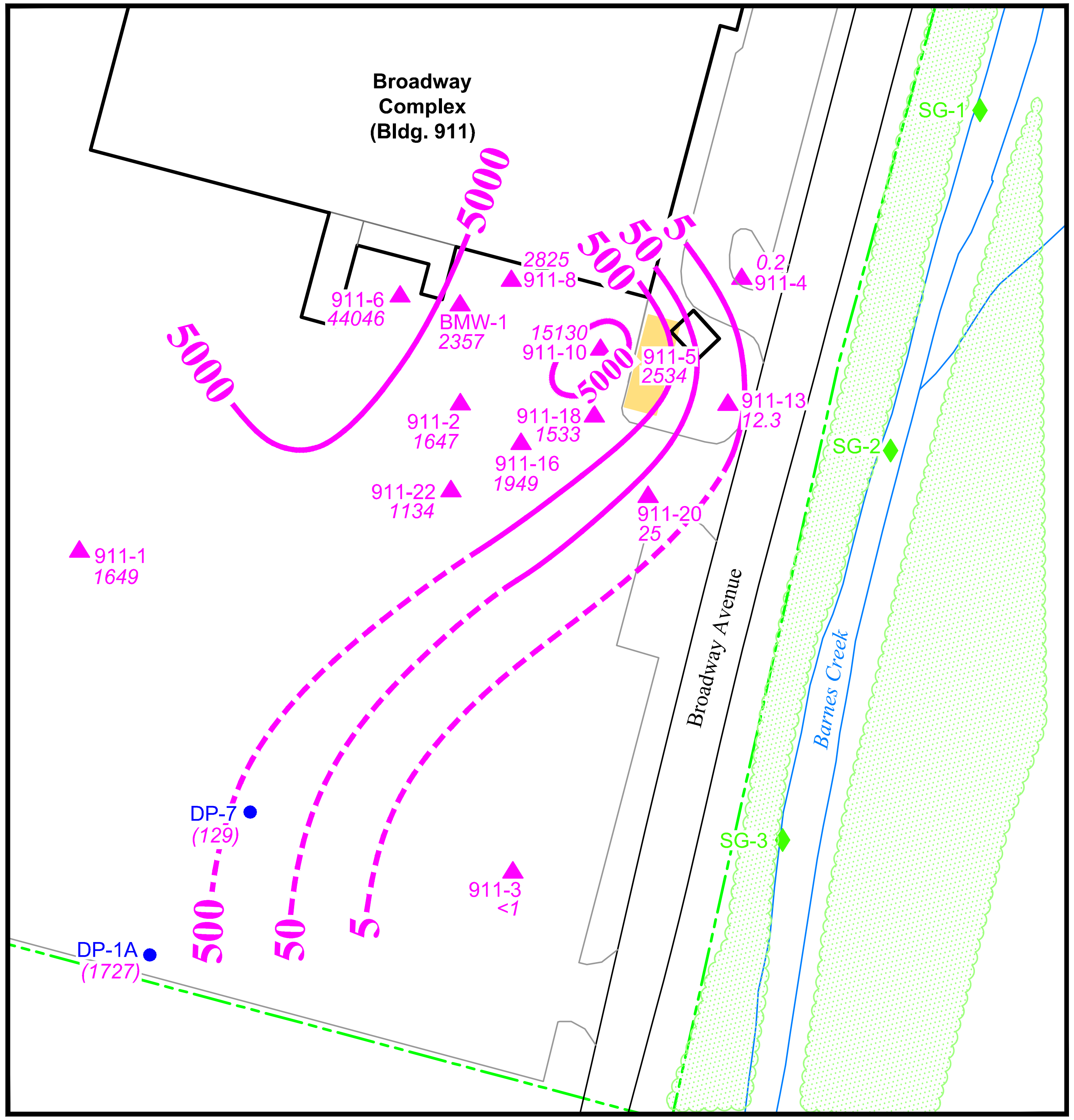
Scale
0 30' 60'

IBM
Corporate Environmental Affairs

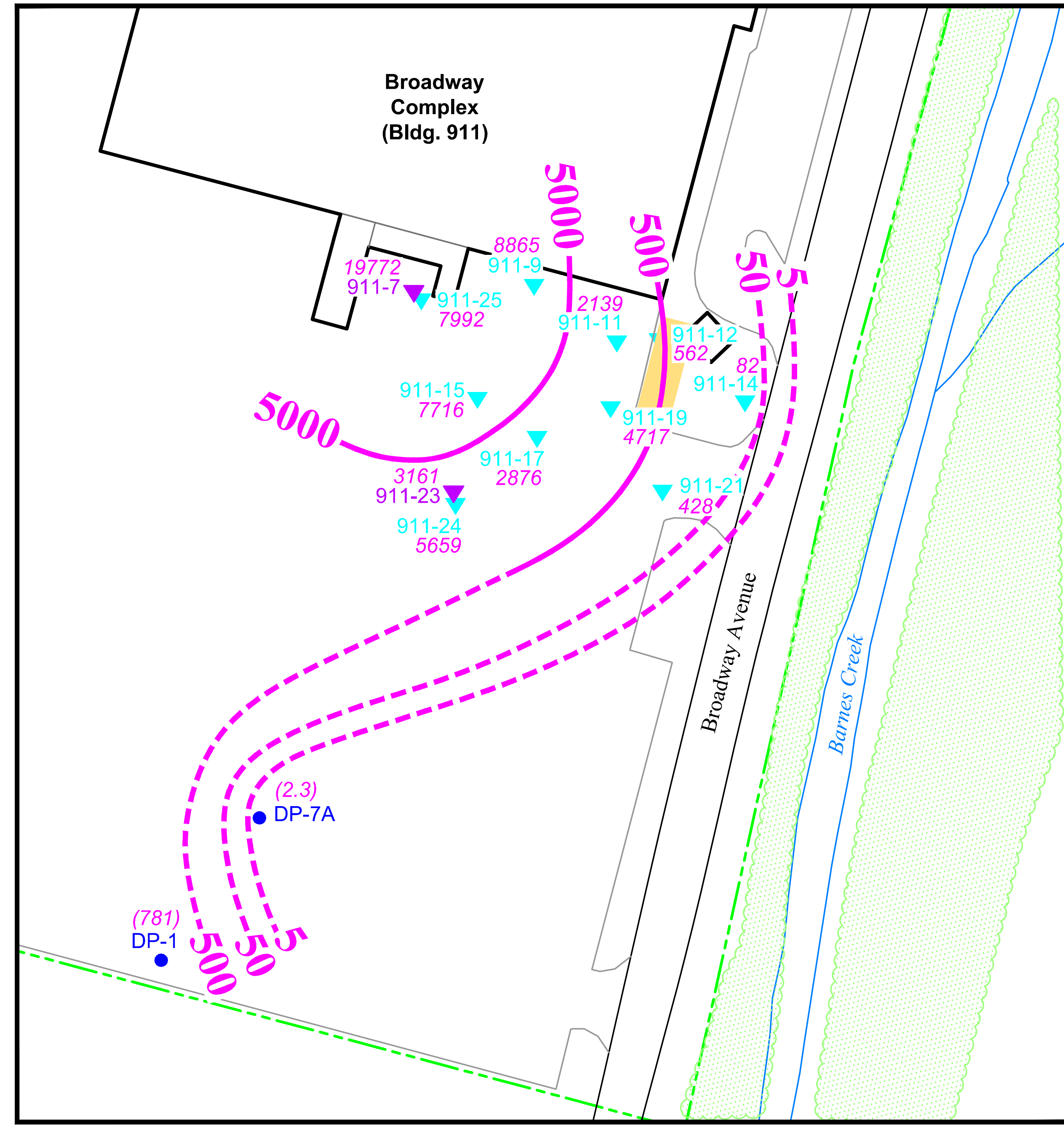
Groundwater Elevation Contour Maps
March 22, 2010

DRAWN BY: MHM/JPB	DATE: 8/29/13	DRAWING NO.
CHECKED & APPROVED BY: RCW		29003-004-B1

GROUNDWATER SCIENCES CORPORATION



Shallow Wells - Alluvium



Deep Wells - Alluvium

Figure 3-5

LEGEND

- Shallow Groundwater Monitoring Well
- Intermediate Groundwater Monitoring Well
- Deep Groundwater Monitoring Well
- Staff Gauge
- Direct-Push Groundwater Sampling Probe (April 2008)
- Property Line (approx.)
- Approx. Location of Former Septic Tank Excavation

1649 - TCE-Series Concentration (µg/l)

(129) - TCE-Series Concentration (µg/l; April 2008)

50 - TCE-Series Isoconcentration Contour (µg/l, dashed where inferred)

Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).

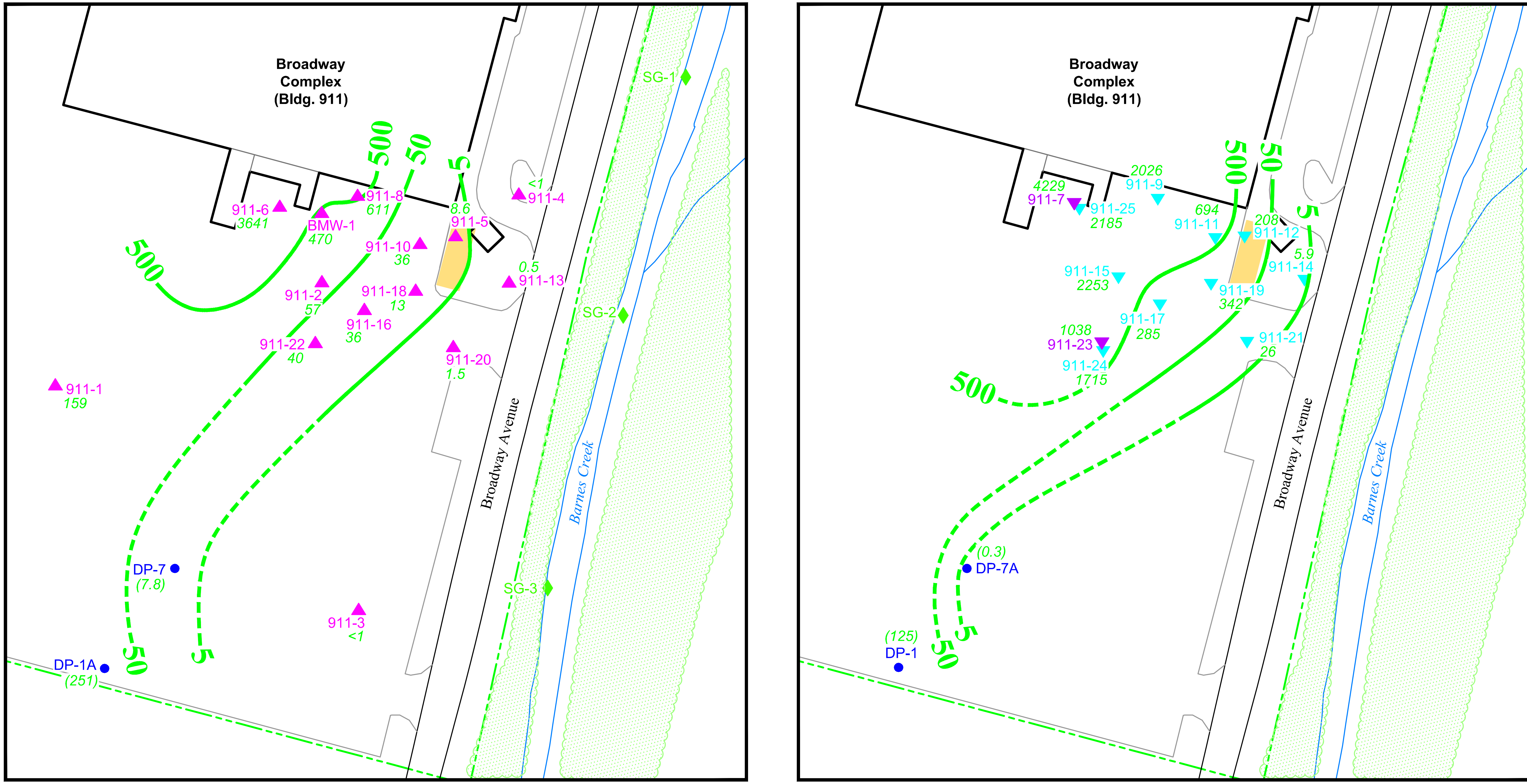
Scale
0 30' 60'

IBM
Corporate Environmental Affairs

TCE-Series Isoconcentration Contour Maps
March 22 and 23, 2010

DRAWN BY: MHM/JPB	DATE: 8/29/13	DRAWING NO.
CHECKED & APPROVED BY: RCW		29003-005-B1

GROUNDWATER SCIENCES CORPORATION



Shallow Wells - Alluvium

Deep Wells - Alluvium

Figure 3-6

LEGEND

- Shallow Groundwater Monitoring Well
- Intermediate Groundwater Monitoring Well
- Deep Groundwater Monitoring Well
- Staff Gauge
- Direct-Push Groundwater Sampling Probe (April 2008)
- Property Line (approx.)
- Approx. Location of Former Septic Tank Excavation

159 - TCA-Series Concentration (µg/l)

(7.8) - TCA-Series Concentration (µg/l; April 2008)

50 - TCA-Series Isoconcentration Contour (µg/l, dashed where inferred)

Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).

Scale 0 30' 60'

IBM Corporate Environmental Affairs

TCA-Series Isoconcentration Contour Maps
March 22 and 23, 2010

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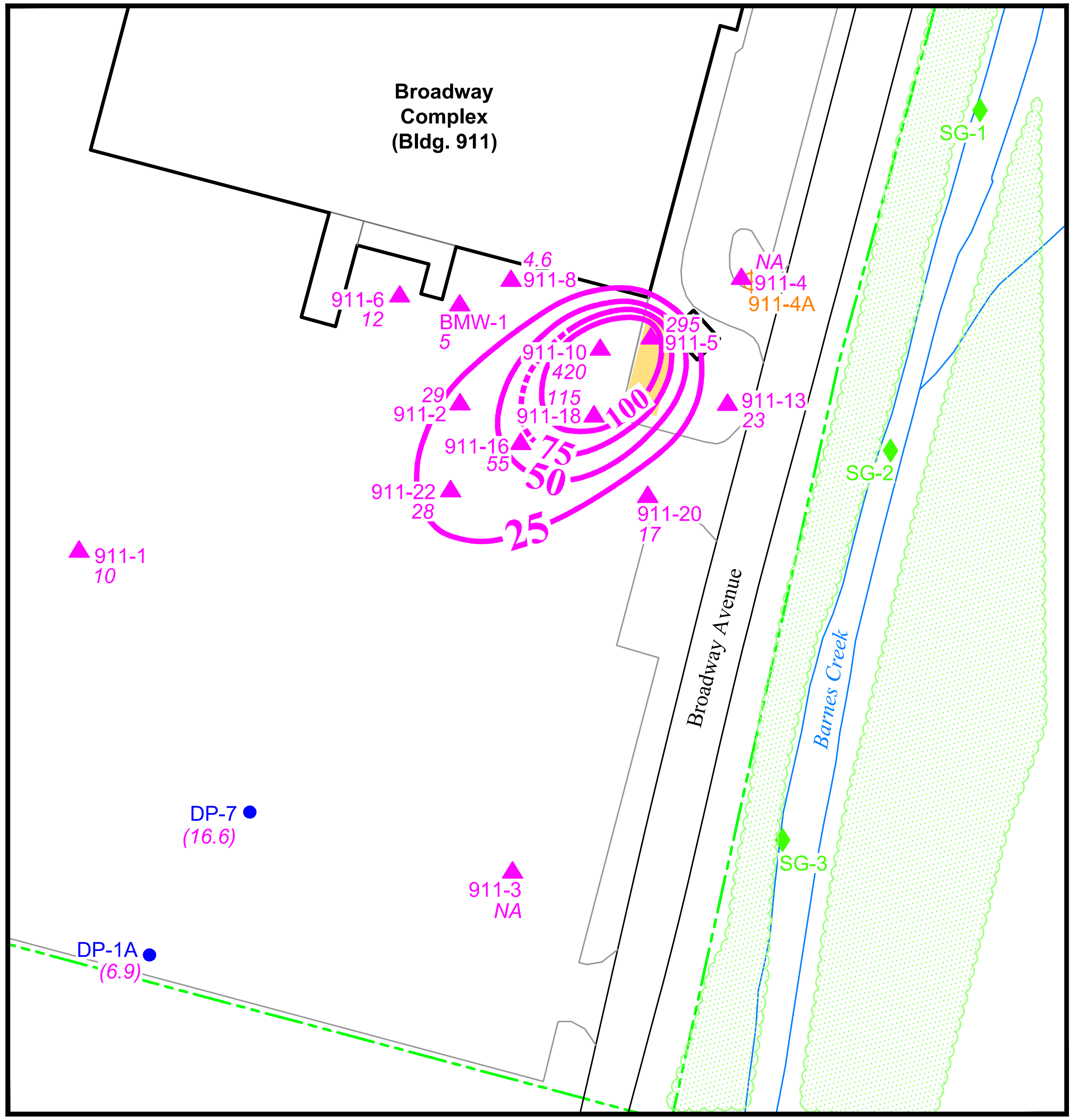
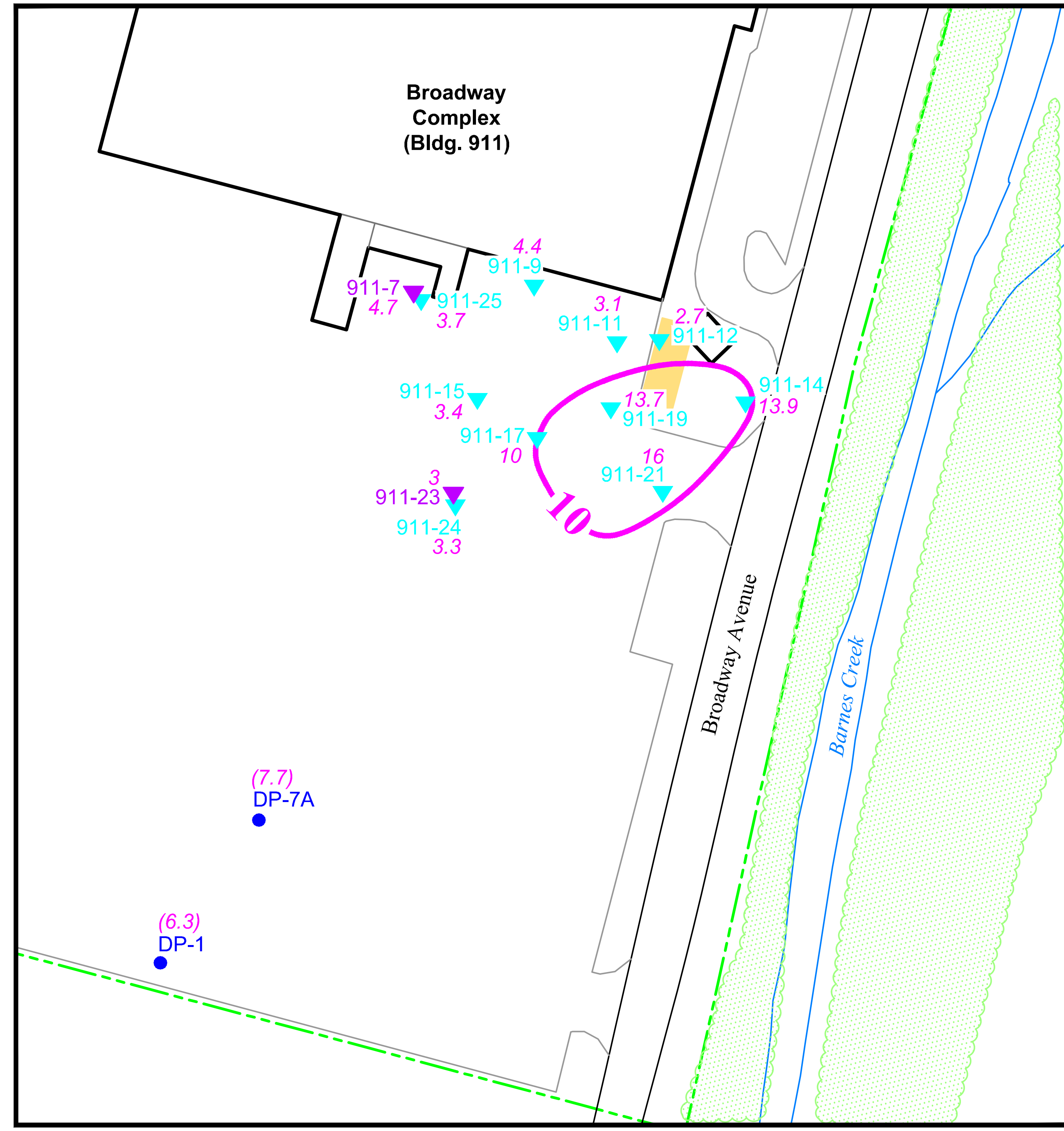
CHECKED & APPROVED BY: RCW		29003-006-B1

GROUNDWATER SCIENCES CORPORATION



Shallow Wells - Alluvium



Deep Wells - Alluvium

LEGEND

- Shallow Groundwater Monitoring Well
- Intermediate Groundwater Monitoring Well
- Deep Groundwater Monitoring Well
- Staff Gauge
- Direct-Push Groundwater Sampling Probe (April 2008)
- Property Line (approx.)
- Approx. Location of Former Septic Tank Excavation

10 - TCE-Series/TCA-Series Ratio
(16.6) - TCE-Series/TCA-Series Ratio (April 2008)
NA - Not Applicable
25 - TCE-Series/TCA-Series Ratio Contour

Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).

