Enhanced Reductive Dechlorination (ERD) Pilot Test Workplan

25 MELVILLE PARK ROAD SITE
MELVILLE, NEW YORK

ARCADIS

Infrastructure, buildings, environment, communications

ARCADIS

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25 Melville Park Road Site
Melville, New York

Steven Feldman
Steven M. Feldman
Project Manager

Nicholas Valkenburg
Nicholas Valkenburg
Vice President/Project Director

ARCADIS Engineers and Architects of New York, P.C.

Frank Lenzo
Frank Lenzo, P.E.
Vice President
NV

Prepared for:
25 MPR, LLC
445 Broad Hollow Road
Suite 430
Melville, New York 11747

Prepared by:
ARCADIS G&M, Inc.
88 Duryea Road
Melville
New York 11747
Tel 631 249 7600
Fax 631 249 7610

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Disclosure Statement

The laws of New York State require that the corporations which render engineering services in New York be owned by individuals licensed to practice engineering in the State. ARCADIS cannot meet that requirement. Therefore, all engineering services rendered to 25 MPR, LLC in New York are being performed by ARCADIS Engineers and Architects of New York, P.C., a New York Professional corporation qualified to render professional engineering in New York. There is no surcharge or extra expense associated with the rendering of professional services by ARCADIS Engineers and Architects of New York, P.C.

ARCADIS is performing all those services that do not constitute professional engineering, and is providing administrative and personnel support to ARCADIS Engineers and Architects of New York, P.C. All matters relating to the administration of the contract with 25 MPR, LLC are being performed by ARCADIS pursuant to its Amended and Restated Services Agreement with ARCADIS Engineers and Architects of New York, P.C.

1. Introduction

This Enhanced Reductive Dechlorination (ERD) Pilot Test Workplan (Workplan) was prepared by ARCADIS and ARCADIS Engineers and Architects of New York, P.C., on behalf of 25 MPR, LLC, for the 25 Melville Park Road Site (hereinafter referred to as the "Site") in Melville, New York. Under the provisions of the New York State Voluntary Cleanup Program, WHCS Melville, L.L.C. (WHCS) and the New York State Department of Environmental Conservation (NYSDEC) entered into a Voluntary Remediation Agreement (Agreement) on January 13, 1998 to remediate the on-site portion of the groundwater plume that is impacted with chlorinated volatile organic compounds (CVOCs).

In the Draft Remedial Action Plan (RAP) issued on January 24, 2002, enhanced reductive dechlorination (ERD) is identified as the preferred technology for remediation of groundwater. This Workplan has been prepared in response to an August 19, 2002 letter from the NYSDEC indicating their receptiveness to a pilot demonstration of the ERD technology prior to conditional approval of the Remedial Action Work Plan (RAWP). The ERD technique was selected based on an evaluation of the most appropriate remedial technologies. In addition to addressing dissolved-phase CVOC mass, the ERD technique will also treat sorbed-phase CVOC mass, and has the potential to be used in the source area to remediate residual non-aqueous phase liquid (NAPL).

This workplan describes a six to twelve-month pilot test of ERD technology. The data collected during the pilot test will be used to evaluate whether ERD can be successfully applied at the Site. If the pilot test proves the technology is successful, it will be retained for use in the remedial action for groundwater.

2. Objectives

The primary CVOCs present in site groundwater include: tetrachloroethene (PCE), trichloroethene (TCE), 1,1,1-trichloroethane (1,1,1-TCA), cis-1,2-dichloroethene (cis-1,2-DCE), 1,1-dichloroethane (1,1-DCA).

The main goal of implementing the ERD technology at the Site will be to reduce the concentrations of these CVOCs. This will be accomplished through the injection of an easily degradable carbohydrate solution, creation of an anaerobic and strongly reducing in-situ reactive zone (IRZ), and transformation of the CVOCs to progressively less chlorinated intermediates until they are completely degraded to carbon dioxide and water. Consequently, the objectives of this pilot test will be to:

- Demonstrate that an anaerobic and reducing IRZ can be established at the Site;
- Determine how much the natural rate of reductive dechlorination can be enhanced;
- Determine the carbohydrate loading necessary to create and maintain the IRZ; and
- Confirm the optimal delivery parameters.

Performance data collected during operation of the pilot test will be periodically compared to the baseline data and evaluated against the above performance objectives. Ultimately, the determination as to whether the pilot test was a success will be based on the ability to demonstrate that the technology is capable of satisfying the short-term and long-term preliminary remedial action goals presented in the Draft RAP. Specifically, this involves short-term stabilization of the CVOC plume to prevent further off-site migration and long-term reduction of on-site CVOC mass such that cleanup goals are achieved at the downgradient property boundary.

3. Review of ERD Technology

CVOCs have long been perceived as recalcitrant and difficult to remediate in groundwater environments. In recent years, engineered bioremediation techniques have proven (through field application and laboratory study) to be effective for treating these types of compounds in groundwater.

ERD is an engineered bioremediation technique that falls into a class of remedial technologies known as In-situ Reactive Zones (IRZ). This technique is accepted by both federal and state regulatory agencies, and has been approved for use at several sites in New York and USEPA Region II. ERD employs an easily degradable carbohydrate solution (i.e., molasses), which is injected into the groundwater. The molasses injection provides excess organic carbon, which promotes microbial activity in the subsurface, subsequently enhancing the rates of reductive dechlorination of the CVOCs present.

When added to groundwater, naturally occurring bacteria begin to metabolize the molasses solution, consuming dissolved oxygen at a rate greater than it can be recharged naturally. Following depletion of oxygen, subsurface microbes begin the successive utilization of alternative electron acceptors to support respiration. The general sequence of alternate electron acceptor utilization and respiration byproduct formation is as follows (from most thermodynamically favorable to least):

Nitrate (NO_3) → Nitrogen (N_2)

Mangenic Manganese (Mn^{4+}) → Mangenous Manganese (Mn^{2+})

Ferric Iron (Fe^{3+}) → Ferrous Iron (Fe^{2+})

Sulfate (SO_4^{2-}) → Sulfide (S^{-2})

Carbon Dioxide (CO_2) → Methane (CH_4)

By maintaining excess organic carbon in the groundwater environment, ERD technology stimulates microbial activity, driving the groundwater environment to anaerobic and strongly reducing conditions. The zone in which this environment is established serves as an IRZ. Within the IRZ, there are three primary processes by which microbes can degrade CVOCs dissolved in groundwater:

1. Cometabolism: In this process, CVOCs are fortuitously degraded by the enzymes and cofactors produced by microbes as they metabolize excess organic carbon.

2. Hydrogenolysis: In this process, chlorine atoms in CVOC molecules are directly replaced by excess hydrogen atoms created as a result of the reducing environment and through hydrolysis and fermentation of the excess organic carbon.

3. Dehalorespiration: In this process, microbes use the CVOC molecule itself to support respiration under the anaerobic and reducing environment maintained by the presence of excess organic carbon.

The degradation of VOCs by anaerobic bacteria occurs primarily through the process of dehalogenation (or reductive dechlorination), which is the successive removal of chlorine atoms from the VOC molecule via a biologically mediated pathway. For example, TCE is formed when a chlorine atom is removed from PCE. Under the proper reducing conditions, this process can continue, resulting in the successive formation of cis-1,2-DCE, vinyl chloride (VC), and finally ethene. Ethene is then degraded to ethane, and finally carbon dioxide and water are formed. A similar process of chlorine removal occurs for 1,1,1-TCA, in which 1,1-DCA, chloroethane, and ethane are formed.

In addition to the above, direct mineralization of various CVOC transformation intermediates to water and carbon dioxide is possible in the presence of iron reduction. Where observed, this process prevents the buildup of compounds such as vinyl chloride. This process has been demonstrated and discussed in numerous literature accounts including: Bradley and Chappelle, 1996; Bradley and Chappelle, 1997; Wiedemeier and Chappelle, 1998; and Ferrey and Wilson, 2002.

The biological activity stimulated by the ERD process also results in a disruption of the natural dissolved phase-adsorbed phase equilibrium in the subsurface. This disruption transfers CVOC mass from the adsorbed phase to the dissolved phase (i.e., desorption), making it available for treatment. This same principle applies to NAPL. This feature makes the ERD technology much more aggressive than some of the more traditional remediation technologies which rely on natural dissolution to access sorbed or separate-phase mass.

4. Existing Site Conditions

This section of the workplan contains a brief overview of existing conditions at the Site. Included in this section are a brief description of the geology and hydrogeology, and a summary of recent groundwater quality data.

4.1 Geology/Hydrogeology

The deposits encountered during subsurface investigations on-site have been predominantly characterized as tan to light brown/light red-brown/gray/white, fine to coarse sand and gravel. Thin lenses of reddish-brown clay and sandy silt have been encountered in boreholes MW-18D [60-64 feet below land surface (ft bls)], MW-19D (58-62 ft bls), and MW-20D (60-64 ft bls). In addition, a medium gray clay was encountered at 56.5 ft bls during the installation of MW-12 and a clay layer was encountered from 60-62 ft bls in MW-11.

The direction of groundwater flow on-site is south-southeast. The horizontal hydraulic gradient in the shallow aquifer zone (45 to 60 ft bls) is approximately 0.001 ft/ft. Depth-to-water at the site is approximately 50 ft bls. Site-specific hydraulic conductivity data is not available for the site. Based on an examination of geologic logs for on-site wells, slug test and aquifer test data collected by ARCADIS at a nearby site in Melville, and regional hydrogeologic studies conducted by the U.S. Geological Survey, ARCADIS estimates the hydraulic conductivity (K) in the area of the plume to be approximately 50 to 100 ft/day. Based on this range of hydraulic conductivities and an estimated effective porosity of 0.25, the estimated average horizontal groundwater velocity is approximately 0.3 ft/day. Due to the relatively homogeneous nature of the geology, the advective groundwater velocities in the shallow, intermediate (75 to 90 ft bls), and deep aquifer zones (100 to 185 ft bls) are expected to be similar.

