New York State Department of Environmental Conservation

GROUNDWATER SOURCE AQUIFER EVALUATION

Hoosick Falls Alternate Water Supply Study

July 2017

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New York State Department of Environmental Conservation

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EXECUTIVE SUMMARY

Arcadis CE, Inc. (Arcadis), on behalf of the New York State Department of Environmental Conservation (NYSDEC), has been evaluating alternate water supply (AWS) options for the Village of Hoosick Falls, New York to address elevated levels of Perfluorooctanoic Acid (PFOA) found in the existing water supply for the Village. Several alternatives are being explored for providing raw water to the Village of Hoosick Falls Water Treatment Plant (Village WTP). These alternatives include identification and assessment of a new groundwater source to replace the existing source aquifer. Pursuant to the scope of services included in Work Order #D0076618-43, Arcadis has completed evaluation of a potential groundwater source aquifer present beneath agricultural land along the Hoosic River adjacent to New York State Route 22 (Site), approximately two miles south of the Village of Hoosick Falls.

Preliminary Site Characterization

Geophysical data, soil boring data, and preliminary hydraulic evaluations at the site between March and October 2016 indicated that the primary water bearing unit beneath the Site consists of a heterogeneous, semi-confined glacial outwash of channelized sand and gravel deposits juxtaposed to, and interbedded with, fine sand and silty sand deposits. These deposits are up to 20 feet in thickness beneath the Site, and thin toward the west and south. The aquifer is overlain by Pleistocene lacustrine silt and silt-clay deposits up to 80 feet in thickness, which represent the primary confining unit at the Site. To the north of the Site at the Village well field, and at the southernmost end of the Site, the lacustrine deposits thin considerably, resulting in a greater connection between the overlying recent alluvial deposits and the outwash deposits.

The preliminary hydraulic screening of the site in June 2016 suggested that the aquifer beneath the site had production potential, and that further evaluation of the confined aquifer beneath the Site for use as a potential groundwater source aquifer for the Village was warranted. Water quality samples collected on June 28, 2016 from the preliminary test well (LC4-TW01) did not indicate the presence of Polyfluorinated Alkyl Substances (PFAS) compounds in the groundwater sample from the test well. Except for a low-level detection of butyl benzyl phthalate (8.4 micrograms per liter, or µg/L), there were no additional detections of SVOCs or VOCs in the test well groundwater sample. Therefore, with approval from the NYSDEC, Arcadis abandoned the preliminary test well, installed four additional observation wells (OBS-02 through OBS-05), and conducted additional baseline analytical sampling in September and October 2016, in anticipation of production testing.

Aquifer Evaluation

During January through March of 2017, Arcadis further evaluated the aquifer by installing a 10-inch diameter production test well, and completing stepped-drawdown testing, a 72-hour constant-rate aquifer pumping test, and additional post-pumping water quality analytical testing. The data collected during the test was used as the basis for assessment of the potential yield of the aquifer, and its suitability for use as a replacement for the existing village wellfield. A pumping rate of 300 gallons-per-minute (gpm) was used for the constant-rate pumping evaluation, based on the results of the prior stepped-drawdown testing.

Based on analysis of the pumping data and the resultant hydraulic assessment of the aquifer characteristics, the estimated maximum single-well yield for the Site is approximately 300 gpm. While the aquifer has the potential to provide additional yield to the well, the 300 gpm yield provides a reasonable estimate of yield given these uncertainties imposed by aquifer conditions during the testing period, and the limitations of the analytical methods used.

Data from adjacent production wells during testing, including the High School well and other local private and commercial pumping wells, indicated that pumping in the Test Well during the 72-hour period did not adversely affect water levels or pumpage in these wells. Given the observed data, it is unlikely that groundwater withdrawals at the 300 gpm rate tested would negatively impact surrounding wells under similar aquifer conditions. However, additional stresses to the aquifer in the future (e.g. new production wells installed in the vicinity, or drought conditions) could increase the likelihood that local supply wells could be adversely affected by pumping in the future. Development of a wellfield to include additional production wells and increased groundwater withdrawals would require additional assessment for the potential of adverse effects on surrounding supply wells.

The estimated maximum yield is less than 50 percent of the target production value of 1 million gallons-per-day (MGD). Based on raw water production estimates provided by the Village of Hoosick Falls for the period of February through April 2016, which indicate an average daily production of 382,158 gallons-per-day (gpd), with a maximum daily production of 814,314 gpd. Based on these data, production from a single well at the Site could not provide sufficient yield to entirely replace production at the existing Village well field. However, through use of an adaptive water management strategy, it is feasible that production from a single well could provide a significant percentage of the required daily usage, and at considerably lower contaminant concentrations, than those from the existing Village wells.

Geophysical data suggest there may not be enough aquifer thickness in areas south of the Test Well to support an additional well to significantly increase overall production. However, if there is sufficient areal extent and thickness of the sand and gravel confined aquifer toward the north or east, an additional well may provide additional yield. Additional testing and analysis would be required to evaluate the suitability of the aquifer for additional production using multiple wells.

Water Quality Assessment

Baseline Analytical Screening - Polyfluorinated Alkyl Substances

Analytical results from the August and September 2016 water quality sampling rounds for Polyfluorinated Alkyl Substances (PFAS) are summarized on Figure 5a. Water quality samples collected on August 25, 2016 indicate the presence of PFOA in observation well OBS-03 and OBS-02 (at concentrations of 2.5 nanograms per liter (ng/L) and an estimated 0.79 ng/L, respectively), along with Perfluoroheptanoic Acid (PFHpA) in three of the five observations wells (OBS-03, OBS-04, and OBS-05, at concentrations of 13 ng/L, 5.1 ng/L, and 4.2 ng/L, respectively). The results also indicated the presence of PFHpA in the sampling pump equipment blank, which suggests that the PFHpA identified in the August samples was due to incidental sample contamination during collection.

Water quality samples to confirm the August results were collected from the observation wells on September 15, 2016. The results confirmed PFOA in observation wells OBS-03 and OBS-02 at concentrations of 3.1 ng/L and an estimated 0.80 ng/L, respectively. The results for PFHpA were non-detect (at a method detection limit of 0.87 ng/L), which further suggested that the PFHpA identified in the August series of samples was most likely the result of incidental sampling equipment contamination. A potential source for the PFOA found in the August and September water quality samples was not evident.

Baseline Analytical Screening - Additional Chemical Constituents

Additional baseline screening for additional chemical constituents in the Site observation wells was performed in October 2016. Groundwater samples were collected from observation well OBS-02 on October 6, 2016 as provided in *New York State Part 5, Subpart 5-1 - Public Water Supply Systems* (NYS Part 5), considering its proximity to the then proposed test well location. The results indicated that Trihalomethane Compounds, Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), Chlorinated Pesticides, Polychlorinated Biphenyls (PCBs), Herbicides, Halogenated Acids, Carbamate Pesticides, Glyphosate, Diquat, Paraquat, and Tetra-Chlorinated Dioxin were not present in the groundwater sample from OBS-02. Propylene Glycol (a Non-Halogenated Organic Compound) was detected at an estimated concentration of 2.2 milligrams per liter (mg/L) in the sample, which is greater than the established NYS Part 5, Subpart 5-1 Drinking Water Maximum Contaminant Level (MCL). However, the absence of this compound in a March 2017 groundwater sample collected from the nearby Test Well (PW-01) suggests that its detection in the October 2016 was anomalous.

Of the seven metals detected in the October OBS-02 sample (iron, manganese, sodium, zinc, barium, copper, and nickel), only manganese exceeded the applicable NYS Part 5 MCL. Cyanide and radiological constituents were also screened for and detected at an estimated concentration of 0.0043 mg/L for total cyanide, 0.299 picocuries per liter (pCi/L) for Radium-226 alone, 0.505 pCi/L for Radium-226 and Radium-228 combined, and 4.04 µg/L for Uranium - all of which are less than the established NYS Part 5 MCL for these potential contaminants. The groundwater sample from OBS-02 was also screened for potential microbiological contaminants, including fecal coliform, Escherichia coli (E. coli), and other coliform bacteria. The analysis did not indicate the presence of these potential microbiological contaminants in the groundwater sample.

Groundwater samples were collected from observation wells OBS-01, OBS-03, OBS-04, and OBS-05 on October 6 and 7, 2016 for VOC, SVOC, Organochlorine Pesticides, PCBs, Organophosphorus Compounds, Herbicides, Metals, Mercury, and Cyanide analysis. The results indicate that VOCs, SVOCs, PCBs, Organophosphorus Compounds, Herbicides, Mercury, and Cyanide were not present in the groundwater from these observation wells. Trace levels of the organochlorine pesticides Alpha-BHC (in OBS-05), Gamma-BHC (Lindane) (in OBS-04 and OBS-05), and Endrin Aldehyde (in OBS-01, OBS-04, and OBS-05) were detected in the baseline groundwater samples, however none of the results exceeded their respective Part 5 MCLs. Arsenic, iron, and manganese were the only metals detected that exceeded their respective Part 5 MCLs with arsenic at 0.021 mg/L (OBS-05); iron at 9.4 mg/L (OBS-05); and manganese at 0.32, 0.37, 0.40, and 0.44 mg/L (in OBS-01, OBS-02, OBS-03, and OBS-05, respectively).

Post-Pumping Test Screening - Confirmation - Test and Observation Wells - Volatile Organic Compounds
Water quality samples to confirm the March 2017 VOC results were collected from the series of observation wells and the Test Well on April 13, 2017. Acetone was found again in OBS-02 - this time at an estimated 5.2 µg/L - and was found in OBS-01 at an estimated 3.2 µg/L and in OBS-03 at an estimated 3.6 µg/L. Based on the absence of acetone in any of the previous sampling results, the acetone found in the April series of samples is likely attributable to laboratory contamination. Toluene was detected again in the April 2017 sample from PW-01 - this time at a concentration of 0.0092 mg/L (or, 9.2 µg/L) - a level above the applicable Part 5 MCL. Toluene was not found in any of the other April samples. A potential source for the toluene found in the March and April water quality samples was not evident. No other VOCs were detected in the April 2017 samples. General water chemistry results found bromide in OBS-05 and OBS-04 at 0.45 mg/L and an estimated 0.080 mg/L, respectively. Bromide was not detected in the April samples from the Test Well, OBS-01, OBS-02, or OBS-03. A potential source for the bromide found in the two April water quality samples from the observations wells (OBS-04 and OBS-05) and the March water quality sample from the Test Well, was not evident but could be related to the low-level detections of pesticides found earlier in the baseline groundwater samples.

Conclusions and Recommendations

Due to the complex response of the aquifer to pumping during the test, and lack of hydrogeologic information to the north and east of the Test Well location, it was not possible to assess the potential for multiple pumping wells to provide the targeted production rate of 1 MGD. Given the complexity of the aquifer system, additional assessment through numerical modeling of the groundwater system could be useful to ascertain what increase in production, if any, could be acquired using multiple wells within the vicinity of the site. Based on the geophysical data, the aquifer thins toward the south, and there may not be enough aquifer thickness in areas south of the Test Well to support an additional well with similar performance to the test well to significantly increase overall production. However, if there is sufficient areal extent and thickness of the sand and gravel confined aquifer toward the north or east, an additional well may provide greater yield for use as mixing water, or as a primary source during low-demand periods. Additional testing and analysis would be required to evaluate the suitability of the aquifer for additional production using multiple wells.

If the Site will be used as a supporting source of groundwater production for the Village of Hoosick Falls, Arcadis recommends the following additional evaluation to support development of the production wellfield:

- Completion of additional geophysical investigation to the north and east of the Site to evaluate the nature and extent of the semi-confined aquifer and the confining unit in those areas.
- Development of a numerical model to further assess the production potential of the aquifer, and support design and evaluation of multiple well production.
- Development of a wellhead protection program, or expansion of an existing program, to include the Site and existing Village well field.
- Additional assessment of the nature and extent of PFAS in groundwater in the vicinity of the site, including identification and assessment of potential sources of PFOA in groundwater.

In addition, design of suitable wellhead structures would be necessary to protect wellhead areas from seasonal flooding from the Hoosic River.

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FIGURES

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ACRONYMS AND ABBREVIATIONS

AWS	Alternate Water Supply
bgs	Below Ground Surface
cm/sec	Centimeters per Second
CSM	Conceptual Site Model
ER	Electrical Resistivity
ft/d	Feet per Day (also **fps** – feet per second, and **ft^2/day** – square feet per day)
gpm	Gallons per Minute (also **gpd** – gallons per day, and **gpm/ft** – gallons per minute, per foot)
K	Aquifer Hydraulic Conductivity
MGD	Million Gallons per Day
MCL	Maximum Contaminant Level
MTBE	Methyl tert-butyl ether
mg/L	Milligrams per Liter (also **µg/L** – Micrograms per Liter, and **ng/L** – Nanograms per Liter)
NAVD88	North American Vertical Datum of 1988
NWS	National Weather Service
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
PCB	Polychlorinated Biphenyls
PFAS	Polyfluorinated Alkyl Substance
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
PFHpA	Perfluoroheptanoic Acid
Q	Discharge Rate
S	Aquifer Storage (Storativity)
SC	Specific Capacity
SVOC	Semi-Volatile Organic Compounds
VOC	Volatile Organic Compounds
T	Aquifer Transmissivity
TAL	Target Analyte List
TIC	Tentatively Identified Compound
TOC	Total Organic Carbon
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency

1 INTRODUCTION

Arcadis CE, Inc. (Arcadis), on behalf of the New York State Department of Environmental Conservation (NYSDEC), has been evaluating alternate water supply (AWS) options for the Village of Hoosick Falls, New York to address elevated levels of Perfluorooctanoic Acid (PFOA) found in the existing water supply for the Village. Several alternatives are being explored for providing raw water to the Village of Hoosick Falls Water Treatment Plant (Village WTP). These alternatives include identification and assessment of a new groundwater source to replace the existing source aquifer.

Pursuant to the scope of services included in Work Order #D0076618-43, Arcadis has completed evaluation of a potential groundwater source aquifer present beneath agricultural land along the Hoosic River adjacent to New York State Route 22 (Site), approximately two miles south of the Village of Hoosick Falls (Figure 1). This Groundwater Source Aquifer Evaluation Report (Report) provides a summary of the field activities completed in support of the aquifer evaluation, and the results and conclusions of the testing and analyses performed.

1.1 Site Overview

The Site consists of the northern portion of lands adjacent to the Hoosic River, present along the western side of the Hoosick River Valley between the river and New York State Route 22 (Figure 1). The property consists of agricultural lands adjoining the western river bank, and extending westerly toward Route 22 to the west. Additional agricultural lands are present to the north and south of the investigation area, with residential and commercial property in the northwestern most corner of the site between the agricultural land and Route 22 (Figure 1). The Site generally consists of topographically flat to slightly undulating floodplains along the river.

Based on the geophysical data, and subsequent soil boring data collected during preliminary geologic evaluations at the Site, a confined aquifer of variable thickness is present beneath the site, extending an unknown distance to the north, east, and west, and decreasing in extent and thickness toward the south of the site. The aquifer is a heterogeneous mixture of sands, silty sands, and coarse-grained sand and gravel, overlain by a silty clay confining unit of varying thickness. A conceptual site model (CSM), which summarizes the physical, geologic, and hydrologic characteristics of the portion of the aquifer beneath the Site is provided in Section 4.

1.2 Purpose and Objectives

Arcadis, in cooperation with the NYSDEC and the United States Geological Survey (USGS), performed an assessment of the geologic, hydrologic, and hydrogeologic characteristics of the portion of the confined aquifer present beneath the Site for the feasibility of using the Site as an alternate source of groundwater to supply the Village of Hoosick Falls. The evaluation included an assessment of aquifer hydraulic characteristics, and estimation of potential well yield as the basis of suitability as an alternate public water source. Based on discussions with the NYSDEC and the Village of Hoosick Falls, a target rate of 1 million gallons per day (MGD) was targeted as a suitable production rate for a replacement well field.

The assessment included review and development of the preliminary geophysical and geologic boring data, in addition to stepped-drawdown and constant-rate aquifer pumping tests to evaluate hydraulic properties of the confined aquifer, specifically aquifer transmissivity (*T*), storativity (*S*), production well specific capacity. These parameters were developed as the basis for estimates of potential well yield and anticipated aquifer production capacity. In addition, adjacent production wells at the Hoosick Falls High School, the Village well field, and several other surrounding wells were monitored to assess potential influence on nearby water wells during pumping in the aquifer.

The evaluation field work was completed in accordance with the Village of Hoosick Falls AWS Study *Groundwater Source Evaluation Field Activities Program*, prepared for the NYSDEC by Arcadis, dated February 13, 2017. While the groundwater source aquifer evaluation activities presented herein are not being completed for the purposes of certification or permitting of groundwater withdrawals, the pumping test procedures presented herein are in general accordance with the NYSDEC *Pumping Test Procedures for Water Withdrawal Applications* (Appendix 10, TOGS 3.2.1, Water Withdrawal Supply Permit Program Application Processing, February 2015).

1.3 Report Organization

Arcadis has prepared this Groundwater Source Aquifer Report to summarize the data collected, provide a summary of the data evaluation and estimates of aquifer properties, and provide the conclusions and recommendations based on the evaluation. The remainder of this Report is organized as follows;

- **Section 2** summarizes the preliminary investigations completed at the Site, including preliminary Site geologic investigations and collection of baseline analytical data;
- **Section 3** summarizes the field work completed at the Site in support of the aquifer evaluation, including collection of analytical data, and completion of aquifer testing;
- **Section 4** provides an analysis and interpretation of the hydraulic data, and an assessment of water quality;
- **Section 5** presents the conclusions of the aquifer evaluation, and provides recommendations for further consideration; and,
- **Section 6** provides the references cited in this Report.

2 INITIAL SITE INVESTIGATION

2.1 Geophysical Survey

During March and April 2016, a preliminary seismic refraction survey was completed by Northeast Geophysics at the Site to determine bedrock depth beneath the Site. Seven seismic lines totaling 8,940 lineal feet were surveyed, and were supplemented with data from nine soil borings (Figure 2). The Seismic Refraction Survey Report completed by Northeast Geophysics (May 2016) is provided in Appendix A, and the soil boring logs are provided in Appendix B.

The survey identified three velocity layers. The median Layer 1 velocity for the survey was 877 feet per second (fps) and is interpreted to represent dry soil. The median Layer 2 velocity for the survey was 4,862 fps and is interpreted to saturated soil. The median Layer 3 velocity was 16,021 fps and is interpreted to represent bedrock. Seismic profiles developed from the refraction data are presented in the Northeast Geophysics Report (May 2016) provided in Appendix A. Interpretation of the seismic refraction data indicated depth to bedrock at the Site ranging from 23 to 160 feet below ground surface (bgs), with the depth to bedrock trending deeper at the northernmost end of the Site (Figure 3).

In addition to the seismic refraction data, corresponding surface electrical resistivity (ER) lines were completed along each of the seismic refraction survey lines (Figures 2 and 3). The electrical resistivity data was used in conjunction with the soil boring data to assess and interpret the presence and thickness of unconsolidated stratigraphic units beneath the Site. The ER profiles developed from the resistivity data are presented in Appendix A. The ER data, supported by soil boring data along the same profile lines, suggested the presence of a silt/clay unit beneath the Site, overlain by recent alluvial sediments from deposition by the Hoosic River, and underlain by silty sands and gravels. This clay unit ranges from 60 to 80 feet in thickness in the northern and middle portions of the Site, thinning toward the southern end of the property. The clay unit was underlain by a heterogeneous distribution of coarse to fine sands, silty sands, and coarse sand-gravel units representing a confined to semi-confined water bearing unit at the Site.

The geologic and geophysical data collected during the preliminary study indicated that the portion of the aquifer within the vicinity of Location 4 (Figure 3) provided the best potential for groundwater production. Data suggested that the water bearing unit in this portion of the Site had the greatest thickness (ranging from approximately 20 to 40 feet), and consisted primarily of coarse sand and gravel.

2.2 Preliminary Site Screening

2.2.1 Initial Hydraulic Testing

Based on the results of soil boring and geophysical data, and with agreement from the NYSDEC, Arcadis proceeded with the installation of observation and preliminary test wells during June 2016 to evaluate the hydraulic properties of the confined aquifer below the Site. A single test well cluster consisting of two 1.25-inch wells (one pumped well and one observation well) were installed in the vicinity of LOC4-SB-02 (Figure 2). The observation well was installed within 10 feet of the pumped well, and used to monitor drawdown in the aquifer independent of well efficiency and effects of well loss present in the pumped well. During the pumping evaluation, the test well (LOC4-TW-01) was pumped using a surface suction pump, while water level in the observation well (OBS-01) was monitored using a datalogging pressure transducer and manual water level measurements using an electronic water level probe. A theoretical estimate of specific capacity (SC) was made based on the observed drawdown in the observation well (s) at the discharge rate (Q), as a qualitative assessment of the potential yield of the aquifer.

The test well was pumped for a period of approximately 3.5 hours before reaching a relatively stable drawdown level of 2.4 feet from static, which was measured at approximately 10.2 feet bgs. The pumping rate stabilized at a maximum of approximately 38 gallons-per-minute (gpm). Based on the observed drawdown of 2.4 feet and the discharge rate, an approximate specific capacity was estimated at 16 gpm per foot (gpm/ft) of saturated thickness. This value was an approximation, which would be further evaluated under longer duration pumping conditions. However, using this value, and an empirical equation developed from the modified non-equilibrium equation (Driscoll, F. G. 1986. Groundwater and wells, 2nd Ed. St. Paul, MN: Johnson Division.), aquifer T, in gallon-per-day per foot of saturated thickness (gpd/ft) can be approximated by:

$T = 2000\ Q/s$ (confined aquifer), where $Q/s = SC$

Using this empirical formula and the approximate specific capacity established from the pumping data, the aquifer T is approximately 31,660 gpd/ft. Based on available data from the Village of Hoosick Falls production well #7 72-hour test, which indicated an estimated specific capacity of 23.36 gpm/ft and an estimated T of 34,905 gpd/ft, the approximated value of T estimated from the preliminary pumping evaluation of 31,660 gpd/ft is comparable to this value. Therefore, the preliminary testing suggested that the aquifer beneath the Site could provide at least a portion of the water needed by the Village of Hoosick Falls (approximately 1 MGD).

The hydraulic performance of the test well suggested that further evaluation of the confined aquifer beneath the Site for use as a potential groundwater source aquifer for the Village was warranted. Therefore, with approval from the NYSDEC, Arcadis moved forward with abandonment of the preliminary test well and installation of four additional observation wells (OBS-02 through OBS-05) at the Site during the Summer of 2016, and additional baseline analytical sampling in September 2016, in anticipation of production testing.

2.2.2 Water Quality Screening – June 2016

During the initial hydraulic testing, at the end of the pumping period and prior to terminating pumping, the groundwater at LOC4-TW01 was sampled for the following:

- Polyfluorinated Alkyl Substances (PFAS), including PFOA and Perfluorooctane sulfonate (PFOS) using USEPA Method 537 1.1(modified);
- Volatile Organic Compounds (VOCs) using USEPA method 8260B (including MTBE, TICs);
- Semi-Volatile Organic Compounds (SVOCs) using USEPA method 8260B (including TICs);
- Target Analyte List (TAL) Metals using USEPA method 6010B;
- Total Organic Carbon (TOC) – EPA 415.1; and,

- Hardness (USEPA 130.1; SM 2340).

Equipment blank samples were also collected from the suction pump, pressure transducer, and water level probe for PFAS analysis. Analytical samples were submitted to TestAmerica Laboratories. Summary analytical reports are provided in Appendix C-1.

The analytical results did not indicate the presence of PFAS compounds in the groundwater sample from the test well. Except for a low levels of butyl benzyl phthalate (8.4 μg/L), there were no additional detections of SVOCs or VOCs in the test well groundwater sample.

2.2.3 Additional Soil Boring and Well Installation

As shown on Figure 4, four additional observation wells were installed on the Site in support of the aquifer evaluation program (OBS-02 through OBS-05) during late summer and fall of 2016. The new observation wells were constructed the same as the initial 1.25-inch test wells installed for the preliminary hydraulic testing. The wells were screened across the confined aquifer, with an appropriate screen size and length based on textural data from laboratory and field sieve analysis. Well construction details are provided in Appendix B. A summary of the observation well construction details is provided on Table 1.

The well locations and well elevations (top of casing, measuring point, and adjacent ground surface), and staff gauges were surveyed to establish the vertical elevation of a reference point on each observation well and on the pumping well (e.g., "top of casing") were established to the nearest 0.01 foot, based on the North American Vertical Datum of 1988 (NAVD88).

2.2.4 Baseline Analytical Sampling – August and September 2016

On August 25, 2016, after installation and development of the four additional observation wells, all five observation wells (OBS-01 through OBS-05) were sampled and analyzed for PFAS (including PFOA and PFOS) using USEPA Method 537 1.1(modified). The data was used to screen the potential groundwater production site for the presence of PFAS compounds prior to further assessment. Equipment blank samples were also collected from the suction pump, pressure transducer, and water level probe for PFAS analysis. Summary analytical reports for the August sampling round are provided in Appendix C-2, and the results are summarized on Figure 5a.

The August analytical results indicated the presence of PFOA in observation well OBS-03 and OBS-02 (at concentrations of 2.5 nanograms per liter (ng/L) and an estimated 0.79 ng/L, respectively), along with Perfluoroheptanoic Acid (PFHpA) in three of the five observations wells (OBS-03, OBS-04, and OBS-05, at concentrations of 13 ng/L, 5.1 ng/L, and 4.2 ng/L, respectively). The results also indicated the presence of PFHpA in the sampling pump equipment blank, which suggests that the PFHpA identified in the August samples was likely due to incidental contamination of the sample during sample collection.

On September 15, 2016, additional groundwater sampling was performed to confirm the August PFAS results. The September sampling data confirmed the presence of PFOA in groundwater samples from observation wells OBS-03 and OBS-02 (3.1 ng/L and an estimated 0.80 ng/L, respectively). The results for PFHpA were non-detect (at a method detection limit of 0.87 ng/L), which further suggested that the PFHpA identified in the August 25th samples was likely the result of incidental sample contamination. A potential source for the PFOA found in the August and September water quality samples was not evident.

The summary analytical reports for the September sampling round are provided in Appendix C-3, and the results are summarized on Figure 5a.

2.2.5 Additional Analytical Screening – October 2016

Groundwater samples were collected from observation well OBS-02 during October 2016 as provided in New York State Part 5, Subpart 5-1 - Public Water Supply Systems (NYS Part 5), considering its proximity to the then proposed test well location. In addition, the other four observation wells (OBS-01 and OBS-03 through OBS-05) were screened for the following:

- VOCs using USEPA method 8260B (including MTBE, TICs);
- SVOCs using USEPA method 8260B (including TICs);
- TAL Metals using USEPA method 6010B;
- Poly-chlorinated Biphenyls (PCBs);
- Organochlorine Pesticides;
- Organophosphorus Compounds; and,
- Herbicides.

The data was used to screen the potential groundwater production site for the presence of other potential drinking water contaminants prior to completing further hydraulic assessment of the site. Summary analytical reports for the October samples are provided in Appendix C-4.