Scale
0 30' 60'

Figure 3-7

IBM
Corporate Environmental Affairs

TCE-Series/TCA-Series Ratios
March 22 and 23, 2010

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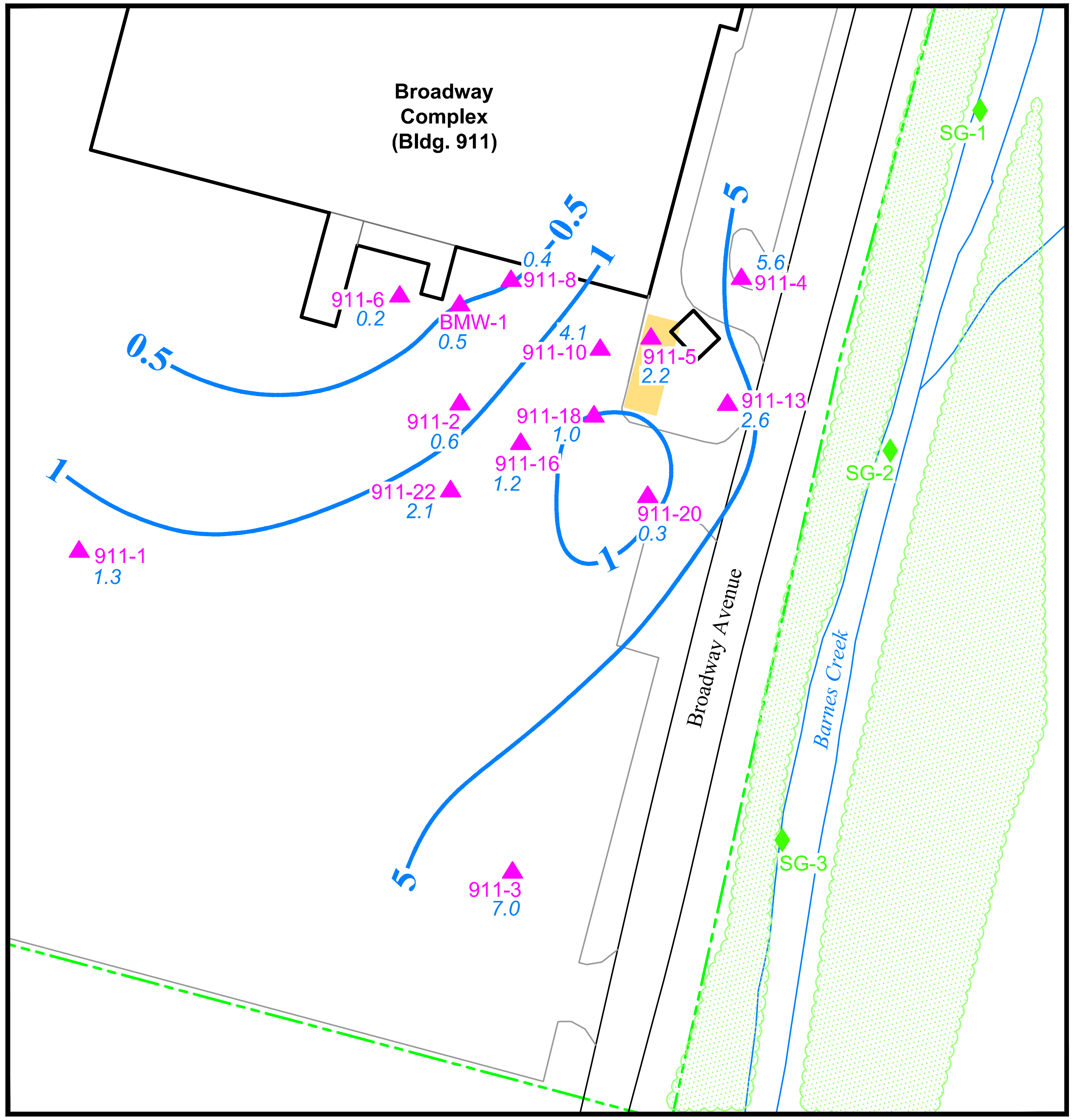
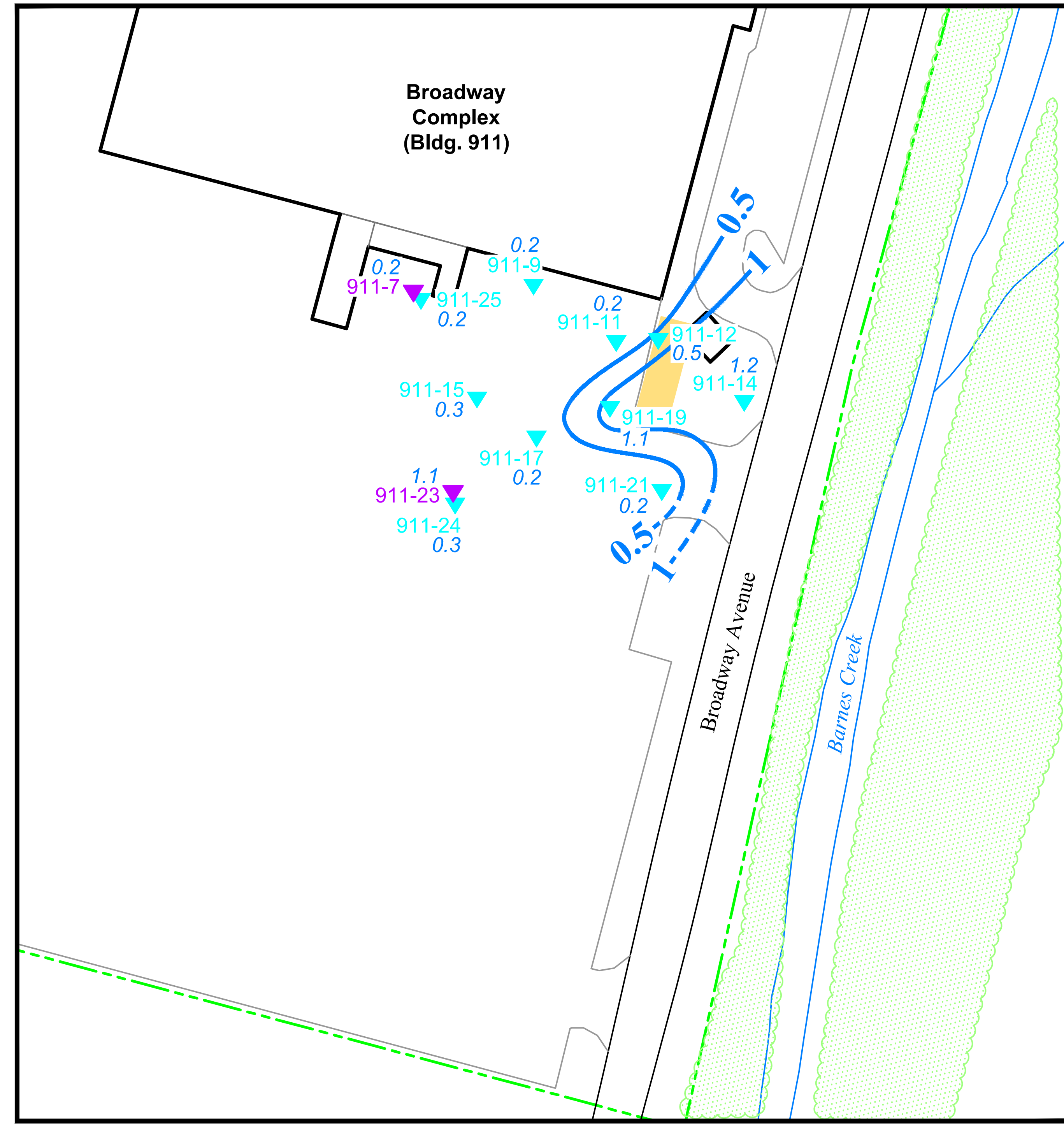
CHECKED & APPROVED BY: RCW		

GROUNDWATER SCIENCES CORPORATION



Shallow Wells - Alluvium



Deep Wells - Alluvium

Figure 3-8

LEGEND

- 1 - Dissolved Oxygen Isooncentration Contour (mg/L)
- *0.3* - Dissolved Oxygen Concentration (mg/L)
- ▲ - Shallow Groundwater Monitoring Well
- ▼ - Intermediate Groundwater Monitoring Well
- ▼ - Deep Groundwater Monitoring Well
- ◆ - Staff Gauge
- - Property Line (approx.)
- - Approx. Location of Former Septic Tank Excavation

Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).

Scale
0 30' 60'

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Corporate Environmental Affairs

Dissolved Oxygen
Isoconcentration Contour Maps
March 29-31, 2010

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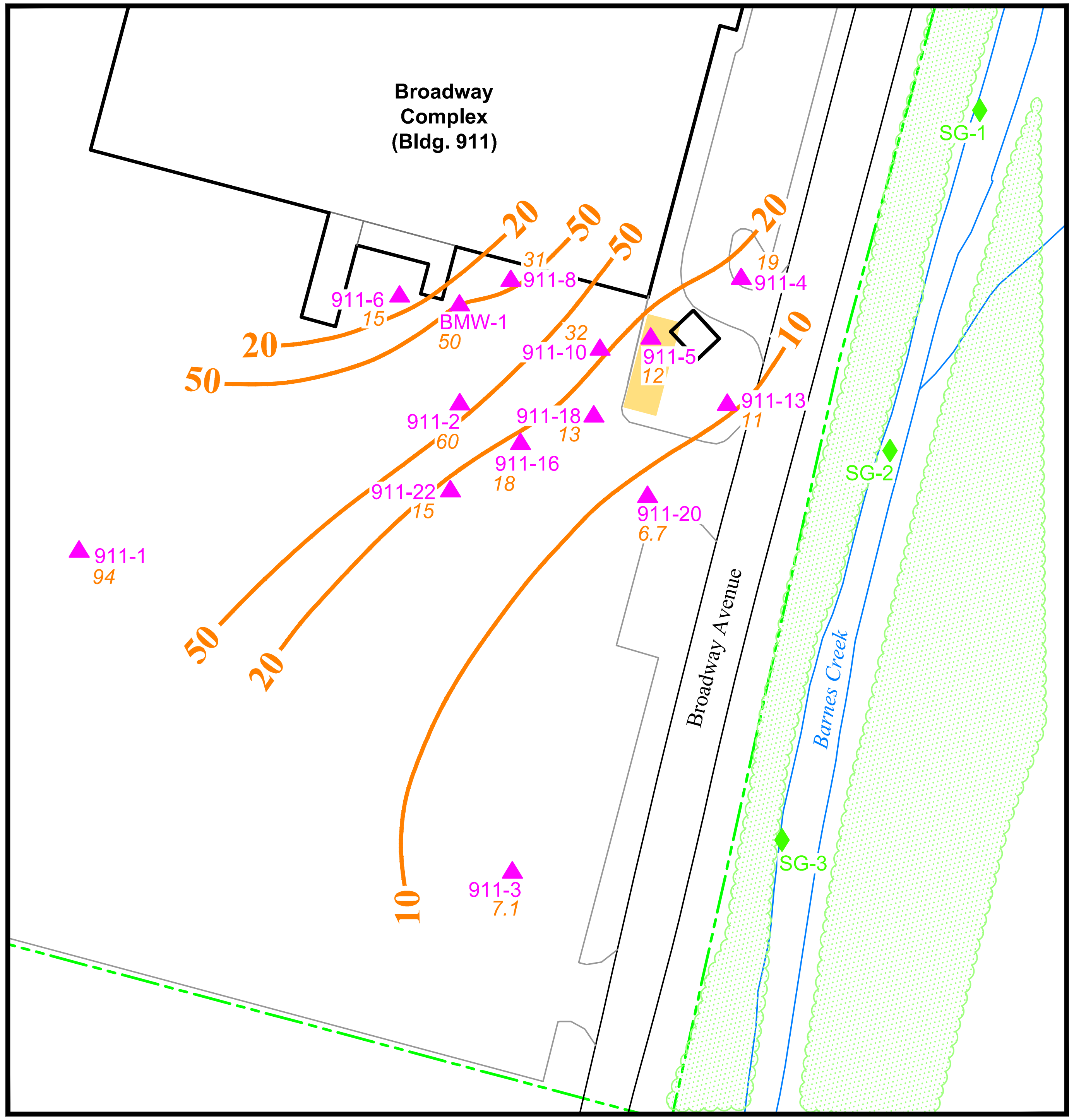
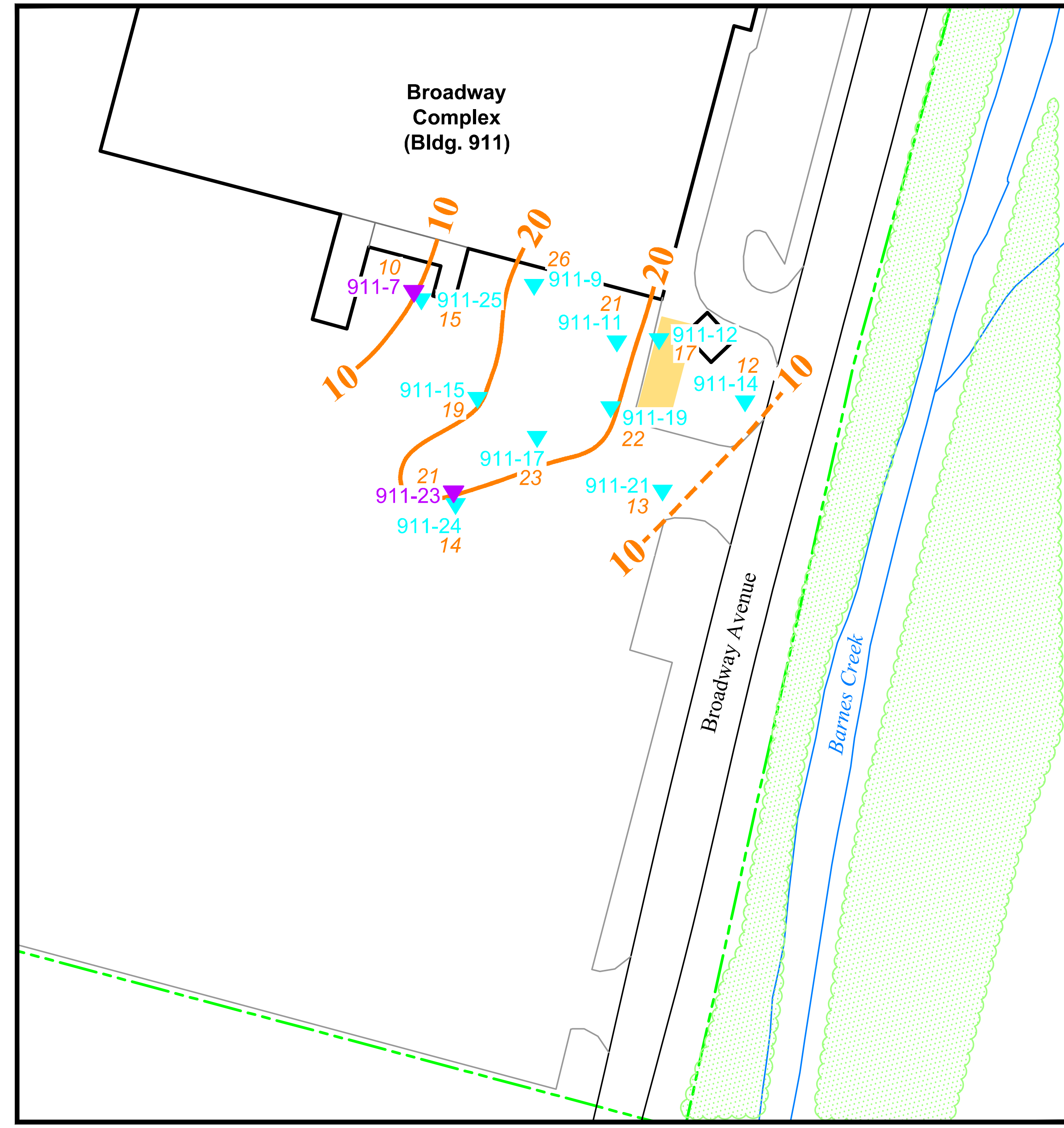
CHECKED & APPROVED BY: RCW		29003-009-B1

GROUNDWATER SCIENCES CORPORATION



Shallow Wells - Alluvium



Deep Wells - Alluvium

Figure 3-9

LEGEND

- 5 - Nitrate Isoconcentration Contour (mg/L)
- 6.7 - Nitrate Concentration (mg/L)
- Shallow Groundwater Monitoring Well
- Intermediate Groundwater Monitoring Well
- Deep Groundwater Monitoring Well
- Staff Gauge
- Property Line (approx.)
- Approx. Location of Former Septic Tank Excavation

Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).