4.2 Existing Groundwater Conditions

In order to gain a better understanding of current groundwater conditions, ARCADIS collected groundwater samples from most of the site monitoring wells between July and August 2001. Figure 1 shows the existing well network at the site with the exception of MW-6, which is located in the northwest corner of the site. The apparent configurations of the CVOC plumes in the shallow, intermediate, and deep aquifer zones are depicted on Figures 2, 3, and 4, respectively. Key observations are as follows:

- Total CVOC concentrations in the shallow zone (Figure 2) ranged from 3.4 micrograms per liter (µg/L) (MW-4) to 32,000 µg/L (IW-3). The highest concentrations were detected just east of the loading dock area. A second area of high concentrations exists in the vicinity of MW-8 (15,083 µg/L) and MW-7 (11,900 µg/L).

- Total CVOC concentrations in the intermediate zone (Figure 3) ranged from 52.3 µg/L (MW-16D) to 13,130 µg/L (MW-13D). The highest concentration was detected just east of the loading dock area. A high concentration was also detected at MW-27D (8,835 µg/L).

- Total CVOC concentrations in the deep zone (Figure 4) ranged from 2 µg/L (MW-20D) to 275 µg/L (MW-18D). These wells are both located in the area just east of the loading dock area where the highest concentrations were reported in the shallow and intermediate zones. The third deep zone monitoring well (MW-19D) had a reported concentration of 2.5 µg/L.

The significant decrease in concentrations with depth between the shallow and deep zones indicates that the dissolved CVOC plume has been vertically delineated. Furthermore, the most significant CVOC concentration in the deep zone was reported in MW-18D (275 µg/L), which is screened from 133 to 143 ft bls. Based on the reported concentrations in the two other wells that comprise the deep zone monitoring network, MW-19D (2.5 µg/L), screened from 160 to 170 ft bls, and MW-20D (2 µg/L), screened from 175 to 185 ft bls, the vertical extent of contamination does not appear to extend below 150 ft bls.

4.3 Biogeochemical Conditions

As part of the July/August 2001 monitoring event, groundwater samples from select monitoring wells were also analyzed for a suite of biogeochemical parameters. The data provide insight into the occurrence and types of natural biodegradation processes ongoing at the site. The results indicate that natural degradation of the CVOCs in groundwater is occurring (most likely as a result of the presence of petroleum hydrocarbons in the source area), but at a rate that is insufficient to achieve remedial goals.

The ambient groundwater environment, as exhibited at Well MW-15, is aerobic and oxidizing. This is generally characterized by dissolved oxygen (DO) concentrations above 1 milligram per liter (mg/L) and an oxidation-reduction potential (ORP) greater than +100 millivolts (mV). The dissolved oxygen concentration observed at MW-15 was 6.87 and 3.21 mg/L, as measured in the field and in the laboratory, respectively. In addition to abundant dissolved oxygen concentrations, the next most preferred electron acceptor (nitrate) was also detected at a concentration of 1.3 mg/L. Finally, the field-measured oxidation-reduction potential (ORP) at MW-15 was +208 millivolts (mV).

By comparison, the groundwater environment in the area of CVOC impacts exhibits a lack of DO, negative ORP, and the presence of the reduced forms of various alternate electron acceptors (e.g., dissolved iron, dissolved manganese, sulfide, and methane). Background concentrations of dissolved iron and dissolved manganese were below the limits of detection and 14.5 µg/L, respectively. Concentrations of dissolved iron and dissolved manganese within the core of the CVOC plume range from 8,700 to 13,100 µg/L (iron) and 168 to 651 µg/L (manganese), respectively. The presence of sulfide and methane indicate that strongly reducing conditions are present in at least a portion of the CVOC plume. The reducing conditions are further confirmed by the presence of PCE transformation intermediates (TCE and DCE) and end products (ethene and ethane). It is also worth noting that there is an absence of VC in a plume where ethene and ethane are present, indicating that reducing conditions can be created that will achieve complete reductive dechlorination without VC build-up. Collectively, the data provide strong lines of evidence to support the suitability of the ERD technique for application at the site.

5. ERD Pilot Test Program

ARCADIS proposes to implement a six- to twelve-month pilot test program to demonstrate the ERD technology downgradient of the source area. The following sections present an overview of the rationale, objectives, and scope of work for the ERD Pilot Test Program.

5.1 Pilot Test Location

In order to properly evaluate ERD technology in a pilot test, molasses-solution injection wells and groundwater observation wells will be required. The test must be conducted in an area of the site where sufficient impacts are present, and the well network should be designed to both evaluate the performance of the ERD process and determine the extent of the IRZ.

Based on the short-term remedial goals for the site and current groundwater conditions, ARCADIS proposes to conduct the pilot test in a location just south of the primary area of high CVOC concentrations. As depicted on Figures 5 and 6, two transects of injection wells will be used to target the shallow and intermediate aquifer zones in this area. The selection of this area for the pilot test is based on the following:

- The recent groundwater sampling data indicate the presence of dissolved CVOC concentrations ranging up to 1,000 μg/L;
- A successful pilot system in this area can be maintained after the test has concluded, providing a barrier to mitigate further migration of impacted groundwater from the source area. This would satisfy the short-term remedial goals for the site; and
- There is an existing network of wells in and downgradient of this area that can be used for the pilot test.

A summary of the completion details for the pilot test injection and monitoring wells associated with each aquifer zone is presented in Table 1. Specific details regarding the positioning, installation, completion, and development of the pilot test well network are presented in the following two sections.

5.2 Injection Well Network

A network of eight injection wells (three shallow zone and five intermediate zone) will be used to deliver the molasses solution to the subsurface. This network will make use of both new and existing wells, and will be arranged in a transect oriented perpendicular to the direction of groundwater flow. Specifically, the shallow zone injection network will consist of existing injection wells IW-5 and IW-6, plus proposed injection well IW-16 (Figure 5). The intermediate zone injection network will consist of existing injection wells IW-10 and IW-11, plus proposed injection wells IW-13, IW-14, and IW-15 (Figure 6).

Each of the existing injection wells are constructed of 2-inch diameter, schedule 40 polyvinyl chloride (PVC) well casing and screen. Existing shallow zone injection wells IW-5 and IW-6 are screened from 45 to 60 ft bls and existing intermediate zone injection wells IW-10 and IW-11 are screened from 75 to 90 ft bls.

The four new injection wells (IW-13, IW-14, IW-15, and IW-16) will also be constructed of 2-inch diameter, schedule 40 PVC well casing and 2-inch diameter, 0.020-inch (20 slot) PVC well screen. Intermediate zone injection well IW-13 will be completed to a total depth of 90 ft bls with a screened interval from 75 to 90 ft bls. Both IW-14 and IW-15 will be completed to a total depth of 75 ft bls with a screened interval from 60 to 75 ft bls. Shallow zone injection well IW-16 will be completed to a total depth of 60 ft bls with a screened interval from 45 to 60 ft bls.

5.3 Monitoring Well Network

A network of six monitoring wells (three shallow zone and three intermediate zone) will be used to track the progress of the pilot test. This network will make use of both new and existing wells, and will be arranged to allow confirmation of the length and width of the resulting IRZ.

The shallow zone monitoring network will consist of existing monitoring wells MW-7 and MW-8, and proposed monitoring well MW-32. The intermediate zone monitoring network will consist of existing monitoring wells MW-23 and MW-27D, and proposed monitoring well MW-33. As proposed, these monitoring points are positioned approximately 12, 25, and 50 feet downgradient of the injection wells. Based on an average groundwater seepage velocity of 0.3 feet per day (Section 4.1), these positions correspond to advective transport times of approximately 40, 80, and 165 days.

With the exception of MW-27D, each of the existing monitoring wells are constructed of 2-inch diameter, schedule 40 polyvinyl chloride (PVC) well casing and screen. Existing shallow zone monitoring wells MW-7 and MW-8 are screened from 40 to 60 ft bls. Existing intermediate zone monitoring well MW-23 is screened from 70 to 85 ft bls. Existing intermediate zone monitoring well MW-27D is constructed of 4-inch diameter, schedule 40 PVC and is screened over two intervals: 40 to 55 ft bls (upper) and 75 to 90 ft bls (lower). The two new monitoring wells (MW-32 and MW-33) will be constructed of 4-inch diameter, schedule 40 PVC well casing and 4-inch diameter, 0.020-inch (20 slot) PVC well screen. Monitoring well MW-32 will be completed to a total depth of 60 ft bls with a screened interval from 45 to 60 ft bls. Monitoring well MW-33 will be completed to a total depth of 85 ft bls with a screened interval from 70 to 85 ft bls.

In the event that monitoring data indicate advective transport times are faster than anticipated (see discussion in Section 6.2), the network described above will be supplemented by additional wells. Specifically, this will include existing shallow-zone monitoring wells MW-10, MW-11, and MW-29; existing intermediate zone monitoring wells MW-16D and MW-28D; and proposed monitoring wells MW-30 (intermediate) and MW-31 (shallow). Construction details for these wells are provided in Table 1.

