Leica, Inc.

Southwest Corner Pilot Study Work Plan – Zero Valent Iron Permeable Reactive Barrier

Former Leica, Inc. Facility

Town of Cheektowaga
Erie County, New York
Inactive Hazardous Waste Disposal Site No. 915146

9 June 2023; Revised 23 October 2023

Project No.: 0671863

The business of sustainability

Signature Page

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Certification Page

I, Jaydeep Parikh, certify that I am currently a New York State license Professional Engineer and that this Work Plan was prepared in accordance with all applicable statutes and regulations and in substantial conformance with New York State Department of Environmental Conservation Division of Environmental Remediation's Technical Guidance for Site Investigation and Remediation (DER-10).

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Certificate of Authorization:	0014854

Date: 9 June 2023; Revised 23 October 2023

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Contents

List of Attached Tables

List of In-Text Tables

List of Figures

Acronyms and Abbreviations

µg/L	Micrograms per Liter
bgs	Below ground surface
CAMP	Community Air Monitoring Plan
CCR	Construction Completion Report
CFR	Code of Federal Regulations
COCs	Constituents of Concern
DER	NYSDEC's Division of Environmental Remediation
DUSR	Data Usability Summary Report
EMR	Experience Modification Rate
EOR	Engineer-of-Record
ERM	ERM Consulting & Engineering, Inc.
GPS	Global Positioning System
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
Leica	Leica Microsystems, Inc.
MW	Permanent Monitoring Well
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NYCRR	New York State Codes, Rules, and Regulations
NYSDEC	New York State Department of Environmental Conservation
OSHA	Occupational Safety and Health Administration
PARCC	Precision, Accuracy, Representatives, Completeness, and Comparability
PID	Photoionization Detector
PRB	Permeable Reactive Barrier
PS	Pilot Study
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RAO	Remedial Action Objective
ROD	Record of Decision
Sam-Son	Sam-Son Distribution
SCG	Standards, Criteria and Guidance
TAGM	Technical and Administrative Guidance Memorandums
TCE	Trichloroethene
TRIR	Total Recordable Incident Rate
TW	Temporary Monitoring Well
VI	Vapor Intrusion
VOC	Volatile Organic Compounds
Work Plan	Pilot Study Work Plan
ZVI	Zero-valent Iron

1. INTRODUCTION

ERM Consulting & Engineering, Inc. (ERM) prepared this Pilot Study (PS) Work Plan (herein referred as "Work Plan") on behalf of Leica, Inc. (Leica) to support the planning and implementation of a PS in the southwest portion of the former Leica facility located at 203 Eggert Road in Cheektowaga, New York (the Site), as shown on **Figure 1**.

The Site is listed in the Registry of Inactive Hazardous Waste Disposal Sites in New York State as Site Number 915156. In March 1997, a Record of Decision (ROD) was issued for the Site by the New York State Department of Environmental Conservation (NYSDEC). The ROD established goals for the Site's remedial program. This PS, which consists of a zero-valent iron (ZVI) permeable reactive barrier (PRB) in the southwest portion of the Site, was designed to address the following goals:

- Groundwater—To eliminate contaminant migration via the groundwater so that potential releases of and contact with contaminated groundwater does not present a human or environmental threat.
- Air—To prevent or mitigate the release and inhalation of airborne contaminants above acceptable standards.

2. BACKGROUND

2.1 Purpose

Data gap investigation activities were completed at the Site between 2019 and 2022, the results of which are summarized in the *Data Gap Investigation Status Report* originally submitted to NYSDEC on 11 November 2022, revised based on NYSDEC comments on 3 February 2023, and approved by NYSDEC in a letter dated 24 February 2023. These activities identified the intermittent presence of trichloroethene (TCE)-impacted groundwater in unconsolidated deposits in the southwestern portion of the Site.

As such, Leica proposes to proactively implement a PS to address potential off-Site migration of impacted groundwater. Evaluation of multiple potential technologies relative to Site-specific conditions and constituents of concern (COCs) resulted in the selection of a ZVI PRB, which is discussed further in Section 3.

This Work Plan has been prepared in general accordance with NYSDEC's Division of Environmental Remediation (DER) *Technical Guidance for Site Investigation and Remediation* (DER-10).

2.2 Property Description

The Site is in Cheektowaga, Erie County, New York and is identified as Section 91.00, Block 1, Lot 26.12 (owned by Calypso Development of WNY, Inc.) and Lot 26.11 (owned by Leica, Inc.) on the Town of Cheektowaga Tax Map. The Site is approximately 24 acres of commercial land located in a mixed commercial and residential area. It is bound by Sugar Road and Saint Stanislaus Cemetery to the north, Saint John's Cemetery to the east, single-family residential dwellings to the south, and Eggert Road and a vacant undeveloped lot to the west.

The Site has an approximately 360,000-square-foot multi-story brick building (the "Main Building"), an approximately 3,100-square-foot single-story metal building, and an approximately 325-square-foot single-story brick pump house. The Main Building was originally built in 1938 and reached its current configuration in 1967. The remainder of the Site is either asphalt-paved parking or landscaped. The Site topography is generally flat. **Figure 1** shows the general Site layout along with the groundwater monitoring well network.

2.3 Summary of Previous Investigations

A summary of Site operational history, investigation and remedial activities is presented in the *Site Management Plan* (ERM 2020) and the *Data Gap Investigation Status Report* (ERM 2023).

2.4 Primary Constituents of Concern

The primary COCs in overburden groundwater in the southwest portion of the Site are TCE and its breakdown products (i.e., cis & trans 1,2-dichloroethene and vinyl chloride), though TCE is the primary COC. Passive soil vapor data confirm that the lateral limits of the COCs in soil vapor are constrained to one area adjacent to overburden monitoring well MW-36 in this area.

As described in Section 2.2.1 of the *Data Gap Investigation Status Report* (ERM 2023), TCE and its breakdown products were detected in soil beneath the Main Building and are considered to have originated from releases during historical facility operations. The presence of TCE in overburden groundwater in the southwest portion of the Site appears to originate from these source areas under the Main Building.

2.5 Hydrogeology

Overburden groundwater flow in the southwestern portion of the Site is toward the southwest. Water table contour maps have historically indicated flow that varies from southeast to southwest; however, this variation is due to differences in data distribution, not changes in the flow direction. During dry seasons, several overburden wells become dry and the lack of head data in these wells causes the map to suggest flow to the southeast. **Figure 3** shows representative overburden groundwater elevation contours from the December 2019 gauging event. Additional lines of evidence supporting the conclusion that overburden groundwater flow is toward the southwest are discussed in Section 2.6.

In fractured bedrock aquifers, groundwater elevation values can vary significantly based on well construction (i.e., wells that intersect transmissive fractures typically exhibit lower groundwater elevations than do nearby wells that do not intersect transmissive fractures). As such, the groundwater elevation contours for bedrock shown on **Figure 2** suggest a complex groundwater flow regime; however, this complexity is likely due to the generally low permeability of the bedrock aquifer and the presence of very few transmissive bedrock fractures.

The ultimate groundwater discharge boundary for the bedrock aquifer is Lake Erie, which is located to the west of the Site. As such, the general groundwater flow direction in bedrock, as shown on **Figure 3**, is to the west, with localized flow toward high-transmissivity fractures.

2.6 Overburden Groundwater & Soil Vapor Analytical Data

Temporary (TW-13 through TW-38) and permanent (MW-36 and MW-39) monitoring wells were installed in overburden to investigate the distribution of groundwater impacts in the southwest portion of the Site between 2019 and 2020. **Figure 4** presents a map for TCE, the most prevalent COC present in groundwater in the southwest portion of the Site. Groundwater analytical results for those wells where groundwater was present with enough volume for sample collection are summarized in **Table 1** and the geochemical field parameters are presented in **Table 2**.

The results of soil vapor samples collected in the southwest portion of the Site are presented in **Table 3** and shown on **Figure 5**. These data were collected to evaluate the distribution of COC mass in soil vapor, given that very little groundwater was present within overburden at the time of the investigation. The assumption was that if COCs were historically transported in groundwater through an area, some COC mass would remain in the unsaturated soils, resulting in formation of a soil vapor plume.

The distribution of COCs in groundwater and soil vapor are consistent with historical releases of TCE from operations (degreasers) in the Main Building that migrated southwest via groundwater advection to the southwest corner of the Site. These three lines of evidence: groundwater flow direction, TCE plume configuration, and distribution of VOCs in soil vapor are consistent and form the technical basis for design of a PS.

3. PILOT STUDY

3.1 Remedial Objectives

The objective of this PS is to minimize the potential for dissolved-phase COCs, specifically TCE, to migrate within overburden groundwater from the southwest portion of the Site into off-Site areas. In accordance with the remedial goals set forth in the ROD, this PS was designed to:

- Reduce TCE migration in groundwater so the potential releases of, and contact with, TCE-impacted groundwater do not present a threat to human health or the environment.
- Mitigate release and inhalation of airborne constituents (originating from TCE-impacted groundwater).

The Remedial Action Objective (RAO) for TCE in overburden groundwater is defined in the ROD as 5 micrograms per liter (µg/L).

3.2 Standards, Criteria and Guidance

The identification of all applicable standards, criteria, and guidance (SCG)s including chemical- and location-specific can be found in the *Feasibility Study*, prepared by Conestoga-Rovers & Associates (1996). Potential SCGs related to the proposed PS include:

- Technical Guidance and Technical and Administrative Guidance Memorandums (TAGM)
    - NYSDEC DER-10 Technical Guidance for Site Investigation and Remediation
    - NYSDEC TAGM No. 3028—Contained-In Criteria for Environmental Media
    - NYSDEC TAGM No. 4031—Fugitive Dust Suppression and Particulate Monitoring
- New York State Codes, Rules and Regulations (NYCRR)
    - 6 NYCRR Part 364—Waste Transporter Permits
    - 6 NYCRR Part 370—Hazardous Waste Management System
    - 6 NYCRR Part 371—Identification and Listing of Hazardous Waste
    - 6 NYCRR Part 372—Standards Applicable to Generators of Hazardous Waste
    - 6 NYCRR Part 373—Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
    - 6 NYCRR Part 376—Land Disposal Restrictions and Treatment Standards
- Code of Federal Regulations (CFR)
    - 29 Part 1910.120—Hazardous Waste Operations and Emergency Response Standard
    - 29 CFR Part 1926—Safety and Health Regulations for Construction
    - 40 CFR Part 261—Identification and Listing of Hazardous Waste
    - 40 CFR Part 262—Standards Applicable to Generators of Hazardous Waste
    - 40 CFR Part 264—Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
    - 40 CFR Part 268—Land Disposal Restrictions and Treatment Standards

3.3 PS Technology Evaluation

3.3.1 Potentially Applicable Technologies

3.3.1.1 Groundwater Extraction

This technology captures COC-impacted groundwater and reduces the potential for off-Site COC migration. COC-impacted groundwater can be captured via vertical or horizontal wells or a trench collection system and is then either treated or discharged to the municipal sanitary sewer system, depending on the permit-specific discharge requirements. The low permeability of the overburden material coupled with the relatively small phreatic zone, which is intermittently dry, limit the effectiveness of groundwater extraction.

3.3.1.2 PlumeStop + ZVI

This technology has the ability to decrease COC concentrations and migration in overburden groundwater. PlumeStop is a colloidal carbon material that will bind to the soil matrix and adsorb COCs, similar to activated carbon. The addition of ZVI can enhance abiotic and biotic degradation of COCs by inducing reducing conditions within the aquifer. Since these reagents are stable and stay in place, they are able to continue to treat COC mass over time. However, PlumeStop is a new product with a limited track record and is not readily implementable without additional bench or pilot-scale testing.

3.3.1.3 ZVI PRB

This technology has the ability to decrease COC concentrations and migration in overburden groundwater. ZVI is a reducing agent and works by providing free electrons to support the abiotic degradation of the COCs. The material requires direct contact with the COCs and is available as a granulated powder down to nano-scale size particles for various emplacement options. When emplaced as a PRB, the material forms a barrier that impacted groundwater must pass through. In-place ZVI is able to treat COC mass over time. ZVI has a well-established track record for treating the COCs, and Site-specific characteristics (i.e., relatively narrow flux pathway, limited depth to bedrock, confined vertical treatment interval, etc.) make emplacement of an PRB ideal remedial technology.

3.3.1.4 Conclusion

In summary, a ZVI PRB was selected because the treatment efficacy is well established for the Site COCs, which eliminated the need for extensive evaluation (e.g., literature review, bench-scale testing, or pilot-scale testing). Characterization efforts conducted to date have established key design parameters (e.g., COC concentrations, groundwater gradient), which suggest the implementation of a ZVI PRB is an appropriate and reasonable PS.

3.3.2 Selection Criteria Evaluation

This section evaluates application of a ZVI PRB at the Site in accordance with the evaluation criteria presented in Chapter 4 of DER-10.

- <u>Overall protectiveness of the public health and the environment</u>—Implementation of the proposed ZVI PRB has the potential to reduce migration of COC-impacted groundwater into off-Site areas. The proposed PS would immediately start treating COC-impacted groundwater that passes through it and continue to treat impacted groundwater for decades.

- Standards, criteria and guidance (SCGs)—The proposed PS will treat COCs in groundwater to minimize the potential for off-Site migration. Over time, groundwater downgradient of the ZVI PRB will attain SCG compliance.
- Long-term effectiveness and permanence—The long-term effectiveness and permanence of ZVI PRBs are well established in literature. The proposed PS is designed for a 30-year service life.
- Reduction of toxicity, mobility or volume of contamination through treatment—The toxicity of the COCs will be reduced as impacted groundwater passes through the PRB.
- Short-term impact and effectiveness—The proposed PS can be implemented with limited short-term impacts. Nuisance conditions from dust and odors will be managed and limited through the implementation of the Community Air Monitoring Plan (CAMP). The small scale of the proposed PS limits environmental impacts. The anticipated relatively quick installation period also limits any short-term impacts to receptors.
- Implementability—The proposed PS is readily implementable; there are no significant technological or administration difficulties anticipated to install the PRB in this area of the Site.
- Cost effectiveness—The cost of the proposed PS is proportional to its overall effectiveness in comparison to the alternatives. The PRB is similar or less than its alternatives in capital costs and has minimal long-term operation and maintenance costs.
- Land use—The proposed PS is consistent with current Site use and is not anticipated to prohibit future Site development or changes.

3.4 Summary of Pilot Study Strategy

As described in the *Data Gap Investigation Status Report,* TCE-impacted overburden groundwater in the southwest portion of the Site has been delineated during previous investigations (ERM 2022). The following sub-sections summarize the alignment and sizing (vertical and width requirements for passive treatment) of the proposed PRB. The PRB design was developed based on the following key assumptions:

- The expected lifespan of the ZVI PRB is 30 years;
- The maximum TCE concentration of 1,100 micrograms per liter was assumed to be the TCE mass loading for the entire 30-year lifespan;
- Current groundwater geochemical conditions will remain relatively consistent throughout the 30-year lifespan of the PRB; and
- Any future Site redevelopment activities will not significantly affect the saturated thickness or groundwater flow direction in overburden.

3.4.1 Horizontal and Vertical Alignment

The ZVI PRB will be placed to intercept the defined dissolved-phase COC plume at a location proximal to the property boundary on Site to allow for passive treatment of the COCs through abiotic degradation. The passive treatment process will degrade COCs, namely TCE, prior to potential migration off-Site.

The alignment of the ZVI PRB is based on Site-specific hydrogeology and groundwater and soil vapor analytical data. A 135-foot long PRB was designed to intersect the zone where dissolved-phase COCs are present in overburden groundwater in the southwestern portion of the Site (see **Appendix A**).

The vertical depth of the PRB will be variable, depending on the depth to bedrock which is nominally expected to be approximately 8 feet below grade. To inhibit underflow, the PRB total depth includes a maximum inset of 1.5 feet into the bedrock, or to the depth of excavatable weathered bedrock, depending on subsurface conditions. As such, the total depth of the PRB is expected to be approximately 10 feet (maximum). The lower 5 feet will be filled with the ZVI mixture, to approximately 2 feet above the seasonal-high water table. The upper 5 feet above the ZVI material will be filled with undifferentiated fill (see **Appendix A**).

3.4.2 PRB Width

<u>Residence Time</u>

TCE is the primary COC for the PRB sizing because the TCE concentrations in overburden groundwater in the southwest portion of the Site are an order of magnitude greater than the other COCs in this area. TCE passing through the PRB will degrade with sufficient residence time by reacting with the ZVI via abiotic degradation processes. Literature references for the half-life ($t_{0.5}$) of TCE in a ZVI PRB range from 1.1 to 4.6 hours. By assuming pseudo-first order kinetics, the maximum of this range can be used to predict the slowest (and therefore most conservative) reaction rate constant (k_{rxn}) according to the following equation:

$$k_{rxn} = \frac{\ln\left(\frac{C}{C_0}\right)}{t} = \frac{\ln(0.5)}{t_{0.5}}$$

- <u>Reaction Rate Constant:</u> Reaction rate constant (krxn) was calculated using the maximum reported half-life (t0.5) value for TCE[1], 4.6 hours.
- <u>Influent Concentration:</u> The influent concentration (C0) for TCE was assumed to be 1,100 µg/L (10 December 2018, MW-2).

Using the influent TCE concentration (C_0) and the k_{rxn}, the residence time (t) necessary for the groundwater to be in contact with the ZVI can be calculated. The calculated residence time for the proposed PRB is approximately 35.8 hours.

<u>PRB Width</u>

The PRB width (oriented generally perpendicular to groundwater flow) is determined by the product of the residence time to reach the target TCE concentration (C) and the Site-specific groundwater seepage velocity (V), as determined using Darcy's Law:

V = ki/n, where
k = hydraulic conductivity; i = hydraulic gradient; n = effective porosity

[1] Suthersan, S. S., Horst, J., Schnobrich, M., Welty, N., & McDonough, J. (2016). *Remediation Engineering: Design Concepts, Second Edition* (2nd ed.). Productivity Press.

- Hydraulic conductivity: The overburden hydraulic conductivity is 6.47×10^{-5} centimeters per second (**Appendix B, Attachment A, Reference 1**). The bedrock hydraulic conductivity is 1.05×10^{-2} centimeters per second in MW-2 (**Appendix B, Attachment A, Reference 1**). The PRB will be keyed into bedrock, so the higher of the two hydraulic conductivity values was used as the PRB design basis to allow groundwater to readily flow through the PRB (i.e., if the hydraulic conductivity of the PRB is significantly lower than the formation hydraulic conductivity, it will act as a barrier to flow and groundwater will flow around the PRB rather than through it). Therefore, the ZVI/sand mixture within the PRB will exhibit a hydraulic conductivity of approximately 1.0×10^{-2} centimeters per second.
- Porosity: Porosity values can vary based on grain size, degree of heterogeneity, and emplacement/compaction techniques. A range of porosity values (25 percent to 35 percent) was used to evaluate the sensitivity of this parameter. The selected PRB effective porosity is 25 percent which yields the fastest groundwater migration through the PRB and therefore the most conservative residence time and PRB width.
- Hydraulic Gradient: Hydraulic gradient was computed using Site-specific groundwater elevation data collected between November 2017 and October 2021. To be conservative, the highest hydraulic gradient value was used (0.014 feet/foot). The gradient through the PRB is assumed to be the same.

Using these input parameters, the groundwater seepage velocity was calculated as 0.32 centimeters per day.

The calculated residence time is then multiplied by the groundwater seepage velocity to determine the requisite thickness or width of the PRB. The calculations determine that the minimum PRB width should be approximately 2.5 feet. Based on the size of a typical excavator bucket/soil blender, and for constructability purposes, the PRB width is designed to be 4 feet and provides a factor of safety of approximately 1.5.

3.4.3 Amendment Mixture

The weight of ZVI required to meet the remedial goals needs to account for surface passivation, fouling, competition from non-target constituents, and the demand of reducing TCE concentrations to less than or equal the RAO for groundwater (i.e., 5 µg/L) and the COC mass flux for the design life of the PRB. Each consideration is briefly described below:

- Surface passivation and precipitate formation are common fouling mechanisms in ZVI PRBs, which could hinder its ability to react with COCs and decrease porosity. To mitigate the impact of fouling, a ZVI-sand mix will be used throughout the treatment zone.
- Competition among other oxidation-reduction sensitive geochemical constituents in an oxidized state could hinder the ZVI PRB's ability to react with COCs. To account for this competition, the consumption rate of ZVI for the relevant non-target parameters found on Site (i.e., dissolved oxygen, nitrate, and sulfate) was considered. The demand from non-target constituents was estimated to be 5.6 tons. Refer to **Appendix B** for a more detailed discussion on the effect of geochemical constituents on ZVI PRBs.
- The ZVI demand for TCE removal over a 30-year design life was estimated to be 0.5 ton. A more detailed discussion on the evaluation of the design life of ZVI PRB is provided **Appendix B**.
- To preserve retention of the ZVI within the sand matrix, a specific grain size distribution has been included within the technical specifications for both the sand and ZVI material.

The final amendment mixture will need to satisfy the requirements and demands presented above, along with regulatory requirements for imported/reused soil described in Section 5.2.3. Typical ratios for

ZVI/sand mixtures range from 15 to 35 percent ZVI by weight. Based on the proposed alignment and thickness, a ZVI:sand mixture ratio of 15:85 percent by weight was selected; the resultant weight of ZVI to be emplaced equals approximately 20 tons.

3.4.4 Preliminary Design

Preliminary (60 percent complete) PS Design package (5 sheets) is provided in **Appendix A.**

4. GENERAL IMPLEMENTATION INFORMATION

4.1 Project Organization

The following individuals will be involved in the implementation of this PS.

Table 4-1: Project Organization

Title—Role	Name
Partner-in-Charge	Joe Fiacco
Principal Consultant—Project Manager	Kathleen Kwasniak
Partner—NY Engineer-of-Record (EOR)	Jaydeep Parikh, P.E.
Associate Partner—Program Lead	Mac Bonner
Principal Consultant, Geologist	Tim Daniluk, P.G.

The NYSDEC Project Manager is Megan Kuczka and the NYSDOH contact is Stephen Lawrence.

4.1.1 Engineer-of-Record

The EOR for this PS is Jaydeep Parikh, P.E.; NYS Professional Engineer License No. 088083. The EOR has the responsibility for the design and implementation of this PS. The EOR will be responsible for certification of the Construction Completion Report (CCR), which verifies that the PS activities were observed by personnel under their supervision. Further, the EOR will verify in the CCR that the requirements set forth in this Work Plan and any other relevant provisions of New York State Environmental Conservation Law Article 27, Title 14 have been achieved in full conformance with this Work Plan.

The EOR, through the Program Lead, will coordinate the work of contractors involved in the implementation of this PS including, but not limited to, the trench excavation, sand / ZVI mixing and emplacement of the sand/ZVI mixture, ambient air monitoring, and management of wastes.

The EOR, through the Project Manager, will be responsible for communication with NYSDEC, NYSDOH, Leica, and the Site owner.

4.1.2 Remediation Contractor

Bids will be solicited from remediation contractors, which will include a screening of each contractor's safety record, qualifications with technically similar projects, financial stability, and insurance. Bid evaluation will include a review of these qualifications and the price to complete the work.

Following selection of the contractor, ERM will prepare a Notice of Award letter for the successful bidder and a Subcontractor Work Authorization for contracting implementation of the PS.

4.2 Scope of Work

The scope of work for this PS consists of the following tasks:

- Mobilization and Site preparation
- Trench excavation, sand / ZVI mixing, and emplacement
- Backfill above emplaced sand / ZVI mixture
- Site restoration and demobilization

- Preparation of the CCR

This scope of work will not be implemented without approval by NYSDEC and prior notice in accordance with DER-10, Section 1.4(c) (NYSDEC, 2010a), and the notice will be a minimum of 7 calendar days prior to the actual start of field activities.

4.2.1 Mobilization and Site Preparation

Mobilization will include delivery of equipment, materials, and personnel to the Site. The selected remediation contractor will supply qualified labor (trained as required in Hazardous Waste Operations and Emergency Response [HAZWOPER]) and certified in accordance with OSHA 1910.120. Site health and safety orientations will be provided to familiarize personnel with the Site's Health and Safety Plan (HASP) and CAMP as part of mobilization activities. In addition, insurance, bonds, and licenses required to complete the scope of work will be in place prior to mobilization.

Site preparation activities will include:

- Utility Clearance
- Establishing Stockpile Staging Area(s)
- Installation of Erosion and Sediment Controls
- Development of traffic routes

Utility clearance will be completed prior to any ground disturbance activities and will be managed in accordance with ERM's subsurface clearance procedures, developed to minimize the potential for striking subsurface infrastructure. A public utility locate will be completed as required by law and an independent underground utility locating service will also be contracted to evaluate and clear the proposed ZVI PRB location prior to commencement of intrusive activities. The private utility location contractor will scan, identify, locate, and mark potential subsurface utilities to the extent practical.

Equipment and materials delivered to the Site will be staged in a manner that complies with applicable local, state, and federal regulations. The staging area will be proximal to the ZVI PRB location in the southwest corner of the Site. The stockpile and staging areas will be established in accordance with the requirements described in Section 5.2.2.1. Individual stockpiles will be underlaid by a minimum of 9-mil polyethylene sheeting, surrounded by a compost filter sock, and covered by 9-mil polyethylene sheeting. The cover will be adequately weighted to prevent displacement by wind.

In parallel with establishing the stockpile and staging areas, erosion and sediment controls will be installed within the limits of disturbance in accordance with the Erosion and Sediment Control Plan described in Section 5.4.

Site preparation will also include establishing temporary sanitary facilities (e.g., porta potties) and demarcating the exclusion, contamination reduction, and support zones; as appropriate.

Traffic routes for the movement of equipment and materials on Site will be developed in the field based on logistical needs for the work, potential Site restrictions (e.g., safety off-sets from the partially collapsed building), and other encumbrances identified during mobilization. Where needed, traffic routes will be delineated with traffic cones, caution tape, or means necessary to separate pedestrian traffic and sensitive areas from mobile construction equipment.

4.2.2 Trench Excavation, Amendment Mixing, and Emplacement

The trench will be excavated in compliance with OSHA excavation requirements defined in 29 CFR 1926.651, with standard trench construction methodologies used either by trench box or benching. This methodology will be reviewed by ERM and the remediation contractor prior to initiation. The ZVI material and sand will be mechanically mixed either in situ or ex situ and then backfilled into the trench. The bottom of the PRB will be keyed into the underlying weathered bedrock to minimize the risk of underflow.

The PRB (and backfill above the PRB) will be installed in accordance with the Technical Specifications (in preparation) and Drawings (see **Appendix A**). The ZVI-sand mixture will be emplaced from the trench bottom to 2 feet above the high groundwater level. The remainder of the trench will be backfilled with undifferentiated fill. During construction, a Trimble® global positioning system (GPS) with sub-meter accuracy will be used to measure excavation extents, and relative elevations will be measured from the ground surface or nearby surveyed well locations when possible.

4.2.3 Site Restoration and Demobilization

Exposed soil areas will be stabilized with a regionally appropriate turf grass seed. This includes the PRB Construction area, as well as support / traffic areas disturbed during construction activities.

Upon completion of PS construction and Site restoration activities, demobilization will occur. Temporary modifications made to the Site as part of construction activities, including but not limited to stockpile staging areas, construction barricades, temporary support facilities, and temporary erosion and sediment features will be removed and these areas restored by reseeding, as needed. All general construction trash and associated containers will be removed and disposed of in accordance with applicable local, state, and federal regulations.

Construction equipment and materials scheduled for demobilization will be decontaminated prior to leaving the Site. Decontamination fluids will be managed in accordance with the Materials Plan described in Section 5.2.

4.2.4 Post-Construction Performance Monitoring

Post-construction performance monitoring of the ZVI PRB will consist of concentration-based and hydraulic performance monitoring to be performed in concert with the current annual monitoring program specified in the NYSDEC-approved Site Management Plan (SMP).

Concentration-based performance monitoring will be done using up to four overburden groundwater monitoring wells that will be installed upgradient (2) and downgradient (2) of the PRB post-construction. Groundwater quality data will be collected to assess reductions in COC concentrations (primary purpose) and groundwater geochemical parameters will be collected to support evaluation of the ZVI PRB.

To monitor hydraulic performance, six piezometers (total) will be installed upgradient (3) and downgradient (3) of the proposed PRB following construction. Groundwater elevation measurements will be used to confirm hydraulic gradient and groundwater flow direction proximal to the PRB. The final surface grade and top of casing position and elevations will be professionally surveyed by a licensed surveyor. The horizontal survey will reference the North American Datum of 1983 (NAD83), projected on the New York State Plane Coordinate System (West Zone), and vertically to the North American Vertical Datum of 1988 (NAVD88). Vertical accuracy will be to the nearest 0.01 feet, horizontal coordinates will be to the nearest 0.1 feet.

The criteria for determining that this PS is meeting the remedial objectives described in this Work Plan are:

- Reduction in COC concentrations from the upgradient to the downgradient side of the ZVI PRB. Note: due to the presence of COC mass downgradient of the PRB (i.e., proximal to well MW-36), reduction of TCE concentration in MW-36 is not anticipated in the near-term following installation of the PRB. After the PS is completed and groundwater is treated by the PRB, the groundwater quality in MW-36 is anticipated to progressively improve, reflecting the COC degradation by the PRB.

- Hydraulic performance will be assessed using groundwater elevation contour maps to verify proper PRB orientation relative to the groundwater flow direction.

The proposed post-construction performance monitoring will be incorporated into an updated SMP. A proposal for amending the annual monitoring plan to incorporate performance monitoring of the ZVI PRB will be made with the submission of the CCR.

4.2.5 Preparation of the Construction Completion Report

A CCR will be prepared to document the PS, as described in Section 6.2.

5. SUPPORTING PLANS

5.1 Quality Assurance/Quality Control Plans

5.1.1 Construction

Quality assurance/quality control (QA/QC) measures for the construction of this PS will be incorporated into the Technical Specifications (to be developed). At a minimum, the following QA/QC measures will be conducted as part of this PS :

- Verification that the design depth and width has been reached for each segment of the PRB.
- Verification that the ZVI and sand procured for installation has been approved by the EOR and meets the Technical Specifications.
- Verification that the ZVI:sand ratio is consistent with the specifications. This will be based on analysis of the mixed material samples collected prior to emplacement. Samples will be dried and magnetically separated to determine if ZVI meets the minimum required percent by weight. A total of five samples will be collected representative of material being emplaced along the length of the PRB.

The QA/QC results will be included in the CCR.

5.1.2 Analytical

A Site-specific Quality Assurance Project Plan (QAPP) is included as Appendix G of the Site Management Plan (ERM 2020). The QAPP is consistent with the requirements of DER-10, Section 2.4 (NYSDEC 2010a), and describes sampling and analysis procedures to be used during implementation of these activities along with QA/QC criteria. The field team will collect representative samples. The chemist at the laboratory will analyze samples using accepted protocols resulting in data that meet precision, accuracy, representatives, completeness, and comparability standards as part of the Data Usability Summary Report (DUSR) described in Section 6.3.

Note: The QAPP as it relates to this PS will be implemented for the analytical samples collected as part of the post-construction performance monitoring. Recommendations for post-construction performance monitoring will be incorporated into an updated SMP. A proposal for amending the annual monitoring plan to incorporate performance monitoring of the ZVI PRB will be made with the submission of the CCR.

