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August 14, 2015

Division of Environmental Remediation
Remedial Bureau E, 12th Floor
New York State Department of
Environmental Conservation
625 Broadway
Albany, New York 12233-7017

Attention: Joshua Haugh, Project Manager

Subject: Pre-Design Investigation - Field Activities Plan Addendum
Scobell Chemical – NYSDOT Site (828076) Remedial Design WA D007619-32
MACTEC Engineering and Consulting, P.C. Project No. 3617147328

Dear Mr. Haugh,

This Pre-Design Investigation Field Activities Plan (FAP) Addendum has been prepared for the Scobell Chemical – New York State (NYS) Department of Transportation (NYSDOT) Site (828076) (Site) in Town of Brighton, Monroe County, New York (Figure 1) in response to the NYS Department of Environmental Conservation (NYSDEC) Work Assignment (WA) No. Approval Letter for D0076919-32 dated August 29, 2014 (NYSDEC, 2014), and with the July 2011 Superfund Standby Contract between MACTEC Engineering and Consulting, P.C. (MACTEC) and the NYSDEC. The FAP Addendum provides the scope of work for the in-situ chemical reduction (ISCR) injection pilot study being conducted as part of the Site's Remedial Design Work Assignment D007619-32 on behalf of the NYSDEC under the state superfund program.

INTRODUCTION

This FAP Addendum presents a technical scope of work to conduct ISCR pilot study activities in support of the Remedial Design, including injection well and monitoring well installation, groundwater sampling, and injecting a chemical reductant (zero valent iron [ZVI]), to evaluate whether the selected remedy will be effective at the Site. Work will be conducted in accordance with the NYSDEC DER-10 Guidance (NYSDEC, 2010), the "Field Activities Plan, Pre-Design Investigation – Scobell Chemical – NYSDOT Site No 828076", dated October 2014 (MACTEC, 2014).

REMEDIAL DESIGN OBJECTIVES

The Remedial Design WA D007619-32 has several objectives. A pre-design investigation was completed in 2014 and included:

- Collecting additional information on the extent of trichloroethene (TCE) as a dense non-aqueous phase liquid (DNAPL) in bedrock at and downgradient of the Site;
- Evaluating the extent of the overburden and bedrock groundwater plume;
- Completing a bench scale test to evaluate the effectiveness of ZVI in treating source area DNAPL and reducing volatile organic compound (VOC) concentrations in Site groundwater; and
- Collecting surface water and sediment samples from the storm water retention pond/Grass Creek, located to the northeast of the Site, to supplement historical data.

Remaining objectives include:

- Completing an ISCR pilot study with the ZVI chosen from the bench scale test to evaluate the effectiveness of implementing ZVI technology to treat the DNAPL source area present in bedrock; and
- Evaluating the potential for TCE in soil vapor downgradient of the Site.

The Pre-Design FAP (MACTEC, 2014) provided the scope of work for the activities described above as being completed. This FAP Addendum provides the technical scope of work associated with the ISCR (ZVI) pilot study. The soil vapor sampling activities will be described in separate work plan upon request of the NYSDEC project manager.

PRE-DESIGN INVESTIGATION FINDINGS

A pre-design investigation was conducted at the site to better define the extent of bedrock contamination, and characterize bedrock fractures at the Site. The pre-design investigation confirmed previous findings that the primary flow path for contaminated groundwater and the DNAPL is interpreted to be horizontal bedding plane fractures located between approximately 420 and 430 feet above mean sea level (msl) across the study area. Within this interval, an approximately four to five-foot zone of bedrock with several (2-3) horizontal fractures contains the majority of the contaminant mass (Feasibility Study Data Gaps Analysis Report, MACTEC, 2013). This zone of contamination may be slightly thicker in the source area at the Site. Borehole geophysics of MW-17D, located at the Site, indicated two larger fractures in this zone, with an aperture of 7 and 28 mm, with several other fractures noted with apertures less than 1 mm (slightly higher TCE concentrations in the rock chips from the smaller fractures at 425 and 430 feet above msl). Of the other three wells where geophysics was conducted, apertures were slightly smaller, with the maximum aperture in MW-12D of 3 mm, MW-20DD of 10 mm, and MW-22D of 22 mm. Based on measured apertures of fractures over the anticipated contaminant zone, effective porosity ranges from 0.25% in MW-12D to 1.7% in MW17D (measured apertures divided by borehole length).

The pre-design investigation also confirmed that the DNAPL is present in an area approximately 200 feet wide be 500 feet long, although the DNAPL is not present consistently across this area, likely the result of pockets of DNAPL being trapped in low spots.

The pre-design investigation also included a bench scale study (i.e., column test) conducted by Sirem to evaluate the effectiveness of two ZVI products on the TCE plume using Site groundwater and including rock chips within the column. The bench scale study indicated that the RioTinto H2O Met86 ZVI gave better results than the H2OMet 56 (i.e. more reactive and more mass removal). Although there appeared to be some passivation of the ZVI with the Site groundwater and rock, the bench scale study did not indicate that this passivation would negatively impact the overall results of ZVI as a Site remedy. The study was also used to derive a range of mass of iron that would be needed to treat the estimated mass of contamination. Using the upper range of ZVI mass needed for full scale, and dividing it by the pilot test area, a total of approximately 67,500 lbs of ZVI will be injected during the pilot test. This is equivalent to approximately 7,500 lbs at each injection well and 2,500 lbs at each of three injection intervals per well.

SCOPE OF WORK

The record of decision (ROD) for the Site, as amended in 2013, includes the implementation of ISCR to destroy the VOCs in the on-site and off-site source area (i.e. area of DNAPL) (NYSDEC, 2013). The ISCR technology evaluated in the ROD was the injection of ZVI into the fractured bedrock within the source area (an approximately 180,000 square foot area, located both on-site and off-site) to destroy the contaminants. The ROD also includes long term monitoring of groundwater contamination, including the addition of monitoring wells downgradient of the Site to evaluate the extent of groundwater contamination and facilitate additional soil vapor intrusion investigations off-site.

This FAP Addendum has been developed for the purpose of addressing the ISCR pilot study portion of the selected remedy, including

- Installation of pilot injection wells (IW) for ZVI injection
- Pre-injection baseline groundwater sampling
- Injection of ZVI
- Installation of additional post-injection monitoring wells
- Post-injection groundwater sampling

A summary of these field tasks and methodologies, sample IDs, and analytical program are described in more detail in Table 1, as well as in the following subsections. Proposed pilot injection wells, new monitoring wells, and sample locations are shown on Figure 2.

Subcontractors selected to support the ISCR pilot study include:

- Geologic, NY –Installation of bedrock injection and monitoring wells.
- ARS Technologies, Inc.– Injection of ZVI
- Rio Tinto – supplier of H_2OMet 86 ZVI (under ARS)
- ALS – laboratory services
- Op-Tech - transport and disposal of Investigation Derived Waste (IDW).
- Popli Design Group – Completion of Site survey for the newly installed injection and monitoring and wells.

Health and Safety. MACTEC anticipates that the fieldwork will be conducted in Level D personal protection. Specific investigation activities, utility clearance procedures, and required level of personal protection are set forth in the Site-specific Health and Safety Plan (HASP). Criteria for upgrading or downgrading the specified level of protection are also provided in the Site-specific HASP. Additional health and safety requirements are set forth in the Program HASP (MACTEC, 2011b). Should Site conditions pose a threat to those present on-Site, and/or should Site conditions warrant an upgrade from Level D, as defined by the HASP, work will stop and the situation will be reevaluated by the NYSDEC and MACTEC. Per the FAP (MACTEC, 2014), the NYS Department of Health Community Air Monitoring Plan (CAMP) will also be followed.

Access and Utility Clearance. Current proposed explorations are located on the Site property. The NYSDEC will be responsible for coordinating access with the property Owner (NYSDOT). MACTEC will work with Geologic, NY to obtain an updated NYSDOT permit for drilling on the Site property. Geologic, the drilling contractor, will be responsible for marking locations in the field and coordinating utility clearance with Dig Safely – New York. MACTEC will confirm drilling locations and utility clearance prior to conducting drilling activities.

Mobilization. Mobilization will include obtaining utility clearances for proposed locations, procurement of subcontractors, and the acquisition and coordination of supplies. Small trees and brush will be cleared, as necessary, to allow access by the drilling rig.

Pilot Injection Well Installation. Nine IWs (IW-1 through IW-9) will be installed approximately 30 feet apart over a 60-foot by 60-foot area, resulting in an approximate 90-foot by 90-foot treatment zone (8,100 square feet), assuming a 15-foot radius of influence (Figure 2). IWs will be advanced using a drilling rig to auger to bedrock using 6 ¼ inch inside diameter (ID) hollow stem augers and then continue two feet into rock using a tri-cone bit. The proposed injection wells will have permanent four inch-ID carbon steel casing set (grouted) into the top of bedrock. Three of the wells (IW-3, IW-4, and IW-6) will be cored using a five foot HQ (3 7/8 inch outside diameter) core barrel to between approximately 35 and 40 feet below ground surface (bgs). Rock cores will be described using the procedures outlined in Section 4.4.3.5 of the Quality Assurance Program Plan (QAPP). Cores will be examined visually for water bearing fractures and DNAPL, and screened with a photoionization detector (PID) for potential contaminant transporting fractures. Up to three fracture zones from the three cored IWs will be sampled using the methanol extraction of rock chips (MERC) technique following Section 4.5.3 of the QAPP. Fractures will be chosen to evaluate those with the highest PID readings that are located below 20 feet bgs. IWs are currently planned to be completed to 35 feet bgs, to allow injection of ZVI to approximately 30 feet bgs (need approximately 3-feet below planned injection zone for packer placement). If visual inspection and PID readings indicate possible contaminated fractures between 30 and 35 feet bgs, borings will be extended another five feet, for a total depth of approximately 40 feet bgs. At least one MERC sample will be collected from the bottom core run (i.e., last five feet of boring).

The remaining six IWs will be completing by air hammering to the depth determined based on the evaluation of the cored IWs (either 35 or 40 feet bgs). Air will be used for drilling both the cored borings and hammered borings, and the generator will be equipped with an air filter to prevent oil within the air compressor from entering the borings.

Each boring will be completed with an 8-inch flush mount casing. Upon completion, the driller will develop each injection well to remove fines.

Based on coordination between the drilling firm and the injection firm, completion of several of the borings (e.g., IW-5, IW-7, IW-8, and IW-9), may occur after the injection of the first five borings, to reduce the potential for the injection wells to fill up with iron prior to injection. If this occurs, one or two of these borings (preferably closer to those already injected) may be completed using coring technique, to evaluate the potential for iron within the fractures.

Dust and VOC air monitoring will be conducted as per the CAMP (MACTEC, 2013) for all intrusive work.