5.4 Well Installation Methodology

Monitoring wells MW-30, MW-31, MW-32, and MW-33 and injection wells IW-13, IW-14, IW-15, and IW-16 will be installed with a drill rig using 6.25-inch (monitoring wells) and 4.25-inch (injection wells) inside diameter hollow-stem augers. Once the well casing and screen are inserted into the borehole, the annular space between the well screen and the borehole will be backfilled with Morie #2 filter pack, or equivalent. The filter pack will be followed by a 2-foot thick bentonite seal and then backfilled with grout. In addition, a locking cap will be placed on the well and a flush-mount protective surface casing will be installed. Lithologic samples will be collected every five feet between the interval of 50 and 90 ft bls in the MW-30 and MW-33 boreholes.

Following installation of the new injection and monitoring wells, each well will be developed to remove fine-grained material and ensure hydraulic communication with the surrounding formation. Drill cuttings and development water will be containerized for proper disposal.

5.5 Injection Procedures

Following installation of the well network, the pilot test program will begin. The pilot test will consist of two components, molasses solution injections and performance monitoring. Details regarding the molasses injection procedures are outlined below. Pilot test performance monitoring is addressed in Section 6.

5.5.1 Feed Solution

As previously discussed, the ERD pilot will involve adding molasses to the subsurface in the form of a dilute solution. The molasses contains sucrose, reducing sugars, organic non-sugars, and water, all of which are fully soluble in water. The total consumable carbohydrate concentration in the molasses is approximately 60% by weight.

In some hydrogeologic settings, the organic acids produced during the enhanced microbial activity results in a groundwater pH drop. Based on the ambient groundwater alkalinity and the type of underlying geology, the need for a buffer against pH fluctuations is not anticipated. However, if field data indicate that additional buffering capacity is required, sodium bicarbonate (baking soda) will be added to the injection solution.

5.5.2 Injection Loading and Frequency

In order for the ERD technology to be successful, a sufficient amount of carbohydrate must be added to the subsurface to stimulate microbial activity, provide excess organic carbon, create the zone of anaerobic and reducing conditions, and propagate the IRZ in the target zone. Our experience indicates that a target carbohydrate concentration of 1,000 mg/L in the groundwater is optimum.

Given this target carbohydrate concentration, and the anticipated hydraulic conditions in the test area, the total volume of molasses feed solution injected into each well during each injection event will be between 100 and 500 gallons. These volumes represent between one and six percent of the total volume of groundwater in the effective pore space around each injection well. Consequently, water-table mounding or other hydraulic effects are unlikely. At the beginning of the pilot test, the prescribed volume of dilute molasses feed solution will be injected every two weeks. Following the fourth injection event, it is anticipated that injection events will be reduced to a monthly frequency. However, the injection volume, solution concentration, and/or the frequency of injection may be altered during the test depending on field measurements made in the observation wells and the analytical results obtained during groundwater monitoring conducted to track pilot test performance. Adjustments will be reported in the Monthly Progress Reports (see Section 7.0).

5.5.3 Molasses Solution Injection Procedure

During each injection event, the dilute molasses solution will be prepared in batches. Each batch will be prepared in a portable polyethylene tank on the back of a field truck or trailer by thoroughly mixing the molasses and the potable water (along with the bromide tracer and bicarbonate, if warranted) in the proper ratio. The molasses feed solution will then be pumped into the injection wells using a gas-powered centrifugal transfer pump. The tank will be graduated, allowing the total volume injected into each well to be monitored over time.

A log will be kept during each injection event to record the solution strength (molasses and water volumes used), the total volume of solution injected into each injection well, the injection pressure at each injection well, and the injection flow rate. These measurements will be monitored to evaluate the condition of the well screens (i.e., biofouling) and whether well maintenance activities are needed. The wells will be redeveloped, as necessary. A copy of the injection log is presented in Appendix A.

5.5.4 Conservative Tracer Injection Procedure

ARCADIS will add potassium bromide (KBr) to the molasses reagent mixture as a conservative tracer to estimate advective transport times and confirm and document the lateral extent of ambient hydraulic mixing in the test area. A predetermined quantity of KBr will be uniformly dissolved in the reagent solution added to injection wells IW-6 (shallow zone) and IW-11 (intermediate zone) to generate a target concentration of 10 mg/L of bromide in the treatment area. This concentration should be readily detected above background Br concentrations at the downgradient monitoring wells.

5.5.5 Ambient Air Quality Monitoring

ARCADIS will conduct indoor ambient air quality monitoring as part of the ERD pilot test to evaluate whether remedial activities are affecting the potential pathway of vapor intrusion. Historic air quality monitoring data collected by Camp Dresser & McKee (CDM) from October 1999 to April 2001 indicated that the highest detected concentration of a site-related constituent of concern (COC) was 1.4 ppbv (PCE). This concentration is within background levels for PCE that were established by the New York State Department of Health (NYSDOH) in a study conducted by the Bureau of Toxic Substance Assessment. The study was conducted between 1989 and 1996 and is entitled "Background Indoor/Outdoor Air Levels of Volatile Organic Compounds in Homes Sampled by the New York State Department of Health, 1989-1996" (NYSDOH, 2003). A baseline monitoring event will be conducted prior to commencing the ERD technology in order to aid in the evaluation of indoor air quality data. In addition, a second indoor ambient air quality monitoring event will be conducted at a period three months from the time the injections begin. If site-related COC concentrations in indoor air are consistent with background levels and groundwater concentrations decline (or remain relatively stable) over time, then additional indoor ambient air quality monitoring will not be conducted.

Air quality sampling will be conducted in accordance with procedures set forth in USEPA Compendium Method TO-14A, "Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography." Air quality sampling will be conducted at two (2) locations within floor space currently occupied by AT&T, which is located adjacent to the area where the IRZ will be established. Air samples will be collected over an 8-hour time period utilizing 6-liter Summa Canisters. Each Summa Canister will contain a calibrated flow controller regulated to collect samples at a continuous and constant flow rate over an 8-hour period. Summa canisters will be placed on the existing floor surface (in the AT&T facility along the eastern wall of the building) during sampling.

During each sampling event a log will be completed and signed by the sampler. Sampling parameters recorded in the log will include sample location and ID number, time of initiating and termination of sampling at each location, and initial and final Summa Canister vacuum.

In addition to the two ambient air samples to be collected, a field (trip) blank will be submitted for laboratory analysis. The field blank will be a Summa Canister carried into the field, but never opened. The results from the field blank will identify if there is any interference during sample collection that could influence the sample results. In addition, the laboratory will analyze a method blank in accordance with TO-14A procedures to determine if there are any sample interferences from the laboratory environment.

Following collection of all samples, a chain-of-custody will be completed and packaged with the samples prior to shipment to the analytical laboratory. Samples will be shipped to the laboratory via overnight courier.

All sample analyses will be performed by Air Toxics Ltd. located in Folsom, California and will follow USEPA Method TO-14A. Samples will be analyzed for PCE, TCE, 1,1,1-TCA, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCA, 1,1-DCE, and VC.

Following receipt of the laboratory analytical data for an individual monitoring round, the results of the monitoring round will be tabulated and submitted to the NYSDEC, NYSDOH, and Suffolk County Department of Health Services (SCDHS) as part of the monthly progress reports. In addition, a figure will be prepared showing the sampling locations and copies of the air quality sampling logs and original analytical data packages will be included.

6.0 Groundwater Monitoring

A critical portion of the ERD pilot test will be the groundwater monitoring used to demonstrate performance. Performance monitoring will include a baseline event, followed by a series performance monitoring events. The data collected from these performance monitoring activities will be evaluated against the proposed performance objectives. This comparison will be used to determine whether the pilot test is successful. Details regarding performance monitoring are presented in the following sections. A summary of the proposed sampling and analysis schedule for the ERD pilot test performance monitoring is presented in Table 2.

6.1 Baseline Data Collection

To establish baseline conditions (i.e., groundwater conditions prior to the start of the molasses injections), an initial round of groundwater elevation measurements and groundwater quality samples will be collected. Baseline data for the pilot test will be collected from the injection wells, upgradient (background) monitoring well MW-15, and Pilot Test monitoring wells MW-7, MW-8, MW-23, MW-27D, MW-32, and MW-

33. In addition, to establish baseline conditions for longer-term performance monitoring beyond the six-month data collection period, groundwater quality samples will be collected from shallow zone monitoring wells MW-10, MW-11, MW-29, and MW-31; and intermediate zone monitoring wells MW-16D, MW-28D, and MW-30. Furthermore, to determine the present-day CVOC dissolved-phase plume configuration, groundwater quality samples will be collected from the following monitoring wells and will be analyzed for VOCs (plus tentatively identified compounds [TICs]) only: shallow zone monitoring wells MW-1, MW-3, MW-4, MW-12, MW-13, MW-14, IW-2, IW-4, and IW-7; intermediate zone monitoring wells MW-13D, MW-26D, IW-8, and IW-12; and deep zone monitoring wells MW-18D, MW-19D, and MW-20D.