The results from the OBS-02 groundwater samples collected on October 6, 2016 indicated that Trihalomethane Compounds, Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), Chlorinated Pesticides, Polychlorinated Biphenyls (PCBs), Herbicides, Halogenated Acids, Carbamate Pesticides, Glyphosate, Diquat, Paraquat, and Tetra-Chlorinated Dioxin were not present in the groundwater sample from OBS-02. Propylene Glycol (a Non-Halogenated Organic Compound) was detected at an estimated concentration of 2.2 milligrams per liter (mg/L) in the sample, which is greater than the established NYS Part 5, Subpart 5-1 Drinking Water Maximum Contaminant Level (MCL). However, the absence of this compound in a March 2017 groundwater sample collected from the nearby Test Well (see Section 4.3) suggests that its detection in the October 2016 sample was anomalous.

Of the seven metals detected in the October OBS-02 sample (iron, manganese, sodium, zinc, barium, copper, and nickel), only manganese exceeded the applicable NYS Part 5 MCL. Cyanide and radiological constituents were also screened for and detected at an estimated concentration of 0.0043 mg/L for total cyanide, 0.299 picocuries per liter (pCi/L) for Radium-226 alone, 0.505 pCi/L for Radium-226 and Radium-228 combined, and 4.04 µg/L for Uranium - all of which are less than the established NYS Part 5 MCL for these potential contaminants. The groundwater sample from OBS-02 was also screened for potential microbiological contaminants, including fecal coliform, Escherichia coli (E. coli), and other coliform bacteria. The analysis did not indicate the presence of these potential microbiological contaminants in the groundwater sample.

As summarized on Figures 5b and 5c, results from groundwater samples collected in observation wells OBS-01, OBS-03, OBS-04, and OBS-05 on October 6 and 7, 2016 indicated that VOCs, SVOCs, PCBs, Organophosphorus Compounds, Herbicides, Mercury, and Cyanide were not present in the groundwater samples from these observation wells. Trace levels of the organochlorine pesticides Alpha-BHC (in OBS-05), Gamma-BHC (Lindane) (in OBS-04 and OBS-05), and Endrin Aldehyde (in OBS-01, OBS-04, and

OBS-05) were detected in the baseline groundwater samples, however none of the results exceeded their respective Part 5 MCLs. As summarized on Figure 5d, arsenic, iron, and manganese were the only metals detected that exceeded their respective Part 5 MCLs with arsenic at 0.021 mg/L (OBS-05); iron at 9.4 mg/L (OBS-05); and manganese at 0.32, 0.37, 0.40, and 0.44 mg/L (in OBS-01, OBS-02, OBS-03, and OBS-05, respectively).

3 SOURCE AQUIFER EVALUATION

During January through March of 2017, Arcadis further evaluated the aquifer by completing a constant-rate aquifer pumping test. The data collected during the test was used as the basis for assessment of the potential yield of the aquifer, and its suitability for use as a replacement for the existing village wellfield. The source aquifer evaluation program was supported by the following additional field activities:

- Installation of a 10-inch diameter test well;
- Setup and operation of a rain gauge and staff gauges, and barometric monitoring in the vicinity of the pumping site;
- Completion of a stepped-rate pumping test to evaluate test well efficiency and establish a suitable production rate for constant-rate test.
- Completion of a 72-hour constant-rate pumping test in the 10-inch diameter test well;
- Additional sampling and analysis of groundwater from the test well for PFAS and NYS Part 5 analytical requirements at the end of the aquifer pumping test; and,
- Monitoring of recovery for up to 24 hours in the test well and monitoring well network (MWN) after pumping termination.

The remainder of Section 3 summarizes the completion of the field activities supporting the investigation, and performance of the pumping tests and analytical testing. The findings and interpretation of the testing results are presented in Section 4.

The field program and pumping test procedures and protocols governing the testing and data collection during the source aquifer evaluation are provided in the Village of Hoosick Falls AWS Study *Groundwater Source Evaluation Field Activities Program*, prepared for the NYSDEC by Arcadis, dated February 13, 2017.

3.1 Soil Boring and Test Well Installation

During mid-January through early February 2017, a 10-inch production test well was installed adjacent to observation well OBS-2, within 10 feet to the south of the observation well. The bedrock in this area drops to a depth of up to approximately 140 feet bgs. Boring data indicates aquifer material consisting of fine to coarse sand and fine gravel, with an estimated aquifer thickness of up to approximately 52 feet. Based on the geophysical and boring data, this location was estimated to provide the best potential for groundwater production.

Prior to installation of the 10-inch production well, a pilot boring was completed adjacent to the proposed production well location (Figure 6), using drive casing to obtain aquifer material from beneath the clay confining unit to the base of the overburden aquifer for laboratory for sieve analysis. The pilot boring was completed in January 2017, with six sieve samples collected for textural analysis. The casing was driven into the top of the rock, which was indistinct, to confirm competent rock at approximately 136.9 feet bgs. A water bearing fracture was encountered at approximately 143 feet bgs, and the NYSDEC agreed that the pilot boring drive casing would be left in place (as observation well OBS-BR) during subsequent testing to monitor groundwater head in bedrock near the Production Test Well.

The aquifer material samples were sent to Johnson Well Screens for textural analysis, and used as the basis for screen design of the 10-inch diameter production test well (provided in Appendix B). Based on assessment of the textural data, the production test well was designed as a naturally-developed well emplaced in the formation material, with a 10-inch outer diameter (8.57-inch inner diameter) 20-foot long, stainless-steel wire-wound 0.100-inch slot well screen, placed from approximately 118 to 138 feet bgs.

As shown on Figure 7, the production test well was installed using a telescopic screen installation, in which the 10-inch screen was installed within a surface casing. Prior to installation, a 12-inch surface conductor casing was installed to 20 feet bgs into the clay confining unit. A steel surface casing (riser casing) with an internal diameter of over 10 inches was installed using cable-tool drive-and-wash techniques to the base of the aquifer (approximately 138 feet bgs). The well screen was then installed into the surface casing to the bottom of the boring, and held in place with rods while the surface casing was retracted to the top of the screen interval at approximately 118 feet bgs, leaving approximately 20 feet of screen exposed to the formation. A 3-foot tight-wound section of screen at the top of the open screen was included as a riser section for installation of a packer assembly within the surface casing to seal the screen within the surface casing (Figure 7).

The well was then developed to remove finer material from the surrounding formation and improve the hydraulic performance of the well. During development, the well and surrounding formation were “washed” using a surge block, while simultaneously pumped to remove the mobilized fine silts and sands passing through the screen. During development, the pumping rate and drawdown were periodically monitored to assess changes in well performance over time using estimates of well specific capacity (see well development logs provided in Appendix B).

During development, estimates of pumping rate and observed water levels in the well suggested that aquifer performance was potentially less than initially anticipated, with estimates of specific capacity at a maximum of 5 gpm/ft. Given an estimated available saturated thickness (available drawdown) of up to 100 feet, the data indicated a maximum yield of up to 400 gpm, which was less than initial estimates. Based on this information, and in consultation with the NYSDEC, the planned pumping rate schedule for the stepped-drawdown testing was decreased throughout the planned steps, as discussed below in Section 3.3.

3.2 Groundwater and Surface Water Monitoring

3.2.1 Monitoring Well Network (MWN)

A MWN consisting of both on-site (local) observation wells and off-site (regional) wells was established for observation of drawdown during the pumping test. The observation well locations shown on Figures 4, 6, and 8 were selected in coordination with the NYSDEC and the USGS.

As shown on Figure 4, the local MWN consists of 6 wells, including the 1.25-inch observation wells (OBS-01 through OBS-05) and the adjacent bedrock observation well installed during the pilot boring program. In addition to monitoring the local MWN in support of the aquifer evaluation at the Site, the USGS, in coordination with Arcadis and the NYSDEC, monitored water levels in several production and monitoring wells in the surrounding area, as shown on Figure 8 and listed below:

- High School Well (RE108);
- Private Supply Well RE7003;
- Private Supply Well RE158;
- Private Supply Well RE157;
- Commercial Supply Well RE6814; and,
- Observation wells RE123 and RE124, at the northern and southern sides of the Village of Hoosick Falls Production Wellfield, respectively.

The wells were selected to characterize hydraulic connections in the confined sand & gravel aquifer and overlying unconfined aquifer. As summarized in the the Village of Hoosick Falls AWS Study *Groundwater Source Evaluation FAP* (Arcadis, 2017), water levels were monitored:

- During pre-pumping test background periods, to evaluate groundwater elevation and flow trends;
- During the stepped-drawdown and constant-rate pumping tests; and
- For a period of up to 40 hours after the constant-rate pumping test to monitor aquifer recovery.

The data was used to assess background water level trends in the confined and unconfined portions of the local valley-fill aquifer, and the relationship between stream stage fluctuations and water levels in the confined aquifer, if any (see Section 4). In addition, current major stresses on the overburden aquifer, including pumpage from the Town wellfield, the Hoosick Falls High School Well, and the other monitored private and commercial water supply wells were evaluated with respect to the extent and magnitude such pumpage has on water levels in the confined portion of the Site aquifer (see Section 4).

Static water levels at the production test well and the local and regional MWN were monitored using datalogging pressure transducers, and supplemented with manual readings, as summarized in the Village of Hoosick Falls AWS Study *Groundwater Source Evaluation FAP* (Arcadis, 2017).

A datalogging barometric recorder was deployed above the water table at OBS-04 to log barometric pressure during periods when groundwater levels were being logged to correct the water levels for barometric effects. A stilling tube was installed in the production test well to facilitate the installation of manual water level probe and pressure transducer and prevent entanglement with down-well pumping equipment.

3.2.2 Surface Water Monitoring

To evaluate if any hydraulic connection exists between the Hoosic River and confined aquifer in the vicinity of the test area, a staff gauge and associated stilling well were installed at a location on the Hoosic River adjacent to the Site (Figure 6). The staff gauge allowed for a qualitative assessment of the connection between the river and the aquifer that could have resulted from a significant and rapid change in surface water level during pumping.

3.2.3 Precipitation Monitoring

A tipping-bucket, data-logging rain gauge was installed at the test site to record precipitation through all phases of the aquifer testing. The rain gauge was sited adjacent to OBS-01 (see Figure 6) where there are no overhead obstructions or other potential interference.

3.3 Aquifer and Well Yield Testing

The groundwater source aquifer evaluation consisted of both a stepped-drawdown test and constant-rate pumping test to evaluate the potential yield of the aquifer and production test well. The test procedures are detailed in the Village of Hoosick Falls AWS Study *Groundwater Source Evaluation FAP* (Arcadis, 2017), and summarized below.

3.3.1 Pumping Test Setup

As detailed in the Village of Hoosick Falls AWS Study *Groundwater Source Evaluation FAP* (Arcadis, 2017), the discharge chain included a submersible pump, flow meter combination, and conveyance hose as described below.

A six-inch submersible pump was installed in the test well, and connected to the surface by a 3-inch diameter riser pipe. The pump was installed with a suitable check-valve apparatus to prevent backflow of water in the discharge line into the well. The discharge header included a gate valve prior to the flow meter to provide additional discharge/ flow control. The pump was set within the surface casing, with the intake at approximately 113 feet bgs.

As the pumping test was completed during freezing conditions, the electronic flow meter failed to function properly and was substituted with an orifice plate at the discharge point during testing. The orifice plate was used in conjunction with a mechanical flow totalizer to monitor the flow rate with two independent measurements, which provided greater confidence in measurement accuracy.

Water discharged during the constant-rate test was conveyed away to the north from the pumping well, in a down gradient direction to the drainage swale at the north end of the property (Figure 6). The resultant discharge point is at a sufficient distance (approximately 300 feet away) to eliminate recharge of pumped water to the confined aquifer.

3.3.2 Stepped-Drawdown Testing

Stepped-drawdown testing in the production test well was completed on 21 February 2017. The test well was pumped at increasing rates, and water levels were monitored in the pumping well and adjacent observation well (OBS-02), to establish a suitable constant pumping rate for the 72-hour constant-rate pumping test, and assess well efficiency and specific capacity.

As discussed in Section 3.1, estimated of production test well specific capacity during well development resulted in deviation from the original pumping rates developed for the testing program in the Village of Hoosick Falls AWS Study *Groundwater Source Evaluation FAP* (Arcadis, 2017). The maximum pumping rate planned for the test was reduced to 400 gpm, with targeted steps at approximately 25, 50, 75, and 100 percent of the anticipated maximum pumping rate (100, 200, 300, and 400 gpm, respectively). With the pump intake at 113 feet bgs (approximately 116 feet from the measurement point at the top of the stilling well), and a static water level of 8.38 feet below the top of the stilling well, an estimated 97 feet of available drawdown (from static to 10 feet above the top of the pump intake) was indicated at the beginning of the test.

A summary of water levels observed in the test well during the stepped-drawdown test is provided on Figure 9. As shown on the figure, the resultant steps were at 130, 221, 319, and 342 gpm. The maximum drawdown observed during the fourth step was 63.72 feet (water level of 72.1 feet below the measure point). Due to the magnitude of the drawdown, there was insufficient head to increase the pumping rate beyond 342 gpm. Therefore, this represented the final step, which resulted in dewatering the well to approximately 66 percent of the available drawdown after 30 minutes of pumping at this rate.

As discussed in Section 4.2, the resultant estimates of specific capacity for the test well indicate an average specific capacity of approximately 5 gpm/ft. A comparison of water levels in the test well and adjacent observation well OBS-02 indicate a well efficiency of approximately 88 percent.

Based on an assessment of projected drawdown of stepped-drawdown water levels over a three-day (72-hour) pumping duration (Figure 10), a pumping rate of up to 350 gpm was potentially sustainable for the constant-rate test. However, given the recent rain and snow melt in the vicinity of the Site, and an indication in background water level trends that water levels in the aquifer were on a decreasing trend during the period leading up to the scheduled constant-rate test, a pumping rate of 300 gpm was conservatively chosen for the constant rate test.

The 300 gpm (432,000 gpd) rate is approximately 13 percent above the average daily production rate, but approximately 53 percent below, the maximum daily production rate for the Village of Hoosick Falls, based on production data from February through April 2016 provided by the Village Water Department in May 2016. However, it was anticipated that a 300 gpm rate would sufficiently stress the aquifer, while considering that continued decreasing heads within the aquifer could result in decreased available drawdown at the start of the constant-rate test.

3.3.3 Constant-rate Pumping Test

3.3.3.1 Pre-test (Background) Conditions

Pre-testing conditions were monitored from completion of the stepped-pumping test on 21 February until prior to the start of the constant-rate pumping test on 3 March 2017. As shown on Figure 11, water levels in the aquifer continued to decline after a recharge event on 26 February 2017. This recharge event coincided with increased discharge in the Hoosic River resulting from increased runoff from snow melt and precipitation. Water levels in the aquifer began to level off by 1 March, with a slight increase again in river and aquifer water levels late on 2 March.

Pumping in the High School well caused minor drawdown effects in the Test Well during the background monitoring period (Figure 11), resulting in less than a foot of drawdown in the test Well during High School Pumping with relatively rapid recovery after the pumping stress ceased. As it was unfeasible for the High School to cease pumping for more than 8 to 12 hours, the constant-rate test was performed over a weekend (when school water usage is significantly less) to minimize interference caused by pumping in the High School well. In addition, Arcadis coordinated with the High School Maintenance Office to suspend pumping for at least an 8-hour period starting just prior to the beginning of the constant-rate test, and started the test after school hours. Although the school needed to fill its storage tank prior to shutting down for this period, water levels in the Test Well recovered to pre-stress levels prior to the start of the constant-rate test.

The background data suggest that while water levels in the aquifer were still above a baseline trend, water levels were returning to pre-recharge conditions as temperatures decreased below freezing, limiting further recharge through snow melt prior to the test. There was no additional measurable precipitation between 28 February and 3 March, and no additional precipitation forecast by the National Weather Service (NWS) for the following 5-day period. Therefore, with concurrence from the NYSDEC, the constant-rate test proceeded as planned on 3 March 2017.

3.3.3.2 Pumping Test Completion

The constant-rate aquifer pumping test was started at approximately 5:50 pm on 3 March 2017. During the morning of 3 March, a short pumping period (less than 5 minutes of pumping) was performed to set the control valve to the proper position to obtain the desired 300 gpm flow rate for the test. The flow rate was again closely monitored for the first hour of the test, and periodically throughout the test duration using measurements from the totalizer and orifice plate, to ensure a constant flow rate was initiated and maintained.

A summary of the drawdown in the Test Well and the High School well is presented on Figure 12 and summary water level plots for individual observation wells are provided in Appendix D. Pumping continued for 72 hours at 300 gpm, resulting in a total drawdown of approximately 64 feet. A summary of the maximum observed drawdown in the Test Well and observation wells is provided below. The data indicates that the cone of influence in the pumping well expanded outward to all of the observation wells on the Site, and to some in the regional MWN. However, pumping during the 72-hour period did not result in significant drawdown in the adjacent potable supply wells, including the High School well.

Well Location	Distance from pumping center (Feet)	Maximum Observed Drawdown (Feet)
OBS-01	283.6	8.38
OBS-02	8.1	60.62
OBS-03	415.52	9.38
OBS-04	840.24	9.13
OBS-05	2305	5.53
Bedrock Well	8.93	55.56
PW-01 (Test Well)	---	64.51

As shown on Figure 12, pumping in the Test Well did not result in adverse effects to groundwater pumping at the High School. Less than 9 feet of drawdown was observed in the High School well, during static conditions in that well, throughout constant-rate test. While under the constant-rate pumping stress, drawdown in the High School well due to pumping by the High School did not significantly change for the observed 18-20 feet. In addition, pumping in the High School well during the constant-rate test resulted in a change in minimum water levels in the High School well of up to 8 feet from normal levels observed during pre-stress conditions (Figures 11 and 12). Therefore, the data indicated that pumping in the Test Well during the 72-hour period did not adversely affect water levels or pumpage in the High School well. The same was true for more distal potable source wells monitored during the test.

3.3.3.3 Test Well Analytical Sampling

The Test well was sampled on March 6, 2017 during the final 12-hour period prior to completion of the 72-hour pumping test. The samples were sent to TestAmerica Laboratories for analysis of:

- New York State Part 5 requirements for public water supplies; and,
- PFAS Compounds (including PFOA/PFOS) using USEPA Method 537 1.1 (modified).

The laboratory analytical report is provided in Appendix C-5, and a summary of analytical results is provided in Table 2 (Part 5 Parameters), Table 3 (PFAS), and Table 4 (VOCs). The analytical results for the Test Well post-pumping sampling during March 2017 are summarized on Figure 13.

The analytical results for the Post-Pumping Test samples from Test Well PW-01 were similar to the October 2016 results for OBS-02 in that they indicated that Trihalomethane Compounds, SVOCs, Chlorinated Pesticides, PCBs, Herbicides, Halogenated Acids, Carbamate Pesticides, Glyphosate, Diquat, Paraquat, and Tetra-Chlorinated Dioxin were not present in the groundwater from PW-01. The non-halogenated organic compound Propylene Glycol was not detected in this sample either, a finding that supports the possibility that the detection of this compound in the October 2016 sample from nearby OBS-02 may have been anomalous.

Toluene was the only VOC detected in the March 2017 sample from PW-01, and was reported at an estimated concentration of 0. 11 μg/L - significantly less than the applicable Part 5 MCL of 5 μg/L for Principal Organic Compounds (POCs) including toluene. As discussed in Section 4.3, toluene is a potential laboratory contaminant and the March Test Well sample could be an indication of this, considering that toluene was not found in any of the nearby wells. However, toluene was found in a subsequent sample collected from PW-01 during April 2017 (see Sections 3.3.5). Since toluene was not detected in any of the other Site wells during this or other sampling events, the toluene detected in the Test Well sample is likely also anomalous.

Of the ten metals (iron, manganese, sodium, zinc, arsenic, barium, cadmium, copper, nickel, and lead) detected in the March Test Well sample, only manganese exceeded the applicable Part 5 MCL. In addition, general water chemistry analysis found bromide in this sample above its applicable Part 5 MCL at an estimated concentration of 0.26 mg/L. Cyanide and radiological constituents were also screened for and detected at an estimated concentration of 0.0036 mg/L for total cyanide, 0.539 picocuries per liter (pCi/L) for Radium-226 alone, 0.676 pCi/L for Radium-226 and Radium-228 combined, and 4.24 µg/L for Uranium - all levels are well below the established Part 5 MCL for these potential contaminants. The water from PW-01 was also screened for fecal coliform, Escherichia coli (E. coli), and other coliform bacteria. The results were negative for all of these microbiological contaminants. The results of the PFAS analysis found a trace level of PFOA at an estimated concentration of 1.6 ng/L in the water sample.

3.3.4 Recovery Monitoring

The recovery monitoring period began on 6 March 2017, after the completion of NYS Part 5 and PFOA sampling in the Test Well. Prior to shutting down pumping, transducers in the Site observation wells were re-set to the same recording parameters as applied at the start of the pumping test to capture the early-time recovery data.

As shown on the pumping and recovery curves provided on Figure 14 (Test Well) and in Appendix D, the recovery monitoring period lasted for 40 hours after pumping stopped. The aquifer recovered to 11.10 feet bgs (within 10 percent of the original static water level of 10.38 feet bgs) approximately 26 hours after pumping stopped. After 35 hours, static water levels across the Site had reached a peak to within approximately 5 percent of the pre-pumping static water levels, after which water levels began to decline similarly to pre-pumping water level trends.

3.3.5 Post-Pumping Analytical Sampling

After the completion of the recovery monitoring period, analytical samples were collected from the five Site observation wells (OBS-01 through OBS-05) during March 2017, and analyzed for PFAS Compounds (including PFOA/PFOS) using USEPA Method 537 1.1 (modified), and for VOCs using USEPA method 8260B (including MTBE, TICs). Based on the results of the March 2017 Site sample round a subsequent sampling round for the Site observation wells was performed on April 13, 2017, as discussed below. The samples were sent to TestAmerica Laboratories for analysis. The laboratory analytical reports are provided in Appendices C-5 (March) and C-6 (April), and a summary of analytical results is provided in Tables 3 and 4, and summarized on Figure 13.

The results for the March 16, 2017 data indicate the presence of PFOA in observation well OBS-03 and OBS-02 at concentrations of 2.3 ng/L and an estimated 1.4 ng/L, respectively (Figure 13). No other PFAS compounds analyzed for were detected in the Site observation well samples. To complete the Post-Pumping Test screening program, groundwater was sampled from the five Site observation wells (OBS-01 through OBS-05) on March 21, 2017 for VOC analysis. No VOCs were detected in the March 2017 samples with the exception of Acetone in well OBS-02, at an estimated concentration of 4.0 µg/L (Figure 13). Acetone is a common laboratory contaminant, and the March result is likely an indication of this considering that acetone was not found in OBS-02 (or in any of the nearby observation wells) during the October 2016 sampling event, or in March 6, 2017 sample collected from the nearby Test Well PW-01.

To further evaluate the presence of PFOA and VOCs noted in groundwater samples during the March 2017 sampling round, additional confirmatory analytical sampling was performed on April 13, 2017 in the Site observation wells (OBS-01 through OBS-05) and the Test Well (Figure 13). The April 2017 analytical results confirmed the presence of PFOA in groundwater samples from observation wells OBS-03 and OBS-02 (at concentrations of 2.3 and an estimated 1.4 ng/L, respectively) and in the Test Well (an estimated concentration of 1.3 ng/L). Other PFAS compounds analyzed for were not detected in the April 2017 samples. A potential source for the PFOA present in the March and April water quality samples was not evident.

The results of the VOC analysis indicated that acetone was again present in the sample from OBS-02 (at an estimated concentration of 5.2 µg/L, and greater than the March concentration). Acetone and was also present in OBS-01 at an estimated 3.2 µg/L and in OBS-03 at an estimated 3.6 µg/L. Based on the absence of acetone in any of the previous sampling results, and the relatively low levels present, the acetone found in the April groundwater samples is likely attributable to laboratory contamination.

The only other VOC detected in the April 2017 samples was toluene from the Test Well groundwater sample, at a concentration of 0.0092 mg/L (or, 9.2 µg/L), which is greater than the applicable Part 5 MCL of 0.005 mg/L (or, 5 µg/L) for POCs. Toluene was not present in other samples collected during the April 2017 event. Since toluene was not detected in any of the other Site wells during this or other sampling events, the toluene detected in the Test Well sample is likely also anomalous.

No other VOCs were detected in the April 2017 samples. General water chemistry results found bromide in OBS-05 and OBS-04 (at concentrations of 0.45 mg/L and an estimated 0.080 mg/L, respectively). Bromide was not detected in the April samples from the Test Well, OBS-01, OBS-02, or OBS-03. A potential source for the bromide found in the OBS-04 and OBS-05 groundwater samples from April 2017, and the March groundwater sample from the Test Well, was not evident, but may be related to the low-level detections of pesticides found earlier in the baseline groundwater samples.

4 EVALUATION RESULTS

4.1 Conceptual Site Model

Arcadis has developed a preliminary geologic CSM for the Site, as summarized below. The CSM provides a summary of the geologic and hydrogeologic setting, as the basis for interpreting the data collected during the investigation.

4.1.1 Geologic Setting

The primary geologic features within the Hoosic Valley generally consist of fluvial terraces associated with Pleistocene glaciation and modern floodplain sediment, overlying an eroded valley fill of pro-glacial outwash and lake (lacustrine) sediment (MacFayden, 1956). The valley extends in a generally northerly-southerly orientation in the vicinity of the Site, south of the Village of Hoosick Falls. The unconsolidated pro-glacial lacustrine, alluvial, and recent fluvial deposits at the site constitute the stratified valley-fill aquifer system within the Hoosic River Valley (DeSimone, 2017). The valley-fill sediments are generally thickest near the valley floor, thinning toward the valley walls at the upland areas toward the east and west, where they drape over bedrock (Figure 15).

The unconsolidated deposits are underlain by bedrock units of the Barnveld and Walloomsac Formations, which consist of heavily fractured and weathered mid-Ordovician age limestone, carbonaceous slate and phyllite flanking the western edge of the Precambrian rocks of the Green Mountains (Fisher et. al., 1970; MacFayden, 1956). The bedrock profile at the valley floor is undulating due to differential erosion of the bedrock units. Bedrock outcrops to the east and west of the Site, and at the southernmost end of the Site, indicating the edge of the unconsolidated aquifer in those areas.

The primary water bearing unit in the vicinity of the Site consists of a heterogeneous, semi-confined glacial outwash of channelized sand and gravel deposits juxtaposed to, and interbedded with, fine sand and silty sand deposits. These deposits are up to 20 feet thick in the vicinity of the Test Well, and thin toward the west and south of the Site (Figure 15).

The aquifer is overlain by Pleistocene lacustrine deposits of varying thickness, consisting of silts and silt-clays. The lacustrine unit represents the primary confining unit at the Site, which is up to 80 feet thick at the northern end of the Site, yet thins considerably and is discontinuous toward the southern end of the Site. To the north of the Site at the Village well field, the lacustrine deposits thin considerably, resulting in a greater connection between the overlying recent alluvial deposits and the outwash deposits.