Pre-Injection Groundwater Sampling. After installation and development of the IWs, and prior to ZVI injection, groundwater samples from two of the nine IWs (IW-2 and IW-6) will be sampled. Groundwater analytical data will be used to assess baseline source area concentrations of the following parameters:

- VOCs by United States Environmental Protection Agency (USEPA) Method 8260, as described in the NYSDEC Analytical Services Protocol of June 2005 (NYSDEC, 2005)
- Alkalinity by Method 2320B
- Chloride by Method SM4500 CL
- Nitrate by Method SM4500-NO3
- Sulfate by USEPA Method 375.2
- Iron, calcium, magnesium, and manganese by USEPA Method 6010B
- Ethene, ethane, and methane by Method RSK-175
- Total organic carbon by Method 415.1

Groundwater samples will be collected no sooner than two weeks following the development of the newly installed injection wells. Prior to groundwater sampling, a round of water levels (depth to groundwater) will be measured from the bedrock injection and monitoring wells located on-Site to evaluate groundwater flow direction with additional data points.

IWs will be sampled using low-flow sampling procedures with a geopump as described in Section 4.5.4.3.2 of the QAPP (MACTEC, 2011a). If sufficient volume of water is present, field measurements for pH, temperature, specific conductivity, oxidation reduction potential, dissolved oxygen, and turbidity will be collected through a flow through cell (with the exception of turbidity) from each injection well during pre-sample purging to evaluate well stabilization, as well as to collect geochemical parameters for evaluation. Field measurements and IW sampling activities will be documented using a Low Flow Groundwater Data Record (QAPP Figure 4.17; MACTEC, 2011a).

Purge water will be collected, containerized, and stored on-site in labeled containers awaiting treatment and/or proper disposal based on IDW characterization sampling results.

ZVI Injection. Approximately 7,500 pounds of micro-scale ZVI (H_2OMet 86, supplied by Rio Tinto – see Attachment 1) will be injected into each of the nine IWs. The ZVI will be divided evenly between three target zones (approximately 2,500 pounds per target zone), for a total of approximately 67,500 pounds of H_2OMet 86 injected during the pilot study. This quantity is based on the upper range of the ZVI mass estimate for full scale design, calculated based on the column tests conducted by Sirem during the bench testing.

Packers will be utilized to isolate target zones, and the zones will be pressurized with nitrogen (and monitored with surface gauges) to expand/dilate existing fractures (initial pressure at the borehole of up to 700 pounds per square inch [PSI], then lowers to 200 or 300 PSI as fracture opens). The ZVI will then be mixed with water and injected into the nitrogen stream and into the formation (typical injection pressure of 100 PSI or less) (See Attachment 2). The injection pressures will be monitored and adjusted automatically by computer to ensure flow of the iron slurry. The three injections zones shall be between 19 and 29 feet bgs, unless field observations from the installation of the IWs indicates that injections should be extended to 35 feet bgs. In the event that the required mass of ZVI cannot be injected into a particular injection interval, the remaining volume will be added to the next injection interval, if possible.

- ARS injections will be sequenced so that they are conducted first in the injection wells closest to the edge of the impacted area, to minimize potential off-site migration of contaminated groundwater and/or DNAPL. The sequence of injections will be IW-3, IW-1, IW-2, IW-6 and IW-4. The order of the last four injections will be determined in the field. IW locations are shown on Figure 2.
- The ZVI slurry consistency will vary based on what the formation will take. ZVI to water ratios are anticipated to range from three pounds ZVI per gallon of water, to 10 pounds ZVI per gallon of water (e.g., the 2500 pounds ZVI per injection interval will be mixed with between approximately 250 gallons and 850 gallons water). This ratio could change based on field conditions. ARS will mix approximately 3.3 pounds of sodium bromide and 0.33 pounds of red dye with the ZVI slurry per IW (i.e., 1.1 pounds of sodium bromide and 0.11 pounds of dye per injection interval) for use as tracers to evaluate the radius of influence during the ZVI injections and the groundwater velocity post injections.
- During injection, the potential ground deflection caused by reagent injection will be monitored by ARS using heave rods at the ground surface and along the adjacent commercial building. Heave rods will be observed constantly by a dedicated person during the first four injections (and/or those in the vicinity of the adjacent building). If any building deflection is observed during the injections, the injection process will be stopped immediately, and the NYSDEC contacted to discuss next steps to proceed.
- During injection, MACTEC field staff will monitor the progress of the injection by taking field measurements, including pH, oxidation reduction potential, conductivity, dissolved oxygen, temperature, and water levels in nearby existing monitoring wells and inactive injection wells.

Dust and VOC air monitoring will be conducted as per the CAMP (MACTEC, 2013) during the injection activities.

Post-Injection Monitoring Well Installation. Prior to installation of new monitoring wells, the driller will remove ZVI, if present, from three existing monitoring wells (MW-17D, MW-11, and MW-16D), to enable continued groundwater monitoring from the same elevations as injection/previous monitoring.

The driller will then advance three borings, MW-27D, MW-28D, and MW-29D, to be used as post injection monitoring wells, as well as to visually inspect for the presence of ZVI during installation. The monitoring wells will be advanced to bedrock at approximately 10 feet bgs, using 6 ¼ inch ID hollow stem augers. The driller will then install/cement a 4-inch carbon steel casing in each boring, through the overburden and two feet into bedrock. Borings will be continued using HQ core barrel to approximately 35 feet bgs (the coring will be conducted with air, with a filter on the air coming out of the generator to ensure no oil from the generator goes down the borehole). Borings will be completed with an 8 inch flush mount casing, after which the driller will develop each well. Approximate locations of these three new monitoring wells are shown on Figure 2 and will be as follows:

1. In the middle of four injection wells (approximately 21 feet from each)
2. 15 feet downgradient from IW-6
3. Cross-gradient from IW-8, at a distance to be determined after visual observations of the first two new monitoring wells.

Field staff will evaluate the possible presence of ZVI in the borings by visual inspection of the rock cores, and by using a magnetometer on rock cores to identify potential iron lenses. In addition, groundwater will be inspected for color, to see if dye is visible from the iron injections.

Post-Pilot Groundwater Sampling. Groundwater samples will be collected from the three new monitoring wells (MW-27D to MW-29D) and eight existing monitoring wells (MW-2D, MW-3D, MW-11D, MW-12D, MW-13D, MW-15D, MW-16D, and MW-17D), approximately one month after ZVI injections. Samples will be collected using low flow methods and will be analyzed for the same analytes as for the pre-injection groundwater sampling listed above, as well as bromide. Results will be reviewed to evaluate changes in groundwater chemistry as a result of the injections, and to monitor for increased degradation of the TCE. Bromide will be monitored in the downgradient wells to evaluate potential direction and velocity of groundwater flow. Post-injection sampling will be repeated for an additional three quarters to evaluate effects of the injections for an approximate 10-month to one year period. Existing monitoring well details are presented in Table 4.3 in the FAP (MACTEC, 2014).

Survey. Prudent Engineering, will survey the new monitoring wells. Horizontal locations and vertical elevation data will be presented to MACTEC in a database to be used with geographic information system software. No property boundary survey of the Site and surrounding area is anticipated. Sample locations will be presented on an aerial photograph of the Site and surrounding area. Horizontal locations will be tied to the NYS Plane Coordinate System using North American Datum of 1983 to an accuracy of 0.1 foot. Vertical elevations of groundwater wells will be tied to existing monitoring well data, which is based on msl, using North American Vertical Datum of 1988, and measured to an accuracy of 0.01 feet.

DELIVERABLE

Data obtained under this FAP, including analytical laboratory data, will be reviewed and incorporated into a Pre-Design Investigation Report. The Pre-Design Investigation Report will summarize findings of the pre-design investigation, ZVI bench scale testing, and ZVI pilot study, including a comparison of laboratory analytical results to applicable NYS groundwater and surface water standards (NYS, 1999) and soil cleanup objectives (NYS, 2006). Boring logs and environmental sampling data will be included as appendices to the report. The information provided in the report will be used to aid in the design of the full-scale remediation.

The report will be submitted in draft to the NYSDEC for review and comment. Upon receipt of NYSDEC comments, MACTEC will address the comments and submit a final report in portable document format (PDF) format. Analytical data will be uploaded to EQuIS and laboratory deliverables will also be submitted electronically (PDF and electronic data deliverable) with the report at the completion of the Pre-Design Investigation.

Please feel free to contact us if you have any questions.

Sincerely,
MACTEC Engineering and Consulting, P.C.

Chuck R. Staples	Bryanna Chute
Task Leader	Jayme P. Connolly w/permission by J.P.C.
	Project Manager

Enclosures (2)
Attachment 1: RioTinto H_2Omet86 Information
Attachment 2: Zero Valent Iron Injection Information

cc: Josh Haugh, NYSDEC

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
DNAPL	dense non-aqueous phase liquid
FAP	Field Activities Plan
HASP	Health and Safety Plan
ID	inside diameter
IW	injection well
IDW	investigation-derived wastes
ISCR	in-situ chemical reduction
MACTEC	MACTEC Engineering and Consulting, P.C.
MERC	Methanol Extraction of Rock Chips
msl	mean sea level
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
pdf	portable document format
PID	photoionization detector
QAPP	Quality Assurance Program Plan
ROD	Record of Decision
Site	Scobell Chemical– NYSDOT Site

GLOSSARY OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

TCE	trichloroethene
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WA	Work Assignment
ZVI	zero valent iron

REFERENCES

MACTEC Engineering and Consulting, P.C. (MACTEC), 2014. Field Activities Plan – Scobell Chemical – NYSDOT Site No 828076 Prepared for the New York State Department of Environmental Conservation, Albany, New York. October 2014.

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MACTEC, 2011a. Program Quality Assurance Program Plan. Prepared for the New York State Department of Environmental Conservation, Albany, New York. June 2011.

MACTEC, 2011b. Program Health and Safety Plan. Prepared for New York State Department of Environmental Conservation, Albany, New York. June 2011.

New York State (NYS), 2006. New York Codes, Rules, and Regulations, Title 6, Part 375 Inactive Hazardous Waste Disposal Sites Remedial Program. Amended December 2006.

NYS, 1999. New York Codes, Rules, and Regulations, Title 6, Part 700-705 Water Quality Regulations Surface Water and Groundwater Classifications and Standards. Amended August 1999.

