American Cleaners Kingston
Ulster County, New York

Interim Remedial Measures Construction Completion Report:

Sub-Slab Soil Vapor Extraction and Bioremediation of Groundwater
NYSDEC Site Number: V-00601-3

Prepared for:
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CERTIFICATIONS

I, Jolanda G. Jansen, am currently a registered professional engineer licensed by the State of New York, I had primary direct responsibility for implementation of the remedial program activities, and I certify that the Interim Remedial Measure Work Plan was implemented and that all construction activities were completed in substantial conformance with the Department-approved Interim Remedial Measure Work Plan.

068972-1	4/17/2018	
NYS Professional Engineer #	Date	Signature

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LIST OF ACRONYMS

AS	Air Sparging
ASP	Analytical Services Protocol
BCA	Brownfield Cleanup Agreement
BCP	Brownfield Cleanup Program
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CAMP	Community Air Monitoring Plan
C/D	Construction and Demolition
CFR	Code of Federal Regulation
CLP	Contract Laboratory Program
COC	Certificate of Completion
CO2	Carbon Dioxide
CP	Commissioner Policy
DER	Division of Environmental Remediation
EC	Engineering Control
ECL	Environmental Conservation Law
ELAP	Environmental Laboratory Approval Program
ERP	Environmental Restoration Program
EWP	Excavation Work Plan
GHG	Green House Gas
GWE&T	Groundwater Extraction and Treatment
HASP	Health and Safety Plan
IC	Institutional Control
IRM	Interim Remedial Measure(s)
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYCRR	New York Codes, Rules and Regulations
O&M	Operation and Maintenance
OM&M	Operation, Maintenance and Monitoring
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PID	Photoionization Detector
PRP	Potentially Responsible Party
PRR	Periodic Review Report
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RAO	Remedial Action Objective
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RP	Remedial Party
RSO	Remedial System Optimization
SAC	State Assistance Contract

SCG	Standards, Criteria and Guidelines
SCO	Soil Cleanup Objective
SMP	Site Management Plan
SOP	Standard Operating Procedures
SOW	Statement of Work
SPDES	State Pollutant Discharge Elimination System
SSD	Sub-slab Depressurization
SVE	Soil Vapor Extraction
SVI	Soil Vapor Intrusion
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leachate Procedure
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VCA	Voluntary Cleanup Agreement
VCP	Voluntary Cleanup Program

CONSTRUCTION COMPLETION REPORT

1.0 BACKGROUND AND SITE DESCRIPTION

American Cleaners Kingston entered into a Voluntary Cleanup Agreement (VCA) with the New York State Department of Environmental Conservation (NYSDEC) in March 2003 to investigate and remediate a 0.44 acre property located in the City of Kingston in the County of Ulster, New York (Figure 1-1). The property will be remediated to commercial or industrial use, and will continue to be used for dry cleaning and laundry.

The site is located in the County of Ulster, New York and is identified as Section, Block and Lot 48.58-6-17 on the Ulster County Real Property Tax Map. The site is situated on an approximately 0.44 acre area bounded by Merchant Wine & Liquor Store to the north, Meineke Muffler to the south, CSX Railroad to the east, and Ulster Avenue also known as Albany Avenue to the west (Figure 1-2). The boundaries of the site are fully described in Appendix 1 : Survey Map, Metes and Bounds.

An electronic copy of this IRM CCR ~~FER~~ with all supporting documentation is included as Appendix 2 on the associated CD-ROM..

2.0 SUMMARY OF SITE REMEDY

2.1 REMEDIAL ACTION OBJECTIVES

Based on the results of the Remedial Investigation, the following Remedial Action Objectives (RAOs) were identified for this site.

2.1.1 Soil RAOs

RAOs for Public Health Protection

- Prevent ingestion/direct contact with contaminated soil.
- Prevent inhalation of, or exposure to, contaminants volatilizing from contaminated soil.

RAOs for Environmental Protection

- Prevent migration of contaminants that would result in groundwater or surface water contamination.

2.1.2 Groundwater RAOs

RAOs for Public Health Protection

- Prevent ingestion of groundwater containing contaminant levels exceeding drinking water standards.
- Prevent contact with, or inhalation of, volatiles emanating from contaminated groundwater.

RAOs for Environmental Protection

- Restore ground water aquifer, to the extent practicable, to pre-disposal/pre-release conditions.
- Prevent the discharge of contaminants to surface water.
- Remove the source of ground or surface water contamination.

2.2 DESCRIPTION OF SELECTED REMEDIES

For the two remedies, there were three specific mobilizations for construction activities: Installation of Sub-Slab Soil Vapor Extraction System, Subsurface Injection of Bio-nutrients in 15 points around the property with Geoprobe®, and Similar Injection of the Mirobes a few months later.

As proposed in IRMWP Section 4.1, the soil vapor remedy was implemented below the slab, within the building, and above the roof:

October 10, 2015 Installation of the Sub-Slab Soil Vapor Extraction System

As proposed in the IRMWP Section 4.2, the injection of the Regenesis bioremediation products occurred in two separate periods of injection.

April 6-10, 2015 Injection of 3-D Microemulsion (3DMe™)
October 6-8, 2015 Injection of Bio-Dechlor Inoculum (BDI Plus™)

The bioremediation components cannot be mixed together and the nutrients were allowed to disperse in the groundwater aquifer prior to injection of the microbes. The injection points were marked on the ground at 15-foot spacing with spray paint. The Geoprobe® penetrated the ground in approximately the same locations for both series of injections.

The site was remediated in accordance with the remedy selected by the NYSDEC in ~~the~~ a letter of approval dated July 24, 2014 with some required modifications of the IRMWP submitted in June 2014.The factors considered during the selection of the remedy are those listed in 6NYCRR 375-1.8. The following are the components of the selected remedy:

1. Passive Sub-Slab Soil Vapor Extraction System consisting of installation of four extraction points, use of wind-driven turbines above the roof top, and sampling port for each point.

2. Bioremediation of PCE in groundwater by injection of nutrients followed by injection of microbes in locations around the northern and western site boundaries.

3. Execution and recording of an Environmental Easement to restrict land use and prevent future exposure to any contamination remaining at the site.

4. Development and implementation of a Site Management Plan for long term management of remaining contamination as required by the Environmental Easement, which includes plans for: (1) Institutional and Engineering Controls, (2) monitoring, (3) operation and maintenance and (4) reporting;

5. Periodic certification of the institutional and engineering controls listed above.

3.0 INTERIM REMEDIAL MEASURES, OPERABLE UNITS, AND REMEDIAL CONTRACTS

3.1 INTERIM REMEDIAL MEASURES

Both remedial actions reported in this document were conducted as Interim Remedial Measures. Specifically, remedial construction of the vapor extraction system is described in Section 4 and the ground water remedial measures are documented in Section 5. The field activities are shown and explained in the Project Photo Log (Appendix 5).

3.2 OPERABLE UNITS

There were no separate operable units defined for the remediation of the American Cleaners Kingston site.

3.3 REMEDIAL CONTRACTS: Contractors and Consultants

The following persons are consultants and contractors for the VCP at American Cleaners Kingston:

- Engineer of Record: Jolanda G. Jansen, P.E. Jansen Engineering, PLLC responsible for review of the design of remedation systems, implementing the remedial programs, and inspection of the completed construction and remedial tasks as defined in the IRM Work Plan.

- Project Manager: Katherine J. Beinkafner, Ph.D., CPG, Mid-Hudson Geosciences, responsible for planning. research, logistics, scheduling, resource coordination, drafting construction design plans, writing work plans and reports, coordination with NYS DEC and contractors.

• Todd Syska, Todd Syska Inc. materials aquisition and construction. Preparation and Geoprobe® injection of bioremediation fluids.

• York Analytical Laboratories, Inc. Delivery of sample containers and pickup of refrigerated samples, analysis of vapor, soil and water samples.

• Nancy Potak, Data Validation.

3.4 INTERIM REMEDIAL MEASURES WORK PLAN (June 5, 2014)

General Work Plan Elements

- Remedial Action Objectives for Soil Vapor and Groundwater
- QA/QC Plan
- Health & Safety Plan
- Community Air Monitoring Plan
- Remedial Implementation Schedule
- Site Remedial Action Consultants

Specific Work Plan Elements: Sub-Slab Vapor Extraction

- Pre-design investigation: Sub-Slab Soil & Vapor Sampling, Pilot Testing
- Basis of design: Passive or Active Vapor Extraction
- Design specifications: Materials required for Passive System
- Design drawings: Schematic Diagram of Planned Sub-Slab VES
- Calculation Sheet: VES Loading of VOC to atmosphere
- Design Issues: Schedule 40 or 80, blower or turbines

Specific Work Plan Elements: Groundwater Bioremediation

- Design investigation: Groundwater VOC Laboratory Sampling & Flow Direction
- Basis of design: Polishing of Low Levels of PCE Concentrations
- Design specifications: Regenesis Products: Nutrients & Microbes
- Design drawings: Map of Proposed 15 Injection Points on edge of AC Property
- Calculation Sheet: Porosity of Sand Aquifer with 15-foot Injection Spacing
- Design Issues: Quantities of Reagents and Mixtures and Timing of Injections

4.0 DESCRIPTION OF SOIL VAPOR REMEDIAL MEASURE

Remedial activities completed at the Site were conducted in accordance with the NYSDEC-approved Interim Remedial Measures Work Plan to Remediate Ground Water and Sub-Slab Soil Vapor for the American Cleaners Kingston site (June 2014). All deviations from the Interim Remedial Measures Work Plan are noted below.

4.1 REMEDIAL PROGRAM ELEMENTS

4.1.1 Site Preparation

The following activities were conducted for preparation of the site for installation of the Sub-Slab Soil Vapor Extraction System. A photo log of various site activities is included in Appendix 5.

- Prior to installation of the vapor extraction system, four vapor extraction points were drilled through the slab and 1-inch slotted PVC was installed in the hole with a PVC point on the bottom. They were used for the initial VOC testing conducted with Summa Canisters in March of 2013. Also soil samples were taken from each of the four vertical holes for VOC testing on the same day.

- Air flow testing was conducted around two vacuum testing points near the backdoor and near the location of XP3 near the north wall. It was determined that the fill material immediately below the concrete slab was not very permeable with respect to movement of gases or vapors. For that reason, use of a single-stage ring compressor for vapor extraction was not an effective option for vapor extraction. Hence, wind-blown turbines were chosen as a mechanism for extraction of the sub-slab vaoprs from each extraction point.

- Measurements from the floor to ceiling were made to purchase enough PVC pipe for the system. The system was designed with 2-inch schedule 80 PVC risers from the floor to the ceiling with the 2-inch PVC to a height of about 3 feet above the roof.

- Four-inch wind-driven metal turbines were planned for installation at the top of the PVC with an adapter from the 2-inch riser to the 4-inch riser.

- A shut off valve and sampling port were planned for each riser about 3 feet above the slab where the extraction point was driven to about 2 feet below the slab.

- Todd Syska prepared the list of construction materials and acquired them.

- Katherine Beinkafner acquired the turbines.

4.1.3 General Site Controls

• Since all the work was done inside the building or on the roof, we did not need site control for pedestrians or traffic. Access to the VES construction was through the backdoor or onto the roof with a ladder near the back door.

• Record keeping was accomplished by documenting significant happenings and visitors in the field notebook.

4.1.3 Nuisance controls and CAMP recordings were not required

4.1.4 Reporting

Daily reports were not a regular activity since most of the project team were present for the field work. In the event that our NYS DEC project manager Parag Amin was not present for the day's activities, an email was sent that evening to keep him up to date on project progress.

The digital photo log required by the IRMWP is included in electronic format in Appendix 5 complete with informative captions.

4.2 REMEDIAL CONSTRUCTION: INSTALLATION OF VAPOR EXTRACTION SYSTEM

The following **observations and conclusions** were included in the summary report (Dec. 2013):

● The chemical of concern Tetrachloroethylene was not detected in soil samples from XP2 and XP3. Very low estimated concentrations of 7.2J and 9.9J were detected in soil samples from XP1 and XP4, respectively. Comparison of these soil analyses and the following soil vapor analyses indicates that the majority of sub-slab VOCs is in the form of vapors and not attached to or associated with soil particles.

● As indicated by its presence in the trip blank, small concentrations of acetone detected in the soil samples are likely a lab contaminant.

4.2.3 Sub-Slab Soil Vapor Sampling: March 25, 2013

Sampling of vapors beneath the concrete slab inside the American Cleaners Kingston building was necessary to assess potential sub-slab contaminant conditions. The procedures and locations for installing four vapor extraction points were provided in the ***SI&SVEPTWP*** (Sep. 2012). The sub-slab vapor sampling event of March 25, 2013 was reported in the ***SRAC*** (Dec.

2013). Four vapor samples were collected using Summa canisters from the extraction point screened intervals including the sub-slab construction material and top of the natural sandy soil. The analyses by US EPA method TO15 full list of volatile organic compounds for 6-Liter Summa Canister are reported by York Analytical Laboratories in Report No: 13C0768, 04/04/2013. The four soil vapor extraction point locations are shown on Figure 2A and the analytical results are summarized in Table 1.

The following observations, conclusions and recommendation were included in the ***SRAC*** (Dec. 2013):

● Tetrachloroethylene was detected in all four vapor samples at concentrations ranging from 1300 to 22,000 μg/m^3.

● Helium was injected into the bucket sealed to the floor around the extraction point to make sure that the gas in the sample was coming from below the slab. Helium gas was not detected in any of the 4 Summa canisters indicating that the samples came from beneath the slab.

● The presence of the VOC vapors beneath the slab and spotty VOC concentrations in soil samples from the same locations suggests that the vapors originate from the underlying groundwater and soil. The contaminants vaporize from the groundwater and soil, migrate upward, and are trapped under the building slab.

● The sample from XP2 by the back door also has measurable concentrations of Trichloroethylene and cis1,2-Dichloroethylene, which are both breakdown products of Tetrachloroethylene. The presence of these compounds indicates that some natural degradation of Tetrachloroethylene is occurring beneath the slab.

● Table 1 shows that the four soil vapor samples had PCE concentrations of 2300, 22,000, 12,000, and 1300 μg/m^3, for XP1 to XP4, respectively. Comparison of Table 1 with Soil Vapor/Indoor Air Matrix 2 (Final NYSDOH CEH BEEI Soil Vapor Intrusion Guidance, 2006) indicates that mitigation is appropriate for all four locations because the PCE concentrations are greater than 1000 μg/m^3 and the values of indoor air concentrations are essentially insignificant. For that reason, sub-slab vapor extraction pilot testing was recommended and conducted.

4.2.4 Sub-Slab Vapor Extraction Pilot Testing: August 5, 2013

The pilot study **procedure** consisted of 8 tests with Figure 2-1 showing locations of XP and VP Vacuum Measuring Points. Methods and results are summarized here.

● Tests 1 to 4 were determined to be invalid because the flow meter was discovered to not be working correctly on Test 5. It was quite likely the meter was not working correctly on the first 4 tests; consequently, those results were deemed invalid.

● To replace the flow meter, a manometer was constructed with water in a bucket and a tube connected to the suction line. The vacuum was measured in inches of water from the height of water in the tube from the water level in the bucket. The vacuum reading was converted to flow in standard cubic feet per minute (SCFM) using the performance curve of the regenerative blower.