Recent alluvial and floodplain deposits up to 15 feet in thickness overlie the lacustrine silt-clay unit at the site. These deposits represent a shallow, unconfined water-bearing unit connected directly to the Hoosic River. At some point to the north of the site, and potentially toward the south of the Site, the deep and shallow aquifers are connected in areas where the confining unit is thinner or absent, as evidenced by response of the deep aquifer to changes in river stage, as discussed below.

4.1.2 Recharge Mechanisms and Sources of Water

Unchanneled runoff from the surrounding hills provides a significant portion of the recharge to the valley-fill aquifer, along with recharge from bedrock through the valley walls and floor. The semi-confined source aquifer receives recharge both indirectly from infiltration of surface water (including recharge from the Hoosick River, precipitation infiltration, and snow melt infiltration) through the overlying unconfined shallow aquifer, and directly from fracture flow through the underlying bedrock. Additional recharge from direct infiltration along the valley walls at the bedrock contact and from baseflow through the bedrock is also likely. Leakage from the overlying confining unit, either from the upper unconfined aquifer or in combination with water released from storage in the confining unit during pumping.

While the confining unit is up to 80 feet thick in the vicinity of the Test Well, the unit thins toward the south of the Site, and there may be an increased connection between the upper and lower aquifers in that area. Also, as indicated by geologic information and performance characteristics of the Village public supply wells, there is a potential that the confining unit is discontinuous north of the Site, where the lower source aquifer is receiving water directly from the Hoosic River, either through induced infiltration during pumping stress, or during peak flow periods when the river reach is losing water to the aquifer. As shown on Figure 16**,** there is a clear correlation between groundwater levels in the lower aquifer and increases in flow in the Hoosick River. However, stream elevation measurements during baseflow conditions suggest that the river reach in the vicinity of the Site is gaining (i.e., receiving groundwater flow from the aquifer) during river baseflow periods.

4.1.3 Groundwater Withdrawals

Pumping in the vicinity of the Site includes withdrawals from the High School pumping well, local residential and light commercial supply wells, and the Village of Hoosick Falls public well field, located approximately 1 mile to the North (Figure 2).

Background and pumping test data suggests that production of the source aquifer at the Site is not significantly limited by present levels of groundwater withdrawals in the area. Based on background monitoring data (Figure 11), pumping by the High School has the most significant effect on heads in the lower source aquifer, with observed drawdown of up to one foot in the Test Well and OBS-02 during High School pumping at an estimated 35 gpm (with observed drawdown in the High School well of up to 42 feet during the same period).

Groundwater withdrawals from other residential and single-user light commercial wells monitored during the background period (at pumping rates generally estimated to be less than 5 gpm) did not significantly influence heads in the source aquifer in the vicinity of the Test Well. Private supply well RE157, screened in the shallow aquifer (Figure 8), showed no response to pumping in the lower aquifer during the production test (Figure 12).

In addition to local groundwater withdrawals, a comparison of water levels in the Village wellfield with water levels during background water levels at the Site indicated that groundwater withdrawals by the public supply system (up to an estimated 575 gpm, or approximately 830,000 gpd of production) were not influencing heads at the Site. Conversely, pumping stress at the Site did not appear to influence heads in the vicinity of the Village wellfield during the constant-rate pumping test.

4.2 Data Evaluation and Estimation of Aquifer Properties

Arcadis evaluated the water level data collected during the step-drawdown and constant-rate pumping tests, as discussed in Section 3, to estimate aquifer hydraulic parameters of T, and S as the basis for evaluating an estimated yield of the aquifer. Well performance parameters, specifically well efficiency and S, were also assessed based on observed well performance during pumping as described below. Plots of the well analysis curves for individual wells, derived from analysis software (AQTESOLV®) or evaluated through graphical means are presented in Appendix E.

4.2.1 Stepped-drawdown Testing

As discussed in Section 3, the primary purpose of the step-drawdown test was to determine a suitable pumping rate for the constant-rate pumping test. In addition, the data was used to provide a preliminary estimate of well efficiency and SC. The value of SC is an estimate of the productive capacity of the well, as estimated by pumping rate and observed drawdown, as (Driscoll, 1986):

$$SC = \frac{Q}{s}$$

Where: SC = Well specific capacity, in gpm/ft

Q = Well yield, in gpm

S = Drawdown, in feet

As shown on **Figure 9**, the drawdown from the static water level of 8.53 feet below top of casing (TOC) was calculated for each pumping step, and an average calculated for the Test Well:

Step	*Q* (gpm)	*s* (feet)	*SC* (gpm/ft)
1	130	22.75	5.71
2	221	41.59	5.31
3	319	63.97	4.99
4	342	71.56	4.78

The average SC for the Test Well was estimated at approximately 5 gpm/ft. Therefore, for a well with 90 feet of available drawdown, and assuming no casing storage effects, the estimated short-term yield is estimated to be a maximum of 450 gpm. However, this value does not consider the extent of the aquifer, or potential boundary effects that may affect well levels during longer term pumping. The data also shows that SC is generally decreasing with increasing rate, which is due to an increase in turbulent flow (and resultant decrease in well efficiency) during an increase in pumping rate. Therefore, while the average estimate for SC is 5 gpm/ft, the actual SC will decrease as a result of increasing flow. Based on this, an estimate of the contribution of turbulent flow with increasing flow rate can be made to assess the drawdown at higher pumping rates using the relationship (Driscoll, 1986):

$$s = BQ + CQ^2$$

and,

$$Lp = \frac{BQ}{BQ + CQ^2}$$

Where B and C are derived from a graph of s/Q versus Q, as shown on Figure 17 (B = 0.1549, C = 0.0002), and *Lp* is the percentage of laminar flow to the well (as a percentage of total flow). Based on the analysis, *Lp* for each pumping step is shown below.

Step	***Q* (gpm)**	***s/Q***	***Lp***	***s* (feet)**
1	130	0.1750	86%	22.75
2	221	0.1882	78%	41.59
3	319	0.2005	71%	63.97
4	342	0.2092	69%	71.56
Estimated	400	---	66%	94
Estimated	450	---	63%	110
Estimated	500	---	61%	127

Based on this assessment, the drawdown due to decreasing laminar flow and increasing well loss is estimated to be approximately 94 feet at 400 gpm, which would exceed the available drawdown of 90 feet. However, this assessment still does not consider potential boundary effects during longer-term pumping.

Well efficiency was evaluated using water levels from the adjacent OBS-02, located within nine feet of the Test Well. Well efficiency in this instance is estimated by dividing the observed water level in the adjacent observation well (which is assumed to be unaffected by well loss) by the level in the Test Well at the same time. As shown on Figure 9, the resulting average well efficiency was estimated to be 88.5 percent. A general rule of thumb (Driscoll, 1986) suggests that well efficiency greater than 70 percent for a production well is considered acceptable. However, as shown above, this estimate of well efficiency does not take into account changes in laminar flow and resultant losses due to turbulent flow with increasing pumping rate.

4.2.2 Constant Rate Testing

The constant-rate pumping test data was assessed using graphical and analytical methods to calculate T and S based on the response of water levels in the observation wells to pumping in the Test Well, as discussed below. The water level data from the Test Well was not used as the basis for estimating aquifer parameters, due to the potential effects of well loss and casing storage on observed water levels. Summary drawdown and recovery data plots for the Test Well, and each of the Site observation wells are provided in Appendix D.

As shown on a semi-logarithmic plot of the time-drawdown data from OBS-02 (Figure 18), an initial drawdown slope occurs from the start of the test until approximately four minutes after pumping began, when the curve flattens. While initially interpreted to be casing storage in the Test Well, a similar initial slope is present in all of the observation wells at the Site, beginning at different times after pumping began. Casing storage (an initial rapid removal of water from the casing from the pumped well, prior to stressing the aquifer) is not a factor in an observation well, which instead responds to the change in the surrounding aquifer during pumping. Wellbore storage in an observation well does not result in a rapid initial decline of head, but instead may result in dampening the observed drawdown with respect to levels in the adjacent aquifer (Black and Kipp, 1977), an effect which is considered negligible in this assessment due to the small diameter (1.25 inches) of the observation wells.

The early initial slope instead is interpreted as an indication of the limited extent of the sand and gravel aquifer, which is being quickly depleted as the cone of depression in the potentiometric surface expands. The observed flattening of the drawdown slope at t = 5 minutes at OBS-02 (similarly in the adjacent Test Well), indicates a possible hydraulic connection between the aquifer and some source of recharge, potentially leakage from the overlying aquiclude, flow from the underlying bedrock, inflow from the valley wall, leakage from the unconfined alluvial aquifer, or a combination of those sources (Figure 18). However, drawdown in the Test Well and OBS-02 continues until the curve again flattens at t = 300 minutes (Figure 18), at which point additional recharge is available to the aquifer, and the drawdown curve further stabilizes. At this point, the change in slope is interpreted as intersection of the cone of depression with a potential recharge boundary at some distance from the Test Well, possibly the Hoosic River.

Evidence for a recharge boundary to the north of the Test Well, possibly a connection to the Hoosic River, is indicated by the late time slopes of the more distal observation wells (Appendix E). Observation wells OBS-01 and OBS-05 (approximately 283 and 2,305 feet south of the pumping center, respectively) show the first slope change at t = 800 and t = 1,000 minutes, respectively. The second slope change does not occur in OBS-05, but is encountered in OBS-02 at approximately t = 1,100 minutes. However, OBS-03 and OBS-04 (approximately 415 and 840 feet west of the pumping center, respectively) both show the same changes in slope at t = 300 minutes, and t = 2,000 minutes. However, the third slope does not stabilize in the observation wells to the extent it does in the Test Well, which generally flattens toward the end of the test. This data may suggest that the Test Well is encountering a recharge boundary toward the north and east, to which it is closer to than the observation wells. The observation wells are much further, showing a lag in response time to the recharge boundary, potentially based on their distance from it.

While the data suggests that the confined portion of the aquifer in the vicinity of the Test Well is leaky (i.e., receiving water through the aquiclude) and/or receiving water through adjacent boundaries, it is not possible through the scope of this investigation to determine or quantify the particular contribution of any contributor to recharge. However, based on the drawdown data, the aquifer test analysis was based on a confined aquifer approach assuming a leaky confining unit, with storage contributions from the aquiclude, as suggested by Hantush (1960), and Neuman and Witherspoon (1969). Both methods are based on graphical curve-matching assuming Theis assumptions modified for leaky aquifer conditions (Driscoll, 1986; Hantush, 1960; Neuman and Witherspoon, 1969). The data analysis was completed using AQTESOLV® analytical software, which provides automated curve matching and parameter estimation. The resultant curve match provides the constants necessary to calculate T and S based on both the drawdown and recovery data for each observation well. The resultant curve plots are provided in Appendix E.

As shown in the plots provided in Appendix E, the wells closest to the pumping center (OBS-02 and OBS-BR) were best fit to type curves based on an analysis using the Neuman-Witherspoon solution for a leaky confined aquifer assuming a dual-transmissivity system, where a second aquifer is supplying water similar to a recharge boundary (Neuman and Witherspoon, 1969). The solution estimates hydraulic properties of leaky confined aquifer systems (T and S of pumped aquifer; vertical hydraulic conductivity and storage coefficient of aquitard; and transmissivity and storage coefficient of unpumped aquifer). Analysis involves matching solution type curves to drawdown data collected during the pumping test. Unlike the Hantush (1960) solutions for leaky confined aquifers, the Neuman and Witherspoon (1969) solution accounts for drawdown in the unpumped aquifer.

The more distal observation wells (OBS-01, OBS-03, OBS-04, and OBS-05) were best fitted to the Hantush (1960) solution (Appendix E), which estimates the hydraulic properties (T and S of pumped aquifer; vertical hydraulic conductivity and storage coefficient of aquitard) of leaky confined (semi-confined) aquifers. Evaluation of aquifer properties involves matching the Hantush H(u, β) well function to water-level drawdown data collected during the pumping test. The solution also assumes storage in the leaky compressible aquitard. The results of the analysis provided the following estimates of aquifer parameters:

	Transmissivity (*T*)		
Well	**ft^2/day**	**gpd/ft**	**Storage Coeff. (*S*)**
OBS-01	2,402	17,966	4.28E-04
OBS-02	2,105	15,743	8.05E-04
OBS-03	2,457	18,378	1.14E-04
OBS-04	2,252	16,848	4.15E-05
OBS-05	2,240	16,754	4.21E-05

In addition, a separate analysis for the recovery data (Agarwal, 1980) was completed for OBS-01 and OBS-02 to compare to the drawdown evaluation. Agarwal (1980) devised a procedure for the interpretation of recovery data that allows the application of standard curve-matching techniques through a simple data transformation. The resultant curves were matched using the Neuman-Witherspoon or Hantush type-curves, as for the drawdown data (Appendix E), and compared to the drawdown results. The results of the analysis provided the following estimates of aquifer parameters:

	Transmissivity (*T*)		
Well	**ft^2/day**	**gpd/ft**	**Storage Coeff. (*S*)**
OBS-01	2,421	18,106	4.22E-04
OBS-02	1,516	11,337	6.91E-04

With *T* in square feet per day (ft^2/day) or gallons per day, per foot of aquifer (gpd/ft). The storage coefficient, *S* is dimensionless. The resultant average aquifer *T* is approximately 2,199 ft^2/day (16,447 gpd/ft), and the average S is 0.000363, which is consistent with ranges of values for sandy gravel to dense sand provided in Batu (1998), based on values of specific storage (*Ss*) and the aquifer thickness.

An additional analysis was completed for the drawdown data from OBS-01 and OBS-03 for comparison to the methods provided by AQTESOLV®. Using an analytical method developed by Hantush (1959), as suggested by Batu (1998), estimates for *T* and *S* can be determined from observation well data during a pumping test in a confined aquifer near a recharge boundary (river). The method also uses graphical solutions to estimate the constants needed to solve the equations, as described in the method (see Appendix E). The results of the assessment provided a *T* of 2,275 ft^2/day (17,017 gpd/ft) and 2,205 ft^2/day (16,493 gpd/ft), and an S of 0.000467 and 0.000124, for observation wells OBS-01 and OBS-03, respectively. These values are consistent with the values derived from the leaky confined aquifer solutions.

The resultant hydraulic conductivities calculated from the *T* (*T = Kb, where b = aquifer thickness*), assuming a 20-foot aquifer thickness are somewhat lower than expected, yielding an average *K* of approximately 110 ft/day, or 3.53×10^{-2} centimetres per second (cm/sec). Freeze and Cherry (1979) suggests that a *K* in the range of 10^{-2} cm/sec would be classified as a clean sand, below the range of a sand and gravel. This lower value is likely indicative of the heterogeneity observed in the aquifer material comprising the lower semi-confined aquifer, and represents an average of the hydraulic properties of these materials.

4.2.3 Estimation of Potential Well Yield

Based on the hydraulic analysis completed above, the potential short-term estimated well yield can be assessed using the estimated *T* and *S* values provided by the pumping test analysis. These hydraulic properties can then be used to predict the long-term drawdown in a potential production well. The assessment requires an understanding of the available drawdown for the pumped well and the CSM of the aquifer.

A comparison of groundwater levels in the aquifer over a 30-day period during both dry and wet periods (Figure 19) indicates that water levels in the aquifer were up to two feet higher during the February - March 2017 testing period than those during the previous early Fall period (late September 2016 through October 2016). The Hoosic River discharge was also generally higher during the winter 30-day period than the fall 30-day period shown on the chart (Figure 19). Therefore, estimates of yield for the aquifer must consider the additional depletion of available yield that may occur during drier periods, potentially resulting in increased drawdown in a production well.

With a static water level of 424 feet AMSL, and a pump intake set at the bottom of the casing (approximately 317 feet AMSL), based on pumping test conditions, there is a maximum available drawdown of approximately 97 feet. This assumes a minimum level of 10 feet of water is maintained above the pump intake (maximum drawdown of up to 90 percent of total available drawdown). However, given the additional water available in the aquifer during testing, a drawdown limit of 20 feet above the pump intake (maximum drawdown of up to 80 percent of the total available drawdown), or, 87 feet of drawdown from the static water level based on pumping test conditions. These result in minimum groundwater elevations of 327 and 337 feet AMSL, respectively in the Test Well.

As shown in Figure 20, assuming the range of aquifer parameters estimated from the constant-rate test, an assessment of predicted drawdown over time for different pumping rates for times after the 3-day pumping period. The estimated drawdowns are calculated using the Hantush (1960) leaky confined aquifer solution, where drawdown (*s*) at any radius (*r*), and time (*t*) is found by:

$$s(r,t) = \frac{Q}{4\pi T} H(u,\beta)$$

And,

$$u = \frac{r^2 S}{4Tt}$$

Where *u* and *β* are constants relating to the leaky aquifer, and are based on the values estimated from the aquifer test, including *T* and *S*. The well function H(u,β) was obtained from tabulated values in Batu (1998), which are derived from (Hantush, 1960):

$$H(u,\beta) = \int_u^\infty \frac{e^{-y}}{y}\ erfc\left\{\frac{\beta u^{1/2}}{[y(y-u)]^{1/2}}\right\} dy$$

The resultant estimated drawdown values estimate drawdown considering leakage from the aquiclude, but do not include additional recharge from the boundary encountered during later pumping time (e.g., the river or other recharge boundary source). Therefore, the 300 gpm estimate of drawdown begins to diverge from the more horizontal drawdown, and indicates higher drawdown after *t* = 1 day than observed during the test. This is a limitation of analytical solutions for confined aquifers, and additional evaluation using 3-dimensional numerical modelling would be required to further assess the contribution of an aquifer recharge boundary. In addition, this assessment does not consider the effects of depleted storage or changes in aquifer storage, reduced leakage, or encountering an additional no-flow boundary at some later time during the 30-day period assessed.

Therefore, based on the analysis, the estimated well yield provided by the assessment is 300 gpm (432,000 gpd). This value should be considered a maximum estimated value for well yield, based on the observed aquifer conditions during the pumping test, and the limitations of the analytical methods used during the assessment, as summarized below.

4.2.4 Hydraulic Assessment Limitations

The assessment of pumping test data uses graphical methods that may rely on subjective interpretation of the data to characterize the aquifer. In addition, the analytical solutions used to derive hydraulic parameters from the pumping test data include simplifying assumptions to derive the solutions, including (Hantush, 1960; Batu; 1998):

1. The discharge rate of the well is constant.
2. The well fully penetrates the aquifer.
3. The diameter of the well is infinitesimally small.
4. The K values for the confining unit (K’) are very small compared with those of the aquifer, resulting in primarily horizontal flow in the aquifer, and primarily vertical flow in the aquitard.
5. The aquifer and confining layers are horizontal.
6. The hydraulic head supplying the leakage is constant.
7. The aquifer is of infinite areal extent, and is homogeneous and isotropic.
8. Flow to the well is radial.

Any natural system will likely not fit all of the assumptions for a given analytical solution. The portion of the aquifer beneath the Site is not homogeneous, as there are many different types of deposits, from silty sands to coarse-grained channel gravels. The aquifer is not of infinite extent, and there is significant uncertainty of the aquifer extent to the north and east for the Site. Therefore, estimates of aquifer hydraulic parameters are considered average approximations of actual aquifer hydraulic properties, based on the limitations of the method.

In addition to the uncertainties inherent in the analytical solutions applied to the data analysis, aquifer conditions during testing also introduce additional uncertainty. Testing was not done during the driest part of the year (Figure 19), and surface water elevations in the Hoosic River were not at baseflow levels, due to on-going snow melt and runoff.

While the aquifer has the potential to provide additional yield to the well, the 300 gpm yield provides a reasonable estimate of maximum yield given these uncertainties.

4.3 Water Quality Assessment

As discussed in Section 3.3, and summarized in Table 2, the results of the March post-pumping testing for NYS Part 5 parameters in the production Test Well were similar to the October 2016 results for OBS-02 in that they indicated that Trihalomethane Compounds, SVOCs, Chlorinated Pesticides, PCBs, Herbicides, Halogenated Acids, Carbamate Pesticides, Glyphosate, Diquat, Paraquat, and Tetra-Chlorinated Dioxin were not present in the groundwater from the Test Well.

Based on an evaluation of the baseline and post-pumping analytical data, detections of bromide, organic chemicals (including VOCs and non-halogenated organic compounds), are not likely indicative of a contaminant source in the vicinity of the Test Well. As discussed in Section 3.3, detections of compounds including propylene glycol, toluene, and acetone at the Site are likely anomalous.

Of the ten metals (iron, manganese, sodium, zinc, arsenic, barium, cadmium, copper, nickel, and lead) detected in the March Test Well water sample, only manganese concentrations exceeded the applicable Part 5 MCL (Table 2.1). Other NYS Part 5 parameters, including Nitrate and Nitrite (Table 2.2), microbiological contaminants (Table 2.4), and radiological constituents (Table 2.5) were not detected in samples, or were less than their respective Part 5 MCLs during the March 2017 post-pumping sampling.

As discussed in Sections 2.2 and 3.3, the results of the PFAS analysis in Site observation wells and the Test Well have consistently indicated trace levels of PFOA in observation wells (OBS-02 and OBS-03), and in the Test well at the Site (Table 3). While PFHpA was initially detected in some observation wells (OBS-03, OBS-04, and OBS-05, Figure 5d) in August 2016, the presence of this compound in a sampling equipment blank suggests they were likely the result of incidental sample contamination during sampling. As discussed in sections 2.2 and 3.3, no other PFAS compounds besides PFOA that were analyzed for under USEPA Method 537 1.1 (modified) were detected in subsequent observation well samples.

Based on the analytical data collected during this investigation, there are no constituents present that would preclude using the groundwater at the Site as a public water supply. However, long-term trends of water quality from the production well should be considered to verify this.

5 CONCLUSIONS

As discussed in Section 1, the purpose of the study summarized herein was to evaluate the feasibility for developing the semi-confined aquifer beneath the Site as a replacement groundwater source aquifer for the Village of Hoosick Falls, New York, with a targeted production rate of 1 MGD. This section presents the conclusions of the study, and recommendations for additional assessment for consideration.

5.1 Single Well Production Potential

Based on analysis of the pumping data and the resultant hydraulic assessment of the aquifer characteristics, the estimated maximum single-well yield for the Site is approximately 300 gpm. While the aquifer has the potential to provide additional yield to the well, the 300 gpm yield provides a reasonable estimate of yield given these uncertainties. Maximum daily groundwater production at this pumping rate is as follows:

- 432,000 gpd, assuming 24 hours of continuous pumping;
- 144,000 gpd assuming 8 hours of continuous pumping during any 24-hour period; and,
- 72,000 gpd, assuming 4 hours of continuous pumping during any 24-hour period.

This value is based on an assessment of the aquifer conditions during the testing period, and the limitations of the analytical methods used, as described in Section 4.2. The estimated maximum yield is less than 50 percent of the target production value of 1 MGD.

Raw water production estimates provided by the Village of Hoosick Falls for the period of February - April 2016 indicate an average daily production of 382,158 gpd, with a maximum daily production of 814,314 gpd. During this period, there was a total of 25 out of 90 days where total daily production exceeded the estimated single well yield. Based on these data, production from a single well at the Site could not provide sufficient yield to entirely replace production at the existing Village well field.

However, through use of an adaptive water management strategy, it is feasible that production from a single well could provide a significant percentage of the required daily usage, and at considerably lower contaminant concentrations than those from the existing Village wells. Production from a single well source is feasible as a mixing-water source to lower contaminant concentrations prior to treatment. In addition, through an adaptive pumping strategy, the single well source could be used as the primary source during periods of low demand, with existing Village production wells used as additional make-up supplies during peak production periods. Treatment of water from these potential combined sources is beyond the scope of this investigation.

5.2 Suitability for Well Field Development

Due to the complex response of the aquifer to pumping during the test, and lack of hydrogeologic information to the north and east of the Test Well location, it was not possible to assess the potential for multiple pumping wells to provide the targeted production rate of 1 MGD. Given the complexity of the aquifer system, additional assessment through numerical modeling of the groundwater system could be useful to ascertain what increase in production, if any, could be acquired through the use of multiple wells within the vicinity of the site. Based on the geophysical data, the aquifer thins toward the south, and there may not be enough aquifer thickness in areas south of the Test Well to support an additional well with similar performance to the test well to significantly increase overall production. However, if there is sufficient areal extent and thickness of the sand and gravel confined aquifer toward the north or east, an additional well may provide greater yield for use as mixing water, or as a primary source during low-demand periods. Additional testing and analysis would be required to evaluate the suitability of the aquifer for additional production using multiple wells.

Based on the observed response of the surrounding water supply wells, it is unlikely that groundwater withdrawals at the 300 gpm rate tested would negatively impact surrounding wells under similar aquifer conditions. However, additional stresses to the aquifer in the future (e.g. new production wells installed in the vicinity, or drought conditions) could increase the likelihood that local supply wells could be adversely affected by pumping in the future. Development of a wellfield to include additional production wells and increased groundwater withdrawals would require additional assessment for the potential of adverse effects on surrounding supply wells.

5.3 Recommendations for Additional Assessment

If the Site will be used as a supporting source of groundwater production for the Village of Hoosick Falls, Arcadis recommends the following additional evaluation to support development of the production wellfield:

- Completion of additional geophysical investigation to the north and east of the Site to evaluate the nature and extent of the semi-confined aquifer and the confining unit in those areas.
- Development of a numerical model to further assess the production potential of the aquifer, and support design and evaluation of multiple well production.
- Development of a wellhead protection program, or expansion of an existing program, to include the Site and existing Village well field.
- Additional assessment of the nature and extent of PFAS in groundwater in the vicinity of the site, including identification and assessment of potential sources of PFOA in groundwater.

In addition, design of suitable wellhead structures would be necessary to protect wellhead areas from seasonal flooding from the Hoosic River.

6 REFERENCES CITED

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TABLES

Table 2. New York State Part 5 Analytical Results (Test Well)

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Table 2.1 - Inorganic Chemicals and Physical Characteristics

Compound	MCL (mg/L[1])	Concentration
Asbestos	7.0 MFL[2]	ND (<0.5) MFL
Antimony	*0.006*	*ND (<0.40) ug/L*
Arsenic	0.010	0.65 ug/L (J)
Barium	2.0	320 ug/L
Beryllium	*0.004*	*ND (<0.15) ug/L*
Cadmium	0.005	0.00012 ug/L (J)
Chromium	*0.1*	*ND (<1.0) ug/L*
Copper	1.3[5]	0.013 mg/L
Cyanide, Total	0.2	0.0036 mg/L (J)
Mercury	*0.002*	*ND (<0.058) ug/L*
Nickel	0.005	0.0012 mg/L (J)
Lead	0.015[5]	0.0012 mg/L
Selenium	*0.05*	*ND (<0.58) ug/L*
Silver	*0.1*	*ND (<0.00060) mg/L*
Thallium	*0.002*	*ND (<0.10) ug/L*
Fluoride	*2.2*	*ND (<0.040) mg/L*
Chloride	250	73 mg/L
Iron	0.3[3]	0.30 mg/L
Manganese	0.3[3]	0.42 mg/L
Sodium	No designated limits[4]	42 mg/L
Sulfate	250	24 mg/L
Zinc	5.0	0.03 mg/L
Color	15 PCU	5 PCU
Odor at 60°C	3 T.O.N.	<1.0 T.O.N.
Bromate	*0.01*	*ND (<2.5) ug/L*
Chlorite	*1.000*	*ND (<3.7) ug/L*
Bromide	0.05	0.26 mg/L (J)
Turbidity	5 NTU	1.8 NTU

Table 2.2 - Nitrate, Nitrite, Total Nitrate/Nitrite

Compound	MCL (mg/L[1])	Concentration
Nitrate as N	10 (as nitrogen)	0.075 mg/L
Nitrite as N	*1 (as nitrogen)*	*ND (<0.023) mg/L*
Total Nitrate and Nitrite	10 (as nitrogen)	0.075 mg/L

Exceeds Respective MCL value

Notes:

J - Laboratory qualifier indicating result is less than the reporting limit, but greater than or equal to the analytical method detection limit, and therefore the concentration is an approximate value. The method detection limit is the lowest concentration at which the analytical method can qualitatively identify the presence of a compound. The reporting limit is the lowest concentration at which the instrument is calibrated, and can quantify a compound concentration.