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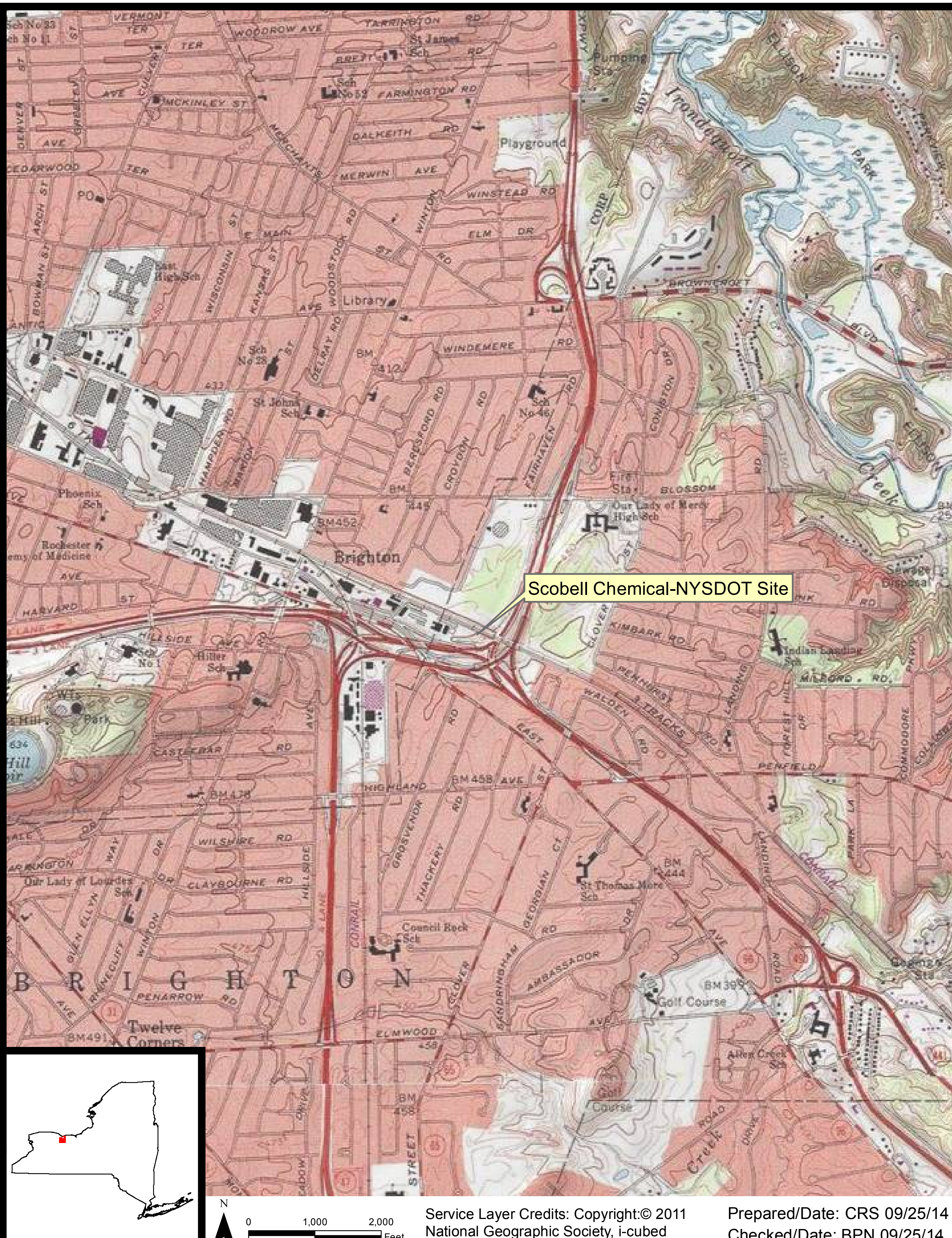
NYSDEC, 2010. DER-10, Technical Guidance for Site Investigation and Remediation. May 3, 2010.

NYSDEC, 2005. “Analytical Services Protocols”; 7/05 Edition; July 2005.



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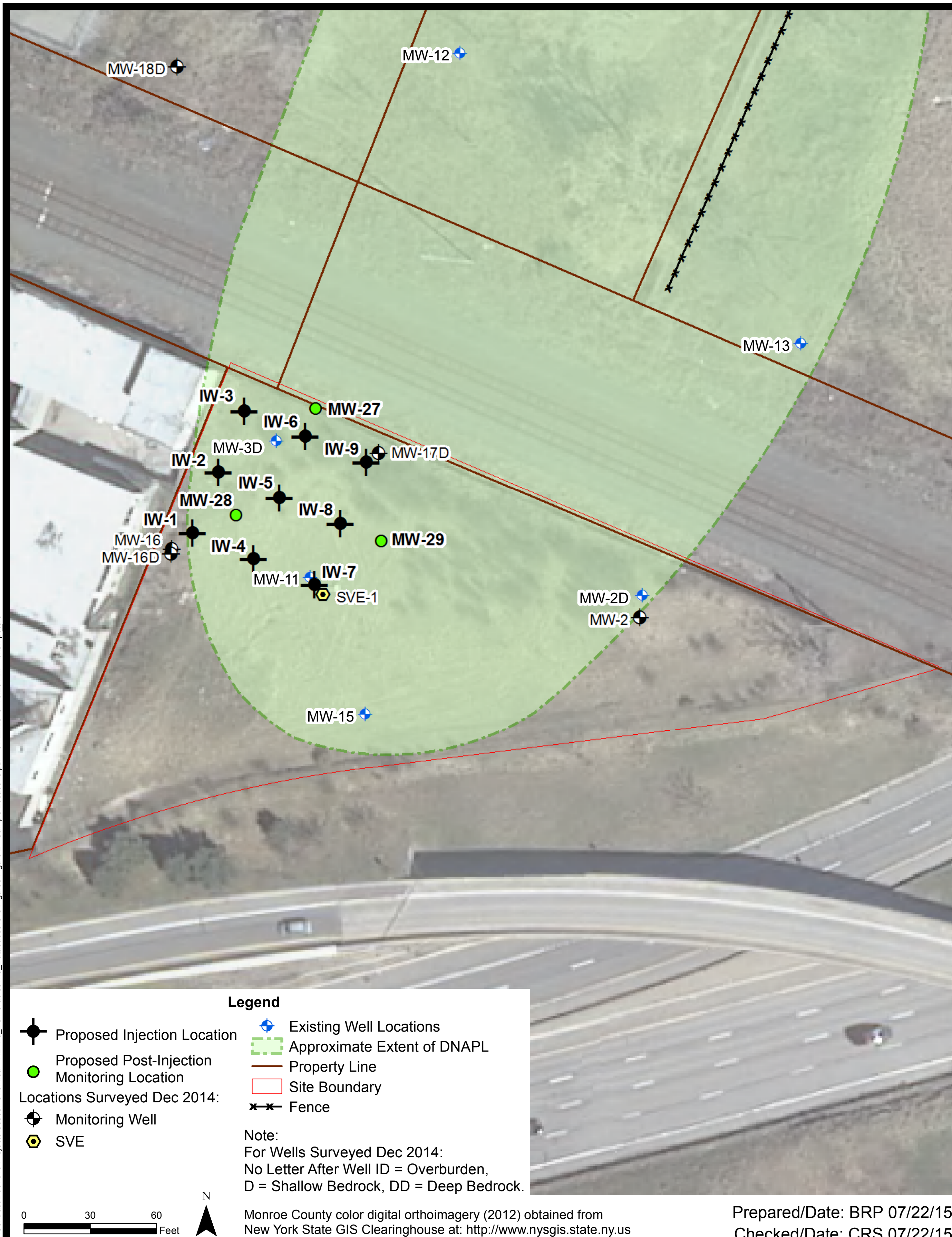
Prepared/Date: CRS 09/25/14
Checked/Date: BPN 09/25/14

SCOBELL CHEMICAL-NYSDOT SITE
BRIGHTON, NEW YORK

MACTEC

SITE LOCATION
Site 828076
Figure 1



Monroe County color digital orthoimagery (2012) obtained from
New York State GIS Clearinghouse at: http://www.nysgis.state.ny.us

Prepared/Date: BRP 07/22/15
Checked/Date: CRS 07/22/15

SCOBELL CHEMICAL-NYSDOT SITE BRIGHTON, NEW YORK	MACTEC	Sample Locations Project 3617147328 Figure 2

Document: P:\Projects\nysdec1\Contract D007619\Projects\Scobell Chemical - RD\4.0_Deliverables\4.5_Databases\GIS\MapDocuments\On_Site_Locs_8.5x11P.mxd
PDF: P:\Projects\nysdec1\Contract D007619\Projects\Scobell Chemical - RD\4.0_Deliverables\4.5_Databases\GIS\Figures\Figure 2 - Sample Locations.pdf 07/22/2015 10:28 AM brian.peters

Table 1: Proposed Field Tasks and Methodology

Methodology and Rationale	Loc I.D.	Medium	Depth bgs ft.	Sample I.D.		VOCs	Special Par.
					method water	8260C	See Note
					method rock	5035A/8260C	NA
					Validation level	Chem Rev.	Chem Rev.
To prepare for ZVI installation, install three open hole Pilot Injection Wells into bedrock using coring techniques. Rock cores will be evaluated with a PID to identify potential contaminant lenses for sampling.	IW-2	Rock	20-40 feet	828076-IW002__		1	
	IW-2	Rock	20-40 feet	828076-IW002__		1	
	IW-2	Rock	30-40 feet (bottom 5 ft)	828076-IW002__		1	
	IW-2	Rock (duplicate)	30-40 feet (bottom 5 ft)	828076-IW002__		1	
	IW-3	Rock	20-40 feet	828076-IW003__		1	
	IW-3	Rock	20-40 feet	828076-IW003__		1	
	IW-3	Rock	30-40 feet (bottom 5 ft)	828076-IW003__		1	
	IW-6	Rock	20-40 feet	828076-IW006__		1	
	IW-6	Rock	20-40 feet	828076-IW006__		1	
	IW-6	Rock	30-40 feet (bottom 5 ft)	828076-IW006__		1	
To prepare for ZVI installation, install six open hole Pilot Injection Wells into bedrock using air hammer techniques. No sampling to be conducted.	IW-1, IW-4, IW-5, IW-7, IW-8, and IW-9	Rock	35-40 feet (depending on depth of above borings)	No Samples			
To evaluate baseline source area concentrations, collect baseline groundwater samples from two open hole IWs in the vicinity of MW-3D and the western edge of injections.	IW-2	Groundwater	30 feet	828076-IW-002030		1	1
	IW-6	Groundwater	30 feet	828076-IW-006030		1	1
To evaluate feasibility of iron injections and radius of influence/effectiveness, inject approximately 7,500 pounds of micro-scale ZVI into each IW. ZVI will be divided evenly between three target zones per well.	IW-1 through IW-9	NA	20-30 feet	No Samples			
To visually inspect for placement of iron within bedrock fractures during installation and allow for additional groundwater monitoring points, install three open hole post injection groundwater monitoring wells into bedrock using coring techniques.	MW-27D, MW-28, and MW-29D	Rock	35 feet	No Samples			
To evaluate effectiveness of ZVI on bedrock groundwater quality, collect four rounds of post injection groundwater samples from select monitoring wells using low flow sampling techniques. Samples will be collected one month after injection and then quarterly for three additional quarters..	MW-2D	Groundwater	30	828076-MW2D030		1	1
	MW-3D	Groundwater	30	828076-MW3D030		1	1
	MW-3D	Groundwater (duplicate)	30	828076-MW3D030D		1	1
	MW-11D	Groundwater	25	828076-MW11D025		1	1
	MW-12D	Groundwater	25	828076-MW12D025		1	1
	MW-13D	Groundwater	30	828076-MW13D030		1	1
	MW-15D	Groundwater	25	828076-MW15D025		1	1
	MW-16D	Groundwater	25	828076-MW16D25		1	1
	MW-17D	Groundwater	25	828076-MW17D25		1	1
	MW-27D	Groundwater	25	828076-MW27D25		1	1
	MW-28D	Groundwater	25	828076-MW28D25		1	1
	MW-29D	Groundwater	25	828076-MW29D25		1	1

Notes:
ZVI = Zero Valent Iron
Sample ID: 828076 = NYSDEC Site No.; __ represents the 3 digit sample depth bgs be determined in field;
8260B VOCs = Target Compound List Volatile Organic Compounds
Duplicates will be collected at a frequency of 5% (1:20 samples).
Rock VOC samples to assume percent moisture of 98%
TBD = To Be Determined
bgs = below ground surface
NA = not applicable
Special Parameters = Nitrate by USEPA Method 4500-NO3, Sulfate by USEPA Method 375.2, ethene, ethane, and methane by RSK 375, TOC by USEPA Method 415.1
Alkalinity by USEPA Method 2320B, chloride by USEPA Method 4500_CL, calcium, iron, manganese, and magnesium will be analyzed by USEPA Method 6010B, and bromide by USEPA Method 300.
In addition, oxygen and reduction/oxidation potential and pH will be measured in the field.