● Test 5. A vacuum of 39 inches of water and air flow of 42 SCFM was maintained on XP4 for one hour. Sand grains were sucked from the natural sands in which the extraction point was seated under the slab, indicating that the vacuum field was limited in radius.

● A vapor pressure measuring point VP1 was drilled through the slab 5 feet across the floor and southwest of XP2.

● Test 6, when a vacuum of 40 inches of H_2O (39 SCFM) was applied to XP2, a small vacuum of 0.07 in H_2O was measured at VP1 at a distance of 5 feet to the southwest (Figure 2A).

● VP2 was drilled through the slab part way between XP1 and XP3 (Figure 2A).

● Test 7, when a vacuum of 43 inches of H_2O (27 SCFM) was applied to XP1, essentially no vacuum was detected at VP2 at a distance of 7 feet 2 inches toward XP3.

● Test 8, when a vacuum of 43 inches of H_2O (32 SCFM) was applied to XP3, a small vacuum of 0.04 inH2O was measured at VP2 at a distance of 8 feet 9 inches toward XP1.

The following **conclusions** were drawn from the vapor extraction pilot testing:

● The construction material beneath the concrete slab was observed to be a heterogeneous mixture of particle sizes.

● The pilot testing indicates that the material is well packed and has low permeability to vapors. The vacuum field drops off substantially within 5 feet of the extraction points with a 1-horsepower regenerative blower.

● The 1-horse power blower is a reasonable size to evacuate vapors from porous media under the slab of this size building. However, in the American Cleaners Kingston building, the sub-slab material is not very permeable with respect to gas or vapor.

● Increasing the horsepower of the regenerative blower is not likely to significantly increase the radius of the vacuum field because it varies with the inverse square of the distance.

● The slab creates a barrier to upward migration and flow of volatile gases; otherwise, they would not be trapped there.

● Because the slab presents a barrier to vertical movement of vapors and because within the loose, but packed material, vapor permeability is virtually below the practical limit of measurability; the slab should not be penetrated or compromised.

● Annual testing of volatile organic gases in the work environment has shown continuous compliance with NYSDEC regulations and operational standards for dry cleaning plants. That testing indicates that the air in the work environment is not considered injurious to the employees.

The following **remedial mitigation measure** was recommended based on the pilot testing:

● Because ventilation of the sub-slab with a regenerative blower is not feasible, the four extraction points, installed through the slab and sub-slab fill material into the natural sandy soil, are proposed as a passive means to remove vapors which make their way to the four points. Each of the extraction points were vented to and through the roof and capped with 4-inch wind-driven stainless steel turbines to facilitate release of vapors to the atmosphere.

4.2.5 Installation of Sub-Slab Soil Vapor Extraction Points

The four extraction points (XP1, XP2, XP3, XP4) were installed on March 25, 2013. Construction consisted of drilling a 2-inch diameter hole through the concrete slab and the layer of item 4 material below the slab. A Geoprobe® 1B sampler was driven through the item 4 material and into the underlying natural soils. The depth of penetration of the sampling device was approximately 30 inches below the floor surface. Approximately 20 inches of natural soil was penetrated as shown by recovered length of sediment in the sampler of 23.5, 23.5,23, and 18 inches, respectively. The sample included a few inches of Item 4 and the remainder of redbrown, fine to medium sand and silt with trace of clay. A length of 18 inches of slotted screen was installed from approximately 10-inches below the surface of the concrete floor to sample vapors from within the natural soils below the slab. The 1-inch PVC riser sticks up about 1 foot above the floor in each of the four locations.

4.2.6 SVE System Installation

Two conceptual designs were considered to extend the PVC from each extraction point through the roof to the wind turbine. Four of the points could be piped to one central point and then through the ceiling and roof to one turbine. However, it was decided that piping each PVC extraction point directly upward and through the roof would be far more efficient and reduce friction of turns in the pipe. The method of construction is shown in the accompanying diagram (Figure 3). The risers from the floor up through the roof to the turbines were constructed of 2-inch diameter schedule 80 PVC. Schedule 80 is thicker and stronger than the original proposed Schedule 40. The smallest wind turbines available are four-inch diameter. An adapter was used to attach the 2-inch diameter PVC pipe on top of the roof to the 4-inch turbine opening. The connection was sealed with silicon. About three feet from the floor, a sampling port was installed for a 3/8 inch hollow brass fitting to attach to the Summa Canister used for sampling.

To allow sampling of the vapors from the soils screened in each point, a valve was installed above a sampling port to close off the flow to the atmosphere while sampling with a Summa Canister. The valve will be open most of the time to allow escape of vapors to the atmosphere as drawn up the riser by the wind turbine.

An estimate of the maximum potential loading of volatile organic compounds was made for the release to the air by the system. Based on the Summa Canister testing of March 25, 2013, the four volumes of reported VOCs for each of the extraction points (Table 1), resulting in a sum of 43,106 $\mu g/m^3$. The Summa Canister tests were run for about one hour each with the 6-liter canisters. A flow rate of 6 liters/hour is equivalent to about 6 gallons/hour and 0.8 cuft/hour. The calculation is shown on the attached calculation sheet (Figure 3) for VOC Atmospheric Loading. The estimate of the total emissions from the 4 sub-slab vapor extraction points is about 0.00003 pounds per hour or 3 x 10^{-6} pounds per hour. The emissions limit of 0.5 pounds/hour is about 100,000 times the estimated load.

4.2.7 SVE System Startup

The passive sub-slab soil vapor extraction system began working immediately after the wind-driven 4-inch turbines were installed on top of the risers about three feet above the roof (April 10, 2015). All four were spinning in the breeze after they were installed on top of the 2-inch schedule 80 PVC risers.

4.2.8 Deviation from Design

As mentioned above the one change made from the original design to final construction included use of 2-inch Schedule 80 PVC risers in place of Schedule 40. The other change involved using four separate risers from the sub-slab vapor extraction points making four locations above the roof where the turbines draw the vapors up the riser. The alternative would have been to duct all four together into one ring compresser where the vapor laiden air would be vented to the outside above the roof. The change from electric blower to wind-driven turbines was designed to work with a low permeability fill directly under the slab.

4.2.9 Sub-Slab Soil Vapor Monitoring Results (System Performance)

On Monday, November 28, 2016 samples were collected in Summa Canisters from the 4 sub-slab vapor extraction points which were installed in the March 2013. One canister was connected to each sampling port on each of the four risers constructed of schedule 80 2-inch PVC. The valve was closed in the PVC pipe to keep the soil vapor from going up the pipe and exiting above the roof. The pressures in the canister were recorded on the York Analytical Laboratory's Chain of Custody Form. The canisters were set up to collect vapors for one hour and the valves were closed and pressures recorded after one hour at each location. Following sample collection, the valves on the PVC risers were opened for the system to continue discharging soil vapors to the atmosphere.

The canisters were picked up by the lab on Tuesday, November 29, 2016. The resulting data is recorded on Table 1 showing a comparison of the original sampling of March 25, 2013 and that of November 28, 2016. The concentrations of Tetrachloroethylene declined by 39, 78, 94, and 73 percent respectively for the four extraction points originally labelled XP1, XP2, XP3, XP4. Trace amounts of some additional compounds were detected in the recent sampling event, possibly because higher concentrations of Tetrachloroethylene were masking them in the earlier event.

The total VOC concentrations of the **November 2016 end point sampling** is shown in Figure 4. Table 2 shows the VOCs detected in the soil gas sampling with Summa canisters on March 25, 2013 and November 11, 2016. The total VOCs have declined by 35, 72, 94, and 67 percent respectively in XP1 through XP4. Those declines in VOC concentrations have occurred between April 1, 2015 and November 29, 2016, a period of 19 months. If the rate of cleanup remains constant, the VOCs would decline to zero in 5 years. However, vapor decline is usually observed as asymptotic. The total vapor concentration gradually approaches a limit.

The lab report is included as Appendix 6. The B package has been obtained from the lab and was forwarded to the data evaluator. The Data Usability Summary Reports (DUSRs) are found in Appendix 7. Based on the DUSRs, all of the analyses are suitable for use in reporting sampling results to NYS DEC for regulatory compliance.

5.0 DESCRIPTION OF GROUNDWATER REMEDIAL MEASURE

5.1 REMEDIAL PROGRAM ELEMENTS

5.1.1 Site Preparation

- Marking the proposed injection locations on the ground with spray paint for first injection (nutrients) and metal stakes for second injection (microbes).
- Utility markout
- Order Materials from Regenesis for timely receipt
- Schedule Todd Syska, select equipment for mixing injection fluids, plan for two pumping alternatives and other Geoprobe® accessories for site work.
- Verify on-site water connection and electrical receptacles

5.1.2 General Site Controls

- The bioremediation activities occurred outdoors. Beginning in the backyard, gave us some isolation from the traffic and general public to perfect our movements and actions before working on the north side of the building and the front sidewalk with more traffic. Both automobiles and pedestrians were moving along the edge of project work zones.

Reflective Orange Traffic Cones and Yellow Hazard Zone Warning Tape were used to mark out the work area and warn traffic. Reflective vests were worn.

- Record keeping was accomplished by writing significant happenings and visitors in the field notebook.
- Equipment used for the bioremedial injection was not contaminated with a toxic or deleterious substance. All equipment was rinsed with water which was poured on the ground or into the storm drains on site. There was no waste requiring special handling or disposal.

5.1.3 Nuisance controls and CAMP recordings were not required

5.1.4 Reporting

Daily reports were not a regular activity since most of the project team were present for the field work. In the event that our NYS DEC project manager, Parag Amin. was not present for the day's activities, an email was sent that evening to keep him up to date on project progress.

The digital photo log required by the IRMWP is included in electronic format in Appendix 5 complete with informative captions.

5.2 REMEDIAL CONSTRUCTION: ENHANCED BIOREMEDIATION

5.2.1 Summary of Groundwater Contamination

Groundwater contamination at the site originated from spills on the ground surface near the dumpster from disposal of cartridges of spent Tetrachloroethylene (PCE). Two other spills occurred within the back of the building and probably contributed to groundwater contamination. The sandy soils of the site allowed the VOC to infiltrate down to the top of the water table at approximately 10 feet below ground surface. Groundwater contamination has been shown to be confined to the approximate interval from 10 to 25 feet. PCE was not detected in deeper samples. The PCE plume has been traced with groundwater direction to the west northwest with low concentrations of PCE at less than 20 µg/L at Lincoln Park Place. Groundwater flow is toward the Esopus Creek Floodplain west of Lincoln Park Place.

5.2.2 Groundwater Sampling for VOCs

Historical groundwater sampling was mapped in Figure 5-3 (Figure 5A in this report) of the Remedial Investigation Report (2009) showing a bifurcated plume with one section flowing northwest from the northern area and another sub-plume flowing west from the southern part of the site. The concentrations of PCE shown on that map are a compilation of groundwater sampling from Geoprobe® borings and monitoring wells from 2005 to 2009. The water table is about 10 feet below ground surface and its gradient is approximately -0.003 to the west-northwest.

More recent groundwater sampling has been accomplished over the past few years with installation of five monitoring wells on parcels directly across Ulster Avenue, and most recently by sampling groundwater at three locations with Geoprobe® on Lincoln Park Place, and on-site sampling of six monitoring wells (Figure 5B). As shown on that map, PCE concentrations in groundwater are from sampling on November 3 to 6, 2013. The 14 groundwater analyses by US EPA method SW 846 8260B for volatile organic compounds are reported by York Analytical Laboratories in Report No: 13K0219, 11/18/2013. Laboratory results for 14 samples, 1 duplicate sample, and two blanks are summarized in Table 4. By comparison of Figure 5A and Figure 5B, PCE concentrations show reduction both on-site and on parcels across the street.

The following **conclusions** were drawn from examination of historical and recent sampling events:

● On-site groundwater concentrations of PCE have diminished from 2007 to 2009 and to 2013, except at MW5 where concentrations have remained at approximately 50 µg/L.

● On the west side of Albany/Ulster Avenue, groundwater PCE concentrations are generally low, less than 50 µg/L, except at MW8 in front of the rear RCAL building where PCE was measured at 150 µg/L. Another analyte not previously detected at the site, 1,1,2-Trichloroethane was also detected in MW8 at a concentration of 5.1 µg/L. That compound may be from some source other than American Cleaners.

● On Lincoln Park Place, the highest PCE concentration of 47 µg/L was detected at 16 feet in sample LP1 between the driveways at #746 and #752.

The following **recommendations** were included in the ***SRAC*** (Dec. 2013):

● ***Additional Groundwater Wells or Borings:*** The stratigraphic levels that have been sampled for groundwater on-site and off-site are 11 to 16 feet and 20 to 25 feet below the nearly flat land surface. Farther from American Cleaners and beyond the homes on the west side of Lincoln Park Place, the ground surface drops off steeply to the floodplain level of the Esopus Creek, farther to the west. The strata which have been sampled are eroded away at the edge of the floodplain by higher waters of the Esopus Creek during periods of flooding. For that reason sampling farther to the west from the east side of Lincoln Park Place is not recommended. Because the measured PCE concentrations are representative of the migrating groundwater, sampling 200 or 300 feet farther downgradient between Lincoln Park Place and the drop-off is not likely to gain significant information. The next sampling event started on the west side of Ulster Avenue. The 5 wells showed lower concentrations of PCE compared to previous sampling events. However, those PCE concentrations exceeded the NYS DEC Class GA groundwater standard of 5μg/L. Such a decline in PCE values most likely demonstrate that the bioremediation is working, and downgradient locations are also going to clean up as the nutrients and microbes reach those points as the remediation products travel within the groundwater flow.

● ***Natural Attenuation and Degradation:*** Tetrachloroethylene concentrations at the American Cleaners site are declining. No other VOC was detected except 1,1,2-Trichloroethane at MW8. PCE concentrations are summarized as

4 locations ND

2 locations less than 10 μg/L

7 locations between 10 and 50 μg/L

1 location at 150 μg/L

Groundwater in this area is not used for potable water because the entire area is served by the City of Kingston Water Department and or the Town of Ulster Water Department.

5.2.3 Consideration of In-Situ Remediation of PCE in Groundwater

Because PCE concentrations are detected in monitoring wells, a remedial action must be selected and implemented for groundwater at the American Cleaners Kingston site. Two common methods of remediation were considered: (1) chemical oxidation or (2) bioremediation with or without bioaugmentation. Because current concentrations of PCE range from ND to 150 μg/L or parts per billion with an average of 25 μg/L, a method of treating such low concentrations of PCE over a fairly large area was sought. Treatment of such low concentrations is considered “polishing” because it is usually employed after much higher concentrations of VOCs have been reduced by a rapid acting industrial strength chemical agent. The existing “Plume” is approximately 800 feet long and widening from a “point” source behind the AC building to a width of approximately 400 feet at Lincoln Park Place. The appropriate remedy is similar to finding a needle in a haystack and destroying it. The injected treatment fluid will have to find low concentrations of PCE molecules in a sandy water-bearing zone with a depth of approximately 10 feet over an area of 160,000 square feet, or a volume of 1,600,000 cubic feet of saturated groundwater. The reactivity of a chemical oxidation agent or virility of bacterial dechlorinating emulsion will have to be long-lived to move with natural groundwater flow from the on-site injection borings to off-site contaminated locations. Once the remedial agents reach the PCE-contaminants, the chemical oxidation or biological dechlorination will have to occur. Downgradient movement of the treatment products may take up to five years to travel from the site to locations across the street on to Lincoln Park Place, and on toward the Esopus Creek floodplain. For that reason, a long lasting remedy is needed to cleanup the low level plume. Chemical Oxidation was considered using a Regenesis product called PersulfOX. After serious consideration and working on a plan to inject that material into the ground at American Cleaners, that remedy was disqualified because in a webinar on April 20, 2014, two managers (Drew Baird and Scott Mullin) at Regenesis stated that chemical oxidation with PersulfOX or RegenOX is not appropriate to “polish” groundwater or rid groundwater of such low concentrations of VOCs detected at the American Cleaners site. Also PersulfOX is highly corrosive and caustic and requires special handling. The persistence of PersulfOX in the groundwater is of limited time and space and often requires more than one injection.