5.2 Materials Management Plan

5.2.1 Amendment

The ZVI amendment will be stored in accordance with the manufacturer's instructions. Best management practices for the storage of the amendment will be employed, including the following:

- Minimize exposure to heat and excess moisture to the extent practicable.
- Keep storage containers sealed to avoid oxidation.
- Store material away from acids and strong oxidizers.
- Limit the time stored on Site prior to application.

5.2.2 Excess Soil

Excess soil will be generated as part of this PS. This soil represents the material displaced by the ZVI/sand mixture within the footprint of the PRB. The following describes how excess soil will be stockpiled, characterized, and managed.

5.2.2.1 Stockpiling

A stockpile area will be prepared in accordance with the Erosion and Sediment Control Plan presented in Section 5.4, and applicable regulations related to the management of hazardous waste. Individual stockpiles will be underlaid by a 9-mil polyethylene sheeting (or similar), surrounded by a compost filter sock, and covered by the same polyethylene sheeting. The cover will be adequately weighted to prevent displacement by wind. Stockpiles will be covered when not actively being managed.

Stockpiles will be inspected weekly, and after significant precipitation events; 0.25 inches of rain or more within a 24-hour period as measured at the nearest airport. Damaged coverings and erosion and controls measures will be promptly repaired or replaced. Stockpile accumulation time will be limited to 90 days.

5.2.2.2 Waste Characterization and Off-Site Management

Waste characterization will be performed for off-Site disposal in a manner suitable to the receiving facility. Excess soil proposed for off-Site management will be analyzed at minimum for the following parameters (and as otherwise required by the receiving facility / permit requirements):

- Toxicity Characteristic Leaching Procedure VOC
- Toxicity Characteristic Leaching Procedure semi-volatile organic compounds
- Polychlorinated biphenyls
- Resource Conservation and Recovery Act metals
- Ignitability (solids) or flammability (liquids)
- Reactivity
- pH

Sampling and analytical methods, sampling frequency, analytical results, and QA/QC will be reported in the CCR.

Waste characterization data and Site history will be used to categorize waste as hazardous or non-hazardous prior to disposal and will inform the type of off-Site management required. The potential for listed hazardous waste exists based upon the Site history. The presence of listed hazardous waste constituents will be reviewed against the waste characterization data to evaluate the presence of listed constituents. A Bill of Lading system or equivalent will be used for off-Site transportation and disposal of nonhazardous wastes and excess soils. Material identified as hazardous waste will be transported and disposed of in compliance with applicable local, state, and federal regulations. Appropriately licensed haulers will be used to transport material from this Site and will be in compliance with all applicable local, state, and federal regulations. The final disposition of excess soil including Bills of Lading and Manifest copies will be reported in the CCR.

5.2.3 Backfill from Off-Site Sources

Aggregate material from industrial sites, known release sites, other environmental remediation sites or other potentially contaminated sites will not be allowed as part of this PS. In accordance with DER-10, Section 5.4(e)5 (NYSDEC 2010a), material may be imported, without chemical testing, to be used as backfill, provided that it contains less than 10 percent by weight material which would pass through a size 80 sieve and consists of gravel, rock or stone, consisting of virgin material from a permitted mine or quarry.

Prior to importing soils to the Site, a “Request to Import/Reuse Fill Material” form will be filed with the NYSDEC Project Manager for review and approval. Bills of Lading will be used document that the fill delivered was from a NYSDEC-approved source(s) and be reported in the CCR.

5.2.4 Fluids

It is anticipated that minimal groundwater will be encountered as part of this PS and dewatering will likely not be required; however, if required, all fluids to be removed from the Site will be handled, transported, and disposed of in accordance with applicable laws and regulations.

Decontamination fluids may be generated as part of this PS. Decontamination fluids will be containerized, characterized and disposed as required in a similar manner to the excess soil described in Section 5.2.2.2. Fluid waste Bill of Lading and Manifests copies will be reported in the CCR.

5.3 Construction Stormwater Pollution Prevention Plan

A Construction Stormwater Pollution Prevention Plan is not required to implement this PS. In accordance with NYSDEC State Pollutant Discharge Elimination System General Permit for Stormwater Discharges from Construction Activity (GP-0-20-001), construction activities involving soil disturbances of one or more acres are required to obtained coverage under GP-0-20-001 and prepare a Construction Stormwater Pollution Prevention Plan.

This PS does not propose soil disturbances greater than one acre; therefore, coverage under GP-0-20-001, and preparation of a Construction Stormwater Pollution Prevention Plan is not required. An Erosion and Sediment Control Plan, refer to Section 5.4, will be prepared consistent with the New York State Guidelines for Urban Erosion and Sediment Control.

5.4 Erosion and Sediment Control Plan

An Erosion and Sediment Control Plan will be prepared in support of this PS. The Erosion and Sediment Control Plan will be prepared consistent with the New York State Guidelines for Urban Erosion and Sediment Control and will be included within the final engineering drawings (to be prepared). The Erosion and Sediment Control Plan will be prepared to address the potential impacts of the proposed activities to surrounding receptors and resources (which is anticipated to be minimal).

The Erosion and Sediment Control Plan will include the following:

- A brief narrative describing the proposed work, existing conditions, drainage, stabilization and restoration plan, and inspection procedures to be implemented during soil disturbance activities
- Temporary practices for runoff control and measures to capture, retain, and control sediment within the boundaries of the work area, in addition to final soil stabilization measures
- Drawings the contractor shall adhere to showing the actual required control measures to be implemented and maintained throughout construction
- A Site Inspection and Maintenance Log

5.5 Odor, Dust, and Nuisance Control Plan

Odor, dust, and nuisance control will be in accordance with the Site-specific HASP and CAMP; described in Sections 5.6 and 5.8 below, respectively.

The procedures set forth in the HASP and CAMP are intended to limit air-related emissions in the vicinity of the ground disturbance areas. If emissions (odor, dust, or other nuisances) are identified, work will be paused, the source(s) identified, and corrective actions will be implemented to the extent practicable and reasonable and will be proportional to the degree of hazard posed by the emission. NYSDEC will be notified of third-party complaint events via email within 24 hours of the event.

5.5.1 Odor Control

Odor control is not anticipated to be necessary based on the COC concentrations in the PS area. However, odor controls will be employed if necessary to mitigate off-Site odor nuisances. Best management practices to limit odors include limiting the open area of excavations and covering exposed soils. If odors are persistent and unable to be reasonably abated, soils will be loaded out for off-Site disposal or odor suppressants / foams may be employed during soil management and load out.

5.5.2 Dust Control

Dust controls will be employed during soil disturbance activities to limit the transport of particulates in the vicinity of the ground disturbance areas. Best management practices for dust control include the following:

- Use of properly anchored polyethylene sheeting to cover stockpiles.
- Exercising care during dry and high-wind periods.
- Water[2] will be used, as appropriate, to wet areas of disturbed soil.
- Gravel will be used on roadways and staging areas to limit dust on roadways and staging-area surfaces, as required.

5.5.3 Other Nuisances

Work activities that may produce noise will be limited to normal working hours (Monday through Friday, 07:30 AM to 5:30 PM), and work activities will conform to applicable noise-control standards. Rodent control is not anticipated to be required as part of this PS.

5.6 Contingency Plan

If subsurface structures or other previously unidentified impacted materials are discovered, they will be reported to NYSDEC. Recognizing the need for flexibility when encountering unknowns, this plan does not predetermine the sampling and analytical methods or other response action. At the time of discovery, and if it is safe to do so, visual and olfactory observations will be made and PID readings will be collected. Based on the initial screening, a more thorough sampling plan may be developed if warranted. NYSDEC will be notified via email within 24 hours of the event. Notification will include initial observations, and recommendations on how to proceed.

5.7 Site-specific Health and Safety Plan

ERM maintains a Site-specific HASP for activities conducted at the Site. The procedures set forth in the HASP are designed to minimize the risk of exposure to chemical and physical hazards that may be present at the Site. These procedures generally conform to applicable federal, state, and local regulations—including Occupational Safety and Health Administration requirements governing activities at hazardous waste sites contained in 29 CFR 1910.120 (Hazardous Waste Operations and Emergency

[2] Water will be available on Site at suitable supply and pressure for use in dust control.

Response). Specific practices and procedures, including the level of personal protective equipment, are based on a review of currently available information for the Site. Every potential safety hazard associated with this investigation may not be predicted. The HASP does not attempt to establish rules to cover every contingency that may arise, but it does provide a basic framework for the safe completion of field activities and plans for reasonable contingencies. The Site-specific HASP is presented in **Appendix C.**

5.8 Community Air Monitoring Plan

A CAMP for the Site is presented in **Appendix D**. The CAMP is consistent with the requirements of DER-10, Appendix 1A (NYSDEC, 2010a), and describes monitoring requirements and response action levels associated with the monitoring of VOCs and particulates (i.e., dust) downwind of intrusive activities. The action levels specified in the CAMP require increased monitoring, corrective actions to abate emissions, and/or work stoppage, if necessary. The CAMP provides a measure of protection for the downwind community from potential airborne contaminant releases that could result from the PS activities discussed in this Work Plan.

6. REPORTING

6.1 Pilot Study Periodic Progress Reports

Due to the limited duration of the PS construction period (less than one month), Periodic Progress Reports (PRRs) specifically related to construction will not be submitted. ERM on behalf of Leica will provide NYSDEC with email updates of noteworthy construction developments on an as-needed basis. The current annual PRR schedule specified in the approved SMP will continue and will include reporting of the post-construction performance monitoring described above in Section 4.2.4.

6.2 Construction Completion Report

A CCR will be prepared to document this PS. The CCR will be prepared in general accordance with DER-10, Section 5.8 (NYSDEC, 2010a). The CCR will include the following components:

- A description of the PS, as constructed, pursuant to this Work Plan including, but not limited to;
  - Position and elevation data of all constructed surfaces including monitoring wells and piezometers will be obtained post-construction by a subcontracted professional surveyor as described in Section 4.2.2. Positioning data will also be obtained using a GPS with sub-meter accuracy during construction as described in Section 4.2.4.
- A summary of activities completed including, but not limited to, the following:
  - A description of problems encountered and their resolution,
  - A description of changes, if any, and why they were made,
  - A listing of waste streams and their final disposition, and
  - Restoration activities.
- A tabular summary of all performance monitoring results and other sampling and chemical analyses performed as part of this PS.
- As-built drawings bearing the seal and signature of the EOR.

The CCR will also include a proposal for amending the annual monitoring plan to incorporate performance monitoring of the ZVI PRB.

6.3 Data Usability Summary Report

DUSRs will be prepared for all samples collected as part of this PS and appended to the CCR. The DUSRs will be prepared consistent with DER-10, Appendix 2B (NYSDEC, 2010a). The results of the data usability evaluation will be presented in an Electronic Data Summary consistent with the requirements of DER 10 Section 3.14(b).

Each DUSR will include a discussion on Data Quality Objectives, which are qualitative and quantitative criteria required to support the decision-making process. Data Quality Objectives define the uncertainty in an analytical data set and are expressed in terms of precision, accuracy, representatives, completeness, and comparability (PARCC)—outlined below:

- Precision is a measure of mutual agreement among measurement of the same property usually under prescribed similar conditions. Precision is best expressed in terms of the standard deviation.
- Accuracy is the degree of agreement of a measurement (or an average of measurements) with an accepted reference of “true value”. Accuracy is an estimate of potential numerical bias (i.e., low or high) in analytical data.

- Representativeness expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point a process condition, or an environmental condition.
- Completeness is a measure of the amount of valid data obtained compared to the amount that was expected to be obtained under correct normal conditions.
- Comparability expresses the confidence with which one data set can be compared with another. Comparability is a qualitative measurement. Comparability is assessed by reviewing results or procedures for analytical data that do not agree with expected results.

7. SCHEDULE

This PS is anticipated to begin following the final engineering design of the proposed ZVI PRB and selection of the subcontractor. It is anticipated to follow the schedule below.

Table 7-1: Schedule of Activities

Activity	Timeframe
Mobilization & Site Preparation	May 2024
Trench Excavation, Amendment Mixing, and Emplacement	June 2024
Site Restoration and Demobilization	June 2024
Preparation of the Construction Completion Report	October 2024

8. REFERENCES

Conestoga Rovers & Associates. 1996. Feasibility Study.

ERM. 2020. Site Management Plan. 27 August 2020.

ERM. 2022. Data Gap Investigation Status Report. 3 February 2023.

Freeze, R.A. & Cherry, J.A. 1979. Groundwater. Prentice-Hall. 604 pp

NYSDEC, 2010a. DER-10: Technical Guidance for Site Investigation and Remediation. NYSDEC Division of Environmental Remediation, Albany, May 2010.

NYSDEC, 2010b. Analytical Services Protocol. NYSDEC Division of Environmental Remediation, Albany, May 2010.

TABLES

Table 1
Groundwater Summary Table
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

Analyte		Location ID	MW-2	MW-2	MW-2	MW-2	MW-2	MW-2	MW-2	MW-31	MW-31	MW-31	MW-31	MW-31	MW-31	MW-31
		Sample Date	**11/28/17**	**12/10/18**	**12/10/18**	**5/15/19**	**5/15/19**	**10/29/19**	**4/8/20**	**12/4/17**	**7/3/18**	**12/5/18**	**5/15/19**	**8/20/19**	**4/9/20**	**6/22/21**
		Sample Type	**N**	**N**	**FD**	**N**	**FD**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**
		Unit														
VOCs	1,1,1-Trichloroethane	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	1,1,2,2-Tetrachloroethane	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	1,1,2-Trichloroethane	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	1,1-Dichloroethane	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	1,1-Dichloroethene	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	1,2,4-Trichlorobenzene	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	1,2-Dibromo-3-chloropropane	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	1,2-Dichlorobenzene	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	1,2-Dichloroethane	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	1,2-Dichloropropane	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	1,3-Dichlorobenzene	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	1,4-Dichlorobenzene	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	2-Butanone (Methyl ethyl ketone)	µg/L	< 20.00	< 200	< 200	< 200	< 200	--	< 100	< 10.00	3.2 J	< 10	< 10	< 10	< 10	< 10
	2-Hexanone	µg/L	< 20.00	< 100	< 100	< 100	< 100	--	< 50	< 10.00	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
	4-Methyl-2-pentanone	µg/L	< 20.00	< 100	< 100	< 100	< 100	--	< 50	< 10.00	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
	Acetone	µg/L	< 20.00	< 200	< 200	< 200	< 200	--	< 100	< 10.00	16	< 10	< 10	< 10	< 10	< 10
	Benzene	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Bromodichloromethane	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Bromoform	µg/L	< 10.00	< 20 J	< 20 J	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Bromomethane	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Carbon disulfide	µg/L	< 20.00	< 20	< 20	< 20	< 20	--	< 10	< 10.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Carbon tetrachloride	µg/L	< 10.00	< 20 J	< 20 J	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Chlorobenzene	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Chloroethane	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Chloroform	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Chloromethane	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	0.35 J	< 1.0	< 1.0
	cis-1,2-Dichloroethene	µg/L	79.00	120	120	47	42	--	8.9 J	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	cis-1,3-Dichloropropene	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Cyclohexane	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Dibromochloromethane	µg/L	< 10.00	< 20 J	< 20 J	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Dichlorodifluoromethane (Freon 12)	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Ethylbenzene	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Ethylene dibromide	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Isopropylbenzene (Cumene)	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	m,p-Xylenes	µg/L	< 10.00	--	--	--	--	--	--	< 5.00	--	--	--	--	--	--
	Methyl acetate	µg/L	--	< 50	< 50	< 50	< 50	--	< 25	--	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
	Methyl tert-butyl ether	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Methylcyclohexane	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Methylene chloride	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	o-Xylene	µg/L	< 10.00	--	--	--	--	--	--	< 5.00	--	--	--	--	--	--
	Styrene	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Tetrachloroethene	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Toluene	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	trans-1,2-Dichloroethene	µg/L	16.00	28	28	20	22	--	26	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	trans-1,3-Dichloropropene	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Trichloroethene	µg/L	890.00 D	1,100 J	1,100	870	860	--	790	< 5.00	< 1.0	< 1.0	< 1.0	0.85 J	< 1.0	< 1.0
	Trichlorofluoromethane (Freon 11)	µg/L	--	< 20	< 20	< 20	< 20	--	< 10	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Vinyl chloride	µg/L	< 10.00	< 20	< 20	< 20	< 20	--	< 10	< 5.00	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Xylene, Total	µg/L	--	< 40	< 40	< 40	< 40	--	< 20	--	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
	VOC, Total	µg/L	--	--	--	937	924	--	824.9	--	--	--	0	1.2	0	0
Dissolved Gases	Ethane	µg/L	--	--	--	--	--	< 7.5	--	--	--	--	--	--	--	--
	Ethene	µg/L	--	--	--	--	--	< 7.0	--	--	--	--	--	--	--	--
	Methane	µg/L	--	--	--	--	--	< 4.0	--	--	--	--	--	--	--	--
SVOCs	1,4-Dioxane	µg/L	--	2.8	--	--	--	--	--	--	--	--	--	--	--	--
Total Metals	Iron	mg/L	--	--	--	--	--	0.17	--	--	--	--	--	--	--	--
	Manganese	mg/L	--	--	--	--	--	0.0017 J	--	--	--	--	--	--	--	--
Dissolved Metals	Iron	mg/L	--	--	--	--	--	0.045 J	--	--	--	--	--	--	--	--
	Manganese	mg/L	--	--	--	--	--	< 0.0030	--	--	--	--	--	--	--	--
PFAS	Perfluorobutanoic acid (PFBA)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluoropentanoic acid (PFPeA)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluorohexanoic acid (PFHxA)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluoroheptanoic acid (PFHpA)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluorooctanoic acid (PFOA)	ng/L	--	0.66 J	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluorononanoic acid (PFNA)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluorodecanoic acid (PFDA)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluoroundecanoic acid (PFUnDA)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluorododecanoic acid (PFDoDA)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluorotridecanoic acid (PFTrDA)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluorotetradecanoic acid (PFTeDA)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluorobutane sulfonic acid (PFBS)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluorohexane sulfonic acid (PFHxS)	ng/L	--	0.70 J	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluoroheptane sulfonic acid (PFHpS)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluorooctane sulfonic acid (PFOS)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluorodecane sulfonic acid (PFDS)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	Perfluorooctane sulfonamide (FOSA)	ng/L	--	< 1.9	--	--	--	--	--	--	--	--	--	--	--	--
	6:2 Fluorotelomer sulfonic acid (6:2 FTS)	ng/L	--	< 19 J	--	--	--	--	--	--	--	--	--	--	--	--
	8:2 Fluorotelomer sulfonic acid (8:2FTS)	ng/L	--	< 19	--	--	--	--	--	--	--	--	--	--	--	--
	N-ethyl perfluorooctanesulfonamidoacetic acid (NEtPFOSAA)	ng/L	--	< 19	--	--	--	--	--	--	--	--	--	--	--	--
	N-Methyl perfluorooctanesulfonamidoacetic acid (NMePFOSAA)	ng/L	--	< 19	--	--	--	--	--	--	--	--	--	--	--	--
General Chemistry	Sulfate	mg/L	--	--	--	--	--	R	--	--	--	--	--	--	--	--
	Nitrate as N	mg/L	--	--	--	--	--	1.1	--	--	--	--	--	--	--	--
	Organic Carbon, Total	mg/L	--	--	--	--	--	5.7	--	--	--	--	--	--	--	--

Notes:
< = Compound not detected at concentrationsabove the laboratory reporting detection limit.The laboratory reporting detection limit is shown.
J = Estimated value. The Target analyte concentration is below the quantitation limit (RL), but above the Method Detection Limit (MDL).
R = Rejected - data quality insufficient
-- = Not analyzed
N = Normal Environmental Sample
FD = Field Duplicate Sample
mg/L = milligrams per liter
µg/L = micrograms per liter
ng/l = nanogram per liter

Table 1
Groundwater Summary Table
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

Analyte		Location ID	MW-31	MW-36	MW-36	MW-36	MW-36	MW-36	MW-36	MW-36	MW-39	MW-39	MW-39	MW-39	TW-13	TW-14	TW-16
		Sample Date	6/7/22	10/30/19	4/9/20	10/13/20	6/22/21	10/26/21	6/7/22	10/27/22	4/9/20	10/26/21	6/7/22	10/27/22	3/4/20	3/4/20	3/5/20
		Sample Type	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
		Unit															
VOCs	1,1,1-Trichloroethane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	1,1,2,2-Tetrachloroethane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	1,1,2-Trichloroethane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	1,1-Dichloroethane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	1,1-Dichloroethene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	1,2,4-Trichlorobenzene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	1,2-Dibromo-3-chloropropane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	1,2-Dichlorobenzene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	1,2-Dichloroethane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	1,2-Dichloropropane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	1,3-Dichlorobenzene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	1,4-Dichlorobenzene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	2-Butanone (Methyl ethyl ketone)	µg/L	< 10	< 20	< 20	< 10	< 50	< 40	< 40	< 40	< 20	< 20	< 20	< 20	5.4 J	< 10	< 10
VOCs	2-Hexanone	µg/L	< 5.0	< 10	< 10	< 5.0	< 25	< 20	< 20	< 20	< 10	< 10	< 10	< 10	< 5.0	< 5.0	< 5.0
VOCs	4-Methyl-2-pentanone	µg/L	< 5.0	< 10	< 10	< 5.0	< 25	< 20	< 20	< 20	< 10	< 10	< 10	< 10	< 5.0	< 5.0	< 5.0
VOCs	Acetone	µg/L	< 10	< 20	< 20	< 10	< 50	< 40	< 40	< 40	21	< 20	< 20	< 20	99	33	17
VOCs	Benzene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	1.3 J	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Bromodichloromethane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Bromoform	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Bromomethane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Carbon disulfide	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Carbon tetrachloride	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Chlorobenzene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Chloroethane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Chloroform	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Chloromethane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	cis-1,2-Dichloroethene	µg/L	< 1.0	11	11	< 1.0	< 5.0	15	< 4.0	12	2.5	1.7 J	5.1	1.6 J	< 1.0	< 1.0	< 1.0
VOCs	cis-1,3-Dichloropropene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Cyclohexane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	0.40 J	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Dibromochloromethane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Dichlorodifluoromethane (Freon 12)	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Ethylbenzene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Ethylene dibromide	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Isopropylbenzene (Cumene)	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	m,p-Xylenes	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
VOCs	Methyl acetate	µg/L	< 2.5	< 5.0	< 5.0	< 2.5	< 13	< 10	< 10	< 10	< 5.0	< 5.0	< 5.0	< 5.0	< 2.5	< 2.5	< 2.5
VOCs	Methyl tert-butyl ether	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Methylcyclohexane	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	0.45 J	< 1.0	< 1.0
VOCs	Methylene chloride	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	o-Xylene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
VOCs	Styrene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Tetrachloroethene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Toluene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	1.1 J	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	trans-1,2-Dichloroethene	µg/L	< 1.0	4.3	9.3	< 1.0	< 5.0	6.7	< 4.0	5.6	< 2.0	< 2.0	2.3	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	trans-1,3-Dichloropropene	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Trichloroethene	µg/L	< 1.0	160	360	51	100	250	160	290	90	88	110	110	1.6	< 1.0	< 1.0
VOCs	Trichlorofluoromethane (Freon 11)	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Vinyl chloride	µg/L	< 1.0	< 2.0	< 2.0	< 1.0	< 5.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0
VOCs	Xylene, Total	µg/L	< 2.0	< 4.0	< 4.0	< 2.0	< 10	< 8.0	< 8.0	< 8.0	< 4.0	< 4.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0
VOCs	VOC, Total	µg/L	0	175.3	380.3	51	100	271.7	160	307.6	116.3	89.7	117.4	111.6	106.45	33	17
Dissolved Gases	Ethane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dissolved Gases	Ethene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dissolved Gases	Methane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SVOCs	1,4-Dioxane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Metals	Iron	mg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Metals	Manganese	mg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dissolved Metals	Iron	mg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dissolved Metals	Manganese	mg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorobutanoic acid (PFBA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluoropentanoic acid (PFPeA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorohexanoic acid (PFHxA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluoroheptanoic acid (PFHpA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorooctanoic acid (PFOA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorononanoic acid (PFNA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorodecanoic acid (PFDA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluoroundecanoic acid (PFUnDA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorododecanoic acid (PFDoDA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorotridecanoic acid (PFTrDA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorotetradecanoic acid (PFTeDA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorobutane sulfonic acid (PFBS)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorohexane sulfonic acid (PFHxS)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluoroheptane sulfonic acid (PFHpS)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorooctane sulfonic acid (PFOS)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorodecane sulfonic acid (PFDS)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	Perfluorooctane sulfonamide (FOSA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	6:2 Fluorotelomer sulfonic acid (6:2 FTS)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	8:2 Fluorotelomer sulfonic acid (8:2FTS)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	N-ethyl perfluorooctanesulfonamidoacetic acid (NEtPFOSAA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFAS	N-Methyl perfluorooctanesulfonamidoacetic acid (NMePFOSAA)	ng/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
General Chemistry	Sulfate	mg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
General Chemistry	Nitrate as N	mg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
General Chemistry	Organic Carbon, Total	mg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes:
< = Compound not detected at concentrationsabove the laboratory reporting detection limit.The laboratory reporting detection limit is shown.
J = Estimated value. The Target analyte concentration is below the quantitation limit (RL), but above the Method Detection Limit (MDL).
R = Rejected - data quality insufficient
-- = Not analyzed
N = Normal Environmental Sample
FD = Field Duplicate Sample
mg/L = milligrams per liter
µg/L = micrograms per liter
ng/l = nanogram per liter

Table 1
Groundwater Summary Table
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

Analyte		**Location ID**	**TW-18**	**TW-19**	**TW-19**	**TW-22**
		Sample Date	**3/4/20**	**3/4/20**	**3/4/20**	**3/5/20**
		Sample Type	**N**	**N**	**FD**	**N**
		Unit				
VOCs	1,1,1-Trichloroethane	µg/L	< 4.0	< 10	< 10	< 1.0
	1,1,2,2-Tetrachloroethane	µg/L	< 4.0	< 10	< 10	< 1.0
	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	µg/L	< 4.0	< 10	< 10	< 1.0
	1,1,2-Trichloroethane	µg/L	< 4.0	< 10	< 10	< 1.0
	1,1-Dichloroethane	µg/L	< 4.0	< 10	< 10	< 1.0
	1,1-Dichloroethene	µg/L	< 4.0	< 10	< 10	< 1.0
	1,2,4-Trichlorobenzene	µg/L	< 4.0	< 10	< 10	< 1.0
	1,2-Dibromo-3-chloropropane	µg/L	< 4.0	< 10	< 10	< 1.0
	1,2-Dichlorobenzene	µg/L	< 4.0	< 10	< 10	< 1.0
	1,2-Dichloroethane	µg/L	< 4.0	< 10	< 10	< 1.0
	1,2-Dichloropropane	µg/L	< 4.0	< 10	< 10	< 1.0
	1,3-Dichlorobenzene	µg/L	< 4.0	< 10	< 10	< 1.0
	1,4-Dichlorobenzene	µg/L	< 4.0	< 10	< 10	< 1.0
	2-Butanone (Methyl ethyl ketone)	µg/L	< 40	< 100	< 100	5.7 J
	2-Hexanone	µg/L	< 20	< 50	< 50	< 5.0
	4-Methyl-2-pentanone	µg/L	< 20	< 50	< 50	< 5.0
	Acetone	µg/L	< 40	< 100	< 100	65
	Benzene	µg/L	< 4.0	< 10	< 10	< 1.0
	Bromodichloromethane	µg/L	< 4.0	< 10	< 10	< 1.0
	Bromoform	µg/L	< 4.0	< 10	< 10	< 1.0
	Bromomethane	µg/L	< 4.0	< 10	< 10	< 1.0
	Carbon disulfide	µg/L	< 4.0	< 10	< 10	< 1.0
	Carbon tetrachloride	µg/L	< 4.0	< 10	< 10	< 1.0
	Chlorobenzene	µg/L	< 4.0	< 10	< 10	< 1.0
	Chloroethane	µg/L	< 4.0	< 10	< 10	< 1.0
	Chloroform	µg/L	< 4.0	< 10	< 10	< 1.0
	Chloromethane	µg/L	< 4.0	< 10	< 10	< 1.0
	cis-1,2-Dichloroethene	µg/L	9.3	27	25	< 1.0
	cis-1,3-Dichloropropene	µg/L	< 4.0	< 10	< 10	< 1.0
	Cyclohexane	µg/L	< 4.0	< 10	< 10	< 1.0
	Dibromochloromethane	µg/L	< 4.0	< 10	< 10	< 1.0
	Dichlorodifluoromethane (Freon 12)	µg/L	< 4.0	< 10	< 10	< 1.0
	Ethylbenzene	µg/L	< 4.0	< 10	< 10	< 1.0
	Ethylene dibromide	µg/L	< 4.0	< 10	< 10	< 1.0
	Isopropylbenzene (Cumene)	µg/L	< 4.0	< 10	< 10	< 1.0
	m,p-Xylenes	µg/L	--	--	--	--
	Methyl acetate	µg/L	< 10	< 25	< 25	< 2.5
	Methyl tert-butyl ether	µg/L	< 4.0	< 10	< 10	< 1.0
	Methylcyclohexane	µg/L	< 4.0	< 10	< 10	0.21 J
	Methylene chloride	µg/L	< 4.0	< 10	< 10	< 1.0
	o-Xylene	µg/L	--	--	--	--
	Styrene	µg/L	< 4.0	< 10	< 10	< 1.0
	Tetrachloroethene	µg/L	< 4.0	< 10	< 10	< 1.0
	Toluene	µg/L	< 4.0	< 10	< 10	< 1.0
	trans-1,2-Dichloroethene	µg/L	4.4	15	13	< 1.0
	trans-1,3-Dichloropropene	µg/L	< 4.0	< 10	< 10	< 1.0
	Trichloroethene	µg/L	150	500	460	< 1.0
	Trichlorofluoromethane (Freon 11)	µg/L	< 4.0	< 10	< 10	< 1.0
	Vinyl chloride	µg/L	< 4.0	< 10	< 10	< 1.0
	Xylene, Total	µg/L	< 8.0	< 20	< 20	< 2.0
	VOC, Total	µg/L	163.7	542	498	70.91
Dissolved Gases	Ethane	µg/L	--	--	--	--
	Ethene	µg/L	--	--	--	--
	Methane	µg/L	--	--	--	--
SVOCs	1,4-Dioxane	µg/L	--	--	--	--
Total Metals	Iron	mg/L	--	--	--	--
	Manganese	mg/L	--	--	--	--
Dissolved Metals	Iron	mg/L	--	--	--	--
	Manganese	mg/L	--	--	--	--
PFAS	Perfluorobutanoic acid (PFBA)	ng/L	--	--	--	--
	Perfluoropentanoic acid (PFPeA)	ng/L	--	--	--	--
	Perfluorohexanoic acid (PFHxA)	ng/L	--	--	--	--
	Perfluoroheptanoic acid (PFHpA)	ng/L	--	--	--	--
	Perfluorooctanoic acid (PFOA)	ng/L	--	--	--	--
	Perfluorononanoic acid (PFNA)	ng/L	--	--	--	--
	Perfluorodecanoic acid (PFDA)	ng/L	--	--	--	--
	Perfluoroundecanoic acid (PFUnDA)	ng/L	--	--	--	--
	Perfluorododecanoic acid (PFDoDA)	ng/L	--	--	--	--
	Perfluorotridecanoic acid (PFTrDA)	ng/L	--	--	--	--
	Perfluorotetradecanoic acid (PFTeDA)	ng/L	--	--	--	--
	Perfluorobutane sulfonic acid (PFBS)	ng/L	--	--	--	--
	Perfluorohexane sulfonic acid (PFHxS)	ng/L	--	--	--	--
	Perfluoroheptane sulfonic acid (PFHpS)	ng/L	--	--	--	--
	Perfluorooctane sulfonic acid (PFOS)	ng/L	--	--	--	--
	Perfluorodecane sulfonic acid (PFDS)	ng/L	--	--	--	--
	Perfluorooctane sulfonamide (FOSA)	ng/L	--	--	--	--
	6:2 Fluorotelomer sulfonic acid (6:2 FTS)	ng/L	--	--	--	--
	8:2 Fluorotelomer sulfonic acid (8:2FTS)	ng/L	--	--	--	--
	N-ethyl perfluorooctanesulfonamidoacetic acid (NEtPFOSAA)	ng/L	--	--	--	--
	N-Methyl perfluorooctanesulfonamidoacetic acid (NMePFOSAA)	ng/L	--	--	--	--
General Chemistry	Sulfate	mg/L	--	--	--	--
	Nitrate as N	mg/L	--	--	--	--
	Organic Carbon, Total	mg/L	--	--	--	--