Because the injection activities disturb equilibrium conditions that affect dissolved-phase CVOC concentrations, the injection wells are unsuitable for monitoring or demonstration of technology performance. Consequently, the baseline groundwater samples collected from the eight injection wells will be analyzed for VOCs (plus TICs) and total organic carbon (TOC) only. Groundwater samples collected from the observation wells during the baseline event will be analyzed for the following:

- CVOCs - The relative concentrations of individual CVOCs provide the strongest evidence of enhanced reductive dechlorination.
- Electron Acceptors - The presence or lack of electron acceptors provides an indication of the primary microbial respiration processes controlling the groundwater environment. Specifically, the baseline sampling event will include analysis for nitrate and sulfate.
- Reduced Electron Acceptors and Degradation End Products - The presence of reduced electron acceptors provides another measure of the primary microbial respiration processes controlling the groundwater environment. The presence and relative concentrations of CVOC degradation end products provides confirmation that the ERD process is being driven to completion. Specifically, the baseline sampling event will include analysis for nitrite, dissolved (ferrous) iron, dissolved (manganous) manganese, sulfide, chloride, ethene, ethane, and methane.
- Other Indicator Parameters - Total organic carbon (TOC) will be analyzed to evaluate the performance of the injection program and provide the basis for adjustments. Alkalinity will be analyzed as an indicator of the formations ability to buffer against swings in pH, and as an additional indicator of enhanced

microbial activity. Bromide will be analyzed to evaluate advective transport times and lateral dispersion of the molasses solution from the injection wells.

- Field Parameters - These parameters are measured in the field using a water quality meter, to demonstrate adequate well development and to confirm the prevailing groundwater environment (aerobic and oxidizing vs. anaerobic and reducing). The field parameters that will be measured as part of the baseline sampling event include DO, ORP, pH, temperature, and specific conductance.

6.2 Performance Monitoring Data Collection

Following completion of the baseline sampling event and initiation of molasses solution injections, groundwater monitoring will be conducted to evaluate the extent of the IRZ and the effectiveness of the ERD process. Over the first six-months of the pilot test, two types of performance monitoring will be completed, as follows:

- "Standard" performance monitoring will be completed at two, four, and six months following the initiation of injections, as outlined in Table 2. This data will be used to evaluate the progress and performance of the pilot test.

- "Interim" performance monitoring will be completed between each standard performance monitoring event. These events will be limited to the collection of down-hole field parameter measurements and grab samples for TOC analysis. TOC samples will be collected from the injection wells and selected monitoring wells using disposable bailers (no purging). Similarly, down-hole field parameter measurements will be collected from select injection wells and select monitoring wells using a water quality probe. The measurements will be collected at the center of the screened interval for each well. This data will allow real-time evaluation of the injection program performance and provide the basis for timely adjustments. A tentative schedule for these events is outlined in Table 2. Modifications to the schedule (frequency, wells included) may be made as warranted by the data collected.

- Together, the "interim" and "standard" performance monitoring data will be used to refine estimates of advective transport times and evaluate whether additional downgradient wells need to be included for monitoring of VOC concentrations and biogeochemical parameters.

Due to its reactivity, sulfide analysis will be completed in the field using a HACH™ spectrophotometer (Table 2). The groundwater samples collected for off-site laboratory analysis will be placed in the appropriate sampling containers and shipped to a NYSDOH certified laboratory for analysis. Tables 3 and 4 provide the groundwater sample collection and analytical protocols for the parameters associated with the performance monitoring events. A NYSDEC Analytical Services Protocol (ASP) Category A sample data package will be provided for the groundwater samples. Quality assurance/quality control (QA/QC) sampling will include collection of one field duplicate sample per sampling event. The field duplicate sample will be analyzed for all specified parameters from that sampling event with the exception of the dissolved gases.

6.3 Groundwater Sampling Procedures

Prior to sample collection, water-level measurements will be collected from each of the molasses solution injection and groundwater monitoring wells. The water level in the well will be measured to the hundredth of a foot with an electronic water-level indicator and the total depth of the well will be sounded.

Due to the highly sensitive nature of the biogeochemical sampling parameters to be collected, both purging and sampling will be performed via low-flow (or micropurge) techniques using a low-flow submersible pump (Grundfos Redi-Flo II or equivalent). These methods are well documented and are preferred for obtaining representative groundwater samples for biogeochemical and VOC analysis (Puls and Barcelona, 1996; Wiedemeier, et al., 1998; Piontek, 1995).

The submersible pump and dedicated polyethylene discharge tubing will be lowered to the center of the screened interval of each well for the purging process, or the midpoint of the saturated portion of the screen if the well bridges the water table. Groundwater will then be extracted from each well using micropurge techniques and will be directed into a flow-through chamber, or cell. This cell will contain the DO, ORP, pH, specific conductance, and temperature probes and will be designed and constructed in such a manner as to preclude groundwater contact with atmospheric air. The wells will be purged at rates that do not exceed 500 milliliters per minute (ml/min). Ideally, the purge rate of each well should equal the recharge rate of that well.

During purging, field parameters will be collected at 5-minute intervals. Groundwater will continue to be purged from each well until the field parameters stabilize (i.e., within 10%). Following stabilization of field parameters, the flow rate will be decreased to 100 mL/min to allow groundwater sampling to take place. Subsequent to lowering the flow rate to 100 mL/min, the groundwater samples will be collected from the discharge of the submersible pump. For the analyses that require field filtering of groundwater samples, dedicated, single-use, 0.45 micron filters will be affixed to the discharge of the submersible pump.

All non-dedicated equipment used during groundwater sampling will be decontaminated between monitoring well locations using the following methods. The submersible pump will be immersed in a 5-gallon pail containing a potable water/detergent (Micro™) solution. The pump will be scrubbed using a brush and approximately 5 gallons of solution will be run through the pump and containerized in a 55-gallon drum. Following this, approximately 5 gallons of potable water will be run through the pump and containerized in a 55-gallon drum. A low-flow groundwater sampling log and downhole probe parameter form designed for the documentation of field observations and parameters during monitoring events are included as Appendix B.

7.0 Data Evaluation and Reporting

During the course of the pilot test, status updates will be provided to the NYSDEC in the Monthly Progress Reports. These updates will include a summary of the activities completed to date and groundwater quality data collected during the previous month. The groundwater quality data summaries presented in each update will include the data from previous updates for comparison.

After six months of implementation, ARCADIS will evaluate the results of the pilot test to determine whether the pilot test has met the performance objectives. A pilot test report will then be prepared. The report will include an evaluation of the extent of the IRZ developed; the primary biodegradation processes occurring within the IRZ; the extent to which the ERD process made sorbed mass available for treatment within the IRZ; and if possible, the degree to which natural rates of degradation were enhanced. In addition, a discussion regarding the feasibility of applying the technology at the site will be included.

8.0 References

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Tables

ARCADIS

Table 2. Summary of Proposed Performance Monitoring, ERD Pilot Test Workplan, 25 Melville Park Road Site, Melville, New York.

			Analysis/Parameter																		
Sampling Event		Well	VOCs plus TICs	Dissolved (ferrous) Iron	Dissolved (manganous) Manganese	Nitrate	Nitrite	Sulfate	Sulfide	Ethene	Ethane	Methane	TOC	Alkalinity*	Chloride	Bromide	pH	ORP	DO	Temperature	Specific Conductance
Baseline	*Injection Wells*																				
	Shallow	IW-5	L	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-6	L	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-16	L	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
	Intermediate	IW-10	L	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-11	L	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-13	L	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-14	L	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-15	L	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
	Monitoring Wells																				
	Shallow	MW-1	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-3	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-4	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-7	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-8	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-10	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-11	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-12	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-13	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-14	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-15	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-29	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-31	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-32	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		IW-2	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		IW-4	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		IW-7	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
	Intermediate	MW-13D	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-16D	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-23	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-26D	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-27D	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-28D	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-30	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-33	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		IW-8	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		IW-12	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
	Deep	MW-18D	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-19D	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-20D	L	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F

See notes on last page.

Table 2. Summary of Proposed Performance Monitoring, ERD Pilot Test Workplan, 25 Melville Park Road Site, Melville, New York.

			Analysis/Parameter																		
Sampling Event		Well	VOCs plus TICs	Dissolved (ferrous) Iron	Dissolved (manganous) Manganese	Nitrate	Nitrite	Sulfate	Sulfide	Ethene	Ethane	Methane	TOC	Alkalinity*	Chloride	Bromide	pH	ORP	DO	Temperature	Specific Conductance
Performance Monitoring Month 2	*Injection Wells*																				
	Shallow	IW-5	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-6	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-16	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
	Intermediate	IW-10	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-11	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-13	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-14	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-15	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
	Monitoring Wells																				
	Shallow	MW-7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		MW-8*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		MW-32	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
	Interm.	MW-23*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		MW-27D	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		MW-33	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
Performance Monitoring Month 4	*Injection Wells*																				
	Shallow	IW-5	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-6	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-16	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
	Intermediate	IW-10	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-11	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-13	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-14	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-15	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
	Monitoring Wells																				
	Shallow	MW-7*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		MW-8	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-32	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
	Interm.	MW-23	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-27D*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		MW-33	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F

See notes on last page.

Table 2. Summary of Proposed Performance Monitoring, ERD Pilot Test Workplan, 25 Melville Park Road Site, Melville, New York.

			Analysis/Parameter																		
Sampling Event		Well	VOCs plus TICs	Dissolved (ferrous) Iron	Dissolved (manganous) Manganese	Nitrate	Nitrite	Sulfate	Sulfide	Ethene	Ethane	Methane	TOC	Alkalinity*	Chloride	Bromide	pH	ORP	DO	Temperature	Specific Conductance
Performance Monitoring Month 6	*Injection Wells*																				
	Shallow	IW-5	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-6	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-16	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
	Intermediate	IW-10	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-11	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-13	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-14	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-15	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
	Monitoring Wells																				
	Shallow	MW-7	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-8	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-15	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-32	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
	Interm.	MW-23	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-27D	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
		MW-33	L	L	L	L	L	L	H	L	L	L	L	L	L	L	F	F	F	F	F
Field Parameter Monitoring Months 1, 3, and 5	*Injection Wells*																				
	Shallow	IW-5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		IW-6 (1, 3, 5)*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-16	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Intermediate	IW-10 (1, 3, 5)*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		IW-11	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		IW-13	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		IW-14	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		IW-15 (1, 3, 5)*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
	Monitoring Wells																				
	Shallow	MW-7 (3, 5)*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		MW-8 (1, 3, 5)*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		MW-10 (3, 5)*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		MW-11 (3, 5)*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-15 (1, 3, 5)*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-29 (5)*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-31 (5)*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-32 (1, 3, 5)*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
	Intermediate	MW-16D (5)*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-23 (1, 3, 5)*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		MW-27D (3, 5)*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F
		MW-28D (3, 5)*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-30 (5)*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	F	F	F	F	F
		MW-33 (1, 3, 5)*	---	---	---	---	---	---	---	---	---	---	L	---	---	---	F	F	F	F	F

See notes on last page.