By comparison, bioremediation using Regenesis products have a high probability for effective cleanup of the low PCE concentrations both on-site and off-site over a period of five years.

5.2.4 Subsurface Injection of Bio-Nutrients into 15 points with Geoprobe®

The bioremediation and bioaugmentation was planned to inject the nutrients first and few months later inject the microbes. Regenesis products were chosen for the project.

Two Regenesis products were selected appropriate to treat the groundwater beneath the American Cleaners site and downgradient properties: 3-D Microemulsion and Bio-Dechlor Inoculum. The required quantities and water mixture proportions are shown in Table 5 for both products.

Regenesis recommends injection of the liquid bioremediation mixtures of emulsion and bacteria into the top five feet of the sandy aquifer using direct push equipment (Geoprobe®). The injection points were recommended to be placed 15 feet apart as shown in Figure 7. Fifteen injection points were arranged on the property to cover the original back yard source and the perimeter of the site where groundwater is migrating off-site to the north, northwest, and west. Each injection location consisted of two Geoprobe® borings, one for injection of the emulsion and a second for the injection of the bacteria.

3-D Microemulsion (3DMe™) is a factory emulsified electron-donor material used to facilitate anaerobic reductive dechlorination of chlorinated solvents by microbial action in groundwater. The product is a mixture of organic chemicals classified as HRC-PED (Hydrogen Release Compound – Partitioning Electron Donor). The mixture is made up of neutralized fatty acids, glycerol tripolylactate, and glycerol. 3-D Microemulsion is a liquid with a consistency similar to milk. The emulsion is characterized by three stages of active ingredients with three overlapping periods of time release for each electron donor material

(1) lactate, 0 to 1 year

(2) polylactate 0.3 to 2.2 years

(3) free fatty acids with fatty acid esters. 1 to 5 years

This characteristic is most cost effective because it will create an anaerobic reducing environment for a significant period of time while the material migrates downgradient with natural groundwater flow.

The 3-D Microemulsion product is mixed with water and injected into Geoprobe® borings. The material is generally innocuous with neutral pH and non-corrosive and non-caustic properties. The most hazardous characteristic of the product is that if it is spilled, it can be very slippery on surfaces; but it can be easily washed off with water. The material readily degrades and hydrolyses within hours. The product is diluted with water before it is injected into the subsurface.

Regenesis recommended injection of 100 pounds (13 gallons) of 3DMe™ for each injection point (Table 5). Regenesis recommended dilution of the factory shipped product in the range of 1 percent to 10 percent. A dilution of approximately 2.5 percent has been calculated to fill the available pore space in a cylinder around the axis of the injection boring with a vertical length of 5 feet and a radius of 7.5 feet, assuming a porosity of 7 percent in the sandy water-bearing zone. The 2.5 percent dilution would be made by mixing 13 gallons of 3DMe™ with 507 gallons of water for a total of 520 gallons per injection point (Table 5). In an ideal aquifer, the entire pore space of the cylinder around the vertical injection interval would be filled to the perimeter of the adjacent injection points. In that manner, a front of bioremedial material will move down gradient similar to the movement of the PCE from former spills at the site. Pumping and slug testing has shown that the water table is very difficult to depress and the hydraulic conductivity is high. The slug testing shows very rapid recovery on the order of 2 to 4 seconds. Those tests suggest that the sandy aquifer can accept a high volume of low concentration emulsion. However, the actual capability of the formation to accept the water in a timely manner determines the dilution factor.

Hence, the actual percent of the 3DMe™ was determined empirically in the first injection wells. When the Geoprobe® assembly is in place, the vertical zone of 3DMe™ injection is the top 5 feet of the aquifer (approximately 10 to 15 feet below ground surface). The rate of injection was determined by the capability of the sandy aquifer to accept the rate of flow and the practicality of how much water could be mixed in our 200 gallon container and injected within an hour into the formation. Documentation of the injection mixtures is provided in Tables 6A and 6B.

3DMe™ Injection Procedure

- The 3DMe™ was delivered to the site in four 400 pound drums.
- Premix in 200 gallon tank, for each injection point, 13 gallons of 3DMe™ was mixed with 162 to 182 gallons of water for a total of 175 to 195 gallons of mixture per injection point.
- Geoprobe® drills down to 15 feet below ground surface, approximately 5 feet into the top of the sand aquifer. Release the drive point and pull up the casing and drill string up from 15 to

10 feet during injection.

- Hydraulic high pressure GS2000 pump connected to the Geoprobe® drill string. Fill the 75 gallon tank while pumping the 3DMe mixture into the Geoprobe® boring until the entire 195 gallons is pumped into the subsurface. Pumping with the high pressure hydraulic pump tool about 40 to 50 minutes.
- Dispersion of the injection fluid in the formation was sometimes faster than other times. In that case, the high pressure pump was used for about 5 to 10 minutes and then an electric submersible pump was used to pump the fluid out of the 200 gallon mixture tank directly to the Geoprobe®. Using the two pumps, injection time was somewhat reduced.
- After completion of injection, the borings were filled with sand and capped with about 6 inches of sand and cement.

5.2.5 Subsurface Injection of Microbes in 15 points with Geoprobe®

Bio-Dechlor Inoculum (BDI Plus™) is a mixture of ***Dehalococcoides sp*** bacteria. Regenesis indicates that it "has been shown to stimulate rapid and complete dechlorination of compounds such as tetrachloroethylene (PCE), trichloroethene (TCE), dichloroethene (DCE), and vinyl chloride (VC)." Members of the genus ***Dehalococcoides*** are capable of driving the dechlorination chain of reactions of chloroethenes, such as PCE, to the end product of harmless ethane. At this time, it is not known exactly which dechlor species are associated with each sequential breakdown reaction, but the Regenesis inoculum consists of several species and is proven effective at promoting the entire breakdown of PCE to ethane.

The BDI Plus product is a murky, yellow to gray liquid with a musty odor. The live bacteria culture comes in a keg or canister pressurized to 10 to15 psi with nitrogen to maintain a reducing (non-oxygen) environment in the container. The container must be kept at 2° to 3°C until the material is injected into the ground. The culture is miscible with water, so it can be diluted to appropriate levels at the site. The water that the culture is mixed with is first aerated with nitrogen to remove the oxygen from the water to make sure the water will maintain the anaerobic conditions for the survival of the bacteria.

Regenesis recommends a ratio of BDI plus to water of 1 liter to 10 gallons, or for our specific site 0.75 liters to 7.5 gallons of water. The water for BDI plus™ must be aerated with nitrogen to assure that the water is oxygen free. Only 120 gallons of the nitrogen treated water was needed for the 16 injection points. However, since it was recommended to fill the annular space with water to prevent air from reaching the bacteria, additional water aerated with nitrogen was used for that purpose. The water was aerated while the boring was advanced with the Geoprobe®. The inoculum solution was injected into the top of the aquifer through the Geoprobe® hollow rods.

The second phase of injection proceeded much the same as the first, except that the water had to be treated and the volume of mixture per injection boring was substantially less.

● Most of the spray paint marks were still visible on the ground except for the three behind the building which were also marked with magnetic stakes.

● A 55 gallon food grade drum was used for deoxidizing water. Water from the outdoor spigot was run via garden hose into the drum. To maintain a reducing environment for the bacteria, the oxygen had to be removed from the water. The oxygen was dispersed to the atmosphere by sparging nitrogen into the drum of water using a defusing device such as an aquarium aerator. The oxygen concentration was measured using a USI 550 Dissolved Oxygen Meter. The oxygen readings were all below 0.5 mg/L or 0.5 ppm.

● The BDI Plus™ keg came with a measuring cylinder, so that pressure from the nitrogen tank could be used to drive the microbe mixture into the cylinder and after the correct amount was in the cylinder, it could be emptied into the clear plastic bottle with a mark on the side at 0.75 liters.

● First 7.5 gallons of deoxygenated water was placed in the hopper for the high pressure hydraulic pump GS2000. Next 0.75 liters of the BDI Plus™ was added to the tank. The microbe material easily dispersed within the water in the hopper. The mixture was pumped in the Geoprobe® boring. Injection time was approximately 2.5 to 3 minutes per boring. A little additional nitrogenated water was used to flush the injection line before the Geoprobe® was raised from the boring.

● The temperature of the microbe keg had to be maintained fairly constant at 2 to 4ºC. Dry ice was placed in the cooler or the container bag when the keg was in use outside of the cooler. For connection to the nitrogen tank and use with the measuring the cylinder, the keg was out of the cooler. A special bag was provided to keep the keg and dry ice inside while in use out of the cooler.

5.2.6 Remedial Performance/ Documentation Sampling

Existing monitoring wells (6 on the east side of Ulster Avenue and 5 on the west side) were sampled November 30 through December 4, 2015. The low-flow sampling technique was used. The chemical of concern at the site is the dry cleaning compound tetrachloroethylene (PCE or Perc for short). Three 40 ml vials with a few drops of Hydrochloric Acid preservative were filled with groundwater samples from each well and sent to York Analytical Laboratories for analysis using US EPA method 8260B for a complete list of volatile organic compounds. For quality assurance, additional samples were also sent to the lab including duplicate of monitoring well MW3, 4 trip blanks (one for each day of sampling), one equipment blank, matrix spike, and matrix spike duplicate using water from MW3. The samples were sent to the laboratory in two batches to avoid exceeding holding time. Two days of rain delayed the sampling. The two lab reports are summarized in Table 5 and Figure 8.

The following conclusions reflect the laboratory data.

● All the concentrations have gone down since the last sampling in 2013, except MW6, the shallow well behind the back door of the building.

● One PCE breakdown product 1,2DCE at 11 ug/L has appeared in MW2 right by the street in front of the AC building. This occurrence may be the first finding of a breakdown product in the monitoring wells.

● PCE concentrations appear to be mostly in the shallow Upper Aquifer wells on both sides of Ulster Avenue. At one Geoprobe® sample boring on the east side of Lincoln Park Place (LP2 sampled in 2013) and a new monitoring well (L14 sampled in 2017), PCE is found in the Lower Aquifer 20 to 25 feet with PCE concentrations of 18 and 16 µg/L, respectively. Those two (LP2 and L14) sampling points are within 20 feet of each other. Based on that information the PCE plume is evidently sinking from the Upper Aquifer levels or 10 to feet to the Lower Aquifer levels as groundwater migrates westward toward the Esopus Creek floodplain. The two zones are not really separate aquifers, they were defined by early consultants for sampling groundwater at different depths below the ground surface. There are no confining beds between the sands although there are some finer stratigraphic lenses.

Field monitoring of groundwater parameters

As part of the groundwater sampling procedure, the following additional parameters are measured and recorded in the field: pH, conductivity, turbidity, dissolved oxygen, temperature, salinity, ORP, and sulfate concentration. The Horiba instrument is used to measure pH, conductivity, turbidity, and temperature during the slow pumping phase to identify when the flow water exhibits stabilized properties. Stabilization of these parameters shows that the water is coming into the well by pumping from the formation beyond the well screen. Stabilization is achieved when 3 consecutive readings at 3 to 5 minute intervals are within the following limits: turbidity within 10 percent, specific conductance within 3 percent, temperature within 3 percent, and pH within 0.1 unit. Oxidation Reduction Potential (ORP) was measured with a new American Marine Pinpoint Monitor to stabilization within 10 millivolts.

Dissolved oxygen was measured with a YSI model 55 meter. Sulfate Concentration was measured with an HI96751 Sulfate Ion Selective Meter by Hanna Instruments, a colorimetry or refractometry meter with a silicon photocell narrow band interference filter at 466 nm and a resolution of 1 mg/L over a range of 0 to 150 mg/L.

Four parameters measured on-site relate to the presence of a reducing environment suitable for dechlorination of chlorinated solvents, in this case tetrachloroethylene.

- pH levels of 5 to 9 are desirable for dechlorination. All pH measurements of the monitoring well groundwater were in the range of 5.15 to 6.25.
- ORP reducing conditions are identified by negative values. All well show negative readings except MW9 and MW2. Values at those locations were less than 30 mV, which may be statistically close to negative, given that the calibration solution is +400 mV.
- Dissolved Oxygen (DO) should be less than 1 mg/L for anaerobic dechlorination to occur. The groundwater from 9 of the 11 monitoring wells ranged between 1.7 and 2.6 mg/L. Such readings are significantly less than 1 percent concentration because 1 mg/L is equal to 1 part per million (ppm).
- Sulfate is an alternate electron acceptor for microbial respiration. Depleted concentrations of sulfate relative to background indicate that the groundwater environment is sufficiently reducing to sustain sulfate reduction and for anaerobic dechlorination to occur. Sulfate levels of less than 20 mg/L are desirable but not required for anaerobic dechlorination to occur. Comparison of recent Sulfate concentrations with those measured in April indicate that Sulfate content is declining in the monitoring wells. Such decline may indicate that the injection of the Regenesis 3D Microeemulsion is reaching the monitoring wells across the street by transport with groundwater advection.

Chlorine is another indicator parameter. A colorimetry method may be used in the future to measure concentrations of the chloride ion. Such ions are the breakdown product of the anaerobic dechlorination process.

A table and figure summarizing all end-point sampling is included in Table 4 and Figure 5D, respectively, and all exceedances of SCOs are highlighted.

Data Usability Summary Reports (DUSRs) were prepared for all data generated in this remedial performance evaluation program. These DUSRs are included in Appendix 7, and associated raw data (laboratory reports) are provided in PDFs in Appendix 6. Data validation indicates that all of the data sets conform to the standards of data validity. Based on the DUSRs, all of the analyses are suitable for use in reporting sampling results to NYS DEC for regulatory compliance.

For the purpose of defining the end of the PCE plume, two well couplets were placed on the east side of Lincoln Park Place, near where groundwater samples were obtained in 2013 from Geoprobe® borings which had to be filled in because they were on the right-of-way for the street. Wells on the west side of Lincoln Park Place would have been better because they would be in the backyards of a couple of homes and would be much closer to the Esopus Floodplain. Cooperative homeowners could not be found, so locations were selected where the people would allow installation and sampling of monitoring wells. On Monday, July 17, 2017 two monitoring well couplets were installed at 740 and 752-762 Lincoln Park Place. The wells were developed on July 21 and 23. Sampling for VOCs occurred on July 25, 2017.