Scale
0 30' 60'

IBM
Corporate Environmental Affairs

Nitrate Isoconcentration Contour Maps
March 29-31, 2010

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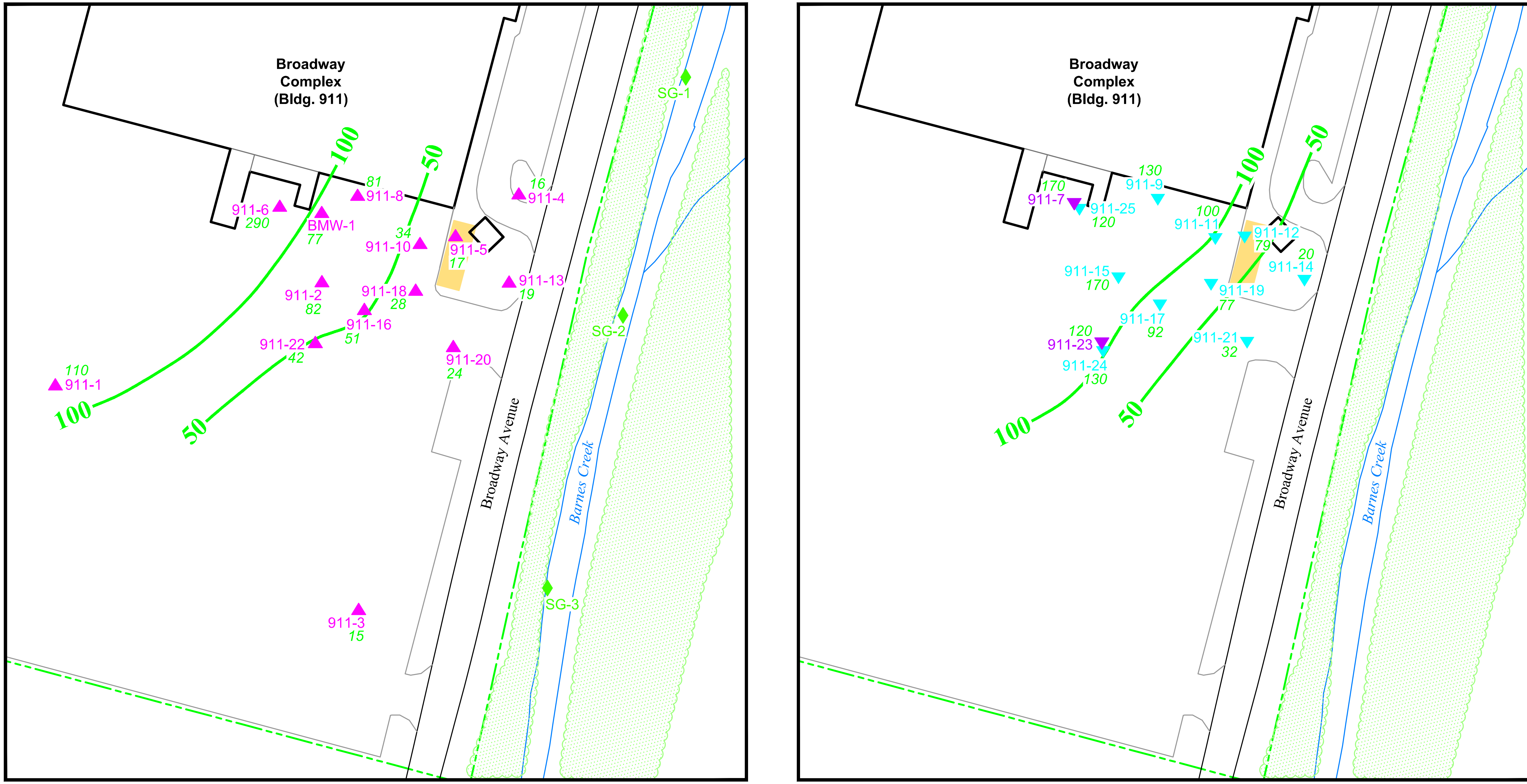
CHECKED & APPROVED BY: RCW		29003-010-B1

GROUNDWATER SCIENCES CORPORATION



Shallow Wells - Alluvium

Deep Wells - Alluvium

Figure 3-10

LEGEND

- 50 - Sulfate Isoconcentration Contour (mg/L)
- 24 - Sulfate Concentration (mg/L)
- ▲ - Shallow Groundwater Monitoring Well
- ▼ - Intermediate Groundwater Monitoring Well
- ▼ - Deep Groundwater Monitoring Well
- ◆ - Staff Gauge
- - - Property Line (approx.)
- Approx. Location of Former Septic Tank Excavation

Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).

Scale
0 30' 60'

IBM
Corporate Environmental Affairs

Sulfate Isoconcentration Contour Maps
March 29-31, 2010

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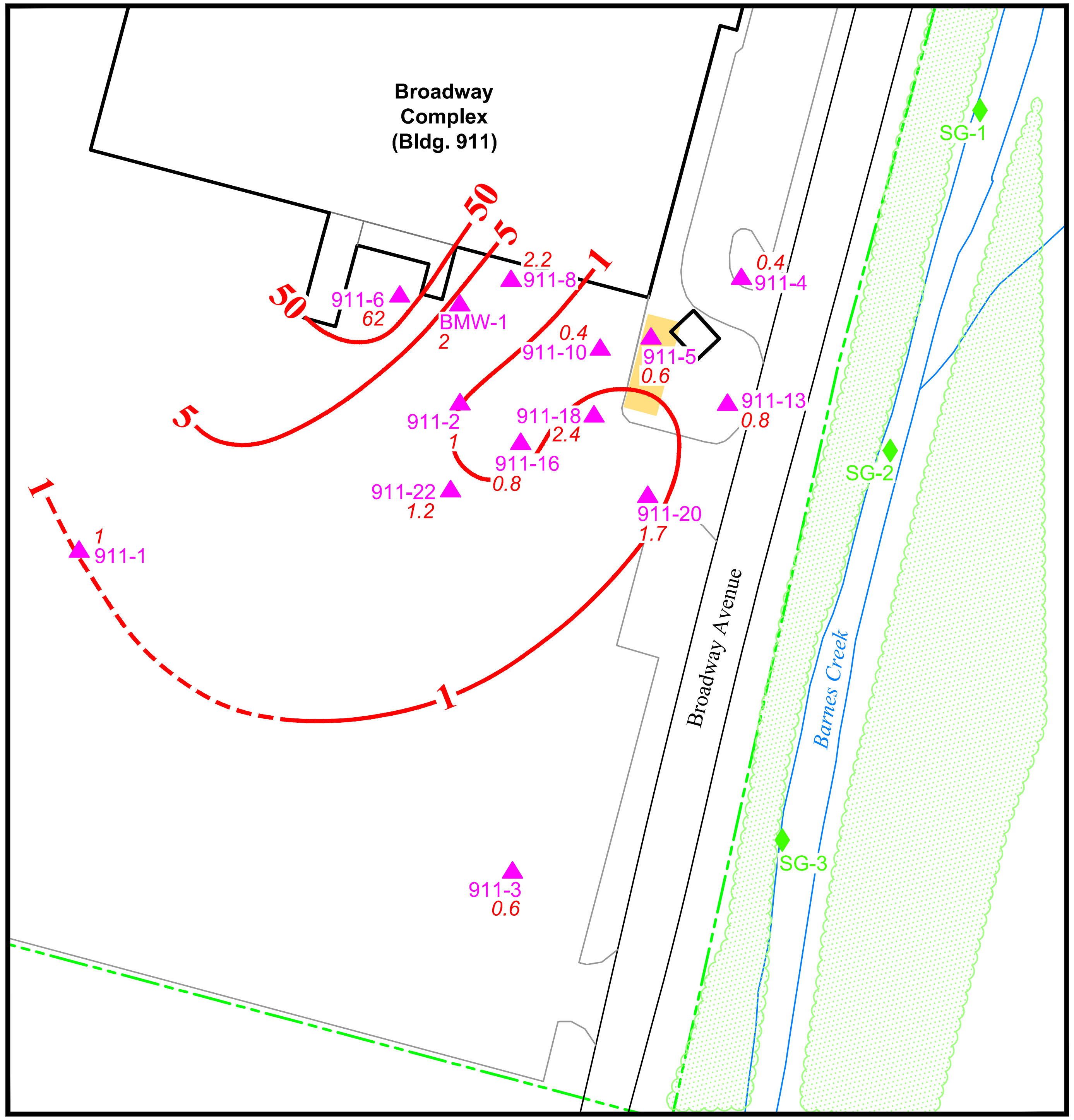
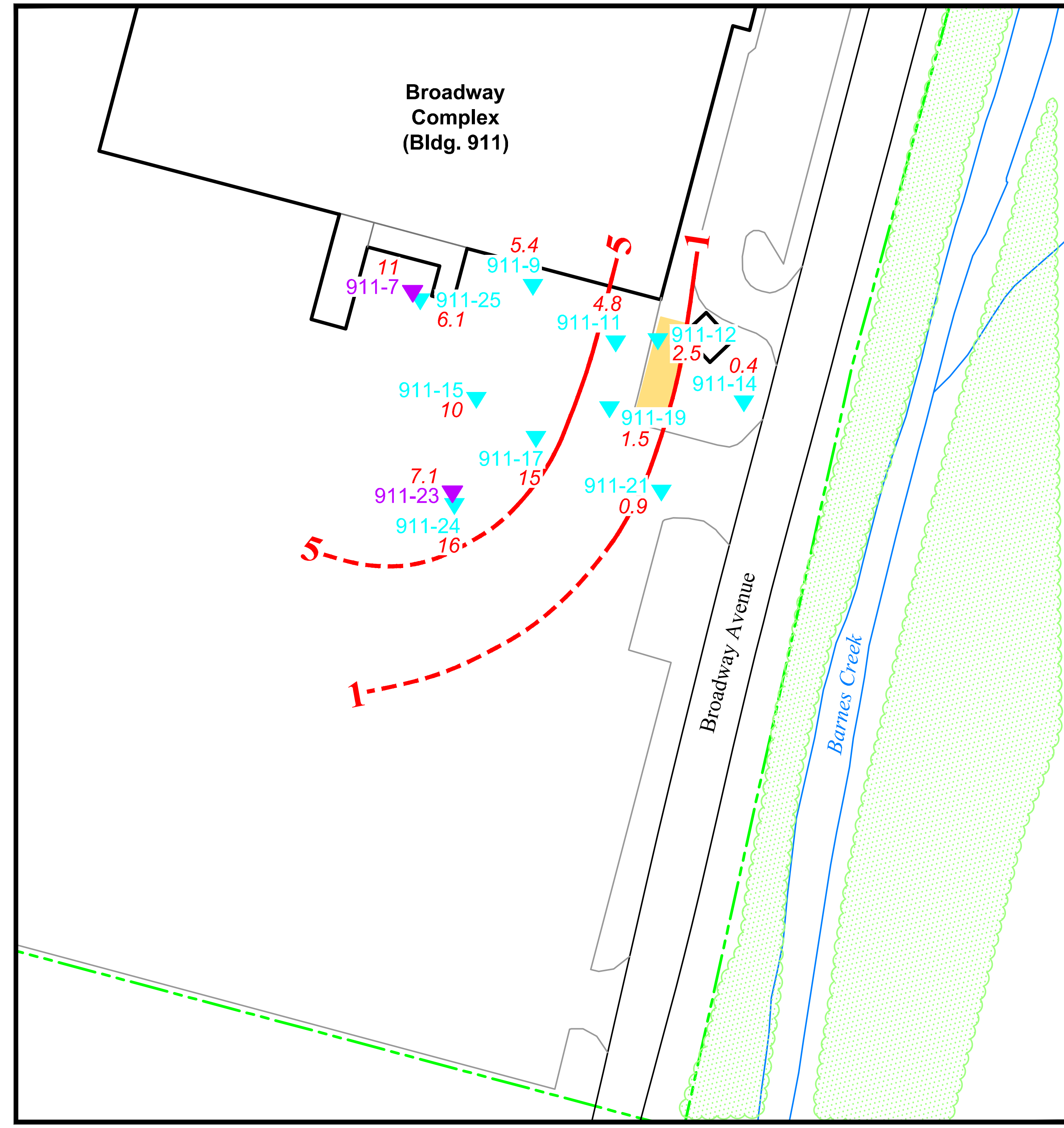
GROUNDWATER SCIENCES CORPORATION



Shallow Wells - Alluvium



Deep Wells - Alluvium

Figure 3-11

LEGEND

- 1 - Methane Isoconcentration Contour (mg/L)
- 1.2 - Methane Concentration (mg/L)
- Shallow Groundwater Monitoring Well
- Intermediate Groundwater Monitoring Well
- Deep Groundwater Monitoring Well
- Staff Gauge
- Property Line (approx.)
- Approx. Location of Former Septic Tank Excavation

Original photogrammetric digital mapping by L. Robert Kimball & Associates, Inc. (Ebensburg, PA; dated August 1995). Property lines from Tioga County GIS (2013).

Scale
0 30' 60'

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Corporate Environmental Affairs

Methane Isoconcentration Contour Maps
March 29-31, 2010

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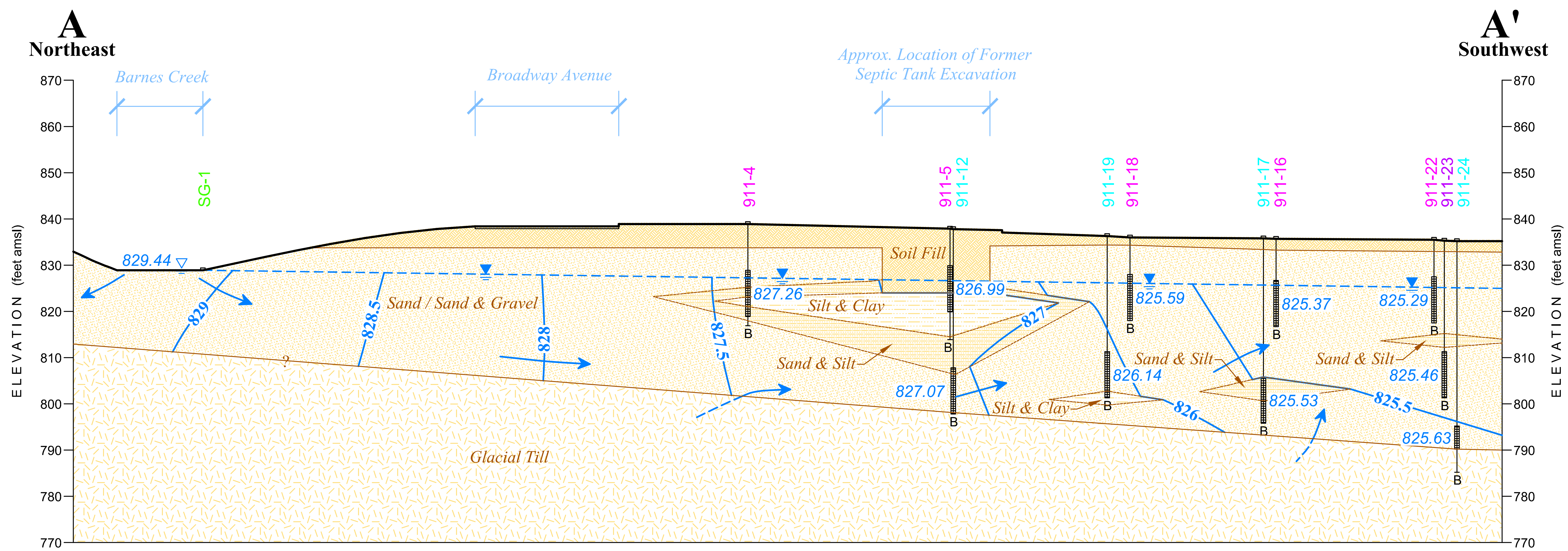
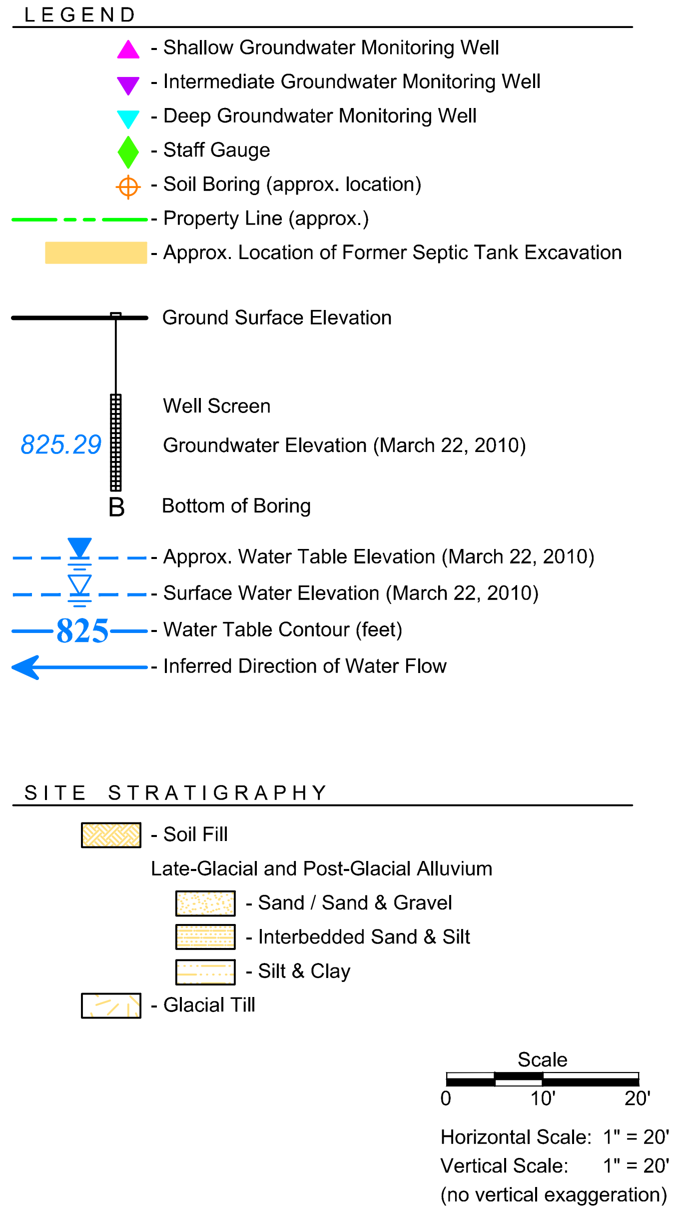
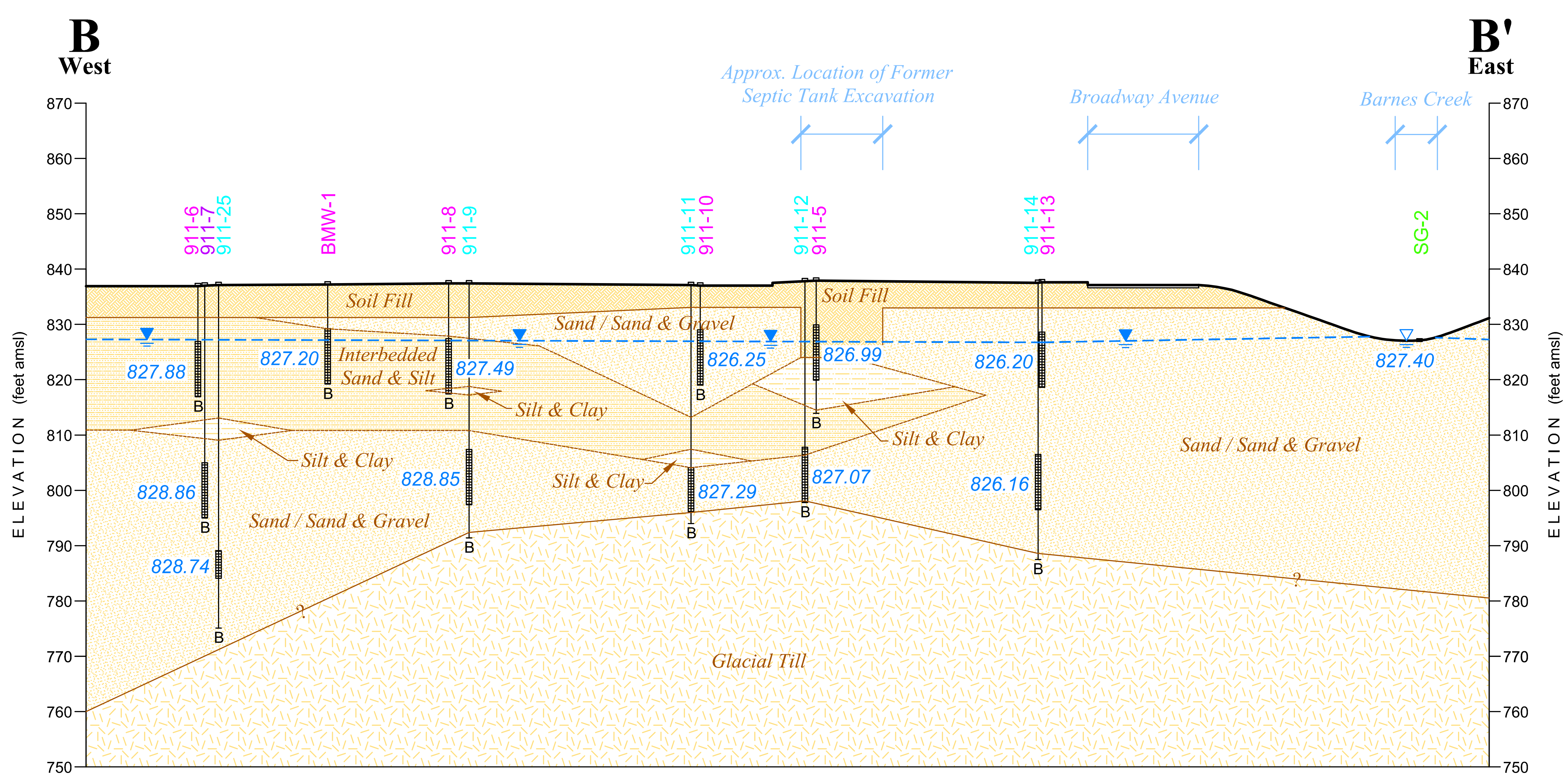
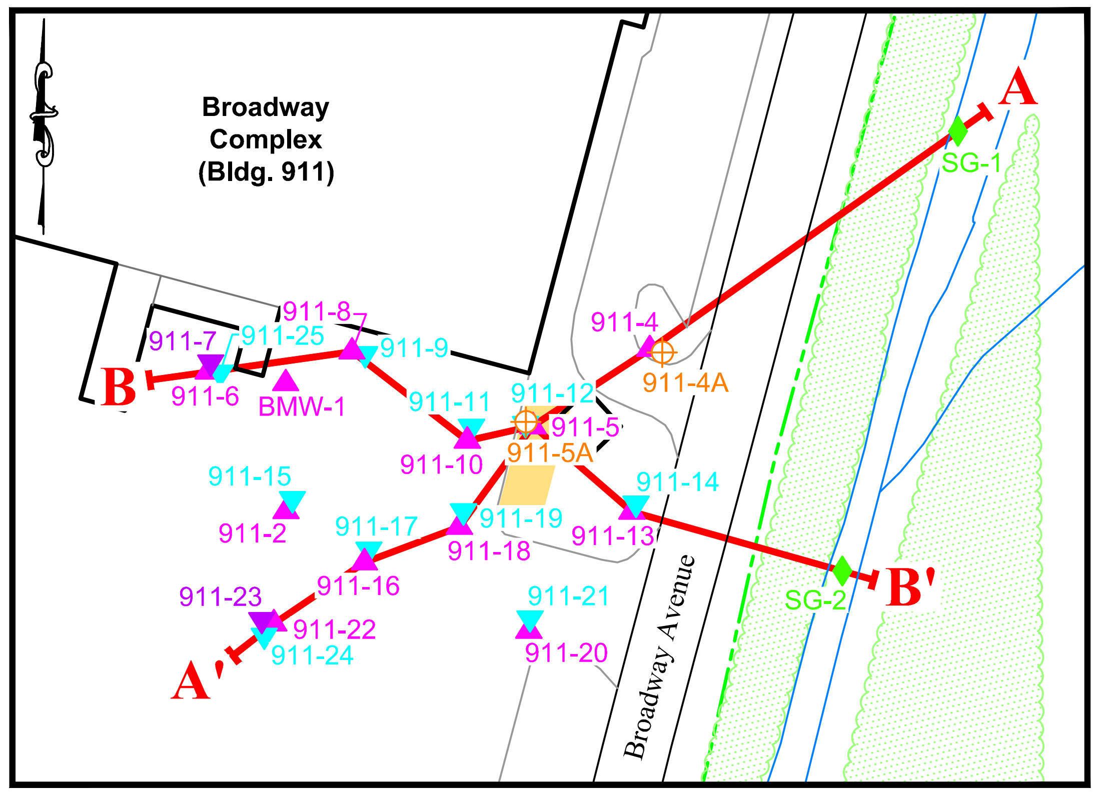
CHECKED & APPROVED BY: RCW		29003-012-B1