Prepared by: CRS 7/20/2015
Checked by: JPC 7/21/2015

ATTACHMENT 1

RioTinto H_2Omet86 INFORMATION

RioTinto

H_2Omet 86

H_2Omet™ 86 is a high purity fine granular zero valent iron (ZVI), less than 250 µm, designed for injection, source zone remediation and permeable reactive barriers.

FEATURES AND BENEFITS

EXCELLENT REACTIVITY	Because of its unique manufacturing process, **H_2Omet™ 86** offers excellent contaminant degradation rate.	• Reduces treatments costs • Increases reactivity rate
HIGH PURITY	**H_2Omet™ 86** is produced from ore, not scrap, assuring a consistently pure product with low levels of alloying element, residuals and impurities.	• Assures consistency • Increases efficiency
MANY PACKAGING OPTIONS	**H_2Omet™ 86** can be delivered in the format suitable for any site location (bulk pack, big bags, etc.)	• Allows high flexibility • Facilitates handling

PHYSICAL AND CHEMICAL PROPERTIES

Chemical Analysis (wt %)

C	0.050
S	0.01
O	0.180
P	0.01
Mn	0.01
Si	0.01
V	0.02
Ti	0.02
Cu	0.03
Fe	>99

Typical Screen Analysis

U.S mesh	µm	wt%
+60	+250	<1
+100	+150	6
+200	+75	49
+325	+45	24
-325	-45	21

Rio Tinto, Metal Powders
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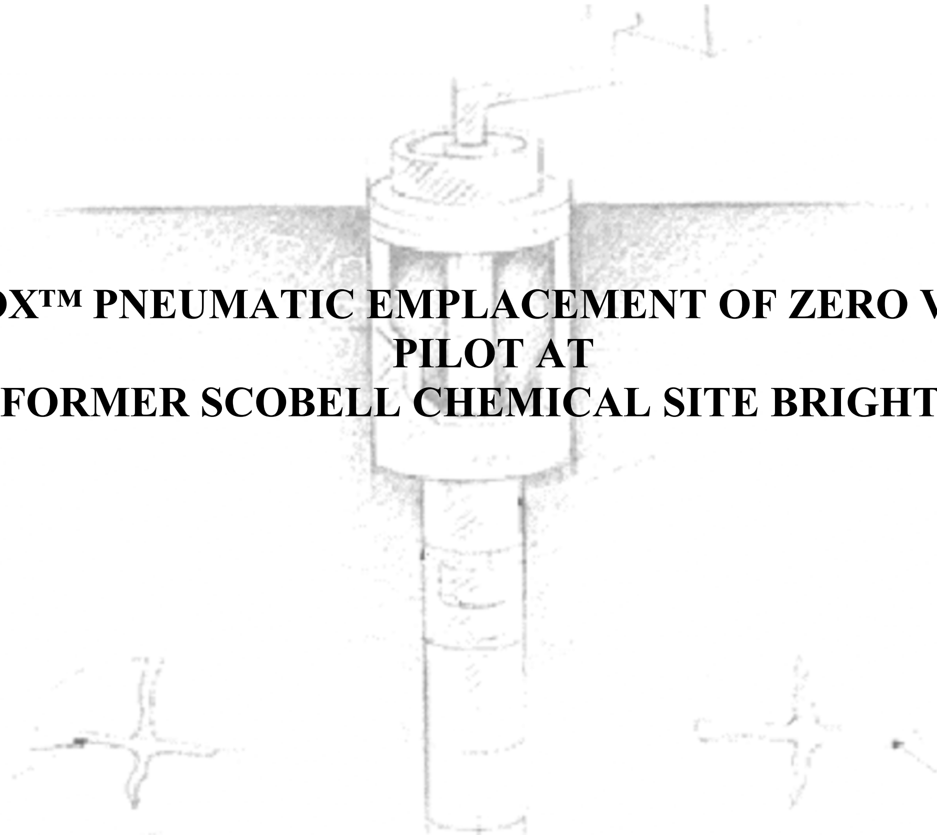
ATTACHMENT 2

ZERO VALENT IRON INJECTION INFORMATION



FEROX™ PNEUMATIC EMPLACEMENT OF ZERO VALENT PILOT AT THE FORMER SCOBELL CHEMICAL SITE BRIGHTON, NY

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June 16, 2015

ARS Technologies, Inc.

ARS Technologies Incorporated (ARS) is pleased to present Amec/Foster Wheeler with this proposal for Pilot injection by Ferox™ pneumatic emplacement of Zero Valent Iron (ZVI) at the Former Scobell Chemical Site in the Town of Brighton, NY. ARS has the experience and expertise to effectively emplace ZVI in various low and high permeability overburden consisting of silts, clays and fractured rock lithologies. In reviewing the specifications and background information provided by Amec/Foster Wheeler, ARS is confident that the technical approach presented herein will accomplish the goal of effectively and safely emplacing the ZVI, resulting in the effective treatment of the Contaminants of Concern (COC) on time and within the budget. ARS is uniquely qualified to perform this work based on the following:

- ARS will use its patented Ferox™ ZVI emplacement treatment that has been successfully used to remediate hundreds of sites.
- ARS has vast experience in the use of a variety of geologies, including applications with ZVI in environments similar to the Scobell Chemical site:
    - Experienced in fracture injection in the Scobell Chemical geology of bedded dolomite
    - Experience and successful track record at more than 500 sites world-wide (see Table 1)
    - >23 years of injection experience with fracture emplacement of ZVI
    - >23 years of zero field work time loss accidents
    - In-house drilling services with licensed drillers

TECHNOLOGY BACKGROUND

Effective treatment starts with effective distribution of the amendment that is emplaced to degrade those contaminants passing through the treatment zone. Success depends on the knowledgeable manipulation of hydrological, biological, geological and chemical interactions. No chemistries can work unless they make direct contact with the COCs. Direct contact in the low permeability environments, such as low permeability fractured rock present at this site, will require a more robust injection technique. In the last twenty years, fracture emplacement has emerged as one of the most cost effective methods for the emplacement ZVI for the remediation of contaminated soil and groundwater **(Figure 1)**. The general approach of the technology is to create a network of fractures in a geologic formation that serves a principal function. The fractures serve as receptors to introduce beneficial amendments (ZVI) into the formation. The overall objective of fracturing is to overcome the transport limitations and diffusion limited treatment zones that are inherent at many heterogeneous remediation sites.

Table 1: ARS Technologies, Inc. Selected Past ZVI Project

Scope of Work	Amount of EHC/ZVI Injected (lbs)	Location	Client	Year Completed
ZVI Injection	68,000	Huntsville, AL	NASA / CH2M	**2015**
ZVI Injection	2,237,800	Wichita, KS	AECOM/URS	**2014**
ZVI Injection	66,000	Irvine, CA	Environ	**2014**
ZVI Injection	187,000	San Francisco, CA	NAVY / CB&I	**2014**
ZVI Injection	13,230	Lafayette, CA	ERM	**2014**
ZVI Injection	117,000	Granby, Quebec	Geosyntec	**2013**
EHC Injection	350,000	River Edge, NJ	Excel	2012
ZVI/EVO	193,797	Morris Plains, NJ	ROUX	2013
ZVI Injection	115,000	Toronto	Pinchin	2012
ZVI Injection	26,460	Irvine, CA	Geosyntec	2012
ZVI Injection	400,000	Randallstown, MD	Langan	2012
EHC & ZVI Injection	9,196	Savannah, GA	CH2M Hill	2012
EHC Injection	40,000	Monroe, PA	Tetra Tech	2011
ZVI Injection	71,000	York, SC	TRC	2011
ZVI Injection	7,650	Franklin Park, NJ	The Hartford	2011
ZVI Injection	104,500	San Francisco, CA	NAVY / Shaw	2010
ZVI Injection	132,000	Newfield, NJ	TRC	2009
ZVI Injection	37,300	Irvine, CA	ENVIRON	2009
ZVI Injection	137,728	Silver Spring, MD	CH2M Hill	2008
EHC Injection	247,500	Chamblee, GA	GE	2008
ZVI Injection	45,000	Valhalla, NY	Dvirka & Bartilucci	2008
EHC Injection	8,745	Metuchen, NJ	TRC	2008
ZVI Injection	612,000	Sunnyvale, CA	Treadwell & Rollo	2008
ZVI Injection	230,000	San Francisco, CA	Navy, Battelle	2008
EHC & ZVI Injection	91,792	Quebec, Canada	Dessau-Soprin, Inc.	2006
	5,548,698			

Ferox™ Technology

Ferox™ technology is a patented (US# 5,975,798) treatment process for the *in situ* reduction of halogenated organic compounds. The Ferox™ technology consists of multi-phase injection and emplacement of specific quantities of a highly reactive ZVI powder into subsurface contaminant zones. ARS' Pneumatic Fracturing and Atomized Liquid Injection (ALI) technology are patented (US# 5,975,798 and 5,560,737) treatment processes for the *in situ* treatment of contaminants in low permeable formations. The integrated technology relies on Pneumatic Fracturing to increase the bulk hydraulic conductivity of the formation, interconnect both primary and secondary fracture networks and dilate existing fractures to facilitate a more uniform emplacement of the reagents.