ND - Not detected at or above method detection limit in parantheses.

MCL - Maximim Contaminant Level - New York State Part 5, Subpart 5-1 - Public Water Supply Systems

[1] Miligrams per liter (mg/L), unless otherwise indicated.

[2] Million Fibers per Liter (MFL).

[3] If iron and manganese are present, the total concentration of both should not exceed 0.5 mg/L. Higher levels may be allowed by the State when justified by the supplier of water.

[4] Water containing more than 20 mg/L of sodium should not be used for drinking by people on severely restricted sodium diets. Water containing more than 270 mg/L of sodium should not be used for drinking by people on moderately restricted sodium diets.

[5] See NYS Part 5. Section 5-1.41 - Lead and Copper Action Levels.

Table 2. New York State Part 5 Analytical Results (Test Well)

Hoosick Falls Alternate Water Supply Study

Village of Hoosick Falls, New York

Groundwater Source Aquifer Evaluation

Table 2.3 - Organic Chemicals

Compound		MCL (mg/L[1])	Analytical Results
General Orgainc Chemicals	*POC*	*0.005*	*ND*
	UOC	0.05	0.00011 mg/L (J)
	Total POC and UOC	0.100	0.00011 mg/L (J)
Disinfection Byproducts	*Total trihalomethanes*	*0.08*	*ND (0.079)* ug/L
	Haloacetic acids	*0.06*	*ND (0.38)* ug/L
Specific Organic Chemicals	*Alachlor*	*0.002*	*ND (<0.000032) mg/L*
	Aldicarb	*0.003*	*ND (<0.00050) mg/L*
	Aldicarb sulfone	*0.002*	*ND (<0.00025) mg/L*
	Aldicarb sulfoxide	*0.004*	*ND (<0.00025) mg/L*
	Atrazine	*0.003*	*ND (<0.000022) mg/L*
	Benzo(a)pyrene	*0.0002*	*ND (<0.000028) mg/L*
	Carbofuran	*0.04*	*ND (<0.00025) mg/L*
	Chlordane	*0.002*	*ND (<0.0000017) mg/L*
	Di(2-ethylhexyl)phthalate	*0.006*	*ND (<0.00059) mg/L*
	Dibromochloropropane(DBCP)	*0.0002*	*ND (<0.0000048) mg/L*
	2,4-D	*0.05*	*ND (<0.000036) mg/L*
	Dinoseb	*0.007*	*ND (<0.00015) mg/L*
	Diquat	*0.02*	*ND (<0.40) ug/L*
	Endrin	*0.002*	*ND (<0.0000021) mg/L*
	Ethylene dibromide(EDB)	*0.00005*	*ND (<0.0000021) mg/L*
	Heptachlor	*0.0004*	*ND (<0.0000061) mg/L*
	Heptachlor epoxide	*0.0002*	*ND (<0.0000017) mg/L*
	Hexachlorobenzene	*0.001*	*ND (<0.000040) mg/L*
	Lindane	*0.0002*	*ND (0.0000023) mg/L*
	Methoxychlor	*0.04*	*ND (<0.0000076) mg/L*
	Methyl-tertiary-butyl-ether(MTBE)	*0.01*	*ND (<0.000093) mg/L*
	Pentachlorophenol	*0.001*	*ND (<0.000037) mg/L*
	Polychlorinated biphenyls(PCBs)	*0.0005*	*ND (0.000045) mg/L*
	Propylene glycol	*1*	*ND (<0.88) mg/L*
	Simazine	*0.004*	*ND (<0.000034) mg/L*
	Toxaphene	*0.003*	*ND (<0.000056) mg/L*
	2,4,5-TP (Silvex)	*0.01*	*ND (<0.000059) mg/L*
	2,3,7,8-TCDD (dioxin)	*30 pg/L*	*ND (<0.76) pg/L*
	Vinyl chloride	*0.002*	*ND (<0.00016) mg/L*

Notes:

J - Laboratory qualifier indicating result is less than the reporting limit, but greater than or equal to the analytical method detection limit, and therefore the concentration is an approximate value. The method detection limit is the lowest concentration at which the analytical method can qualitatively identify the presence of a compound. The reporting limit is the lowest concentration to which the instrument is calibrated, and can quantify a compound concentration.

ND - Not detected at or above method detection limit in parantheses (where applicable, lowest MDL shown).

MCL - Maximim Contaminant Level - New York State Part 5, Subpart 5-1 - Public Water Supply Systems

[1] Miligrams per liter (mg/L), unless otherwise indicated.

Table 2. New York State Part 5 Analytical Results (Test Well)

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Table 2.4 - Microbiological Contaminants

Contaminant	Sample Location	MCL/TT[1]	Analytical Results
Total Coliform	Test Well/ raw water	No positive sample (MCL)	Negative
Escherichia coli (E. coli)		No positive sample (MCL)	Negative
Fecal indicator: E. coli, and/or enterococci, and/or coliphage	Test Well/ raw water	No fecal indicator in samples collected from raw source water from a ground water source (TT)	<1 per 100 ml

Notes:

[1] Maximum contaminant level (MCL)/ Treatment Technique (TT)

Table 2. New York State Part 5 Analytical Results (Test Well)

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Table 2.5 - Radiological

Compound	MCL	Result
Combined radium-226 and radium-228	5 picocuries per liter (pCi/L)	0.676 pCi/L
Gross alpha activity (including radium-226 but excluding radon and uranium)	15 pCi/L	3.69 pCi/L
Gross beta activity	N/A	1.63 pCi/L
Uranium	30 ug/L	4.24 ug/L

Exceeds Respective MCL value

Notes:

N/A - No MCL specified.

MCL - Maximim Contaminant Level - New York State Part 5, Subpart 5-1 - Public Water Supply Systems

Table 3. Summary of Perfluorinated Alkyl Substances (EPA 537 1.1)

March 2017 Post-Pumping Test and April 2017 Confirmatory Samples

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Analysis Results (ng/L)

Compound	HAL (ng/L)	**Test Well (PW-01)**		**OBS-01**			**OBS-02**		
		3/6/2017	4/13/2017	3/16/2017	3/16/2017 (DUP)	4/13/2017	3/16/2017	4/13/2017	4/13/2017 (DUP)
Perfluorooctanoic acid (PFOA)	70	**1.6 (J)**	**1.3 (J)**	*ND (<0.75)*	*ND (<0.75)*	*ND (<0.75)*	**1.4 (J)**	**1.4 (J)**	*ND (<0.75)*
Perfluorooctanesulfonic acid (PFOS)	70	*ND (<1.3)*	*ND (<0.58)*	*ND (<1.3)*	*ND (<1.3)*	*ND (<1.3)*	*ND (<1.3)*	*ND (<1.3)*	*ND (<1.3)*
Perfluorobutanesulfonic acid (PFBS)	70	*ND (<0.92)*	*ND (<0.84)*	*ND (<0.92)*	*ND (<0.92)*	*ND (<0.92)*	*ND (<0.92)*	*ND (<0.92)*	*ND (<0.92)*
Perfluorohexanesulfonic acid (PFHxS)	70	*ND (<0.87)*	*ND (<0.80)*	*ND (<0.87)*	*ND (<0.87)*	*ND (<0.87)*	*ND (<0.87)*	*ND (<0.87)*	*ND (<0.87)*
Perfluoroheptanoic acid (PFHpA)	70	*ND (<0.80)*	*ND (<0.74)*	*ND (<0.80)*	*ND (<0.80)*	*ND (<0.80)*	*ND (<0.80)*	*ND (<0.80)*	*ND (<0.80)*
Perfluorononanoic acid (PFNA)	70	*ND (<0.65)*	*ND (<0.60)*	*ND (<0.65)*	*ND (<0.65)*	*ND (<0.65)*	*ND (<0.65)*	*ND (<0.65)*	*ND (<0.65)*

Analysis Results (ng/L)

Compound	HAL (ng/L)	**OBS-03**		**OBS-04**		**0BS-05**	
		3/16/2017	4/13/2017	3/16/2017	4/13/2017	3/16/2017	4/13/2017
Perfluorooctanoic acid (PFOA)	70	**2.3**	**2.3**	*ND (<0.75)*	*ND (<0.75)*	*ND (<0.75)*	*ND (<0.75)*
Perfluorooctanesulfonic acid (PFOS)	70	*ND (<1.3)*	*ND (<1.3)*	*ND (<1.3)*	*ND (<1.3)*	*ND (<1.3)*	*ND (<1.3)*
Perfluorobutanesulfonic acid (PFBS)	70	*ND (<0.92)*	*ND (<0.92)*	*ND (<0.92)*	*ND (<0.92)*	*ND (<0.92)*	*ND (<0.92)*
Perfluorohexanesulfonic acid (PFHxS)	70	*ND (<0.87)*	*ND (<0.87)*	*ND (<0.87)*	*ND (<0.87)*	*ND (<0.87)*	*ND (<0.87)*
Perfluoroheptanoic acid (PFHpA)	70	*ND (<0.80)*	*ND (<0.80)*	*ND (<0.80)*	*ND (<0.80)*	*ND (<0.80)*	*ND (<0.80)*
Perfluorononanoic acid (PFNA)	70	*ND (<0.65)*	*ND (<0.65)*	*ND (<0.65)*	*ND (<0.65)*	*ND (<0.65)*	*ND (<0.65)*

Exceeds Respective HAL value

Notes:

J - Laboratory qualifier indicating result is less than the reporting limit, but greater than or equal to the analytical method detection limit, and therefore the concentration is an approximate value. The method detection limit is the lowest concentration at which the analytical method can qualitatively identify the presence of a compound. The reporting limit is the lowest concentration at which the instrument is calibrated, and can quantify a compound concentration.

ND - Not detected at or above method detection limit in parantheses (in ng/L).
HAL - Lifetime Health Advisory Level - New York State Department of Health
Dup - Quality Assurance/Quality Control sample duplicate

Table 4. Summary of Volatile Organic Compounds (EPA 8260C, 524.2)

March 2017 Post-Pumping Test and April 2017 Confirmatory Samples

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

		EPA 524.2 (ug/L)		EPA 8260C (ug/L)											
Compound	NYS Part 5 MCL (ug/L)	**Test Well (PW-01)**		**OBS-01**			**OBS-02**			**OBS-03**		**OBS-04**		**0BS-05**	
		3/6/2017	4/13/2017	3/21/2017	3/21/2017 (DUP)	4/13/2017	3/21/2017	4/13/2017	4/13/2017 (DUP)	3/21/2017	4/13/2017	3/21/2017	4/13/2017	3/21/2017	4/13/2017
1,1,1-Trichloroethane	5.0	ND (<0.15)	ND (<0.21)	ND (<0.82)	ND (<0.82)	ND (<0.82)	ND (<0.82)	ND (<0.82)	ND (<0.82)	ND (<0.82)	ND (<0.82)	ND (<0.82)	ND (<0.82)	ND (<0.82)	ND (<0.82)
1,1,2,2-Tetrachloroethane	5.0	ND (<0.13)	ND (<0.07)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)
1,1,2-Trichloro-1,2,2-trifluoroethane	50.0	---	---	ND (<0.31)	ND (<0.31)	ND (<0.31)	ND (<0.31)	ND (<0.31)	ND (<0.31)	ND (<0.31)	ND (<0.31)	ND (<0.31)	ND (<0.31)	ND (<0.31)	ND (<0.31)
1,1,2-Trichloroethane	5.0	ND (<0.16)	ND (<0.17)	ND (<0.23)	ND (<0.23)	ND (<0.23)	ND (<0.23)	ND (<0.23)	ND (<0.23)	ND (<0.23)	ND (<0.23)	ND (<0.23)	ND (<0.23)	ND (<0.23)	ND (<0.23)
1,1-Dichloroethane	5.0	ND (<0.078)	ND (<0.18)	ND (<0.38)	ND (<0.38)	ND (<0.38)	ND (<0.38)	ND (<0.38)	ND (<0.38)	ND (<0.38)	ND (<0.38)	ND (<0.38)	ND (<0.38)	ND (<0.38)	ND (<0.38)
1,1-Dichloroethene	5.0	ND (<0.15)	ND (<0.16)	ND (<0.29)	ND (<0.29)	ND (<0.29)	ND (<0.29)	ND (<0.29)	ND (<0.29)	ND (<0.29)	ND (<0.29)	ND (<0.29)	ND (<0.29)	ND (<0.29)	ND (<0.29)
1,2,4-Trichlorobenzene	5.0	ND (<0.12)	ND (<0.13)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)
1,2-Dibromo-3-Chloropropane	50.0	---	---	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)
1,2-Dibromoethane	50.0	---	---	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)
1,2-Dichlorobenzene	5.0	ND (<0.16)	ND (<0.16)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)
1,2-Dichloroethane	5.0	ND (<0.086)	ND (<0.14)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)	ND (<0.21)
1,2-Dichloropropane	5.0	ND (<0.096)	ND (<0.11)	ND (<0.72)	ND (<0.72)	ND (<0.72)	ND (<0.72)	ND (<0.72)	ND (<0.72)	ND (<0.72)	ND (<0.72)	ND (<0.72)	ND (<0.72)	ND (<0.72)	ND (<0.72)
1,3-Dichlorobenzene	5.0	ND (<0.11)	ND (<0.13)	ND (<0.78)	ND (<0.78)	ND (<0.78)	ND (<0.78)	ND (<0.78)	ND (<0.78)	ND (<0.78)	ND (<0.78)	ND (<0.78)	ND (<0.78)	ND (<0.78)	ND (<0.78)
1,4-Dichlorobenzene	5.0	ND (<0.13)	ND (<0.13)	ND (<0.84)	ND (<0.84)	ND (<0.84)	ND (<0.84)	ND (<0.84)	ND (<0.84)	ND (<0.84)	ND (<0.84)	ND (<0.84)	ND (<0.84)	ND (<0.84)	ND (<0.84)
2-Butanone (MEK)	50.0	---	---	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)
2-Hexanone	50.0	---	---	ND (<1.2)	ND (<1.2)	ND (<1.2)	ND (<1.2)	ND (<1.2)	ND (<1.2)	ND (<1.2)	ND (<1.2)	ND (<1.2)	ND (<1.2)	ND (<1.2)	ND (<1.2)
4-Methyl-2-pentanone (MIBK)	50.0	---	---	ND (<2.1)	ND (<2.1)	ND (<2.1)	ND (<2.1)	ND (<2.1)	ND (<2.1)	ND (<2.1)	ND (<2.1)	ND (<2.1)	ND (<2.1)	ND (<2.1)	ND (<2.1)
Acetone	50.0	---	---	ND (<3.0)	ND (<3.0)	**3.2 (J)**	**4.0 (J)**	**5.2 (J)**	**5.6 (J)**	ND (<3.0)	**3.6 (J)**	ND (<3.0)	ND (3.0)	ND (<3.0)	ND (3.0)
Benzene	5.0	ND (<0.082)	ND (<0.13)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)	ND (<0.41)
Bromodichloromethane	5.0	---	---	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)	ND (<0.39)
Bromoform	50.0	ND (<0.17)	---	ND (<0.26)	ND (<0.26)	ND (<0.26)	ND (<0.26)	ND (<0.26)	ND (<0.26)	ND (<0.26)	ND (<0.26)	ND (<0.26)	ND (<0.26)	ND (<0.26)	ND (<0.26)
Bromomethane	5.0	ND (<0.20)	ND (<0.23)	ND (<0.69)	ND (<0.69)	ND (<0.69)	ND (<0.69)	ND (<0.69)	ND (<0.69)	ND (<0.69)	ND (<0.69)	ND (<0.69)	ND (<0.69)	ND (<0.69)	ND (<0.69)
Carbon disulfide	50.0	---	---	ND (<0.19)	ND (<0.19)	ND (<0.19)	ND (<0.19)	ND (<0.19)	ND (<0.19)	ND (<0.19)	ND (<0.19)	ND (<0.19)	ND (<0.19)	ND (<0.19)	ND (<0.19)
Carbon tetrachloride	5.0	ND (<0.11)	ND (<0.21)	ND (<0.27)	ND (<0.27)	ND (<0.27)	ND (<0.27)	ND (<0.27)	ND (<0.27)	ND (<0.27)	ND (<0.27)	ND (<0.27)	ND (<0.27)	ND (<0.27)	ND (<0.27)
Chlorobenzene	5.0	ND (<0.14)	ND (<0.12)	ND (<0.75)	ND (<0.75)	ND (<0.75)	ND (<0.75)	ND (<0.75)	ND (<0.75)	ND (<0.75)	ND (<0.75)	ND (<0.75)	ND (<0.75)	ND (<0.75)	ND (<0.75)
Chloroethane	5.0	ND (<0.22)	ND (<0.2)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)
Chloroform	50.0	ND (<0.20)	---	ND (<0.34)	ND (<0.34)	ND (<0.34)	ND (<0.34)	ND (<0.34)	ND (<0.34)	ND (<0.34)	ND (<0.34)	ND (<0.34)	ND (<0.34)	ND (<0.34)	ND (<0.34)
Chloromethane	5.0	ND (<0.15)	ND (<0.17)	ND (<0.35)	ND (<0.35)	ND (<0.35)	ND (<0.35)	ND (<0.35)	ND (<0.35)	ND (<0.35)	ND (<0.35)	ND (<0.35)	ND (<0.35)	ND (<0.35)	ND (<0.35)
cis-1,2-Dichloroethene	5.0	ND (<0.090)	ND (<0.12)	ND (<0.81)	ND (<0.81)	ND (<0.81)	ND (<0.81)	ND (<0.81)	ND (<0.81)	ND (<0.81)	ND (<0.81)	ND (<0.81)	ND (<0.81)	ND (<0.81)	ND (<0.81)
cis-1,3-Dichloropropene	5.0	ND (<0.081)	ND (<0.08)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)
Cyclohexane	50.0	---	---	ND (<0.18)	ND (<0.18)	ND (<0.18)	ND (<0.18)	ND (<0.18)	ND (<0.18)	ND (<0.18)	ND (<0.18)	ND (<0.18)	ND (<0.18)	ND (<0.18)	ND (<0.18)
Dibromochloromethane	50.0	ND (<0.079)	---	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)	ND (<0.32)
Dichlorodifluoromethane	5.0	ND (<0.34)	ND (<0.15)	ND (<0.68)	ND (<0.68)	ND (<0.68)	ND (<0.68)	ND (<0.68)	ND (<0.68)	ND (<0.68)	ND (<0.68)	ND (<0.68)	ND (<0.68)	ND (<0.68)	ND (<0.68)
Ethylbenzene	5.0	ND (<0.099)	ND (<0.11)	ND (<0.74)	ND (<0.74)	ND (<0.74)	ND (<0.74)	ND (<0.74)	ND (<0.74)	ND (<0.74)	ND (<0.74)	ND (<0.74)	ND (<0.74)	ND (<0.74)	ND (<0.74)
Isopropylbenzene	5.0	ND (<0.15)	ND (<0.16)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)	ND (<0.79)
Methyl acetate	50.0	---	---	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)	ND (<1.3)
Methyl tert-butyl ether	50.0	ND (<0.093)	ND (<0.12)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)
Methylcyclohexane	50.0	---	---	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)	ND (<0.16)
Methylene Chloride	5.0	ND (<0.20)	ND (<0.99)	ND (<0.44)	ND (<0.44)	ND (<0.44)	ND (<0.44)	ND (<0.44)	ND (<0.44)	ND (<0.44)	ND (<0.44)	ND (<0.44)	ND (<0.44)	ND (<0.44)	ND (<0.44)
Styrene	5.0	ND (<0.089)	ND (<0.13)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)	ND (<0.73)
Tetrachloroethene	5.0	ND (<0.18)	ND (<0.2)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)	ND (<0.36)
Toluene	5.0	**0.11 (J)**	**9.2**	ND (<0.51)	ND (<0.51)	ND (<0.51)	ND (<0.51)	ND (<0.51)	ND (<0.51)	ND (<0.51)	ND (<0.51)	ND (<0.51)	ND (<0.51)	ND (<0.51)	ND (<0.51)
trans-1,2-Dichloroethene	5.0	ND (<0.090)	ND (<0.13)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)
trans-1,3-Dichloropropene	5.0	ND (<0.11)	ND (<0.1)	ND (<0.37)	ND (<0.37)	ND (<0.37)	ND (<0.37)	ND (<0.37)	ND (<0.37)	ND (<0.37)	ND (<0.37)	ND (<0.37)	ND (<0.37)	ND (<0.37)	ND (<0.37)
Trichloroethene	5.0	ND (<0.13)	ND (<0.18)	ND (<0.46)	ND (<0.46)	ND (<0.46)	ND (<0.46)	ND (<0.46)	ND (<0.46)	ND (<0.46)	ND (<0.46)	ND (<0.46)	ND (<0.46)	ND (<0.46)	ND (<0.46)
Trichlorofluoromethane	5.0	ND (<0.23)	ND (<0.19)	ND (<0.88)	ND (<0.88)	ND (<0.88)	ND (<0.88)	ND (<0.88)	ND (<0.88)	ND (<0.88)	ND (<0.88)	ND (<0.88)	ND (<0.88)	ND (<0.88)	ND (<0.88)
Vinyl chloride	2.0	ND (<0.16)	ND (<0.18)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)	ND (<0.90)
Xylenes, Total	5.0	ND (<0.086)	ND (<0.12)	ND (<0.66)	ND (0.66)	ND (<0.66)	ND (<0.66)	ND (<0.66)	ND (<0.66)	ND (<0.66)	ND (<0.66)	ND (<0.66)	ND (<0.66)	ND (<0.66)	ND (<0.66)

🟨 Exceeds Respective MCL value

Notes:

J - Laboratory qualifier indicating result is less than the reporting limit, but greater than or equal to the analytical method detection limit, and therefore the concentration is an approximate value. The method detection limit is the lowest concentration at which the analytical method can qualitatively identify the presence of a compound. The reporting limit is the lowest concentration at which the instrument is calibrated, and can quantify a compound concentration.

ND - Not detected at or above method detection limit in parantheses (in ug/L).

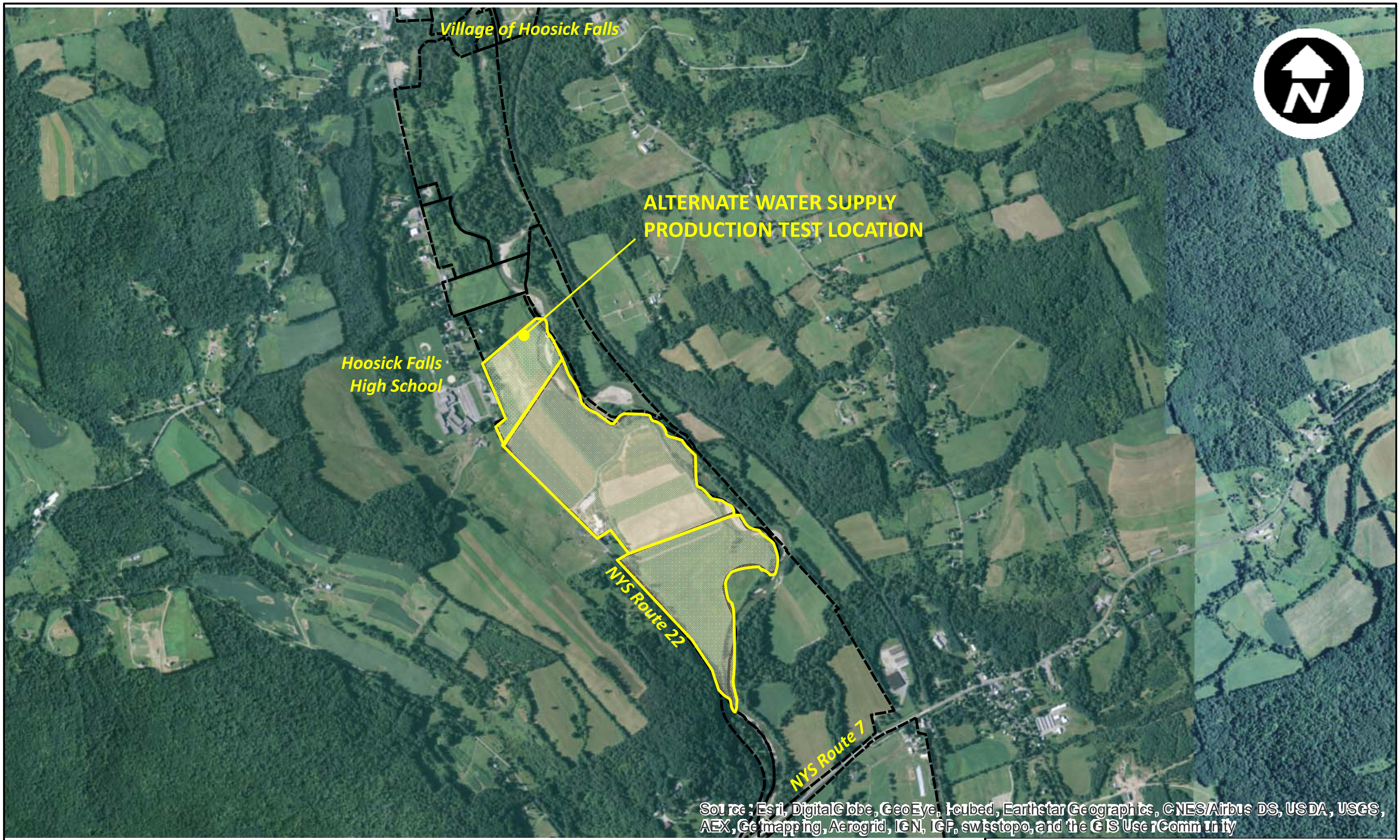
MCL - Maximim Contaminant Level - New York State Part 5, Subpart 5-1 - Public Water Supply Systems

--- indicates constituent not included in analytical method

Dup - Quality Assurance/Quality Control sample duplicate

Due to non-detections in initial round, Dibromochloromethane, Chloroform, and Bromoform, were not analyzed during subsequent confirmatory sampling