GROUNDWATER SCIENCES CORPORATION









Cross Section Location Map (1"=60')

Plate 3-1

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Corporate Environmental Affairs

Cross Sections A-A' and B-B'

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CHECKED & APPROVED BY: RCW		29003-CS02-1

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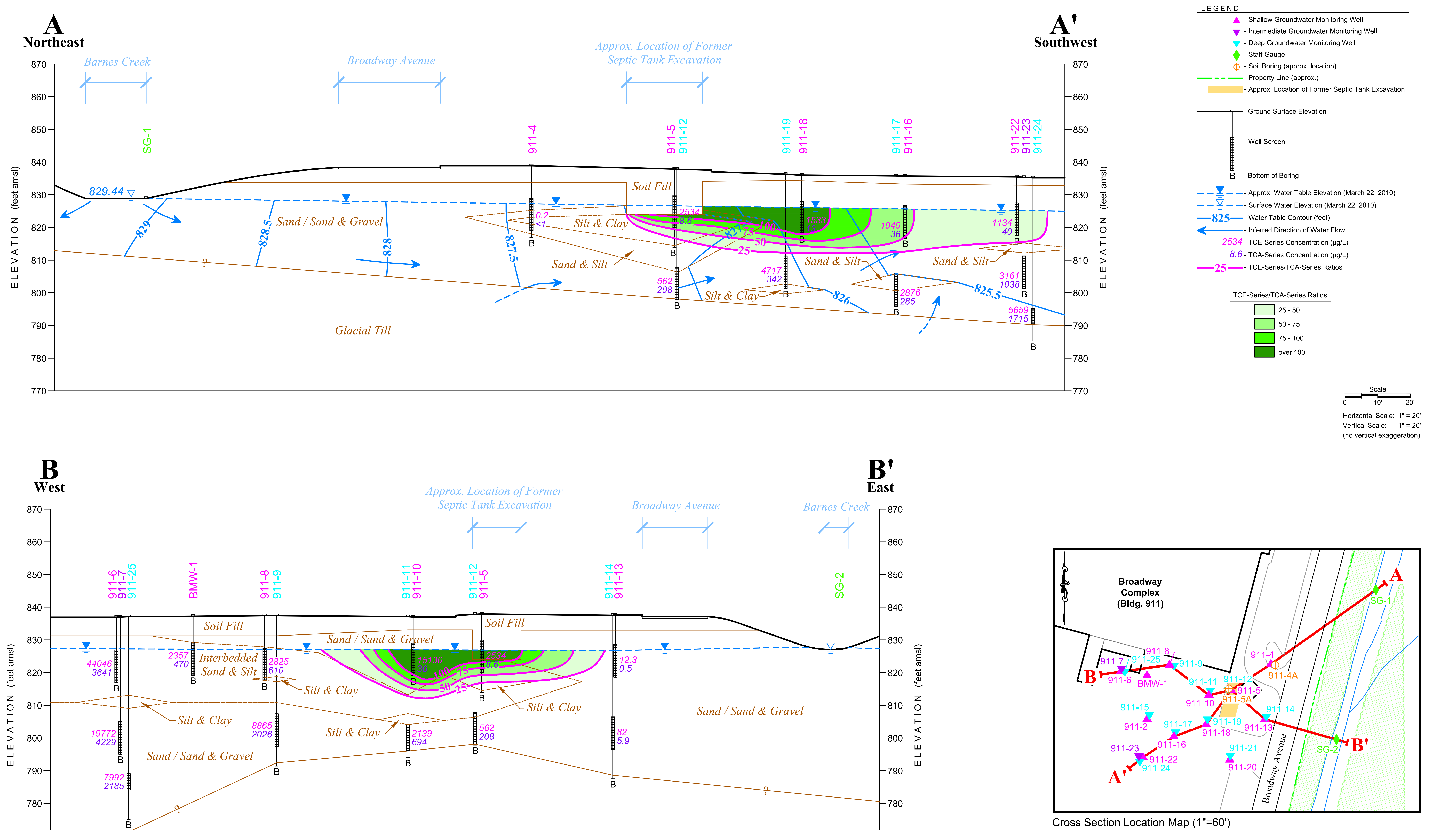

Cross Section Location Map (1"=60')

Plate 3-2

IBM
Corporate Environmental Affairs

Cross Sections A-A' and B-B'
TCA- and TCE-Series Concentrations/Ratios

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GROUNDWATER SCIENCES CORPORATION

Appendix A

Limitations

APPENDIX A

LIMITATIONS

1. The findings and conclusions contained in this report are based, in part, on our interpretation of data and information obtained by others as presented in reports and files made available to GSPC for review. As additional data becomes available, it may be necessary to re-evaluate the findings and conclusions of this report.

2. In preparing this report, GSPC has relied on various sources of information as specified in the report text. Although there may have been some degree of overlap in the information extracted by the various sources, GSPC did not attempt to independently verify the accuracy or completeness of the information reviewed during the course of this evaluation.

3. The generalized soil profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed in part on the data obtained from soil and groundwater samples from subsurface explorations observed and logged by Groundwater Sciences Corporation (GSC) or others. The nature and extent of variations between these explorations may not become evident until further investigation or remediation.

4. Water level measurements have been recorded by GSC at times and under conditions stated within the text of this report. Note that fluctuations in the level of the groundwater may occur due to variations in rainfall and other factors not evident at the time measurements were made.

5. The findings and conclusions contained in this report are based, in part, upon various types of chemical data as well as historical and hydrogeologic information developed by previous investigators. While GSPC has reviewed that data and information as stated in this report, any of GSPC's findings and conclusions that have relied on that information will be contingent on its validity. Should additional chemical data, historical information, or hydrogeologic information become available in the future, such information should be reviewed by GSPC and the findings and conclusions presented herein may be modified accordingly.

6. Sampling and quantitative laboratory testing was performed by GSC or others as noted within the report. Where such analyses have been conducted by an outside laboratory, GSPC has relied upon the data provided, and has not conducted an independent evaluation of the reliability of these data.

7. This report has been prepared for, and is intended for the exclusive use of the IBM Corporation. The contents of this report should not be relied upon by any other party other without the express written consent of IBM and GSPC. No other warranty, express or implied, is made.

8. In the event that any changes in the nature, design, or location of the facilities are planned, the findings and conclusions contained in this report should not be considered valid unless the changes are reviewed and findings and conclusions of this report modified or verified in writing by GSPC. GSPC is not responsible for any claims, damages, or liability associated with interpretation of subsurface data or re-use of the subsurface data without the express written authorization of GSPC.

App A Limitations 11Oct2013.doc

Appendix B

Physical Data

Appendix B.1

Physical Data Summary Table

(SSI Report, April 2011)

TABLE C-1

PHYSICAL DATA SUMMARY - MONITORING WELLS, SOIL BORINGS, AND STAFF GAUGES

Supplemental Site Investigation

Broadway Complex Site, Owego, New York

Well ID	Northing	Easting	M.P./ TOC Elevation	G.S. Elevation	Stickup	Surface Completion	Installation Date	Stratum Screened	Drilled Depth	Casing Depth	Boring Diameter	Depth to Screen Top	Depth to Screen Bottom	Screen Length	Screen Diameter	Slot Size	Screen Material	Casing Diameter	Casing Material	Depth to Top of Till	Top of Till Elevation
	(grid feet)	(grid feet)	(ft amsl)	(ft amsl)	(feet)				(ft bgs)	(ft bgs)	(in)	(ft bgs)	(ft bgs)	(ft)	(in)	(in)		(in)		(ft bgs)	(ft amsl)
Groundwater Monitoring Well																					
911-1	766235.5	916455.1	832.56	832.9	-0.44	MH	14-Jan-98	Shallow Alluvium	19.0	19.0	8.0	9.0	19.0	10.0	2.0	0.010	PVC	2.0	PVC	NE	NA
911-2	766295.1	916609.2	835.71	836.1	-0.39	MH	13-Jan-98	Shallow Alluvium	20.0	20.0	8.0	10.0	20.0	10.0	2.0	0.010	PVC	2.0	PVC	NE	NA
911-3	766106.0	916630.2	831.69	832.0	-0.31	MH	14-Jan-98	Shallow Alluvium	17.0	17.0	8.0	7.0	17.0	10.0	2.0	0.010	PVC	2.0	PVC	NE	NA
911-4	766345.7	916722.7	838.53	838.9	-0.37	MH	23-Jul-98	Shallow Alluvium	22.0	20.0	8.0	10.0	20.0	10.0	2.0	0.010	PVC	2.0	PVC	NE	NA
911-5	766321.6	916686.2	837.49	837.9	-0.41	MH	23-Jul-98	Shallow Alluvium	24.0	18.0	8.0	8.0	18.0	10.0	2.0	0.010	PVC	2.0	PVC	NE	NA
911-6	766338.6	916584.8	836.62	836.9	-0.28	MH	15-Aug-09	Shallow Alluvium	20.0	20.0	8.0	10.0	20.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	NA
911-7	766341.6	916585.6	836.71	837.0	-0.29	MH	15-Aug-09	Deep Alluvium	42.0	42.0	8.0	32.0	42.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	NA
911-8	766344.9	916629.7	837.09	837.4	-0.31	MH	19-Aug-09	Shallow Alluvium	20.0	20.0	8.0	10.0	20.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	NA
911-9	766344.2	916633.8	837.03	837.4	-0.37	MH	18-Aug-09	Deep Alluvium	46.0	40.0	8.0	30.0	40.0	10.0	2.0	0.020	PVC	2.0	PVC	45.0	792.4
911-10	766317.1	916665.7	836.55	837.0	-0.45	MH	21-Aug-09	Shallow Alluvium	18.0	18.0	8.0	8.0	18.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	NA
911-11	766321.5	916667.0	836.84	837.1	-0.26	MH	21-Aug-09	Deep Alluvium	43.1	41.0	8.0	33.0	41.0	8.0	2.0	0.020	PVC	2.0	PVC	41.0	796.0
911-12	766322.4	916683.9	837.34	837.8	-0.46	MH	19-Aug-09	Deep Alluvium	40.0	40.0	8.0	30.0	40.0	10.0	2.0	0.020	PVC	2.0	PVC	39.0	798.1
911-13	766294.9	916717.1	837.13	837.6	-0.47	MH	13-Aug-09	Shallow Alluvium	19.0	19.0	8.0	9.0	19.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	NA
911-14	766297.5	916718.4	837.09	837.5	-0.41	MH	12-Aug-09	Deep Alluvium	50.0	41.0	8.0	31.0	41.0	10.0	2.0	0.020	PVC	2.0	PVC	49.0	788.6
911-15	766298.9	916611.1	835.91	836.2	-0.29	MH	14-Aug-09	Deep Alluvium	42.0	42.0	8.0	32.0	42.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	< 794.2
911-16	766279.1	916633.6	835.37	835.7	-0.33	MH	16-Aug-09	Shallow Alluvium	19.0	19.0	8.0	9.0	19.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	NA
911-17	766283.2	916635.0	835.53	835.8	-0.27	MH	16-Aug-09	Deep Alluvium	40.0	40.0	8.0	30.0	40.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	< 795.8
911-18	766290.2	916663.2	835.65	836.0	-0.35	MH	19-Aug-09	Shallow Alluvium	18.0	18.0	8.0	8.0	18.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	NA
911-19	766295.1	916664.5	835.82	836.3	-0.48	MH	19-Aug-09	Deep Alluvium	35.0	35.0	8.0	25.0	35.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	< 801.3
911-20	766257.7	916684.9	834.85	835.3	-0.45	MH	14-Aug-09	Shallow Alluvium	18.0	18.0	8.0	8.0	18.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	NA
911-21	766261.7	916685.3	834.97	835.4	-0.43	MH	13-Aug-09	Deep Alluvium	39.0	39.0	8.0	29.0	39.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	< 796.4
911-22	766260.0	916605.3	834.94	835.5	-0.56	MH	18-Aug-09	Shallow Alluvium	18.0	18.0	8.0	8.0	18.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	NA
911-23	766261.2	916601.5	834.86	835.3	-0.44	MH	18-Aug-09	Deep Alluvium	34.0	34.0	8.0	24.0	34.0	10.0	2.0	0.020	PVC	2.0	PVC	NE	NA
911-24	766256.3	916602.3	834.85	835.2	-0.35	MH	17-Aug-09	Deep Alluvium	50.0	45.0	8.0	40.0	45.0	5.0	2.0	0.020	PVC	2.0	PVC	45.0	790.3
911-25	766338.4	916588.6	836.71	837.1	-0.39	MH	20-Aug-09	Deep Alluvium	62.0	53.0	8.0	48.0	53.0	5.0	2.0	0.020	PVC	2.0	PVC	NE	< 775.1
BMW-1	766338.6	916619.7	836.75	837.2	-0.45	MH	unknown	Shallow Alluvium	~18	~18	8.0	~8	~18	~10	2.0	0.020	PVC	2.0	PVC	NE	NA
Soil Boring																					
911-4A	766345	916727	NA	838.9	NA	NA	17-Aug-09	NA	18.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NA
911-5A	766323	916684	NA	837.8	NA	NA	22-Jul-10	NA	17.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NA
Surface Water Staff Gauge																					
SG-1	766413.8	916818.9	832.62	829.2	NA	metal stake	11-Aug-09	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SG-1 (reinstall)	*766414.1*	*916818.9*	*832.00*	*828.9*	NA	metal stake	22-Mar-10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SG-2	766276.4	916782.8	828.99	826.9	NA	metal stake	11-Aug-09	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SG-2 (reinstall)	*766276.9*	*916782.8*	*830.16*	*826.9*	NA	metal stake	22-Mar-10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SG-3	766119.1	916739.2	828.41	825.0	NA	metal stake	11-Aug-09	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SG-3 (reinstall)	*766117.8*	*916741.2*	*827.97*	*824.9*	NA	metal stake	22-Mar-10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Former IBM Owego "Group 3" Wells																					
160	765642.58	916618.61	824.31	821.63	2.68	Stand Pipe	09/17/86	Deep Overburden	61.0	59.5	8.0	49.5	59.5	10.0	4.0	0.020	PVC	4.0	PVC	~55	NA
161	765648.60	916615.27	824.95	821.79	3.16	Stand Pipe	09/18/86	Shallow Alluvium	20.0	20	8.0	10.0	20.0	10.0	4.0	0.020	PVC	4.0	PVC	NA	NA
317	765642.24	916612.33	822.98	820.58	2.40	Stand Pipe	02/05/87	Deep Overburden/ Glacial Till	45.0	45	8.0	35.0	45.0	10.0	4.0	0.020	PVC	4.0	PVC	NA	NA

Notes:

Planar coordinates, measuring point elevations and ground surface elevations are based on a September 1, 2009 field location and elevation survey by Butler Land Surveying LLC (BLS) of Little Meadows, Pennsylvania.