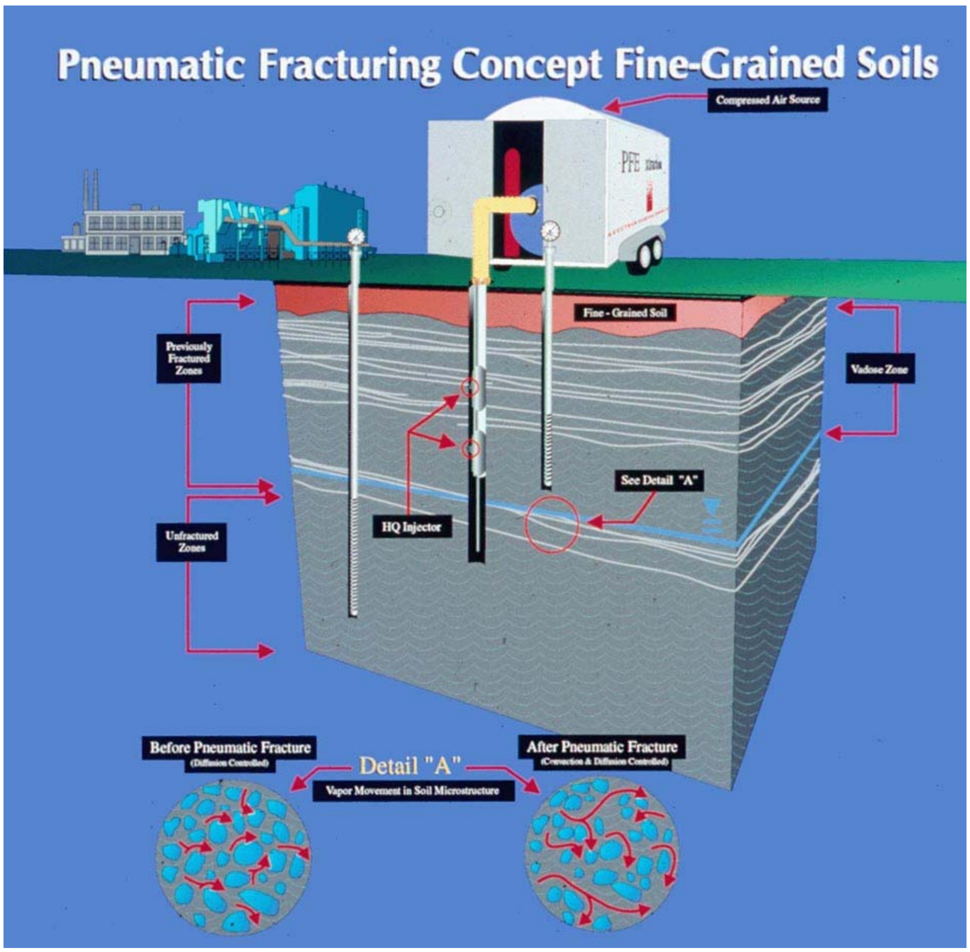

Figure 1: Conceptual Diagram of Pneumatic Fracture Emplacement (PFE)

Pneumatic Fracturing Process

Pneumatic Fracturing can be described as a process whereby a gas is injected into the subsurface at pressures exceeding the natural *in situ* pressures (i.e. overburden pressure, cohesive stresses, etc.) and at flow volumes exceeding the natural permeability of the formation. Pneumatic Fracturing was originally researched and developed for environmental remediation by New Jersey Institute of Technology.[1] Through collaborative effort with ARS, the process was vetted by the US EPA Superfund Innovative Technology Evaluation (SITE) program.[2] See attached literature references.

Although at the injection point up to several hundred PSI of pressure may be applied, the pressure and velocity of the gas and ZVI slurry decreases exponentially with respect to distance away from the entry point due to the disproportional increase in the affected volume. As an example, the exit area of the injection nozzle is less than 0.07 square feet, whereas at the 15-ft radius the surface of the treatment volume is approximately 1,700 square feet, an increase by more than 24,000 times. In short, the injected gas very quickly loses momentum and therefore velocity. This leak-off effect also causes the ZVI particles to deposit onto the soil matrix (Stokes Law), therefore necessitating a close spacing of the injection points. However, the propagation of fractures outward is at a rates of 2+/- m/sec. Depending on treatment depth, fracture propagation distances of 5-8 m have been observed in unconsolidated geology and 9-20 m in fractured rock formations. Examination of a Pressure - Time History curve **(Figure 2)** provides *real-time* evidence that the cohesive bonds within the geologic matrix are broken and the creation of a fracture network occurs within the subsurface. The result is the enhancement of existing fractures and planes of weakness (for example, bedding planes) and the propagation of a dense fracture network surrounding the injection well. In turn, this fracture network enhances the overall effective bulk permeability of the formation, thus allowing the selected *in situ* treatment approach to work more effectively.

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[1] Schuring, John R., Valdis Jurka, and Paul C. Chan. 1991. "Pneumatic fracturing to remove VOCS". Remediation Journal. 2 (1): 51-68

[2] U S Environmental Protection Agency, Response, Emergency Office, Technology Innovation. (April. 1995). *In Situ Remediation Technology Status Report : Hydraulic and Pneumatic Fracturing*. EPA542-K-94-005

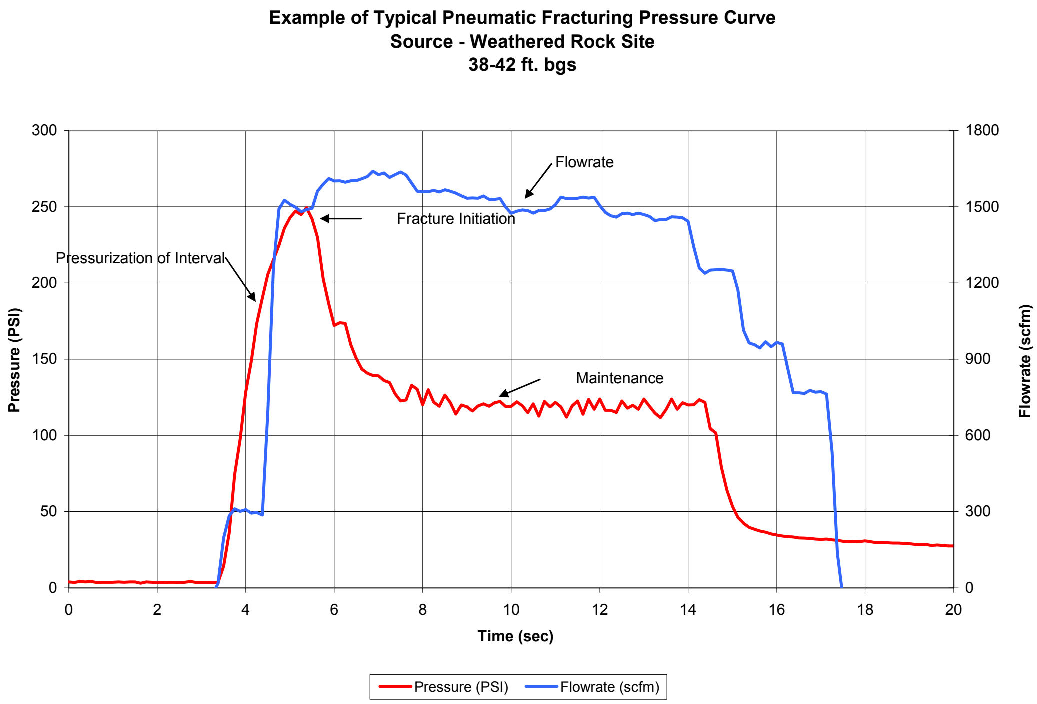


Figure 2: Example of Pressure vs Time Curve (100 psi)

Within the effective radius of influence, there will be localized displacement of groundwater, with the effect being more pronounced at the injection point and significantly decreases with respect to distance out to the zone of influence. Since the overall treatment area consists of multiple injection points, localized movement within individual cells around each injection point does not constitute displacement of the overall plume. Closely monitoring injection pressure coupled with the influence at the monitoring well will mitigate extended influence off-site. ARS can adjust the injection intensity in the field based on responses detected at nearby monitoring wells. Injection in each area (Zone) will be initiated at points with nearby monitoring wells to access the pressure influence.

Once a geologic zone has been fractured, the injection of the amendment such as ZVI is performed in an integrated sequential process. The amendment is introduced into the nitrogen gas stream above the ground and becomes atomized. Relatively low pressures are required to sustain the flow into the formation. The atomization apparatus consists of a down-hole injection assembly that consists of an injection nozzle with straddle packers that isolate and focus the injection to the interval in between.

A critical component of any injection process is ensuring that the amendment is distributed within the subsurface in a manner that maximizes its dispersion. The challenge to successfully implement any active *in situ* treatment is the physical emplacement and dispersion of the reactive material.

To accomplish this distribution, ARS incorporates a gas-based delivery approach called Atomized Liquid Injection (ALI) for the emplacement of the amendment.

Atomized Liquid Injection (ALI) Process

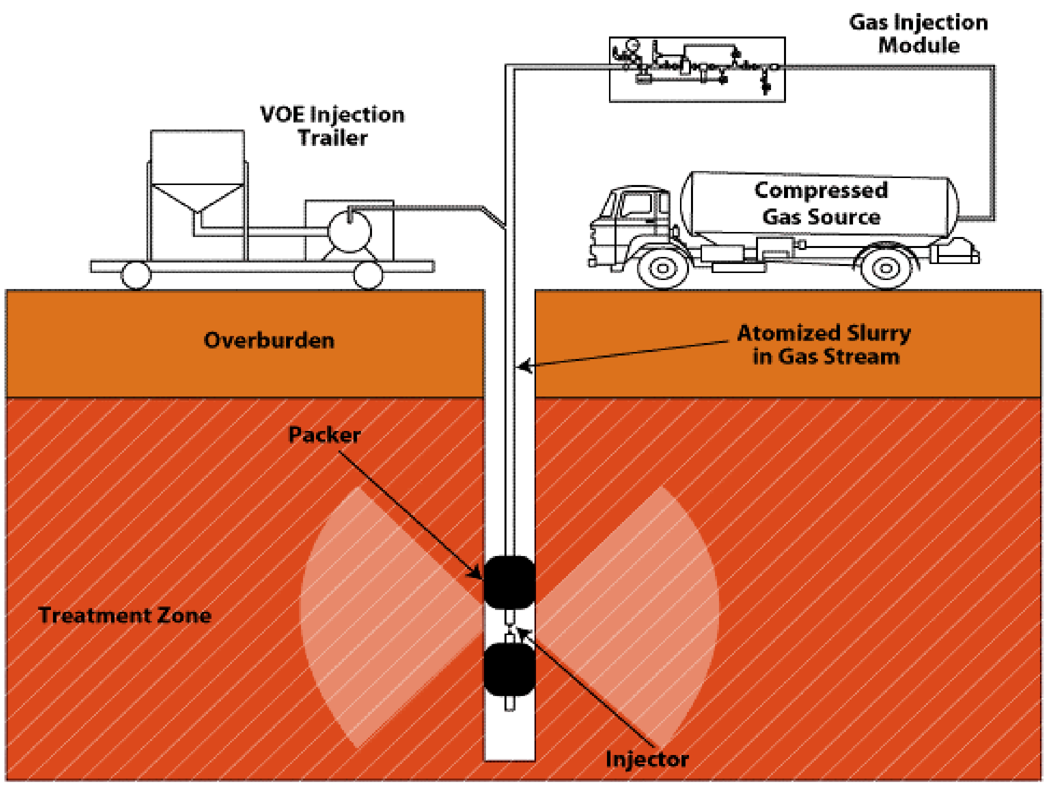


Figure 3: Pneumatic Fracture Emplacement (PFE) Process with Atomized Liquid Injection (ALI)

Atomized Liquid Injection (ALI) can be described as a process whereby liquids or liquid slurries are injected directly into a gas stream to cause the injected material to atomize **(Figure 3)**. With ALI, a slurry consisting of the amendment and water is atomized into a high velocity pressurized nitrogen stream, which is quickly delivered and dispersed into the subsurface geologic treatment zone.

INJECTION PROCEDURE

ARS' pneumatic emplacement is a well-established commercial injection method. The specialized equipment used by ARS allows for the amendment to be uniformly mixed within potable water and fed into a high velocity nitrogen gas stream which is directed down-hole and radially outward from the injection location. Using this method and based upon other applications applied in the site formation and depth, it can be expected that the amendment will be effectively distributed a minimum of 15 feet at the site.