Notes:
< = Compound not detected at concentrationsabove the laboratory reporting detection limit.The laboratory reporting detection limit is shown.
J = Estimated value. The Target analyte concentration is below the quantitation limit (RL), but above the Method Detection Limit (MDL).
R = Rejected - data quality insufficient
-- = Not analyzed
N = Normal Environmental Sample
FD = Field Duplicate Sample
mg/L = milligrams per liter
µg/L = micrograms per liter
ng/l = nanogram per liter

Table 2
Summary of Analytical Results
Former Leica Microsystems - Cheektowaga
Cheektowaga, New York

Field Parameter (GW)	Location ID	MW-2	MW-2	MW-2	MW-2	MW-31	MW-31	MW-31	MW-31	MW-31	MW-31	MW-31	MW-36	MW-36	MW-36
	Sample Date	**12/10/2018**	**5/15/2019**	**10/29/2019**	**4/8/2020**	**7/3/2018**	**12/5/2018**	**5/15/2019**	**8/20/2019**	**4/9/2020**	**6/22/2021**	**6/7/2022**	**10/30/2019**	**4/9/2020**	**10/13/2020**
	Sample Type	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**
	Unit														
Temperature, Field	deg C	9.3	8.60	14.74	8.18	19.60	8.9	10.90	18.3	7.18	13.23	11.8	15.54	8.42	17.0
pH, Field	pH units	6.23	6.87	6.95	6.99	7.04	7.04	6.94	7.16	7.15	6.96	7.07	6.92	7.39	7.79
Specific Conductivity, Field	uS/cm	1,141	620	811	485	620	1,175	690	5,663	697	777	823	872	489	846
Oxidation-Reduction Potential, Field	mV	210.1	48.50	18.2	-210.4	26.40	33.7	56.20	-93.0	36.9	46.5	-213.8	59.9	0.1	-183.0
Turbidity, Field	NTU	1.46	4.23	3.43	6.49	2.97	1.72	2.06	2.51	2.08	14.60	2.65	44.50	2.23	8.09
Color, Field	-	clear	clear	colorless	clear	--	clear	clear	--	clear	Light yellow	Clear	colorless	clear	Clear
Odor, Field	-	--	none	none	none	--	--	none	--	--	Organic-like	None	none	none	None
Dissolved Oxygen, Field	mg/L	3.19	4.10	0.652	1.90	9.90	2.78	1.94	0.22	0.32	2.63	4.05	0.714	4.46	4.29

Notes:
-- = not measured
- = No Unit
N = Normal Environmental Sample
deg C = degrees Celsius
pH units = pH units
uS/cm = microSiemens per centimeter
mV = millivolts
NTU = nephelometric turbidity units
mg/L = milligrams per liter
ft = feet

Table 2
Summary of Analytical Results
Former Leica Microsystems - Cheektowaga
Cheektowaga, New York

Field Parameter (GW)	Location ID	MW-36	MW-36	MW-36	MW-36	MW-39	MW-39	MW-39
	Sample Date	6/22/2021	10/26/2021	6/7/2022	10/27/2022	10/26/2021	6/7/2022	10/27/2022
	Sample Type	N	N	N	N	N	N	N
	Unit							
Temperature, Field	deg C	15.12	16	13.9	15.20	14.70	12.3	--
pH, Field	pH units	7.77	6.80	6.77	6.75	6.75	6.98	--
Specific Conductivity, Field	uS/cm	617	590	504	771	608	793	--
Oxidation-Reduction Potential, Field	mV	-9.0	12.10	90.0	156.20	27.60	78.2	--
Turbidity, Field	NTU	59.80	3.61	3.95	9.19	49.60	Over	--
Color, Field	-	None	Clear	Clear	Clear	Clear	Brown	Clear
Odor, Field	-	Slight chemical-like	None	None	None	Organic-like	None	Organic-like
Dissolved Oxygen, Field	mg/L	4.62	1.65	6.38	2.72	3.08	7.43	--

Notes:
-- = not measured
- = No Unit
N = Normal Environmental Sample
deg C = degrees Celsius
pH units = pH units
uS/cm = microSiemens per centimeter
mV = millivolts
NTU = nephelometric turbidity units
mg/L = milligrams per liter
ft = feet

Table 3
Soil Gas Summary Table
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

Analyte		Location ID	PSG-01	PSG-02	PSG-03	PSG-04	PSG-05	PSG-06	PSG-07	PSG-08	PSG-09
		Sample Date	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020
		Sample Type	N	N	N	N	N	N	N	N	N
		Unit									
VOCs	1,1,1,2-Tetrachloroethane	µg/m3	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*
	1,1,1-Trichloroethane	µg/m3	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*
	1,1,2,2-Tetrachloroethane	µg/m3	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*
	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	µg/m3	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*
	1,1,2-Trichloroethane	µg/m3	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*
	1,1-Dichloroethane	µg/m3	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*
	1,1-Dichloroethene	µg/m3	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*
	1,2,3-Trichlorobenzene	µg/m3	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*
	1,2,3-Trichloropropane	µg/m3	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*
	1,2,4-Trichlorobenzene	µg/m3	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*
	1,2-Dichlorobenzene	µg/m3	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*
	1,2-Dichloroethane	µg/m3	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*
	1,3-Dichlorobenzene	µg/m3	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*
	1,4-Dichlorobenzene	µg/m3	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*
	Carbon tetrachloride	µg/m3	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*
	Chlorobenzene	µg/m3	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*
	Chloroform	µg/m3	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*
	cis-1,2-Dichloroethene	µg/m3	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*
	Tetrachloroethene	µg/m3	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*
	trans-1,2-Dichloroethene	µg/m3	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*
	Trichloroethene	µg/m3	*< 1.46*	*< 1.46*	*< 1.46*	*< 1.46*	*< 1.46*	*< 1.46*	*< 1.46*	*< 1.46*	*< 1.46*
	Vinyl chloride	µg/m3	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*
	VOC, Total	µg/m3	0	0	0	0	0	0	0	0	0

Notes:
< = Compound not detected at concentrations above the laboratory reporting detection limit. The laboratory reporting detection limit is shown.
N = Normal Environmental Sample
FD = Field Duplicate Sample
µg/m3 = micrograms per cubic meter

Table 3
Soil Gas Summary Table
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

Analyte		Location ID	PSG-10	PSG-10	PSG-11	PSG-12	PSG-13	PSG-14	PSG-15	PSG-16	PSG-17
		Sample Date	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020
		Sample Type	N	FD	N	N	N	N	N	N	N
		Unit									
VOCs	1,1,1,2-Tetrachloroethane	µg/m3	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22
	1,1,1-Trichloroethane	µg/m3	< 0.49	< 0.49	< 0.49	< 0.49	< 0.49	< 0.49	< 0.49	< 0.49	< 0.49
	1,1,2,2-Tetrachloroethane	µg/m3	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22
	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	µg/m3	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58
	1,1,2-Trichloroethane	µg/m3	< 1.47	< 1.47	< 1.47	< 1.47	< 1.47	< 1.47	< 1.47	< 1.47	< 1.47
	1,1-Dichloroethane	µg/m3	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58
	1,1-Dichloroethene	µg/m3	< 1.50	< 1.50	< 1.50	< 1.50	< 1.50	< 1.50	< 1.50	< 1.50	< 1.50
	1,2,3-Trichlorobenzene	µg/m3	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27
	1,2,3-Trichloropropane	µg/m3	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68
	1,2,4-Trichlorobenzene	µg/m3	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27
	1,2-Dichlorobenzene	µg/m3	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68
	1,2-Dichloroethane	µg/m3	< 0.89	< 0.89	< 0.89	< 0.89	< 0.89	< 0.89	< 0.89	< 0.89	< 0.89
	1,3-Dichlorobenzene	µg/m3	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68
	1,4-Dichlorobenzene	µg/m3	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68
	Carbon tetrachloride	µg/m3	< 1.16	< 1.16	< 1.16	< 1.16	< 1.16	< 1.16	< 1.16	< 1.16	< 1.16
	Chlorobenzene	µg/m3	< 0.59	< 0.59	< 0.59	< 0.59	< 0.59	< 0.59	< 0.59	< 0.59	< 0.59
	Chloroform	µg/m3	< 1.39	< 1.39	< 1.39	< 1.39	< 1.39	< 1.39	< 1.39	< 1.39	< 1.39
	cis-1,2-Dichloroethene	µg/m3	< 0.92	< 0.92	< 0.92	< 0.92	< 0.92	< 0.92	< 0.92	< 0.92	< 0.92
	Tetrachloroethene	µg/m3	< 1.21	< 1.21	< 1.21	< 1.21	< 1.21	< 1.21	< 1.21	< 1.21	< 1.21
	trans-1,2-Dichloroethene	µg/m3	< 1.13	< 1.13	< 1.13	< 1.13	< 1.13	< 1.13	< 1.13	< 1.13	< 1.13
	Trichloroethene	µg/m3	< 1.46	< 1.46	< 1.46	< 1.46	< 1.46	< 1.46	< 1.46	< 1.46	< 1.46
	Vinyl chloride	µg/m3	< 0.64	< 0.64	< 0.64	< 0.64	< 0.64	< 0.64	< 0.64	< 0.64	< 0.64
	VOC, Total	µg/m3	0	0	0	0	0	0	0	0	0

Notes:
< = Compound not detected at concentrations above the laboratory reporting detection limit. The laboratory reporting detection limit is shown.
N = Normal Environmental Sample
FD = Field Duplicate Sample
µg/m3 = micrograms per cubic meter

Table 3
Soil Gas Summary Table
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

Analyte		Location ID	PSG-18	PSG-20	PSG-21	PSG-22	PSG-23	PSG-24	PSG-25	PSG-26	PSG-27
		Sample Date	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020
		Sample Type	N	N	N	N	N	N	N	N	N
		Unit									
VOCs	1,1,1,2-Tetrachloroethane	µg/m3	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*
	1,1,1-Trichloroethane	µg/m3	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*
	1,1,2,2-Tetrachloroethane	µg/m3	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*
	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	µg/m3	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*
	1,1,2-Trichloroethane	µg/m3	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*
	1,1-Dichloroethane	µg/m3	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*
	1,1-Dichloroethene	µg/m3	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*
	1,2,3-Trichlorobenzene	µg/m3	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*
	1,2,3-Trichloropropane	µg/m3	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*
	1,2,4-Trichlorobenzene	µg/m3	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*
	1,2-Dichlorobenzene	µg/m3	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*
	1,2-Dichloroethane	µg/m3	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*
	1,3-Dichlorobenzene	µg/m3	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*
	1,4-Dichlorobenzene	µg/m3	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*
	Carbon tetrachloride	µg/m3	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*
	Chlorobenzene	µg/m3	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*
	Chloroform	µg/m3	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*
	cis-1,2-Dichloroethene	µg/m3	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*	2.06	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*
	Tetrachloroethene	µg/m3	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*
	trans-1,2-Dichloroethene	µg/m3	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*	2.26	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*
	Trichloroethene	µg/m3	*< 1.46*	*< 1.46*	*< 1.46*	9.23	127	*< 1.46*	*< 1.46*	*< 1.46*	*< 1.46*
	Vinyl chloride	µg/m3	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*
	VOC, Total	µg/m3	0	0	0	9.23	131.32	0	0	0	0

Notes:

< = Compound not detected at concentrations above the laboratory reporting detection limit. The laboratory reporting detection limit is shown.
N = Normal Environmental Sample
FD = Field Duplicate Sample
µg/m3 = micrograms per cubic meter

Table 3
Soil Gas Summary Table
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

ERM

Analyte		Location ID	PSG-28	PSG-29	PSG-30	PSG-31	PSG-32	PSG-33	PSG-34	PSG-35	PSG-36
		Sample Date	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020
		Sample Type	N	N	N	N	N	N	N	N	N
		Unit									
VOCs	1,1,1,2-Tetrachloroethane	µg/m3	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*
	1,1,1-Trichloroethane	µg/m3	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*	*< 0.49*
	1,1,2,2-Tetrachloroethane	µg/m3	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*	*< 1.22*
	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	µg/m3	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*
	1,1,2-Trichloroethane	µg/m3	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*	*< 1.47*
	1,1-Dichloroethane	µg/m3	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*	*< 0.58*
	1,1-Dichloroethene	µg/m3	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*	*< 1.50*
	1,2,3-Trichlorobenzene	µg/m3	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*
	1,2,3-Trichloropropane	µg/m3	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*
	1,2,4-Trichlorobenzene	µg/m3	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*	*< 1.27*
	1,2-Dichlorobenzene	µg/m3	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*
	1,2-Dichloroethane	µg/m3	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*	*< 0.89*
	1,3-Dichlorobenzene	µg/m3	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*
	1,4-Dichlorobenzene	µg/m3	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*	*< 0.68*
	Carbon tetrachloride	µg/m3	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*	*< 1.16*
	Chlorobenzene	µg/m3	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*	*< 0.59*
	Chloroform	µg/m3	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*	*< 1.39*
	cis-1,2-Dichloroethene	µg/m3	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*	*< 0.92*
	Tetrachloroethene	µg/m3	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*	*< 1.21*
	trans-1,2-Dichloroethene	µg/m3	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*	*< 1.13*
	Trichloroethene	µg/m3	*< 1.46*	*< 1.46*	8.20	*< 1.46*	*< 1.46*	*< 1.46*	*< 1.46*	*< 1.46*	*< 1.46*
	Vinyl chloride	µg/m3	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*	*< 0.64*
	VOC, Total	µg/m3	0	0	8.2	0	0	0	0	0	0

Notes:

< = Compound not detected at concentrations above the laboratory reporting detection limit. The laboratory reporting detection limit is shown.
N = Normal Environmental Sample
FD = Field Duplicate Sample
µg/m3 = micrograms per cubic meter

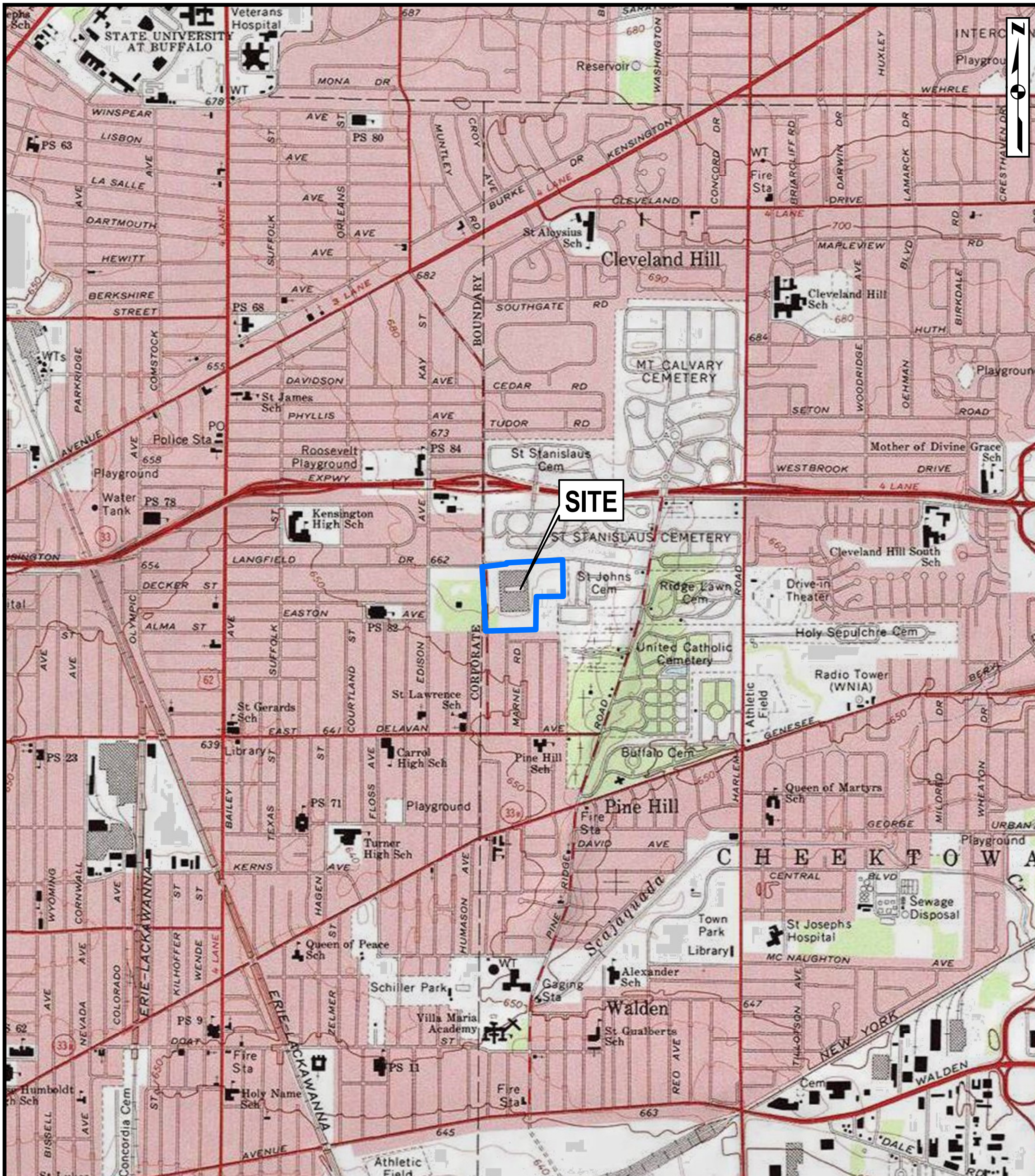
Table 3
Soil Gas Summary Table
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

Analyte		Location ID	PSG-36	PSG-37	PSG-38	PSG-39	PSG-40	PSG-41
		Sample Date	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020	9/15/2020
		Sample Type	FD	N	N	N	N	N
		Unit						
VOCs	1,1,1,2-Tetrachloroethane	µg/m3	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22
	1,1,1-Trichloroethane	µg/m3	< 0.49	< 0.49	< 0.49	< 0.49	< 0.49	< 0.49
	1,1,2,2-Tetrachloroethane	µg/m3	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22	< 1.22
	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	µg/m3	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58
	1,1,2-Trichloroethane	µg/m3	< 1.47	< 1.47	< 1.47	< 1.47	< 1.47	< 1.47
	1,1-Dichloroethane	µg/m3	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58	< 0.58
	1,1-Dichloroethene	µg/m3	< 1.50	< 1.50	< 1.50	< 1.50	< 1.50	< 1.50
	1,2,3-Trichlorobenzene	µg/m3	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27
	1,2,3-Trichloropropane	µg/m3	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68
	1,2,4-Trichlorobenzene	µg/m3	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27	< 1.27
	1,2-Dichlorobenzene	µg/m3	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68
	1,2-Dichloroethane	µg/m3	< 0.89	< 0.89	< 0.89	< 0.89	< 0.89	< 0.89
	1,3-Dichlorobenzene	µg/m3	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68
	1,4-Dichlorobenzene	µg/m3	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68	< 0.68
	Carbon tetrachloride	µg/m3	< 1.16	< 1.16	< 1.16	< 1.16	< 1.16	< 1.16
	Chlorobenzene	µg/m3	< 0.59	< 0.59	< 0.59	< 0.59	< 0.59	< 0.59
	Chloroform	µg/m3	< 1.39	< 1.39	< 1.39	< 1.39	< 1.39	< 1.39
	cis-1,2-Dichloroethene	µg/m3	< 0.92	< 0.92	< 0.92	< 0.92	< 0.92	< 0.92
	Tetrachloroethene	µg/m3	< 1.21	< 1.21	< 1.21	< 1.21	< 1.21	< 1.21
	trans-1,2-Dichloroethene	µg/m3	< 1.13	< 1.13	< 1.13	< 1.13	< 1.13	< 1.13
	Trichloroethene	µg/m3	< 1.46	< 1.46	< 1.46	< 1.46	< 1.46	< 1.46
	Vinyl chloride	µg/m3	< 0.64	< 0.64	< 0.64	< 0.64	< 0.64	< 0.64
	VOC, Total	µg/m3	0	0	0	0	0	0

Notes:

< = Compound not detected at concentrations above the laboratory reporting detection limit. The laboratory reporting detection limit is shown.
N = Normal Environmental Sample
FD = Field Duplicate Sample
µg/m3 = micrograms per cubic meter

FIGURES



Legend

Site Boundary

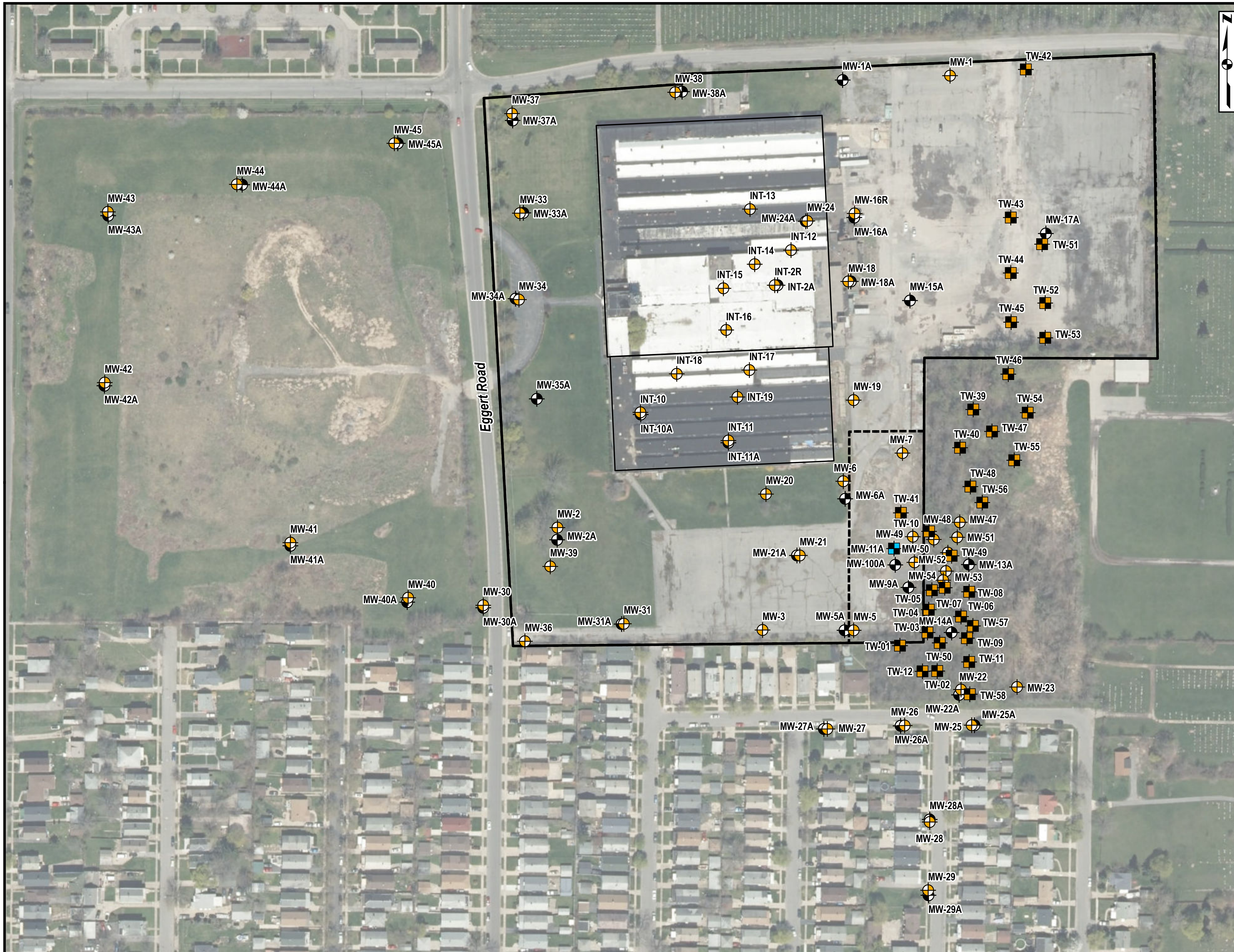
0 0.1 0.2 0.3 0.4 0.5 Miles

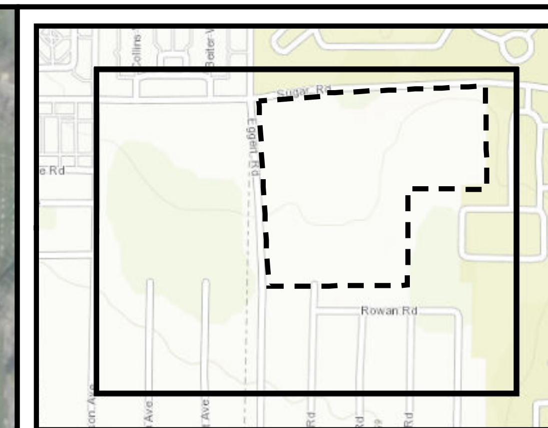
1:24,000

Figure 1: Site Locus Map
Former Leica, Inc. Facility
203 Eggert Road
Cheektowaga, New York

SOURCE: USGS scanned topographic quad maps provided by National Geographic Society (© 2019).

ERM





Legend

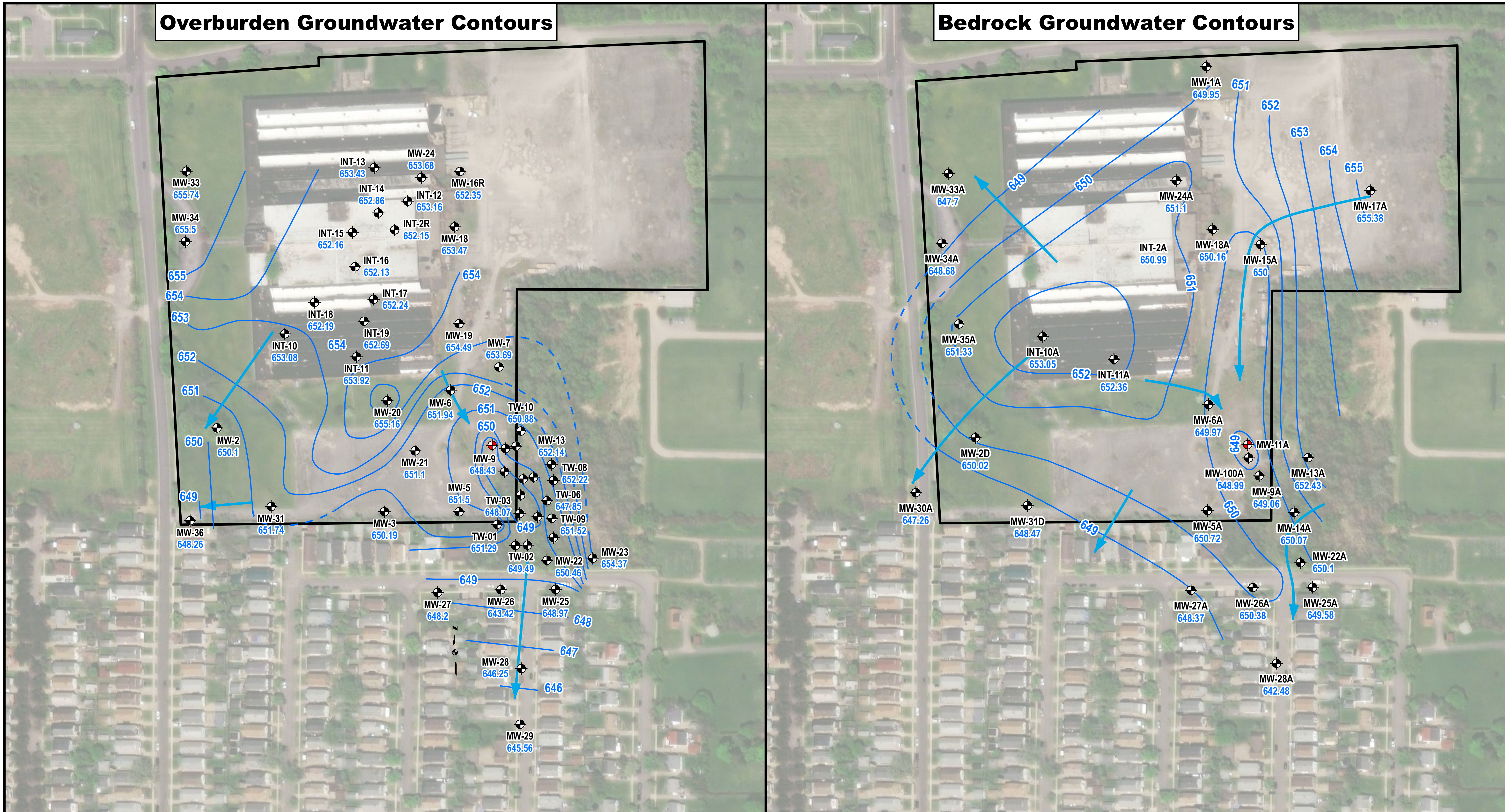
- Bedrock Monitoring Well Location
- Overburden Monitoring Well Location
- Overburden Temporary Monitoring Well Location
- Groundwater Extraction Well
- Site Boundary
- Property Boundary
- BuildingOutline

NOTE:
- Aerial Imagery from ESRI World Imagery Reproduced under license in ArcGIS 10.5

0 50 100 200
Feet

Figure 2: Monitoring Well Network
Former Leica, Inc. Facility
203 Eggert Road
Cheektowaga, New York

ERM



M:\US\Projects\D-F\Danaher\CheektowagaNY\MXD\SMP Report\Figure_GWContour_December2019_Combined_20230411.mxd - Dikshya.Khanal - 4/11/2023

Legend

- Monitoring Well
- Extraction Well
- Groundwater Contour
- Groundwater Contour (Inferred)
- Groundwater Flow Direction
- Site Property Boundary

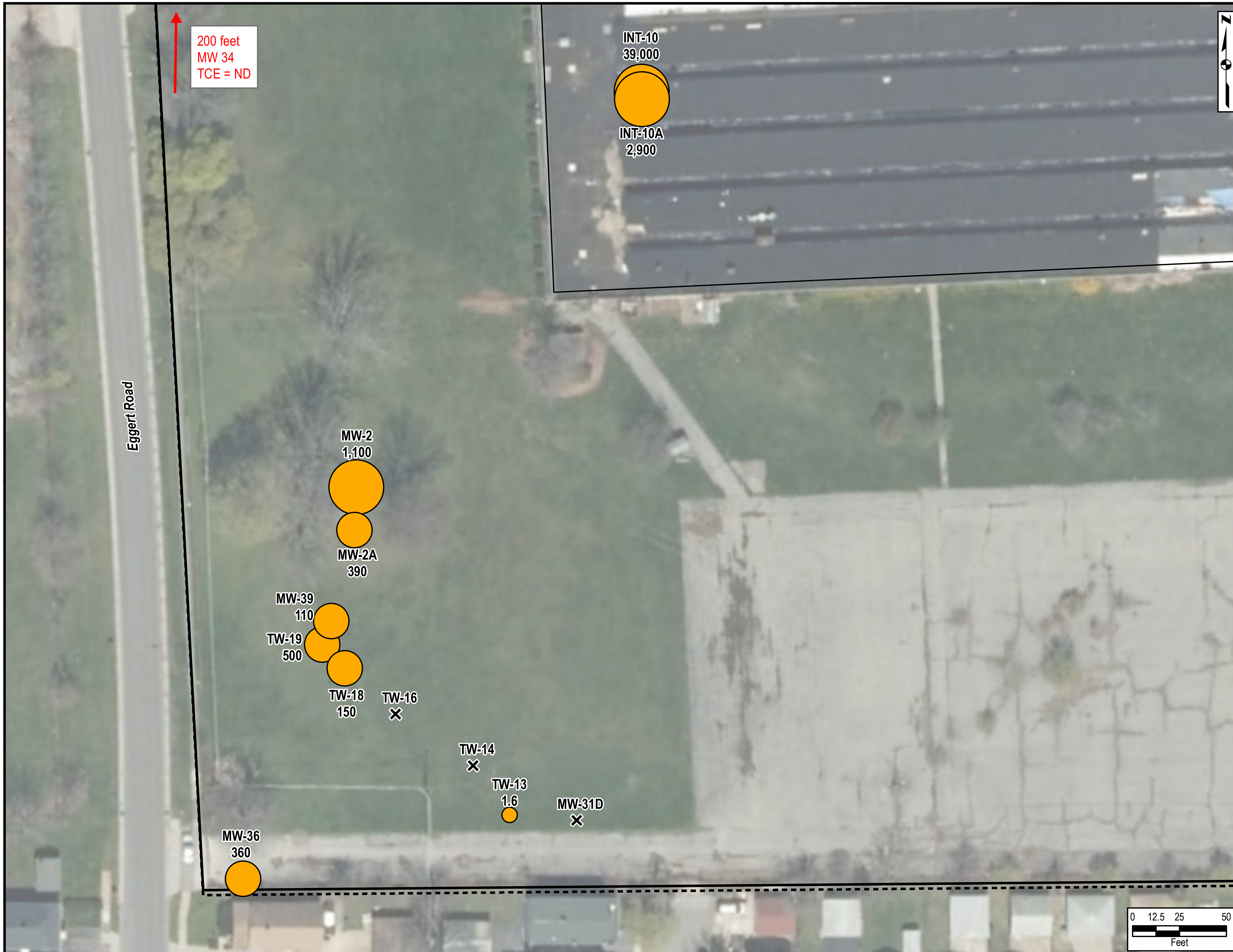
N

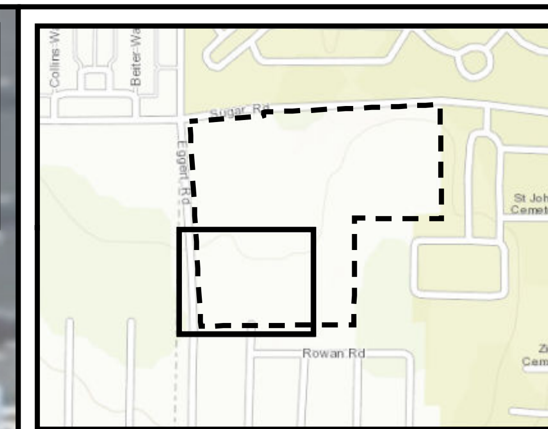
0 70 140 280 420 560 Feet

Notes
1. Groundwater elevations measured 19 December 2019.
2. Groundwater elevations are reported as feet above mean sea level (ft. amsl).
3. ESRI World imagery. Reproduced under license with ArcGIS 10.5.