Survey data for staff gauges SG-1 through SG-3 shown in italtics are based on a March 29, 2010 field location and elevation survey by BLS after the staff gauges were reinstalled by GSC on March 22, 2010.

Planar coordinates and ground surface elevations for soil borings 911-4A and 911-5A are estimated by GSC based on taped measurements to nearby monitoring wells.

Key:

M.P./TOC = measuring point / top of casing (groundwater elevation reference point)
G.S. = ground surface
ft bgs = feet below ground surface
ft amsl = feet above mean sea level
SP = Standpipe surface completion
MH = Flush-mount manhole surface completion
PVC = Polyvinyl Chloride
NA = Data not available or not applicable
NE = Glacial Till not encountered (Glacial Till believed to be present at greater depth)
< = less than

Appendix B.2

Groundwater Level Elevation Data Table

(SSI Report, April 2011)

TABLE 4-2
GROUNDWATER AND SURFACE WATER LEVEL ELEVATION DATA
Supplemental Site Investigation
Broadway Complex Site, Owego, New York

Well ID	Northing	Easting	M.P./ TOC Elevation	G.S. Elevation	Depth to Bottom	9/21/2009		10/26/2009		3/22/2010	
						Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation
	(grid feet)	(grid feet)	(ft amsl)	(ft amsl)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Broadway Complex Site - Shallow Alluvium Monitoring Wells											
911-1	766235.5	916630.2	832.56	832.9	18.07	9.48	823.08	9.33	823.23	8.97	823.59
911-2	766295.1	916609.2	835.71	836.1	19.47	10.87	824.84	10.68	825.03	10.46	825.25
911-3	766106.0	916630.2	831.69	832.0	15.96	7.06	824.63	6.91	824.78	6.98	824.71
911-4	766345.7	916722.7	838.53	838.9	19.80	11.81	826.72	11.50	827.03	11.27	827.26
911-5	766321.6	916686.2	837.49	837.9	17.58	10.81	826.68	10.63	826.86	10.50	826.99
911-6	766338.6	916584.8	836.62	836.9	19.20	10.18	826.44	10.20	826.42	8.74	827.88
911-8	766344.9	916629.7	837.09	837.4	19.97	10.81	826.28	10.68	826.41	9.60	827.49
911-10	766317.1	916665.7	836.55	837.0	17.78	10.90	825.65	10.60	825.95	10.30	826.25
911-13	766294.9	916717.1	837.13	837.6	17.80	11.50	825.63	11.20	825.93	10.93	826.20
911-16	766279.1	916633.6	835.37	835.7	18.50	10.36	825.01	10.17	825.20	10.00	825.37
911-18	766290.2	916663.2	835.65	836.0	17.61	10.48	825.17	10.25	825.40	10.06	825.59
911-20	766257.7	916684.9	834.85	835.3	16.92	9.52	825.33	9.25	825.60	9.05	825.80
911-22	766260.0	916605.3	834.94	835.5	17.33	10.02	824.92	9.88	825.06	9.65	825.29
BMW-1	766338.6	916619.7	836.75	837.2	17.65	10.69	826.06	10.56	826.19	9.55	827.20
Broadway Complex Site - Deep Alluvium Monitoring Wells											
911-7	766341.6	916585.6	836.71	837.0	41.04	9.36	827.35	9.36	827.35	7.85	828.86
911-9	766344.2	916633.8	837.03	837.4	39.70	9.66	827.37	9.66	827.37	8.18	828.85
911-11	766321.5	916667.0	836.84	837.1	37.22	10.51	826.33	10.33	826.51	9.55	827.29
911-12	766322.4	916683.9	837.34	837.8	38.47	11.06	826.28	10.96	826.38	10.27	827.07
911-14	766297.5	916718.4	837.09	837.5	38.60	11.51	825.58	11.21	825.88	10.93	826.16
911-15	766298.9	916611.1	835.91	836.2	40.72	10.80	825.11	10.71	825.20	9.75	826.16
911-17	766283.2	916635.0	835.53	835.8	38.80	10.42	825.11	10.31	825.22	10.00	825.53
911-19	766295.1	916664.5	835.82	836.3	34.24	10.28	825.54	10.04	825.78	9.68	826.14
911-21	766261.7	916685.3	834.97	835.4	39.17	9.57	825.40	9.35	825.62	9.07	825.90
911-23	766261.2	916601.5	834.86	835.3	33.80	10.07	824.79	9.96	824.90	9.40	825.46
911-24	766256.3	916602.3	834.85	835.2	44.80	10.04	824.81	9.92	824.93	9.22	825.63
911-25	766338.4	916588.6	836.71	837.1	52.36	9.54	827.17	9.50	827.21	7.97	828.74
Surface Water Staff Gauge											
SG-1	766413.8	916818.9	832.62	829.2	NA	3.22	829.40	3.00	829.62	NA	NA
SG-1 (reinstall)	*766414.1*	*916818.9*	*832.00*	*828.9*	NA	NA	NA	NA	NA	2.56	829.44
SG-2	766276.4	916782.8	828.99	826.9	NA	1.80	827.19	1.70	827.29	NA	NA
SG-2 (reinstall)	*766276.9*	*916782.8*	*830.16*	*826.9*	NA	NA	NA	NA	NA	2.76	827.40
SG-3	766119.1	916739.2	828.41	825.0	NA	3.15	825.26	2.92	825.49	NA	NA
SG-3 (reinstall)	*766117.8*	*916741.2*	*827.97*	*824.9*	NA	NA	NA	NA	NA	2.65	825.32
Former IBM Owego - Soil Monitoring Wells											
MW-160	765642.6	916618.6	824.31	821.6	58.46	NR	NA	NR	NA	11.01	813.30
MW-161	765648.6	916615.3	824.96	821.8	22.74	NR	NA	NR	NA	11.45	813.51
MW-163	765802.6	916749.6	825.40	823.8	25.49	NR	NA	NR	NA	9.44	815.96
MW-167	765175.2	916605.7	813.26	811.7	25.52	NR	NA	NR	NA	7.73	805.53
MW-179	765297.4	916931.4	818.32	815.6	71.51	NR	NA	NR	NA	33.58	784.74
MW-316	765161.3	916608.8	813.46	812.0	48.99	NR	NA	NR	NA	22.00	791.46
MW-317	765642.2	916612.3	823.00	820.6	47.16	NR	NA	NR	NA	9.58	813.42
MW-386	765601.5	917106.5	822.26	819.4	17.46	NR	NA	NR	NA	9.85	812.41
MW-387	765481.8	916866.0	817.59	815.1	15.52	NR	NA	NR	NA	6.80	810.79
MW-629	765410.2	916642.9	818.39	816.2	51.45	NR	NA	NR	NA	26.74	791.65
MW-631	766060.3	916906.3	829.38	828.0	31.53	NR	NA	NR	NA	6.15	823.23
Former IBM Owego - Soil/Bedrock Monitoring Wells											
MW-149	765773.6	917229.3	834.27	831.6	33.57	NR	NA	NR	NA	18.93	815.34
MW-157	766538.0	917158.9	854.13	852.7	20.02	NR	NA	NR	NA	6.02	848.11
MW-158	766293.2	916902.0	838.28	836.2	39.76	NR	NA	NR	NA	9.81	828.47
MW-162	765798.6	916741.9	825.50	823.7	50.43	NR	NA	NR	NA	8.58	816.92
MW-165	765493.3	916873.7	817.50	815.6	44.21	NR	NA	NR	NA	7.72	809.78
MW-166	765164.2	916597.5	813.71	812.0	90.56	NR	NA	NR	NA	22.45	791.26
MW-178	765209.7	917421.0	812.22	809.2	36.28	NR	NA	NR	NA	6.96	805.26
MW-185	765206.1	916776.3	815.54	813.0	94.20	NR	NA	NR	NA	27.14	788.40
MW-186	764857.7	917114.0	820.32	817.8	96.27	NR	NA	NR	NA	36.67	783.65
MW-614	764906.7	916538.0	811.80	809.2	105.42	NR	NA	NR	NA	16.03	795.77
MW-630	765399.8	916638.6	817.63	815.5	93.55	NR	NA	NR	NA	26.19	791.44

Note:
Planar coordinates, measuring point elevations and ground surface elevations for Broadway Complex Site wells and surface water staff gauges are based on a September 1, 2009 field location and elevation survey by Butler Land Surveying LLC (BLS) of Little Meadows, Pennsylvania. Survey data for surface water staff gauges shown in italics are based on a March 29, 2010 field location and elevation survey by BLS.

Key:
M.P./TOC = measuring point / top of casing (groundwater elevation reference point)
G.S. = ground surface
ft bgs = feet below ground surface
ft amsl = feet above mean sea level
NA = Data not available or not applicable
NR = Water level not recorded

Appendix B.3

Estimated Hydraulic Conductivity Table

(SSI Report, April 2011)

TABLE 4-3
ESTIMATED HYDRAULIC CONDUCTIVITY
Supplemental Site Investigation
Broadway Complex Site, Owego, New York

Well ID	Screened Interval	Estimated Hydraulic Conductivity	
	ft bgs	cm/sec	ft/day
Shallow Alluvium Monitoring Wells			
911-1	9 to 19	9.5×10^{-3}	27
911-2	10 to 20	9.9×10^{-3}	28
911-3	7 to 17	2.2×10^{-2}	61
911-4	10 to 20	2.8×10^{-3}	7.8
911-5	8 to 18	2.7×10^{-3}	7.7
911-6	10 to 20	9.2×10^{-4}	2.6
911-8	10 to 20	1.9×10^{-3}	5.3
911-10	8 to 18	2.4×10^{-3}	6.9
911-13	9 to 19	2.8×10^{-2}	79
911-16	9 to 19	7.1×10^{-4}	2
911-18	8 to 18	5.3×10^{-3}	15
911-20	8 to 18	2.4×10^{-3}	6.7
911-22	8 to 18	1.5×10^{-3}	4.3
Deep Alluvium Monitoring Wells			
911-7	32 to 42	3.5×10^{-3}	10
911-9	30 to 40	7.8×10^{-3}	22
911-11	33 to 41	1.8×10^{-3}	5.2
911-12	30 to 40	6.4×10^{-4}	1.8
911-14	31 to 41	9.5×10^{-3}	27
911-15	32 to 42	4.2×10^{-3}	12
911-17	30 to 40	1.6×10^{-3}	4.4
911-19	25 to 35	2.6×10^{-3}	7.4
911-21	29 to 39	3.2×10^{-3}	9
911-23	24 to 34	9.9×10^{-4}	2.8
911-24	40 to 45	6.7×10^{-3}	19
911-25	48 to 53	2.4×10^{-3}	6.9

Notes:
1. The hydraulic conductivity estimates are based on pulse (slug) test data collected by GSC personnel. The slug tests for wells 911-1 through 911-3 were performed on April 1, 1998. The slug tests for wells 911-4 through 911-25 were performed on October 27 and 28, 2009.
2. The field data were analyzed by the method of Bouwer & Rice (1976) , based on individual well construction parameters and water level responses. The individual values represent an estimated, vertically averaged horizontal conductivity of the interval screened.

Appendix C

Chemical Data

Appendix C.1

Volatile Organic Compounds – Soil

(SSI Report, April 2011)

TABLE 5-1
SOIL DATA - VOLATILE ORGANIC COMPOUNDS
Supplemental Site Investigation
Broadway Complex Site, Owego, New York

SOIL BORING LOCATION		**911-4A**	**911-12**	**Equipment Rinse Blanks**		
SOIL SAMPLE DEPTH (ft. bgs)		**14-16**	**14-16**	**N/A**	**N/A**	**N/A**
SAMPLE ID		**B9114A1416SS**	**B911121416SS**	**EQSPN090817**	**EQRINSE3**	**EQ91112190809**
SAMPLE DATE		**8/17/2009**	**8/19/2009**	**8/17/2009**	**8/19/2009**	**8/19/2009**
Dilution Factor		**1**	**1**	**1**	**1**	**1**
COMPOUND	**Table 375-6.8(b) Soil Cleanup Objectives - Industrial**	**mg/kg**	**mg/kg**	**µg/l**	**µg/l**	**µg/l**
1,1,1-Trichloroethane	1,000	<0.001	<0.001	<0.8	<0.8	<0.8
1,1,2-Trichloroethane	-	<0.001	<0.001	<0.8	<0.8	<0.8
1,1-Dichloroethane	480	**0.003 J**	<0.001	<1.0	<1.0	<1.0
1,1-Dichloroethene	1,000	<0.001	**0.003 J**	<1.0	<1.0	<1.0
1,2,4-Trimethylbenzene	380	<0.001	<0.001	<1.0	<1.0	<1.0
1,2-Dichlorobenzene	1,000	<0.001	<0.001	<1.0	<1.0	<1.0
1,2,-Dichloroethane	60	<0.001	<0.001	<1.0	<1.0	<1.0
1,3,5-Trimethylbenzene	380	<0.001	<0.001	<1.0	<1.0	<1.0
1,3-Dichlorobenzene	560	<0.001	<0.001	<1.0	<1.0	<1.0
1,4-Dicholorbenzene	250	<0.001	<0.001	<1.0	<1.0	<1.0
1,4-Dioxane	250	<0.070	<0.070	<70	<70	<70
2-Butanone	-	<0.004	<0.004	<3.0	<1.0	<1.0
Acetone	1,000	**0.017 J**	**0.01 J**	R	<6.0	<6.0
Benzene	89	<0.0005	<0.0005	<0.5	<0.5	<0.5
Carbon Tetrachloride	44	<0.001	<0.001	<1.0	<1.0	<1.0
Chlorobenzene	1,000	<0.001	<0.001	<0.8	<0.8	<0.8
Chloroethane	-	<0.002	<0.002	<1.0	<1.0	<1.0
Chloroform (Trichloromethane)	700	<0.001	<0.001	<0.8	<0.8	<0.8
Cis-1,2-dichloroethene	1,000	<0.001	**0.078**	<0.8	<0.8	<0.8
Ethylbenzene	780	<0.001	<0.001	<0.8	<0.8	<0.8
Freon® 113	-	<0.002	<0.002	<2.0	<2.0	<2.0
Freon® 123A	-	<0.002	<0.002	<2.0	<2.0	<2.0
M,P-Xylene	1,000	<0.001	<0.001	<0.8	<0.8	<0.8
Methyl Tert-Butyl Ether (MTBE)	1,000	<0.0005	<0.0005	<0.5	<0.5	<0.5
Methylene Chloride (Dichloromethane)	1,000	<0.002	<0.002	<2.0	<2.0	<2.0
N-Butylbenzene	-	<0.001	<0.001	<1.0	<1.0	<1.0
N-Propylbenzene	1,000	<0.001	<0.001	<1.0	<1.0	<1.0
O-Xylene	1,000	<0.001	<0.001	<0.8	<0.8	<0.8
Sec-Butylbenzene	1,000	<0.001	<0.001	<1.0	<1.0	<1.0
Tert-Butylbenzene	1,000	<0.001	<0.001	<1.0	<1.0	<1.0
Tetracholorethene	300	<0.001	<0.001	<0.8	<0.8	<0.8
Toluene	1,000	<0.001	<0.001	<0.7	<0.7	<0.7
Trans-1,2-dichloroethene	1,000	<0.001	**0.001 J**	<0.8	<0.8	<0.8
Trichloroethene	400	<0.053	<0.053	<1.0	<1.0	<1.0
Trichlorofluoromethane (Freon® 11)	-	<0.002	<0.002	<2.0	<2.0	<2.0
Vinyl Chloride	27	<0.001	**0.006**	<1.0	<1.0	<1.0

Notes:
1. The test borings and soil sampling were performed between August 17 and August 19, 2009 by Parratt-Wolff, Inc. of East Syracuse, New York. The test borings and soil sampling were observed and logged by Groundwater Sciences Corporation personnel. The soil samples were submitted to Lancaster Laboratories, Inc. of Lancaster, Pennsylvania and analyzed for volatile organic compounds SW-846 8260B.

2. The soil quality results are presented in units of milligrams per kilogram (mg/kg). Values greater than laboratory reporting limits are **emboldened**. Equipment rinse blank results are presented in units of micrograms per liter (µg/l). "<" denotes that the compound was not detected. The sample and compound-specific method detection limit is posted for comparison.

3. The data qualifiers have been added as a result of third-party data validation performed by Veridian Environmental of Davis, California. Values flagged with a "J" reflect an estimated value. "R" indicates the result was rejected on the basis of data validation.

4. Column 2 lists Table 375-6.8(b) Restricted Use Soil Cleanup Objectives for Protection of Public Health - Industrial from 6 NYCRR Part 375.