A survey of the wells was conducted to obtain the location coordinates and elevations of the monitoring wells. The survey data and a round of water level measurements are shown on Table 7 and Figure 5C. As generally established with previous work, the gradient of the water table (top of unconfined aquifer) slopes west northwest with about 1 foot of drop for 100 feet of horizontal run toward the Esopus Floodplain.

A summary of laboratory results is provided in Table 4 and spatial distribution of PCE concentrations for the 2017 sampling of all wells is shown on Figure 5D. Table 4 shows a constant decline in PCE concentrations in the monitoring wells and about half of them are ND for PCE. Significant off-site PCE exceedances of the NYS DEC Class GA groundwater standard of 5 µg/L include

MW7	17 µg/L	Upper aquifer 10-15 feet
MW7 Duplicate	29	Upper Aquifer 10-15 feet
MW8	30	Upper Aquifer 10-15 feet
L14	16	Lower Aquifer 20-25 feet

The enhanced bioremediation fluids and microbes are probably active in the area of the Upper Aquifer exceedances, but may not have reached L14 at Lincoln Park Place in the Lower Aquifer. Given more time for groundwater, nutrient, and microbe migration, PCE will continue to be cleaned up in both aquifers.

6.0 CONTAMINATION REMAINING AT THE SITE

End-point sampling is described above in section 5.2.6 for groundwater and section 4.2.9. Summary Table 1 shows a significant decline in PCE concentrations in soil vapor samples between 2013 and 2016 also shown on Figure 2B. Summary Table 4 shows decline in PCE concentrations in groundwater from 2009 to 2017. Spatial distribution of PCE concentrations is shown in Figure 5A (prior to 2009), 5B (2013 & 2015) and Figure 5D (2017). Prior to and after the injection of enhanced bioremediation nutrients and microbes, the concentrations of PCE in groundwater have declined.

The Site Management Plan will be submitted to define future sampling of groundwater and soil vapor to demonstrate the function and operation of the remedial actions. Groundwater sampling is expected to continue to show a westward migration of the bioremediation fluids resulting in decline in PCE in on-site and off-site monitoring wells in the Upper Aquifer and Lower Aquifer. Soil vapor extraction sampling is expected to show continued decline in sub-slab PCE and other VOC concentrations.

7.0 ENGINEERING CONTROLS

This topic will be developed in the near future and documented in the Final Engineering Report.

8.0 INSTITUTIONAL CONTROLS

This topic will be developed in the near future and documented in the Final Engineering Report.

9.0 REFERENCES

FINAL DER-10 TECHNICAL GUIDANCE FOR SITE INVESTIGATION AND REMEDIATION, May 3, 2010, New York State Department of Environmental Conservation, Division of Environmental Remediation, 232 pages.

US EPA Low Stress (Low Flow) Purging and Sampling Procedure for Collection of Ground Water Samples from Monitoring Wells (US EPA Region 1, July 30, 1996, Revision)

LIST OF TABLES (in order of reference in text)

LIST OF FIGURES

LIST OF APPENDICES (on CD-ROM)

1 Survey Map, Metes and Bounds - LATER
2 Digital Copy of IRM CCR
3 Environmental Easement - LATER
4 NYS Approvals of Substantive Technical Requirements: NYS DEC Letter of 07/24/2015
5 Project Photo Log
6 York Analytical Laboratory Reports

Report ID	Report Date	Type of Sampling
12A0661	1/26/12	Geoprobe ground-water across street
13C0810	4/2/13	Sub-slab soil from under bldg
13C0768	4/2/13	Summa Canisters sub-slab vapor
13I0388	10/2/13	Storm Drain Soil on site
13K0219	11/18/13	Groundwater on and off site
15L0069	12/9/15	Groundwater all Monitoring Wells
15L0243	13/14/15	Part 2
16K1174	12/7/16	Sub Slab Soil Vapor
17D0415	4/20/17	SACK-GW part 1
17D0839	5/2/17	SACK-GW part 2
17G0906	8/1/17	LPP

7 Data Usability Summary Reports for each of the Laboratory Reports listed above
8 EC As-Built Drawings, Documentation, Drawings, and comparable information is included in the IRM CCR text and Photo Log.

Table 1
Sub-Slab Soil Sampling Laboratory Results
Units of Measurement µg/kg dry = parts per billiion (ppb)
American Cleaners, 734 Ulster Avenue, Kingston, NY
NYSDEC DER VCP Site: V-00601-3
Sampling Date: March 25, 2013
Laboratory Analysis by US EPA Method SW846-8260B for 8260 List
York Analytical Laboratories, Inc. 129 Research Drive, Stratford, CT 06615
Laboratory Report 13C0810 04/02/2013
Omitted Compounds were Not Detected (ND)
Sampling Conducted by Jansen Engineering, PLLC and Mid-Hudson Geosciences

	Sampling Points			
Analyte	XP1 Back Left Corner	XP2 Inside Back Door on Right side as entering	XP3 Left Back behind last Pressing Station	XP4 Right of Front Door behind Counter
Tetracholoethylene	7.2 J	ND	ND	9.9 J
Acetone	11 J,B	14 J,B	13 J,B	24 J,B

Notes:
ND = Not Detected at MDL
J = Detected below reporting limit (RL), but greater than Method Detection Limit (MDL)
Considered and estimated value
B =Analyte found in blank
Trip Blank contained Naphthalene (Moth Balls) @ 1.3 µg/kg J
Field Blank (Equipment Blank) all VOCs were ND

Table 2
Sub-Slab Soil Vapor Sampling Laboratory Results
All concentrations of Volatile Organic Compounds are measured in µg/m[3.]
American Cleaners, 734 Ulster Avenue, Kingston, NY
NYSDEC DER VCP Site V-00601-3
Comparison of Sampling Dates: March 25, 2013 and November 28, 2016
Sample ID were different for the two sampling events
Laboratory Analysis by US EPA Method TO15 Full List for 6-Liter Summa Canisters
Helium was the Leak Detection Gas analyzed by GC/TCD ND @ 0.95% MDL Dilution 1.902
York Analytical Laboratories, Inc. 129 Research Drive, Stratford, CT 06615
Laboratory Reports: 13C0768 04/04/2013 and 16K1174 12/07/2016
Omitted Compounds were Not Detected (ND)
NA indicates that Helium was not used, nor analyzed in the 2016 sampling event.
Tentatively Identified Compounds were ND in all cases
Sampling Conducted by Jansen Engineering, PLLC and Mid-Hudson Geosciences

	Sampling Points							
	XP1 and NE Back Left Corner		XP2 and BD Inside Back Door on Right side as entering		XP3 and NW Left Back behind last Pressing Station		XP4 and WW Right of Front Door behind Counter	
Analyte	3/25/2013	11/28/2016	3/25/2013	11/28/2016	3/25/2013	11/28/2016	3/25/2013	11/28/2016
Tetracholoethylene	2300	1400	22,000	6,100	17000 .	990	1300	350
Helium	ND	NA	ND	NA	ND	NA	ND	NA
Trichloroethelene	ND	17	150	55	49	33	ND	ND
cis1,2-Dichloroethylene	ND	ND	29	32	ND	ND	ND	ND
Chloroform	ND	ND	27	10	ND	ND	ND	ND
Acetone	ND	18	14	11	69	ND	84	ND
Dichlorofluoromethane	ND	ND	ND	ND	ND	ND	21	14
2 Butanone	ND	16	ND	7.9	ND	ND	ND	11
Methyl Chloride	ND	14	ND	18	ND	ND	ND	ND
Tetrahydrofluran	ND	34	ND	18	ND	ND	ND	33

Total VOCs in µg/m3	2300	1499	22,250	6240	17,000	1023	1405	458

Percent Tetrachlorethylene Decline	35%	72%	94%	67%

Table 4
Summary of Groundwater Sampling Laboratory Results
Years: 2013, 2015, 2017
Units of Measurement are µg/L or ppb
American Cleaners, 734 Ulster Avenue, Kingston, NY
NYSDEC DER VCP Site V-00601-3
Sampling Date: November 30 to December 4, 2015
Laboratory Analysis by US EPA Method SW846-8260B for 8260 List
York Anaytical Laboratories , Inc. 129 Research Drive, Stratford, CT 06615
Reports: 15L0069 12/9/15 and 15L0243 12/14/15
Omitted compounds were Not Detected (ND)
2017 York Sampling Reports: 17D0415 4/20/17, 17D0839 5/2/17, and 17G0906 8/1/17.
2017 Sampling Dates: 4/20/17, 5/2/17, and 7/25/17
Sampling Conducted by Jansen Engineering, PLLC and Mid-Hudson Geosciences
Spatial Distribution of PCE Concentrations are shown on two Maps, Figure 5B (2015), Figure 5C (2017)

Well	Total Depth	**PCE or PERC**			1,1,2TCE		1,2 DCE		Location
		Nov2013	Dec2015	**2017**	Nov2013	Dec2015	Nov2013	Dec2015	
On-site Monitoring Wells									
MW1	16.9	6.5	3.8 J	**2.8**	ND	ND	ND	ND	In front of AC, south along Street
MW2	16.4	13	ND	**11**	ND	ND	ND	11	Directly In front of AC, beside sidewalk opposite Storm Drain in street
MW5*	16.9	50	2.8	**15**	ND	ND	ND	ND	In front of AC, close to sign pole on North side
MW4	32.6	7.4	ND	**3.5**	ND	ND	ND	ND	Behind AC 41 inches out from SE corner of shed
MW3*	16.3	ND	ND	**ND**	ND	ND	ND	ND	Behind AC, about 10 feet northeast of NE corner of building
MW3 Dup*	16.3	ND	ND	--	ND	ND	ND	ND	Behind AC, about 10 feet northeast of NE corner of building
MW6	16.1	14	69	**21**	ND	ND	ND	ND	Behind AC, 8 feet out from SE corner of shed
West Side of Ulster/Albany Avenue									
MW9	16	17	7.5	**5.1**	ND	ND	ND	ND	About 38 feet southeast of Left front corner of Spa
MW16	25	ND	ND	**ND**	ND	ND	ND	ND	5 feet toward road from MW9
MW7	16	28	19	**17**	ND	ND	ND	ND	About 29 feet northeast of right front corner of Spa
MW7 Dup				**29**					
MW17	25	ND	ND	**ND**	ND	ND	ND	ND	Half way between Restaurant and Spa
MW8	16	150	86	**30**	5.1	ND	ND	ND	In front of RCAL back building, to left of front door
Geoprobe Samples along Lincoln Park Place					Not Available for Testing December 2015				
LP1	16	47	--	--	ND		ND		Between driveways close to Road, #752-#746
LP2	25	18	--	--	ND		ND		Near Stop Sign, #732 Lincoln Park Place
LP3	16	ND	--	--	ND		ND		Near Stop Sign, #732 Lincoln Park Place
New MWs installed on east side Lincoln Park Place					Not Available for Testing December 2015				
L4	14.81	--	--	**ND**					South side of driveway 740 LPP, closer to road
L14	22.82	--	--	**16**					South side of driveway 740 LPP, closer to garage
L5	14.55	--	--	ND					end of hedge between 752 & 762 LPP
L15	21.4			ND					north side of hedge about 6 feet back from L5
L15 Dup				ND					

Notes: from Nov 2013
Acetone detected in MW16 at 3.3 J µg/L and in Trip Blank at 2.6 µg/L.
Dup indicates duplicate sample
Sample from MW5 was labeled MW3 on chain of custody and laboratory report
Sample from MW3 was labeled MW5 on chain of custody and laboratory report
Sample from MW3 Dup was labeled MW5 Dup on chain of custody and laboratory report
All information here is the corrected and the same as Figure 5 map.

Note: Remedial Injection occurred in 2015
April injection of nutrients (see map of locations)
November injection of microbes (same locations)

"LPP" = Lincoln Park Place

Table 5: Design Parameters for Bioremediation with Bioaugmentation
Using Regenesis Products
At American Cleaners, Kingston, NY
Note: The variable amount of water for dilution of the 3DMicroemulsion will be determined emphirically in the field

Design Specifications

Injection Point Spacing	15 feet
Number of Injection Points	16
Top of Injection Interval (water table)	10 feet below surface
Bottom of Injection Interval	15 feet below surface
Vertical Treatment Interval	5 feet
Linear Footage of Geoprobe® Drilling	
For Injecton of Both Products	240 feet
For Separate Injection of 2 Products	480 feet

Product Quantities

3DMicroemulsion	1600 pounds in four 55 gallon drums, 400 pounds per drum
Bio-Dechlor Inoculum Plus	12 liters

Field Mixing / Injection Ratios

3DMicroemulsion		***Water***			***Product + Water***	
Per Injection Point	For 16 Total Points	Variable	Per Injection Point	For 16 Total Points	Per Point	For 16 Points
13 gallons (= 100 pounds)	208 gallons (= 1600 pounds)	For 10% solution	117 gallons	1872 gallons	130 gallons	2080 gallons
		For 1% solution	1287 gallons	20592 gallons	1300 gallons	20800 gallons
		Optimal For 2.5% solution	507 gallons	8112 gallons	520 gallons	8320 gallons
Bio-Dechlor Innoculum Plus						
Per Injection Point	For 16 Total Points		Per Injection Point	For 16 Total Points	Per Point	For 16 Points
0.75 liters (= 0.1875 gallons)	12 liters (= 3 gallons)	Re: Instructions	7.5 gallons	120 gallons	7.7 gallons	123.2 gallons

Table 6A

Record of Injection of Nutrients for Enhanced Bioremediation April 7-9, 2015 at

American Cleaners, 734 Ulster Ave, Kingston, NY 12401

NYS DEC DER Voluntary Cleanup Program Site V-00601-3

Mixing of Regenesis 3D Micro Emulsion and Water and Injection Volume

Pumping with GS-2000 (High Pressure) Pump was used except where formation could take the volume of pumping with the submersible pump directly from mixture tank

In many cases the pump was changed during the injection into one point.

The depth is the level where the Geoprobe rods were open for injection measured below ground level.

Mixing occurred on a large tank on the back of a pickup truck so the fluid could be moved close to injection point.

Injection Work Conducted by Jansen Engineering, PLLC, Mid-Hudson Geosciences, and Todd K. Syska, Inc.

		Depth	Mixture			Pumping					
	Injection	Open	3-D Micro	Water	Injection	GS-2000 pump		Pumping	Submersible		
	Point	Interval	Emulsion	Added	Volume	High Pressure		Time	Pump		
Date	ID	Feet	gallons	gallons	gallons	On	Off	minutes	On	Off	Minutes
4/7/15	IP1	12-15	13	167	180	9:12AM	10:20AM	108			
	IP2	14-15.5	13	182	195	10:58AM	11:48AM	50			
	IP3	14-15.5	13	162	175	12:08PM	12:47PM	49			
	IP4	14-15,5	13	162	175	1:15PM	2:05PM	50			
	IP5	14-15.5	13	162	175	2:35PM	3:20PM	45			
4/8/15	IP6	14-15.5	13	177	190	8:05AM	8:30AM	25	8:30AM	8:48AM	18
	IP7	14-15.5	13	177	190	9:12AM	9:17AM	5	9:17AM	9:32AM	15
	IP8	14-15.5	13	177	190				10:07AM	10:30AM	27
	IP9	14-15.5	13	177	190	11:12AM	11:25AM	13	11:25AM	11:36AM	11
	IP10	14-15.5	13	177	190	1:10PM	2:10PM	60			
	1P11	14-15.5	13	177	190	1:35PM	1:47PM	12	1:47PM	2:00PM	13
4/9/15	IP12	14-15.5	13	177	190	8:50AM	9:02AM	12	9:34Am	9:48AM	14
	IP13	14-15.5	13	177	190	10:20AM	10:30AM	10	10:30AM	10:45AM	15
	IP14	14-15.5	19	177	190	11:23AM	11:35AM	13	11:35AM	11:48AM	13
	IP 15	14-15.5	20	177	190	12:34PM	12:40PM	6	12:40PM	12:57PM	17

Table 6B

Record of Injection of Microbes for Enhanced Bioremediation October 7-8, 2015 at

American Cleaners, 734 Ulster Ave, Kingston, NY 12401

NYS DEC DER Voluntary Cleanup Program Site V-00601-3

Mixing of Regenesis Bio-Dechlor Inocculum Plus, Water and Injection Volume

Pumping with GS-2000 (High Pressure) Pump was for each injection point

because the Inocculum could be mixed in the hopper of the pump.