Table 2. Summary of Proposed Performance Monitoring, ERD Pilot Test Workplan, 25 Melville Park Road Site, Melville, New York.

Notes

The baseline event includes additional wells for the purposes of establish baseline conditions for longer-term performance monitoring (beyond the six-month data collection period)

The subset of monitoring wells and frequency of the field parameter monitoring may be modified, as warranted, based on ongoing data collection and evaluation.

* - Groundwater sample will be collected with a bailer and and field measurements will be collected down-hole (no purging)

VOCs - Volatile Organic Compounds
ORP - Oxidation Reduction Potential
DO - Dissolved Oxygen
TOC - Total Organic Carbon
--- Indicates no sample to be collected
(1, 3, 5) - Data Collection During Months 1, 3, and 5
(3, 5) - Data Collection During Months 3 and 5
(5) - Data Collection During Month 5

TICs - Tentatively Identified Compounds
L - Laboratory analysis
H - Field Analysis using a Hach^{TM} Spectrophotometer
F - Field Measurement using a water quality meter
* - Alkalinity will be analyzed only if the pH fluctuates significantly

Table 3. Sample Collection and Analyses Protocols, Sample Containers, Volume, Preservation, and Holding Time Techniques, ERD Pilot Test Workplan, 25 Melville Park Road Site, Melville, New York.

Parameter	Method	Method Detection Limit	Sample Container(s) (a)	Chemical Preservative (b)	Holding Time
VOCs plus TICs	8260	see Table 4	(2) 40 mL, glass voa vials	None HCl	7 days to analysis 14 days to analysis
Ethane and Ethene	AM20	5 ng/L*	(2) 40 mL, glass voa vials	None	14 days
Methane (CH_4)	AM20	15 ng/L*	(2) 40 mL, glass voa vials	None	14 days
Alkalinity	310.1	0.594 mg/L	(1) 1,000 mL, plastic	None	14 days
Nitrate (NO_3)	300.0	0.002 mg/L	(1) 1,000 mL, plastic	None	48 hours
Nitrite (NO_2)	300.0	0.003 mg/L	(1) 1,000 mL, plastic	None	48 hours
Sulfate (SO_4)	300.0	0.012 mg/L	(1) 1,000 mL, plastic	None	28 days
Chloride (Cl)	300.0	0.147 mg/L	(1) 1,000 mL, plastic	None	28 days
Bromide (Br)	300.0	0.006 mg/L	(1) 1,000 mL, plastic	None	28 days
Sulfide	Hach™	0.005 mg/L	NA	NA	NA
Dissolved Iron	6010	0.1 mg/L	(1) 500 mL, plastic	HNO_3	6 months
Dissolved Manganese	6010	0.1 mg/L	(1) 500 mL, plastic	HNO_3	6 months
TOC	415.1	1 mg/L	(2) 40 mL, glass voa vials	H_2SO_4	28 days

(a)	The number of containers required is in parentheses.
(b)	Samples will be cooled to approximately 4 degrees Celcius.
VOCs	Volatile Organic Compounds.
TICs	Tentatively Identified Compounds.
mL	Milliliter.
mg/L	Milligrams per liter.
ng/L	Nanograms per liter.
HCl	Hydrochloric Acid.
Hach™	Field Analysis using a Hach™ Spectrophotometer.
TOC	Total Organic Carbon.
NA	Not applicable.

Method detection limits reported by Severn Trent Laboratories, Inc., Shelton, CT.

* Method quantitation limits reported by Microseeps, Inc., Pittsburgh, PA.

Table 4. Volatile Organic Compounds Method Detection Limits, Laboratory Reporting Limits, and NYSDEC Groundwater Criteria, 25 Melville Park Road Site, Melville, New York.

Compound	Method Detection Limit (ug/L)	Reporting Limit (ug/L)	NYSDEC TOGS (1.1.1) SGV (ug/L)
Chloromethane	1.0	5	-
Vinyl chloride	1.0	5	2
Bromomethane	3.1	5	5
Chloroethane	0.8	5	5
1,1-Dichloroethene	0.8	5	5
Carbon disulfide	0.6	5	-
Acetone	1.9	10	50
Methylene chloride	0.4	5	5
trans-1,2-Dichloroethene	0.6	5	5
1,1-Dichloroethane	0.6	5	5
cis-1,2-Dichloroethene	0.6	5	5
2-Butanone (MEK)	1.1	10	50
Chloroform	0.4	5	7
1,1,1-Trichloroethane	0.4	5	5
Carbon tetrachloride	0.3	5	5
Benzene	0.4	5	1
1,2-Dichloroethane	0.3	5	0.6
Trichloroethene	0.7	5	5
1,2-Dichloropropane	0.6	5	1
Bromodichloromethane	0.4	5	50
cis-1,3-Dichloropropene	0.6	5	0.4
4-Methyl-2-pentanone (MIBK)	0.5	10	-
Toluene	0.3	5	5
trans-1,3-Dichloropropene	0.4	5	0.4
1,1,2-Trichloroethane	0.8	5	1
Tetrachloroethene	0.4	5	5
2-Hexanone	1.3	10	50
Dibromochloromethane	0.2	5	50
Chlorobenzene	0.2	5	5
Ethylbenzene	0.3	5	5
Styrene	0.4	5	5
Bromoform	0.4	5	50
1,1,2,2-Tetrachloroethane	0.7	5	5
Xylenes (total)	1.0	5	5

ug/L	Micrograms per Liter.
NYSDEC	New York State Department of Environmental Conservation.
TOGS	Technical and Operational Guidance Series.
SGV	Ambient Water Quality Standards and Guidance Values.

Table 1. Well Construction Details for Existing and Proposed Injection and Monitoring Wells, ERD Pilot Test Workplan, 25 Melville Park Road Site, Melville, New York.