Figure 3: Potentiometric Contour Map - December 2019
Former Leica, Inc. Facility
203 Eggert Road
Cheektowaga, New York

ERM





Legend

Maxiumum TCE Concentrations

- <10
- 10 - <100
- 100 - <1,000
- >1,000

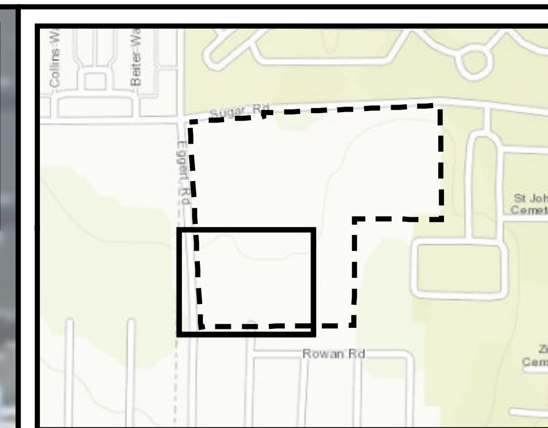
- Non-Detect for TCE
- Site Boundary
- Property Boundary
- BuildingOutline
- **92.5** Max TCE Concentration

NOTE:
- TCE = Trichloroethylene
- ND = Non-detect
- Groundwater results represent highest TCE concentration sampled in micrograms per liter (ug/L).
- TW-13, TW-14, TW-18, TW-19 sampled 4 March 2020.
- MW-2 sampled 10 December 2018.
- MW-2A sampled 15 June 2015.
- MW-31D and MW-36 sampled 9 April 2020.
- MW-39 sampled 7 June 2022.
- INT-10 sampled 13 May 2019
- INT-10A sampled 11 November 2016.
- Aerial Imagery from ESRI World Imagery Reproduced under license in ArcGIS 10.5

Figure 4: Maximum Detected TCE Concentrations in Groundwater

Former Leica, Inc. Facility
203 Eggert Road
Cheektowaga, New York

ERM



Legend

Maximum TCE Concentrations

- <10
- 10 - <100
- >100
- Non-Detect for TCE
- Site Boundary
- Property Boundary
- BuildingOutline
- 92.5 Max TCE Concentration

NOTE:
- TCE = Trichloroethylene
- Passive Soil Gas (PSG) locations sampled 15 September 2020 in micrograms per cubic meter (ug/m³).
- Aerial Imagery from ESRI World Imagery Reproduced under license in ArcGIS 10.5

0 12.5 25 50
Feet

Figure 5: Maximum Detected TCE Concentrations in Soil Vapor
Former Leica, Inc. Facility
203 Eggert Road
Cheektowaga, New York

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APPENDIX A PRELIMINARY (60 PERCENT COMPLETE) PS DESIGN PACKAGE

LEICIA, INC.
Inactive Hazardous Waste Disposal Site No.915158
203 Eggert Road
Cheektowaga, New York
60% SOUTHWEST CORNER IRM DESIGN
MAY 2023

SOURCE: BUFFALO USGS QUADRANGLE 7.5–MINUTE SERIES

CHEEKTOWAGA, NEW YORK
SITE VICINITY MAP

0 2000 4000
SCALE (IN FEET)

SOURCE: GOGGLE EARTH

CHEEKTOWAGA, NEW YORK
SITE LOCATION MAP

0 250 500
SCALE (IN FEET)

JAYDEEP PARIKH, P.E.
NY PROFESSIONAL ENGINEER LICENSE
NO. 088083

PREPARED BY:

ERM®
ERM Consulting & Engineering, Inc.
5784 Widewaters Parkway
First Floor
Syracuse, New York 13214

FILE PATH: \\USBDCFS02\data\Philadelphia\Team\DMMV\CAD\Drawings\Danaher\0671863\60% Design\0671863-01.dwg layout1, PRINTED ON August 26, 2021 BY Khrista Baran

INDEX OF DRAWINGS

DRAWING NO.	DESCRIPTION
G-001	COVER SHEET
GI001	GENERAL INFORMATION
GC101	CONTRACTOR (AND MATERIAL) STAGING AREA(S)
CS101	EXISTING CONDITIONS
CS102	PERMEABLE REACTIVE BARRIER - PLAN
CS301	PERMEABLE REACTIVE BARRIER - PROFILE
CG101	EROSION AND SEDIMENTATION CONTROL PLAN
CS501	CONSTRUCTION AND EROSION AND SEDIMENTATION CONTROL DETAILS

NOTE: THESE DRAWINGS IN GRAY ARE ANTICIPATED TO BE PART OF THE FINAL ENGINEERING DESIGN PACKAGE.

LEGEND

	EXISTING MONITORING WELL
	MONITORING WELL DETECTION ABOVE STANDARD
	PASSIVE SOIL GAS SAMPLE LOCATION
+ 654	SPOT ELEVATION
	SITE LIGHTING
E	ELECTRIC BOX
	UTILITY POLE
	SANITARY MANHOLE
	GAS VALVE
	WATER VALVE
	CATCH BASIN
	STORM MANHOLE
W	WATER APPROXIMATE
E	ELECTRIC
SAN	SANITARY
C	COMMUNICATION LINE
GAS	GAS APPROXIMATE
U	UNKNOWN
ST	STORM
654	EXISTING CONTOUR
654	TOP OF BEDROCK CONTOUR
	LEICA, INC. PARCEL BOUNDARY
	TAX PARCEL BOUNDARY

ABBREVIATIONS

APPROX.	APPROXIMATE
@	AT
CMP	CORRUGATED METAL PIPE
CU.	CUBIC
DIA.	DIAMETER
DCE	DICHLOROETHANE
FT	FEET
HDPE	HIGH DENSITY POLYETHYLENE
I.E.	INVERT ELEVATION
J	LAB QUALIFIER
LBS.	POUNDS
MAX.	MAXIMUM
MIN.	MINIMUM
MW	MONITORING WELL
ND	NONDETECT
NG	NANOGRAM
O.C.	ON CENTER
O.D.	OUTER DIAMETER
OZ.	OUNCE
PCE	TETRACHLOROETHYLENE
PRB	PERMEABLE REACTIVE BARRIER
PSG	PASSIVE SOIL GAS
PSF	POUNDS PER SQUARE FOOT
PVC	POLYVINYL CHLORIDE
SB	SOIL BORING
SQ.	SQUARE
SV	SOIL VAPOR
TCE	TRICHLOROETHYLENE
TYP.	TYPICAL
TW	TEMPORARY WELL
µG/L	MICROGRAM PER LITER
VC	VINYL CHLORIDE
YD.S	YARDS
ZVI	ZERO VALENT IRON

DRAWING REFERENCE:

1. THE EXISTING GRADE SOURCE WAS DEVELOPED FROM GROUND ELEVATION DATA FROM THE WELL LOCATIONS SURVEYED BY NYLD INFRASTRUCTURE NEW YORK LEAK DETECTION INC.
2. UTILITY, MONITORING WELL, SOIL VAPOR LOCATIONS, AND TEMPORARY WELL LOCATIONS PROVIDED BY NYLD INFRASTRUCTURE NEW YORK LEAK DETECTION INC. "UTILITY LOCATE MAP" DATED 31 JULY 2019. TABLE 1 BELOW SHOWS THE NORTHING, EASTING, AND ELEVATION VALUES.
   A. LOCATION OF ALL UTILITIES SHOULD BE VERIFIED IN FIELD PRIOR TO EXCAVATION.
   B. INFORMATION SHOWN HEREON IS BASED UPON AN ACTUAL SURVEY PERFORMED IN THE FIELD UTILIZING A LEICA TS15 TOTAL STATION AND GPS LEICA VIVA GNSS GS12 RECEIVER.
3. STATE PLAN COORDINATES - NEW YORK STATE PLANES, WEST ZONE, US FOOT (NAD 83).
4. THE TOPOGRAPHIC SURVEY HORIZONTAL DATUM IS NORTH AMERICAN DATUM OF 1983 (NAD 83).
5. THE TOPOGRAPHIC SURVEY VERTICAL DATUM IS NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).
6. THE SITE SPECIFIC DATA SHOWN IS FROM THE DATA GAP INVESTIGATION REPORT DATED NOVEMBER 2022.

TABLE 1

LOCATION ID	NORTHING	EASTING	ELEVATION (FEET)
MW-2	1090712.394	1066796.792	656.84
MW-2A	1090711.423	1066773.964	656.26
MW-30	1090576.019	1066654.348	656.23
MW-30A	1090576.060	1066649.563	656.03
MW-31	1090833.636	1066620.115	655.39
MW-31A	1090829.700	1066619.392	655.46
MW-31D	1090829.700	1066619.392	655.46
MW-36	1090652.125	1066588.111	655.58
MW-39	1090699.155	1066725.575	656.11
SB-200	1090707.144	1066717.917	655.78
SB-201	1090709.137	1066716.009	655.70
SB-202	1090711.383	1066713.813	655.85
SB-203	1090713.513	1066710.314	655.91
SSV-002	1090669.807	1066626.605	655.82
SSV-01-032322	1091047.421	1066620.176	655.89
SV-03	1090736.743	1066628.377	655.52
SV-04D	1090655.522	1066654.786	655.66
SV-04S	1090655.522	1066654.786	655.66
SV-05	1090645.336	1066744.742	656.56
TW-01	1091340.732	1066579.869	653.07
TW-02	1091409.036	1066533.530	652.53
TW-03	1091391.278	1066604.343	653.52
TW-04	1091393.420	1066645.916	652.95
TW-05	1091398.787	1066681.755	653.38
TW-06	1091452.618	1066633.158	652.79
TW-07	1091422.647	1066686.241	652.90
TW-08	1091467.246	1066678.521	654.92
TW-09	1091463.346	1066594.029	652.81
TW-10	1091393.865	1066789.459	653.93
TW-11	1091467.242	1066550.037	652.20
TW-12	1091381.520	1066532.849	653.48
TW-13	1090794.071	1066622.182	655.35
TW-14	1090774.550	1066648.535	654.75
TW-15	1090742.757	1066667.518	655.21
TW-16	1090733.261	1066676.033	655.28
TW-17	1090718.235	1066688.080	655.52
TW-18	1090706.224	1066700.396	655.65
TW-19	1090694.308	1066713.044	655.88
TW-20	1090679.627	1066728.298	655.96
TW-21	1090665.472	1066743.391	656.26
TW-22	1090649.151	1066759.630	656.58
TW-23	1090653.759	1066708.652	655.91
TW-24	1090662.704	1066701.192	655.87
TW-25	1090671.752	1066693.597	655.54
TW-26	1090680.423	1066686.232	655.65
TW-27	1090694.567	1066674.242	655.54
TW-28	1090708.174	1066662.455	655.33
TW-29	1090698.752	1066758.222	655.91
TW-30	1090707.245	1066749.515	656.01
TW-31	1090715.814	1066740.667	656.04
TW-32	1090726.499	1066730.628	655.89
TW-33	1090741.527	1066715.387	655.68
TW-34	1090757.659	1066699.375	655.37
TW-35	1090672.839	1066735.768	656.20
TW-36	1090686.528	1066720.822	655.98
TW-37	1090699.317	1066707.572	655.76
TW-38	1090711.705	1066694.345	655.58
TW-39	1091474.656	1067013.148	656.56
TW-40	1091450.625	1066943.000	655.80
TW-41	1091342.383	1066823.758	656.08
TW-42	1091571.281	1067636.773	663.29
TW-43	1091543.887	1067365.243	659.34
TW-44	1091543.932	1067263.288	658.42
TW-45	1091544.223	1067173.313	657.83
TW-46	1091539.240	1067077.856	658.80
TW-47	1091509.578	1066972.965	656.36
TW-48	1091469.401	1066871.561	655.02
TW-49	1091435.385	1066744.779	653.97
TW-50	1091413.356	1066585.402	653.15
TW-51	1091601.388	1067316.059	658.87
TW-52	1091606.925	1067208.453	658.31
TW-53	1091607.125	1067144.831	658.16
TW-54	1091574.827	1067007.253	661.41
TW-55	1091550.111	1066920.265	662.30
TW-56	1091491.539	1066842.279	655.93
TW-57	1091474.544	1066616.065	654.40
TW-58	1091468.418	1066491.179	653.45

GENERAL NOTES:

1. PLAN LOCATIONS AND DIMENSIONS SHALL BE STRICTLY ADHERED TO UNLESS OTHERWISE DIRECTED BY THE OWNER, OWNER'S REPRESENTATIVE, OR ENGINEER.
2. THE CONTRACTOR SHALL FIELD VERIFY EXISTING CONDITIONS AND DIMENSIONS PRIOR TO ORDERING AND/OR FABRICATION OF ANY MATERIALS.
3. THE CONTRACTOR SHALL BE SOLELY RESPONSIBLE FOR INITIATING, MAINTAINING AND SUPERVISING ALL SAFETY PRECAUTIONS AND PROGRAMS IN CONNECTION WITH THE WORK.
4. THE CONTRACTOR SHALL SUPERVISE AND DIRECT THE WORK. HE/SHE WILL BE SOLELY RESPONSIBLE FOR THE MEANS, METHODS, TECHNIQUES, PROCEDURES AND SEQUENCES, EXCEPT FOR SEQUENCE OF CONSTRUCTION WHICH WILL BE CONDUCTED IN ACCORDANCE WITH THE SOIL EROSION & SEDIMENT CONTROL PLAN.
5. THE CONTRACTOR SHALL PATCH, REPAIR AND FINISH ALL DAMAGED SURFACES CAUSED BY THE WORK, USING MATERIALS OF THE SAME WORK.
6. THE FABRICATION AND INSTALLATION OF ALL MATERIALS, FINISHES, ETC. SHALL BE IN ACCORDANCE WITH MANUFACTURER'S WRITTEN INSTRUCTIONS.
7. ALL CONSTRUCTION TO BE IN ACCORDANCE WITH LOCAL BUILDING CODES AND THE NEW YORK DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION UNLESS OTHERWISE SPECIFIED.
8. THE CONTRACTOR SHALL BE RESPONSIBLE FOR DETERMINING THE EXACT LOCATION OF UTILITIES, WHETHER SHOWN OR NOT SHOWN ON THE DRAWINGS, AND SHALL BE RESPONSIBLE FOR ALL COSTS INCURRED IN THE REPAIR OF ANY DAMAGE TO SAME RESULTING FROM THE CONTRACTOR'S WORK ASSOCIATED WITH THIS PROJECT. ANY DISCREPANCIES SHOULD BE REPORTED TO THE ENGINEER IMMEDIATELY.
9. THE CONTRACTOR SHALL TAKE ALL NECESSARY PRECAUTIONS TO PROTECT THE EXISTING UTILITIES AND MAINTAIN UNINTERRUPTED SERVICE AND ANY DAMAGE DONE TO THEM DUE TO HIS/HER NEGLIGENCE SHALL BE IMMEDIATELY AND COMPLETELY REPAIRED AT HIS/HER EXPENSE.
10. ALL EXCAVATIONS SHALL BE KEPT DRY AT ALL TIMES UNLESS OTHERWISE NOTED.
11. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY TEMPORARY UTILITIES, INCLUDING BUT NOT LIMITED TO: ELECTRIC, WATER, TELEPHONE AND SANITARY. THE CONTRACTOR SHALL BE RESPONSIBLE FOR SECURING ALL PERMITS, PAYMENT OF APPLICATION FEES AND COSTS OF INSTALLATION ASSOCIATED WITH OBTAINING NECESSARY UTILITY SERVICE.
12. THE CONTRACTOR SHALL BE RESPONSIBLE FOR SECURING THE CONSTRUCTION AREA.
13. THE EXISTING TREES AND SHRUBS SHALL BE PROTECTED BY THE CONTRACTOR TO ELIMINATE UNNECESSARY DAMAGE.
14. THE CONTRACTOR WILL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS REQUIRED FOR CONSTRUCTION PRIOR TO INITIATION OF WORK.
15. THESE PLANS ARE BASED ON INFORMATION AVAILABLE AT THE TIME THEY WERE PREPARED. ACTUAL CONDITIONS DETERMINED LATER MAY VARY. SOUND ENGINEERING JUDGMENT SHOULD BE EXERCISED DURING CONSTRUCTION TO ASSURE THAT THE DESIGN IS COMPATIBLE WITH THE ACTUAL CONDITIONS.
16. THE CONSTRUCTION SURVEY STAKING TO BE PROVIDED BY THE CONTRACTOR.

Rev.	Date	Description	By	Chk

DRAWN BY KB | CADD Review WM | CHECKED BY MB

JAYDEEP PARIKH
Professional Engineer
NY Lic. No. 088083
Date

ERM CONSULTING AND ENGINEERING, INC.

ERM®

LEICA INC.
60% SOUTHWEST CORNER IRM DESIGN
203 EGGERT ROAD
CHEEKTOWAGA, NEW YORK

GENERAL INFORMATION

SCALE	PROJECT NUMBER	DRAWING	REV.
AS SHOWN	0671863	GI001	0

DATE DRAWN MAY 2023

\\USBDCFS02\data\Philadelphia\Team\DMM\CAD\Drawings\Danaher\0671863\60% Design\0671863-02.03.dwg

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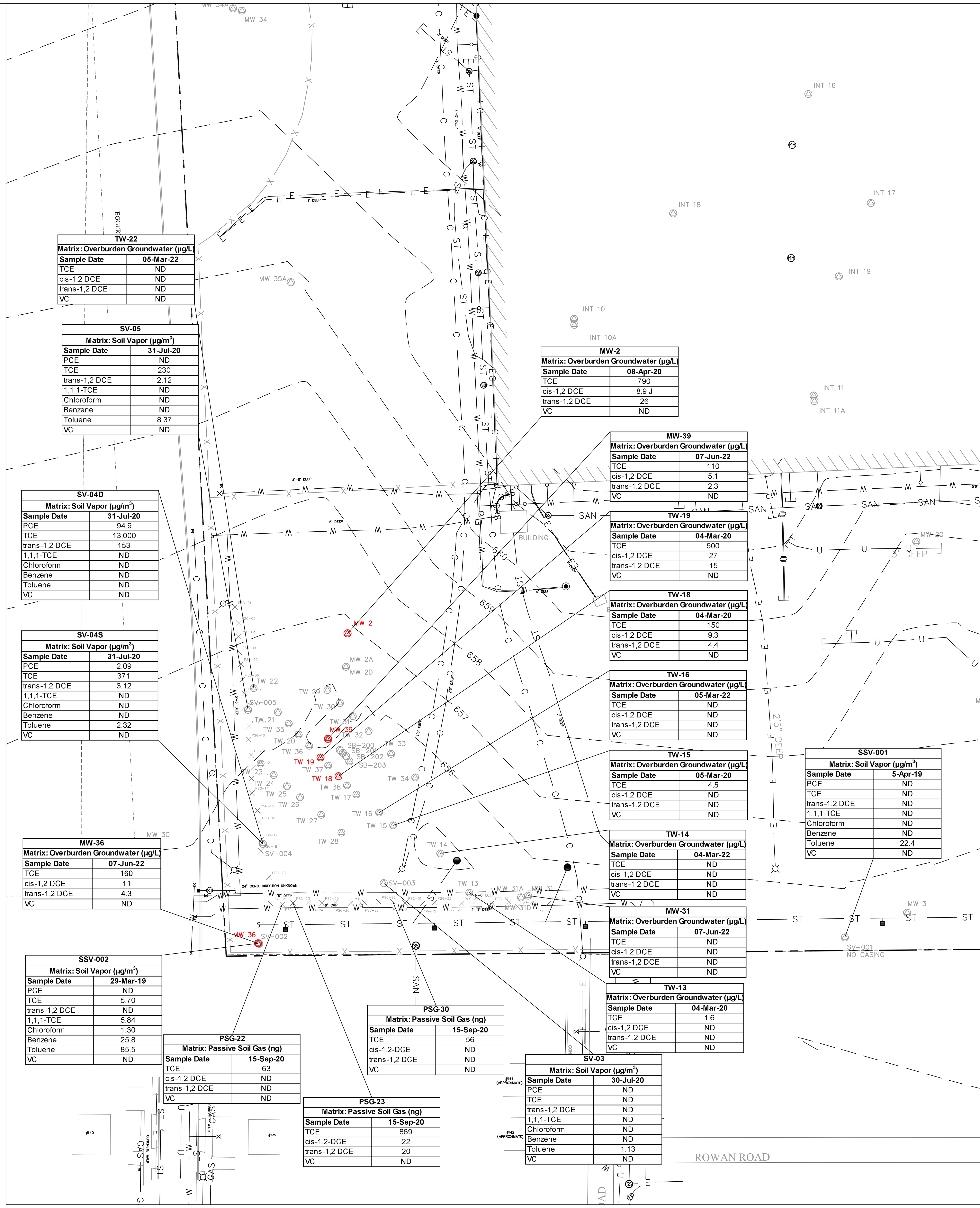


TW-22	
Matrix: Overburden Groundwater (µg/L)	
Sample Date	05-Mar-22
TCE	ND
cis-1,2 DCE	ND
trans-1,2 DCE	ND
VC	ND

SV-05	
Matrix: Soil Vapor (µg/m^3)	
Sample Date	31-Jul-20
PCE	ND
TCE	230
trans-1,2 DCE	2.12
1,1,1-TCE	ND
Chloroform	ND
Benzene	ND
Toluene	8.37
VC	ND

SV-04D	
Matrix: Soil Vapor (µg/m^3)	
Sample Date	31-Jul-20
PCE	94.9
TCE	13,000
trans-1,2 DCE	153
1,1,1-TCE	ND
Chloroform	ND
Benzene	ND
Toluene	ND
VC	ND

SV-04S	
Matrix: Soil Vapor (µg/m^3)	
Sample Date	31-Jul-20
PCE	2.09
TCE	371
trans-1,2 DCE	3.12
1,1,1-TCE	ND
Chloroform	ND
Benzene	ND
Toluene	2.32
VC	ND

MW-36	
Matrix: Overburden Groundwater (µg/L)	
Sample Date	07-Jun-22
TCE	160
cis-1,2 DCE	11
trans-1,2 DCE	4.3
VC	ND

SSV-002	
Matrix: Soil Vapor (µg/m^3)	
Sample Date	29-Mar-19
PCE	ND
TCE	5.70
trans-1,2 DCE	ND
1,1,1-TCE	5.84
Chloroform	1.30
Benzene	25.8
Toluene	85.5
VC	ND

PSG-22	
Matrix: Passive Soil Gas (ng)	
Sample Date	15-Sep-20
TCE	63
cis-1,2 DCE	ND
trans-1,2 DCE	ND
VC	ND

PSG-23	
Matrix: Passive Soil Gas (ng)	
Sample Date	15-Sep-20
TCE	869
cis-1,2-DCE	22
trans-1,2 DCE	20
VC	ND

PSG-30	
Matrix: Passive Soil Gas (ng)	
Sample Date	15-Sep-20
TCE	56
cis-1,2-DCE	ND
trans-1,2 DCE	ND
VC	ND

MW-2	
Matrix: Overburden Groundwater (µg/L)	
Sample Date	08-Apr-20
TCE	790
cis-1,2 DCE	8.9 J
trans-1,2 DCE	26
VC	ND

MW-39	
Matrix: Overburden Groundwater (µg/L)	
Sample Date	07-Jun-22
TCE	110
cis-1,2 DCE	5.1
trans-1,2 DCE	2.3
VC	ND

TW-19	
Matrix: Overburden Groundwater (µg/L)	
Sample Date	04-Mar-20
TCE	500
cis-1,2 DCE	27
trans-1,2 DCE	15
VC	ND

TW-18	
Matrix: Overburden Groundwater (µg/L)	
Sample Date	04-Mar-20
TCE	150
cis-1,2 DCE	9.3
trans-1,2 DCE	4.4
VC	ND

TW-16	
Matrix: Overburden Groundwater (µg/L)	
Sample Date	05-Mar-22
TCE	ND
cis-1,2 DCE	ND
trans-1,2 DCE	ND
VC	ND

TW-15	
Matrix: Overburden Groundwater (µg/L)	
Sample Date	05-Mar-20
TCE	4.5
cis-1,2 DCE	ND
trans-1,2 DCE	ND
VC	ND

TW-14	
Matrix: Overburden Groundwater (µg/L)	
Sample Date	04-Mar-22
TCE	ND
cis-1,2 DCE	ND
trans-1,2 DCE	ND
VC	ND

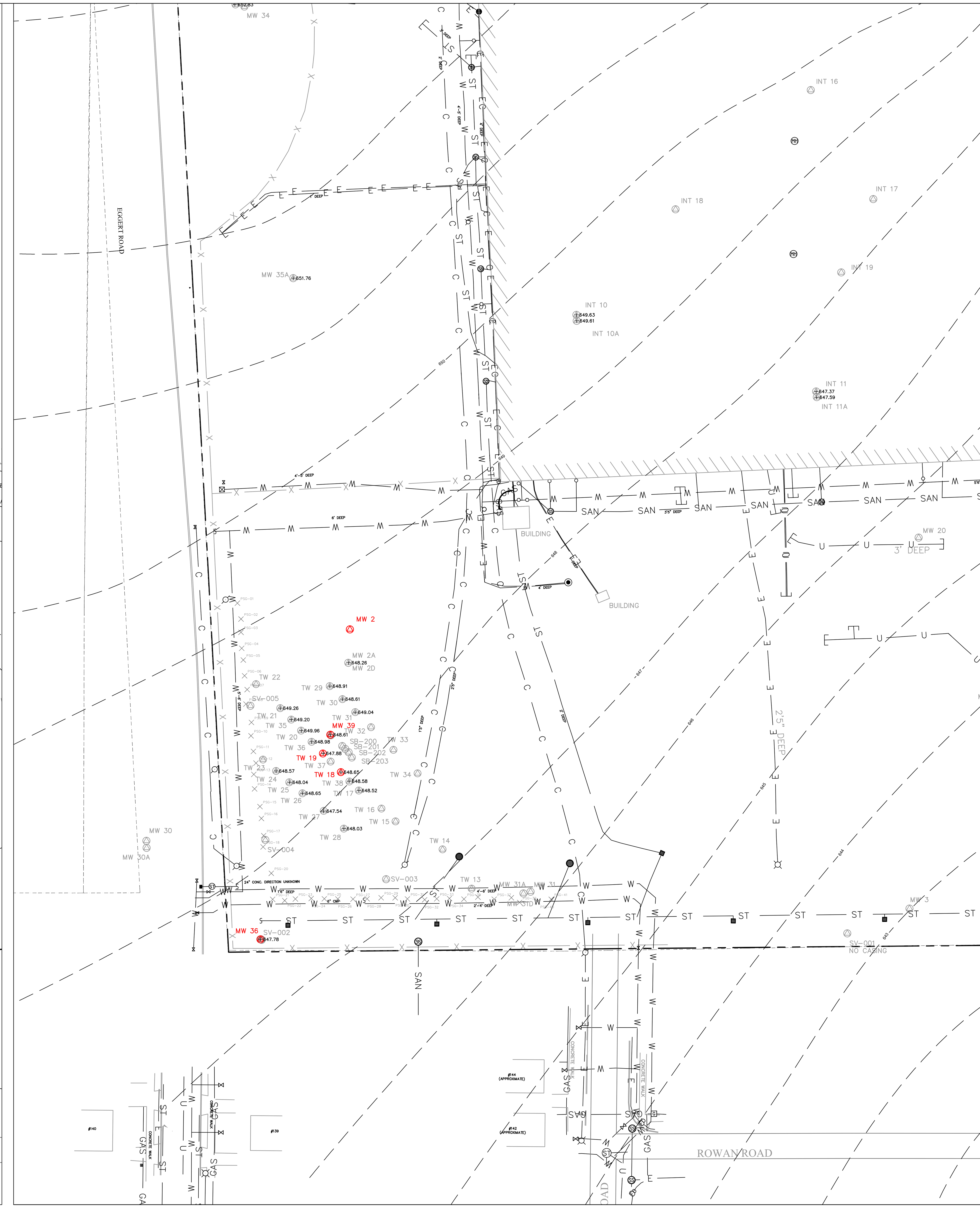
MW-31	
Matrix: Overburden Groundwater (µg/L)	
Sample Date	07-Jun-22
TCE	ND
cis-1,2 DCE	ND
trans-1,2 DCE	ND
VC	ND

TW-13	
Matrix: Overburden Groundwater (µg/L)	
Sample Date	04-Mar-20
TCE	1.6
cis-1,2 DCE	ND
trans-1,2 DCE	ND
VC	ND

SV-03	
Matrix: Soil Vapor (µg/m^3)	
Sample Date	30-Jul-20
PCE	ND
TCE	ND
trans-1,2 DCE	ND
1,1,1-TCE	ND
Chloroform	ND
Benzene	ND
Toluene	1.13
VC	ND

SSV-001	
Matrix: Soil Vapor (µg/m^3)	
Sample Date	5-Apr-19
PCE	ND
TCE	ND
trans-1,2 DCE	ND
1,1,1-TCE	ND
Chloroform	ND
Benzene	ND
Toluene	22.4
VC	ND

EXISTING GRADE CONTOURS



TOP OF BEDROCK CONTOURS

0 40 80
SCALE (IN FEET)

NOTES:

1. THE ANALYTICAL DATA SHOWN IS FROM THE DGI REPORT, THE DATA INCLUDES DETECTIONS AND NON-DETECT RESULTS. IF DATA IS NOT SHOWN, THE MONITORING WELL WAS DRY DURING THE SAMPLE EVENTS. THE FOLLOWING PASSIVE SOIL GAS SAMPLES WERE ANALYZED AND WERE THE RESULTS NON-DETECT: PSG-01, PSG-02, PSG-03, PSG-04, PSG-05, PSG-06, PSG-07, PSG-08, PSG-09, PSG-10, PSG-11, PSG-12, PSG-13, PSG-14, PSG-15, PSG-16, PSG-17, PSG-18, PSG-20, PSG-21, PSG-24, PSG-25, PSG-26, PSG-27, PSG-28, PSG-29, PSG-32, PSG-33, PSG-34, PSG-35, PSG-36, PSG-37, PSG-38, PSG-39, PSG-40, AND PSG-41. THE DETECTIONS ARE ONLY SHOWN ON THE DRAWING FOR CLARITY.