FIGURES



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

▨ Farm Properties

- - - Tax Parcel Boundary

0 0.25 0.5 0.75 1

SCALE IN MILES

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York

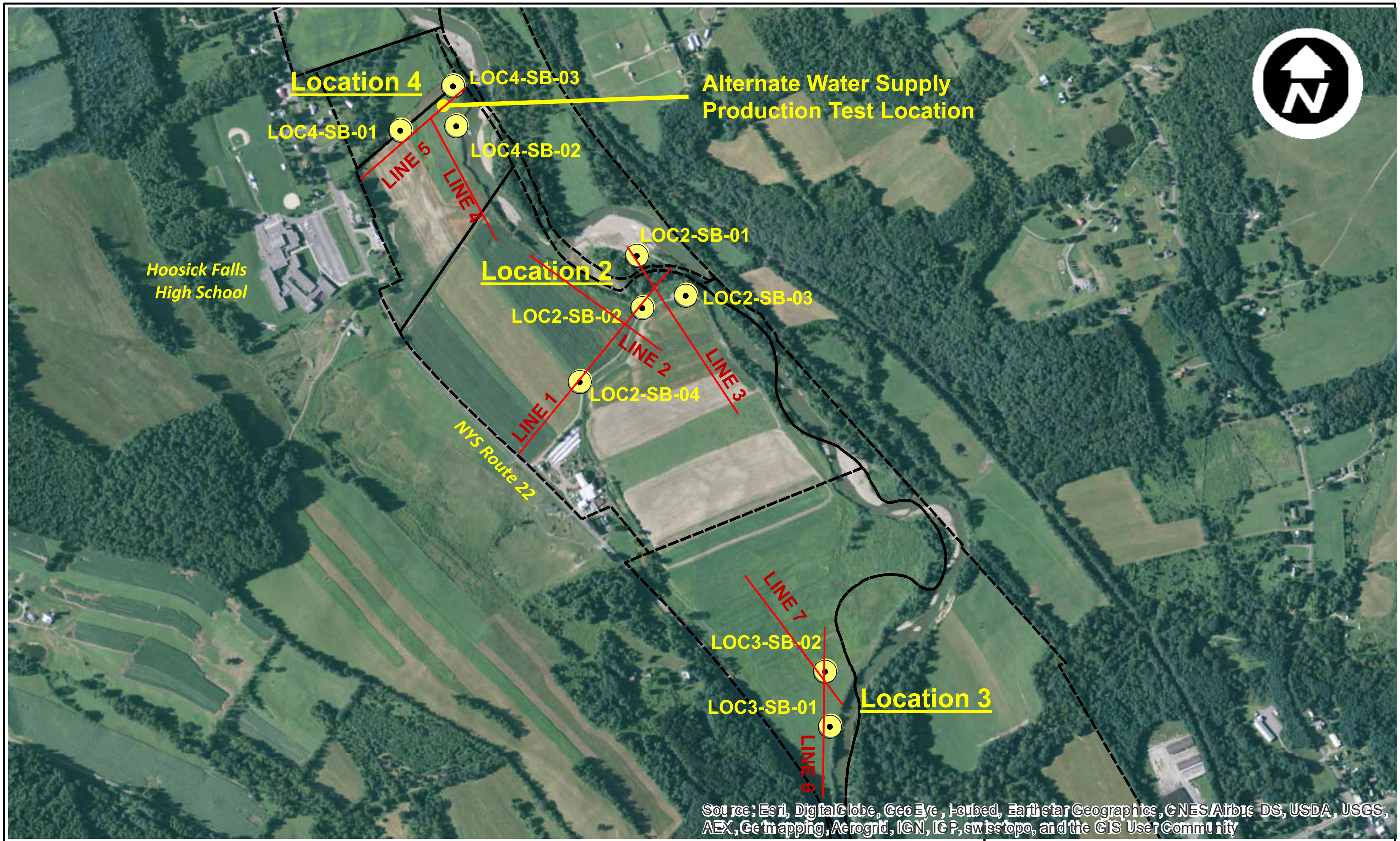
Groundwater Source Aquifer Evaluation

Site Location and Study Area

ARCADIS Design & Consultancy for natural and built assets

1

FIGURE



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

● Existing Soil Boring Location

╱ Tax Parcel Boundary

╱ Surface Geophysical Line

0 500 1,000 1,500 2,000

Approximate Scale in Feet

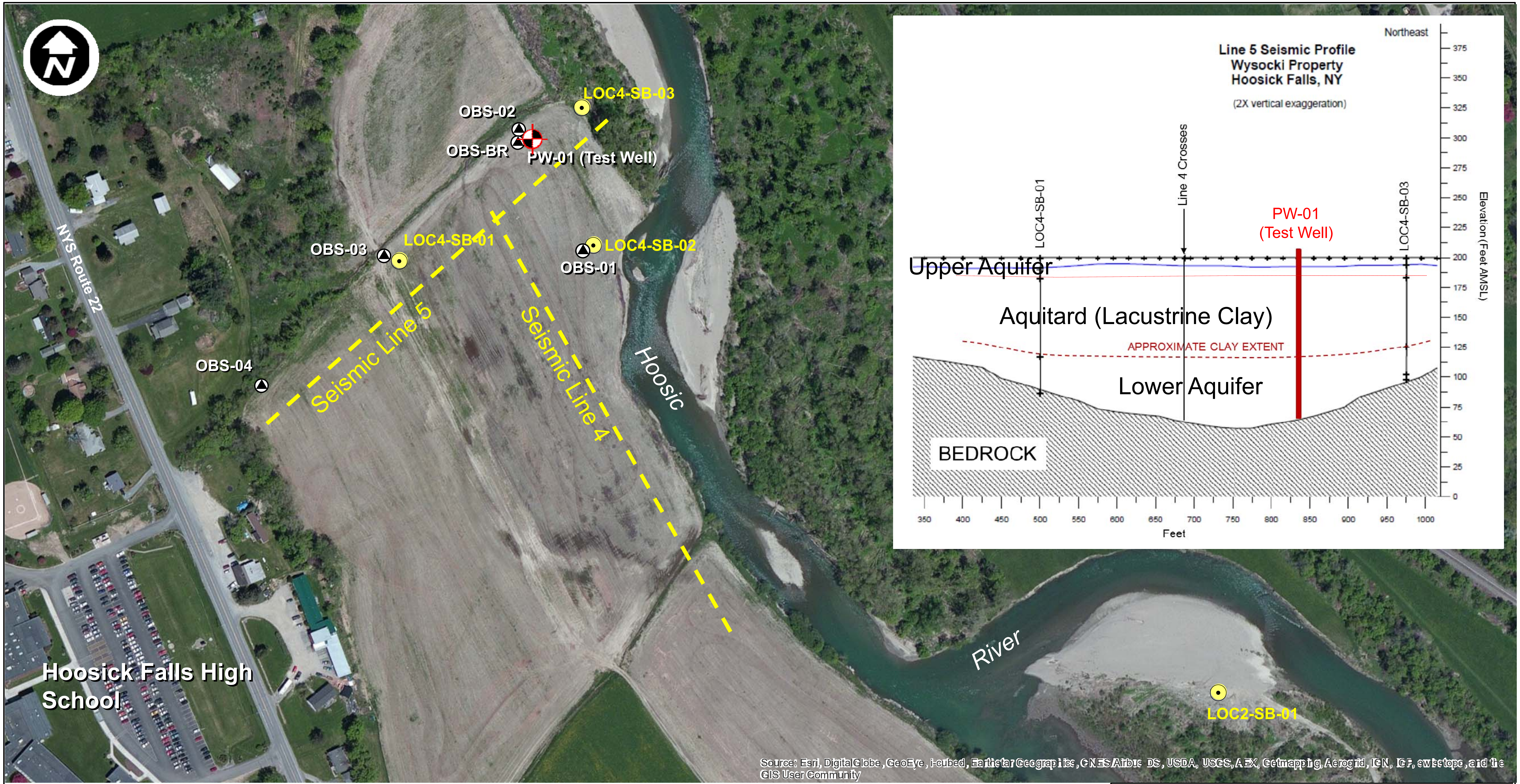
Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York

Groundwater Source Aquifer Evaluation

Geophysical Survey Locations

ARCADIS

2
FIGURE



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- ● Existing Soil Boring Location
- ⊕ Production Test Well
- ▲ Observation Well (Local MWN)

0 100 200 300 400

Approximate Scale In Feet

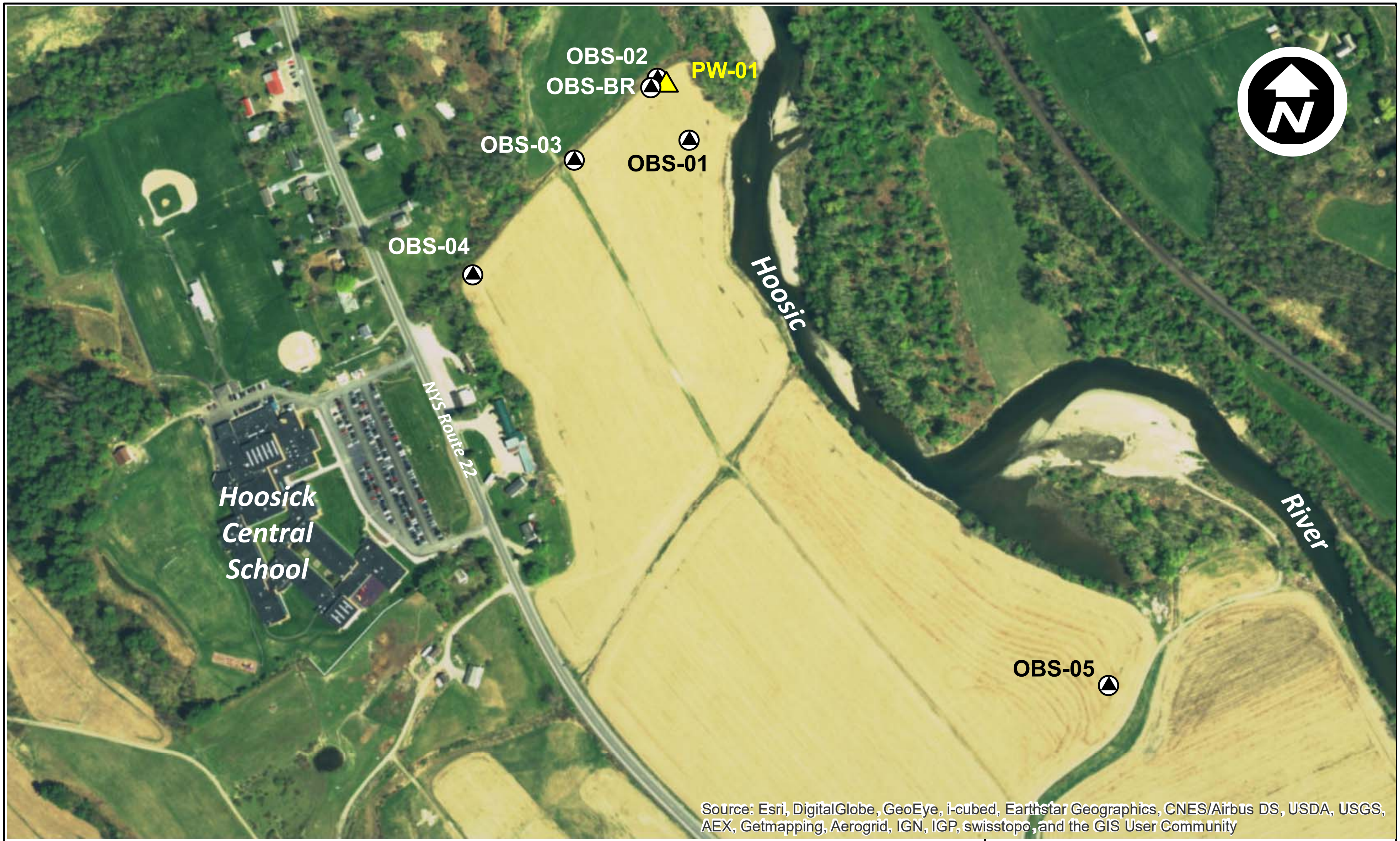
Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York

Groundwater Source Aquifer Evaluation

Subsurface Evaluation

ARCADIS Design & Consultancy for natural and built assets

3
FIGURE



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

▲	Observation Well (Local MWN)
△	Pumped Test Well

0 200 400 600 800

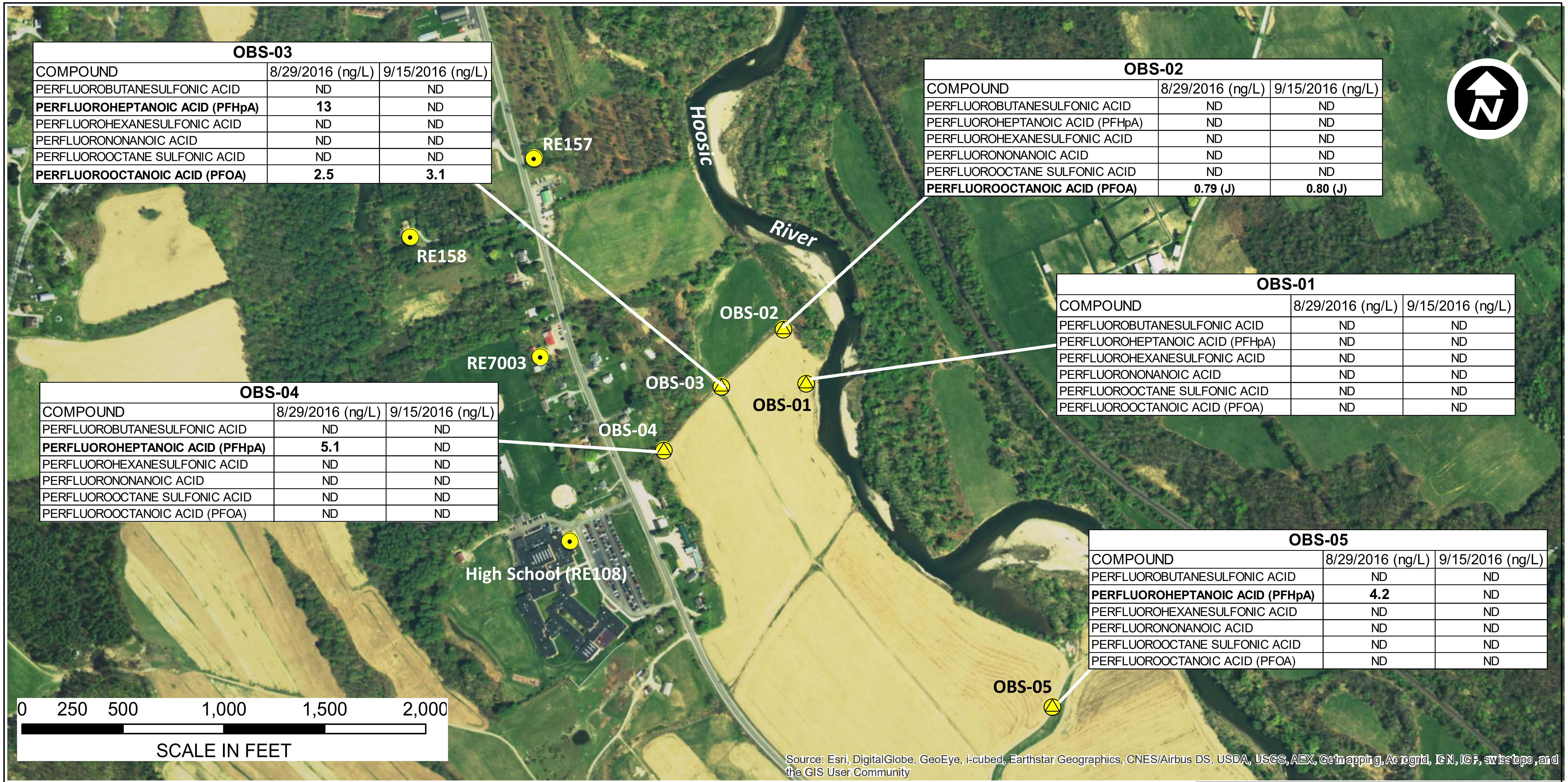
Approximate Scale in Feet

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Report

Local Monitoring Well Network

ARCADIS

4
FIGURE NO.



OBS-03

COMPOUND	8/29/2016 (ng/L)	9/15/2016 (ng/L)
PERFLUOROBUTANESULFONIC ACID	ND	ND
PERFLUOROHEPTANOIC ACID (PFHpA)	**13**	ND
PERFLUOROHEXANESULFONIC ACID	ND	ND
PERFLUORONONANOIC ACID	ND	ND
PERFLUOROOCTANE SULFONIC ACID	ND	ND
PERFLUOROOCTANOIC ACID (PFOA)	**2.5**	**3.1**

OBS-02

COMPOUND	8/29/2016 (ng/L)	9/15/2016 (ng/L)
PERFLUOROBUTANESULFONIC ACID	ND	ND
PERFLUOROHEPTANOIC ACID (PFHpA)	ND	ND
PERFLUOROHEXANESULFONIC ACID	ND	ND
PERFLUORONONANOIC ACID	ND	ND
PERFLUOROOCTANE SULFONIC ACID	ND	ND
PERFLUOROOCTANOIC ACID (PFOA)	**0.79 (J)**	**0.80 (J)**

OBS-01

COMPOUND	8/29/2016 (ng/L)	9/15/2016 (ng/L)
PERFLUOROBUTANESULFONIC ACID	ND	ND
PERFLUOROHEPTANOIC ACID (PFHpA)	ND	ND
PERFLUOROHEXANESULFONIC ACID	ND	ND
PERFLUORONONANOIC ACID	ND	ND
PERFLUOROOCTANE SULFONIC ACID	ND	ND
PERFLUOROOCTANOIC ACID (PFOA)	ND	ND

OBS-04

COMPOUND	8/29/2016 (ng/L)	9/15/2016 (ng/L)
PERFLUOROBUTANESULFONIC ACID	ND	ND
PERFLUOROHEPTANOIC ACID (PFHpA)	**5.1**	ND
PERFLUOROHEXANESULFONIC ACID	ND	ND
PERFLUORONONANOIC ACID	ND	ND
PERFLUOROOCTANE SULFONIC ACID	ND	ND
PERFLUOROOCTANOIC ACID (PFOA)	ND	ND

OBS-05

COMPOUND	8/29/2016 (ng/L)	9/15/2016 (ng/L)
PERFLUOROBUTANESULFONIC ACID	ND	ND
PERFLUOROHEPTANOIC ACID (PFHpA)	**4.2**	ND
PERFLUOROHEXANESULFONIC ACID	ND	ND
PERFLUORONONANOIC ACID	ND	ND
PERFLUOROOCTANE SULFONIC ACID	ND	ND
PERFLUOROOCTANOIC ACID (PFOA)	ND	ND

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

⊙	Monitoring Well
●	Potable Source well
△	Staff Gauge

J - Laboratory qualifier indicating result is less than the reporting limit, but greater than or equal to the analytical method detection limit, and therefore the concentration is an approximate value. The method detection limit is the lowest concentration at which the analytical method can qualitatively identify the presence of a compound. The reporting limit is the lowest concentration at which the instrument is calibrated, and can quantify a compound concentration.

ND - Not detected at or above respective method detection limit (See Table 3).

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Evaluation

Baseline Analytical Sampling Results
(PFAS via USEPA 537 1.1)

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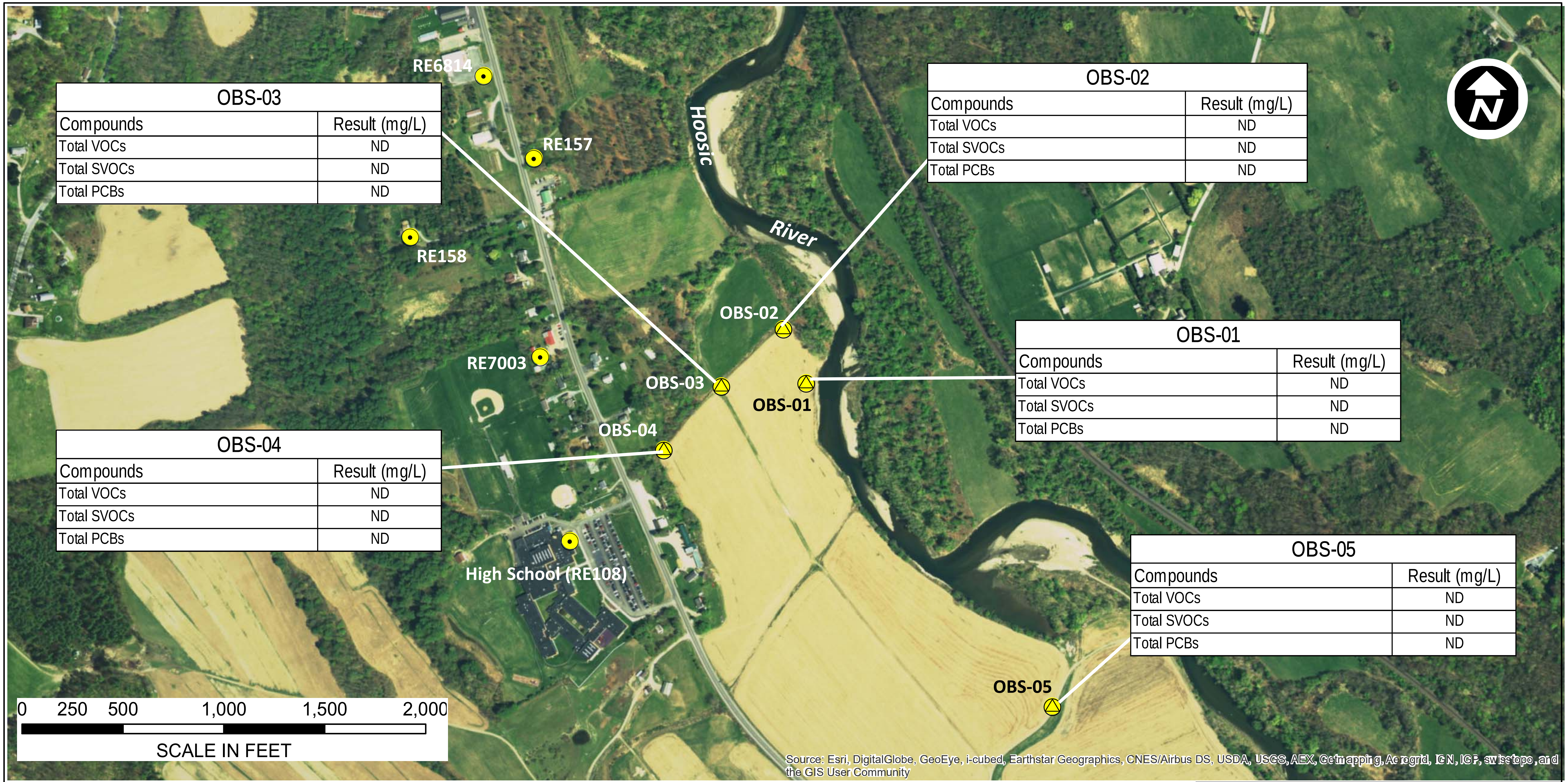
5a
FIGURE NO.



OBS-03

Compounds	Result (mg/L)
Total VOCs	ND
Total SVOCs	ND
Total PCBs	ND

OBS-02

Compounds	Result (mg/L)
Total VOCs	ND
Total SVOCs	ND
Total PCBs	ND

OBS-01

Compounds	Result (mg/L)
Total VOCs	ND
Total SVOCs	ND
Total PCBs	ND

OBS-04

Compounds	Result (mg/L)
Total VOCs	ND
Total SVOCs	ND
Total PCBs	ND

OBS-05

Compounds	Result (mg/L)
Total VOCs	ND
Total SVOCs	ND
Total PCBs	ND

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

◬ Monitoring Well

⊙ Potable Source well

▲ Staff Gauge

ND - Not detected at or above respective method detection limit (See Table 4).

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Evaluation

10/7/2016 Baseline Analytical Sampling Results (VOCs/ SVOCs/ PCBs)

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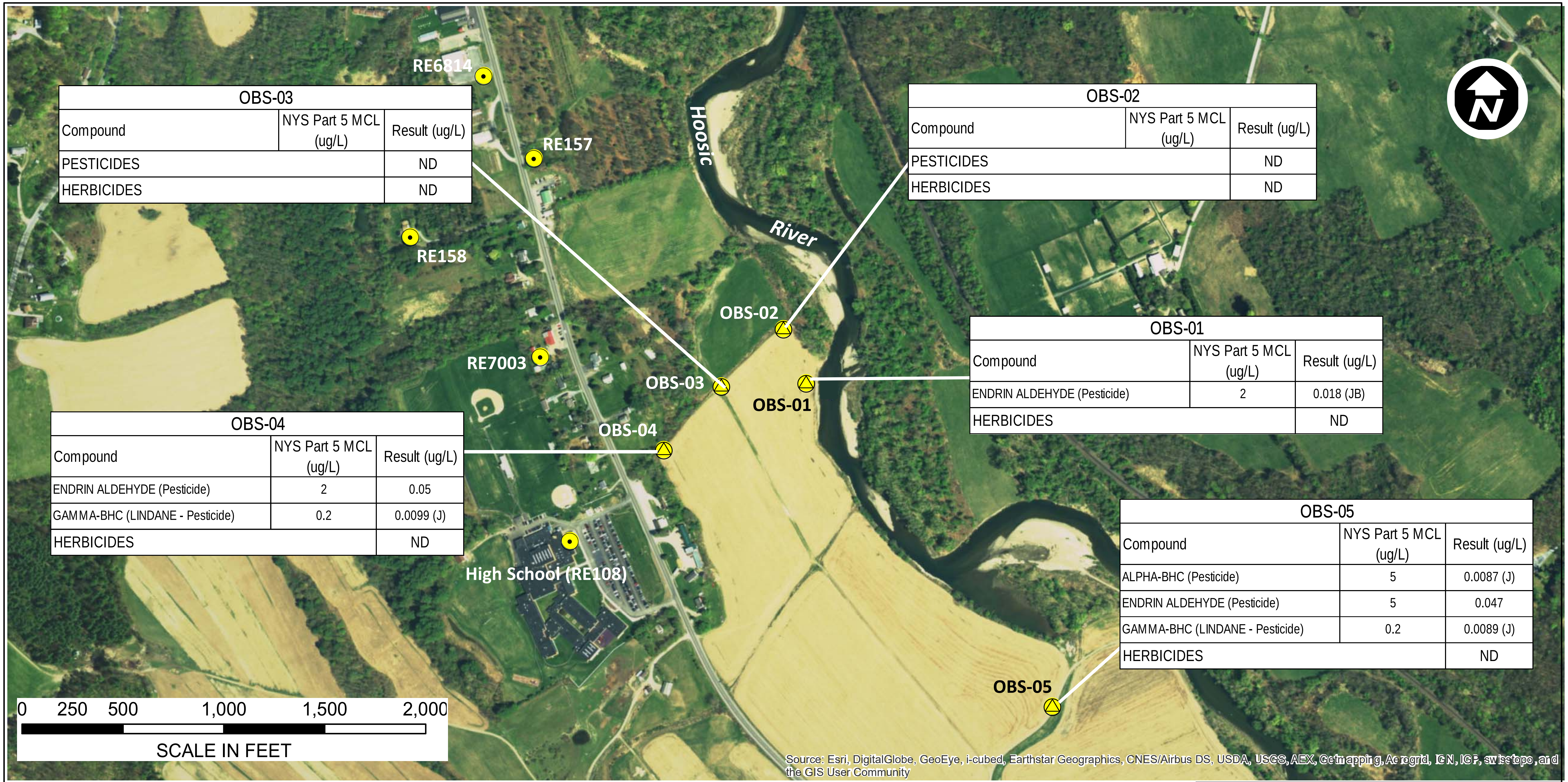
5b
FIGURE NO.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

OBS-03		
Compound	NYS Part 5 MCL (ug/L)	Result (ug/L)
PESTICIDES		ND
HERBICIDES		ND

OBS-02		
Compound	NYS Part 5 MCL (ug/L)	Result (ug/L)
PESTICIDES		ND
HERBICIDES		ND

OBS-01		
Compound	NYS Part 5 MCL (ug/L)	Result (ug/L)
ENDRIN ALDEHYDE (Pesticide)	2	0.018 (JB)
HERBICIDES		ND

OBS-04		
Compound	NYS Part 5 MCL (ug/L)	Result (ug/L)
ENDRIN ALDEHYDE (Pesticide)	2	0.05
GAMMA-BHC (LINDANE - Pesticide)	0.2	0.0099 (J)
HERBICIDES		ND

OBS-05		
Compound	NYS Part 5 MCL (ug/L)	Result (ug/L)
ALPHA-BHC (Pesticide)	5	0.0087 (J)
ENDRIN ALDEHYDE (Pesticide)	5	0.047
GAMMA-BHC (LINDANE - Pesticide)	0.2	0.0089 (J)
HERBICIDES		ND

Legend

◬	Monitoring Well
⊙	Potable Source well
△	Staff Gauge

J - Laboratory qualifier indicating result is less than the reporting limit, but greater than or equal to the analytical method detection limit, and therefore the concentration is an approximate value. The method detection limit is the lowest concentration at which the analytical method can qualitatively identify the presence of a compound. The reporting limit is the lowest concentration at which the instrument is calibrated, and can quantify a compound concentration.