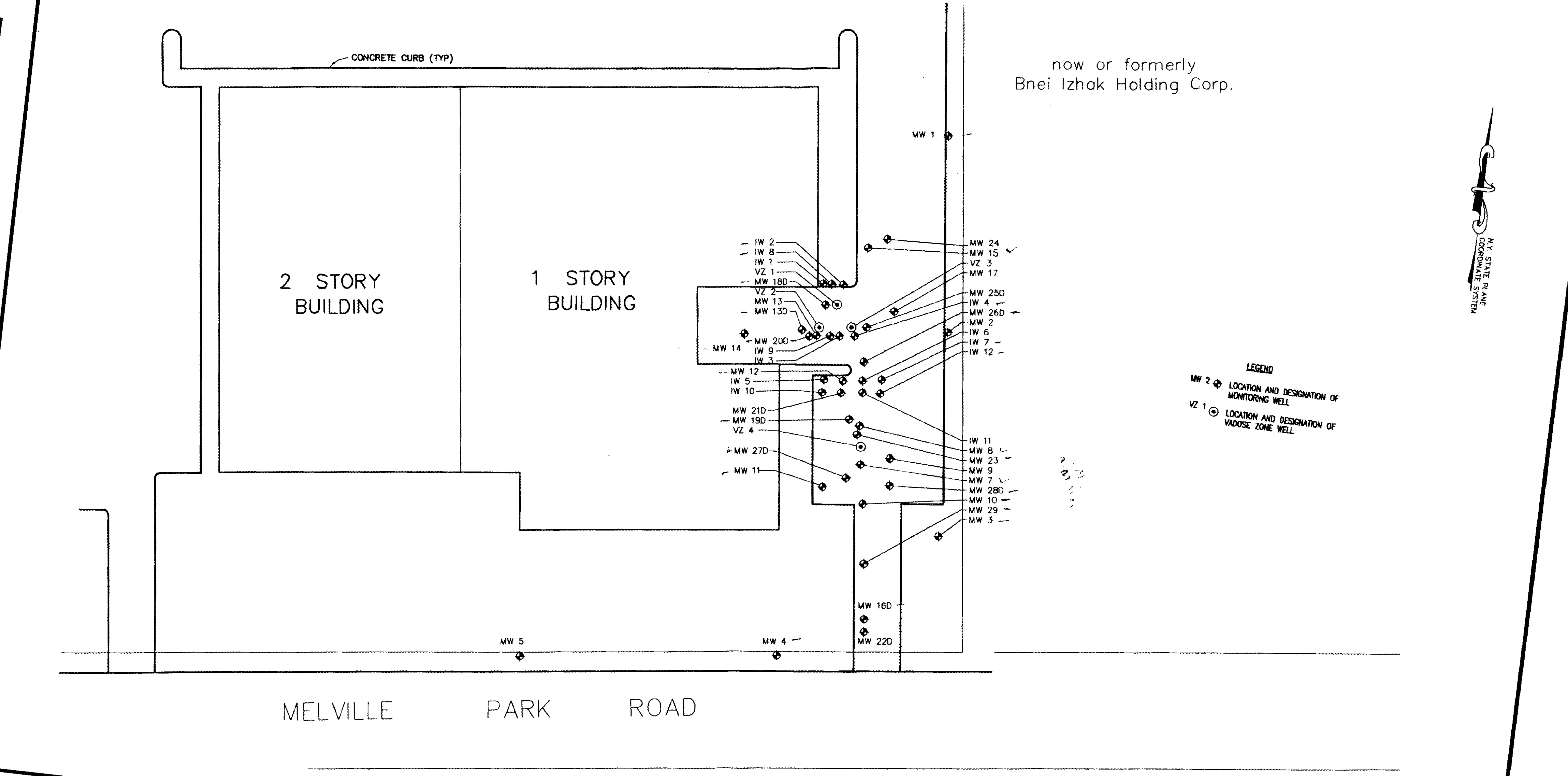
Injection Wells

Well ID	Screened Interval (feet bls)	Total Well Depth (feet bls)	Zone	Notes
IW-5	45-60	60	Shallow	Existing well
IW-6	45-60	60	Shallow	Existing well
IW-16	45-60	60	Shallow	Proposed well
IW-10	75-90	90	Intermediate	Existing well
IW-11	75-90	90	Intermediate	Existing well
IW-13	75-90	90	Intermediate	Proposed well
IW-14	60-75	75	Intermediate	Proposed well
IW-15	60-75	75	Intermediate	Proposed well

Monitoring Wells

Well ID	Screened Interval (feet bls)	Total Well Depth (feet bls)	Zone	Notes
MW-7	40-60	60	Shallow	Existing well
MW-8	40-60	60	Shallow	Existing well
MW-10	45-60	60	Shallow	Existing well
MW-11	45-60	60	Shallow	Existing well
MW-15	48.5-58.5	58.5	Shallow	Existing well
MW-29	45-60	60	Shallow	Existing well
MW-31	60-70	70	Shallow	Proposed well
MW-32	45-60	60	Shallow	Proposed well
MW-16D	79.5-89.5	89.5	Intermediate	Existing well
MW-23	70-85	85	Intermediate	Existing well
MW-27D	40-55 (Upper) 75-90 (Lower)	90	Intermediate	Existing well
MW-28D	40-55 (Upper) 75-90 (Lower)	90	Intermediate	Existing well
MW-30	75-90	90	Intermediate	Proposed well
MW-33	70-85	85	Intermediate	Proposed well

Notes
bls - Below Land Surface



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NO.	DATE	REVISION DESCRIPTION	BY	CKD

ARCADIS G&M
88 Duryea Road
Melville, NY 11747
Tel: (631) 249-7600 Fax: (631) 249-7610

25 MELVILLE PARK ROAD
MELVILLE, NEW YORK
25 MPR, LLC

DRAWN
A.G.

DATE
1/08/02

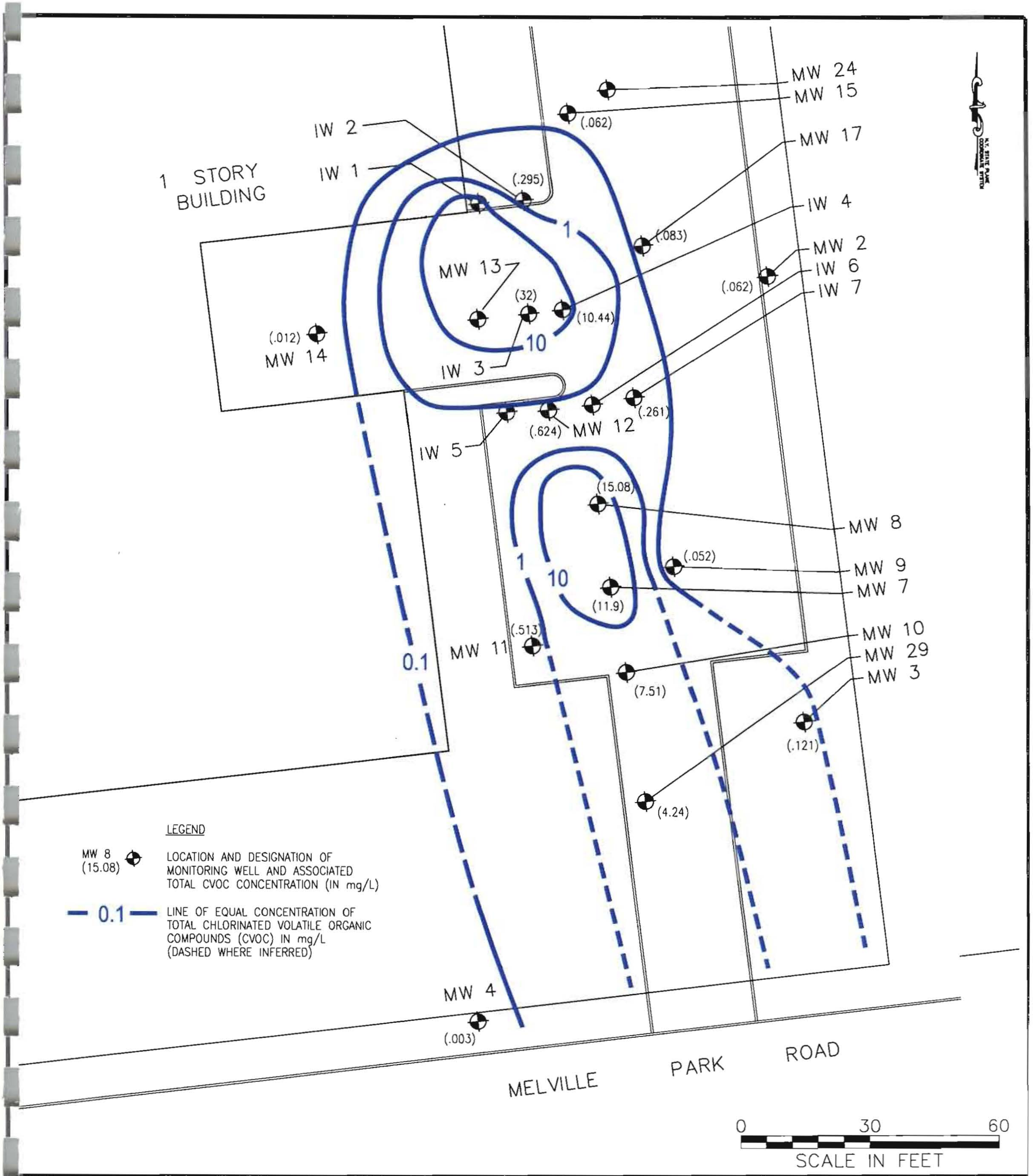
PROJECT MANAGER
S. FELDMAN

DEPARTMENT MANAGER
N. VALKENBURG

LEAD DESIGN PROF.

CHECKED

SITE PLAN



ARCADIS G&M

DRAWN A.G.	DATE 1/14/03	PROJECT MANAGER S. FELDMAN	DEPARTMENT MANAGER N. VALKENBURG
TOTAL CVOC CONCENTRATION DISTRIBUTION IN THE SHALLOW AQUIFER ZONE (45-60 FT BLS) AUGUST 2001 25 MELVILLE PARK ROAD MELVILLE, NEW YORK 25 MPR, L.L.C.		LEAD DESIGN PROF.	CHECKED C. KEEN
		PROJECT NUMBER NY01332.03.03	DRAWING NUMBER 2

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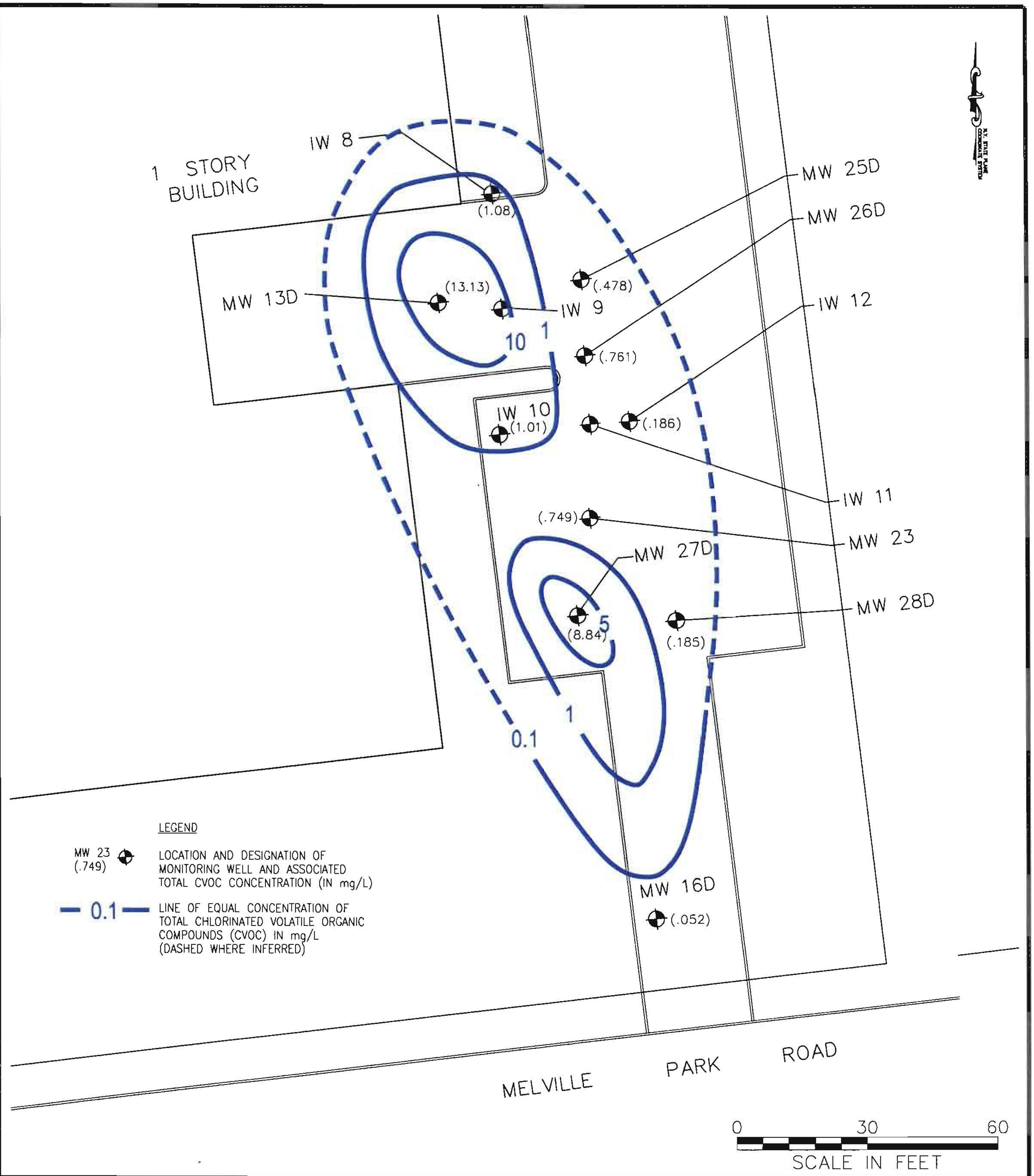