2. THE EXISTING GRADE SOURCE WAS DEVELOPED FROM GROUND ELEVATION DATA FROM THE WELL LOCATIONS SURVEYED BY NYLD INFRASTRUCTURE NEW YORK LEAK DETECTION INC.

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Rev.	Date	Description	By	Chk

JAYDEEP PARIKH — Date
Professional Engineer
NY Lic. No. 088083

DRAWN BY KB | CADD Review WM | CHECKED BY MB

ERM CONSULTING AND ENGINEERING, INC.

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LEICA INC.
60% SOUTHWEST CORNER IRM DESIGN

203 EGGERT ROAD
CHEEKTOWAGA, NEW YORK

EXISTING CONDITIONS

SCALE	PROJECT NUMBER	DRAWING	REV.
AS SHOWN	0671863	CS101	0
DATE DRAWN: MAY 2023			

JAYDEEP PARIKH
Professional Engineer
NY Lic. No. 088083

Date

Rev.	Date	Description	By	Chk

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ZERO VALENT IRON PERMEABLE REACTIVE BARRIER PLAN

SCALE	PROJECT NUMBER	DRAWING	REV.
AS SHOWN	0671863	CS102	0

DATE DRAWN
MAY 2023

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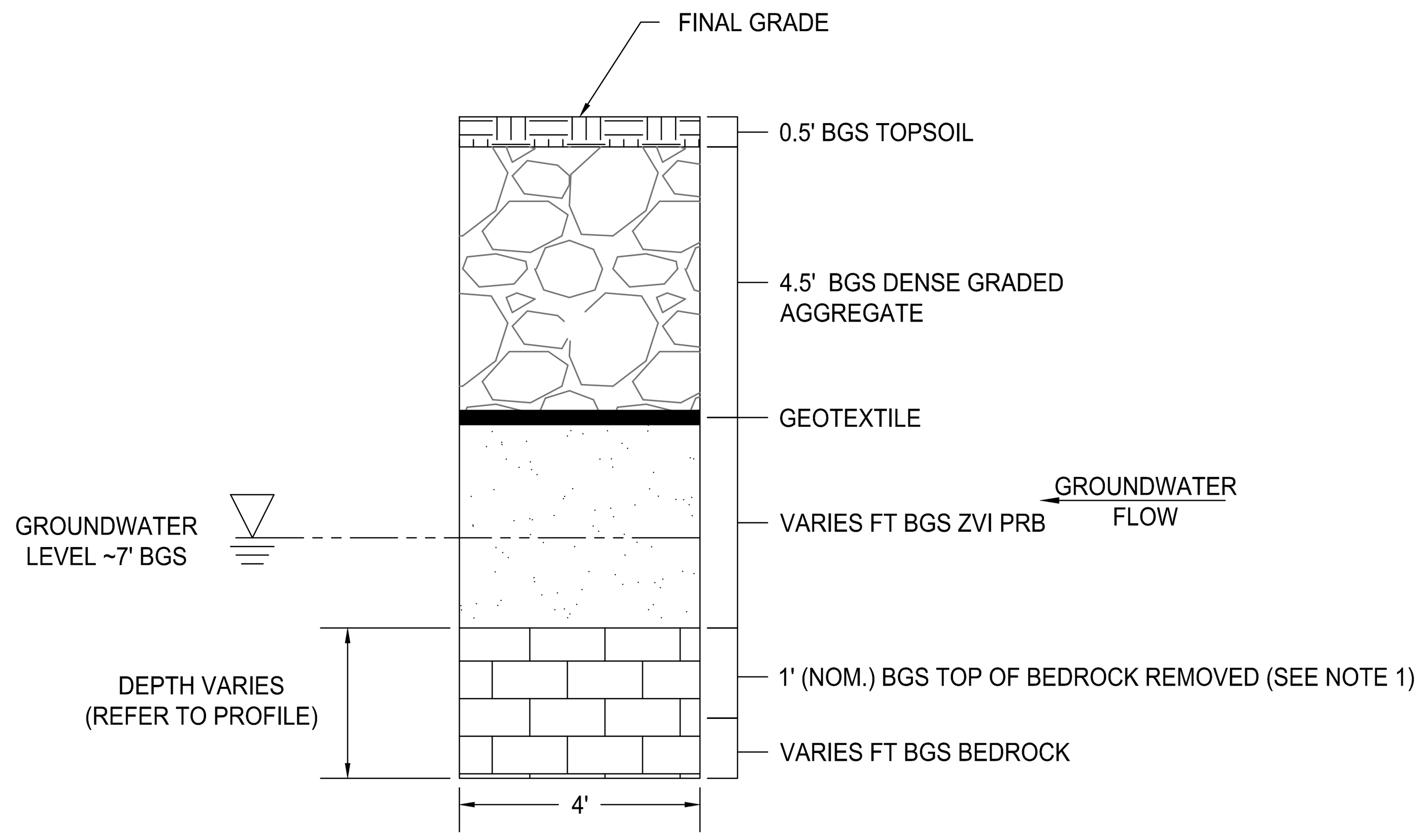

CS501 / C1 TYPICAL ZVI PRB TRENCH DETAIL

NOT TO SCALE

NOTES:

1. THE TRENCH SHALL EXTEND 12" (MAX 1.5') NOMINAL INTO BEDROCK WHERE PRACTICAL, OR TO THE DEPTH OF EXCAVATABLE BEDROCK IF LESS THAN THE NOMINAL DEPTH.

2. THE CONTRACTOR SHALL SUBMIT A WORK PLAN TO THE ENGINEER DESCRIBING THE APPROACH TO THE PROJECT, INCLUDING CONSTRUCTION OF THE TRENCH. CONTRACTOR IS RESPONSIBLE FOR PROPER SHORING, SLOPE LAYBACK, TEMPORARY BENCHES, AND AND AS OTHERWISE REQUIRED IN THE TECHNICAL SPECIFICATIONS AND AS DEFINED IN OSHA 1926.651.

REVISIONS TO BE MADE ON THE CADD FILE ONLY

Rev.	Date	Description	By	Chk

DRAWN BY KB | CADD Review WM | CHECKED BY MB

JAYDEEP PARIKH
Professional Engineer
NY Lic. No. 088083
Date

ERM

ERM CONSULTING AND ENGINEERING, INC.

LEICA INC.
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203 EGGERT ROAD
CHEEKTOWAGA, NEW YORK

DETAILS

SCALE	PROJECT NUMBER	DRAWING	REV.
AS SHOWN	0671863	CS501	0

DATE DRAWN: MAY 2023

APPENDIX B SUPPLEMENTAL PS DESIGN INFORMATION

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Memo

To	Leica, Inc.
From	ERM Consulting and Engineering, Inc.
Date	31 March 2023
Reference	0671863
Subject	Southwest Interim Remedial Measure Supplemental Design Information

1. INTRODUCTION

ERM Consulting and Engineering, Inc. (ERM) has prepared this memorandum for the Southwest Corner Interim Remedial Measure (IRM). The IRM consists of a zero-valent iron (ZVI) permeable reactive barrier (PRB) to be installed at the former Leica, Inc. (Leica) facility (the "Site") located at 203 Eggert Road in Cheektowaga, New York. The purpose of this memorandum is to summarize the evaluation of the effect of effect of geochemical constituents and design life of the proposed IRM.

1.1 Geochemistry / Potential Fouling

The major effect of geochemical constituents on ZVI-based PRBs involves the formation of precipitates (i.e., passivation) on the surface of the ZVI and non-targeted (scavenger) reactions. Surface passivation has been a contributor to decreased reactivity of ZVI and porosity of PRBs. Non-targeted reactions can consume ZVI that would otherwise ideally be consumed by the targeted constituent (i.e., TCE). The specific effects of sulfate, nitrate, and dissolved oxygen (DO) are discussed below. Any oxidation-reduction ("redox") sensitive geochemical constituent in an oxidized state could compete for the reactive surface area of the ZVI; however, Site-specific data discussed below suggest sulfate potentially represents the most influential geochemical constituent.

Sulfate, in the presence of more alkaline pH and low redox similar to the conditions anticipated in a ZVI PRB, can react to form iron sulfide that may precipitate out of groundwater. These precipitates may further transform to pyrite and/or marcasite (FeS_2), troilite and/or mackinawite (FeS), and sulfate green rust, and mainly accumulate on the surface of the ZVI along the upgradient face of the PRB. Similarly, DO and nitrate can create a passivation layer of hydrous ferric oxide ($FeHO_2$) and/or other mineral deposits. Well-established field studies suggest this leading-edge passivation poses a low risk to negatively impact an appropriately designed PRB. ZVI surface passivation and porosity clogging precipitation can increase macropore flow and decrease the groundwater residence time within the PRB. In consideration of the potential for passivation and mineral deposition, this design will include a ZVI-sand mixture to reduce the potential for pore clogging as well as a lower effective porosity (25 percent) to account for potential clogging over time.

Another form of ZVI passivation can occur by naturally occurring cations and anions becoming super saturated due to a change in pH because of the ZVI reactions. As ZVI oxidizes to ferrous iron (Fe^{2+}) and ferric iron (Fe^{3+}), the pH is anticipated to become more alkaline according to the following reactions:

$$2Fe^0_{(s)} + O_{2(g)} + 2H_2O_{(l)} \rightarrow 2Fe^{2+}_{(aq)} + 4OH^-_{(aq)}$$

$$Fe^0_{(s)} + 2H_2O_{(l)} \rightarrow Fe^{2+}_{(aq)} + H_{2(g)} + 2OH^-_{(aq)}$$

The resultant hydroxide (OH^-) typically achieves a pH between 7.5 and 9.0 standard units depending upon the buffering capacity of the aquifer. Calcium, silicon, carbonate, and other naturally occurring species can form precipitates under alkaline pH. A practical indication of the extent of dissolved cations and anions in groundwater is the specific conductivity. Field parameter data collected from MW-2, MW-30A, MW-31, MW-36, and MW-39 (proximal to the location of the PRB) suggest the specific conductivity in the southwestern portion of the Site is within the 100s to low 1,000s of microSiemens per centimeter (µS/cm), which suggests low total dissolved solids and indicates low anion and cation concentrations. This does not mean there are no other anions and cations, only that their presence appears to be minor and, as such, they will exert a minor influence on the ZVI in comparison to sulfate, nitrate, and DO.

The impacts of non-targeted reactions are addressed by using Site-specific DO, nitrate, and sulfate concentration data (as well as geochemical indicator parameters) proximal to the proposed PRB and determining the equivalent stoichiometric ZVI demand for their respective mass loadings (**Attachment A**). It is anticipated that the presence of sulfate, nitrate, and DO will consume some of the ZVI. This has been accounted for in the design by evaluating the total load of non-targeted and targeted (i.e., TCE) reactions. Specifically, for a sulfate concentration of 5 milligrams per liter (mg/L) at MW-2, a ZVI demand of approximately 0.02 tons over 30 years is calculated; for a nitrate concentration of 1.1 mg/L (MW-2), a ZVI demand of approximately 0.004 tons over 30 years is calculated; for a DO of near saturation (8 mg/L; range of field parameters suggest 0.16 to 7.43 mg/L from MW-2 and MW-39), a ZVI demand of approximately 5.6 tons over 30 years is calculated. Therefore, the most influential geochemical scavengers are expected to consume 5.6 tons of ZVI. These calculations and assumptions will be refined during the design process.

1.2 PRB Lifespan

A mass-to-mass ratio using the β-Elimination Reaction (**Attachment A**) and the following balanced chemical reactions were used to estimate the amount of ZVI that is needed to destroy TCE for a 30-year lifespan.

$$C_2HCl_3 + Fe^0 \rightarrow C_2\,HCl + 2Cl^- + Fe^{2+}$$

$$C_2HCl + Fe^0 + H^+ \rightarrow C_2H_2 + Cl^- + Fe^{2+}$$

$$C_2H_2 + Fe^0 + 2H^+ \rightarrow C_2H_4 + Fe^{2+}$$

Given the influent TCE mass loading to the PRB of ~0.09 pounds per day (lb/day), and assuming the β-Elimination Reaction is the primary mechanism for a lifespan of 30 years, approximately 970 lbs (approximately 0.5 tons) of ZVI are necessary in the PRB to treat TCE fluxing through the PRB over a 30-year period. The estimate of ZVI demand for the TCE is added to the estimate of expected geochemical scavenging (5.6 tons) to obtain approximately 6.86 tons of ZVI.

Based on an approximate unit weight of 160 pounds per cubic foot (lb/ft^3) for ZVI and 90 lb/ft^3 for sand, a 15 percent by dry weight ZVI to 85 percent by dry weight sand mixture for the PRB equates to 20 tons of ZVI. This is approximately 33 percent more than the conservative 6.1 tons of ZVI estimated for TCE and non-targeted reaction scavenging. As the design develops, the percentage of sand and ZVI will be evaluated.

ATTACHMENT A SUPPORTING INFORMATION

Ref. 1	Hydraulic Conductivity Extract from Conestoga-Rovers & Associates. 1994. Remedial Investigation / Feasibility Study Report, 2023 Field Data
Ref. 2	Groundwater Geochemical Parameters
Ref. 3	RE2E ZVI Excerpt, Remediation Engineering

Reference 1 Southwest Corner Hydraulic Conductivity

and were installed into the Onondaga Limestone Unit underlying the Site. Wells MW-2A, MW-5A, MW-6A, MW-13A, MW-14A, and MW-15A were installed prior to Round I groundwater sampling and wells MW-1A, MW-16A, and MW-17A were installed prior to Round III groundwater sampling. Stratigraphic and Instrumentation Logs for all Site monitoring wells are contained in Appendix B.

All new monitoring wells were developed prior to sampling. Well development records are contained in Appendix C. All wells were surveyed by a licensed land surveyor following their completion, and have been accurately plotted and presented on Plan 2 (attached). The top of casing and ground elevation were also surveyed and are presented in Table 4.2, with the monitoring well completion details.

4.1.2 Hydraulic Conductivity Testing

Rising head tests were conducted in ten of the 23 overburden wells and in eight of the nine bedrock wells to estimate the hydraulic conductivities of the overburden and bedrock hydrogeologic units. Water level changes were recorded manually using an electronic water level measurement tape.

The rising head test data calculations, using methods by Bower and Rice or Cooper et al, indicate the overburden sandy zone soils have a hydraulic conductivity range of 1.08E-05 cm/sec at MW-22 to 1.05E-02 cm/sec at MW-2. The bedrock exhibits a range of hydraulic conductivities of 9.33E-05 cm/sec at MW-5A to 1.80E-02 cm/sec at MW-14A. The hydraulic conductivity calculations are presented in Appendix D. Table 4.3 summarizes the results for each tested well.

4.1.3 Water Level Monitoring

Water level monitoring was performed on several occasions over a two year period from July 1992 to August 1994, including five

Well ID	Solution	k (cm/sec)	k (ft/day)	Notes:
MW-3	Bouwer-Rice	9.16E-05	2.62E-01	Rising Head
MW-31*	Bouwer-Rice	3.77E-05	1.08E-01	Rising Head

Notes:
1 cm/sec = 1/2834.65 ft/day
* MW-31 boring log not found. Assumued 5 ft screen unconfined aquifer

Classification	Effective Diameter (mm)	Hydraulic Conductivity (cm/s)		
		Minimum	Median	Maximum
Coarse pebble	16	15	30	60
Pebble	4	1	2	4
granule	2	2×10^{-1}	4×10^{-1}	9×10^{-1}
Very-coarse sand	1	6×10^{-2}	1×10^{-1}	2×10^{-1}
Coarse sand	1/2	2×10^{-2}	3×10^{-2}	5×10^{-2}
Medium sand	1/4	4×10^{-3}	7×10^{-3}	1×10^{-2}
Fine sand	1/8	9×10^{-4}	2×10^{-3}	3×10^{-3}
Very fine sand	1/16	2×10^{-4}	4×10^{-4}	9×10^{-4}
Medium silt	1/32	6×10^{-5}	1×10^{-4}	2×10^{-4}

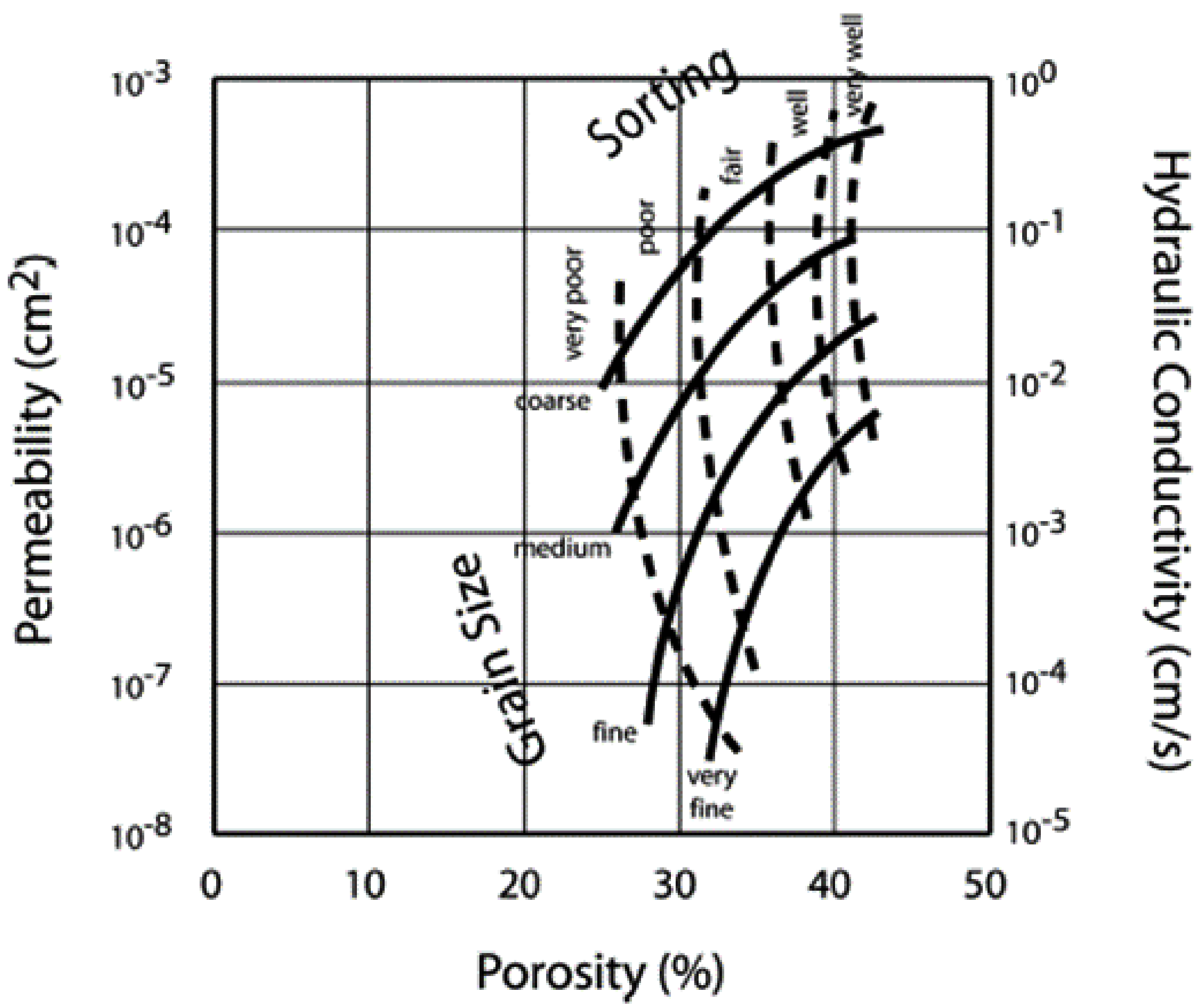

FIGURE 3.9 Conceptual relationship between porosity, permeability and particle sorting, for clay-free sand. Redrawn from Selly (1988).

Reference 2 Groundwater Geochemical Paramters

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	INT-10	INT-10A	INT-10A	INT-10A	INT-11A	INT-11A	INT-13	INT-13	INT-14	INT-14	INT-15	INT-18	INT-19	INT-2A	INT-2A
	Sample Date	13-May-19	13-May-19	21-Aug-19	30-Oct-19	13-May-19	21-Aug-19	08-Apr-20	08-Jun-22	30-Oct-19	08-Apr-20	14-May-19	14-May-19	30-Oct-19	14-May-19	22-Aug-19
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.43	0.19	0.25	0.45	0.26	0.20	11.98	NM	10.50	12.26	1.80	0.12	4.07	0.16	0.19
Oxidation-Reduction Potential, Field	mV	152.2	-30.70	-72.5	-84.4	-18	-145.8	108.9	NM	-24.8	107.1	165.4	178.9	18.1	-136.6	8.4
pH, Field	pH units	6.85	7.40	7.23	7.15	7.49	7.05	7.13	NM	7.04	6.99	6.99	6.86	6.95	7.05	6.76
Specific Conductivity	uS/cm	1.01	1.09	1,173	1,271	1,205	1,363	75	NM	0.009	671	1.03	1.00	0.813	1.18	1,306
Temperature, Field	deg C	14	14.60	16.0	15.65	13.52	17.6	13.71	NM	17.16	13.84	14.3	13.9	17.1	14.1	14.7
Turbidity, Field	NTU	2.19	7.72	23.8	2.48	32.90	28.8	NM	NM	NM	NM	1.18	1.48	NM	7.08	3.54

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	INT-2A	INT-2R	INT-2R	INT-2R	INT-2R	MW-1	MW-1	MW-10	MW-10	MW-100A	MW-100A	MW-11A	MW-13	MW-13A	MW-14
	Sample Date	08-Apr-20	14-May-19	30-Oct-19	08-Apr-20	07-Jun-22	14-May-19	07-Apr-20	16-May-19	08-Apr-20	28-Aug-19	07-Apr-20	08-Jun-22	16-Apr-20	17-Apr-20	16-May-19
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.75	7.12	9.42	9.34	4.61	0.41	11.43	0.27	2.29	0.19	0.07	NM	0.73	0.30	0.13
Oxidation-Reduction Potential, Field	mV	-84.5	148.8	1.2	96.9	74.2	-83.6	16.8	-79.4	-74.7	-358.5	-300.3	NM	-130.7	-52.9	-187.2
pH, Field	pH units	6.94	7.7	7.69	7.46	7.12	7.27	8.08	7.42	7	7.69	6.97	NM	6.95	6.87	7.12
Specific Conductivity	uS/cm	1,040	1.00	0.964	776	1,055	1,131	194.4	974	979	1,098	1,071	NM	767	828	2.14
Temperature, Field	deg C	14.13	13.8	16.74	13.77	15.00	10.55	11.00	10.13	7.02	14.7	10.1	NM	6.95	7.12	9.3
Turbidity, Field	NTU	0.00	1.82	NM	6.16	5.24	3.12	20.8	4.33	NM	20.4	2.89	NM	2.41	NM	4.15

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-14	MW-14	MW-14	MW-14	MW-14	MW-14	MW-14A	MW-14A	MW-14A	MW-15A	MW-16A	MW-16A	MW-16A	MW-16A	MW-16A
	Sample Date	28-Aug-19	16-Apr-20	13-Oct-20	23-Jun-21	27-Oct-21	27-Jul-22	16-May-19	28-Aug-19	16-Apr-20	08-Apr-20	14-May-19	27-Aug-19	16-Apr-20	24-Jun-21	07-Jun-22
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.26	1.84	0.46	0.31	1.06	0.38	0.07	0.71	0.49	0.00	0.17	3.10	0.57	4.19	0.22
Oxidation-Reduction Potential, Field	mV	-186.2	-118.9	-101.8	-93.9	-170	-104.8	-119.4	-204.8	-101.2	17.7	-127.9	-30.2	-84.5	-61.7	-97.8
pH, Field	pH units	7.78	7.09	7.42	7.03	6.8	7.2	6.86	7.15	6.93	9.35	7.57	7.2	7.65	7.29	7.26
Specific Conductivity	uS/cm	1,563	863	1,325	1,462	2,000	1,356	1.41	1.048	946	317.5	1.43	1.814	1,654	1,970	2,035
Temperature, Field	deg C	14.6	6.75	13.9	11.2	13.56	13.2	10.2	13.81	6.78	11.2	9.5	18.27	7.15	15.06	14.7
Turbidity, Field	NTU	8.63	4.13		1.39	66.3	7.25	4.52	29.8	2.01	46.4	3.1	10.9	3.87	9.5	3.81

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-16R	MW-16R	MW-16R	MW-17A	MW-18	MW-18	MW-18A	MW-18A	MW-18A	MW-19	MW-19	MW-19	MW-1A	MW-1A	MW-2
	Sample Date	14-May-19	27-Aug-19	16-Apr-20	07-Apr-20	15-May-19	16-Apr-20	15-May-19	27-Aug-19	16-Apr-20	15-May-19	27-Aug-19	08-Apr-20	30-Oct-19	07-Apr-20	15-May-19
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.49	3.03	0.81	0.40	0.34	1.17	2.58	0.27	5.86	0.61	2.24	13.95	0.23	0.26	4.10
Oxidation-Reduction Potential, Field	mV	-124.7	-127.3	-99	13.5	-77.2	-67.3	32.5	51.6	17.7	-70.3	-57	-29.5	-53.4	13.1	48.5
pH, Field	pH units	7.36	6.8	7.51	7.02	7.61	7.14	6.93	6.89	6.92	7.56	6.84	7.36	7.15	7.21	6.87
Specific Conductivity	uS/cm	2.22	5653	3,202	852	962	1,042	1,215	1,508	2,488	758	693	636.3	1.247	1,452	0.62
Temperature, Field	deg C	9.7	16.4	7.72	10.2	10.24	8.17	10.78	15	8.97	13.49	19.7	10.6	13.61	11.7	8.6
Turbidity, Field	NTU	1.93	40.1	3.09	96	3.64	1.22	3.71	4.68	2.91	3.32	12.9	3.28	10	18.9	4.23

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-2	MW-2	MW-20	MW-21	MW-21A	MW-21A	MW-22	MW-22	MW-22	MW-22A	MW-22A	MW-22A	MW-23	MW-23	MW-23
	Sample Date	29-Oct-19	08-Apr-20	09-Apr-20	09-Apr-20	26-Nov-19	09-Apr-20	16-May-19	28-Aug-19	16-Apr-20	16-May-19	28-Aug-19	16-Apr-20	17-May-19	17-Apr-20	24-Jun-21
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.65	1.90	0.45	1.78	0.61	1.78	0.30	3.07	0.27	0.21	0.31	0.22	0.33	3.64	0.72
Oxidation-Reduction Potential, Field	mV	18.2	-210.4	742.3	861.3	85.6	141.4	-211.9	-109.4	-238.2	-337.9	-374.9	-332.8	-152.1	-9.4	-160.3
pH, Field	pH units	6.95	6.99			7.51	7.39	6.93	7.14	7	6.91	7.92	7	8.37	7.58	7.62
Specific Conductivity	uS/cm	0.811	485	1,954	3,322	2.131	2,518	2.75	1.974	1,169	0.78	759	566	621	433	732
Temperature, Field	deg C	14.74	8.18	9.4	9.4	14.9	12	9	14.73	7.52	10.5	13.7	9.49	9.53	7.32	12
Turbidity, Field	NTU	3.43	6.49	1.49	11.35	1.83	3.92	5.28	42.0	2.06	2.39	10.8	1.24	2.39	4.8	NM

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-23	MW-23	MW-24	MW-24	MW-24A	MW-24A	MW-24A	MW-24A	MW-24A	MW-25	MW-25	MW-25	MW-25	MW-25	MW-25
	Sample Date	27-Oct-21	27-Jul-22	20-May-19	07-Apr-20	20-May-19	22-Aug-19	07-Apr-20	24-Jun-21	07-Jun-22	17-May-19	26-Aug-19	06-Apr-20	14-Oct-20	21-Jun-21	25-Oct-21
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	11.68	2.51	0.50	0.97	0.31	0.22	0.69	0.26	0.36	1.57	0.89	1.25	0.55	8.21	0.58
Oxidation-Reduction Potential, Field	mV	-113	-139.1	-159.8	-29.7	-128.4	-104	-110.8	13.4	-100.7	40.8	150.2	86.6	-39.4	73.5	-128
pH, Field	pH units	7.32	7.49	7.03	7.05	7.71	7.08	7.17	6.77	6.94	6.96	6.86	6.5	7.05	7.08	6.97
Specific Conductivity	uS/cm	1,010	765	1.04	774	1.13	1,610	1,098	1,567	1,467	1.14	1.15	1,087	978	1,117	1,158
Temperature, Field	deg C	12.5	13.7	13.2	12.92	13.94	15.2	13.37	13.61	13.8	10.8	16.24	8.7	15.8	13.7	16
Turbidity, Field	NTU	181	NM	3.42	1.19	26.8	3.83	3.29	3.2	5.68	11.9	2.12	0.98		0.9	2.99