The water for mixing was deoxygenated by dispersing nirtogen into a 55 gallon drum of water.

Oxygen level was measured in the tank using a YSI DO meter.

Water was local water supply from the Town of Ulster Water Department.

Water from the mixing drum was pumped with submersible pump through hose to pump hopper.

The depth is the level where the Geoprobe rods were open for injection measured below ground level.

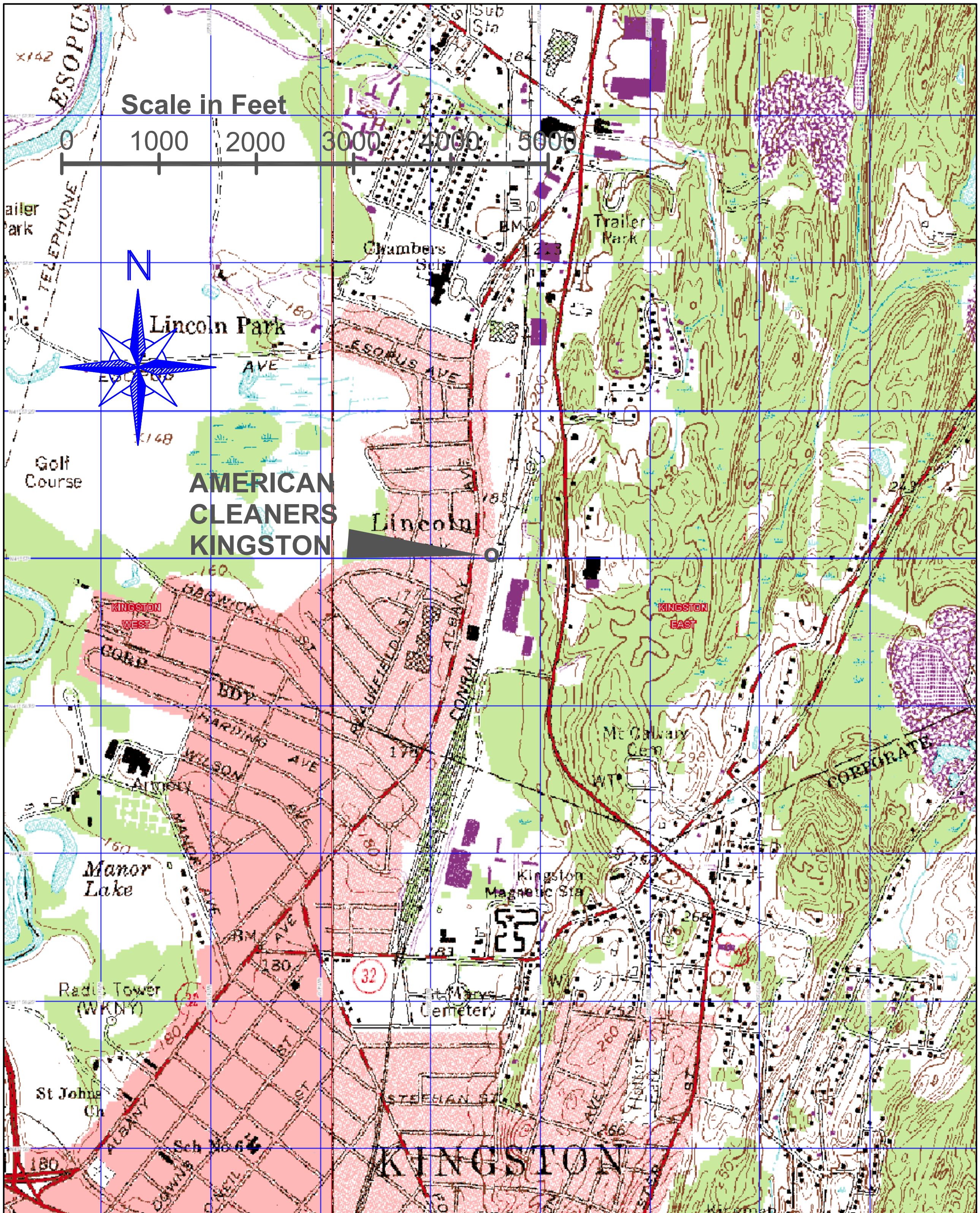
Mixing occurred in the pump hopper after the pump was moved to the injection point.

Injection Work Conducted by Jansen Engineering, PLLC, Mid-Hudson Geosciences, and Todd K. Syska, Inc.

		Depth	Mixture			Injecting	
Date	Injection Point ID	Open Interval Feet	Bio-Dechlor Inoculum Plus liters	Deoxygenated Water gallons	Injection Volume gallons	GS-2000 pump High Pressure On	Pumping Time minutes
10/7/15	MIP1	14-15	0.75	7.5	<8	11:57AM	3
	MIP2	14-15	0.75	7.5	<8	12:30PM	3
	MIP3	14-15	0.75	7.5	<8	12:47PM	3
	MIP4	14-15	0.75	7.5	<8	1:17PM	3
	MIP5	14-15	0.75	7.5	<8	2:45PM	3
	MIP6	14-15	0.75	7.5	<8	3:05PM	3
	MIP7	14-15	0.75	7.5	<8	3:30PM	3
	MIP8	14-15	0.75	7.5	<8	3:47PM	3
	MIP9	14-15	0.75	7.5	<8	3:04PM	3
10/8/15	MIP10	14-15	0.75	7.5	<8	9:25AM	3
	M1P11	14-15	0.75	7.5	<8	9:40AM	3
	MIP12	14-15	0.75	7.5	<8	9:57AM	3
	MIP13	14-15	0.75	7.5	<8	11:20AM	3
	MIP14	14-15	1	7.5	<8	11:50AM	4
	MIP 15	14-15	1.5	7.5	<8	12:25PM	5

Table 7
Monitoring Well Coordinates and Elevations
Prepared by
Brinnier & Larios, P.C.
67 Maiden Lane, Kingston, NY 12401
August 14, 2017

					Aug 23,2017 PM	
					Water	Water
Well Number	Northing	Easting	Elevation	Type	Depth	Elev
1	1135512.59	629661.649	179.722	MW	10.65	169.072
2	1135558.29	629667.168	179.82	MW	10.79	169.03
3	1135581.95	629798.435	180.646	MW	11.32	169.326
4	1135546.46	629791.837	180.3	MW	10.59	169.71
5	1135590.68	629699.971	180.522	MW	11.44	169.082
6	1135546.46	629796.47	180.238	MW	10.89	169.348
7	1135607.9	629449.678	179.05	MW	11.76	167.29
8	1135704.52	629399.686	179.734	MW	13.32	166.414
9	1135517.89	629450.745	177.918	MW	10.37	167.548
16	1135518.48	629445.548	177.78	MW	10.27	167.51
17	1135584.73	629469.742	179.085	MW	11.46	167.625
Building Corner	1135573.44	629784.69	180.365	BLD		
Building Corner	1135583.47	629725.688	180.39	BLD		
Building Corner	1135514.62	629713.764	180.138	BLD		
Building Corner	1135504.57	629772.916	180.339	BLD		
L14	1135635.21	629087.164	177.161	MW	12.54	164.621
L15	1135904.99	629080.559	177.011	MW	13.41	163.601
L4	1135638.07	629080.767	177.028	MW	12.42	164.608
L5	1135904.24	629071.107	176.936	MW	13.43	163.506



3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS 450 ft Scale: 1 : 16,000 Detail: 14-6 Datum: WGS84

Figure 1-1, Site Location Map (USGS 7.5 Minute Quadrangles)

American Cleaners Inc, 734 Ulster Avenue, Kingston, NY

NYSDEC DER VCP Site V-00601-3 December 31, 2009

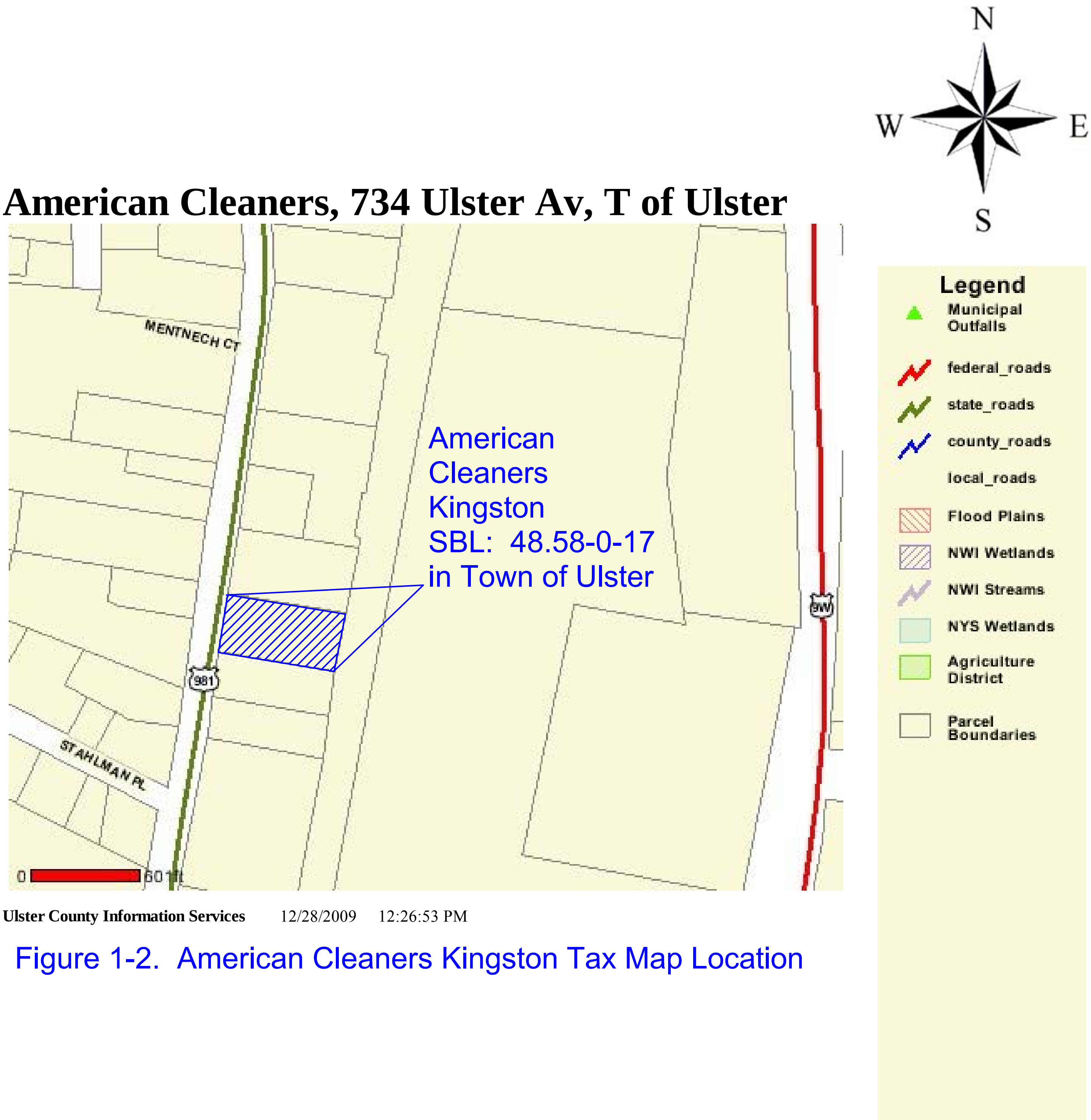
Mid-Hudson Geosciences

Katherine J. Beinkafner, PhD, CPG #6611

1003 Route 44/55, PO Box 332, Clintondale, NY 12515

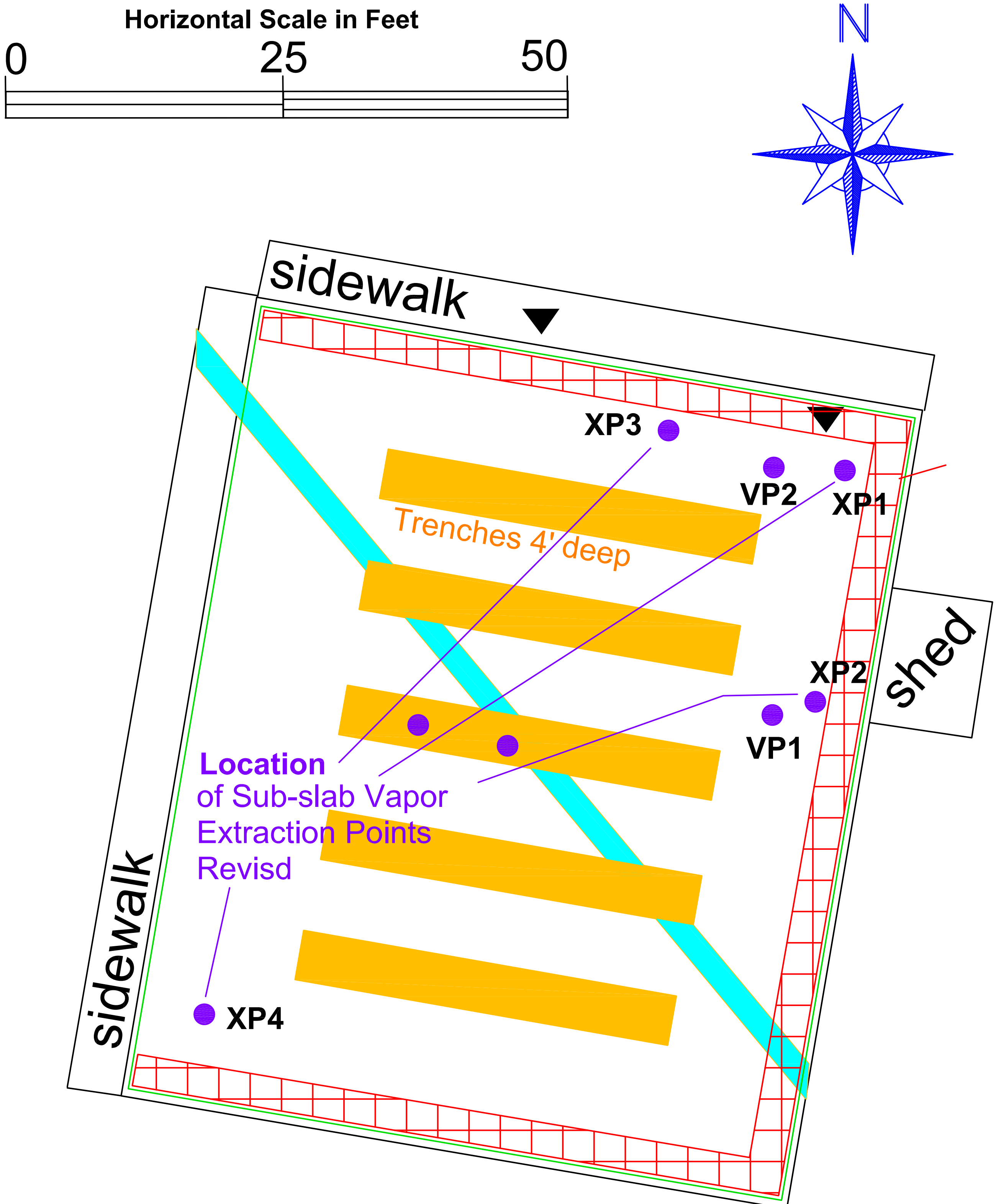
(845) 883-5866 rockdoctor @ optonline.net