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ARCADIS G&M

DRAWN	DATE	PROJECT MANAGER	DEPARTMENT MANAGER
A.G.	1/14/03	S. FELDMAN	N. VALKENBURG

TOTAL CVOC CONCENTRATION
DISTRIBUTION IN THE INTERMEDIATE
AQUIFER (75–90 FT BLS) AUGUST 2001
25 MELVILLE PARK ROAD
MELVILLE, NEW YORK
25 MPR, L.L.C.

LEAD DESIGN PROF.

CHECKED C. KEEN

PROJECT NUMBER NY01332.03.03

DRAWING NUMBER 3

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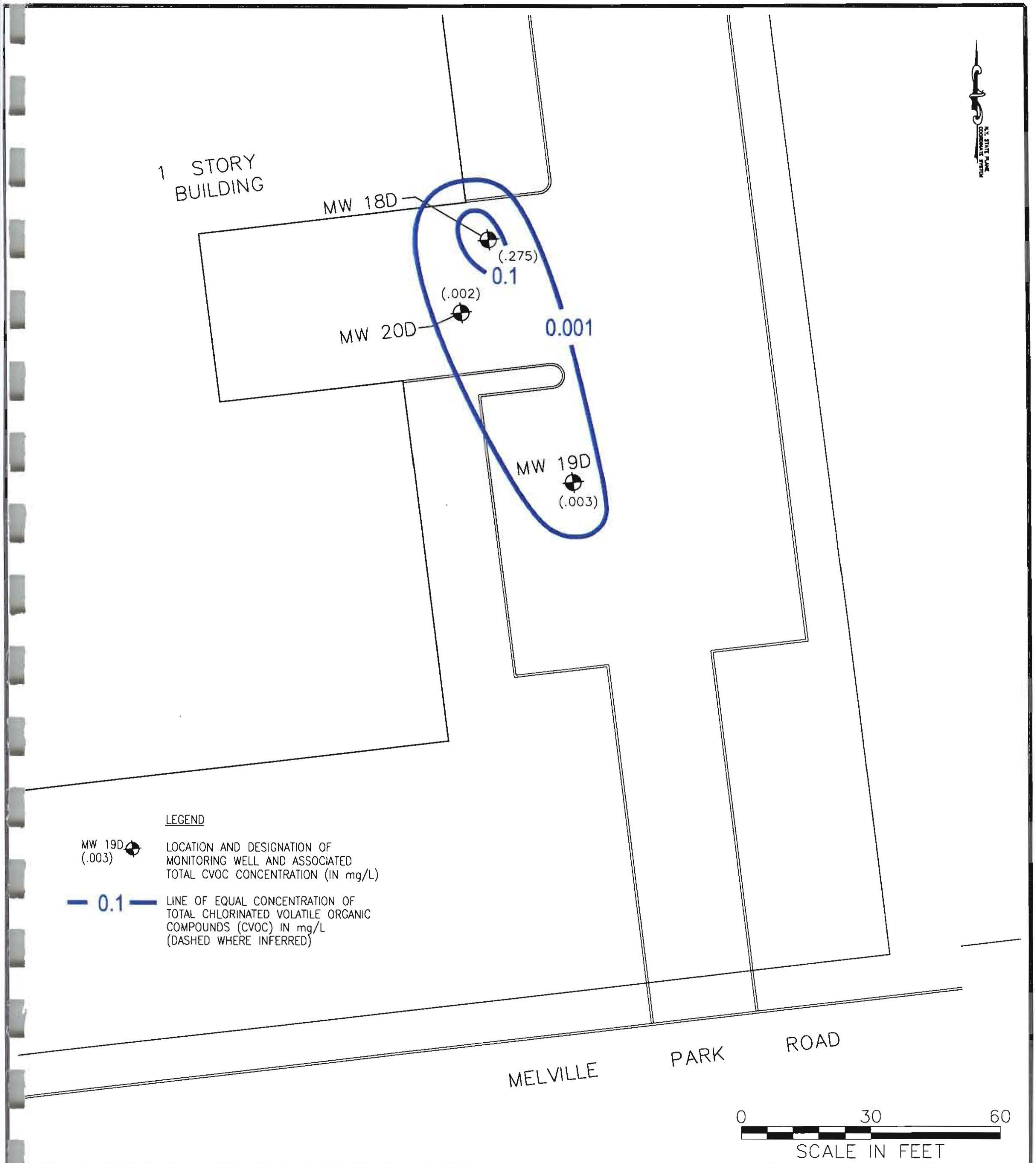


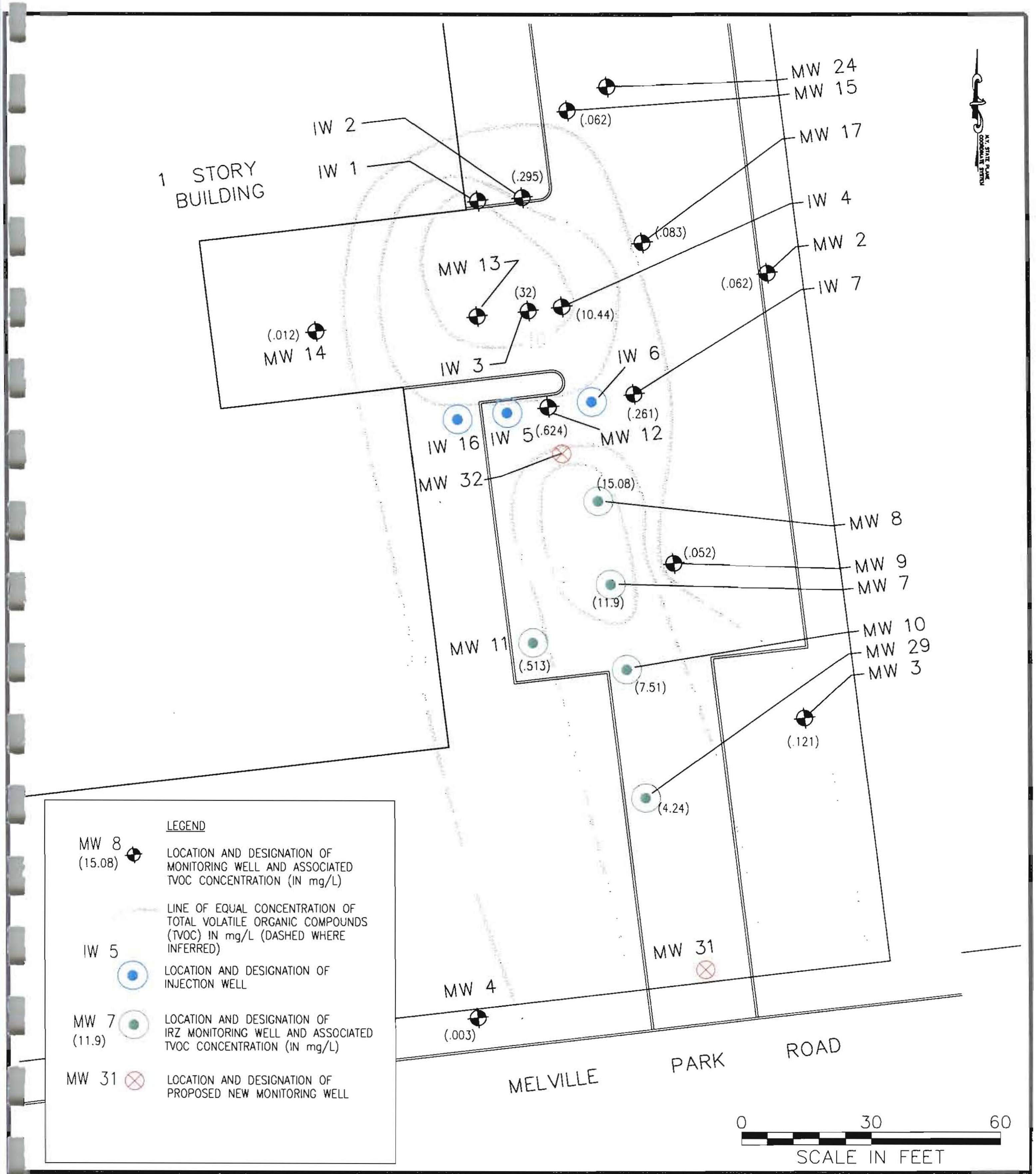
LEGEND

MW 19D (.003) — LOCATION AND DESIGNATION OF MONITORING WELL AND ASSOCIATED TOTAL CVOC CONCENTRATION (IN mg/L)