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-25	MW-25A	MW-25A	MW-25A	MW-25A	MW-25A	MW-25A	MW-25A	MW-26	MW-26	MW-26	MW-26	MW-26	MW-26	MW-26
	Sample Date	07-Jun-22	17-May-19	26-Aug-19	06-Apr-20	14-Oct-20	21-Jun-21	25-Oct-21	06-Jun-22	20-May-19	26-Aug-19	06-Apr-20	14-Oct-20	21-Jun-21	26-Oct-21	07-Jun-22
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.43	0.42	0.25	0.02	0.46	0.07	0.18	0.43	2.12	0.66	1.93	0.94	0.17	1.93	0.24
Oxidation-Reduction Potential, Field	mV	84.6	-241.1	-179.8	-197.2	-174.3	-262.5	-147.1	-160.2	-11.2	11.8	38.3	-34.4	-55.2	-14	-89.9
pH, Field	pH units	6.78	7.55	7.27	7.05	7.71	7.91	6.93	6.73	7.35	7.13	7.59	7.56	7.09	6.91	7.12
Specific Conductivity	uS/cm	1,018	0.64	565.7	484.3	438.4	697	918	877	0.98	985	1,183	820	1,890	980	1,455
Temperature, Field	deg C	12.5	10.6	13.8	11.2	13.6	12.5	14.2	12.3	11.2	18.2	8	17.8	16.8	15.7	13.9
Turbidity, Field	NTU	2.87	24.3	11.5	16.5	6.2	32.6	4.24	3.68	4.55	3.56	10.3	6	2.12	2.44	4.12+DC19

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-26A	MW-26A	MW-26A	MW-26A	MW-26A	MW-26A	MW-26A	MW-27	MW-27	MW-27	MW-27	MW-27	MW-27	MW-27	MW-27A
	Sample Date	20-May-19	26-Aug-19	08-Apr-20	14-Oct-20	22-Jun-21	26-Oct-21	07-Jun-22	20-May-19	26-Aug-19	06-Apr-20	14-Oct-20	22-Jun-21	26-Oct-21	07-Jun-22	20-May-19
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.26	0.17	0.86	0.30	0.04	0.00	0.50	2.83	4.73	1.66	0.99	1.87	6.85	0.59	0.42
Oxidation-Reduction Potential, Field	mV	-230.2	-244.7	-128.6	-245.3	-277.8	-271.1	-250.8	102.3	70.2	26.8	36	176.8	38.4	115.5	-214.2
pH, Field	pH units	8.92	8.18	7.68	7.83	8.21	7.52	8.08	7.03	7.12	7.26	7.49	7.28	7.15	7.25	8.09
Specific Conductivity	uS/cm	0.24	0.369	893	802	829	753	763	1.14	2,356	1,901	1,796	2,031	1,539	2,500	0.55
Temperature, Field	deg C	11.61	14.86	9.41	15.17	12.7	14.4	12.3	10.48	17.6	9.19	17.2	13.7	14.8	12.9	11.7
Turbidity, Field	NTU	7.16	3.6	15.6		12.25	2.14	25.5	4.36	1.4	1.51		1.44	2.86	2.03	85

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-27A	MW-27A	MW-27A	MW-27A	MW-27A	MW-27A	MW-28	MW-28	MW-28	MW-28	MW-28	MW-28	MW-28	MW-28A	MW-28A
	Sample Date	26-Aug-19	06-Apr-20	14-Oct-20	22-Jun-21	26-Oct-21	07-Jun-22	17-May-19	23-Aug-19	06-Apr-20	14-Oct-20	21-Jun-21	26-Oct-21	06-Jun-22	17-May-19	23-Aug-19
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.18	0.30	0.55	0.03	0.13	0.05	0.21	0.36	0.04	0.39	0.37	0.00	0.17	0.08	0.15
Oxidation-Reduction Potential, Field	mV	-187.9	-13.9	-229.2	-232.6	-320.1	-278.8	-13.1	-57.5	18.5	-68.7	107.2	-164.5	5.7	-201.6	-192.7
pH, Field	pH units	8.03	8.25	7.99	8.33	8.26	8.43	7.33	6.73	7.1	7.48	6.77	7.04	7.26	8.29	7.71
Specific Conductivity	uS/cm	0.543	599	576.8	696	689	653	787	0.95	827	614	686	725	894	738	855
Temperature, Field	deg C	14.99	11.25	16.2	13.5	14.5	13.3	11.48	18.64	10	17.9	15.23	15.5	13.8	13.39	15
Turbidity, Field	NTU	330	31.8	3.23	NM	17.7	26.9	3.23	5.82	0.93	5.11	2.2	1.09	4.15	10.77	21.9

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-28A	MW-28A	MW-28A	MW-28A	MW-28A	MW-29	MW-29	MW-29	MW-29	MW-29	MW-29	MW-29	MW-29A	MW-29A	MW-29A
	Sample Date	06-Apr-20	14-Oct-20	21-Jun-21	25-Oct-21	06-Jun-22	17-May-19	23-Aug-19	07-Apr-20	14-Oct-20	21-Jun-21	25-Oct-21	06-Jun-22	17-May-19	23-Aug-19	08-Apr-20
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.00	0.51	0.32	0.00	0.06	0.75	0.09	0.41	0.46	1.54	2.23	2.91	0.69	1.39	0.26
Oxidation-Reduction Potential, Field	mV	-208.9	-225.9	96.8	-219.6	-241.5	-82.4	-218.3	15.9	-74.1	113.6	29.1	103.8	-266.2	-19.7	-84.3
pH, Field	pH units	7.8	8.1	7.82	7.53	8.07	7.24	8.44	7.25	7.61	6.54	7.04	6.81	8.41	7.21	7.85
Specific Conductivity	uS/cm	804	561.4	607	900	848	1.32	422	1,462	1,018	1,517	1,597	2,240	0.45	1,235	401.7
Temperature, Field	deg C	11.9	15.2	14.22	15.3	13.3	10.8	16.7	10.3	18.1	14.74	17.4	14	11.9	17.1	12.4
Turbidity, Field	NTU	13.1	8.08	40.1	9.87	71.5	8.47	45.8	2.74	9.68	10	5.28	3.54	19.2	10	13.8

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-29A	MW-29A	MW-29A	MW-2A	MW-2A	MW-2D	MW-2D	MW-3	MW-3	MW-30A	MW-30A	MW-30A	MW-31	MW-31	MW-31
	Sample Date	14-Oct-20	21-Jun-21	25-Oct-21	15-May-19	20-Aug-19	29-Oct-19	08-Apr-20	28-Aug-19	09-Apr-20	16-May-19	20-Aug-19	09-Apr-20	15-May-19	20-Aug-19	09-Apr-20
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.25	0.46	0.13	0.16	0.32	0.24	0.79	2.85	0.39	0.21	0.31	0.47	1.94	0.22	0.32
Oxidation-Reduction Potential, Field	mV	-287.4	110.8	-284.4	-149.1	-62.4	-200.1	-231.4	104.6	32.4	-77.6	-90.6	-68.7	56.2	-93	36.9
pH, Field	pH units	7.74	8.6	8.04	7.07	7.17	7.15	6.98	7.06	7.14	7.73	7.31	7.46	6.94	7.16	7.15
Specific Conductivity	uS/cm	256.9	1,128	387.2	0.84	0.596	1.325	887	0.763	1,852	2,616	1.909	2,367	0.69	5,663	697
Temperature, Field	deg C	17.7	14.88	17.6	9.4	16.66	12.8	11	21.49	9.9	10.19	14.4	10.23	10.9	18.3	7.18
Turbidity, Field	NTU		57	5.1	1.68	1.72	13.1	1.2	3.93	7.24	12.3	4.33	1.98	2.06	2.51	2.08

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-31	MW-31	MW-31A	MW-31A	MW-31D	MW-31D	MW-31D	MW-31D	MW-33	MW-33	MW-33A	MW-33A	MW-33A	MW-33A	MW-33A
	Sample Date	22-Jun-21	07-Jun-22	15-May-19	20-Aug-19	29-Oct-19	09-Apr-20	22-Jun-21	07-Jun-22	30-Oct-19	26-Oct-21	28-Oct-19	09-Apr-20	12-Oct-20	24-Jun-21	26-Oct-21
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	2.63	4.05	0.15	0.19	0.17	0.14	0.74	0.49	0.61	2.54	1.09	0.26	1.70	0.30	0.13
Oxidation-Reduction Potential, Field	mV	46.5	-213.8	-173.6	-112.6	-253.8	-335.7	-146.7	-345	4.4	10.2	-159.8	-93.8	-123.8	65.7	-240
pH, Field	pH units	6.96	7.07	7.33	7.18	7.27	7.21	7.44	7.3	7.62	7.07	7.25	7.48	7.54	7.15	7.14
Specific Conductivity	uS/cm	777	823	0.79	681	1.34	1,161	946	1,050	0.746	754	1.375	1,087	1,204	1,350	1,146
Temperature, Field	deg C	13.23	11.8	10.9	15.1	14	10.36	12.58	13.9	16.08	14.7	14.16	12.03	14.2	14.36	13.1
Turbidity, Field	NTU	14.6	2.65	14.2	2.08	3.74	3.22	1.3	1.17	8.92	7.02	23.9	0	6.09	11	2.7

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-33A	MW-34	MW-34	MW-34	MW-34	MW-34	MW-34	MW-34A	MW-34A	MW-34A	MW-34A	MW-34A	MW-34A	MW-35A	MW-35A
	Sample Date	08-Jun-22	28-Oct-19	09-Apr-20	13-Oct-20	22-Jun-21	26-Oct-21	07-Jun-22	28-Oct-19	08-Apr-20	12-Oct-20	22-Jun-21	26-Oct-21	07-Jun-22	29-Oct-19	09-Apr-20
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.26	2.22	0.54	1.62	0.44	0.00	NM	1.34	2.17	1.96	0.04	0.03	0.34	0.17	0.60
Oxidation-Reduction Potential, Field	mV	-157.8	19.9	-55.8	12.6	134.2	-144.3	NM	-105.6	-418.3	-116.4	-150.6	-232.6	-199.2	-10.7	-134.9
pH, Field	pH units	7.21	7.85	7.61	7.65	8.08	7.51	NM	6.94	6.92	7.32	7.07	6.76	6.96	6.96	7.42
Specific Conductivity	uS/cm	1,260	2.615	1,479	2,830	2,199	2,794	NM	1.667	1,140	1,356	1,397	1,455	1,472	1.63	1,149
Temperature, Field	deg C	15.3	17.1	8.03	18.6	15.1	16.6	NM	14.65	12.28	14.6	13.3	13.7	13.9	15.4	10.3
Turbidity, Field	NTU	9.01	2.36	0	13.2	4.07	3.45	NM	3.8	4.29	NM	1.44	3.49	0.83	2.22	0

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-35A	MW-35A	MW-35A	MW-35A	MW-36	MW-36	MW-36	MW-36	MW-36	MW-36	MW-37	MW-37A	MW-37A	MW-37A	MW-37A
	Sample Date	13-Oct-20	24-Jun-21	27-Oct-21	08-Jun-22	30-Oct-19	09-Apr-20	13-Oct-20	22-Jun-21	26-Oct-21	07-Jun-22	27-Oct-21	07-Apr-20	12-Oct-20	24-Jun-21	27-Oct-21
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	2.99	0.38	0.20	0.33	0.71	4.46	4.29	4.62	1.65	6.38	1.62	0.69	0.81	0.69	0.00
Oxidation-Reduction Potential, Field	mV	-62	13.2	-116.6	-82.7	59.9	0.1	-183	-9	12.1	90	62.5	63.5	-62.7	-6.8	-111
pH, Field	pH units	7.45	6.91	6.82	6.94	6.92	7.39	7.79	7.77	6.8	6.77	6.86	8.19	7.32	6.89	6.81
Specific Conductivity	uS/cm	1,921	1,605	1,330	1,583	0.872	489	846	617	590	504	547	1,676	1,504	2,315	1,596
Temperature, Field	deg C	14	12.83	14.7	12.5	15.54	8.42	17	15.12	16	13.9	15.2	10.71	13.4	12.49	13.5
Turbidity, Field	NTU	6.04	3.46	1.42	2.17	44.5	2.23	8.09	59.8	3.61	3.95	4.34	5.66	8.91	1.87	3.97

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-37A	MW-38	MW-38	MW-38A	MW-38A	MW-38A	MW-38A	MW-38A	MW-39	MW-39	MW-4	MW-40A	MW-40A	MW-40A	MW-40A
	Sample Date	08-Jun-22	08-Apr-20	27-Oct-21	07-Apr-20	12-Oct-20	24-Jun-21	27-Oct-21	08-Jun-22	26-Oct-21	07-Jun-22	08-Apr-20	02-Sep-20	12-Oct-20	24-Feb-21	22-Jun-21
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.22	2.38	5.53	2.90	0.22	2.57	0.56	6.66	3.08	7.43	0.95	0.19	0.13	0.93	0.20
Oxidation-Reduction Potential, Field	mV	-77	49.3	50.5	83.4	-93.1	-84	-110.2	-97.4	27.6	78.2	-22.8	-307.2	-326.2	-220.3	-41.2
pH, Field	pH units	6.98	7.23	6.93	7.21	7.5	7.04	7.04	7.18	6.75	6.98	6.85	6.87	7.16	7.37	7.08
Specific Conductivity	uS/cm	2,684	526	709	978	1,254	1,517	1,163	1,223	608	793	744	980	1,265	941	1,326
Temperature, Field	deg C	12.4	9	16.5	11.16	14	13.05	14	12.1	14.7	12.3	7.25	12	12.7	10.85	11.62
Turbidity, Field	NTU	1.75	1.34	0.97	2.43	6.48	25.9	1.17	5.59	49.6	NM	4.2	7.1		6.34	4.14

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-40A	MW-40A	MW-41A	MW-41A	MW-41A	MW-41A	MW-41A	MW-41A	MW-42A	MW-42A	MW-42A	MW-42A	MW-42A	MW-42A	MW-43A
	Sample Date	26-Oct-21	06-Jun-22	02-Sep-20	12-Oct-20	24-Feb-21	22-Jun-21	26-Oct-21	07-Jun-22	02-Sep-20	13-Oct-20	24-Feb-21	21-Jun-21	26-Oct-21	07-Jun-22	11-Sep-20
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	4.90	0.10	4.51	6.43	0.14	0.16	5.04	0.14	8.21	0.28	0.83	0.82	4.69	0.15	0.47
Oxidation-Reduction Potential, Field	mV	-333	-270.5	-222	-291.9	-194.8	-152.2	-307	-158.8	-139.9	-191.8	-73.1	-126.1	-307	-140.6	-380.6
pH, Field	pH units	7.34	7.02	6.57	6.86	6.99	6.81	7.35	6.82	6.7	7.02	7.31	7.17	7.49	6.83	7.47
Specific Conductivity	uS/cm	1,440	1,303	1,100	1,476	1.3	1,543	1,730	1,554	900	1,517	1,334.00	1.2	1,610	1,658	2,287
Temperature, Field	deg C	11.26	12.4	11.8	12.8	10.11	12.79	13.94	11.5	11.3	11.7	10.75	11.9	11.15	11.4	11.3
Turbidity, Field	NTU	1.95	1.28	990	7.84	7.42	1.04	2.77	0.73	7.19	NM	21.8	0.93	3.97	1.26	-60

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-43A	MW-43A	MW-43A	MW-43A	MW-43A	MW-44	MW-44	MW-44	MW-44	MW-44A	MW-44A	MW-44A	MW-44A	MW-44A	MW-44A
	Sample Date	13-Oct-20	24-Feb-21	21-Jun-21	26-Oct-21	08-Jun-22	10-Feb-21	23-Jun-21	25-Oct-21	08-Jun-22	02-Sep-20	22-Oct-20	24-Feb-21	22-Jun-21	26-Oct-21	08-Jun-22
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	1.20	0.49	0.00	6.70	0.20	3.75	0.39	8.29	0.30	0.59	0.22	0.82	0.02	9.66	0.59
Oxidation-Reduction Potential, Field	mV	-358.2	-355.7	-289.9	-344	-357.4	-133.6	45.3	115	12.2	-290	-208.3	-174.2	-212	-132	-255.8
pH, Field	pH units	6.81	7.12	6.78	7.53	6.79	6.75	6.56	8.36	6.5	6.54	7	7.91	6.89	7.73	6.95
Specific Conductivity	uS/cm	2,918	2,344.00	2,315	2,810	2,485	794	1,165	1,230	1,169	10,700	1,056	1,160.00	1,752	1,610	1,630
Temperature, Field	deg C	13.4	10.26	14.98	11.36	11.8	5.5	13.15	13.71	12.5	17.1	11.5	10.89	16.06	11.61	12.8
Turbidity, Field	NTU	8.01	8.42	6.43	6.61	1.45	14.8	9.1	6.18	5.54	-56	8.78	42.7	6.41	4.67	3.12

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-45A	MW-45A	MW-45A	MW-45A	MW-45A	MW-45A	MW-47	MW-48	MW-49	MW-5	MW-5	MW-5	MW-50	MW-51	MW-52
	Sample Date	11-Sep-20	22-Oct-20	24-Feb-21	22-Jun-21	26-Oct-21	08-Jun-22	26-Jul-22	26-Jul-22	08-Jun-22	16-May-19	20-Aug-19	07-Apr-20	08-Jun-22	27-Jul-22	26-Jul-22
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.45	0.15	0.55	0.29	7.85	3.41	0.17	1.50	0.27	0.82	0.19	0.33	0.24	3.73	0.22
Oxidation-Reduction Potential, Field	mV	-308.6	-217.3	-250.11	-52.4	-149	-157.9	0.2	74.2	-118.1	-114.2	-94.3	-115.2	-142.4	59	30
pH, Field	pH units	7.74	6.98	6.85	6.91	7.74	6.84	6.94	7.32	6.89	7.38	7.8	7.79	6.95	7.37	6.99
Specific Conductivity	uS/cm	1,181	1,044	1,575.00	1,716	1,570	1,691	1,461	1.09	1,262	0.99	0.734	885	1,052	1.33	1,278
Temperature, Field	deg C	12.1	12.2	11.28	15.93	12.38	13	13.6	13	11.5	11.7	17.94	8.83	11.3	13.7	13.7
Turbidity, Field	NTU	8.21	8.98	6.21	4.33	2.2	1.09	7.9	366	35	2.56	13.8	NM	53	NM	6.2

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-53	MW-54	MW-5A	MW-5A	MW-5A	MW-6	MW-6	MW-6	MW-6A	MW-6A	MW-6A	MW-6A	MW-6A	MW-7	MW-9
	Sample Date	26-Jul-22	26-Jul-22	15-May-19	20-Aug-19	07-Apr-20	15-May-19	27-Aug-19	08-Apr-20	16-May-19	27-Aug-19	08-Apr-20	22-Jun-21	07-Jun-22	09-Apr-20	09-Apr-20
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.52	0.22	0.09	0.09	0.17	0.44	1.81	10.15	0.20	0.12	0.05	0.57	1.80	3.64	2.57
Oxidation-Reduction Potential, Field	mV	54.9	-11.9	-206.7	-154.5	133.9	-18.4	-16.8	21.5	-57.7	-43.3	590.1	8.2	-74	-132.9	-153.2
pH, Field	pH units	6.92	7.22	7.43	7.35	7.27	7.46	7.36	7.8	7.26	6.28		6.97	7.07	7.38	8.22
Specific Conductivity	uS/cm	1,427	1.59	0.96	808	1,026	1,075	1.118	1,034	1,079	1,146	1,147	1,197	1,206	2,763	506
Temperature, Field	deg C	15.7	14	12.2	15.9	10.71	10.33	16.8	10.2	12.03	13.6	11.1	11.93	12.2	8.7	5.84
Turbidity, Field	NTU	7.5	NM	6.56	3.79	9.2	3.22	2.5	1.06	NM	2.16	0.77	3.6	3.06	49	NM

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	MW-9A	TW-01	TW-01	TW-02	TW-02	TW-03	TW-03	TW-04	TW-04	TW-05	TW-05	TW-06	TW-06	TW-07	TW-07
	Sample Date	09-Apr-20	03-Oct-19	24-Jun-21	03-Oct-19	23-Jun-21	04-Oct-19	23-Jun-21	03-Oct-19	23-Jun-21	04-Oct-19	23-Jun-21	04-Oct-19	23-Jun-21	02-Oct-19	30-Oct-19
Geochemical Parameters, Method FIELD																
Dissolved Oxygen, Field	mg/L	0.26	2.70	0.57	4.10	0.38	6.24	4.00	2.31	0.91	1.25	6.59	4.14	3.18	5.73	0.99
Oxidation-Reduction Potential, Field	mV	-141.3	76.7	-179.4	116	50.8	90.5	78.6	-82.3	50.2	-147.6	-61.8	-33.4	-63.8	209.3	46.1
pH, Field	pH units	7.59	7.15	7.08	7.14	7.12	6.97	6.78	6.97	6.7	7.28	6.65	6.77	6.89	7.32	6.75
Specific Conductivity	uS/cm	416	1.839	815	2.072	1,445	1.717	657	3.092	991	1.944	760	1.797	1,071	0.99	1.268
Temperature, Field	deg C	8.12	13.3	11.1	14.4	12.9	14.4	12.6	13.7	11	14.1	11.63	12.9	11.04	15.7	13.44
Turbidity, Field	NTU	6	410	10.67	14.4	0.75	800	NM	176	4.72	NM	NM	430	38.1	6.48	1.11

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Table 4
Groundwater Geochemical Parameters
Former Leica Microsystems - Cheektowaga Facility
Cheektowaga, New York

	Location ID	TW-07	TW-08	TW-08	TW-09	TW-09	TW-10	TW-10	TW-11	TW-11	TW-12	TW-12
	Sample Date	23-Jun-21	04-Oct-19	23-Jun-21	29-Oct-19	23-Jun-21	03-Oct-19	23-Jun-21	29-Oct-19	23-Jun-21	04-Oct-19	24-Jun-21
Geochemical Parameters, Method FIELD												
Dissolved Oxygen, Field	mg/L	0.17	6.48	1.42	1.12	2.09	1.70	1.48	1.06	1.53	4.58	1.68
Oxidation-Reduction Potential, Field	mV	-104.6	190.4	-67.3	-78.5	-66.8	-108.2	-59.2	1.8	-70.2	73.5	92.4
pH, Field	pH units	6.75	6.72	6.75	7.08	6.93	6.99	6.61	7.08	6.99	6.89	6.73
Specific Conductivity	uS/cm	1,352	1	1,093	1.445	1,254	1.758	1,027	1.37	1,911	1.518	748.8
Temperature, Field	deg C	12.4	12.8	10.07	13.26	11.75	14.2	12.95	13.11	10.88	14.7	13.2
Turbidity, Field	NTU	1.12	15	14.5	33	35.7	640	81.1	15.5	33.6	NM	NM

Notes:
mg/L = milligrams per liter
mV = millivolts
pH units = pH units
uS/cm = microSiemens per centimeter
deg C = degrees Celsius
NTU = nephelometric turbidity units
NM = Not Measured

Reference 3 **RE2E ZVI Excerpt, Remediation Engineering**

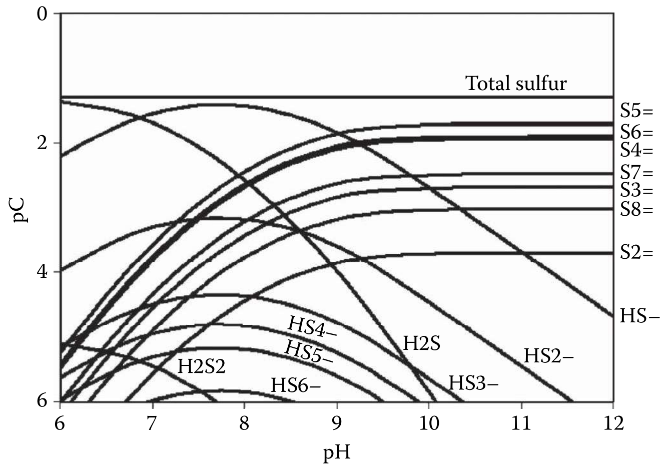

FIGURE 6.86 Concentration of different sulfide (S^{2-}) and polysulfide (S_x^{2-}) species in oversaturated solution of 50 mM polysulfide precursor (K_2S_5) as a function of pH (I = 0.3).[328]

generated by Kamyshny et al., and is a speciation diagram for the polysulfide (S_x^{2-}) system for an oversaturated solution of 5×10^{-2} M potassium polysulfide (K_2S_5). This graph supports the current thought that S_4^{2-}, S_5^{2-}, and S_6^{2-} are the dominant forms of polysulfide (S_x^{2-}) at pH > 7.5. It is noteworthy that HS_2^- is the dominant polysulfide (S_x^{2-}) species over the environmentally significant pH range of 6.0 to 7.0[329] because of the presence of the disulfide ion (S_2^{2-}) in key minerals such as pyrite (FeS_2). Even though pentasulfide (S_5^{2-}) is expected to be the predominant sulfide species in aqueous polysulfide (S_x^{2-}) solutions (Figure 6.86), the potential for other forms complicates even the chemical formula used to refer to polysulfide (S_x^{2-}).

The predictive speciation work and geochemical graphs supported by available thermodynamic constants are theoretical and highly sensitive to the equilibrium constants used to generate them. Based on the pE–pH stability diagram for the sulfur system presented in Figure 7.6, sulfide (S^{2-}) is not expected to predominate in aqueous systems, and under circumneutral mildly oxidizing geochemical conditions, sulfide (S^{2-}) is expected to oxidize to sulfate (SO_4^{2-}) or elemental sulfur (Figure 7.6). Transferring the nebulous and complicated oversaturated sulfide (S^{2-}) aqueous chemistry to in situ chemical reactive zone design and implementation requires that the practitioner recognize the geochemical challenge of injecting a strongly alkaline sulfide (S^{2-})-rich chemical reagent into the natural aquifer.

Similar treatment interaction and by-product formation associated with dithionite ($S_2O_4^{2-}$) are observed for polysulfide (S_x^{2-}) injections. Although not yet reported in the literature, polysulfide (S_x^{2-}) may form the superoxide radical ($O_2^{\bullet-}$) or donate electrons directly to oxidizing contaminants. As demonstrated in Figure 7.3, there are a wide variety of aqueous species associated with injection polysulfide (S_x^{2-}) into an aquifer (polysulfides [S_x^{2-}], sulfane monosulfonic acids [polythiosulfates; $S_xO_3^{2-}$], sulfane disulfonic acids [polythionates; $S_xO_6^{2-}$], sulfite [SO_3^-], and sulfate [SO_4^{2-}]).[330] Most of these reactive species have short residence times in situ because they are rapidly oxidized to sulfate (SO_4^{2-}), indicating that there is an extensive degree of reductive capability of the polysulfide (S_x^{2-}) compound.

6.3.3.1.3 Zerovalent Iron

ZVI metal (Fe^0) can be used as a solid-phase reducing agent in chemical in situ reactive zones. A number of factors determine the reactivity of ZVI (Fe^0), including surface area per volume, processing and handling protocols, and alloys and impurities. Some typical physical characteristics of commercially available granular ZVI (Fe^0) include a grain size of 0.25 to 2 mm, a bulk density of 160 lb/ft^3 (2.6 g/cm^3), a specific surface area of 2600 m^2/L, and a hydraulic conductivity of 5×10^{-2} cm/d.[310] Costs are market driven but typically fluctuate around $0.50 per pound. The purity of ZVI (Fe^0) is usually good, with few trace metals and a low carbon content (typically less than 3%). Surface area is important because many chemical reduction reactions (metal precipitation and solvent destruction) occur on the surface of the ZVI (Fe^0). A larger surface per volume implies greater treatment potential (Section 6.3.3.1.3.5). Processing and handling influences the reactivity of ZVI (Fe^0) because prolonged exposure to oxygen can result in oxidation of the ZVI (Fe^0; i.e., corrosion) from Fe^0 to ferrous (Fe^{2+}) or ferric (Fe^{3+}), effectively decreasing the treatment payload. Lastly, a well-documented method for increasing the chemical reactivity of ZVI (Fe^0) is to create an alloy with another metal (i.e., bimetallic ZVI; e.g., Pd, Pt, Ag, Ni, Cu).[331]

ZVI (Fe^0) reactive zones initiate a complex network of homogeneous (same media; i.e., solid to solid) and heterogeneous (different media; i.e., solid to liquid) reactions that may directly or indirectly destroy or precipitate contaminants. Some of the reactions may be catalyzed by mineral surfaces or by metal-reducing microbial populations that develop in situ. Many reactive zone processes consume the ZVI (Fe^0), and any ZVI (Fe^0) application has a finite life span that is directly related to the flux and chemical composition of groundwater passing through the reactive zone. To achieve effective reduction, the iron surface area concentration (defined as the surface area of soil per volume of liquid; m^2/L) must be significant, and the contact time must be comparatively longer than other in situ chemical reactive processes. To achieve these requirements, ZVI (Fe^0) is generally deployed in a trench oriented perpendicular to groundwater flow. The trench is typically backfilled with a mixture of ZVI (Fe^0) and sand or other porous supporting media to create a reactive barrier (based on hydrogeological and geotechnical considerations; Chapter 10). The most common applications of ZVI (Fe^0) reactive barriers have targeted chlorinated solvents, polychlorinated biphenols, explosives, etc.[332–343] Other ZVI (Fe^0) applications have been applied for hexavalent chromium (Cr^{6+})[344–354] and other dissolved metals and radionuclides.[355–365]

Numerous competing reactions are expected in aquifer formations, and the longevity of ZVI (Fe^0) in situ is more likely to be determined by consumption of nontarget compounds.

Furakawa et al.[366] provided two examples of competing reactions (Equation 6.176 and 6.177):

$$2Fe^0_{(s)} + O_{2(g)} + 2H_2O_{(l)} \rightarrow 2Fe^{2+}_{(aq)} + 4OH^-_{(aq)} \quad (6.176)$$

$$\mathbf{Fe^0_{(s)}} + 2\mathbf{H_2O_{(l)}} \rightarrow \mathbf{Fe^{2+}_{(aq)}} + \mathbf{H}_{2(g)} + 2\mathbf{OH^-_{(aq)}} \quad (6.177)$$

The oxic reaction shown in Equation 6.176 is likely to occur in the upgradient interface between the ZVI (Fe^0) mass and influent groundwater. Further along the migration pathway, the anoxic reaction shown in Equation 6.177 is likely to occur. Reactions with ZVI (Fe^0) lead to pH increases through consumption of protons as well as release of hydroxyl anions (e.g., Equation 6.176 and 6.177).

6.3.3.1.3.1 Reaction Mechanisms There are three general reaction mechanisms related to ZVI (Fe^0), which will be discussed in this section: elimination reactions, hydrogenation, and hydrogenolysis. Additionally, because ZVI (Fe^0) is a solid and is mostly used to treat dissolved contaminants, there are reactions that occur over the two phases, referred to as homogeneous and heterogeneous.