American Cleaners, 734 Ulster Av, T of Ulster



Ulster County Information Services 12/28/2009 12:26:53 PM

Figure 1-2. American Cleaners Kingston Tax Map Location



VP1 & VP2 were temporary vacuum measuring points

Figure 2A. Location of Vacuum and Sub-Slab Vapor Extraction Points on Site Plan of Building showing Features Constructed for Dry-Cleaning Operations
American Cleaners Inc, 734 Ulster Avenue, Kingston, NY
NYSDEC DER VCP Site V-00601-3 December 31, 2009
Revised November 2013

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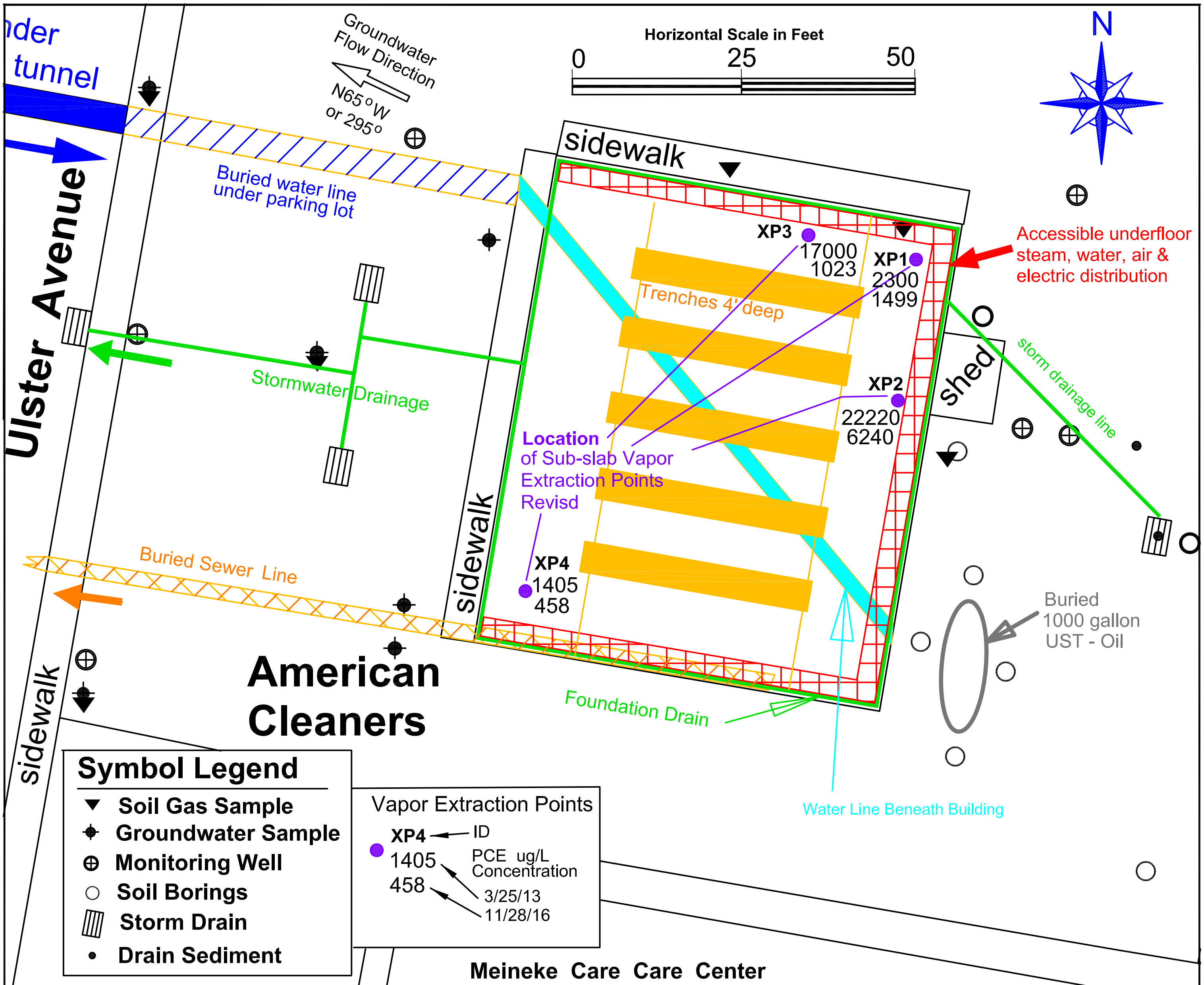

Figure 2B. Location of Sub-Slab Vapor Extraction Points with PCE concentrations in ug/L sampled in 2013 and 2016 on building site plan showing utilities and Features Constructed for Dry-Cleaning Operations

American Cleaners Inc, 734 Ulster Avenue, Kingston, NY
NYSDEC DER VCP Site V-00601-3 December 31, 2009
Revised November 2013 & August 2017

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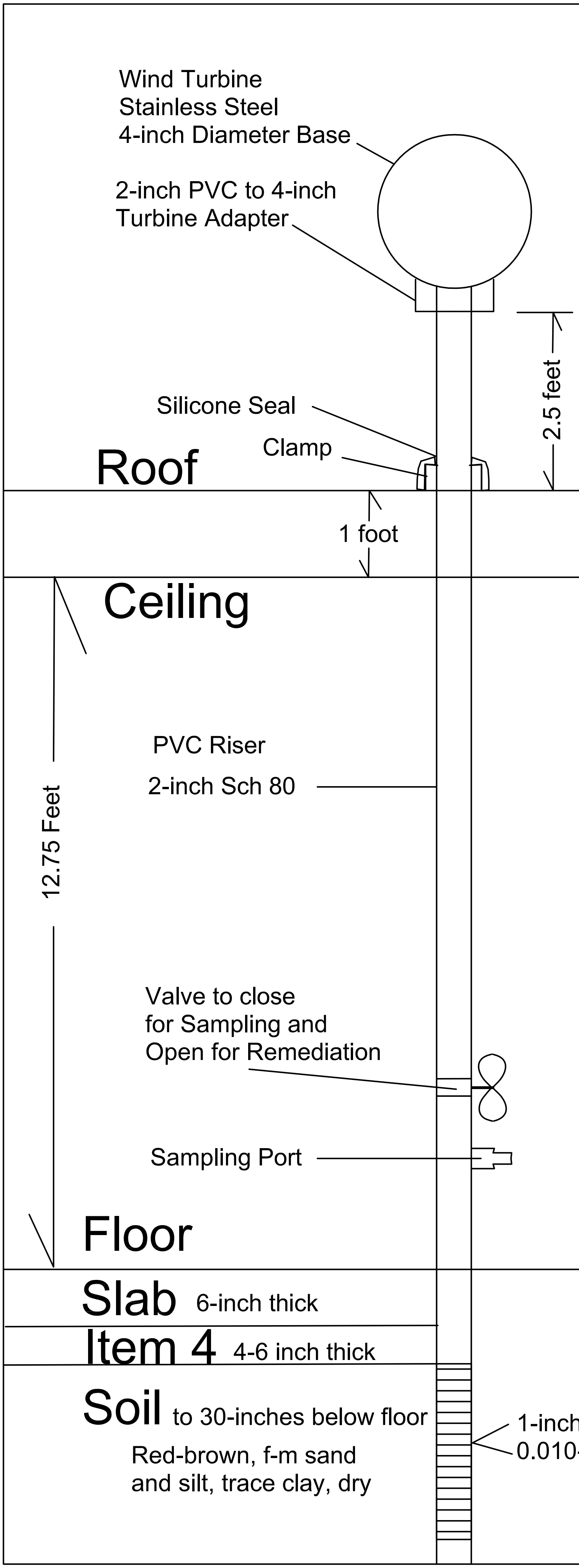

Figure 3.
Construction Diagram for Sub-Slab Vapor Extraction Points (XP1-XP4)

American Cleaners, Inc. 734 Ulster Avenue, Kingston, NY

NYSDEC DER VCP Site V-00601-3, January 2015

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FIGURE 4

Calculation Sheet

Project: American Cleaners, Kingston

Sub-Slab Vapor Extraction System Design

Calculate: VOCs in pounds/hour to estimate contaminant Emissions to Atmosphere

using total VOCs from 4 Summa Canister Tests

From Table 3

XP1	2300 ug/m³
XP2	22220
XP3	17181
XP4	1405

unit conversion check ✓

$43,106\ ug/m^3 = 4.3 \cdot 10^{-5}\ kg/m^3$

Test Duration = 4 hours

6 liters/hr = 24 liters/hr

≈ ~~2~~ 6 gallons/hr

7.48 gal = 1 cuft ≈ 0.8 cuft/hr.

unit conversion check ✓

2.2 pounds/kg

1 cu meter × 35.5 cuft.

1 m³ = cuft/35.3

$4.3 \cdot 10^{-5}\ kg/m^3 = 2.67 \cdot 10^{-6}\ lb/cuft$

$4.3 \cdot 10^{-5}\ kg \times 2.2\ \frac{pounds}{kg} = 9.46 \cdot 10^{-5}\ pounds/m^3$

$\frac{9.46 \cdot 10^{-5}}{35.3} = 2.67 \cdot 10^{-6}\ \frac{pounds}{hour}$

LOAD = roundoff $3 \cdot 10^{-6}$ pounds per hour
= .000003 pounds per hour

Emission limit = 0.5 pounds/hour
= 100,000 times estimated load

KJ Beinkafner
1/14/15

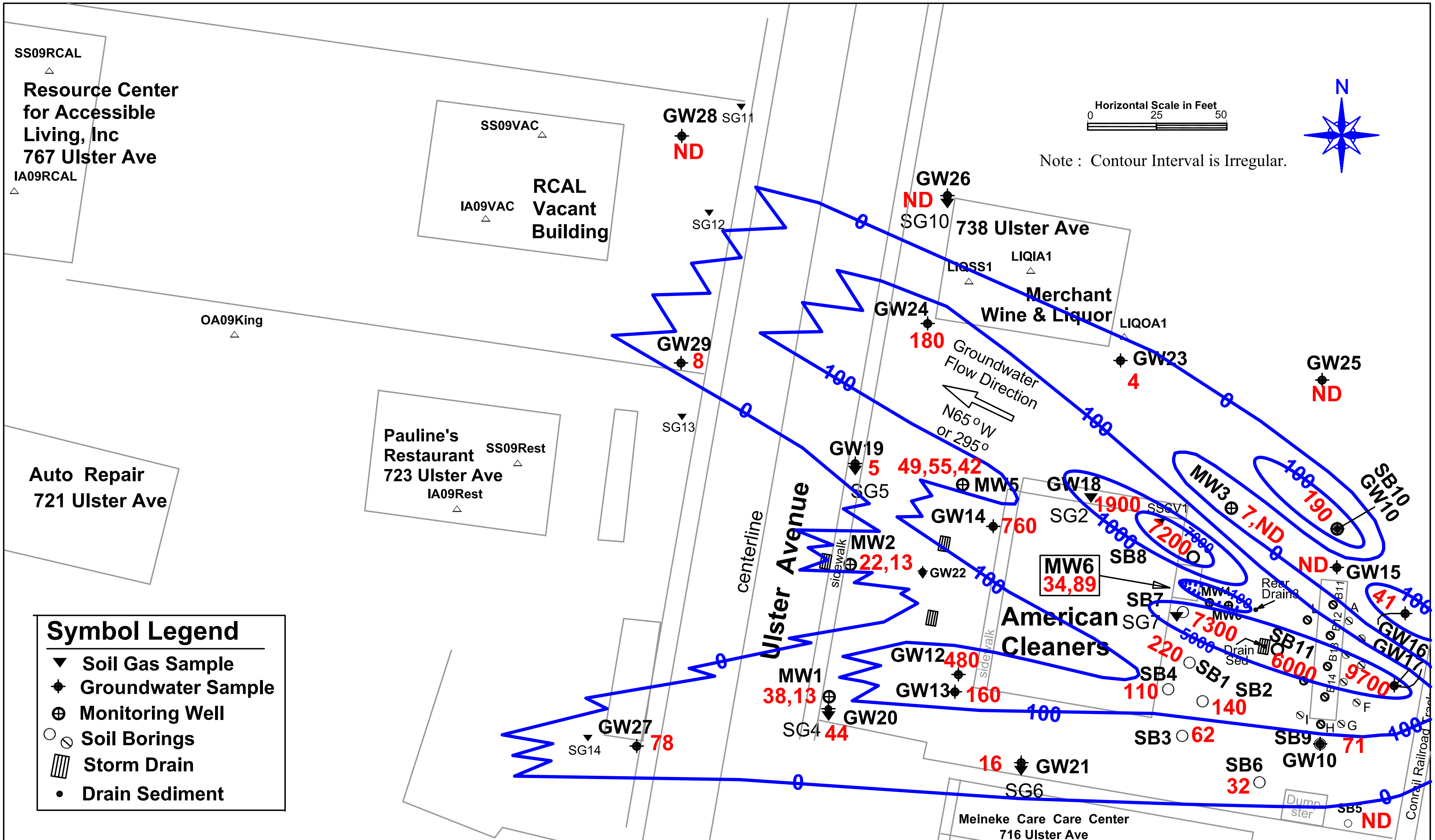

Figure 5A Isopleth Map and PCE Concentrations (ug/L) Detectd in Groundwater between 9.5 and 16 feet below ground surface.
American Cleaners Inc, 734 Ulster Avenue, Kingston, NY
NYSDEC DER VCP Site V-00601-3 December 31, 2009