The injection points will be pre-drilled by other contractor with an air hammer. A 4" steel case will be installed and sealed to 2' into the bedrock and the borehole will be continued to 35' bgs into the bedrock. Once the temporary injection borehole has been installed, injection tooling consisting of a nozzle and straddle packer assembly will be lowered into the borehole and fracturing/injection will proceed in a bottom-up manner. During the fracture phase of the project, the injection is initiated by the introduction of pressurized gas for 10 to 15 seconds to propagate fractures into the formation and to establish the flow. The ZVI amendment is then pumped into the pressurized nitrogen gas stream at the well-head and becomes atomized prior to dispersion within the fractures created. Once the injection is complete at that interval, the packers are deflated and the injection assembly is retracted upward approximately 3 to 3.5 ft. to the next injection interval. This process is repeated until the entire target treatment zone is addressed at that location.

Though ARS can alter the injection technique using different nozzle configurations, gas pressures and flow rates, the physical and mechanical characteristics of the geologic media injecting into will play a significant role in the emplacement mechanism of the amendment. Our field experience working in the similar formation, suggests that fracture filling (see **Figure 4**, diagram c) will be the primary emplacement mechanism at this site.

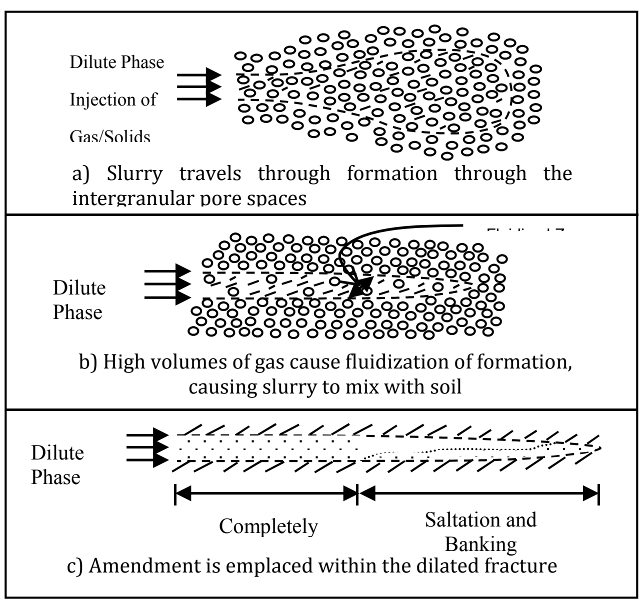


Figure 4: Mechanisms of Amendment Emplacement during Injection

Since fracture propagation requires relatively low pressures (less than 500 psig), the ability of gas to dissipate pressure very quickly is very favorable when fracturing near utilities or buildings. As long as the fracture boring is a safe distance away (minimum 5 ft.) from active utilities, the pressure imparted on the utility is expected to be very low (less than 25 psig), which is well below operating pressures of even lightweight material such as PVC. In addition, it is important to note that most buried utilities are installed with some sort of course backfill material (sand, gravel) to address settling during freeze thaw cycles. This coarse backfill material serves to dissipate any gas pressure applied to the formation during fracturing. ARS recommends that all fracture/injection locations be a minimum of 5-7 feet away from utilities to minimize pressure effects or ground deflection.

SITE EVALUATION/BASIS OF DESIGN

The key to achieving success at this site is using a combination of approaches that will quickly emplace the amendment throughout the treatment area as needed.

Site Description

The Scobell Chemical - NYSDOT Site is located at 1 Rockwood Place in a mixed commercial, industrial, and residential area in the northern section of the Town of Brighton, immediately east of the City of Rochester boundary. The site contains no structures, is covered with grass and scrub growth, and is surrounded by a chain link fence. A small surface water drainage ditch parallels the New York Central Railroad Line that is present immediately north of the property. The Grass Creek is located north of the site beyond the railroad line. The geology in the treatment zone is a porous dolostone of the Lockport Group. The bedrock becomes more competent with depth, with the exception of an approximate 4-foot wide fracture zone ranging from 15 to 25 feet beneath the ground surface. Shallow groundwater occurs at the overburden-bedrock interface at a depth of approximately 4 to 10 feet beneath the ground surface and generally flows to the south. Deeper groundwater encountered in the shallow bedrock occurs at depths of approximately 10 to 20 feet beneath the ground surface and flows to the northeast. The COCs are primarily chlorinated solvents.

Design Criteria

- 9 injection points based upon 15 ft. ROI
- 1% ZVI loading rate
- Target Treatment depth of 19-29 ft. bgs.
- 3 7/8” Pre-drilled holes with 4” Steel casing 2’ into bedrock
- Drilled through bedrock to 35’

This pilot design is based upon fracture emplacement of a 31 MT of ZVI in 9 injection points **(Figure 5**, addressing the depth interval from 19 to 29 ft. (bgs). Loading dosage is is 1% w/w (soil/ZVI) presented in **Table 2**. ARS anticipates that a minimum Radius of Influence (ROI) of >15 ft. for the PFE points will be achieved during the emplacement of the ZVI. It is estimated that the fracturing/injection phase will require ~6 rig days using a 3-4 man crew (10 hours on-site time per day), including setup and breakdown.

Table 2: Design Parameters for Ferox™ Pilot

	Injection Pts. (PFE)	Treatment Intervals (ft.)	Injection Events/Pt	Total Injection Events	Total ZVI Injected (MT)	Total ZVI Injected (gal)
Pilot	9	19-29	3	27	31	16,187

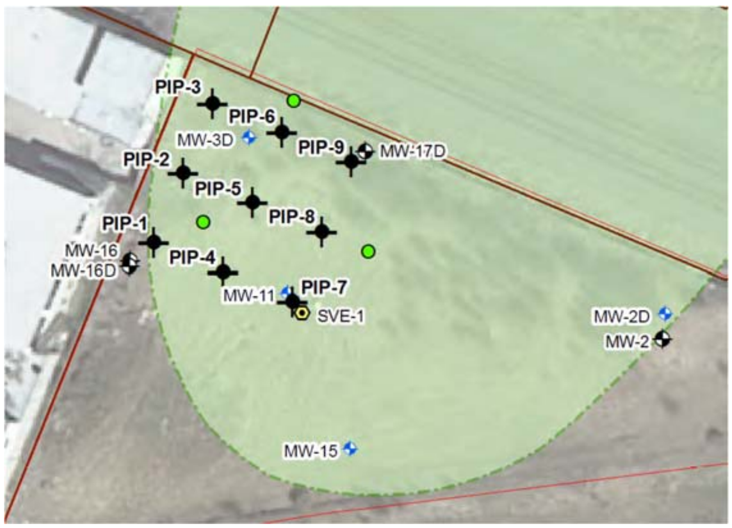


Figure 5: Proposed Location of Pilot Injection Points

Monitoring of Radius of Influence (ROI) of ZVI injections

As part of this pilot, the distance of ZVI propagation from injection points needs to be confirmed. at three locations along within the treatment zone. Tiltmeters and heave rods can be useful in confirming ROI but both methods have serious limitations. First, the surface deflection caused by pneumatic emplacement is usually less than a couple of millimeters. Second, this deflection is usually temporary and only lasts as long as the pneumatic fracturing event, ~15sec. The geology at this site is favorable for good data, but being less than 50 ft from a railroad right-of-way and 200 ft from a major highway the tiltmeters data could be compromised. If primary purpose is to check for lift of the adjacent building, those points will be schedule when car/truck traffic is minimal and between scheduled trains. In addition, crack gauges will be installed along the building foundation and measure any shifts after the injection events.

Performance Metrics

The performance of this pilot should be primarily measured by the following parameters in the available within the treatment area, and upgradient and downgradient monitoring wells:

- Critical Parameters: (Site-wide averages)
  - pH and idea of buffering capacity
  - Dissolved Oxygen, Redox Potential (Eh)
  - Total Organic Carbon (TOC)
  - Metals Scan (iron, calcium, magnesium, manganese included)
  - Anion Scan (chloride, sulfate, nitrate included)

Additional parameter may be measured periodically to determine performance:

- Non-Critical Parameters:
  - Dissolved Organic Carbon (DOC)
  - Alkalinity (goes to buffering capacity)
  - Hardness
  - Volatile Fatty Acids (VFAs)
  - Dissolved Gases (ethene, ethane, methane, hydrogen)

TECHNICAL APPROACH AND COST TASK BREAKDOWN

In developing our technical approach task breakdown, ARS has subdivided the project into the following 4 distinct phases:

Task 1: Planning, Data Review and Engineering

Task 2: Site Specific Health and Safety Report

Task 3: Mobilization and Demobilization

Task 4: Emplacement of the ZVI

The following discussion is a summary of our understanding of tasks and responsibilities to be performed in each these phases.

PROJECT OBJECTIVE AND LAYOUT

Task 1: Planning, Data Review and Engineering Reports, Site Visit

Upon contract execution and receiving notice to proceed, a site visit will be scheduled with Amec/Foster Wheeler to finalize injection point locations. Based upon project objectives and site conditions, ARS will submit to Amec/Foster Wheeler and its client a safety and installation plan addressing all the activities under our work scope and outline the data to be collected during the field work. ARS will be responsible for all installation quality control and material submittals.

ARS will provide a Final Engineering Report 60 working days after completion of the pilot installation. The Final Engineering Report will include a detailed description of work performed and results including final as-built drawings. If needed, ARS will use a New York certified, P.E. structural engineer for the upfront analysis of safety and our senior engineer Steve Chen (certified PE in New York) will sign the final engineering report.

Task 2: Site Specific Health & Safety Plan.

ARS will submit to Amec/Foster Wheeler a HASP focusing on the safety issues specific to the fracturing process and drilling within 7 days of the site visit. All project HASPs are reviewed and approved by our corporate Health and Safety Officer. The H&S officer reviews all on-going field projects at the daily "all-hands" meeting. Regional Manager reports to the Corporate Health & Safety Officer and communicates all concerns, issues, and follow-up on near miss events that occur in the field.

Task 3: Mobe/Demobe, Equipment Prep.

This cost item includes the mobilization/demobilization of ARS' injection equipment, vehicles, materials and field personnel to and from the site. It includes the travel expenses for ARS field personnel to and from the job site. Equipment mobilized will include a large scale production ZVI slurry injection trailer, gas-injection module, compact drill rig and ARS field vehicles. In addition, bulk nitrogen gas and a forklift will be sourced locally. All investigation-derived waste will be containerized in 55-gallon drums and stored on-site for disposal at the end of the project.

Task 4: Emplacement of ZVI

This item includes costs associated with the installation of ZVI as well as costs of specialized injection equipment, equipment rental, water supply, consumable materials, health and safety equipment and data interpretation/reporting. Several individual tasks will be performed as part of the work. The following summarizes the sequence of field activities and related tasks for the reagent injections:

- Injections
- Monitoring of Radius of Influence (ROI) of ZVI injections
- De-contaminate down hole tooling between boreholes
- Site Cleanup and Demobilization

Pneumatic Emplacement of Ferox™-PILOT Zero-Valent Iron

The costs presented for this phase of the work are based upon fracture emplacement of 31 MT of ZVI at a depth interval from 19' to 29' ft. (bgs) to treat the pilot areas of the TCE Plume mass (see Table 2). ARS anticipates that a minimum ROI of 15' for the PFE points will be achieved during the emplaced ZVI.

Several individual tasks will be performed as part of the work. During all injection operations, ARS personnel will record down-hole injection pressure, pressure influence at surrounding MW's or bore holes, actual injected mass of ZVI per interval, and injection pressures and feed rates.