6.3.3.1.3.1.1 Heterogeneous versus Homogeneous ZVI (Fe^0) Reactions Heterogeneous reactions involve two phases, the liquid and solid phases, in the case of reactive zone chemistries (particularly ZVI (Fe^0)). Solid surfaces can participate in reactive zone chemistry in several ways:

- Catalysis. Electrical charge concentrations on the mineral surfaces can attract ions or polar molecules to the surface. There, reaction geometries can be optimized for aqueous-phase molecules reacting with atoms on the mineral surfaces or with other aqueous-phase molecules.
- Regenerable reactive centers. Mineral surfaces can be activated, amended, or reactivated through injection of reagents such as dithionite ($S_2O_4^{2-}$) or iron sulfide (FeS). This is the basis for the creation of in situ reactive zones from iron minerals in aquifer soils.
- Adsorption sites. Aquifer minerals also can provide adsorption sites for contaminants such as the chlorinated alkenes and for reactive metal ions such as ferrous iron (Fe^{2+}) and arsenic.

The reduction reactions mediated by reduced iron compounds are likely heterogeneous processes. Amonette et al.,[288] for example, studied the abiotic reductive dechlorination of carbon tetrachloride (CCl_4). They found that the mineral goethite (α-FeOOH) adsorbed ferrous iron (Fe^{2+}) from aqueous solution and promoted dechlorination of carbon tetrachloride (CCl_4), while ferrous iron (Fe^{2+}) in the aqueous phase was unreactive. A similar observation has been made by others.[297–302] They postulated that the ferrous iron (Fe^{2+}) was adsorbed to the hydroxyl groups of the goethite (α-FeOOH) and that the charge concentration supported the multiple-electron-transfer reactions of reductive dechlorination.

Homogeneous reactions occur in the same media; in the case of ISCR with ZVI (Fe^0), this is within the groundwater. Because ZVI (Fe^0) is a solid granular material, the homogeneous reactions in groundwater associated with ZVI (Fe^0) are likely in the form of ferrous iron (Fe^{2+}) as a result of Equations 6.176 and 6.177.

6.3.3.1.3.1.2 β-Elimination Reaction With respect to abiotic reductive dechlorination of chlorinated ethenes and ethanes facilitated by ZVI (Fe^0), the β-elimination reaction is most simply defined as eliminating chloride (Cl^-) ions from the more chlorinated starting compound. This reaction chain is sometimes referred to as the acetylene pathway because the sequential elimination of chloride (Cl^-) ions from each molecule results in sequentially less chlorinated acetylenes (dichloroacetylene [C_2Cl_2], chloroacetylene [C_2HCl], and acetylene [C_2H_2]). The β-elimination reactions for chlorinated ethenes are presented as Equations 6.178 through 6.181:

$$C_2Cl_4 + Fe^0 \rightarrow C_2Cl_2 + 2Cl^- + Fe^{2+} \quad (6.178)$$

$$C_2Cl_2 + Fe^0 + H^+ \rightarrow C_2HCl + Cl^- + Fe^{2+} \quad (6.179)$$

$$C_2HCl + Fe^0 + H^+ \rightarrow C_2H_2 + Cl^- + Fe^{2+} \quad (6.180)$$

$$C_2H_2 + Fe^0 + 2H^+ \rightarrow C_2H_4 + Fe^{2+} \quad (6.181)$$

The half-lives of the chlorinated acetylenes (dichloroacetylene [C_2Cl_2], chloroacetylene [C_2HCl], and acetylene [C_2H_2]) are short, and they are rarely captured in most practical in situ field applications.

6.3.3.1.3.1.3 Hydrogenolysis With respect to abiotic reductive dechlorination of chlorinated ethenes and ethanes facilitated by ZVI (Fe^0), the hydrogenolysis reaction is most simply defined as exchanging a chloride (Cl^-)–carbon (C) bond with a hydrogen (H^+)–carbon (C) bond. In this sequential process, two electrons are added to the carbon as part of the "reductive" dechlorination. The hydrogenolysis reactions for chlorinated ethenes are presented as Equations 6.182 through 6.185:

$$C_2Cl_4 + Fe^0 + H^+ \rightarrow C_2HCl_3 + Cl^- + Fe^{2+} \quad (6.182)$$

$$C_2HCl_3 + Fe^0 + H^+ \rightarrow C_2H_2Cl_2 + Cl^- + Fe^{2+} \quad (6.183)$$

$$C_2H_2Cl_2 + Fe^0 + H^+ \rightarrow C_2H_2Cl_2 + Cl^- + Fe^{2+} \quad (6.184)$$

$$C_2H_3Cl + Fe^0 + H^+ \rightarrow C_2H_4 + Cl^- + Fe^{2+} \quad (6.185)$$

In each reaction, the half reaction of ZVI (Fe^0) is oxidized to ferrous iron (Fe^{2+}) and gives up two electrons that are transferred to the carbon. Of the ZVI (Fe^0) reaction mechanisms, hydrogenolysis is less desirable because it results in sequentially less chlorinated by-products, which have their own regulatory standard and toxicity profile. Fortunately, based on both laboratory and field studies in the literature,[312,367,368] >90% of the degradation of tetrachloroethene (PCE; C_2Cl_4) and trichloroethene (TCE; C_2HCl_3) is expected to follow the β-elimination reaction. However, a recent evaluation of a 15-year PRB in Elizabeth City, North Carolina, suggested that some sequentially less chlorinated by-products from abiotic reductive dechlorination of influent TCE (C_2HCl_3) were observed at maximum concentrations of 10% of the influent TCE (C_2HCl_3) downgradient of the PRB.[369] A possible explanation for this may be that passivation of available ZVI (Fe^0) surface area over an extended operation may inhibit TCE (C_2HCl_3) contact with the ZVI (Fe^0), and abiotic dechlorination facilitated by dissolved-phase ferrous iron (Fe^{2+}) or biological reductive dechlorination facilitated by hydrogen (H_2) from anoxic corrosion of the ZVI (Fe^0) may be contributing to reductive dechlorination as the PRB matures.

6.3.3.1.3.1.4 Hydrogenation For completeness, hydrogenation, or simply the addition of hydrogen to a compound, is mentioned as a final reaction mechanism in the β-elimination reaction. Note that Equation 6.181 in Section 6.3.3.1.3.1.2 does not involve the removal of a chloride (Cl^-) ion because acetylene (C_2H_2) does not have a chloride (Cl^-) remaining to remove. Nevertheless, acetylene (C_2H_2) may be further reduced to ethene (C_2H_4) via hydrogenation.

6.3.3.1.3.2 Kinetics Because ZVI (Fe^0) is typically emplaced in a trench such as a PRB, at the beginning of treatment, the ZVI (Fe^0) and reactive surface sites are plentiful in comparison to the influent contamination and therefore first-order rate kinetics are an appropriate assumption for ZVI (Fe^0) treatment kinetics. The rate constant (which is typically ZVI [Fe^0] product specific) is influenced by the available surface area of the ZVI (Fe^0), the type of iron, the inorganic composition of the groundwater, the temperature, and the concentration/competition effects (i.e., scavenging losses).[312] A summary of available contaminant half-lives and first-order rate constants for several common chlorinated volatile organic compounds of concern is summarized in Table 6.33. Of all of the factors influencing the rate constant, the surface area is likely the most influential.

6.3.3.1.4 Implementation Methods

For all intents and purposes, it is an appropriate assumption that granular ZVI (Fe^0) is insoluble. The direct injection of granular ZVI (Fe^0) into semipermanent injection wells is not recommended and will almost certainly result in considerable permeability reduction of the injection well and poor distribution of the iron. By far, the most common method of injection ZVI (Fe0) into the subsurface is via the use of pressure-based fracture tooling. As described in Section 6.1.2.2, these included slurried injection with direct push tooling, hydraulic fracturing with a liquid carrier, or pneumatic fracturing with a combination of gas and sand.

TABLE 6.33
Degradation Rates Reported as Half-Lives Normalized to 1 m² Surface Area per mL Solution

Compound	ZVI (Fe^0)-Mediated Half-Life($t_{1/2}$), h
Chlorinated ethenes	
Tetrachloroethene	2.1–10.8[a]; 3.2[f]
Trichloroethene	1.1–4.6[a]; 2.4[f]; 2.8[a]
1,1-Dichloroethene	37.4[f]; 15.2[a]
trans-1,2-Dichloroethene	4.9[c], 6.9[f], 7.6[a]
cis-1,2-Dichloroethene	10.8–33.9[a]; 47.6[f]
Vinyl chloride	10.8–12.3[a]; 4.7[f]
Chlorinated ethanes	
Hexachloroethane	*0.013[b]*
1,1,2,2-Tetrachloroethane	*0.053[b]*
1,1,1,2-Tetrachloroethane	*0.049[b]*
1,1,1-Trichloroethane	1.7–4.1[a]
1,1-Dichloroethane	Not reported
1,1-Dichloroethane	No treatment observed[a]
Methanes	
Tetrachloromethane (carbon tetrachloride)	0.31–0.85[a]
Trichloromethane (chloroform)	4.8[a]
Tribromomethane (bromoform)	*0.041[b]*
Dichloromethane	No treatment observed[b,h,i]
Chloromethane	No treatment observed[a]
Other compounds	
1,1,2-Trichlorotrifluoroethane (Freon 113)	*1.02[a]*
1,2,3-Trichloropropane	24[d]
1,2-Dichloropropane	4.5[d]
1,3-Dichloropropane	2.2[a]
1,2-Dibromo-3-chloropropane	0.72[a]
1,2-Dibromoethane	1.5–6.5[a]
n-Nitrosodimethylamine (NDMA)	*1.83[a]*
Nitrobenzene	*0.008[e]*
1,4-Dichlorobenzene	No treatment observed[a]

Source: Gillham, R.W., In-situ treatment of groundwater: Metal-enhanced degradation of chlorinated organic contaminants, in *Advanced in Groundwater Pollution Control and Remediation*, 1996, pp. 249–274, Kluwer Academic Publishers, Amsterdam, the Netherlands.

Note: *Italicized* results were performed with pure iron.

[a] Gillham (1996)[375]
[b] Gillham and O'Hannesin (1994)[374]
[c] Unpublished Waterloo data (no date or author provided by Gillham 1996)
[d] Focht (1994)[392]
[e] Agrawal and Tratnyek (1994)[370]
[f] Sivavec and Horney(1995)[371]
[h] Matheson and Tratnyek (1994)[372]
[i] Schreier and Reinhard (1994)[393]

In addition to injection-based delivery, ZVI (Fe^0) can be installed in a trench as a PRB or used as a slurry with bentonite grout in an in situ soil stabilization/solidification (ISSS) implementation. The use of ZVI (Fe^0) in PRBs and ISSS implementations is well established and well understood, and numerous successes are reported throughout the literature and technical conferences. Uniform and homogeneous distribution of the ZVI (Fe^0) is achieved through manual placement in the trench or through the mixed monolith without the burden of soil structure straining an insoluble slurry solution.

6.3.3.1.4.1 Iron Type Different types of ZVI (Fe^0) are available, and the differences generally originate from how the ZVI (Fe^0) is prepared. The different types of ZVI (Fe^0) include acid-washed, high-purity iron; oxide-coated commercial materials; slag products from spent foundry sand; and other waste products from iron and steel industries.[312] Some of the iron materials may have the potential for oil or grease coatings if they originate from the automotive or manufacturing industry, and it is generally good practice to avoid the use of ZVI (Fe^0) with oil or grease coatings.

A critical observation from a literature review by Gillham et al. is that the metallic iron component is the treatment efficiency differentiator among the different iron types. Among the different types of ZVI (Fe^0), there was not a large range in reactivity, implying that if a comparable percentage of metallic iron is present in different iron types, selecting the least expensive will have minimal impact on the reactivity.[312]

Other forms of zerovalent metals are available, such as zerovalent zinc (Zn^0) and zerovalent tin (Sn^0).[303,332,377–379] However, a concern with these heavy zerovalent metals is that they themselves are typical contaminants of concern. The designed process of zerovalent metal is to facilitate oxidation of the metal, and zerovalent zinc and zerovalent tin both oxidize to the stable +2 valence as dissolved zinc (Zn^{2+}) and tin (Sn^{2+}); however, these are stable valence states that promote transport in groundwater.

6.3.3.1.4.2 Nanoscale ZVI An alternative material to "macro" ZVI (Fe^0) (i.e., millimeters in size) that can achieve high surface area concentrations by unit volume is nanoscale ZVI (Fe^0) (nZVI; 10 to 200 μm in size). The characteristics that make nanoparticles qualitatively different from larger particles are greater surface area to volume ratios and higher natural reactivity of the reactive surface sites.[380,381]

Although the greater surface area concentration makes nZVI seem like the best choice, there are many issues with nanoparticles that are actively being addressed and researched in the industry. Over the past 15 years, several advancements in nZVI have improved its workability and mobility in situ; however, industry-wide acceptance of nZVI for in situ remediation via injection is not universal. Some of the complications and proposed solutions are discussed here, but for a more thorough review of the advancements in nZVI, the reader is referred to Keane,[308] Crane and Scott,[331] and Liu et al.[382] for "snapshot" critical reviews of nZVI throughout the developmental timeline. There are three main forms of nZVI available for remediation efforts: bare nZVI, bimetallic nanoscale particles (BNPs) (or alloys with other metals), and emulsified zerovalent iron (EZVI).

Bare nZVI particles tend to agglomerate (or aggregate), meaning that the separate particles form larger particles by adhering to themselves or soil particles. This decreases the surface area of the nZVI, which decreases the mobility and reactivity and limits the achieved ROI.[383] The agglomeration on soil grains clogs the porosity and limits the distribution of nZVI in situ. Several conditions can cause the nZVI particles to agglomerate, including the nZVI particle concentration, the magnetism of the particles, and the zeta potential (ζ) (or surface charge).[384,385] Agglomeration caused by magnetism and high concentrations are intuitive, and we will briefly discuss the influence of the zeta potential (ζ). The zeta potential (ζ) is the electric potential of a particle and dictates the attraction to other particles. Generally, a zeta potential (ζ) greater than +30 mV or less than −30 mV is considered stable (there is significant surface charge to facilitate particle-to-particle repulsion). The highest attraction of a particle to other particles occurs when the zeta potential (ζ) equals 0.[386] Many parameters (e.g., surfactants, solution pH, and ionic strength) influence the zeta potential (ζ); thus, the industry has attempted to manipulate these parameters to make a nZVI product that is stable and distributable in situ. The influence of pH on the zeta potential (ζ) is shown in Figure 6.87.[386]

BNPs increase the kinetics of the oxidation–reduction reaction and generally result in more reactive ZVI.[381] BNPs are essentially coatings of metal catalysts (Pt, Au, Ag, Cu, Ni, Pd, etc.) over the surface of the nZVI to reduce agglomeration and improve kinetics.[383] The concept of BNPs is effective because the ZVI (Fe^0) is sacrificially oxidized to protect the catalyst, with chemical reduction occurring at the bimetallic surface either via direct electron transfer with the catalyst or by the hydrogen (H_2) generated through ZVI (Fe^0) corrosion.[331] Complications with BNPs arise from the cost of the catalysts being market driven and regulated metals themselves. In addition to using BNPs, studies have been completed evaluating coatings to support stabilization. Some coatings can be inhibitory in situ by interfering with contact of contaminants and

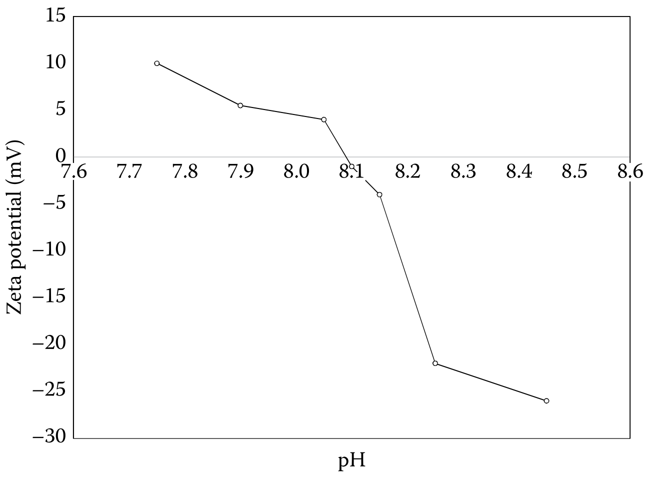

FIGURE 6.87 The influence of pH on the zeta potential. (From Zhang, X.-W. and Elliott, D.W., *Remediat. J.*, 16(2), 7, 2006.)

reactive surface sites on nZVI.[385] Ideal coatings are biodegradable (i.e., eventually stop interfering with contact of contaminants) and facilitate strongly reducing conditions to minimize oxic corrosion of the nZVI (such as polysaccharides like starch and carboxymethyl cellulose).[382] An example of one such coating is the third and final available form of nZVI, EVO coated nZVI (EZVI). This formulation is an agglomerate of nZVI particles packed into a droplet comprising surfactant and oil that forms an oil–liquid membrane. The protective membrane facilitates greater mobility of the iron throughout an aquifer during injection by decreasing corrosion or nZVI sorption onto soil grains. Note that similar EVO injection constraints exist as described earlier in this chapter, and appropriate calibrations are necessary for soil straining of the reagent.

According to Liu et al.,[382] lab-scale studies have demonstrated that stabilized nZVI can improve in situ remediation of soil and groundwater, but field-scale data are minimal. Stabilization has improved the achievable ROI of a nZVI injection; however, the practical distribution distance still remains a limitation to broad-scale implementation of nZVI for in situ remediation, especially as permeability decreases.

6.3.3.1.4.3 Residence Time The longevity of ZVI (Fe^0) reactive zones is determined by the rate of decrease of the ZVI (Fe^0) surface area concentration. There are two main modes of surface area concentration loss:

Consumption. The reactions between ZVI (Fe^0) and target compounds, as well as reactions with nontarget oxidants, consume the ZVI (Fe^0) reagent. Nontarget reactions (e.g., with oxygen [O_2], nitrate [NO_3^-], and sulfate [SO_4^{2-}]) are expected to dominate ZVI (Fe^0) consumption in most aquifers.

Passivation. The ZVI (Fe^0) surfaces may become coated with minerals that block the heterogeneous reactivity or passivate the ZVI (Fe^0). Formation of magnetite (Fe_3O_4), for example, passivates ZVI (Fe^0) surface area and has been observed in field application sites.[366] Laboratory batch and column tests show that reacted ZVI (Fe^0) developed a surface coating of goethite (α-FeOOH) with trivalent chromium (Cr^{3+}) concentrated at the outermost grain boundaries.[387] Other groundwater constituents that may passivate the ZVI (Fe^0) surface area include calcium (Ca^{2+}), carbonate (CO_3^{2-}), sulfate (SO_4^{2-}), and silicate (SiO_4^{4-}).[309]

REFERENCES

1. Payne, F.C., Quinnan, J.A., Potter, S.T. 2008. *Remediation Hydraulics*, CRC Press, Boca Raton, FL.
2. U.S. Environmental Protection Agency. 1988. *Application of Dye-Tracing Techniques for Determining Solute Transport Characteristics of Groundwater in Karst Terranes*, EPA904688001, Atlanta, GA.
3. Smith, S.A., Pretorius, W.A. 2002. The conservative behavior of fluorescein. *Water SA* 28(4): 403–406.
4. Kushner, D.J., Baker, A., Dunstall, T.G. 1999. Pharmacological uses and perspectives of heavy water and deuterated compounds. *Canadian Journal of Physiology and Pharmacology* 77(2): 79–88.
5. Mercer, J.W., Cohen, R.M. 1990. A review of immiscible fluids in the subsurface: Properties, models, characterization and remediation. *Journal of Contaminant Hydrology* 6(2): 107–163.
6. Raymond, R.L. 1974. Reclamation of Hydrocarbon Contaminated Ground Waters. U.S. Patent Office, 3,846,290. Patented November 5, 1974.
7. Pankow, J.F., Cherry, J.A. 1996. *Dense Chlorinated Solvents and Other DNAPLs in Groundwater: History, Behavior, and Remediation*. Waterloo Press, Portland, OR.
8. U.S. Environmental Protection Agency. 2003. *The DNAPL Remediation Challenge: Is There a Case for Source Depletion?* Office of Research and Development. December.
9. Interstate Technology and Regulatory Council. 2005. *Overview of In Situ Bioremediation of Chlorinated Ethene DNAPL Source Zones*. October.
10. Interstate Technology and Regulatory Council. 2007. *In Situ Bioremediation of Chlorinated Ethene DNAPL Source Zones: Case Studies*. April.
11. Miller, C.T., Poirier-McNeill, M.M., Mayer, A.S. 1990. Dissolution of trapped nonaqueous phase liquids—Mass-transfer characteristics. *Water Resources Research* 26(11): 2783–2796.
12. West, C.C., Harwell, J.H. 1992. Surfactants and subsurface remediation. *Environmental Science and Technology* 26(12): 2324–2330.
13. Boving, T.B., Brusseau, M.L. 2000. Solubilization and removal of residual trichloroethene from porous media: Comparison of several solubilization agents.
14. Hood, E., Major, D., Driedger, G. 2007. The effect of concentrated electron donors on the solubility of trichloroethene. *Ground Water Monitoring and Remediation* 27(4): 93–98.
15. Macbeth, T., Nelson, L., Rothermel, J., Wymore, R., Sorenson, K. 2006. Evaluation of whey for bioremediation of trichloroethene in source zones. *Bioremediation Journal* 10(3): 115–128.
16. Nelson, D.K., Novak, P.J. 2009. Enhanced dissolution of trichloroethene: Effect of carbohydrate addition and fermentation processes. *Journal of Environmental Engineering* 135(9): 861–868.
17. Watts, R.J. 1997. *Hazardous Wastes: Sources, Pathways, Receptors*. Wiley, New York.
18. McGuire, T.M., McDade, J.M., Newell, C.J. 2006. Performance of DNAPL source depletion technologies at 59 chlorinated solvent-impacted sites. *Ground Water Monitoring and Remediation* 26(1): 73–84.
19. Vannote, R.L., Minshall, G.W., Cummins, K.W., Sedel, J.R., Cushing, C.E. 1980. The river continuum concept. *Canadian Journal of Fisheries and Aquatic Science* 37: 130–137.
20. Fritsche, W., Hofrichter, M. 2008. Aerobic degradation by Microorganisms. *Biotechnology: Environmental Processes II, Volume 11b, Section Edition*.
21. Torsvik, V., Goksoyr, J., Daae, F.L. 1990. High diversity in DNA of soil bacteria. *Applied Environmental Microbiology* 56: 782–787.
22. Torsvik, V., Salte, K., Sorheim, R., Goksoyr, J. 1990. Comparison of phenotypic diversity and DNA heterogeneity in a population of soil bacteria. *Applied Environmental. Microbiology* 56: 776–781.
23. Mortland, M.M. and Kemper, W.D. 1965. Specific surface, in *Methods of Soil Analysis, Part 1,* American Society of Agronomy, Madison, WI.
24. Wackett, L.P., Hershberger, C.P. 2001. *Biocatalysis and Biodegradation*, ASM Press, Washington, DC,

APPENDIX C SITE-SPECIFIC HEALTH AND SAFETY PLAN

This Level 2 health and safety plan (HASP) is intended to document safety planning considerations for project work meeting one or more of the following criteria:

Some likelihood of physical and/or chemical hazard exposure (e.g., sampling, use of equipment and tools, exposure to hazardous energy, etc.);
Use of on-site subcontractors;
Work involving excavations, trenching, drilling, or other ground disturbance activities (i.e., activities requiring subsurface clearance [SSC]);
Work on, near[1], over, or under water, including any boating operations, diving, or offshore platform work; and
Work on an active or inactive mining site, outside of administration buildings.

The HASP should be developed with input from the project team (including subcontractors) and reviewed with all ERM project team members. The HASP must be reviewed by the Project Manager (PM) and reviewed/approved by the Partner-in-Charge (PIC). A fully signed copy of the HASP must be maintained at the project site during all work and archived in the project files.

Safety Team review is required for a Level 2 HASP. Please e-mail completed US plans to the **ERM US HASP Review Team** and e-mail Canada plans to the **ERM Canada HASP Review Team**.

This HASP must be updated as warranted to address changes in scope, hazards, project personnel, etc. At a minimum, HASPs must be reviewed annually or if the scope of work changes. Updated HASPs should also be sent to the HASP Review Team for review and to the PIC for approval.

All project work that requires a Level 2 HASP is required to have a Field Safety Officer (FSO) assigned and present on-site unless a waiver is approved.

This page may be deleted upon completion of the HASP.

[1] within 1m (3 feet) of water and greater than 15cm (6 inches) deep

Administrative Information *This HASP is valid for a maximum period of one year from the date of initial completion or last revision.*	
Project Name: Leica- Cheektowaga, NY	**Site Name & Location:** Former Leica Microsystems, Inc. Site, 203 Eggert Road, Buffalo, NY
Client: Danaher Corporation Jeff Ryberg 858.335.6324	**GMS Project No:** 0583070
HASP Date: 10/2/2023	**Revision Number and Date:** Rev 04
Field Work Start Date: TBD	**Anticipated Field Work End Date:** TBD
Field Safety Officer: ☐ Standard ☒ High Risk ☐ Waived Jason Reynolds	**Short Service Employees (SSE):** NA
Experienced Person: ☐ n/a ☒ SSC ☐ Aquatic ☐ Mining Jason Reynolds	**SSE Mentor(s):** NA
Additional ERM personnel on site: Jason Reynolds, George Hermance, Mikah Inkawhich, Austin Baker, Katherine Popyack	
Safety Team Review	
Reviewer Name: Ed Graham **Review Date:** **10/5/2023**	Signature File:
Subject Matter Expert Review *Subject matter expert (SME) review is required if the project includes performing work on, over, near, or in water (including transport), work at mine sites, or using mobile construction equipment (MCE), excluding drilling equipment.*	
SME Review Required: ☒ Yes ☐ No SME Type: ☐ Aquatic Work ☒ MCE ☐ Mine Site Work **SME Name:** Ed Graham **Date of SME Review:** 10/5/2023	Signature File:
Project Manager Review	
Name: Tim Daniluk **Review Date:** Click here to enter a date.	Signature File:
Partner-in-Charge Review / Approval	
Name: Joe Fiacco **Review / Approval Date:** Click here to enter a date.	Signature File:

Field Safety Officer Waiver	
☐ Waiver of Standard FSO is being requested in accordance with Section 4.10 of **NAM-1110-PR1** (Note: Projects with high-risk activities requires the use of a High Risk FSO and this requirement cannot be waived)	
Rationale for waiver of Standard FSO requirement: Click here to enter text.	
PIC Name: Click here to enter text. **Approval Date:** Click here to enter a date.	Signature File:
Area Manager: Click here to enter text. **Approval Date:** Click here to enter a date.	Signature File:

Subcontractors	
Subcontractor(s) to be used:	Prescreened under Subcontractor Use Basic Standards Policy?
1. Excavation TBD	☐ Yes ☐ No ☐ Waiver requested/approved
2. GPRS	☒ Yes ☐ No ☐ Waiver requested/approved
3. Test American Laboratories, Inc.	☒ Yes ☐ No ☐ Waiver requested/approved
4. New York Leak Detection	☒ Yes ☐ No ☐ Waiver requested/approved
5. OBAR System, Inc.	☒ Yes ☐ No ☐ Waiver requested/approved
6. Parratt-Wolff	☒ Yes ☐ No ☐ Waiver requested/approved

Approval of Unified Safety Planning Documents

*In accordance with ERM's Global Safety Planning Procedure (**ERM-1110-PR1**), when more than one entity (subcontractor, etc.) is involved in delivering the ERM scope of work, a designated representative from each entity must approve the HASP. This must be an individual with the authority to direct the activities of individuals in the field. If entities will be working under their own safety planning documents, a Bridging Document (**NAM-1117-FM1**) must be completed*

Subcontractor representatives with authority to direct work have approved ERM HASP (signatures below)	☒	A Bridging Document has been developed and attached to this HASP	☐	No subcontractors are being used on this project	☐

Approval Signatures	**Entity:** Click here to enter text.	**Entity:** Click here to enter text.
	Name: Click here to enter text.	**Name:** Click here to enter text.
	Date: Click here to enter a date.	**Date:** Click here to enter a date.
	Signature File:	Signature File:
	Entity: Click here to enter text.	**Entity:** Click here to enter text.
	Name: Click here to enter text.	**Name:** Click here to enter text.
	Date: Click here to enter a date.	**Date:** Click here to enter a date.
	Signature File:	Signature File:

Site Type (check all applicable boxes)			
☐	Commercial / Industrial	☒	Hazardous waste release (HAZWOPER)
☒	Residential	☐	Remote or inactive facility / location
☐	Unsecured	☐	Railroad:
☐	Aquatic (on, near, over or under water)*	☒	Significant vehicle travel**
☐	Mine (active or inactive)*	☒	Other (specify): Warehouse/Distributions Facility

* Requires SME review.

** If driving more than 500 km (310 miles) in a single day, driving in excess of 4.5 hours in a single day, or driving in a remote (including off-road driving) or high-risk location, a Journey Management Plan (***ERM-1430-FM1***) is required and should be appended to this HASP.

Site Description

Include relevant background information regarding the site, such as location, size, type of facility, topography, weather, infrastructure, security, previous site use, etc. Describe nature and extent of any soil/air/water/groundwater contamination. Describe any other aspects of the site that may potentially affect the health, safety, or security of on-site personnel.

The former Leica Microsystems, Inc. Site is an approximately 22 acre parcel at 203 Eggert Road in Buffalo, NY. The Site consists of an approximately 250,000 square foot building, paved parking lots, and landscaped lawn. The Site was built in 1938 for the manufacture of scientific instruments and optical devices. Leica acquired the facility in 1990 and ceased operations in 1993. Since 1993, the Site has been used for warehousing and distribution. The Site is currently inactive and is in the process of being sold to a developer. Site groundwater is known to be impacted by chlorinated solvents, particularly TCE. Monitoring wells exist within the building and the parking lot and an on-Site pump-and-treat system is currently in operation to contain impacted groundwater. A sub-slab depressurization system operates inside of the building to mitigate chlorinated solvent impacts indoors.

Scope of Work

Briefly describe the overall scope of work for this project.

Previous HASP: ERM will perform onsite groundwater monitoring to determine impacted areas and monitoring wells.

October 2023 Scope of Work to include public and private utility locate, installation of erosion/sediment controls, excavation and trench of onsite material, development of traffic routes onsite. This work will take place at ZVI PRB (southwest corner) of the site. The ZVI material and sand will be mechanically mixed either in situ or ex situ and backfilled into the trench. The area will be backfilled with mixed material and surface restored. ERM will only provide oversight.

Job Hazard Analyses

*Include a list of tasks to be completed by ERM and subcontractors. A site-specific Job Hazard Analysis (JHA; **ERM-1115-FM1**) must be completed for each task. Reference/example JHAs for common tasks can be found at: North America Safety Page - JHAs.*

ERM Task 1: Mob Travel to and From Site	☒ JHA Attached?
ERM Task 2: Subcontractor Oversight	☒ JHA Attached?
ERM Task 3: SSC Clearance/ Utility Locate	☒ JHA Attached?
ERM Task 4: Groundwater Sampling	☒ JHA Attached?
ERM Task 5: Click here to enter text.	☐ JHA Attached?
Subcontractor Task 1: Analytical Work to be performed by TestAmerica Laboratories, Inc.	☐ JHA Reviewed?