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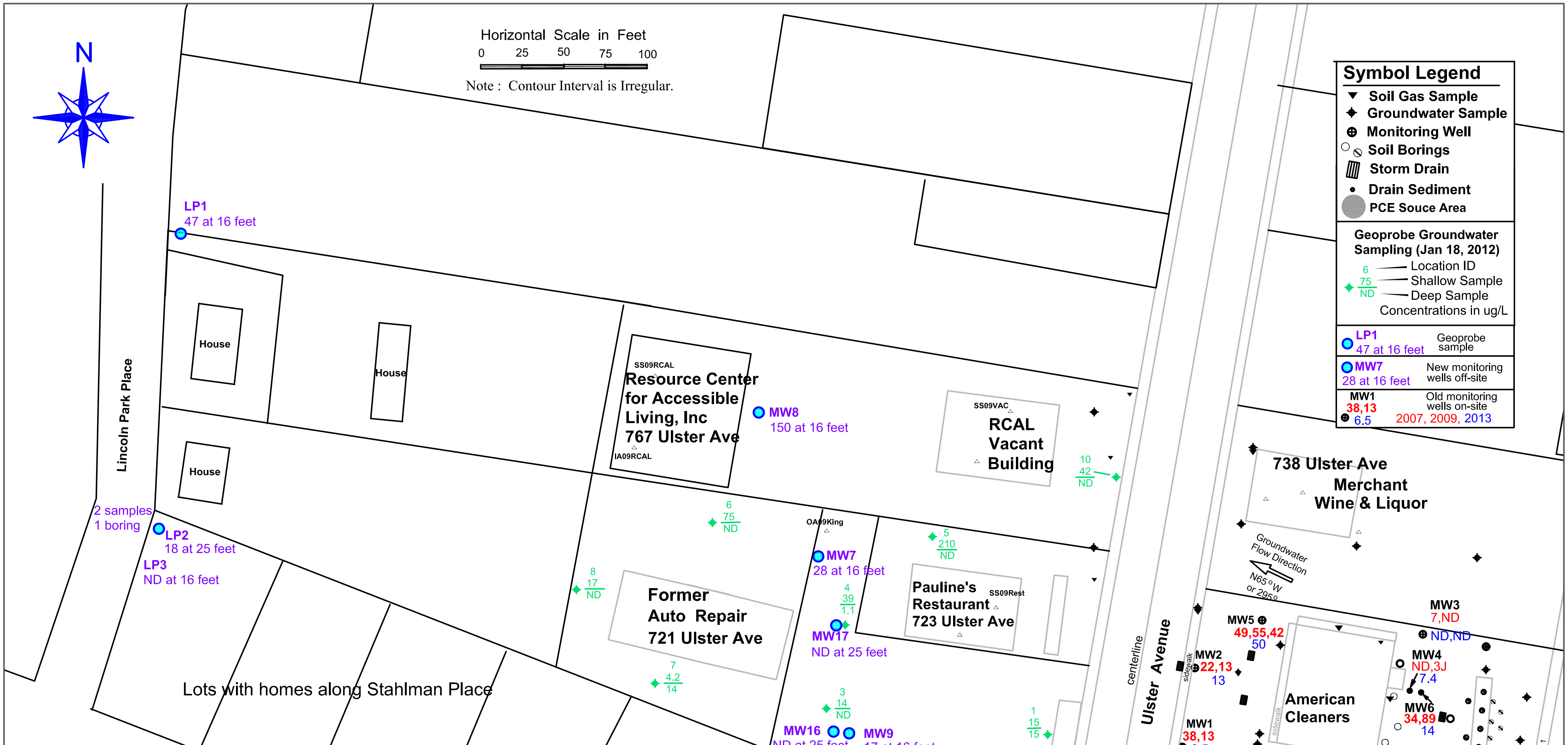

Figure 5B. Tetrachloroethylene (PCE) concentrations detected in groundwater samples collected November 3-6, 2013 in on-site wells, new off-site wells, and geoprobe borings along Lincoln Park Place. Concentrations are measured in ug/L. Geoprobe data from 2012 is shown in green on the west side of Ulster Avenue and 2007 & 2009 concentrations are shown by on-site locations for comparison.

American Cleaners, Inc. 734 Ulster Avenue, Kingston, NY
NYSDEC DER VCP Site V-00601-3 November 2013

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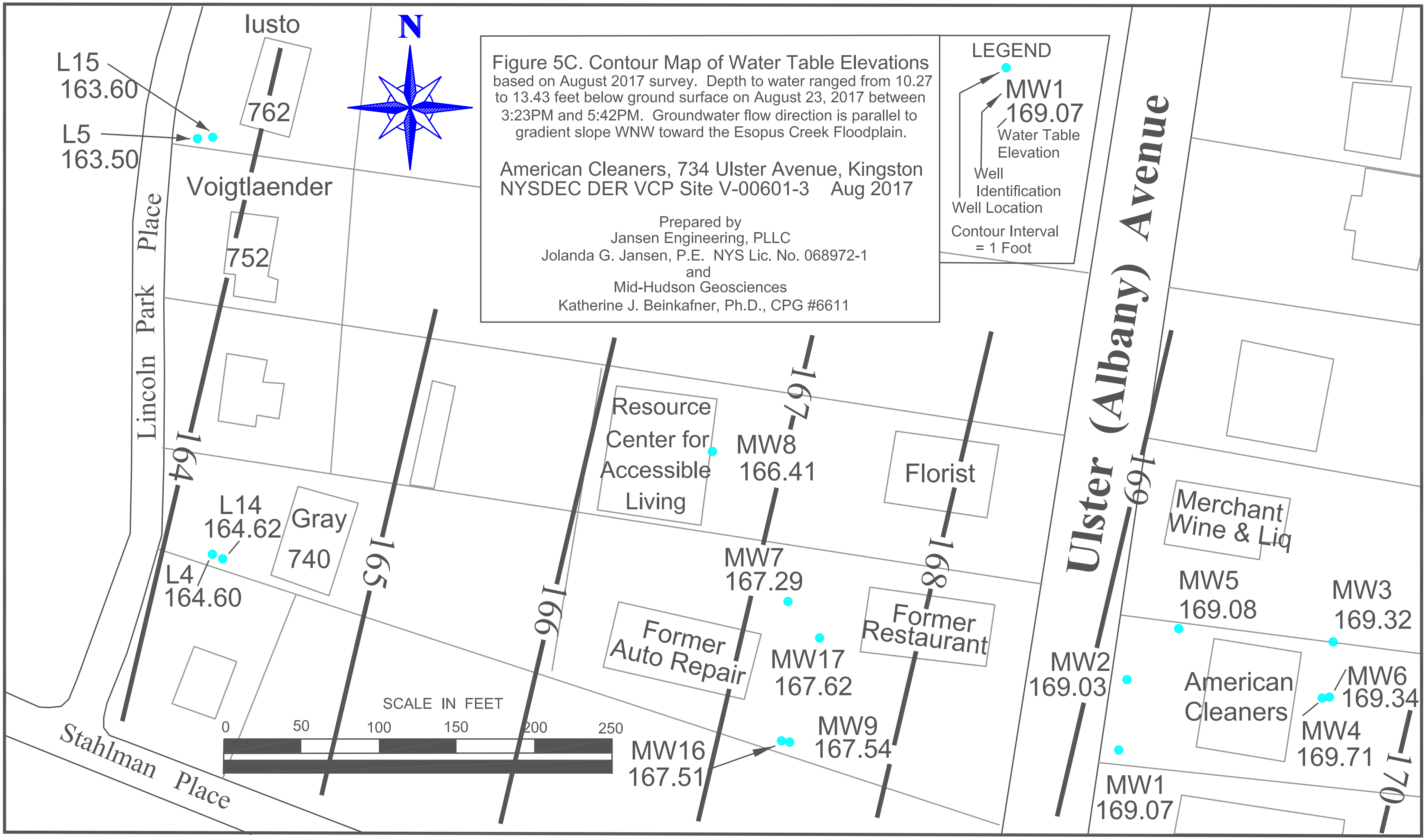
Figure 5C. Contour Map of Water Table Elevations
based on August 2017 survey. Depth to water ranged from 10.27 to 13.43 feet below ground surface on August 23, 2017 between 3:23PM and 5:42PM. Groundwater flow direction is parallel to gradient slope WNW toward the Esopus Creek Floodplain.
American Cleaners, 734 Ulster Avenue, Kingston
NYSDEC DER VCP Site V-00601-3 Aug 2017
Prepared by
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and
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LEGEND
MW1
169.07
Water Table Elevation
Well Identification
Well Location
Contour Interval = 1 Foot
N
SCALE IN FEET
0
50
100
150
200
250
Lincoln Park Place
Stahlman Place
Ulster (Albany) Avenue
Iusto
762
Voigtlaender
752
Gray
740
Resource Center for Accessible Living
Florist
Former Auto Repair
Former Restaurant
Merchant Wine & Liq
American Cleaners
L15
163.60
L5
163.50
L14
164.62
L4
164.60
MW8
166.41
MW7
167.29
MW17
167.62
MW16
167.51
MW9
167.54
MW2
169.03
MW1
169.07
MW5
169.08
MW3
169.32
MW6
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MW4
169.71
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166
167
168
169
170

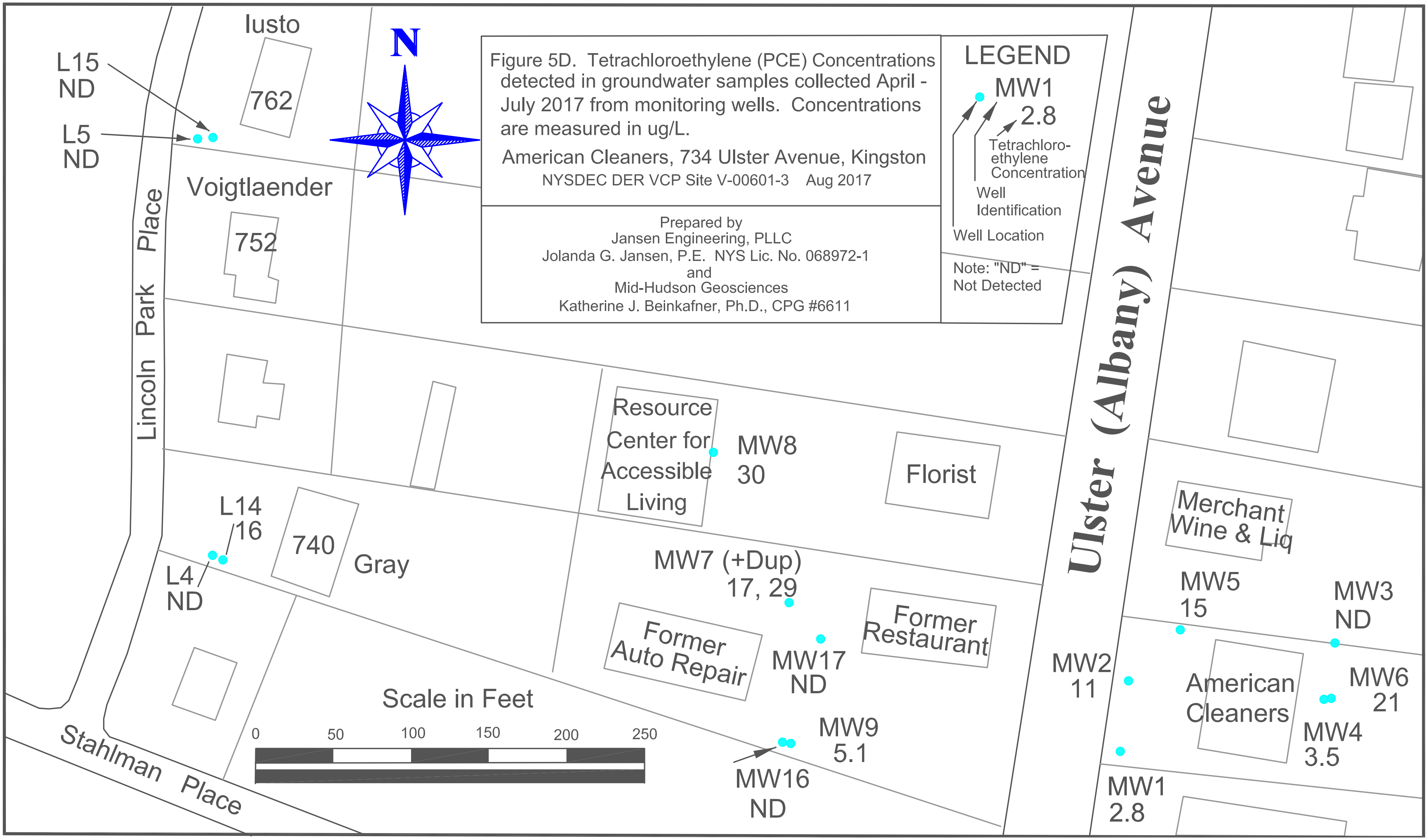

Figure 5D. Tetrachloroethylene (PCE) Concentrations detected in groundwater samples collected April - July 2017 from monitoring wells. Concentrations are measured in ug/L.

American Cleaners, 734 Ulster Avenue, Kingston

NYSDEC DER VCP Site V-00601-3 Aug 2017

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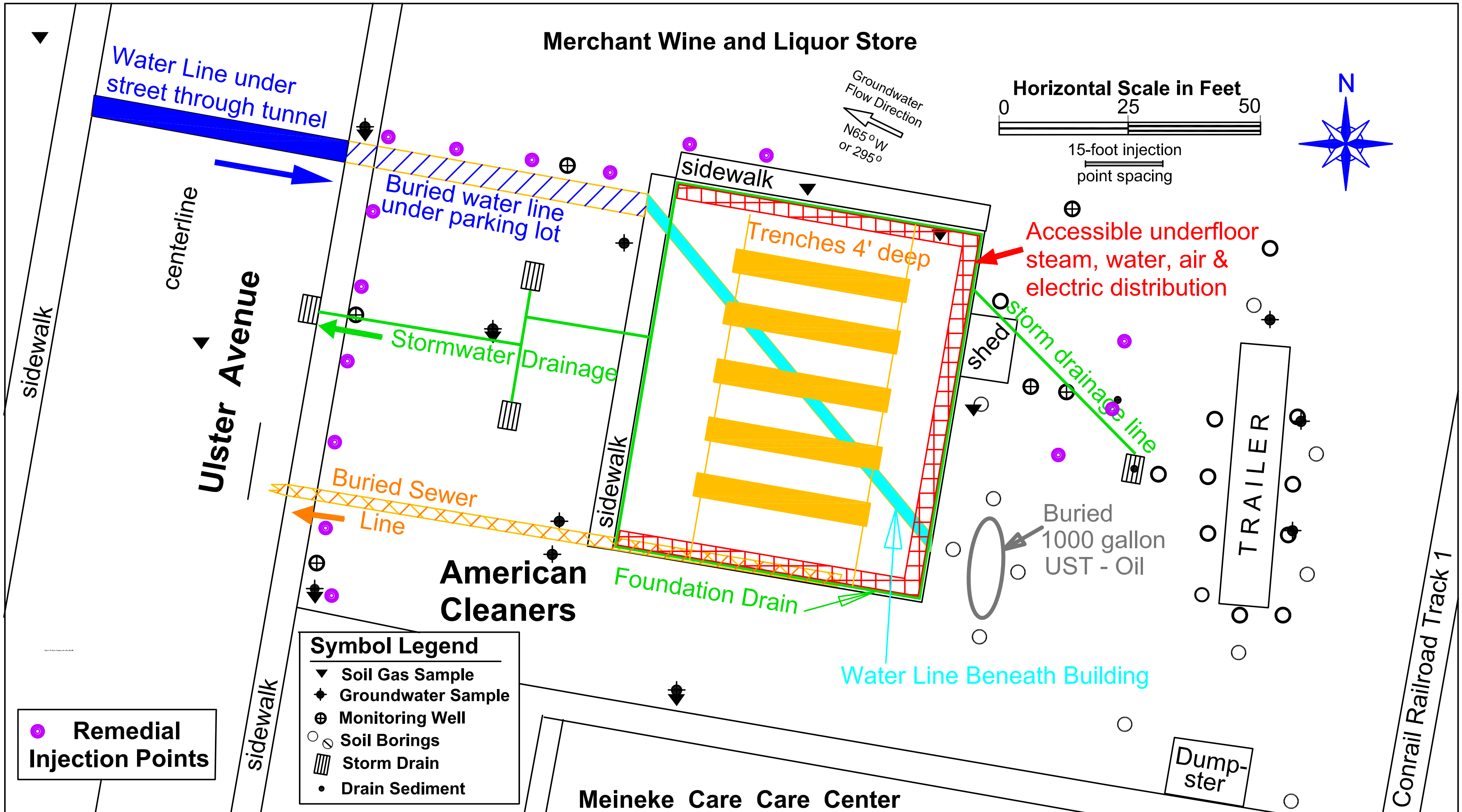