B – Compound was found in laboratory blank and sample.

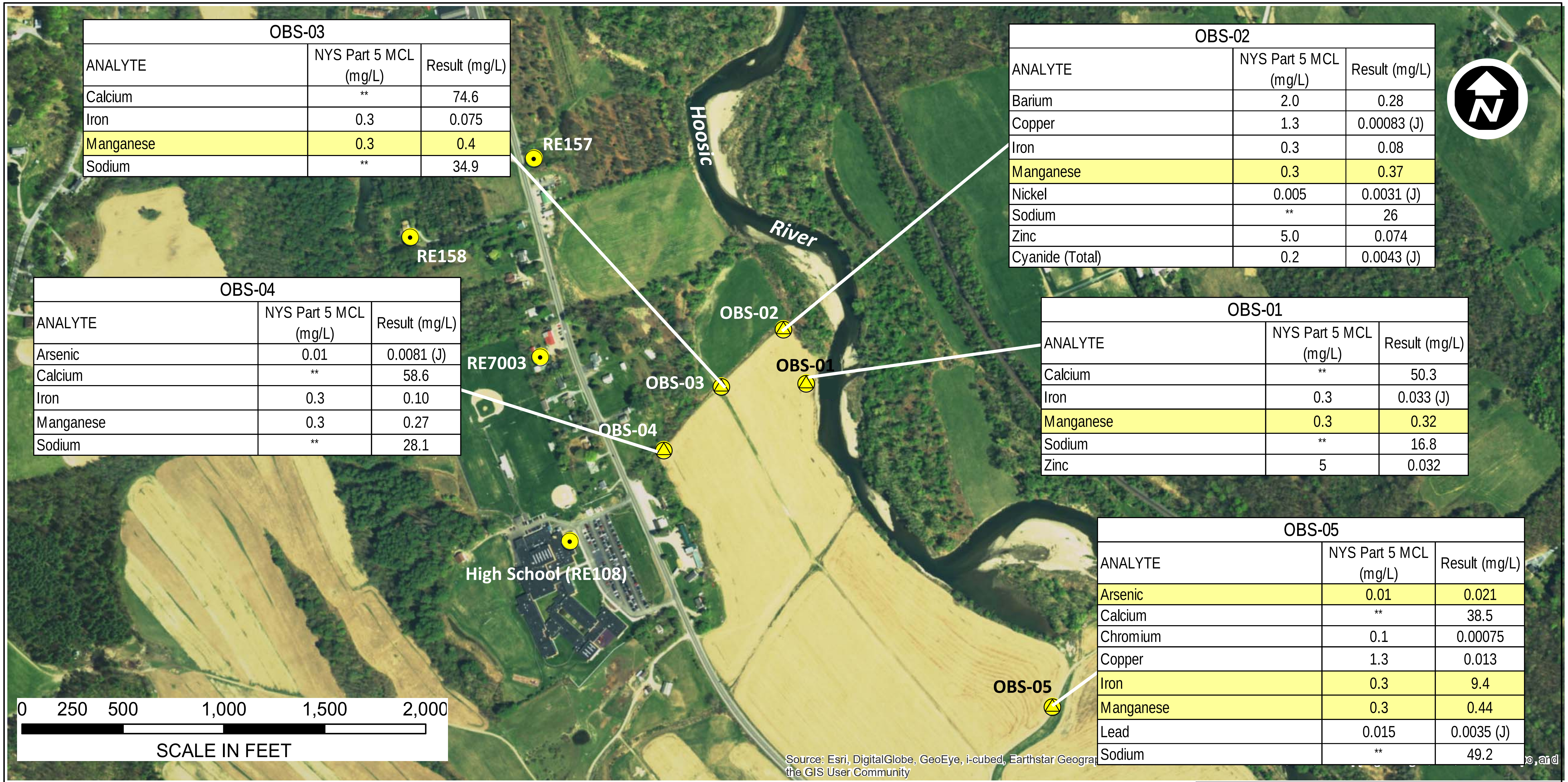
ND - Not detected at or above respective method detection limit (See Table 4).

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Evaluation

10/7/2016 Baseline Analytical Sampling Results
(Herbicides/ Pesticides)

ARCADIS Design & Consultancy for natural and built assets

5c
FIGURE NO.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geograp
the GIS User Community

OBS-03		
ANALYTE	NYS Part 5 MCL (mg/L)	Result (mg/L)
Calcium	**	74.6
Iron	0.3	0.075
Manganese	0.3	0.4
Sodium	**	34.9

OBS-02		
ANALYTE	NYS Part 5 MCL (mg/L)	Result (mg/L)
Barium	2.0	0.28
Copper	1.3	0.00083 (J)
Iron	0.3	0.08
Manganese	0.3	0.37
Nickel	0.005	0.0031 (J)
Sodium	**	26
Zinc	5.0	0.074
Cyanide (Total)	0.2	0.0043 (J)

OBS-04		
ANALYTE	NYS Part 5 MCL (mg/L)	Result (mg/L)
Arsenic	0.01	0.0081 (J)
Calcium	**	58.6
Iron	0.3	0.10
Manganese	0.3	0.27
Sodium	**	28.1

OBS-01		
ANALYTE	NYS Part 5 MCL (mg/L)	Result (mg/L)
Calcium	**	50.3
Iron	0.3	0.033 (J)
Manganese	0.3	0.32
Sodium	**	16.8
Zinc	5	0.032

OBS-05		
ANALYTE	NYS Part 5 MCL (mg/L)	Result (mg/L)
Arsenic	0.01	0.021
Calcium	**	38.5
Chromium	0.1	0.00075
Copper	1.3	0.013
Iron	0.3	9.4
Manganese	0.3	0.44
Lead	0.015	0.0035 (J)
Sodium	**	49.2

Legend

- ⊛ Monitoring Well
- ⊙ Potable Source well
- △ Staff Gauge

J - Laboratory qualifier indicating result is less than the reporting limit, but greater than or equal to the analytical method detection limit, and therefore the concentration is an approximate value. The method detection limit is the lowest concentration at which the analytical method can qualitatively identify the presence of a compound. The reporting limit is the lowest concentration at which the instrument is calibrated, and can quantify a compound concentration.

** See table 2-1 notes, and New York State Part 5 Requirements.

ND - Not detected at or above respective method detection limit (See Table 2).

🟨 Concentration exceeds respective New York State Part 5 MCL.

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Evaluation

10/7/2016 Baseline Analytical Sampling Results
(Summary of Detected Metals)

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5d
FIGURE NO.

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

⊕	Production Test Well
▲	Observation Well (Local MWN)
△	Staff Gauge/ Stilling well Location
▼	Rain Gauge Location

0 100 200 300 400

Approximate Scale in Feet

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York

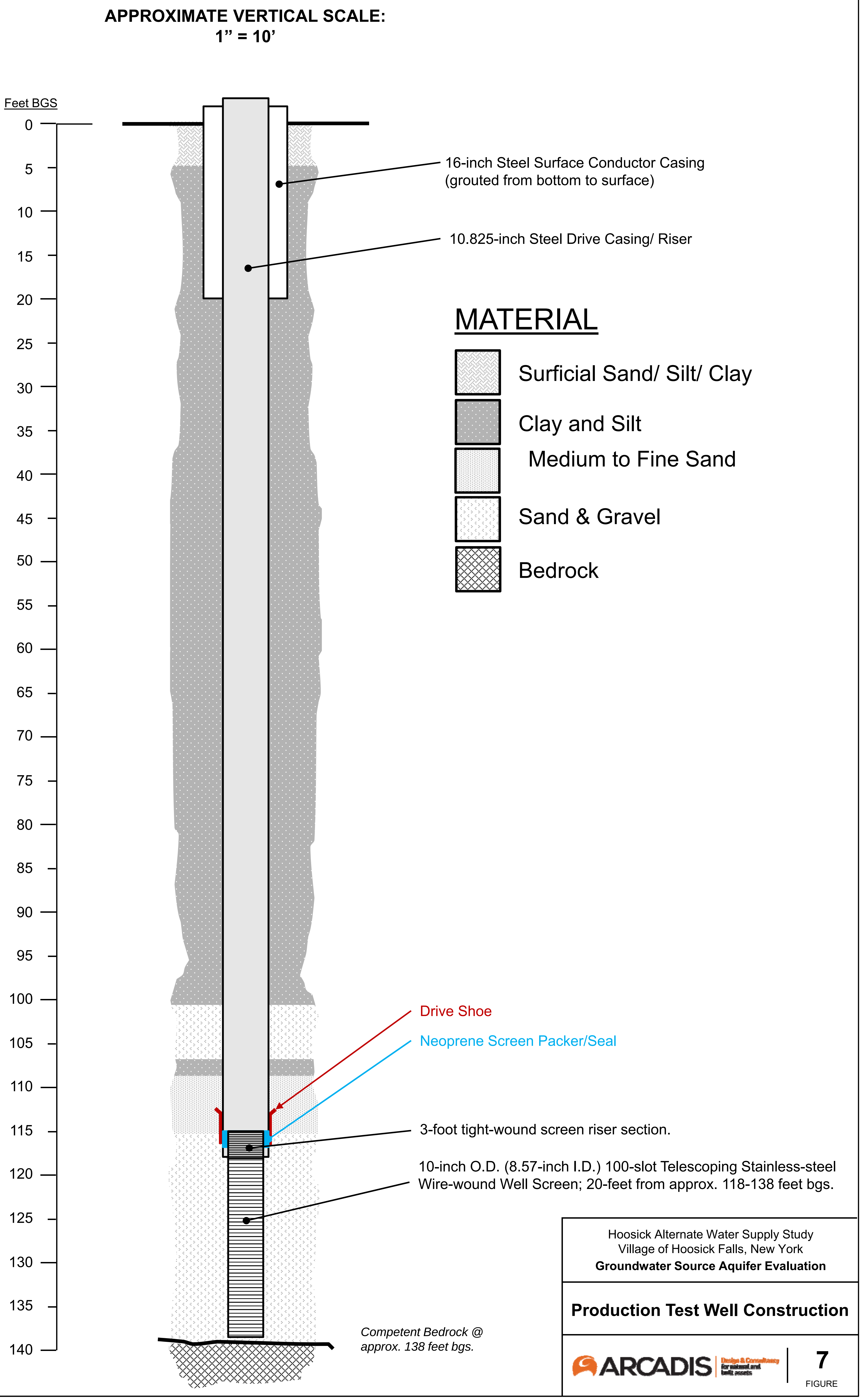
Groundwater Source Aquifer Evaluation

Source Aquifer Test Site Layout

ARCADIS Design & Consultancy for natural and built assets

6

FIGURE



Hoosick Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Production Test Well Construction

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7
FIGURE

Source: Esri, DigitalGlobe, GeoEye, Icubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

LEGEND

- ◬ Monitoring Well
- ⊙ Potable Source well
- △ Staff Gauge
- ⊗ Municipal Well

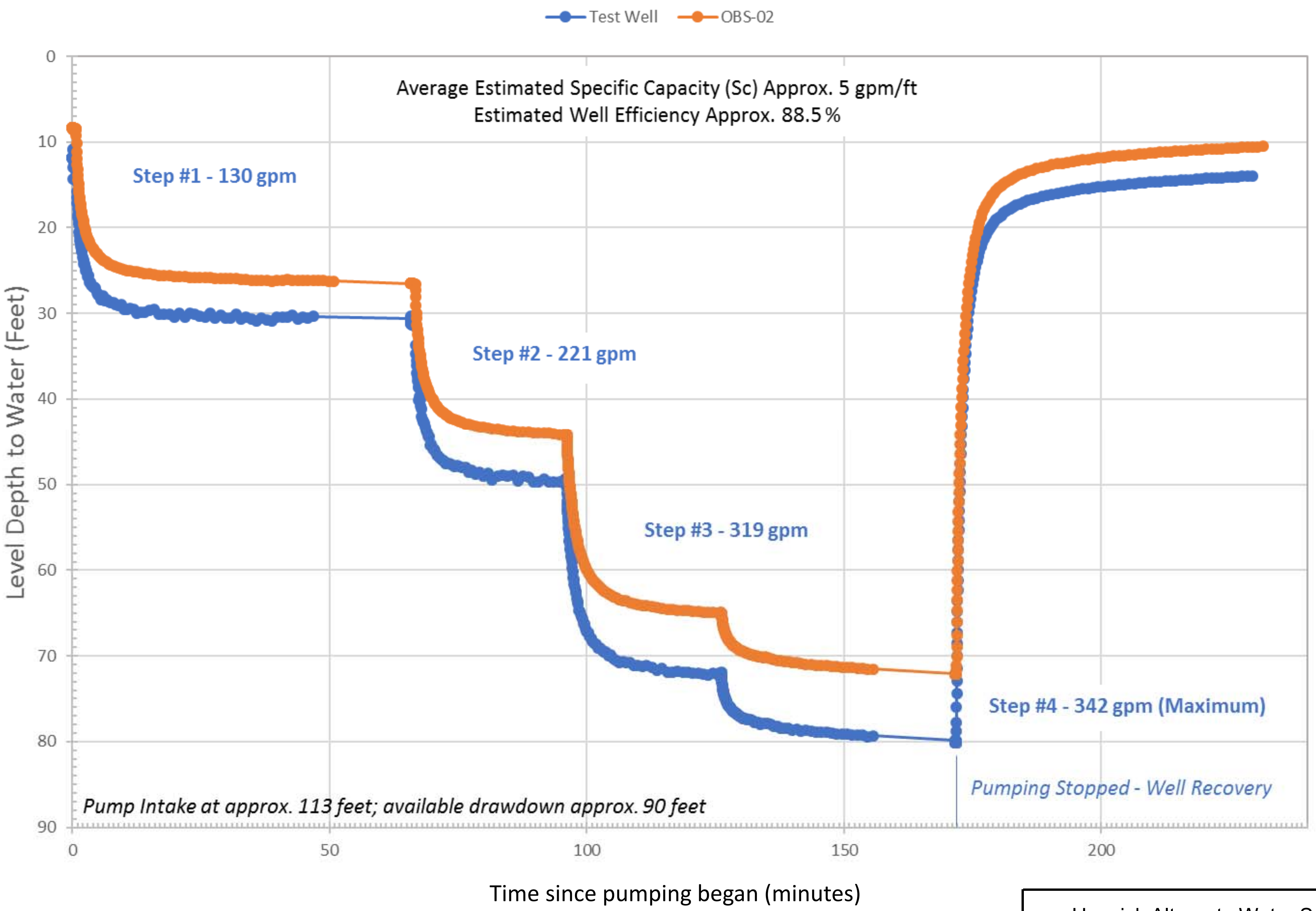
Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, Rensselaer County, New York

Groundwater Source Aquifer Study

Regional Monitoring Well Network

ARCADIS Design & Consultancy for natural and built assets

8
FIGURE



Average Estimated Specific Capacity (Sc) Approx. 5 gpm/ft
Estimated Well Efficiency Approx. 88.5 %

Step #1 - 130 gpm

Step #2 - 221 gpm

Step #3 - 319 gpm

Step #4 - 342 gpm (Maximum)

Pumping Stopped - Well Recovery

Pump Intake at approx. 113 feet; available drawdown approx. 90 feet

Hoosick Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Test Well Stepped-Drawdown Test Summary

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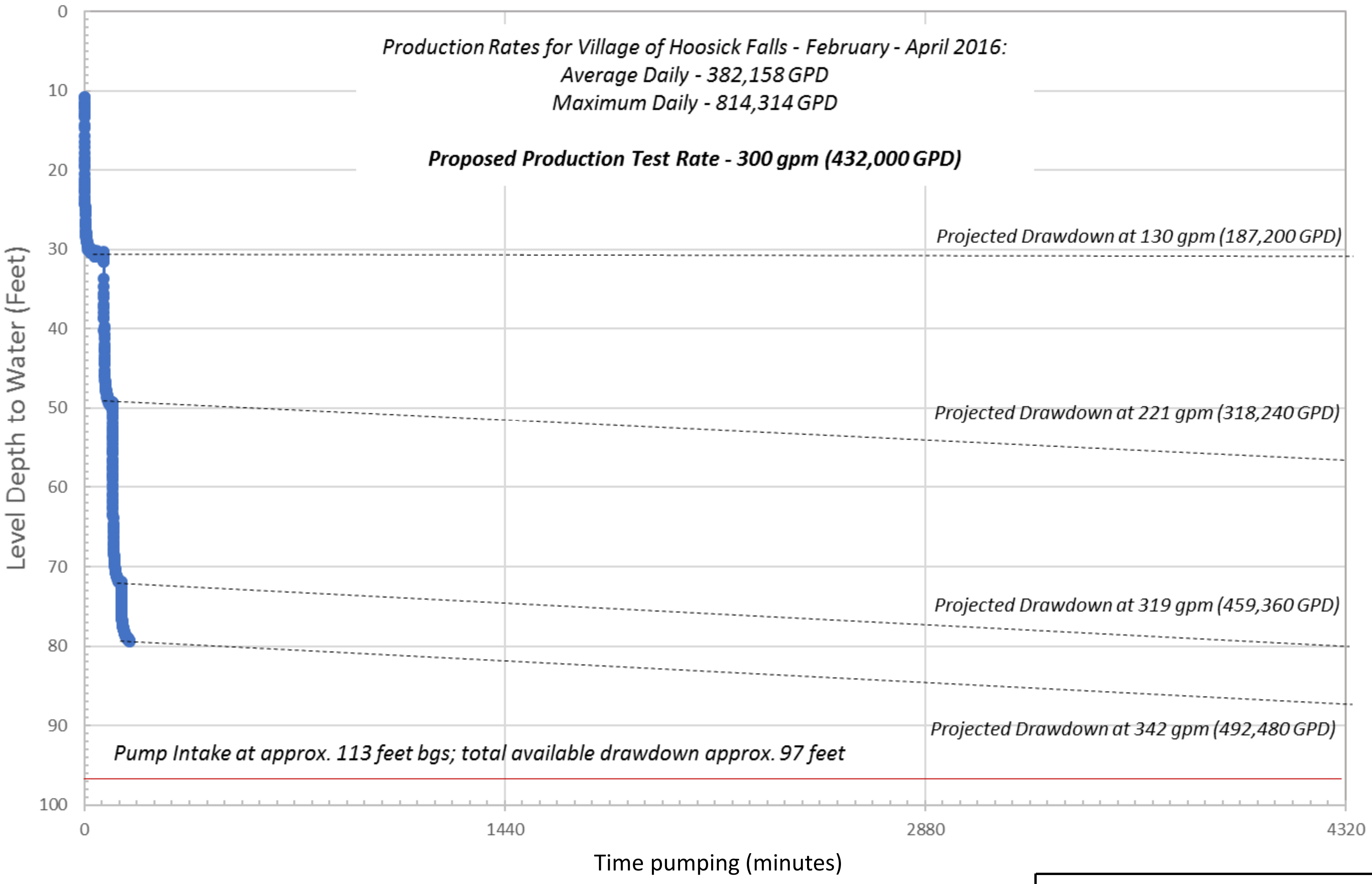
9
FIGURE

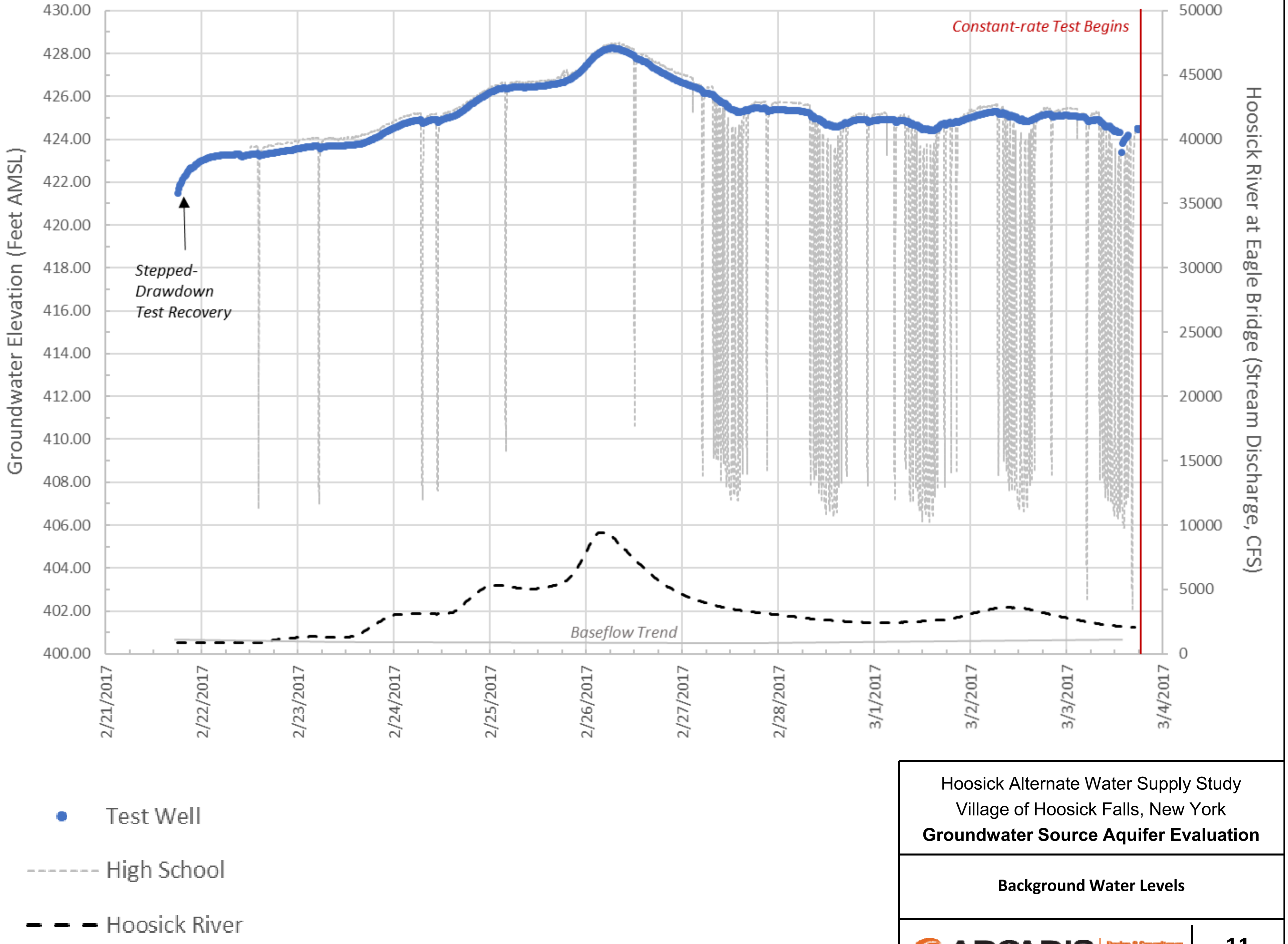


Hoosick Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Extrapolation of Stepped-drawdown Curves

ARCADIS

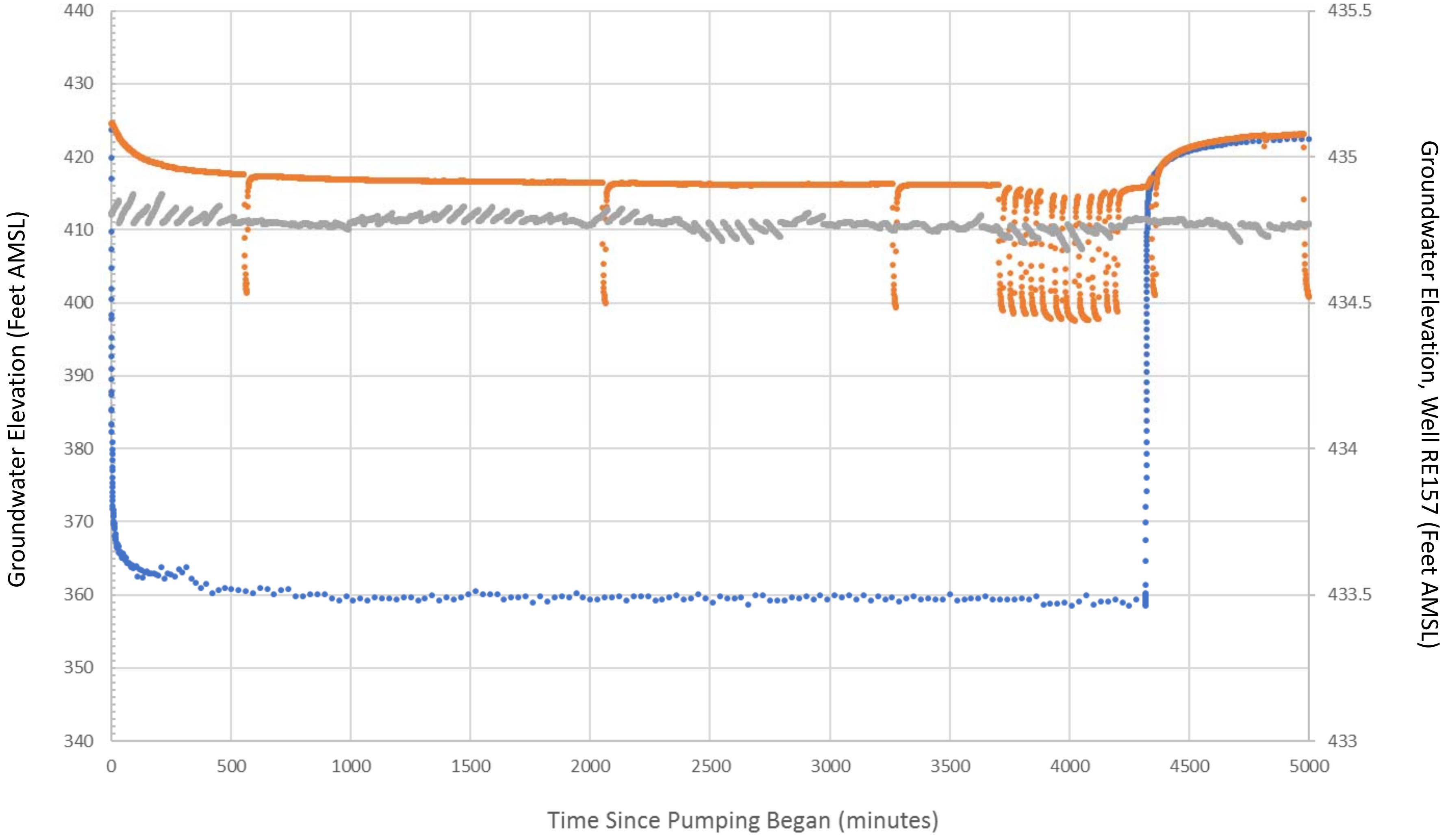
10
FIGURE



Hoosick Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Background Water Levels