Appendix C.2

Volatile Organic Compounds – Groundwater

(SSI Report, April 2011)

TABLE 5-3
GROUNDWATER DATA - VOLATILE ORGANIC COMPOUNDS
Supplemental Site Investigation
Broadway Complex Site, Owego, New York

Monitoring Well	Sample Date	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride	***TCE-Series***	1,1,1-Trichloroethane	1,1-Dichloroethene	1,1-Dichloroethane	1,2-Dichloroethane	***TCA-Series***	***Ratio TCE-Series/TCA-Series***	Chloroform (Trichloromethane)	Freon® 113 (Trifluorotrichloroethane)
Part 703 Groundwater Quality Standards		5	5	5	5	2	*NA*	5	5	5	0.6	*NA*	*NA*	7	5
Broadway Complex Site - Shallow Alluvium Monitoring Wells															
911-1	9/21/09	2.2 J	2,000	120	<2	<2	***2163***	79	58	26	<2	***194***	***11***	<2	<4
	10/26/09	2.2 J	1,800	110	2.2 J	<2	***1949***	91	43	21	<2	***178***	***11***	<2	<4
	3/22/10	2 J	1,500	110	2.2 J	<1	***1649***	74	43	19	<1	***159***	***10***	<1	<2
911-2	9/22/09	<5	2,900	66	<5	<5	***2989***	48	21 J	<5	<5	***77***	***39***	<5	<10
	10/26/09	<5	2,900	71	<5	<5	***2996***	45	17 J	<5	<5	***68***	***44***	<5	<10
	3/23/10	<1	1,600	35	<1	<1	***1647***	34	13	2.4 J	<1 J	***57***	***29***	<1	<2
911-3	9/21/09	<0.1	0.1 J	<0.1	<0.1	<0.1	***0.1***	<0.1	<0.1	<0.1	<0.1	***0.0***	***NA***	<0.1	<0.2
	10/26/09	<0.1	<0.1	<0.1	<0.1	<0.1	***0.0***	<0.1	<0.1	<0.1	<0.1	***0.0***	***NA***	<0.1	<0.2
	3/22/10	<0.1	<0.1	<0.1	<0.1	<0.1	***0.0***	<0.1	<0.1	<0.1	<0.1 J	***0.0***	***NA***	<0.1	<0.2
911-4	9/21/09	<0.1	0.3 J	<0.1	<0.1	<0.1	***0.3***	<0.1	<0.1	<0.1	<0.1	***0.0***	***NA***	0.4 J	<0.2
	10/26/09	<0.1	<0.5	<0.1	<0.1	<0.1	***0.0***	<0.1	<0.1	<0.1	<0.1	***0.0***	***NA***	0.4 J	<0.2
	3/22/10	<0.1	0.2 J	<0.1	<0.1	<0.1	***0.2***	<0.1	<0.1	<0.1	<0.1 J	***0.0***	***NA***	0.3 J	<0.2
911-5	9/22/09	0.6 J	350	5.8	<0.5	1.4 J	***361***	0.7 J	<0.5	<0.5	<0.5	***0.7***	***515***	1 J	<1
	10/26/09	<1	770	38	<1	4.5 J	***831***	2.2 J	<1	<1	<1	***2.2***	***378***	<1	<2
	3/22/10	13 J	2,500	25	<5	<5	***2534***	8.6 J	<5	<5	<5	***8.6***	***295***	<5	<10
911-6	9/22/09	110 J	40,000	1,400	<50	<50	***41897***	660	1,900	320	<50	***3706***	***11***	<50	<100
	10/27/09	150 J	43,000	1,800	<50	<50	***45439***	880	2,000	350	<50	***4104***	***11***	<50	<100
	3/23/10	140	42,000	1,500	26	6.4 J	***44046***	760	1,800	300	10 J	***3641***	***12***	6.6 J	23 J
911-8	9/21/09	8.4 J	2,500	200	<2	<2	***2771***	320	120	10	<2	***499***	***5.6***	<2	<4
	10/26/09	6 J	1,600	130	2.1 J	<2	***1776***	210	64	6.7 J	<2	***307***	***5.8***	<2	<4
	3/23/10	8.6	2,500	240	4.8 J	<1	***2825***	460	100	10	<1 J	***611***	***4.6***	<1	2.8 J
911-10	9/21/09	<50	45,000	270	<50	<50	***45366***	98 J	<50	<50	<50	***98***	***463***	<50	<100
	10/27/09	<50	43,000	300	<50	<50	***43407***	93 J	<50	<50	<50	***93***	***467***	<50	<100
	3/23/10	<10	15,000	96	<10	<10	***15130***	36 J	<10	<10	<10 J	***36***	***420***	<10	<20
911-13	9/21/09	<0.1	8.8	0.1 J	<0.1	<0.1	***8.9***	0.4 J	<0.1	0.1 J	<0.1	***0.5***	***17***	0.5 J	<0.2
	10/26/09	<0.l	7.8	0.1 J	<0.1	<0.1	***7.9***	0.4 J	<0.1	<0.1	<0.1	***0.4***	***20***	0.5 J	<0.2
	3/22/10	<0.l	12	0.2 J	<0.1	<0.1	***12.3***	0.4 J	<0.1	0.1 J	<0.1 J	***0.5***	***23***	0.5 J	<0.2
911-16	9/22/09	<2	2,600	45	<2	<2	***2661***	25	8.1 J	2.1 J	<2	***39***	***68***	<2	<4
	10/26/09	<2	2,800	59	<2	<2	***2880***	30	8.6 J	2.4 J	<2	***45***	***64***	<2	<4
	3/23/10	<1	1,900	36	<1	<1	***1949***	26	5.4	1.6 J	<1	***36***	***55***	<1	<2
911-18	9/22/09	<2	1,700	27	<2	<2	***1737***	11	4.2 J	<2	<2	***17***	***103***	<2	<4
	10/26/09	<2	1,400	27	<2	<2	***1437***	12	3.5 J	<2	<2	***17***	***85***	<2	<4
	3/22/10	<1	1,500	24	<1	<1	***1533***	9.5	2.8 J	<1	<1	***13***	***115***	<1	<2
911-20	9/21/09	<0.1	22	1.1	<0.1	<0.1	***23***	0.6	0.2 J	0.3 J	<0.1	***1.3***	***18***	0.3 J	<0.2
	10/26/09	<0.1	24	1.2	<0.1	<0.1	***26***	0.7	0.1 J	0.3 J	<0.1	***1.2***	***21***	0.3 J	<0.2
	3/22/10	<0.1	24	1.1	<0.1	<0.1	***25***	0.8	0.2 J	0.3 J	<0.1	***1.5***	***17***	0.4 J	<0.2
911-22	9/21/09	<2	1,500	31	<2	<2	***1542***	33	9.3 J	2.6 J	<2	***49***	***31***	<2	<4
	10/26/09	<2	1,300	29	<2	<2	***1339***	32	6.7 J	2.3 J	<2	***44***	***30***	<2	<4
	3/22/10	<1	1,100	25	<1	<1	***1134***	30	5.5	2.1 J	<1	***40***	***28***	<1	<2
BMW-1	9/21/09	8 J	2,700	190	<2	<2	***2957***	290	120	10	<2	***469***	***6.3***	<2	<4
	10/26/09	8.3 J	2,300	180	<2	<2	***2544***	280	100	9.4 J	<2	***430***	***5.9***	<2	<4
	3/23/10	7.2	2,100	190	2.6 J	<1	***2357***	330	93	8.6	<1	***470***	***5.0***	<1	2.5 J
Broadway Complex Site - Deep Alluvium Monitoring Wells															
911-7	9/22/09	71 J	17,000	1,100	<20	<20	***18491***	2,300	860	69 J	<20	***3576***	***5.2***	<20	<40
	9/22/09 Dup	71 J	16,000	1,100	<20	<20	***17491***	2,200	910	69 J	<20	***3545***	***4.9***	<20	<40
	10/27/09	70	16,000	1,200	<10	<10	***17626***	2,300	660	62	<10	***3292***	***5.4***	<10	<20
	10/27/09 Dup	69	16,000	1,200	12 J	<10	***17626***	2,300	660	64	<10	***3294***	***5.4***	<10	<20
	3/23/10	75	17,000	1,200	9.7 J	<5	***18626***	3,000	790	77	<5 J	***4191***	***4.4***	<5	20 J
	3/23/10 Dup	76	19,000	1,400	10 J	<10	***20918***	3,100	770	79	<10 J	***4266***	***5***	<10	<20
911-9	9/21/09	34 J	7,700	830	<10	<10	***8825***	1,500	420	37 J	<10	***2128***	***4.1***	<10	<20
	10/27/09	30	6,700	770	8.7 J	<5	***7743***	1,300	310	31	<5	***1768***	***4.4***	<5	<10
	3/23/10	32	7,700	860	7.0 J	<5	***8865***	1,500	350	33	<5 J	***2026***	***4.4***	<5	<10
911-11	9/21/09	4.4 J	1,600	210	<1	<1	***1885***	400	75	17	<1	***526***	***3.6***	1 J	2.7 J
	10/27/09	4.2 J	1,200	180	2.7 J	<1	***1444***	320	56	14	<1	***416***	***3.5***	<1	<2
	3/23/10	5.9	1,800	250	4.3 J	<1	***2139***	550	76	29	<1	***694***	***3.1***	<1	3 J
911-12	9/22/09	<0.5	240	44	<0.5	<0.5	***300***	55	16	22	<0.5	***107***	***2.8***	0.7 J	<1
	10/26/09	<0.5	210	47	1.7 J	<0.5	***274***	64	14	23	<0.5	***114***	***2.4***	0.7 J	<1
	3/22/10	1 J	450	83	1.1 J	<0.5	***562***	140	26	24	<0.5	***208***	***2.7***	0.8 J	<1
911-14	9/21/09	0.2 J	79	6.1	<0.1	0.2 J	***88***	9.5	2.9	0.6	<0.1	***14***	***6.1***	0.5	<0.2
	10/26/09	0.1 J	56	4.1	0.2 J	0.1 J	***62***	7	1.5	0.4 J	<0.1	***9.6***	***6.4***	0.6	<0.2
	3/22/10	0.1 J	75	4.9	0.2 J	0.3 J	***82***	4	1.2	0.2 J	<0.1	***5.9***	***13.9***	0.8	<0.2
911-15	9/22/09	17 J	6,100	580	<5	<5	***6886***	1,200	300	78	<0.5	***1718***	***4.0***	<5	<10
	10/26/09	19 J	5,700	630	<5	<5	***6554***	1,200	270	76	<5	***1674***	***3.9***	<5	<10
	3/23/10	23 J	6,700	750	8.4 J	<5	***7716***	1,700	310	94	<5 J	***2253***	***3.4***	<5	<10
911-17	9/22/09	<5	3,600	110	<5	<5	***3749***	170	42	10 J	<5	***241***	***16***	<5	<10
	10/26/09	<5	4,800	140	<5	<5	***4990***	150	36	8.8 J	<2	***211***	***24***	<5	<10
	3/23/10	<5	2,700	130	<5	<5	***2876***	210	43	12 J	<5 J	***285***	***10***	<5	<10
911-19	9/22/09	<5	3,500	110	<5	<5	***3649***	200	44	11 J	<5	***275***	***13***	<5	<10
	9/22/09 Dup	<5	3,100	110	<5	<5	***3249***	200	44	11 J	<5	***275***	***12***	<5	<10
	10/26/09	<5	5,000	160	<5	<5	***5217***	270	47	13 J	<5	***352***	***15***	<5	<10
	10/26/09 Dup	<5	5,300	170	<5	<5	***5530***	250	47	13 J	<5	***332***	***17***	<5	<10
	3/22/10	<5	4,600	160	<5	<5	***4817***	260	44	14 J	<5	***339***	***14***	<5	<10
	3/22/10 Dup	<5	4,400	160	<5	<5	***4617***	260	47	14 J	<5	***344***	***13.4***	<5	<10
911-21	9/21/09	<1	570	16	<1	<1	***592***	24	6.8	4.3 J	<1	***39***	***15***	<1	<2
	10/26/09	<1	430	14	<1	<1	***449***	21	4.6 J	3.6 J	<1	***32***	***14***	<1	<2
	3/22/10	<0.5	410	13	0.5 J	<0.5	***428***	17	3.6	3.3	<0.5	***26***	***16***	0.5 J	<1
911-23	9/21/09	3.4 J	2,100	130	<2	<2	***2276***	200	59	21	<2	***309***	***7.4***	<2	<4
	10/26/09	2.2 J	1,700	70	<2	<2	***1795***	120	23	8.5 J	<2	***163***	***11***	<2	<4
	3/23/10	9.3	2,700	340	2.1 J	<1	***3161***	730	180	45	1 J	***1038***	***3***	1.5 J	3.9 J
911-24	9/21/09	11 J	3,900	420	<5	<5	***4469***	800	200	57	<5	***1152***	***3.9***	<5	<10
	10/26/09	12 J	3,900	400	6.8 J	<5	***4442***	950	180	55	<5	***1272***	***3.5***	<5	<10
	3/22/10	16 J	4,900	560	<5	<5	***5659***	1,300	230	73	<5	***1715***	***3.3***	<5	<10
911-25	9/22/09	21 J	5,700	680	<5	<5	***6621***	1,200	310	53	<5	***1698***	***3.9***	<5	<10
	10/27/09	23 J	5,200	710	5.5 J	<5	***6162***	1,300	250	50	<5	***1711***	***3.6***	<5	<10
	3/23/10	26	6,800	880	<5	<5	***7992***	1,700	290	64	<5 J	***2185***	***3.7***	<5	<10
Former IBM Owego "Group 3" Wells															
MW-161 (Shallow Alluvium)	3/22/10	<1	0.2 J	<1	<1	<1	***0.2***	<1	<1	<1	<1	***0.0***	***NA***	<1	<1
MW-160 (Deep Overburden)	3/22/10	<0.5	330	26	<0.5	<0.5	***365***	78	17	4.1	<0.5	***107***	***3.4***	<0.5	<1
MW-317 (Deep Overburden/Till)	3/22/10	0.3 J	120	12	<0.1	<0.1	***136***	28	8.4	1.8	<0.1	***42***	***3.2***	<0.1	0.2 J

Notes:
1. Groundwater monitoring well sampling was performed by Groundwater Sciences Corporation (GSC) personnel in September 2009, October 2009, and March 2010 on the dates listed above.
2. The groundwater samples were submitted to Lancaster Laboratories, Inc. of Lancaster, Pennsylvania and analyzed for volatile organic compounds (VOCs) by SW846 Method 8260. Results for groundwater samples are posted in micrograms per liter (ug/L). Values above applicable Part 703 groundwater quality standards are highlighted in yellow. The analytical data has been subjected to third party data validation by Veridian Environmental of Davis, California. The table includes VOCs detected in one or more groundwater samples.
3. Other notes:
"<" - signifies not detected. Value given is the method detection limit.
"J" - signifies estimated value on the basis of third party data validation.
"NA" - denotes "not applicable"

Appendix C.3

Inorganic and Transformation Indicator Parameters

(SSI Report, April 2011)

TABLE 5-5
GROUNDWATER DATA - INORGANIC AND TRANSFORMATION INDICATOR PARAMETERS
Supplemental Site Investigation
Broadway Complex Site, Owego, New York