— 0.1 — LINE OF EQUAL CONCENTRATION OF TOTAL CHLORINATED VOLATILE ORGANIC COMPOUNDS (CVOC) IN mg/L (DASHED WHERE INFERRED)

ARCADIS G&M

DRAWN A.G.	DATE 1/14/03	PROJECT MANAGER S. FELDMAN	DEPARTMENT MANAGER N. VALKENBURG
TOTAL CVOC CONCENTRATION DISTRIBUTION IN THE DEEP AQUIFER ZONE (100–185 FT BLS) AUGUST 2001 25 MELVILLE PARK ROAD MELVILLE, NEW YORK 25 MPR, L.L.C.		LEAD DESIGN PROF.	CHECKED C. KEEN
		PROJECT NUMBER NY01332.03.03	DRAWING NUMBER 4



ARCADIS G&M

DRAWN
A.G.

DATE
4/1/03

PROJECT MANAGER
S. FELDMAN

DEPARTMENT MANAGER
N. VALKENBURG

PROPOSED IRZ WELL NETWORK
IN THE SHALLOW AQUIFER ZONE
(45-60 FT BLS)
25 MELVILLE PARK ROAD
MELVILLE, NEW YORK
25 MPR, LLC

LEAD DESIGN PROF.

CHECKED
C. KEEN

PROJECT NUMBER
NY01332.03.03

DRAWING NUMBER
5

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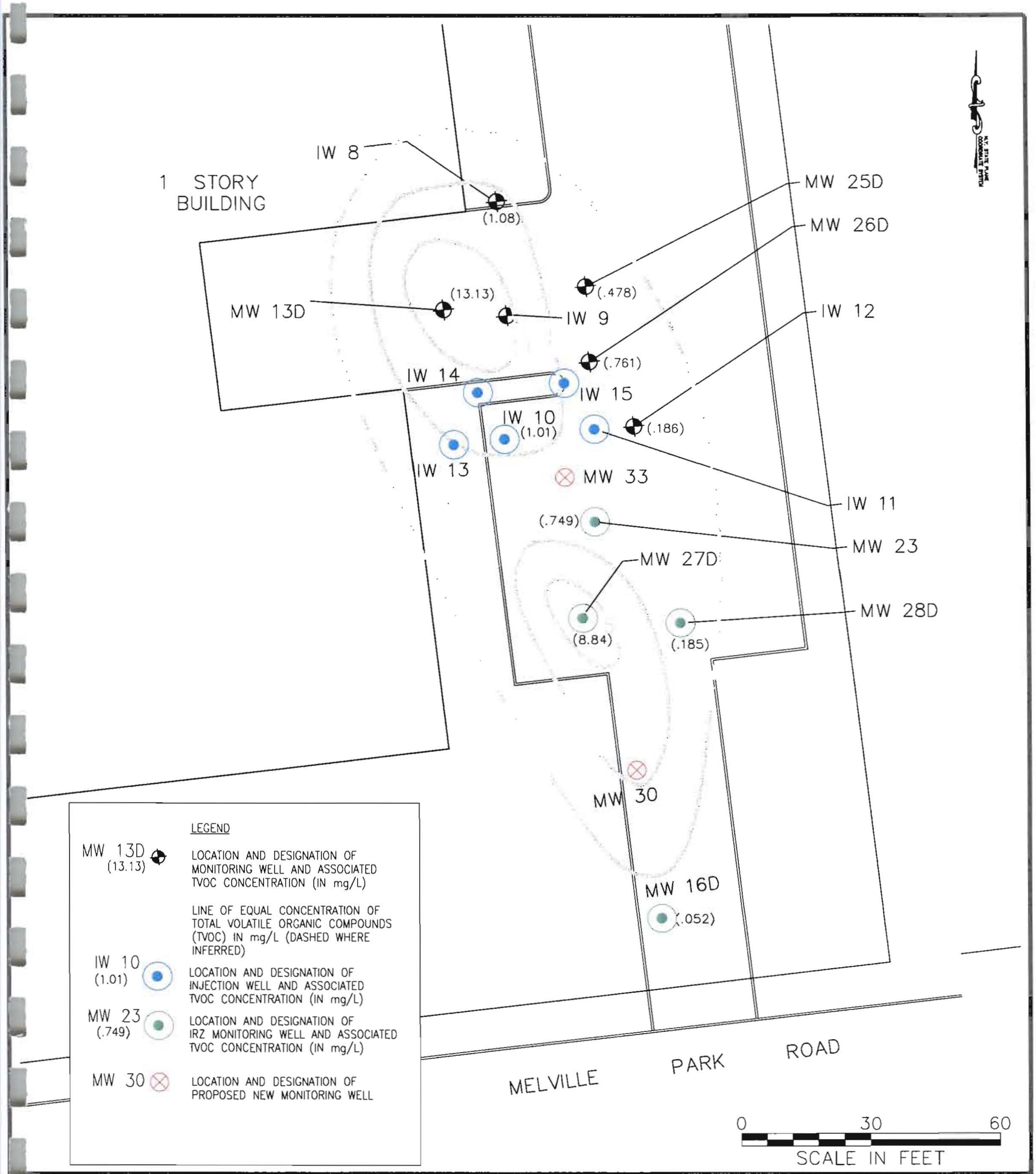

LEGEND

MW 13D (13.13) — LOCATION AND DESIGNATION OF MONITORING WELL AND ASSOCIATED TVOC CONCENTRATION (IN mg/L)

LINE OF EQUAL CONCENTRATION OF TOTAL VOLATILE ORGANIC COMPOUNDS (TVOC) IN mg/L (DASHED WHERE INFERRED)

IW 10 (1.01) — LOCATION AND DESIGNATION OF INJECTION WELL AND ASSOCIATED TVOC CONCENTRATION (IN mg/L)

MW 23 (.749) — LOCATION AND DESIGNATION OF IRZ MONITORING WELL AND ASSOCIATED TVOC CONCENTRATION (IN mg/L)

MW 30 ⊗ — LOCATION AND DESIGNATION OF PROPOSED NEW MONITORING WELL

ARCADIS G&M

DRAWN A.G.	DATE 4/1/03	PROJECT MANAGER S. FELDMAN	DEPARTMENT MANAGER N. VALKENBURG
PROPOSED IRZ WELL NETWORK IN THE INTERMEDIATE AQUIFER ZONE (75–90 FT BLS) 25 MELVILLE PARK ROAD MELVILLE, NEW YORK 25 MPR, L.L.C.		LEAD DESIGN PROF.	CHECKED C. KEEN
		PROJECT NUMBER NY01332.03.03	DRAWING NUMBER 6

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Appendix A

Molasses Injection Daily Log Form

MOLASSES INJECTION LOG

ERD Pilot Test
25 Melville Park Road Site
Melville, New York

Injection Well # ______________________________

Date	Injection No.	Raw Molasses Volume (gallons)	Water Volume (gallons)	Solution Strength (Ratio)	Volume Injected (gallons)	Notes/ Observations

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Appendix B

Groundwater Sampling/Downhole Probe Parameter Log Forms

ARCADIS G&M, Inc.

Low-Flow Groundwater Sampling Log

Project Number: ____________ Task: ____________ Well ID: ____________

Date: ____________ Sampled By: ____________

Sampling Time: ____________ Recorded By: ____________

Weather: ____________ Coded Replicate No.: ____________

Instrument Identification

Water Quality Meter(s): ____________ Serial #: ____________

Purging Information

Casing Material: ____________ Purge Method: ____________

Casing Diameter: ____________ Screen Interval (ft bmp): Top ____________ Bottom ____________

Sounded Depth (ft bmp): ____________ Pump Intake Depth (ft bmp): ____________

Depth to Water (ft bmp): ____________ Purge time Start: ____________ Finish: ____________

Field Parameter Measurements Taken During Purging

Time	Minutes Elapsed	Rate (mL/min)	Volume Purged	Temp (°C)	pH (SI Units)	Spec. Cond. (mS/cm)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Depth to Water (ft bmp)	Comments

Sample Condition Color: ____________ Odor: ____________ Appearance: ____________

Sample Collection

Parameter:	Container:	No.	Preservative:

PID Reading ____________

Comments ____________

____

ARCADIS G&M, Inc.

Downhole Field Parameter Form

Project Number: ____________ Task: ____________ Well ID: ____________
Date: ____________ Recorded By: ____________
Weather: ____________ ____________

Instrument Identification

Water Quality Meter(s): ____________ Serial #: ____________

Well Information

Casing Material: ____________ Depth to Water (ft bmp): ____________ Time: ____________
Casing Diameter: ____________ Screen Interval (ft bmp): Top ____________ Bottom ____________
Sounded Depth (ft bmp): ____________ Downhole Readings Start: ____________ Finish: ____________

Downhole Field Parameter Measurements

Time	Depth (ft bmp)	Temp (°C)	pH (SI Units)	Spec. Cond. (mS/cm)	ORP (mV)	DO (mg/L)	Comments