11
FIGURE



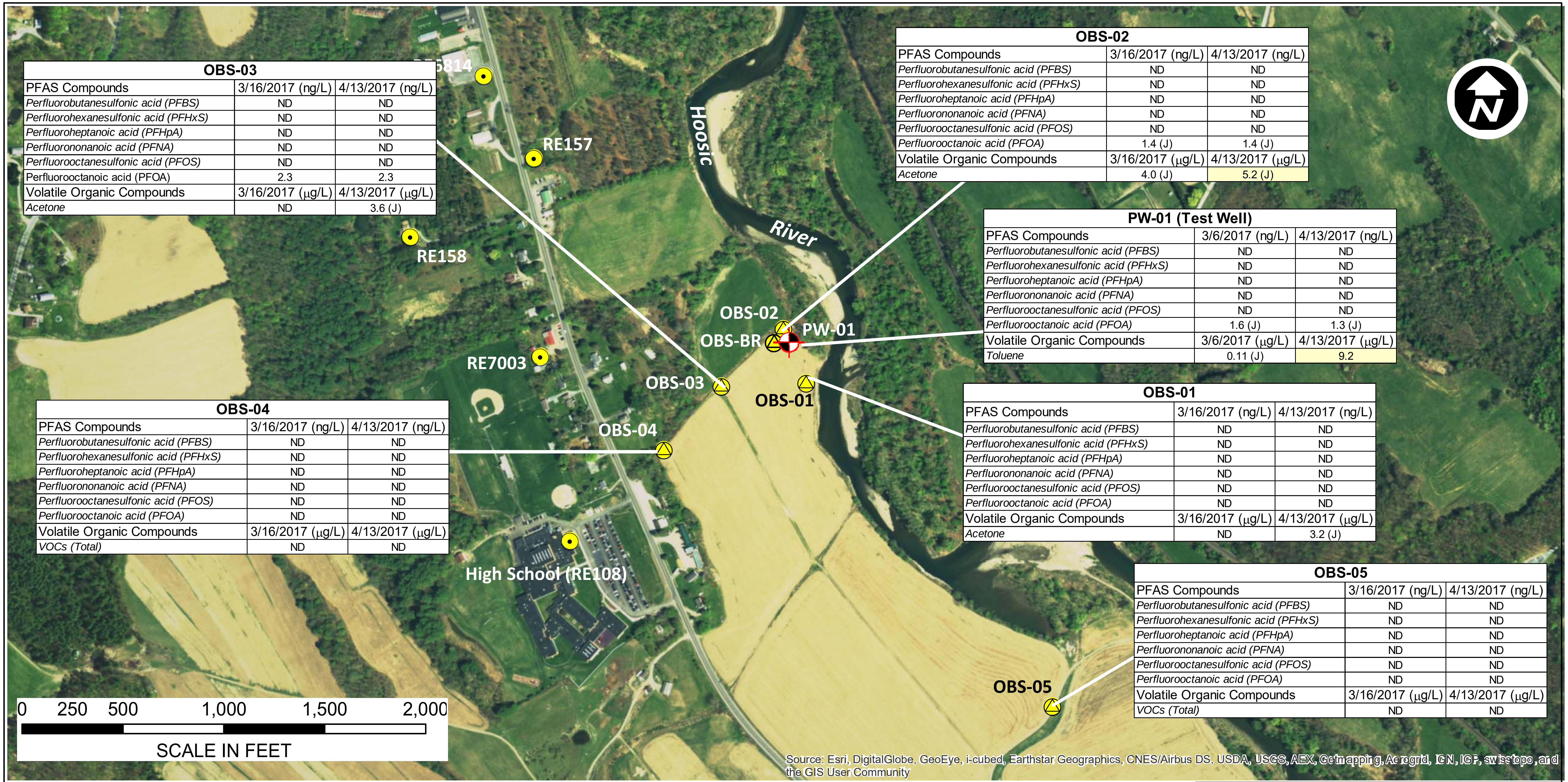
● Test Well
● RE157
● High School

Hoosick Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Test Well Drawdown During Pumping Test

ARCADIS

12
FIGURE



OBS-03		
PFAS Compounds	3/16/2017 (ng/L)	4/13/2017 (ng/L)
Perfluorobutanesulfonic acid (PFBS)	ND	ND
Perfluorohexanesulfonic acid (PFHxS)	ND	ND
Perfluoroheptanoic acid (PFHpA)	ND	ND
Perfluorononanoic acid (PFNA)	ND	ND
Perfluorooctanesulfonic acid (PFOS)	ND	ND
Perfluorooctanoic acid (PFOA)	2.3	2.3
Volatile Organic Compounds	3/16/2017 (μg/L)	4/13/2017 (μg/L)
Acetone	ND	3.6 (J)

OBS-02		
PFAS Compounds	3/16/2017 (ng/L)	4/13/2017 (ng/L)
Perfluorobutanesulfonic acid (PFBS)	ND	ND
Perfluorohexanesulfonic acid (PFHxS)	ND	ND
Perfluoroheptanoic acid (PFHpA)	ND	ND
Perfluorononanoic acid (PFNA)	ND	ND
Perfluorooctanesulfonic acid (PFOS)	ND	ND
Perfluorooctanoic acid (PFOA)	1.4 (J)	1.4 (J)
Volatile Organic Compounds	3/16/2017 (μg/L)	4/13/2017 (μg/L)
Acetone	4.0 (J)	5.2 (J)

PW-01 (Test Well)		
PFAS Compounds	3/6/2017 (ng/L)	4/13/2017 (ng/L)
Perfluorobutanesulfonic acid (PFBS)	ND	ND
Perfluorohexanesulfonic acid (PFHxS)	ND	ND
Perfluoroheptanoic acid (PFHpA)	ND	ND
Perfluorononanoic acid (PFNA)	ND	ND
Perfluorooctanesulfonic acid (PFOS)	ND	ND
Perfluorooctanoic acid (PFOA)	1.6 (J)	1.3 (J)
Volatile Organic Compounds	3/6/2017 (μg/L)	4/13/2017 (μg/L)
Toluene	0.11 (J)	9.2

OBS-04		
PFAS Compounds	3/16/2017 (ng/L)	4/13/2017 (ng/L)
Perfluorobutanesulfonic acid (PFBS)	ND	ND
Perfluorohexanesulfonic acid (PFHxS)	ND	ND
Perfluoroheptanoic acid (PFHpA)	ND	ND
Perfluorononanoic acid (PFNA)	ND	ND
Perfluorooctanesulfonic acid (PFOS)	ND	ND
Perfluorooctanoic acid (PFOA)	ND	ND
Volatile Organic Compounds	3/16/2017 (μg/L)	4/13/2017 (μg/L)
VOCs (Total)	ND	ND

OBS-01		
PFAS Compounds	3/16/2017 (ng/L)	4/13/2017 (ng/L)
Perfluorobutanesulfonic acid (PFBS)	ND	ND
Perfluorohexanesulfonic acid (PFHxS)	ND	ND
Perfluoroheptanoic acid (PFHpA)	ND	ND
Perfluorononanoic acid (PFNA)	ND	ND
Perfluorooctanesulfonic acid (PFOS)	ND	ND
Perfluorooctanoic acid (PFOA)	ND	ND
Volatile Organic Compounds	3/16/2017 (μg/L)	4/13/2017 (μg/L)
Acetone	ND	3.2 (J)

OBS-05		
PFAS Compounds	3/16/2017 (ng/L)	4/13/2017 (ng/L)
Perfluorobutanesulfonic acid (PFBS)	ND	ND
Perfluorohexanesulfonic acid (PFHxS)	ND	ND
Perfluoroheptanoic acid (PFHpA)	ND	ND
Perfluorononanoic acid (PFNA)	ND	ND
Perfluorooctanesulfonic acid (PFOS)	ND	ND
Perfluorooctanoic acid (PFOA)	ND	ND
Volatile Organic Compounds	3/16/2017 (μg/L)	4/13/2017 (μg/L)
VOCs (Total)	ND	ND

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

⊙	Monitoring Well
●	Potable Source well
△	Staff Gauge

J - Laboratory qualifier indicating result is less than the reporting limit, but greater than or equal to the analytical method detection limit, and therefore the concentration is an approximate value. The method detection limit is the lowest concentration at which the analytical method can qualitatively identify the presence of a compound. The reporting limit is the lowest concentration at which the instrument is calibrated, and can quantify a compound concentration.

** See table 2-1 notes, and New York State Part 5 Requirements.

ND - Not detected at or above respective method detection limit (See Tables 3 and 4).

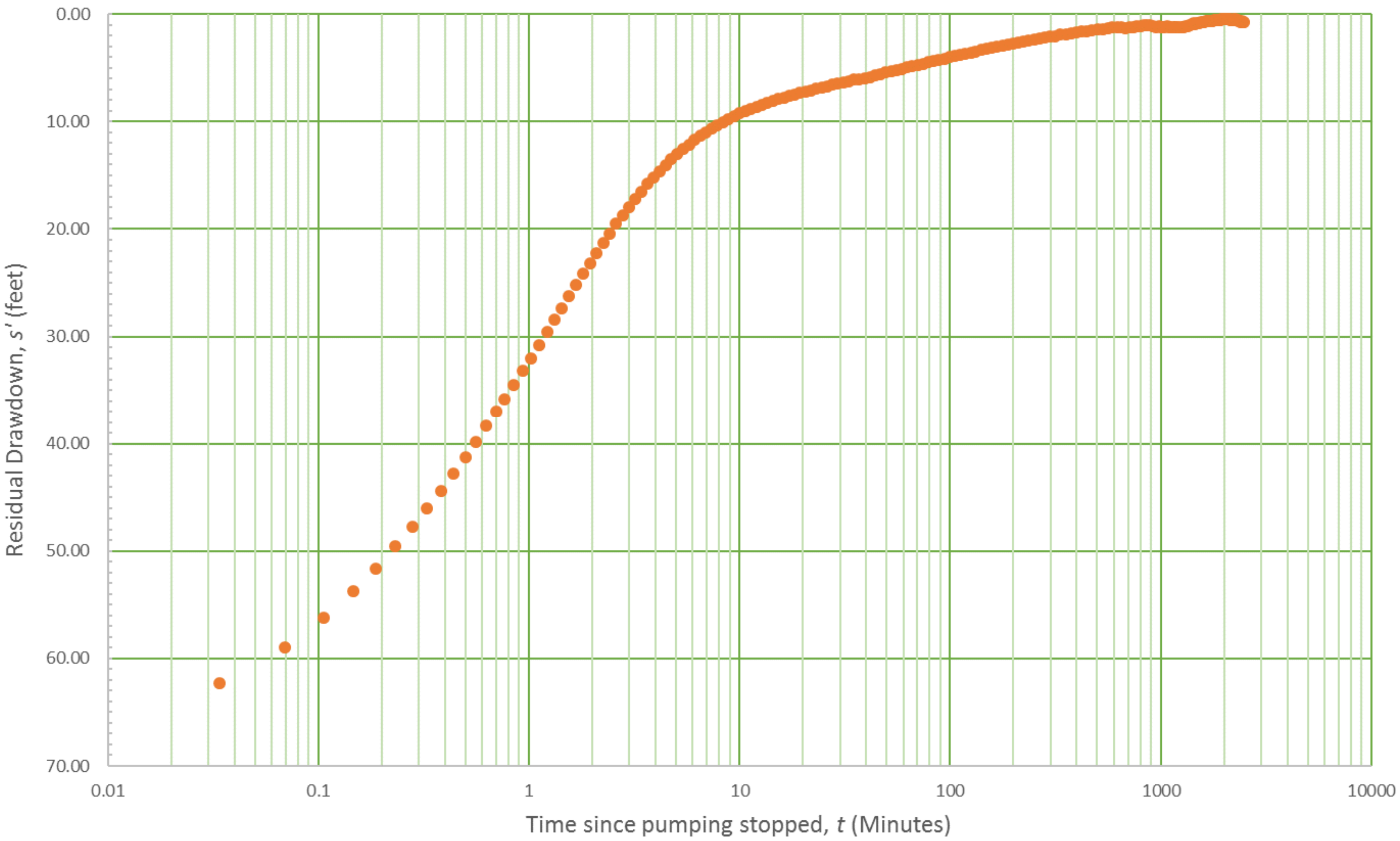
🟨 Concentration exceeds respective New York State Part 5 MCL. (POC)

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Evaluation

March and April 2017 Post-Pumping Test Analytical Summary

ARCADIS Design & Consultancy for natural and built assets

13
FIGURE NO.

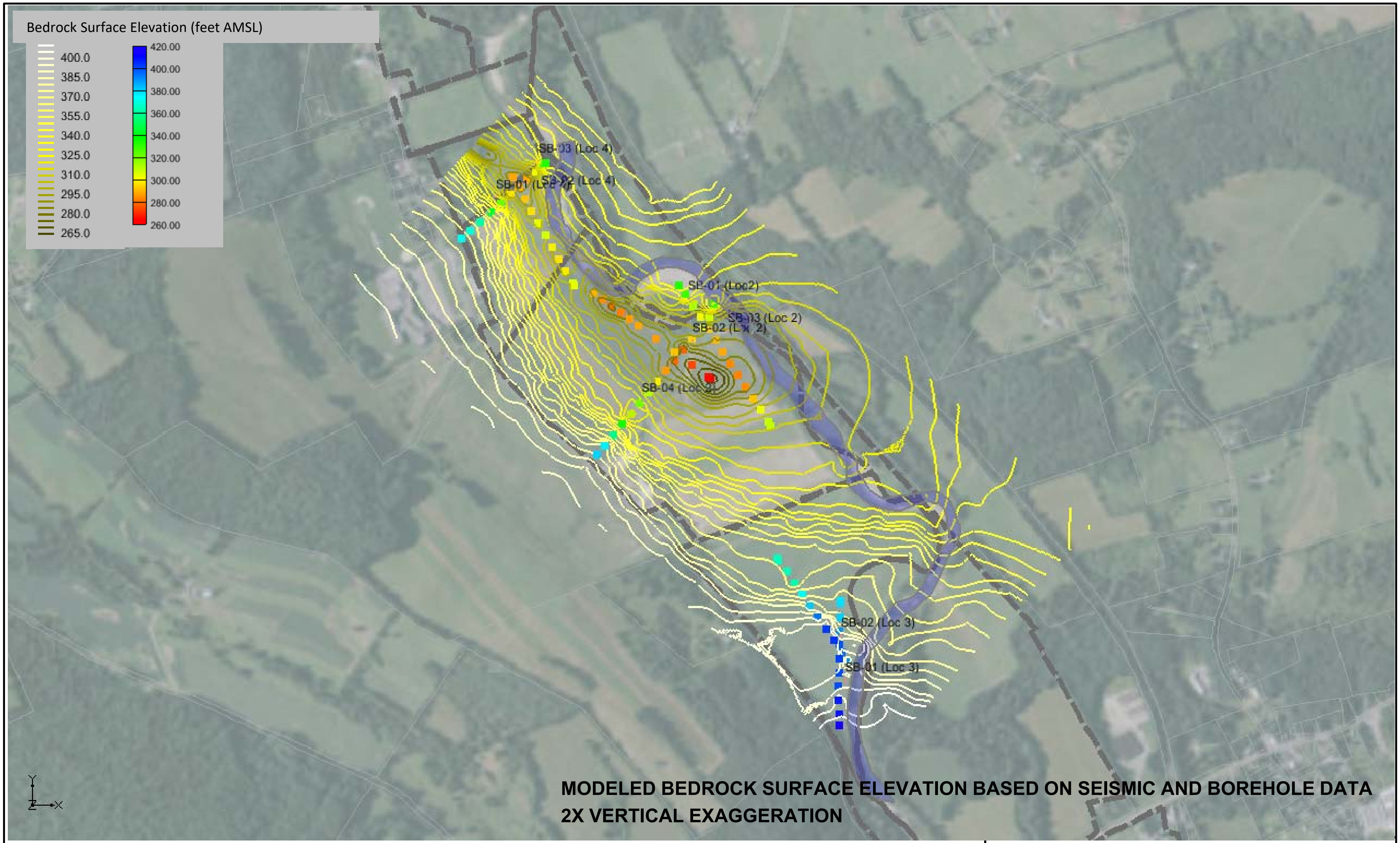


Hoosick Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Test Well Recovery

ARCADIS

14
FIGURE



MODELED BEDROCK SURFACE ELEVATION BASED ON SEISMIC AND BOREHOLE DATA
2X VERTICAL EXAGGERATION

Legend

▨ Approximate Hoosic River Channel

■ Seismic Profile Data Point

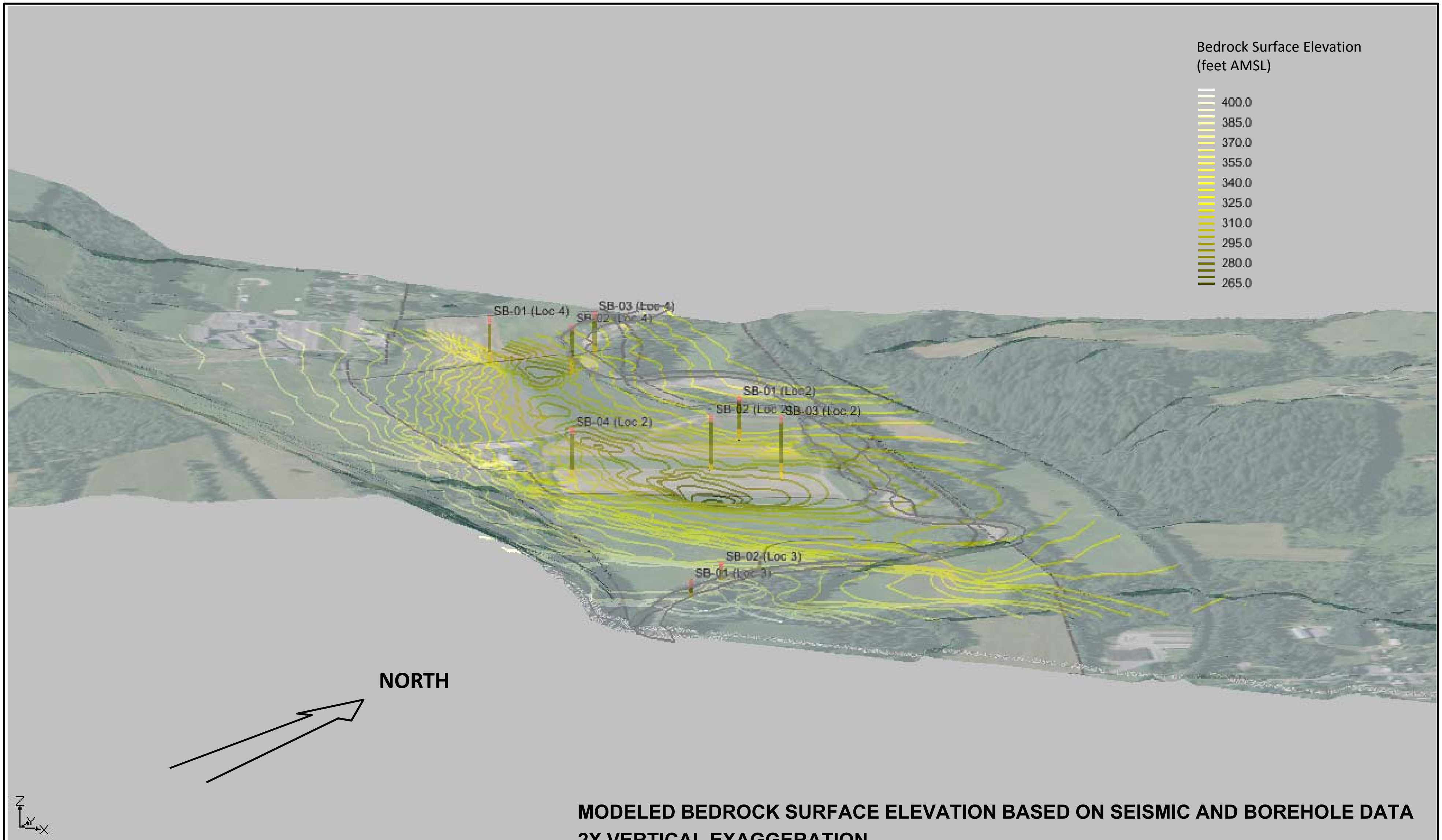
Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York

Groundwater Source Evaluation

Conceptual Model Summary – Bedrock Surface

ARCADIS

15a
FIGURE NO.



MODELED BEDROCK SURFACE ELEVATION BASED ON SEISMIC AND BOREHOLE DATA
2X VERTICAL EXAGGERATION

Legend

SB-01 (Loc2)

Boring Location

General Stratigrapghy

🟥	Alluvium/ Surficial Deposits
🟩	Clay/ Silt Complex
🟨	Sand/ Gravel Complex

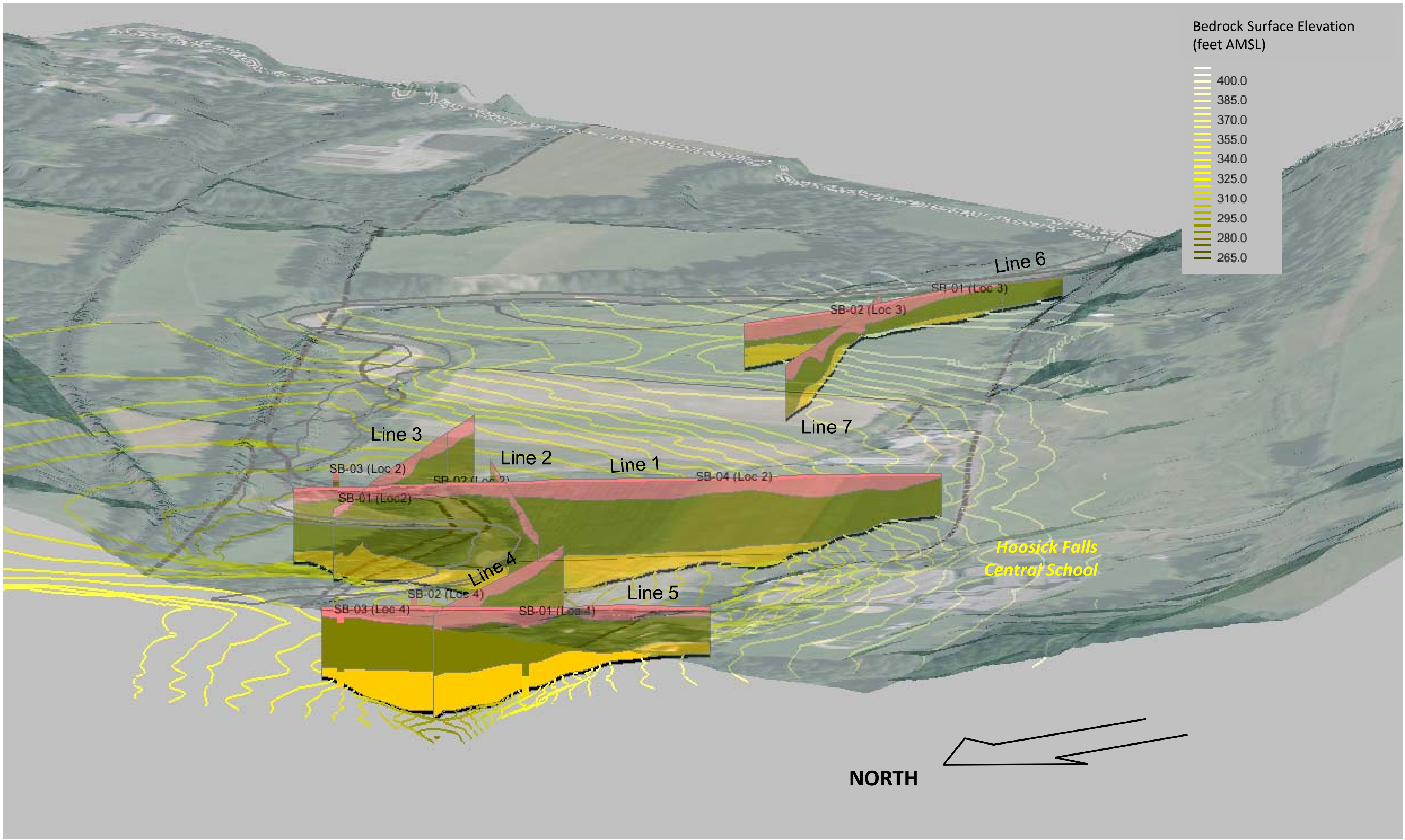
Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York

Groundwater Source Evaluation

Conceptual Model Summary – Borehole Data

ARCADIS

15b
FIGURE NO.