Well Designation	Date	Depth to Water	Purge Rate	Cations											Anions						Other Analytes							Field Screening Parameters					
				Total Ammonia	Dissolved Calcium	Total Hardness	Dissolved Iron	Total Iron	Ferric Iron	Ferrous Iron	Dissolved Manganese	Total Manganese	Dissolved Potassium	Dissolved Sodium	Total Alkalinity	Chloride	Fluoride	Nitrate as Nitrogen	Nitirite as Nitrogen	Sulfate	Chemical Oxygen Demand	Total Organic Carbon	Total Kjeldahl Nitrogen	Total Suspendd Solids	Ethane	Ethene	Methane	Temperature	Specific Conductance	Dissolved Oxygen	pH	Oxidation-Reduction Potential	Turbidity
	Units	ft bgs	ml/min	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	°C	mS/cm	mg/L	S.U.	mV	NTU
Broadway Complex Site - Shallow Alluvium Monitoring Wells																																	
911-1	3/29/2010	9.0	230	1	150	520	<0.050	0.17	<1	<1*	0.22	0.24	5.4	710	61	1400	0.58	94*	<12*	110	72	<5	1.3	5	0.084	0.034	0.99	11.48	3.74	1.28	6.63	201	7.1
911-2	3/30/2010	10.44	210	0.4	140	490	0.06	0.47	<1	<1	0.093	0.11	8	1100	67	1700	<0.5	60	<2.5	82	88	<5	<1	<4	0.100	0.044	0.97	11.79	5.37	0.56	6.26	135	20.8
911-3	3/29/2010	6.85	250	<0.1	56	180	<0.050	<0.050	<1	<1*	<0.005	<0.005	2.5	120	41	330	<0.5	7.1*	<5*	15	<25	<5	<1	<4	<0.025	0.028	0.56	6.43	0.841	6.95	7.03	149	0
911-4	3/31/2010	9.60	200	<0.1	35	130	<0.050	0.19	<1	<1	<0.005	<0.005	4.3	280	92	400	<0.5	19	<5	16	<25	<5	<1	<4	<0.025	<0.025	<0.100	9.10	1.460	5.62	6.65	154	21.8
911-DUP 2				<0.1	37	130	<0.050	0.21	<1	<1	<0.005	<0.005	4.5	290	92	400	<0.5	18	<5	16	<25	<5	<1	<4	<0.025	<0.025	0.41						
911-5	3/31/2010	9.95	210	<0.1	53	190	<0.050	0.059	<1	<1	0.06	0.048	3.0	190	110	360	<0.5	12	<5	17	<25	<5	<1	<4	<0.025	1.8	0.58	10.39	1.378	2.2	6.74	113	6.4
911-6	3/31/2010	8.70	200	1.5	190	660	<0.050	0.42	<1	<1	0.44	0.46	4.6	85	270	190	<.05	15	<5	290	<25	<5	1.9	11	1.4	2.5	62	13.89	1.57	0.17	6.82	118	29.8
911-8	3/31/2010	9.41	180	2.3	62	220	0.36	0.4	<1	<1	0.47	0.48	4.2	150	47	240	0.99	31	<5	81	<25	<5	3.2	5	0.077	0.10	2.2	13.59	1.110	0.35	5.98	161	5.3
911-10	3/31/2010	8.94	240	0.1	42	140	<0.050	0.38	<1	<1	<0.005	0.018	4.0	210	73	280	1	32	<5	34	<25	<5	<1	11	<0.025	<0.025	0.35	9.61	1.460	4.11	6.88	114	0.0
911-DUP 3				<0.1	42	140	<0.050	0.58	<1	<1	<0.005	0.019	3.9	200	73	280	0.99	32	<1	34	<25	<5	<1	8	<0.025	<0.025	0.52						
911-13	3/29/2010	10.76	125	0.2	56	180	<0.050	0.14	<1	<1*	<0.005	0.014	3.2	270	86	10	<0.5	11*	<1*	19	<25	<5	<1	16	<0.025	<0.025	0.75	10.69	1.59	2.59	6.55	141	0.0
911-16	3/30/2010	9.98	210	0.5	47	170	<0.05	0.099	<1	<1	0.058	0.064	4.2	390	94	530	0.83	18	<5	51	26	<5	<1	<4	0.084	0.04	0.77	10.70	2.00	1.24	6.41	139	7.1
911-18	3/30/2010	10.03	210	<0.1	32	120	<0.050	0.11	<1	<1*	0.091	0.098	3.6	220	110	270	0.54	13*	<5*	28	<25	<5	<1	<4	0.056	0.056	2.4	10.51	1.227	1.04	6.76	136	7.3
	4/1/2010	10.55	230	--	--	--	--	--	<1	<1	--	--	--	--	--	280	0.73	19	<5	39	--	--	--	--	--	--	--	10.55	1.310	1.19	6.75	145	2.9
911-20	3/29/2010	9.01	240	<0.1	53	170	<0.050	0.19	<1	<1*	1.9	2.4	3.2	270	86	500	<0.5	6.7*	<5*	24	28	<5	<1	11	<0.025	<0.025	1.7	10.92	1.56	0.34	6.50	113	0.0
911-22	3/30/2010	9.62	210	0.2	49	170	0.84	0.50	<1	<1	<0.005	0.013	4.2	340	90	490	0.65	15	<5	42	<25	<5	<1	4	0.03	0.065	1.2	10.17	1.88	2.14	6.55	172	15.2
BMW-1	3/31/2010	9.27	100	1.8	98	360	0.27	0.58	<1	<1	0.30	0.35	5.1	190	59	390	0.57	50	<5	77	<25	<5	2.6	59	0.100	0.072	2.0	12.08	1.89	0.46	6.09	154	3.3
Broadway Complex Site - Deep Alluvium Monitoring Wells																																	
911-7	3/31/2010	7.38	240	12	67	170	0.29	0.89	<1	<1	5	4.9	6.2	110	24	190	3.50	10	<.05	170	<25	<5	13	17	0.27	0.75	11	15.87	1.315	0.17	5.23	204	0.0
911-9	3/31/2010	7.80	200	8.6	59	240	0.50	1.10	<1	<1	2.4	2.6	5.5	120	33	200	2.80	26	<0.5	130	<25	<5	10	17	0.16	0.34	5.4	15.40	1.079	0.17	5.47	206	22.7
911-11	3/31/2010	8.95	235	2.9	58	220	0.65	1.2	<1	<1	0.65	0.67	4.7	160	53	260	0.72	21	<0.5	100	<25	<5	4.3	8	0.088	0.17	4.8	13.42	1.480	0.22	5.85	119	0.0
911-12	3/29/2010	10.36	165	1.1	83	300	0.28	0.82	<1	<1*	0.49	0.66	3.2	160	110	380	<0.5	17	<5	79	<25	<5	1.5	4	0.13	0.083	2.5	12.65	1.372	0.49	6.58	104	26.3
911-14	3/29/2010	10.74	120	<0.1	28	86	<0.050	0.55	<1	<1*	0.029	0.16	3	170	100	53	<0.5	12	<1	20	<25	<5	<1	12	<0.025	0.03	0.36	11.56	0.839	1.22	7.06	160	21.1
911-15	3/30/2010	9.65	210	2.8	74	290	0.70	0.85	<1	<1	0.93	1	5.0	150	69	300	<0.5	19	<0.05	170	<25	<5	3.6	8	0.23	0.50	10	13.04	1.322	0.34	6.16	115	9
911-17	3/30/2010	10.03	240	1	81	310	0.36	0.53	<1	<1*	0.30	0.31	4.1	160	88	290	<0.5	23*	<5*	92	<25	<5	<1	<4	0.23	0.15	15	13.02	1.375	0.21	6.27	98	10.8
	4/1/2010	13.21	200	--	--	--	--	--	<1	<1	--	--	--	--	--	280	<0.5	23	<1	100	--	--	--	--	--	--	--	13.21	1.301	0.15	6.33	124	2.2
911-19	3/30/2010	9.65	230	1.3	60	220	0.32	0.49	<1	<1	0.19	0.21	4.6	170	67	330	0.58	22	<2.50	77	<25	<5	2.1	4	0.49	0.14	1.5	12.44	1.267	1.14	6.32	164	23.0
911-DUP 1				1.5	59	200	0.34	0.48	<1	<1	0.19	0.21	4.6	170	67	360	<0.5	22	<1	69	<25	<5	1.7	<4	0.054	0.15	1.6						
911-21	3/29/2010	8.99	160	0.2	51	180	<0.050	0.34	<1	<1*	0.14	0.16	3.0	210	94	410	<0.5	13*	<5*	32	<25	<5	<1	<4	0.047	0.038	0.93	11.72	1.211	0.23	6.89	163	10.1
911-23	3/30/2010	9.65	210	0.6	91	340	0.36	0.44	<1	<1	0.12	0.12	4.2	170	110	300	<0.5	21	<5	120	<25	<5	1.1	4	0.25	0.23	7.1	12.56	1.438	1.08	6.36	135	7.6
911-24	3/30/2010	9.18	240	2.1	90	340	0.51	1	<1	<1*	2.4	2.7	4.4	120	80	230	<0.5	14*	<0.5*	130	<25	<5	2.8	8	0.18	0.36	16	12.41	1.225	0.30	6.18	129	21.3
	4/1/2010	8.89	240	--	--	--	--	--	<1	<1	--	--	--	--	--	230	<0.5	14	<0.5	130	--	--	--	--	--	--	--	12.89	1.346	0.18	5.99	143	8.6
911-25	3/31/2010	7.54	240	2.3	68	250	0.87	0.96	<1	<1	1	1	5.2	180	73	260	<0.5	15	<5	120	<25	<5	3.5	<4	0.14	0.27	6.1	15.23	1.57	0.22	6.02	41	0.0
Former IBM Owego "Group 3" Wells																																	
161 (Shallow Alluvium)	3/29/2010	10.98	210	<0.1	10	36	<0.050	0.058	<1	<1*	<0.005	<0.005	1.2	39	31	67	<0.5	1.4*	<0.5*	11	<25	<5	<1	8	<0.025	<0.025	0.44	4.93	0.243	8.14	7.88	116	2.8
160 (Deep Overburden)	3/29/2010	10.49	200	<0.1	52	180	<0.050	0.084	<1	<1*	<0.005	0.006	1.4	56	100	130	<0.5	2.7*	<0.5*	20	<25	<5	<1	5	<0.025	<0.025	0.17	7.16	0.609	2.60	7.46	83	0.0
317 (Deep Overburden/Till)	3/29/2010	8.98	225	<0.1	43	150	<0.050	<0.050	<1	<1*	<0.005	<0.005	1.5	58	71	150	<0.5	3*	<0.5*	14	<25	<5	<1	<4	<0.025	0.027	0.3	6.77	0.549	4.21	7.54	157	8.9

Notes:
1. Groundwater monitoring well sampling was performed by Groundwater Sciences Corporation (GSC) personnel on March 29, 2010 through April 1, 2010. The groundwater samples were collected using USEPA Low Flow/Minimal Drawdown sampling procedures. Samples for dissolved metals were filtered in the field using 0.45 micron filters. The fie screening parameters were recorded in the field using a flow-through cell.
2. The groundwater samples were submitted to Microseeps, Inc. of Pittsburgh, Pennsylvania and analyzed for the inorganic and transformation indicator parameters listed above.
3. Other notes:

ft bgs = feet below ground surface
ml/min = milliliters per minute
mg/L = milligrams per liter
°C = degrees Celsius

mS/cm = microseimens per centimeter
S.U. = Standard Units of pH
mV = millivolts
NTU = Nephelometric Turbidity Units

"<" - signifies not detected. Value given is method detection limit.
"*" - signifies analyte received within 48 hour hold time but analysis completed outside of 48 hour time
"--" - signifies not analyzed

Appendix C.4

Microbial Analyses

(SSI Report, April 2011)

TABLE 5-6
GROUNDWATER DATA - MICROBIAL ANALYSES
Supplemental Site Investigation
Broadway Complex Site, Owego, New York

Well Designation	Sample Date	Microseeps ID	Census		Functional Genes		
			Dehalococcoides spp.	*Dehalobacter spp.*	tceA Reductase	bvcA Reductase	Vinyl Chloride Reductase
		Units	cells/ml	cells/ml	cells/ml	cells/ml	cells/ml
Broadway Complex Site - Shallow Alluvium Monitoring Wells							
911-4	3/31/2010	P1004007-01	**0.5 J**	**45**	<0.5	<0.5	<0.5
911-6	3/31/2010	P1004007-05	**7.2**	**315**	<0.5	<0.5	<0.5
911-10	3/31/2010	P1004007-03	**3.1**	**389**	<0.5	<0.5	<0.5
911-16	3/30/2010	P1003418-04	**2.3**	**2930**	<0.5	<0.5	<0.5
911-18	3/30/2010	P1003418-02	**1.1**	**346**	<0.5	<0.5	<0.5
911-22	3/30/2010	P1003418-01	**2.3**	**234**	<0.5	<0.5	<0.5
Broadway Complex Site - Deep Alluvium Monitoring Wells							
911-7	3/31/2010	P1004007-04	**0.9**	**1950**	<0.5	<0.5	<0.5
911-11	3/31/2010	P1004007-02	**0.6**	**1240**	<0.5	<0.5	<0.5
911-19	3/30/2010	P1003418-03	**1.3**	**540**	<0.5	<0.5	**0.2 J**

Notes:

1. Groundwater monitoring well sampling was performed by Groundwater Sciences Corporation personnel on March 30 and 31, 2010.

2. The groundwater samples were analyzed for populations (census) of dechlorinating bacteria and functional genes of *Dehalococcoides spp.* by Microbial Insights, Inc. of Rockford, Tennessee. Microbial Insights performed the work as a subcontractor to Microseeps, Inc. of Pittsburgh, Pennsylvania. Results are reported in units of cells per milliliter (ml). "<" denotes that the functional gene was not detected above the method detection limit of 0.5 cell/ml.

Appendix D

Figures 3 through 8 from 2010 Semiannual Data Report

Groundwater Monitoring Program

Former IBM Facility, Owego, New York

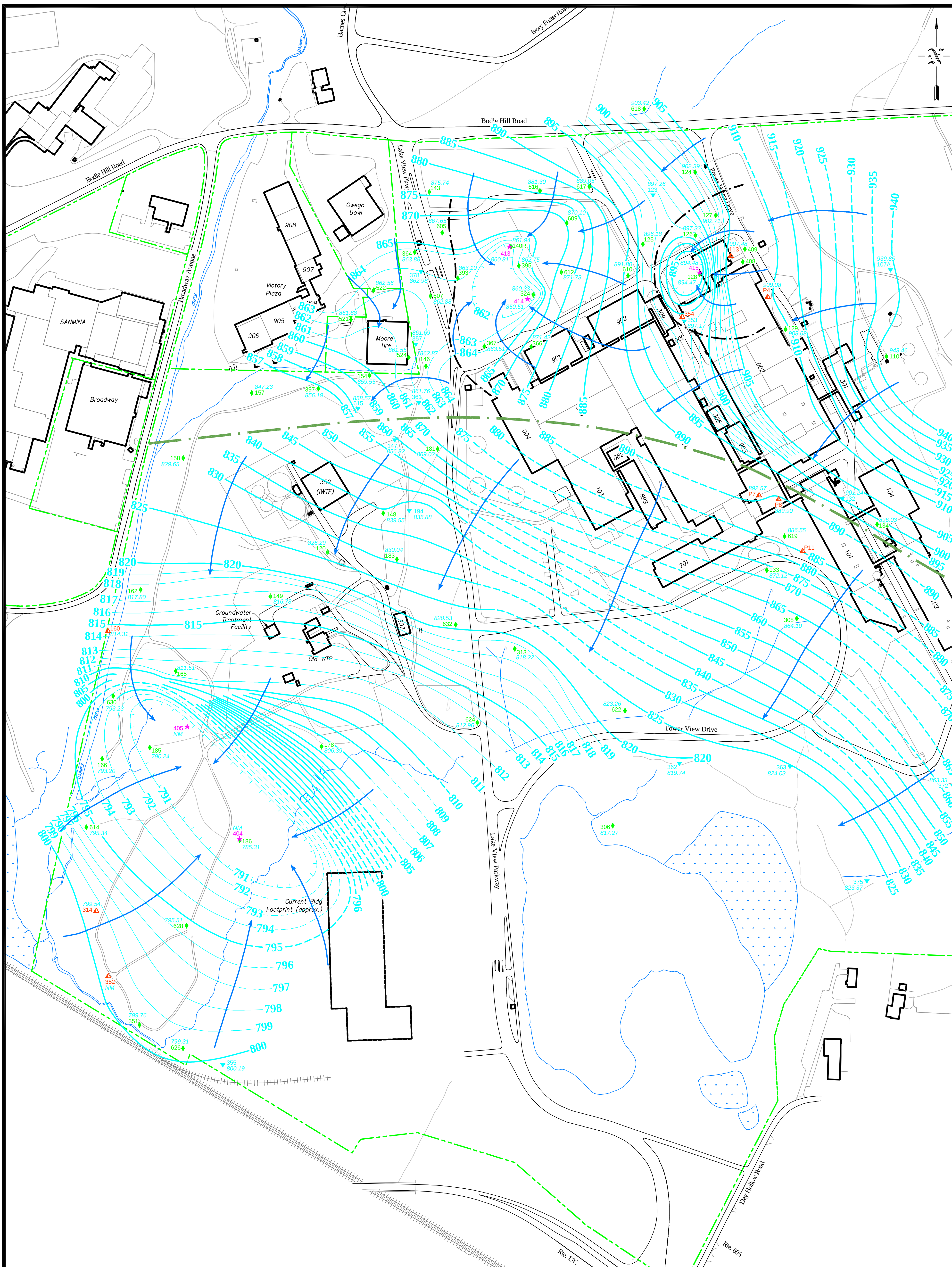

Figure 3

- Bedrock monitoring well
- Till monitoring well
- Soil/Bedrock monitoring well
- Withdrawal well
- Property Line
- Swamp area
- Direction of Groundwater Flow

800.19 - Groundwater Elevation (feet amsl)
NM - Not Measured
795 - Groundwater Elevation Contour (feet amsl)
- Inferred Groundwater Elevation Contour
- Groundwater Flow Divide
- Line of Separation Between Northern and Southern Sampling Events

Northern Area wells measured January 19, 2010; Southern Area wells measured April 2, 2010.

Note: Some wells that monitor the lower till were used to construct this map.

Scale
0 175' 350'

IBM
Owego, New York

Till/Bedrock
Groundwater Elevation Contour Map
First and Second Quarters, 2010

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GROUNDWATER SCIENCES CORPORATION

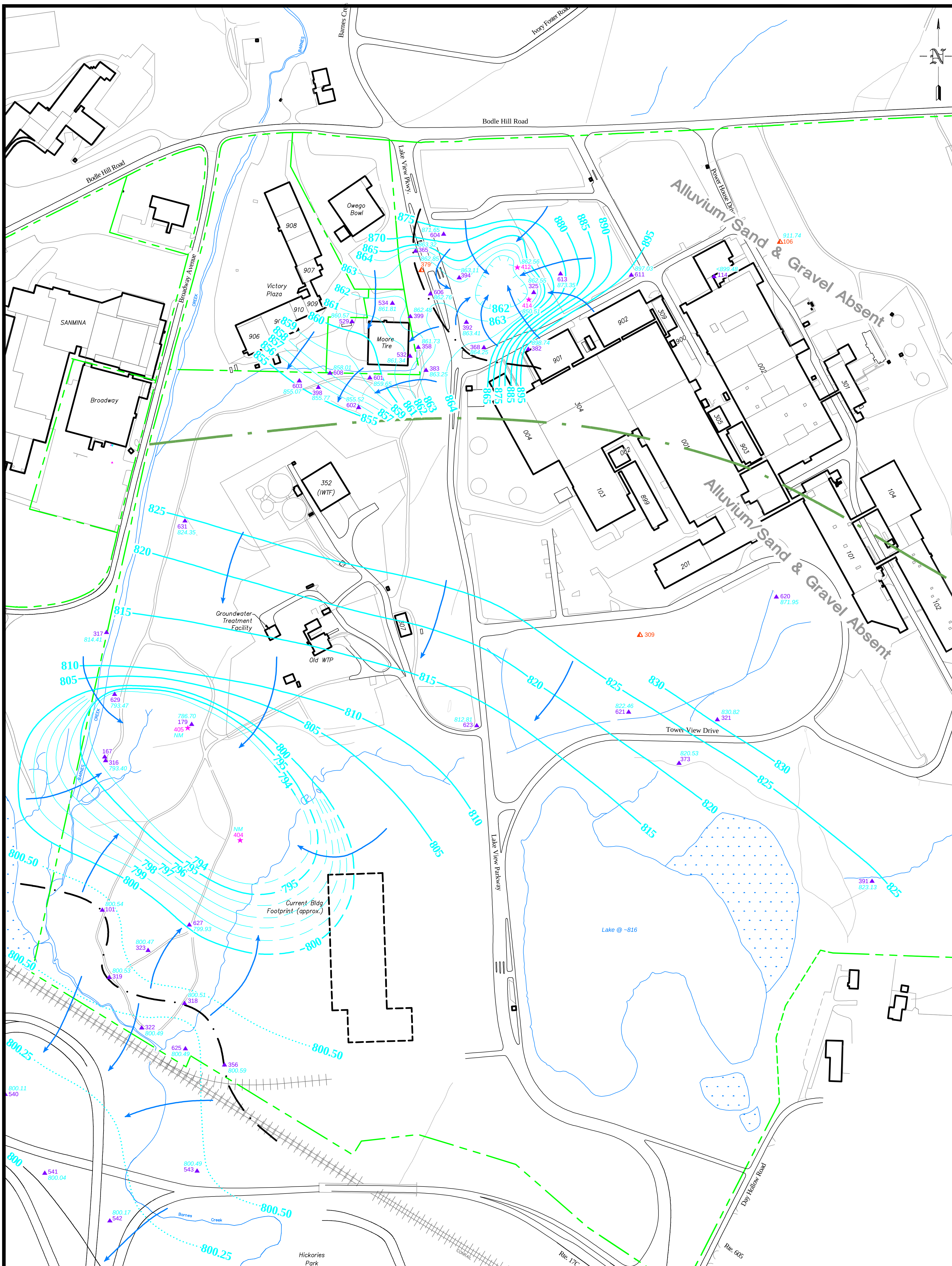

Figure 4

▲ - Soil monitoring well
▲ - Till monitoring well
★ - Withdrawal well
- Property Line
- Line of Separation Between Northern and Southern Sampling Events
- Swamp area

800.49 - Groundwater Elevation (feet amsl)
NM - Not Measured
800 - Groundwater Elevation Contour (feet amsl)
- Supplemental Groundwater Elevation Contour
- Direction of Groundwater Flow
- Groundwater Flow Divide

Note: Groundwater elevations for wells P1, P2, 161, 163, 386, 387 and 374 were not used because these wells monitor a shallow alluvial unit that is different from the outwash unit monitored by other wells in the southern areas.

Northern Area wells measured January 19, 2010; Southern Area wells measured April 2, 2010.