Figure 6. Site Plan showing proposed locations of remedial injection points with 15-foot spacing.
American Cleaners Inc, 734 Ulster Avenue, Kingston, NY
NYSDEC DER VCP Site V-00601-3 April 28, 2014

Prepared by
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Appendix 5
Photo Log of Remedial Project Activities

American Cleaners Kingston
Ulster County, New York

Interim Remedial Measures Construction Completion Report:

Sub-Slab Vapor Extraction and
Bioremediation of Groundwater
NYSDEC Site Number: V-00601-3

August 29, 2017

P1. Drilling through the slab, item 4 material, and into the natural red sandy soil with electric coring machine. 3/25/13

P2. Close-up of drill bit through the slab. 3/25/13

P3. Removing the coring tool from the hole through the slab and into the natural red soils below. 3/25/13

P4. Removing the core from the drill shaft for examination and sampling. 3/25/13

P5. Core examination, ground concrete at bottom of photo, above that itme 4 material, and the natural red sand closest to the geologist's hand. 3/25/13

P6. Preparing to measure VOC concentrations with Photoionization Detector. 3/25/13

P7. Collecting sand samples for laboratory analyses for the presence of volatile organic compounds. 3/25/13

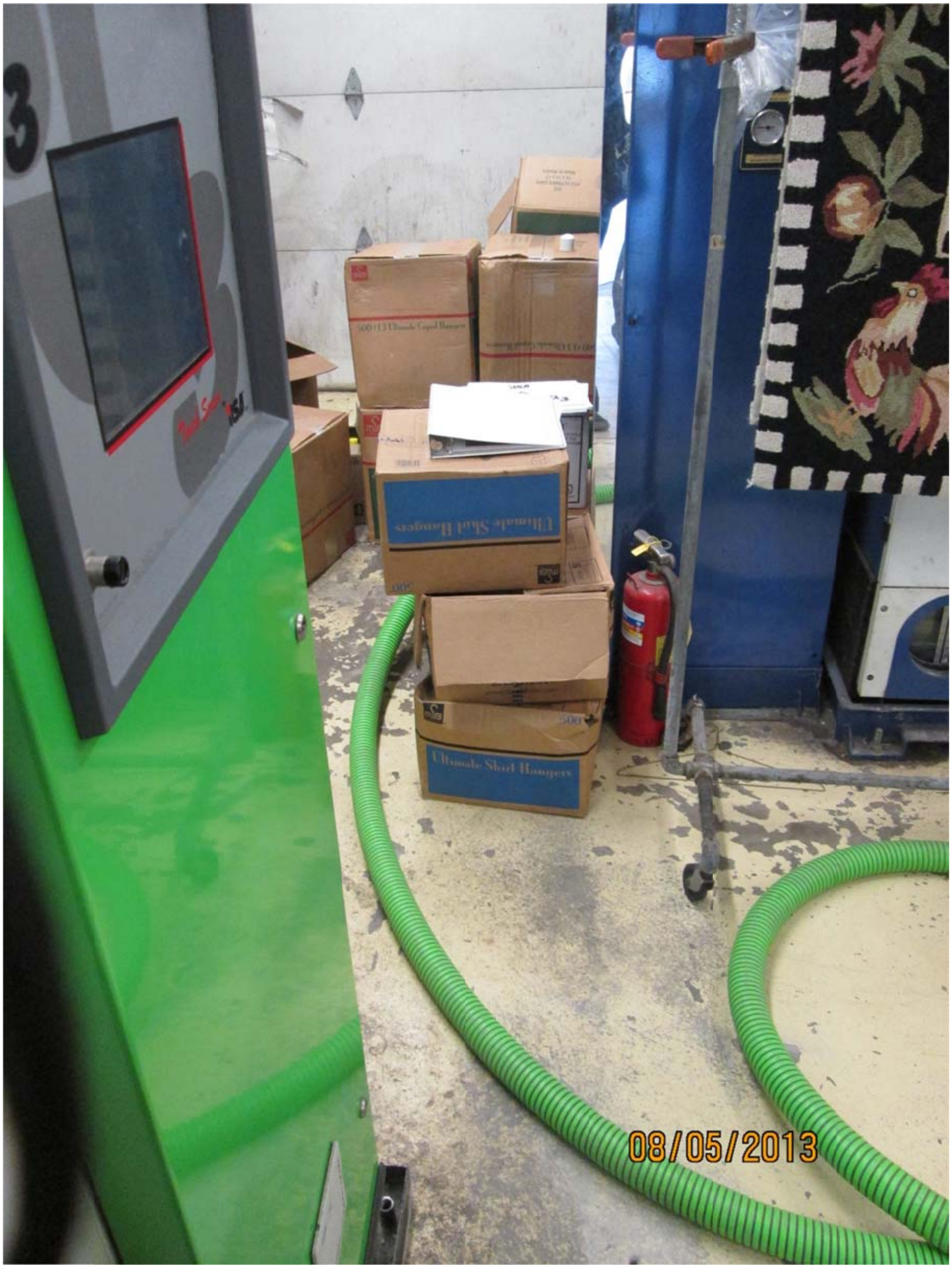
P8. Hole for XP1 through slab. 3/25/13

P9. Schedule 40 PVC casing and slotting placed through slab and item 4 into the natural red sand. 3/25/13

P10. Top of all 4 extraction points, XP1, XP2, XP3, XP4. 3/25/13

P11. Tests were conducting by applying a vacuum to each extraction point (XP1, XP2, XP3, XP4) and measuring any detectable vacuum at the other three XPs while the vacuum was applied to one. No positive results were detected. Hence, Vapor measuring points VP1 and VP2 were installed. 8/5/13

P12. Manometer measuring a vacuum of -0.07 inches of water at VP1 located 5 feet southwest of XP2 while vacuum is applied to XP2 using a 1 horsepower Fuji Blower. 8/5/13



P13. Green hose running from the blower outside the backdoor to XP1 applying a vacuum while VP2 is monitored with manometer. 8/5/13

P14. Measuring vacuum of -0.01 inches of water at VP2 86 inches from XP1 where vacuum is applied from blower. 8/5/13

P15. Vacuum applied to XP3. 8/5/13

XP16. Vacuum of -0.04 inches of water measured at VP2 105 inches from XP3 where vacuum was applied with blower. 8/5/13

P17. 2-inch schedule 80 PVC vertical shaft installed at XP1 with blue-handled on/off valve to close shaft from atmosphere during vapor testing with Summa Canister or Photoionization Detector. 4/10/15

P18. Complete schedule 40 2-inch PVC vertical shaft at XP2 with valve showing adapter on base of PVC. 4/10/15

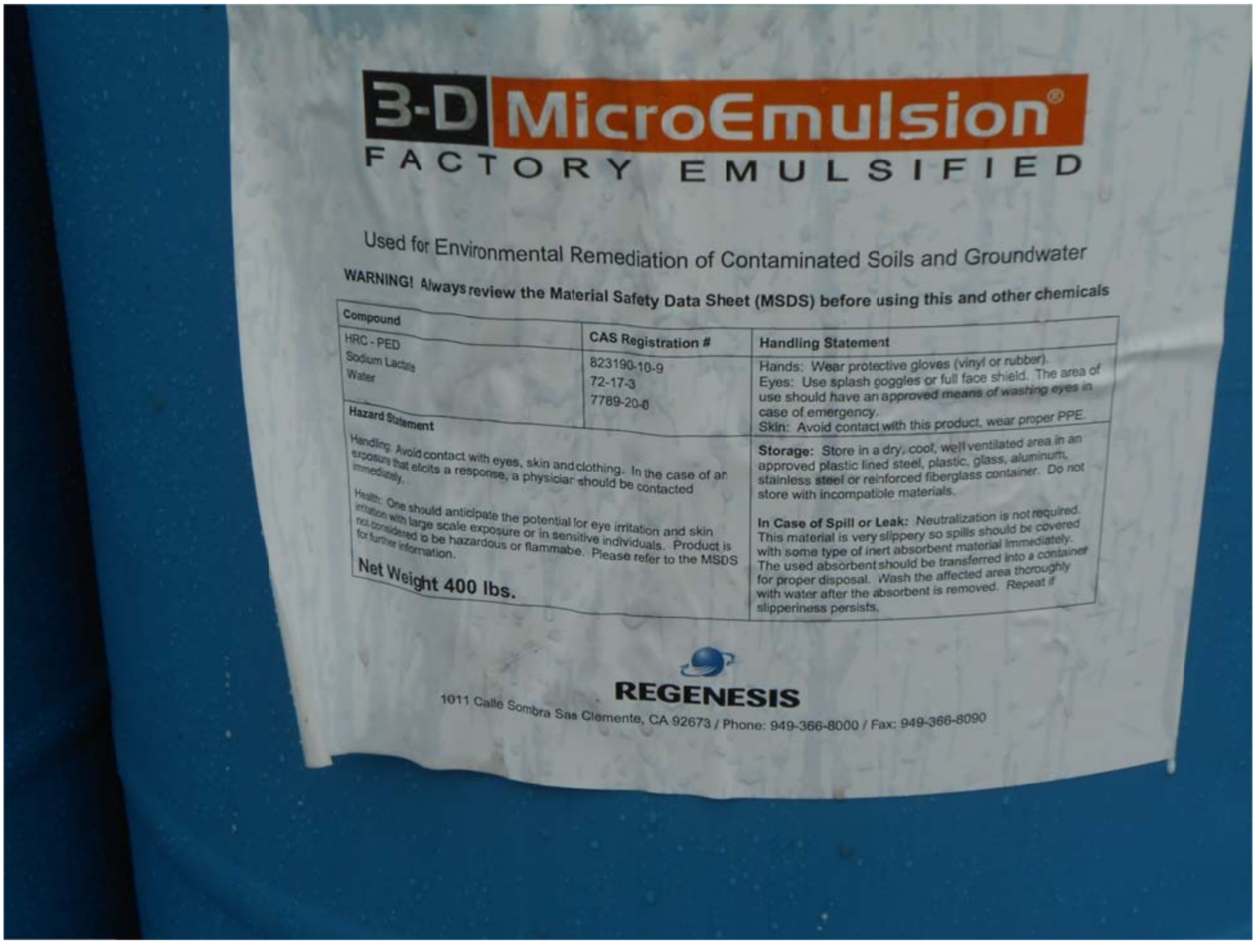
P19. Vertical PVC shaft at XP3. 4/10/15

P20. Vertical PCV shaft at XP4. 4/10/12

P21. Adapters for top of 2-inch PVC shaft above the roof to accommodate the 4-inch Stainless Turbines. For strength a glue had to be used to attach the components. 4/10/15

P22. Three of the turbines are seen from the back of the building. From left to right XP2, XP1, XP3. The turbine for XP4 can be seen from in front of the building. 4/10/15

P23. Four 400 pound drums of 3-D MicroEmulsion were delivered from Regenesis to provide injection of nutrients for microbes to be injects a few months later. 4/15



P24. Label of 3-D MicroEmulsion from Regensis. 4/15

P25. 3-D MicroEmulsion was mixed with water in the black tank and transferred to the tank on the back of the truck to moved to injection locations. 4/15

P26. Drill point attached to bottom of drill rod. When drill rod reaches target depth, the point is released and left in the ground. The fluid is pumped through the rod and into the formation at the bottom where the point was released. 4/15

P27. After the drill rod has been driven to target depth by geoprobe and the point released, the hose and valve is attached to the top of the drill rodto facilitate injection of the 3-D MicroEmulsion. 4/15

P28. Mixed 3-D MicroEmulsion is pumped or drained into the hopper of the high pressure injection pump. 4/15

P29. The entire injection setup can be seen here. The 3-D MicroEmulsion is pumped into the hopper of the high pressure pump which pumps it into the drill rod in the ground. 4/15

P30. The soils in some borings seem to be more permeable and did not require the high pressure pump. in that case a submersible pump in the tank on the truck was used to pump the fluid to the drill rod injection point. Injection was faster with this method. 4/15

P31. A bucket of clean waster was washed down the hopper and hose into the boring before the hoses were disconnected. 4/15

P32. Sand was place into the borehole. 4/15

P33. Concrete was placed at the surface to seal the injection borings. 4/15

P34. The final drum of 3-D MicroEmulsion was emptied into a bucket and placed in the black mixing tank. 4/15

P35. Injection was conducted first in the backyard, second along the north side of parking and sidewalk, and finally along the inside of the front sidewalk shown here. 4/15

P36. Drilling the borehole for injection of inoculum into MIP3 with Geoprobe. October 7, 2015.

P37. Nitrogen in the red tank sparging into water in the 55-gallon black drum to deoxygenate the waterto use with injection of the inoculum. Pressure meter (in PSI) and flow meter (in SCFM) used to control rate of sparging are shown to the right of the tank. October 7, 2015

P38. Red nitrogen tank and black deoxidizing drum. From the outdoor spigot, the water supply hose goes into the drum. A submersible pump in the tank pumps the water through the output hose to the GS2000 pump hopper. October 7, 2015

P39. The deoxygenated water in the beaker is tested to measure the concentration of dissolved oxygen with the YSI DO meter. The meter reads 0.34 mg/L at 20.1^{o}C. Octpber 7, 2015

P40. The inoculum is stored in the keg which is inside the black plastic bag. Dry ice is used to maintain the temperature at 2-4ºC inside the bag or inside the cooler, where ever the keg is stored. October 7, 2015

P41. Pumping the measured amount of deoxygenated water into the hopper of the GS2000 high pressure pump for mixture with inoculum and injection into subsurface injection point with the Geoprobe. October 8, 2015

P42. Preparing to 0.75 liters of inoculum into the calibrated 1 liter coke bottle. The calibrated sight glass to the right of the red nitrogen tank shows the volume of inoculum pumped out into the bottle using the nitrogen pressure from the tank. October 8, 2015

P43. Placing the measured 0.75 liter of inoculum into the 7.5 gallons of deoxygenated water in the hopper of the high pressure GS2000 pump. October 8, 2015

P44. Black hose from the GS2000 pump connects to the Geoprobe drill rods for injection.
April 7, 2015

P45. GS2000 pump in the foreground showing the input hose from the pump to the Geoprobe drill rods. October 8, 2015

P46. Boring hole in the foreground is filled with sand and bentonite. October 8, 2015