Legend

Approximate Hoosic River Channel

SB-01 (Loc2)

Boring Location

General Stratigrapghy

🟥	Alluvium/ Surficial Deposits (Upper Aquifer)
🟩	Clay/ Silt Complex
🟨	Sand/ Gravel Complex (Lower Aquifer)
■	Bedrock

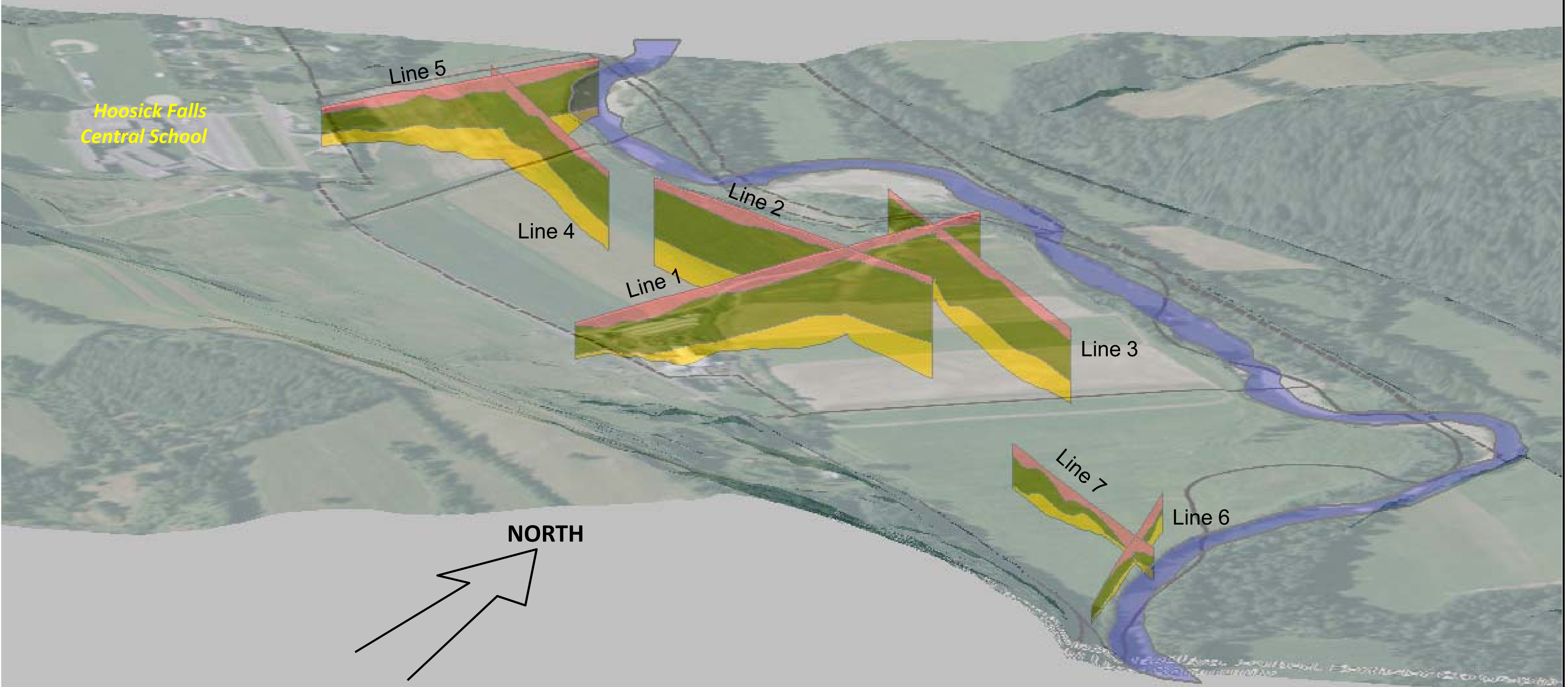
Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York

Groundwater Source Evaluation

Conceptual Model Summary – Fence Diagram (Up-valley)

ARCADIS

15c
FIGURE NO.



STRATIGRAPHIC DATA BASED ON BOREHOLE AND ELECTRICAL RESISTIVITY DATA
2X VERTICAL EXAGGERATION

Legend

▨ Approximate Hoosic River Channel

General Stratigrapghy

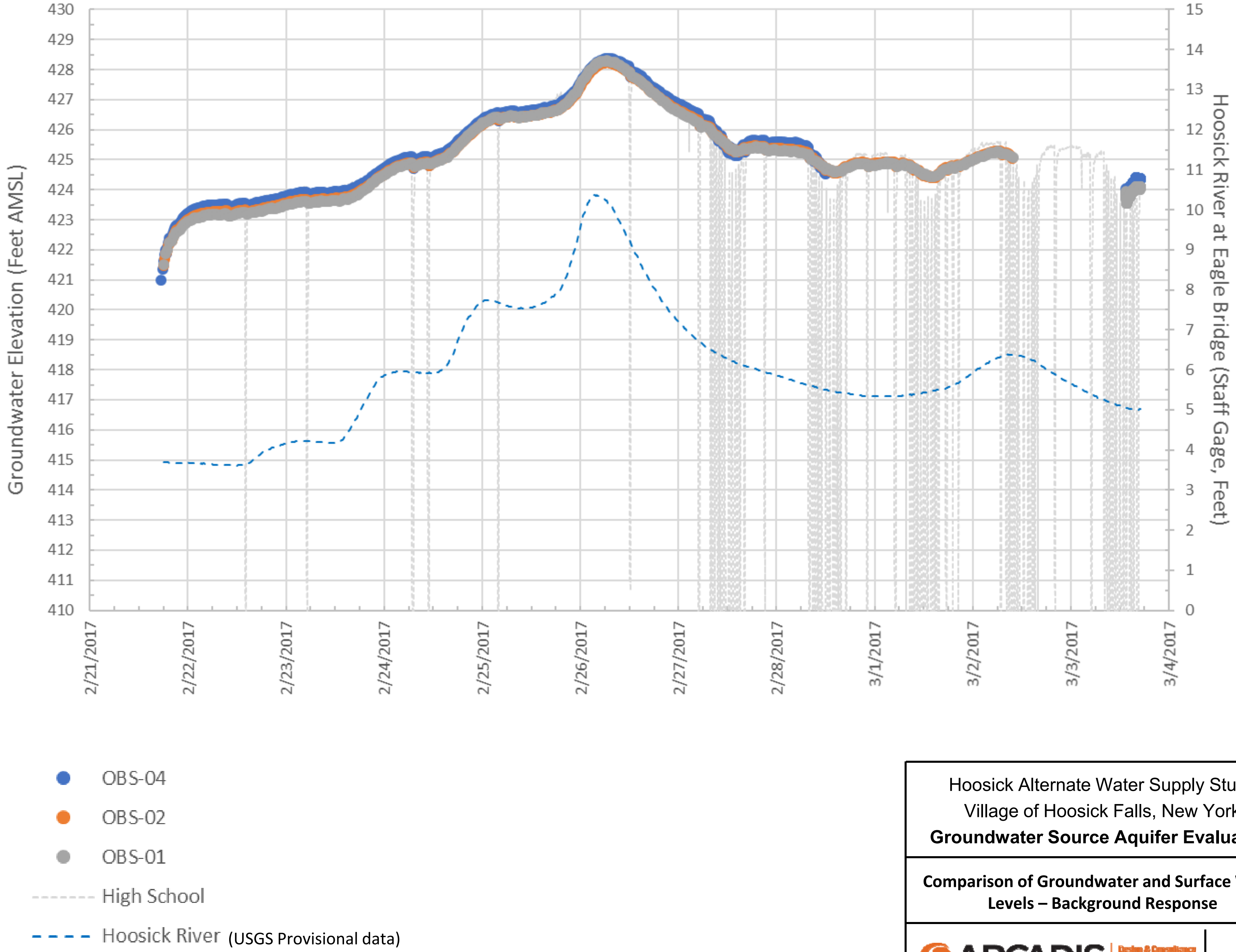
🟥 Alluvium/ Surficial Deposits (Upper Aquifer)
🟩 Clay/ Silt Complex
🟨 Sand/ Gravel Complex (Lower Aquifer)
⬛ Bedrock

Hoosick Falls Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Evaluation

Conceptual Model Summary – Fence Diagram (Down-valley)

ARCADIS

15d
FIGURE NO.

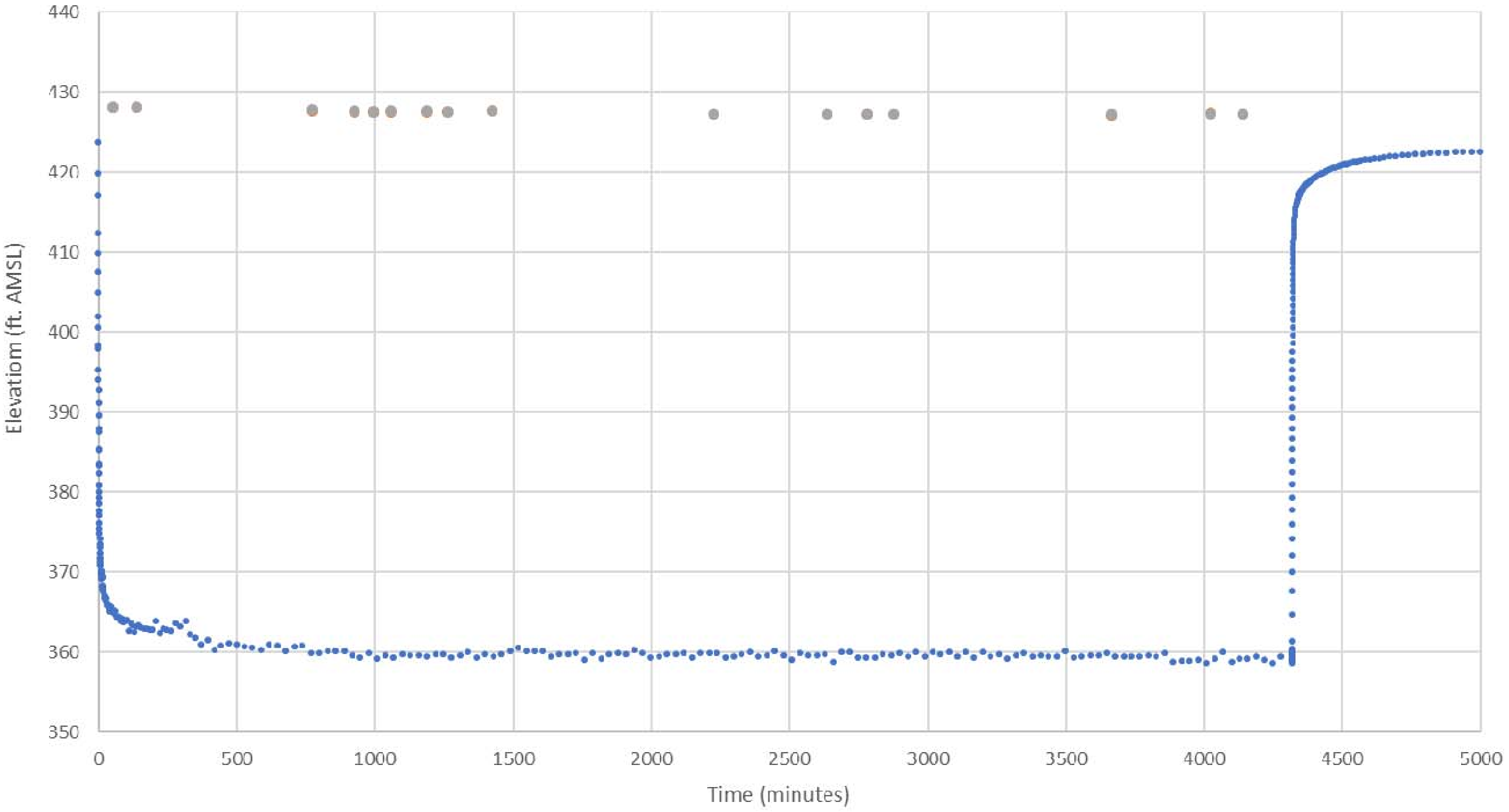


Hoosick Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Comparison of Groundwater and Surface Water Levels – Background Response

ARCADIS

16a
FIGURE



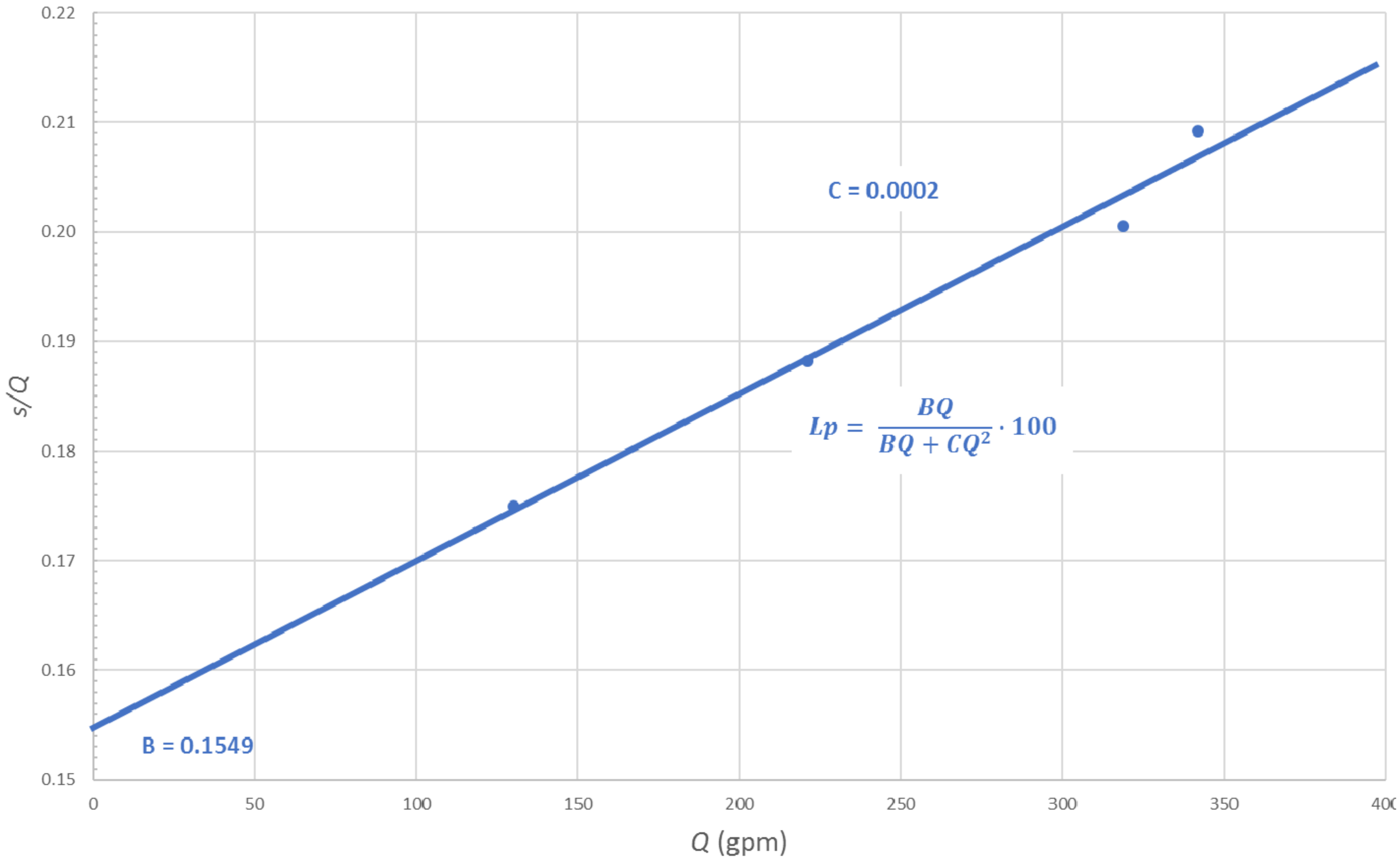
- ● Test Well
- ● Stilling Well Levels
- ● Staff Gauge

Hoosick Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Comparison of Groundwater and Surface Water Levels - During Constant-rate Pumping

ARCADIS

16b
FIGURE

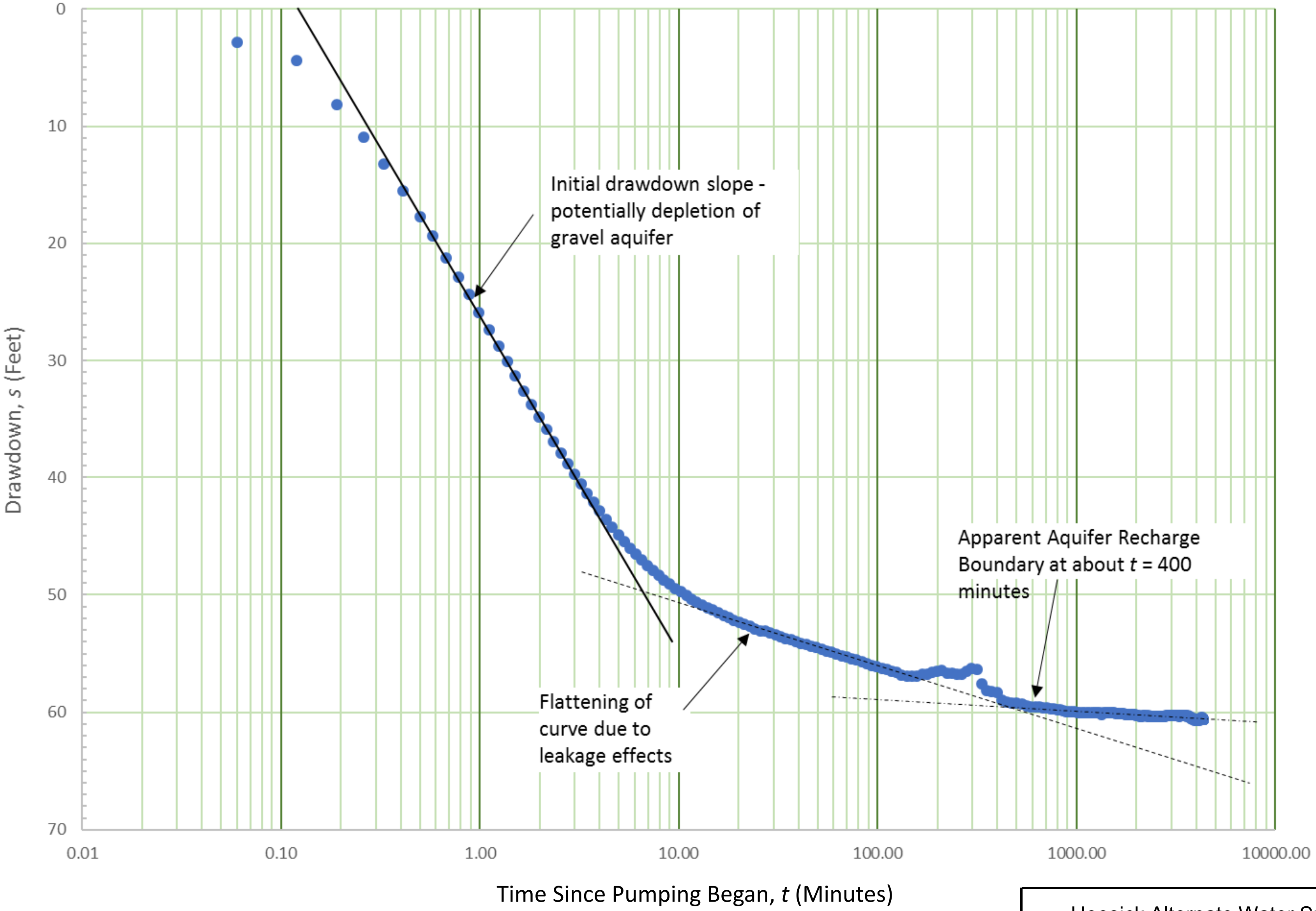


Hoosick Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Analysis of Turbulent Flow – Stepped-Drawdown Assessment

ARCADIS

17
FIGURE



Hoosick Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Assessment of Constant-rate Pumping Test Data (OBS-02)

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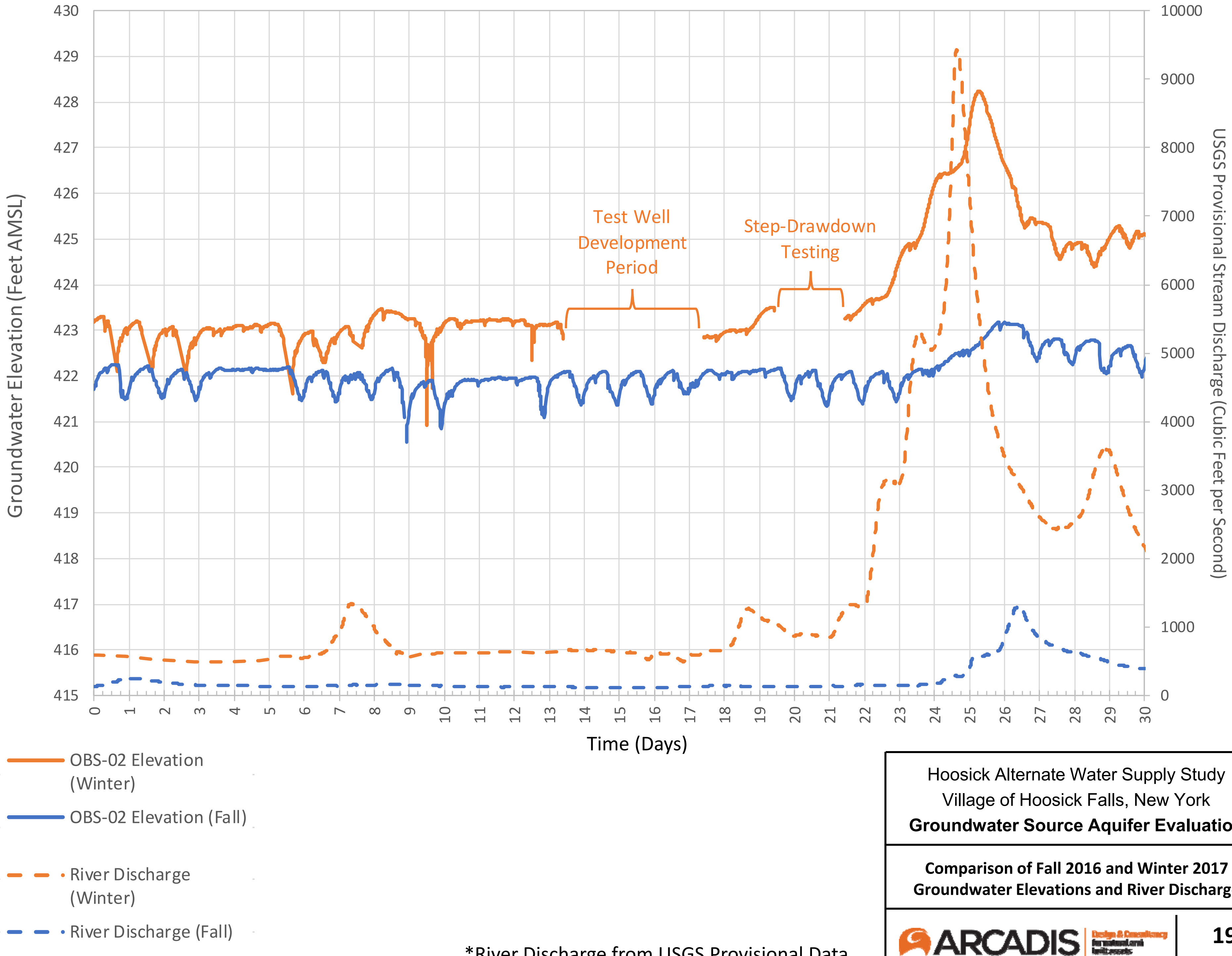
18
FIGURE



*River Discharge from USGS Provisional Data

Hoosick Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Comparison of Fall 2016 and Winter 2017
Groundwater Elevations and River Discharge

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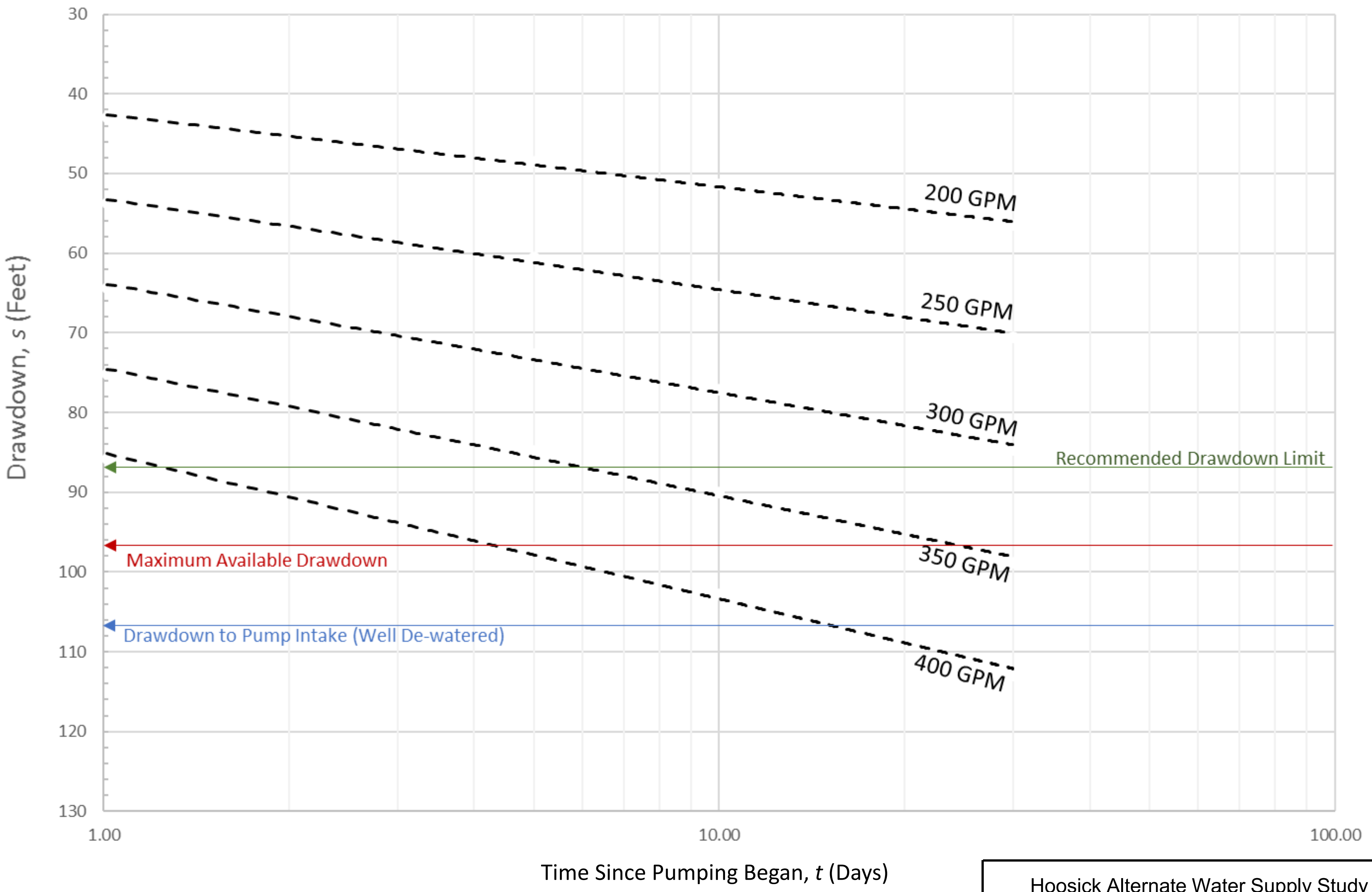
19
FIGURE



Predicted Late-time (30-day) Drawdown in Pumped Well – assuming leakage from aquiclude with storage (Hantush, 1960)

Hoosick Alternate Water Supply Study
Village of Hoosick Falls, New York
Groundwater Source Aquifer Evaluation

Test Well Predicted Drawdown Curves

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20
FIGURE