A 3 man crew will be deployed to the site and several pieces of equipment or vehicles will be required as part of the field operation. They will be mobilized to the site one day before the initiation of injection activities. This includes support vehicles, an injection trailer, generators, and nitrogen cylinders or a nitrogen tube trailer. ARS will stage the various pieces of the equipment/vehicles at the injection site to best minimize disturbance to the facility operations.

Injection Monitoring Parameters

During each fracturing injection event, the following system operational parameters will be observed and collected:

- Down-hole initiation and maintenance pressures at the injection point;
- Pressure influence at surrounding monitoring points; and
- Ground surface deflection at the injection point and at building load points using till meters.

Injection Initiation and Maintenance Pressures

During each fracture initiation, pressures in the discrete fracture interval are recorded by a pressure transducer located in-line within the conduit leading to the injection nozzle. These pressures are recorded by a data-logging system located on the injection module and accessed using a laptop computer for real-time display of the injection pressure. The pattern of a pressure-history curve serves as an indicator of whether fracture initiation and propagation have occurred. This information allows the evaluation of two critical measurements: the fracture initiation pressure and the fracture maintenance pressure. A typical PF event is subdivided into three distinct stages consisting of:

- Borehole Pressurization
- Fracture Initiation
- Fracture Maintenance

These independent stages are illustrated in **Figure 6**. It should be noted that the shape of the pressure-time history curve depends on a number of factors including in situ stress fields, geologic characteristics of the medium being fractured, depth of application and the presence of man-made disturbances (boreholes, utilities, etc.) within the influence of fracturing.

The following section describes each stage as it relates to the PF mechanism as illustrated in **Figure 6**. During the first stage, identified as "Borehole Pressurization," the pressure rapidly builds up as gas and is injected into the target sealed interval within the borehole. This stage is identified as curve segment A-B. This stage is relatively short and typically lasts 1-2 seconds, depending on the length of the conduit (injection hose and piping) that needs to be pressurized. Once the pressure is built to a level that exceeds the in situ stress and overburden pressure within the borehole interval, the formation yields and fractures are initiated. Stage B in **Figure 6** represents the fracture initiation pressure. Following the formation fracture initiation stage, the pressure decreases rapidly and stabilizes at a plateau as the injection continues. This rapid decline in the borehole pressure is represented by segment B-C. During this time period, the injection gas flow rate usually maximizes or steadily increases as the fractures are propagated, thereby reducing the back pressure within the treatment zone to the injection. Segment C-D reflects the continual gas injection under a relatively constant injection pressure. As the injection pressure is terminated, the maintenance pressure declines rapidly from D-E.

The shape and magnitude of the pressure history curve can be affected by factors such as soil cohesion, depth, presence of leak-off points or preferential pathways, and presence of a confining layer within or above the formation.

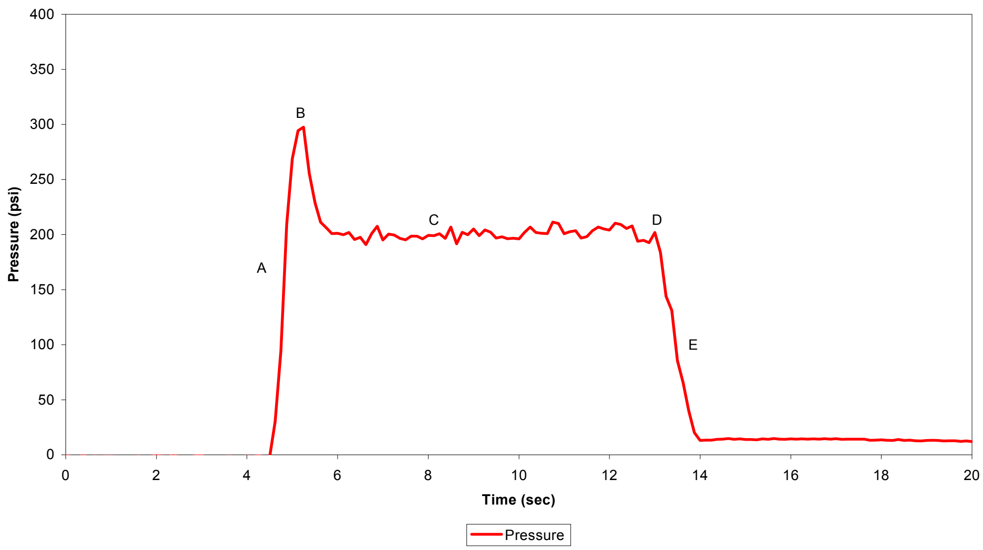


Figure 6: Example of a Pressure vs Time Curve

During the fracturing events, pressure gauges will be placed at selected monitoring wells and adjacent injection borings where available, to monitor pressure influence. Each pressure gauge will be fitted with a maximum drag-arm indicator, which enables the field personnel to identify the maximum pressure influence at that location during each event. The data also assists in determining which directions fractures may have propagated. In addition, the degree of pressure response can often help determine whether a monitoring point has been directly influenced (i.e. fractures propagate outward and intersect wells or boreholes) or indirectly influenced through localized groundwater displacement and/or mounding.

Pressure Influence at Adjacent Wells

During the injections, surface packers fitted with pressure gauges will be placed at adjacent injection points and designated neighboring monitoring wells to monitor for pressure influence.

Each pressure gauge is outfitted with a drag arm indicator that records the maximum pressure detected at the monitoring point during the injection. In addition, visual observations will also be used to indicate pressure influence in surrounding wells. Pressure monitoring will allow for a qualitative estimate of the distribution of the injected nitrogen. The pattern of or changes in the pressure influence during the progression of the injection may also provide real-time indications of the subsurface airflow characteristics so as to allow field personnel to modify or adjust injection parameters accordingly in accomplishing project objectives.

Ground Surface Heave

Ground surface heave monitoring will be conducted during the injections at critical locations (e.g. near load-bearing structures) using a surveying transit in conjunction with heave rod. The heave rod will be placed at or near the injection point. During and immediately after the injection event, field personnel will observe for the maximum amount of upward motion (surface heave) and the post-injection resting position (residual heave).

ARS will provide a detailed quality control program covering all aspects of the injection including monitoring the amount of ZVI placed in each fracture and injection pressure used. ARS shall provide accurate means of determining and recording the mass of ZVI (dry basis) injected at each injection interval. In the event of daylighting the injected ZVI slurry, ARS will minimize and contain its spread.

OPTIONAL: Site Inspection & Structural Review

A professional engineer could conduct a detailed structural analysis of the builidings and railroad sensitivity to the injection operations for an additional $7,500. This analysis will consist of a photo logging of the condition of the wall, comparison of pneumatically fractured sites with similar geologic formations and depths at the site to generate empirical data on the possible response of the retaining wall heave under site-specific conditions. This empirical data will be inputted into an analytical model, DEPORM™ to predict ground surface heave and the effected movement on the structure. The culmination of this research and site survey is presented in a report with detailed movement criteria to be monitored in the field during each fracturing event. Our cost assumption is that Amec/Foster Wheeler will provide to ARS construction as-built of the pipeline and power lines. Based upon both the modeling output contained within this report and ARS' past field experience with similar projects, specific operational parameters will be implemented in the field during all injections under this project. Strict adherence to these procedures will result in effective injection operations with no detrimental impacts to the structure at the site.

KEY PROPOSAL COST ASSUMPTIONS

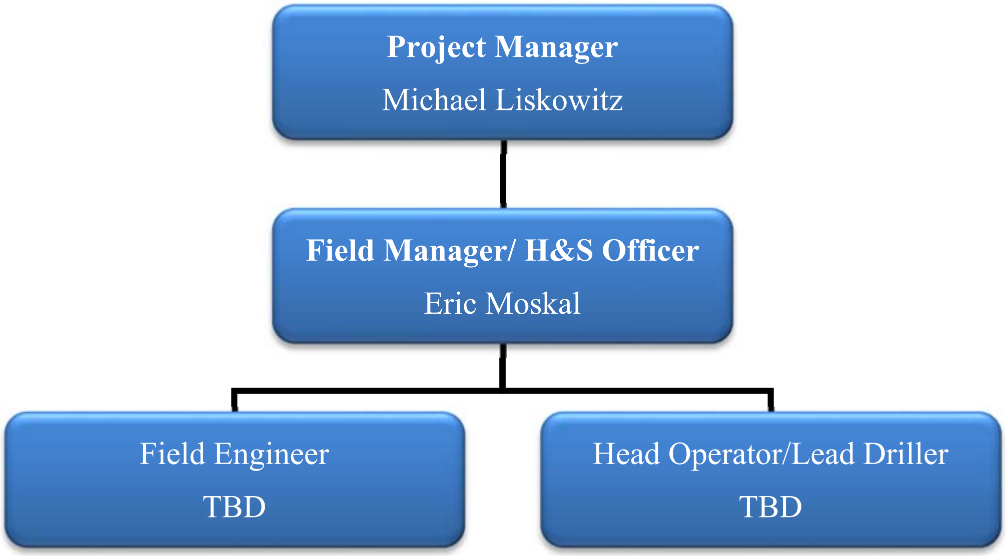
The following assumptions were made while deriving the estimated costs and are incorporated in our pricing:

- Injection activities can occur all day between 7:00 am and 7:00 pm.
- Professional Services Only; No prevailing wage or Davis-Bacon Act labor requirements.

- Ambient daytime temperature is above freezing during all operations. If ambient daytime temperature is below freezing, the Cold Weather Cost Adjustment would apply.
- Estimated costs are accurate for 90 days within the date of this proposal. Payment terms are **Net 45** days from the client's receipt of ARS' monthly invoice.
- Proposed cost is based on the lump sum and unit pricing structure indicated in the RFP. In the event that planned quantities as indicated in the RFP decrease by more than 40%, ARS shall have the right to modify its costs.
- If causes beyond ARS' control delay the field progress, ARS is entitled to compensation at the rate of $700/hr or $6,000/day in addition to the proposed costs. Such causes shall include but not be limited to:
    - Changes to Amec/Foster Wheeler purchase order.
    - Acts or omissions of Amec/Foster Wheeler, its client, regulatory authorities, or contractors employed by others.
    - Unexpected health and safety hazards arising from pre-existing site conditions not communicated to ARS prior to mobilizing to the site.
    - Unanticipated severe weather conditions in excess of 8 work hours for the project.
    - Fire, unusual transportation delays, labor disputes, or accidents not attributable to ARS.
- To date, the exact locations of the injection points have not been finalized in the field. The proposed cost is based on the assumption that all injection points will be positioned at least 15 feet from load-bearing columns, walls or structures and there are no underground utility lines horizontally within 5 feet of the injection points. If any of the above conditions exist at the site, ARS may require a modification to its proposed approach which if including additional points which may translate into additional costs.
- Proposed cost is based on site conditions and contaminant levels provided to ARS to date. Should actual or additional site conditions deviate from the existing information at any time during the project, ARS reserves the right to amend its cost estimate and approach.
- ARS will have full access to the work area. This cost estimate assumes the injection area is open. Should traffic control be required, Amec/Foster Wheeler will obtain permission to alter the traffic pattern and will provide all traffic control when necessary. ARS will provide cones and caution tape for use in traffic control.
- ARS has assumed that all previously installed wells, boreholes and sample locations were properly grouted with cement grout prior to ARS arriving at the site.
- The injection may result in minor ground surface heave and uplift of the ground surface. The proposed cost does not include resurfacing of the ground surface, seeding or repaving of the roadway or parking lots.
- ARS will containerize all wastes (daylighted material, general refuse, PPE, etc.) and stage them near the work area identified by Amec/Foster Wheeler. ARS is not authorized to transport any waste over public roadways. ARS's subcontractor shall be responsible for the classification, transportation (off-site) and disposal of all waste. The Subcontractor shall prepare and sign all manifests.