Subcontractor Task 2: Private Utility Locate	☐ JHA Reviewed?
Subcontractor Task 3: OBAR System Inc. SSDS Modifications, if needed	☐ JHA Reviewed?
Subcontractor Task 4: Parratt-Wolf is responsible for drilling and monitoring well installation.	☐ JHA Reviewed?
Subcontractor Task 5: Trenching, Excavation and ZVI mixing and emplacement.	☐ JHA Reviewed?
Will any client, client contractor, or third-party activities have the potential to expose ERM personnel to hazards? If "Yes", describe mitigation measures below and/or include in task JHAs.	☒ Yes ☐ No
Click here to enter text.	

Main Project Hazards *(check all applicable boxes)*			
High-Risk Hazards *Use of a High Risk FSO is required for any work involving one or more of the following high risk work hazards, except as noted in Section 4.10.2 of **NAM-1110-PR1**. Additional control measures may be required beyond the use of a JHA.*			
☒	Chemical mixing/injection processes	☐	Unexploded ordnance or explosives use
☐	Confined space entry	☐	Unprotected falls greater than 4 feet (1.2 meters) (i.e., use of fall arrest systems required)
☐	Construction	☐	Work with electricity or other hazardous energy
☒	Excavation/Trenching	☐	Other (specify): Click here to enter text.
☒	Mobile construction equipment, excluding drilling rigs	☐	Other (specify): Click here to enter text.
☐	Rigging/lifting		
Other Hazards			
☐	Biological hazards	☐	Off-road driving
☒	Chemical exposure potential (including asbestos)	☒	Natural hazards (e.g., plants, animals, insects)
☐	Compressed gas	☐	Portable or fixed ladders
☐	Extended (>14 hours) or nonstandard work shifts (e.g., night work)	☐	Radiation (ionizing or non-ionizing)
		☐	Ground disturbance (mechanized equipment or hand tools)
☒	Extreme weather	☐	Heat / cold stress
☒	Hand/power tool use	☐	Psychological / invisible hazards
☒	High noise (>85 dBA)	☐	Helicopter use
☐	Body mechanics / muscle exertions	☐	Hot work
☒	Material handling	☐	Other (specify): Click here to enter text.
☒	Slips/trips	☐	Other (specify): Click here to enter text.
☐	Lone work	☐	Other (specify): Click here to enter text.

Societal / Social Concerns

The statements below should be communicated to all project team members prior to project kick-off or as team members are allocated to the project.

ERM supports equitable and inclusive work environments for everyone and seeks to create a safe psychological space for all employees to voice their concerns at any time. Remember there are hazards/concerns that may be invisible to us, as individuals, because our own personal background (or what makes us who we are) may limit our ability to recognize what those different to us might be facing. These hazards/concerns could come in the form of harassment, discrimination, or other safety issues associated with, but not limited to, sex, gender identity or expression, sexual orientation, race/ethnicity, national origin, color, social status, age, religion, disabilities, marital status, childcare or other caring commitments, or medical conditions.

If anyone on our projects experiences harassment, discrimination, or has any safety concerns, they are empowered to stop work, leave the project site, and report the circumstances to the project team, safety team, or ERM confidential reporting line (in the US: website / 855-775-4357; in Canada: website / 855-544-7722). They are also empowered to notify 911 in situations where there is an urgent concern for their safety and well-being.

Societal / Social Concerns (continued)
If a project has the potential to expose team members to invisible hazards or societal biases, mitigation measures must be discussed with and agreed to by all project team members and documented in the space below. Examples of invisible hazards could include BIPOC or LGBTQ+ individuals working in areas prone to discrimination, or a vulnerable person working alone or in remote areas where their personal security or health could be jeopardized. Do not record information specific to individuals; rather, describe additional mitigation measures (e.g., use of buddy system, etc.) that have been agreed to by all project team members. Note that some team members may bring skills due to their backgrounds that could be a strength in mitigating risks. Remember to consider and discuss these as well.
Team doesn’t foresee any concerns but can be discussed during daily tailgate meetings.
If societal and social concerns were evaluated and discussed with project team members and no additional mitigation measures are anticipated, check here ☒.
Accessibility Concerns
Consider if project team members may not be able to fully participate in field duties or perform certain tasks based on their fitness for duty, disabilities, physical limitations, home/family obligations, allergies, or other challenges (e.g., medications, security, availability of restroom facilities, mobility limitations, technology, cultural). Remember, these challenges may not always be visible to you. Do not record information specific to individuals; rather, describe additional mitigation measures that have been discussed with and agreed to by all project team members. Note that some team members may bring skills due to their backgrounds that could be a strength in mitigating risks. Remember to consider and discuss these as well.
Team doesn’t foresee any concerns but can be discussed during daily tailgate meetings.
If accessibility concerns were evaluated and discussed with project team members and no additional mitigation measures are anticipated, check here ☒.

Chemicals of Concern

Chemical Products – Used, Stored, or Shipped

For each chemical product identified, a Safety Data Sheet (SDS) must be attached to this HASP.

☒	Alconox or Liquinox	☐	Isopropyl alcohol
☒	Hydrocholoric acid (HCl)	☐	Household bleach (NaOCl)
☐	Nitric acid (HNO_3)	☒	Calibration gas
☐	Sulfuric acid (H_2SO_4)	☐	Other (specify): Click here to enter text.
☐	Sodium hydroxide (NaOH)	☐	Other (specify): Click here to enter text.

Note: Emergency eyewash solution must be readily available on all project sites where materials are used or stored that pose a risk of getting into the eyes via splashing or through contact with airborne gases, vapors, dusts, or mists. This includes sample preservatives. The size and flushing capability of the eyewash must be proportional to the potential for contact with corrosive or injurious materials in the field and the resulting potential for injury. Contact your Business Unit (BU) Safety Director for additional information or assistance.

Are chemicals being transported to or from the site that are hazardous materials or dangerous goods (HM/DG)? ☒ Yes ☐ No

If the answer to the question above is Yes, follow the requirements of NAM-1559-PR1. For additional assistance with interpretation/evaluation of the potential impacts, contact an ERM HM/DG Compliance Specialist. A list of Compliance Specialists can be found **HERE**.

Regulated Chemicals of Concern

Check any chemicals known or suspected to be present on-site, and which personnel may be exposed, to determine if they are regulated through any federal or provincial laws. These regulations may include OSHA-regulated potential carcinogens (29 CFR 1910.1003 through 1016), those chemicals for which OSHA has established specific respiratory protection requirements (29 CFR 1910.134), or any chemical identified under Canadian provincial regulations. A list of applicable regulations addressing regulated chemicals is provided in Section 5 of ERM Procedure **NAM-1340-PR1** (*Chemical Hazards*). A list of OSHA-regulated chemicals is provided in Appendix 1 of that procedure.

Is there any known or potential exposure to regulated chemicals as defined in **NAM-1340-PR1** on the site?
☒ Yes ☐ No

If the answer to the question above is Yes, follow the requirements of NAM-1340-PR1. For additional assistance with interpretation /evaluation of the regulatory impacts, contact your BU Safety Director.

Additional Known or Suspected Chemicals of Concern

Are there additional known or suspected chemicals of concern present on the site not identified in the ***Regulated Chemicals of Concern*** section above? ☒ Yes ☐ No

If the answer to the question above is Yes, NAM-1340-FM1 (Known or Suspected Chemicals of Concern) must be completed and attached to this HASP. If work is completed in California, attach NAM-1340-FM2 (Known or Suspected Chemicals of Concern – California Specific). Information on each chemical must be provided to all team members.

Ambient Air Monitoring

Ambient air monitoring should be conducted by the FSO when there is a question of employee exposure to hazardous concentrations of substances to assure the proper selection of engineering controls, work practices, and PPE. Additional monitoring should be conducted under any of the following circumstances:

- Work begins on a different portion of the site;
- Change in job tasks;
- Change in weather;
- Change in ambient levels of hazardous constituents as indicated by the sense of smell or in the physical appearance of the soil or ground water;
- When new hazardous substances are encountered; and
- During high risk operations (e.g. drum opening, handling of leaking drums, or when working in areas with obvious liquid contamination).

Ambient air monitoring will be conducted using direct-reading real-time instruments. Not all work at the site will require ambient air monitoring for all contaminants. During the mobilization phase of a particular project task or activity, either the PM or the FSO will determine what contaminants may be encountered in order to have the appropriate instrumentation on-site. The Business Unit (BU) Safety Director is available to assist the PM or the FSO in determining the appropriate instrumentation.

Under stable site conditions, ambient air monitoring will be conducted at least once every two hours in the workers' breathing zone and at other locations based on the professional judgment of the FSO or the Subject Matter Expert (SME). Ambient air monitoring results will be recorded on **NAM-1340-FM4** (*Ambient Air Monitoring Form*). If site conditions become unstable or change dramatically, ambient air monitoring will be conducted more frequently based on the professional judgment of the FSO or the BU Safety Director.

Monitoring Equipment

Will ERM staff be using equipment on the project site to monitor potential exposures to known or suspected chemicals of concern?
☒ Yes ☐ No

If the answer to the question above is Yes, attach ERM Form NAM-1340-FM5 (Direct-Read Air Monitoring Equipment) to define the equipment to be used and the action levels to be applied.

All monitoring equipment on site must be calibrated per manufacturer specifications (including daily bump tests) and results recorded. See ERM Procedure **NAM-1302-PR1** (*Equipment Maintenance and Calibration*) for additional information. Under stable conditions, measurements must be made in the breathing zone at least once every 30 minutes.

Personal Protective Equipment

Req = Required PPE for one or more tasks to be performed; required on site at all times. NA = Not applicable to this project.

Equipment	Req	NA	Supplies	Req	NA
Safety-Toe Boots	☒	☐	Chemical Gloves	☒	☐
Outer Disposable Boots	☐	☒	Leather or Heavy Work Gloves	☐	☒
Long Sleeve Shirt/Pants	☒	☐	Cut-Resistant Level 2 or Higher (e.g., Kevlar) Gloves	☐	☒
Tyvek Suit	☐	☒	Safety Glasses/Goggles	☒	☐
Poly-Coated Tyvek Suit	☐	☒	Face Shield	☐	☐
Fully Encapsulated Chemical Suit	☐	☒	Hearing Protection	☒	☐
Flame Resistant Clothing/Coveralls	☐	☒	Permethrin Treated Clothing	☐	☒
High Visibility Traffic Vest	☒	☐	Half-face Respirator	☐	☒
Hard Hat/Approved Helmet	☒	☐	Full-face Respirator	☐	☐
Wet Suit/Dry Suit	☐	☒	If either half or full-face respirator checked: • Define cartridge type: Click here to enter text. • Define cartridge change frequency: Click here to enter text.		
Personal Floatation Device	☐	☒			
Other (specify): Click here to enter text.	☐	☐			

Respirator selection should be based on the Assigned Protection Factor (APF) and the Maximum Use Concentration (MUC). To determine the appropriate respirator selection, the lowest appropriate published exposure guideline should be known. The BU Safety Director or project H&S consultant can provide assistance in defining the APF and MUC, as necessary. They can also assist in defining actions levels and cartridge change schedules when air-purifying respirators are used. Note that cartridge change schedules must be outlined above and in the JHA for any task requiring respiratory protection.

Use of respiratory protection requires three elements: training in respiratory protection techniques, completion of medical surveillance confirming that you are fit to wear a respirator, and fit testing with the make and model of respirator you will be using. Refer to **NAM-1311-PR1** (*Respiratory Protection*) for additional information.

Safety Supplies	Req	NA		Req	NA
First Aid Kit	☒	☐	Toilets	☒	☐
Emergency Eyewash Solution	☒	☐	Insect Repellent	☒	☐
Air Horn	☐	☒	Other (specify): Click here to enter text.	☐	☐
Decontamination Supplies	☒	☐	Other (specify): Click here to enter text.	☐	☐
Fire Extinguisher	☒	☐	Other (specify): Click here to enter text.	☐	☐
Potable Water	☐	☒	Other (specify): Click here to enter text.	☐	☐

Training/Certification and Medical Surveillance

If training is required for an employee on this project, mark an "X" in the specific training box under their name. Training requirements are based on the specific tasks performed in the field and the type of environments, chemicals, or hazards encountered. Required training must be documented in ERM Academy for ERM employees; required training for on-site subcontractor personnel must be verified prior to the start of work and documentation should be included with the HASP.

Training/Certification	**Jason Reynolds**	**George Hermance**	**Mikah Inkawhich**	**Austin Baker**	**Katherine Popyack**
40-Hour HAZWOPER (with current annual refresher)	☒	☒	☒	☒	☒
8-Hour HAZWOPER Supervisor*	☐	☐	☐	☐	☒
40-Hour MSHA New Miner (with current annual refresher)	☐	☐	☐	☐	☐
ERM FSO – Standard/High Risk	ST☐ HR☒	ST☐ HR☒	ST☒ HR☐	ST☒ HR☐	ST☐ HR☒
DDD Practice FSO / DM	☐	☐	☐	☐	☐
First Aid/CPR Certification	☒	☒	☒	☒	☒
Subsurface Clearance (SSC) EP/GE	EP☒ GE☐	EP☒ GE☐	EP☐ GE☐	EP☐ GE☐	EP☒ GE☐
Aquatic EP/GE	EP☐ GE☐	EP☐ GE☐	EP☐ GE☐	EP☐ GE☐	EP☐ GE☐
Mining EP/GE	EP☐ GE☐	EP☐ GE☐	EP☐ GE☐	EP☐ GE☐	EP☐ GE☐
EPA Hazardous Waste	☐	☐	☐	☐	☐
Hazmat/Dangerous Goods Shipping**	☒	☒	☒	☒	☒
Respirator Wearer Certification	☐	☐	☐	☐	☐
Off-Road Driving	☐	☐	☐	☐	☐
Towing/Trailering	☐	☐	☐	☐	☐
ATV/UTV Usage	☐	☐	☐	☐	☐
Client-Required Training	☐	☐	☐	☐	☐
Other (specify): Click here to enter text.	☐	☐	☐	☐	☐
Other (specify): Click here to enter text.	☐	☐	☐	☐	☐
Other (specify): Click here to enter text.	☐	☐	☐	☐	☐
Medical Surveillance* **					
Medical Clearance	☒	☒	☒	☒	☒
Respirator Clearance and Fit Test (current / valid)	☐	☐	☐	☐	☐
Blood Lead and ZPP	☐	☐	☐	☐	☐
Other: Click here to enter text.	☐	☐	☐	☐	☐

* For HAZWOPER sites with multiple personnel, at least one on-site ERM employee must be certified as a HAZWOPER Supervisor.

** In Canada, Workplace Hazardous Materials Information System (WHMIS)/Globally Harmonized System (GHS) and Transportation of Dangerous Goods (TDG) regulations apply.

*** Examination requirements should be discussed with WorkCare well in advance of project to allow adequate time to schedule exams.

Work Zones

Complete if exclusion zones are necessary because of chemical and/or equipment hazards. Describe the set-up of these zones. Include landmarks, dimensions (as necessary), and whether they are for equipment or personnel decontamination.

Exclusion Zone: Will be 30 feet surrounding all equipment, eye contact and hand signals will be used prior to enter this zone. 2-feet surrounding all excavation/trenching/stock pile areas.

Contamination Reduction Zone: NA

Support Zone: NA

Site Access/Control

Describe procedures for limiting unauthorized entry to the work zone(s). Describe any security requirements.

Leica Microsystems, Inc. has access agreements with St. John Lutheran Church of Amherst (St. John) and Saint Stanislaus Roman Catholic Church Society, Inc. (St. Stanislaus). St. John is the owner of a cemetery property in Cheektowaga and the adjacent wooded property located immediately east of the Site. St Stanislaus is the owner of a cemetery property in Cheektowaga/Buffalo. Access agreements are attached.

Work Permit System(s)

If the client mandates use of a work permit system, please describe the system and the checklists or permits that may be required.

Will confirm with site prior to field activities.

Decontamination Procedures

Describe procedures for the decontamination of personnel and equipment.

Personnel: Sampling team members will wear disposable nitrile gloves when sampling. Proper site worker hygiene practices will be employed when sampling and handling groundwater (hand washing; no smoking; gum chewing or eating in the work area).

Equipment: Non-disposable sampling equipment (i.e. tubing weights and groundwater elevation meters) will be decontaminated with an Alconox and Liquinox rinse between wells and after each use. Drill rods will also be decontaminated between boring locations.

Spill Prevention and Response

Ensure all chemical containers on-site are labeled and lids are secured when not in use. When transferring chemicals from one container to another, or when refueling vehicles or equipment, provide containment beneath the transfer point to capture potential spills. Immediately report all chemical spills to the PIC/PM and submit an ECS entry with 24 hours.

Will ERM staff or ERM-hired subcontractors possess containerized chemicals on the project site? ☐ Yes ☒ No

If the answer is **Yes**, follow the requirements outlined in ERM Procedure **NAM-1123-PR1** (*Spill Prevention and Response*).

Waste Management Planning

Will ERM's project activities generate waste materials? ☐ Yes ☒ No

Will ERM undertake some level of contractual responsibility for handling waste for the client? ☐ Yes ☒ No

If the either answer is **Yes**, follow the requirements outlined in ERM Procedure **NAM-1122-PR1** (*Waste Management Planning*).

Describe any waste reduction/minimization techniques to be used on the site:

Click here to enter text.

Site-Specific Emergency Response

In the event of an emergency, site-specific emergency response procedures may take precedence over ERM established procedures. While engaging in field-related activities on an active site, measures they have in place to signal either emergency response or evacuation need to be reviewed and documented. Once completed, this summary should be discussed with all visitors, subcontractors, and others subject to HASP review upon site visit.

Lights and/or sounds associated with evacuation: In the event of thunder and lightning or other hazardous weather, ERM field personnel will stop work and take shelter inside the building or GWES/monitoring trailer.

Primary and alternative muster points: Primary muster point is the GWES/monitoring trailer

Site-specific evacuation procedures: NA

How we will account for the whereabouts and safety of on-site personnel following an evacuation:
A meeting location and attendance, and touch base with PM once completed.

Is a map associated with evacuation attached? ☐ Yes ☒ No

Emergency Drills: Emergency response drills should be rehearsed regularly. The frequency of drills is outlined below. All drills will be documented on the **NAM-1212-FM2** (*Emergency Drill Evaluation Form*).

Project Duration	***Drill Frequency***
☐ Less than 30 days	None, cover during review/sign-off of HASP
☒ Greater than one month but less than one year	Once
☐ Greater than one year	Annually

Emergency Contacts

Contact	Name	Location	Phone Numbers
Hospital (attach map)	ECMC Hospital	462 Grider St, Buffalo, NY	716-898-3257
Police	Buffalo Police Department	2767 Bailey Ave, Buffalo, NY	716-851-4416
Fire	Buffalo Fire Department	3226 Bailey Ave, Buffalo, NY	716-837-2169
Poison Control*	Upstate New York Poison Control Center	750 East Adams St, Syracuse, NY	800-222-1222
Incident Intervention	WorkCare	NA	888-449-7787
Partner-in-Charge	Joe Fiacco	1 Beacon St, 5th Floor, Boston, MA	Work: 617-646-7840 Cell: 617-285-3714
Project Manager	Tim Daniluk	Syracuse, NY	Cell: 315.317.2044
Field Safety Officer (or field team lead)	Jason Reynolds	5784 Widewaters Parkway, Dewitt, NY	716-725-5369
BU Safety Director	Dave Nickel	Minneapolis	651-270-1131
Regional H&S Director	Millard Griffin	Atlanta, GA	678-294-8658
Subcontractor Contact(s)	Click here to enter text.	Click here to enter text.	Click here to enter text.
Client / Site Contact(s)	Marty	Cheektowaga, NY	716-553-1143

Additional Contact(s)	Click here to enter text.	Click here to enter text.	Click here to enter text.

* Poison control centers in the US can be contacted at 800-222-1222. In Canada, poison control centers are specific to each province; contact information can be found here: **https://safemedicationuse.ca/tools_resources/poison_centres.html**.

In Case of an Injury or Illness

FOR ALL MEDICAL EMERGENCIES, CALL 911 OR THE LOCAL EMERGENCY NUMBER.

For ALL non-emergency incidents resulting in any injury or illness, you must:

- *Give appropriate first aid care to the injured or ill individual and secure the scene.*
- *Immediately notify the PM, PIC, and the ERM Safety Team.*
- *At direction of PM, PIC, or Safety Team, call WorkCare Incident Intervention at (888) 449-7787*

Site Safety Briefings

Communication and Review of the HASP: An initial review of the site-specific HASP will be held either prior to mobilization or after mobilization but prior to commencing work at the site to communicate HASP details to individuals working at the site and answer any questions.

Daily Safety Meeting: A daily safety meeting will be conducted each morning. The meetings will be documented on **NAM-1501-FM1** (*Site Safety Meeting Form*).

Acknowledgement

I have read, understood, and agree with the information set forth in this health and safety plan (HASP), and will follow guidance in the plan and in ERM's Document Control System (DCS). I understand the training and medical monitoring requirements (if any) for conducting activities covered by this HASP and have met these requirements.

Printed Name	Signature	Organization	Date

Attachments ***Check all appropriate documents to be attached to this HASP.***	
☒ Site-specific JHAs for all tasks (including subcontractors)	☒ Map of route to hospital with turn-by-turn instructions
☒ Subsurface Clearance (SSC) Project Plan (ERM-1511-FM1)	☒ SNAP Cards (ERM-1140-FM1)
☒ Site Safety Meeting Form (NAM-1501-FM1)	☐ Lone Worker Communication Plan (NAM-1326-FM1)
☒ Vehicle Inspection Forms (ERM-1430-FM2)	☐ Industrial Hygiene Sample Data (NAM-1340-FM3)
☒ Journey Management Plans (ERM-1430-FM1)	☒ Ambient Air Monitoring Form (NAM-1340-FM4)
☒ Safety Data Sheets (SDS) for chemicals brought to site	☐ Site-specific requirements
☐ PLAN Risk Assessment	☐ Subcontractor training/certification documentation
☐ Facility site map(s)	☐ Other: Click here to enter text.
Applicable ERM Safety Standards/Procedures ***Check procedures/standards that are applicable to this project. Refer to the documents for guidance and, where applicable, use forms, work instructions, and guidelines associated with these standards/procedures in the completion of site work. Indicated documents must be procured from ERM's Document Control System. Note that this list is not comprehensive!***	
Global Standards/Procedures	
☐ Travel Risk Assessment (ERM-1410-ST1)	☒ Subsurface Clearance Standard (ERM-1511-PR1)
☒ Driver and Vehicle Safety (ERM-1430-PR1)	☐ Aquatic Work Management (ERM-1530-PR1)
☐ Fixed Wing Aircraft/Helicopter Standard (ERM-1440-ST1)	☐ Short Service Employees (ERM-1611-PR1)
Regional Standards/Procedures	
☐ Fire Prevention (NAM-1213-PR1)	☒ Mobile Construction Equipment (NAM-1339-PR1)
☐ Confined Space Entry (NAM-1572-PR1)	☒ Excavation and Trenching (NAM-1512-PR1)
☐ Fall Protection (NAM-1313-PR1)	☐ Hazard Communication (NAM-1301-PR1)
☐ Ladder Safety (NAM-1521-PR1)	☐ Cold Stress (NAM-1323-PR1)
☒ Hearing Conservation (NAM-1312-PR1)	☐ Heat Stress (NAM-1323-PR2)
☒ Incident Reporting and Investigation (NAM-1220-PR1)	☐ Medical Services (NAM-1840-PR1)
☒ Medical Surveillance (NAM-1810-PR1)	☒ Personal Protective Equipment (NAM-1310-PR1)
☐ Hot Work (NAM-1542-PR1)	☐ Respiratory Protection (NAM-1311-PR1)
☐ Bloodborne Pathogens (NAM-1325-PR1)	☒ Insect Bite Prevention Standard (NAM-1361-ST1)
☒ Hand Tools/Portable Power Equipment (NAM-1329-PR1)	☒ Incident/Illness Management (NAM-1210-PR1)
☐ Electrical Safety (NAM-1561-PR1)	☐ Hazardous Energy Control (NAM-1562-PR1)
☒ Waste Management Planning (NAM-1122-PR1)	☒ Spill Prevention and Response (NAM-1123-PR1)
☐ Fatigue Management (NAM-1328-PR1)	☒ Safe Use of Cutting Tools (NAM-1324-PR1)
☒ Lone Workers (NAM-1326-PR1)	☒ Compressed Gas Cylinders (NAM-1341-PR1)

Stop Work Authority

It is ERM policy that all ERM and ERM Subcontractor employees have the authority, without fear of reprimand or retaliation to:

- Immediately stop any work activity that presents a danger to the site team or the public.
- Get involved, question and rectify any situation or work activity that is identified as noncompliant with the HASP or with broader ERM health and safety policies.
- Report any unsafe acts or conditions to supervision or, preferably, intervene to safely correct such acts or conditions themselves.

Safety Event Reporting

For all incidents (injuries, illnesses, spills, fires, property damage, etc.) and significant near misses, enter the event into ERM's Event Communication System (ECS) within 24 hours. Proactive safety observations and best practices should also be entered into ECS.

Management of Change

The following process will be followed if any changes are identified with respect to schedule, equipment type, equipment installation/configuration, process or procedure, personnel and/or site conditions. The process, as stated below, can be accepted as written or revised depending on project needs.

1. Work in the impacted area will STOP.
2. All impacted personnel (ERM and subcontractor staff) will discuss the change and suggest options for continuation.
3. The ERM FSO or field team lead, after reaching agreement with any impacted subcontractor(s), will discuss options with the PM and PIC.
4. The PIC will determine an appropriate course of action (may need to discuss options with Safety Team and/or SMEs).
5. The PIC will document necessary changes and get formal agreement with any impacted subcontractor(s).
6. The PIC will communicate approved changes to the ERM FSO or field team lead.
7. The ERM FSO or field team lead will communicate changes to all impacted site staff, including subcontractor staff.
8. Work in the impacted area can resume.

Control of Work

The following process will be followed with respect to Control of Work. The process, as stated below, can be accepted as written or revised depending on project needs.

1. The ERM FSO or field team lead will, prior to authorizing any new major definable feature of work, review the JHA and other applicable safety planning documents associated with the activity.
2. Once the JHA and other documents are approved by the ERM FSO or field team lead, the documents will be reviewed with all site staff involved and/or impacted by the activity (including subcontractor staff).
3. Once all staff involved and/or impacted understand and acknowledge they are in agreement with the documents, the ERM FSO or field team lead can authorize work to commence.
4. Once work commences, the ERM FSO or field team lead must observe the work in accordance with defined project procedures to document compliance with agreed procedures and general safety best practices.
5. Once authorized work is completed, the ERM FSO or field team lead will document any opportunities for improvement or other lessons learned within the ERM ECS or CAPA system.

Auditing and HASP Revisions
Selected project field activities and project files should be audited periodically. A full site audit for conformance with the HASP will occur at least once per year for projects with field duration of one year or longer. Full site audits may also be conducted for shorter duration projects. See ERM Form **ERM-1941-FM4** (Field Audit Form). Project documentation audits may be conducted periodically for shorter term projects. See ERM Form **ERM-1941-FM3** (Project Audit Form). Revisions made to the site HASP in response to audit feedback, lessons learned from incidents, or other reasons will be explained to all site personnel at the first daily safety meeting following the institution of the HASP revision.

APPENDIX D COMMUNITY AIR MONITORING PLAN

COMMUNITY AIR MONITORING PLAN
FORMER LEICA FACILITY
203 EGGERT ROAD – CHEEKTOWAGA, NEW YORK

This Community Air Monitoring Plan (CAMP) involves real-time monitoring for volatile organic compounds (VOCs) and particulates (i.e., dust) at the downwind perimeter of the designated work area when intrusive activities are in progress. Intrusive activities may include soil excavation, grading, staging, movement, or handling; test pitting or trenching; and/or the installation of soil borings and monitoring wells. The CAMP provides a measure of protection for on-Site workers and the downwind community (i.e., potential off-Site receptors including residences, parks, businesses, etc.) not directly involved with the subject work activities. Routine monitoring is required to evaluate concentrations and corrective action and/or work stoppage may be required to abate emissions detected at concentrations above specified action levels. Routine data collected during implementation of the CAMP may also help document that work activities did not spread compounds of potential concern off-Site through the air. Reliance on the procedures and action levels described in this CAMP should not preclude simple, common sense measures to keep VOCs, dust, and odors at a minimum around work areas.

COMMUNITY AIR MONITORING PLAN

VOC concentrations in air will be measured using calibrated photoionization detectors (PIDs). Particulate matter concentrations will be measured using calibrated electronic aerosol monitors.

Relevant weather conditions including wind direction, speed, humidity, temperature, and precipitation will be evaluated and recorded prior to the initiation of subsurface intrusive activities. Background readings of VOCs and particulate matter will be collected on Site prior to the initiation of field work on each day that subsurface intrusive work will be performed. Additional background measurements may be collected if weather conditions change significantly.

Continuous monitoring for VOCs and particulate matter will be performed upwind and downwind of the work area during subsurface intrusive activities.

Periodic monitoring for VOCs will be performed during non-intrusive activities if requested by a New York State Department of Environmental Conservation (NYSDEC) and/or New York State Department of Health (NYSDOH) on-Site representative. Non-intrusive activities include any work activity that does not disturb the subsurface or staged soil piles, including routine Site visits,

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- upon arrival at a sample location or other work activity location;
- during performance of the relevant work activity; and
- prior to leaving a sample location or other work activity location.

VOC MONITORING, RESPONSE LEVELS, AND ACTIONS

VOCs will be monitored at the downwind perimeter on a continuous basis during intrusive activities. Upwind concentrations will be measured continuously or at the start of each workday, during the work activity, and at the end of each work day to establish background conditions. Monitoring equipment will be calibrated at least once a day (excludes equipment that requires factory calibration). Calibration may be performed more frequently if Site conditions or instrument operating conditions are highly variable. The monitoring equipment should be capable of calculating 15-minute running average concentrations, which will be compared to the levels specified below. The monitoring equipment will be equipped with an alarm to indicate an exceedance of a specified action level.

1. If the ambient air concentration of total VOCs at the downwind perimeter exceeds 5 parts per million (ppm) above background (upwind perimeter) for the 15-minute time-weighted average, work activities will be temporarily halted and monitoring continued. If the total VOC concentration readily decreases (per instantaneous readings) below 5 ppm over background, work activities can resume with continued monitoring.

2. If total VOC concentrations at the downwind perimeter persists at concentrations greater than 5 ppm over background but less than 25 ppm, work activities will be halted, the source of the VOCs identified, corrective action will be taken to abate emissions (if the source is related to Site remedial activities), and monitoring will be continued. After these steps, work activities will resume provided that the total VOC concentration 200 feet downwind of the work area, or half the distance to the nearest potential receptor, whichever is less (but in no case less than 20 feet), is below 5 ppm above background for the 15-minute average.

3. If the total VOC concentration is greater than 25 ppm above background at the downwind perimeter, intrusive work activities will be halted and the source of the VOCs will be identified. Work will resume when additional continuous monitoring demonstrates that VOC concentrations have dropped below 25 ppm for a minimum of one-half hour, and the total VOC concentration 200 feet downwind of the work area, or half the distance to the

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