Scale
0 175' 350'

IBM
Owego, New York

Alluvium/Sand & Gravel
Groundwater Elevation Contour Map
First and Second Quarters, 2010

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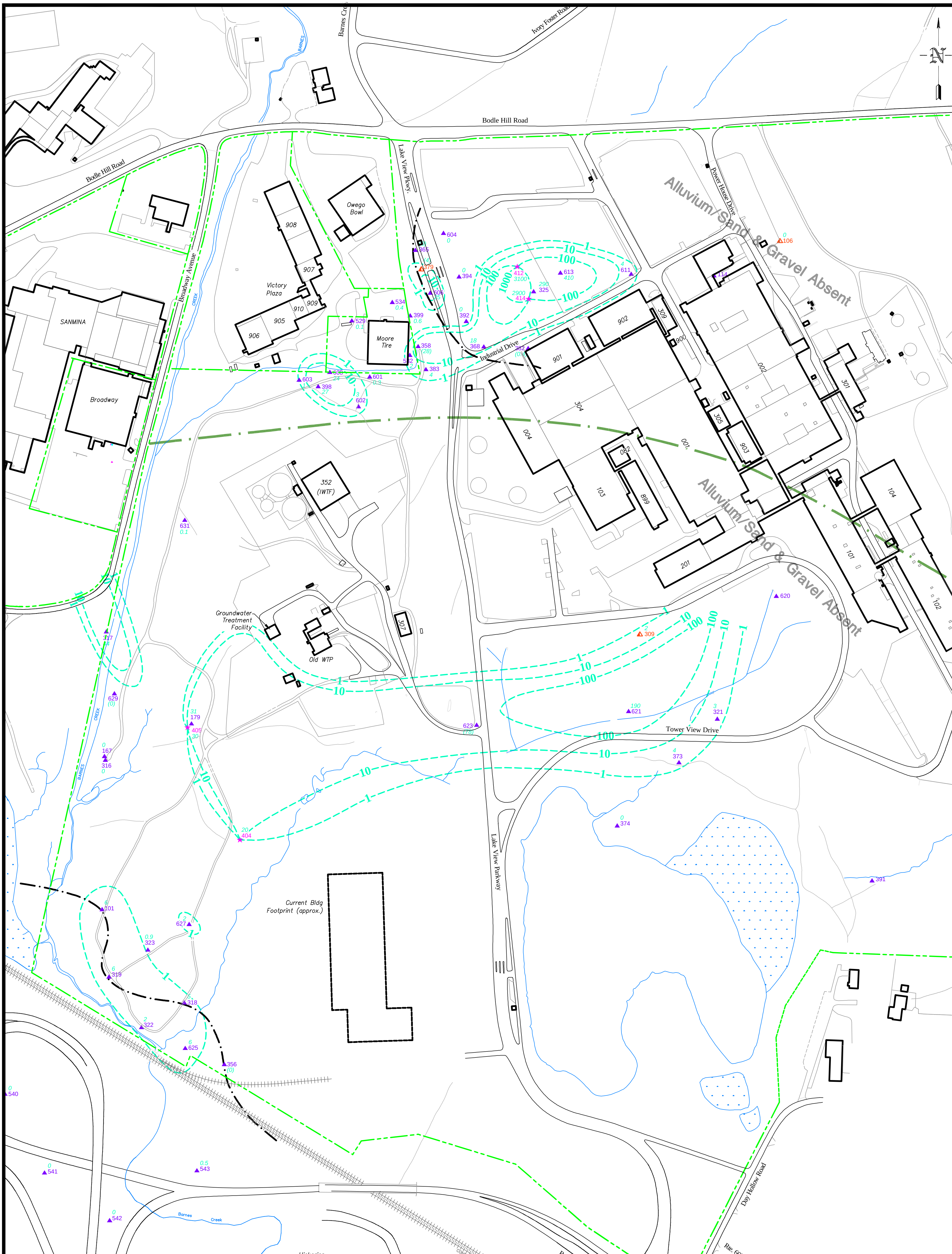

- Soil monitoring well
- Till monitoring well
- Withdrawal well
- TCA-Series Concentration (ug/l)
(73) - Previous sampling result (for wells sampled annually)
- Swamp area

100 - TCA-Series Concentration Contour (ug/l)
- Groundwater Flow Divide
- Property Line
- Line of Separation Between Northern and Southern Sampling Events

Calculation:

$$\text{TCA Series} = \text{TCA} + \text{1,1-DCA}\left(\frac{133.42}{98.97}\right) + \text{1,1-DCE}\left(\frac{133.42}{96.95}\right) + \text{CEA}\left(\frac{133.42}{64.52}\right)$$

where
TCA = 1,1,1-Trichloroethane
1,1-DCA = 1,1-Dichloroethane
1,1-DCE = 1,1-Dichloroethene
CEA = Chloroethane

Notes: *Wells 106, 309 and 379, which monitor the upper till, were also used to construct this map. Values shown have been rounded to two significant figures or one significant figure if less than 10 ug/l.*

Extraction wells 413 and 414 pump from the till/bedrock zone.

Extraction wells 412 and 414 pump from the alluvial zone.

Northern Area wells sampled January 2010.
Southern Area wells sampled April 2010.

Scale
0 175' 350'

Figure 5

IBM
Owego, New York

Alluvium/Sand & Gravel TCA-Series
Isoconcentration Contour Map
First and Second Quarters, 2010

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GROUNDWATER SCIENCES CORPORATION

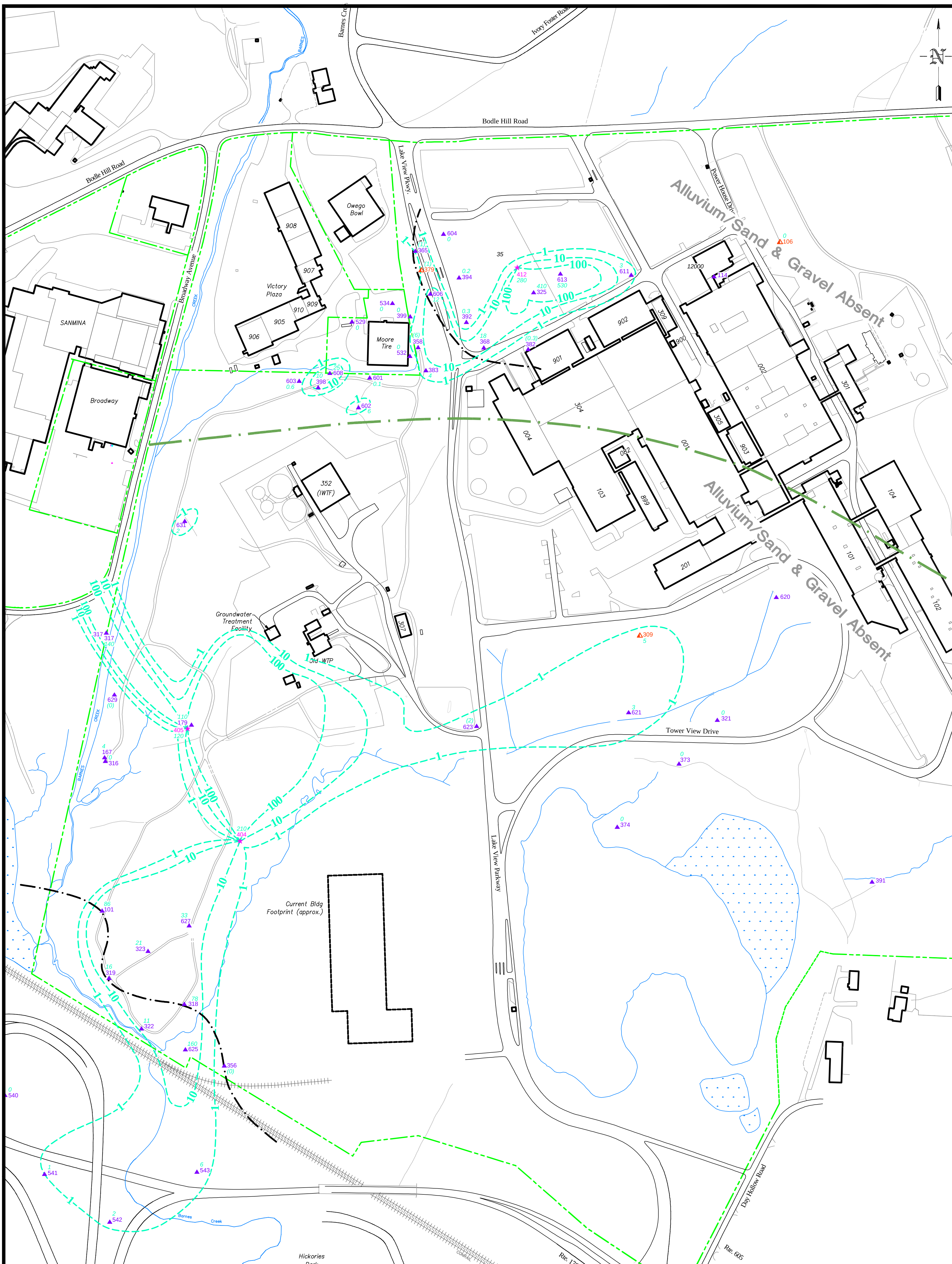

Figure 6

- ▲ - Soil monitoring well
- Till monitoring well
- ★ - Withdrawal well
- 4 - TCE-Series Concentration (ug/l)
- (2) - Previous sampling result (for wells sampled annually)
- 100 - TCE-Series Concentration Contour (ug/l)
- Groundwater Flow Divide
- Property Line
- Line of Separation between Northern and Southern Sampling Events
- Swamp area

Calculation:

$$\text{TCE Series} = \text{TCE} + \text{1,2-DCE(TOT)}\left(\frac{131.4}{96.95}\right) + \text{VC}\left(\frac{131.4}{62.5}\right)$$

where TCE = Trichloroethene
1,2-DCE(TOT) = Total 1,2-Dichloroethene
VC = Vinyl Chloride

Notes: Wells 106, 309 and 379, which monitor the upper till, were also used to construct this map. Values shown have been rounded to two significant figures or one significant figure if less than 10 ug/l.

Extraction wells 413 and 414 pump from the till/bedrock zone.

Extraction wells 412 and 414 pump from the alluvial zone.

Northern Area wells sampled January 2010.
Southern Area wells sampled April 2010.

Scale
0 175' 350'

IBM
Owego, New York

Alluvium/Sand & Gravel TCE-Series
Isoconcentration Contour Map
First and Second Quarters, 2010

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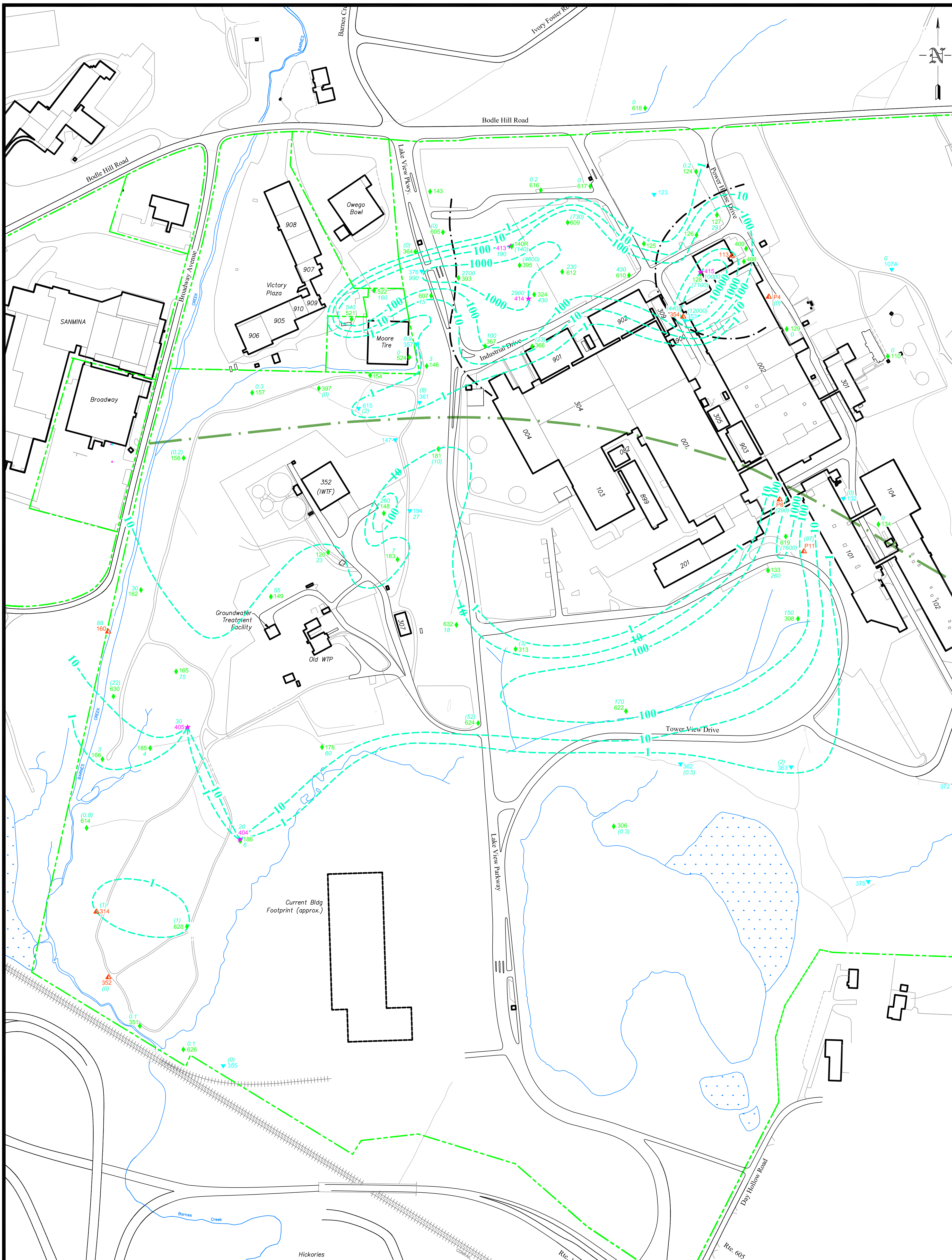

Figure 7

- Bedrock monitoring well
- Soil/Bedrock monitoring well
- Till monitoring well
- Withdrawal well
- 0.4 - TCA-Series Concentration (ug/l)
- (1) - Previous sampling result (for wells sampled annually)
- NS - Not Sampled
- 100 - TCA-Series Concentration Contour (ug/l)
- Groundwater Flow Divide
- Property Line
- Line of Separation Between Northern and Southern Sampling Events
- Swamp area

Calculation:

$$\text{TCA Series} = \text{TCA} + \text{1,1-DCA}\left(\frac{133.42}{98.97}\right) + \text{1,1-DCE}\left(\frac{133.42}{96.95}\right) + \text{CEA}\left(\frac{133.42}{64.52}\right)$$

where
TCA = 1,1,1-Trichloroethane
1,1-DCA = 1,1-Dichloroethane
1,1-DCE = 1,1-Dichloroethene
CEA = Chloroethane

Northern Area wells sampled January 2010.
Southern Area wells sampled April 2010.

Notes: Some wells that monitor the lower till or the bedrock were used to construct this map. Values shown have been rounded to two significant figures or one significant figure if less than 10 ug/l.

Scale
0 175' 350'

IBM
Owego, New York

Till/Bedrock TCA-Series
Isoconcentration Contour Map
First and Second Quarters, 2010

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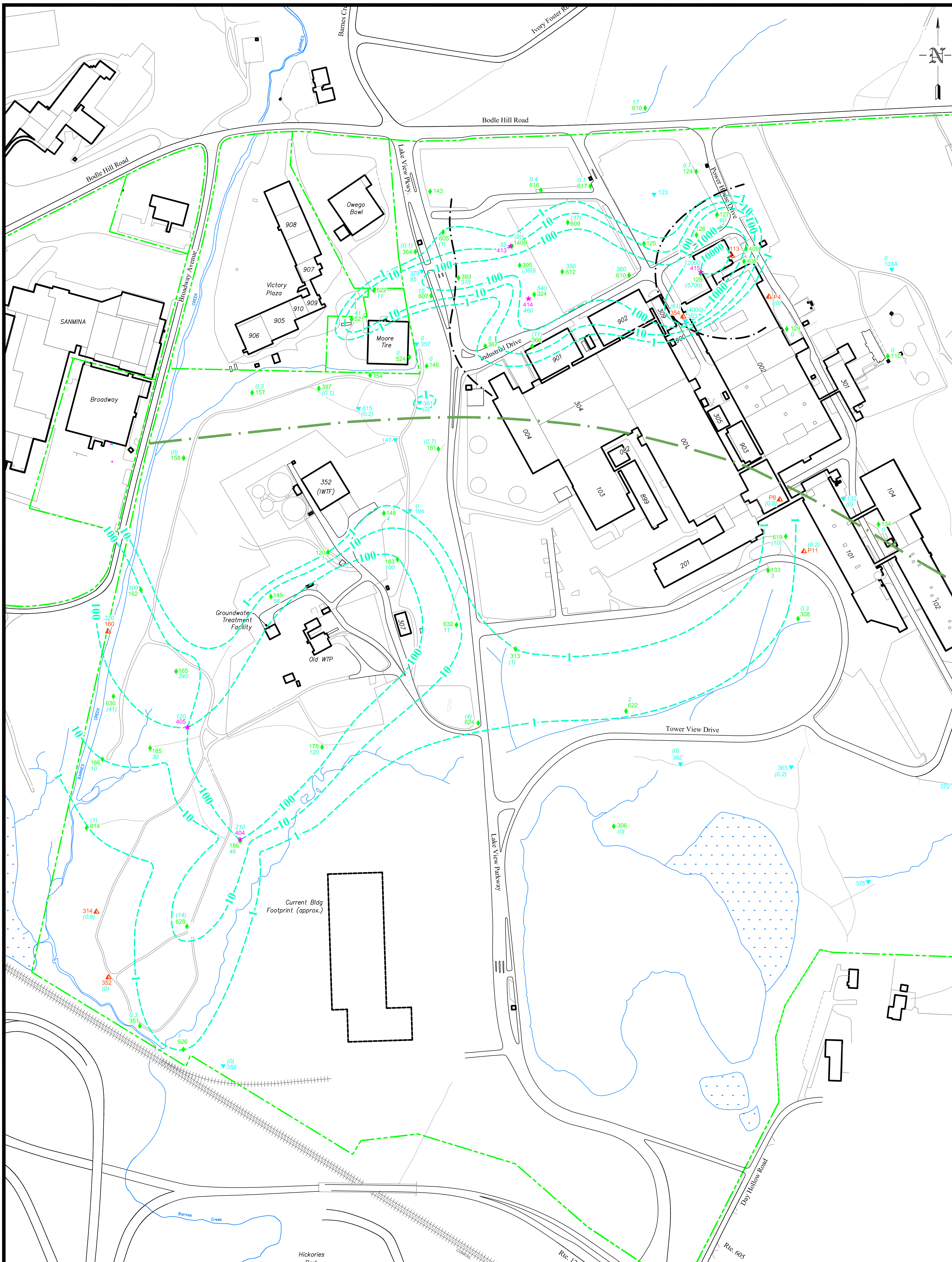
GROUNDWATER SCIENCES CORPORATION



- Bedrock monitoring well
- Soil/Bedrock monitoring well
- Till monitoring well
- Withdrawal well
82 - TCE-Series Concentration (ug/l)
(10) - Previous sample result (for wells sampled annually)
NS - Not Sampled
100 - TCE-Series Concentration Contour (ug/l)
- Groundwater Flow Divide
- Property Line
- Line of Separation Between Northern and Southern Sampling Events
- Swamp area

Calculation:

$$\text{TCE Series} = \text{TCE} + \text{1,2-DCE(TOT)}\left(\frac{131.4}{96.95}\right) + \text{VC}\left(\frac{131.4}{62.5}\right)$$

where TCE = Trichloroethene
1,2-DCE(TOT) = Total 1,2-Dichloroethene
VC = Vinyl Chloride

Notes: Some wells that monitor the lower till or the bedrock were used to construct this map. Values shown have been rounded to two significant figures, or one significant figure if less than 10 ug/l.

Northern Area wells sampled January 2010.
Southern Area wells sampled April 2010.

Scale
0 175' 350'

Figure 8

IBM
Owego, New York

Till/Bedrock TCE-Series Isoconcentration Contour Map First and Second Quarters, 2010

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GROUNDWATER SCIENCES CORPORATION