- Amec/Foster Wheeler will obtain all necessary regulatory approval or permits for the injection and field operations.
- ARS will survey and mark out all utilities at the site prior to ARS mobilization.
- All work to be conducted in Modified Level D PPE.

PROJECT ORGANIZATION



Robert Kelley – VP of Technology Development

Dr. Kelley has over 27 years of experience with chemical oxidation and biodegradation technologies as an environmental researcher, consultant, and vendor. Dr. Kelley has developed and implemented a variety of chemical and biological remediation technologies. He has worked as the Principal Scientist in the development of several innovative remediation technologies for recalcitrant compounds, such as PCBs and PAHs. He conducted and coordinated numerous treatability studies and supervised a diverse group of scientists and engineers who designed and performed remediation pilot studies. As a consultant, he performed and supervised Phase II Environmental Assessments and designed remediation solutions for contaminated properties.

Dr. Kelley has managed product development activities at several leading environmental services firms, which included improvements and refinements of current products as well as development of new products. He worked within these companies to document the performance of current product lines and to determine future market needs. He aided in the development of product launch materials and works alongside technical services groups to ensure successful applications of these products. He also has coordinated outside collaborations with key laboratories and research firms to develop new product opportunities. He has coordinated effort to license or acquire technologies, and maintains understanding of emerging competitive technologies.

William Beachell – Health & Safety Officer

As ARS' Corporate Safety Manager since 2000, Mr. Beachell is responsible for all safety aspects of the company's office, warehousing and field related operations. In addition, he is responsible for establishing all required OSHA compliance training, medical monitoring and record keeping requirements for ARS. During this period he has updated and prepared many of the activity hazardous analysis (AHA) reports which are incorporated as Standard Operating Procedures for ARS' fracturing and injection field teams.

He performs safety field audits and post-project debriefing interviews to ensure ARS' crews are following both corporate and site specific safety procedures. During the fabrication of ARS' proprietary injection systems, Mr. Beachell serves as a design QA/QC Manager, ensuring the components meet the process parameters they will operate under and ensuring that all safety-interlocks operate as designed.

Prior to joining ARS, Mr. Beachell served as an Emergency Management Coordinator, which included responsibility for coordinating all fire, first aid, and police units and as point of contact for (FEMA) during all emergency events. He has extensive state and federal DOT traffic safety training and is a specialist in Human Resources and is also an approved OSHA Instructor.

Mike Liskowitz – Senior Project Manager

Mr. Liskowitz' experience has included the design and application of more than 35 injection systems. He has managed and coordinated numerous projects involving the use of Zero-Valent Iron and chemical oxidants as in-situ remediation technologies in treating chlorinated volatile organic compounds and PCBs.

During his 14 years of experience working with ARS, Mr. Liskowitz project responsibilities have included the management of all phases of a project from start to finish. These include several projects incorporating baseline sampling, treatability testing, pilot testing and eventual full-scale implementation. Mr. Liskowitz has studied the effects of Zero-Valent Iron powder in reducing the Dioxin and PCBs in river sediment collected from the Passaic River in New Jersey. In addition, Mr. Liskowitz was the lead design engineer on several of the proprietary injection components, nozzles and systems ARS currently uses.

Eric Moskal – Field Project Manager

Mr. Moskal has extensive training and experience applying ARS' proprietary Pneumatic Fracturing and injection technologies. His responsibilities include project planning, field management and performance of field injections as well as the subsequent data analysis. Based on his hands-on experience and involvement in many key ARS projects as well as his educational background as a geologist, Mr. Moskal has established himself as valuable technical personnel within the ARS organization and is relied on to complete project objectives.

Selected Publications and Presentations

Below is just a sample list of publications which ARS has authored or peer reviewed related to its technology applications and body of work. Currently we estimate our body of published work well in excess of 100 publications in proceedings, books and government manuscripts:

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4. Canino, M. C., Schuring, J. R. Liskowitz, J. J. & Leonard, A. C. (1998).Applying Pneumatic Fracturing Beneath Industrial Structures for In-situ Remediation. Boston, MA.: 4th International Symposium on Environmental Geotechnology and Global Sustainable Development.
5. Corack, E. MacEwen, S. Liskowitz, J. & Stecklee, D. (2006). Enhanced In-situ Reduction of cVOCs using Zero-valent Iron. Monterey, CA.: Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds.
6. Chen, S. Markesic S. & Abrams S. A. (2002). Injection of Zero-Valent Iron into a Shale Bedrock Formation for the Reduction of Trichloroethene. Monterey, CA.: Third International Conference on Remediation of Chlorinated and Recalcitrant Compounds.
7. Chen, S. (2007). A Biotic/Abiotic Three-Phase In-situ Barrier System to Treat TCE, Presented at the Ninth International Conference on In-situ and On-site Bioremediation, Baltimore, MD., May 7-10 2007.
8. Chen, S. (2003, December 2-4). Demonstration of Zero-Valent Iron Injection for In-situ Remediation of Chlorinated Solvents at Hunters Point Shipyard, San Francisco, California. Washington D.C.: Presented at the 2003 Strategic Environmental Research and Development Program (SERDP) Technical Symposium.
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12. Ding, Y., J. R. Schuring, and P. C. China. 1999. "Volatile Contaminant Extraction Enhanced by Pneumatic Fracturing". PRACTICE PERIODICALS OF HAZARDOUS TOXIC AND RADIOACTIVE WASTE MANAGEMENT. 3 (2): 69-76.

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14. Ding, Y., J. R. Schuring, and P. C. Chan. 2000. "Pneumatic Fracturing for Vadose Zone Remediation". *Hazardous and Industrial Wastes : Proceedings of the ... Mid-Atlantic Industrial and Hazardous Waste.* 32: 252-262.

15. Ding, Y., J. R. Schuring, and P. C. Chan. 2000. "Engineering Reliability Assessment of Contaminant Removal by Pneumatic Fracturing". *PRACTICE PERIODICALS OF HAZARDOUS TOXIC AND RADIOACTIVE WASTE MANAGEMENT.* 4: 24-30.

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18. Fuhr, J. M., & Liskowitz, J. J. (1998). Enhancing Hydrocarbon recovery in a Low Permeability Montmorillonitic Clay. Amherst, ME.: AEHS East Coast Conference on Soil and Sediment Issues.

19. Galbraith, M. T. M. Sc. Thesis, In-situ Enhancement of Well Recovery by Pneumatic Media Injection. New Jersey Institute of Technology, NJ, May 1999.

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21. Gilmore, C. Hess, R. Brooks, G. P. Chen, S. (2005, May 22-25). A Case Study Evaluating Zero-valent Iron Injection Treatment Technology. Monterey, CA.:Presented at the Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds.

22. Goodroad, L. L., and J. R. Schuring. 1994. "Potential of Pneumatic Fracturing to Enhance In Situ Remediation Technologies". *WASTE MANAGEMENT -TUCSON-*. (2): 825-828.

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25. Hamill, Jack. & John Liskowitz, Zero-Valent Iron Particle Type and Characteristics That Influence Treatment Reactivity (2006). Battelle Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA; May 22-25, 2006.

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27. Ijoor, G. C. M. Sc. Thesis, Modeling of a Permeable Reactive Barrier. New Jersey Institute of Technology, NJ, August 1999.

28. Keffer, E. B., Liskowitz, J. J., & Fitzgerald, C. D. (1996). The Effect of Pneumatic Fracturing when applied to Groundwater Aquifers. Long Beach, CA.: The Sixth West Coast Conference on Contaminated Soils and Groundwater, AEHS.

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32. Liskowitz, J., Ito, H., Kimura, T. (1997, September 15-17). The Reductive De-Chlorination of Chlorinated Compounds Using Iron Powder. Pittsburgh, PA.: Presented at the I&EC Special Symposium American Chemical Society.

33. Liskowitz, J., & J. Hamill, (2006). Zero-valent Iron Particle Types and Characteristics that Influence Treatment Reactivity. Monterey, CA.: Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds.

34. Liskowitz J. (2003). Source Zone Treatment Using Injection of Zero-Valent Iron into a Fractured Rock Aquifer. Niagara Falls, NY.: RTDF, Fall Team.

35. Liskowitz J. J., Kimura, T., & Jun, O. (1999). U.S. Patent Office No 5,975,798, In-situ Decontamination of Subsurface Waste Using Distributed Iron Powder, 6 Claims.

36. Liskowitz, J., Korfiatus, G., & Liskowitz, M. J. (1998). Use of Zero Valence Iron Powder for the Treatment of Contaminated Dredge Material and Marine Sediments. New Jersey Commission on Science and Technology, Grant Award #98-2890-020-13

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52. Schuring, J. R., Jurka, V., & Chan, P. Pneumatic Fracturing of a Clay Formation to Enchance Removal of VOC's. Presented at the Fourteenth Annual Madison Waste Conference, Madison, September 25-26, 1991.

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66. Tossell, Robert W, Blair Greenly, Brian Whiffin, Josee Gagnon, Luc Arguin, Michael Duchene, Mark Strong, Steve Chen & Bernard Michaud, A Biotic/Abiotic Three-Phase In Situ Barrier System to Treat TCE in Groundwater (2007). Battelle Ninth International In-situ and On-Site Bioremediation Symposium. Baltimore, MD, May 7 – 10, 2007.

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Price Sheet

PILOT TEST - IN-SITU CHEMICAL REDUCTION REAGENT INJECTION

Scobell Chemical - NYSDOT Site – NYSDEC Site No 828076
Brighton, Monroe County, New York

Item No.	Bid Item[1]	Units	Approximate Quantity	Unit Prices[1]	Amount
1	Mobilization/Demobilization	Lump Sum	1	$ 5,250	$ 5,250.00
2	Packer System and Setup (three intervals per injection point)	Injection Point	9	$ 3,638.89	$ 32,750.00
3	Micro-scale Zero Valent Iron (ZVI) Injection - Reagent and tracer chemical solution injection (three intervals per injection point)	Injection Point	9	$ 3,638.89	$ 32,750.00
4	Water Procurement, Transport, and Storage	Lump Sum	1	$ 5,290.00	$ 5,290.00
5	Tracer Chemicals - Sodium bromide material costs[2]	Pounds	30	$ 3.37	$ 100.07
6	Tracer Chemicals - Red dye material costs[2]	Pounds	3	$ 172.50	$ 465.75
7	Micro-scale ZVI (H_2OMet 86 [Rio Tinto]) - Material costs	Pounds	67,500	$ 0.58	$ 39,080.00
8	Ground Deflection Monitoring (Tilt Meters)	Injection Point	9	$ 1,150.00	$ 10,350.00
9	Management and disposal of unused reagent (including unused tracer chemicals and micro-scale ZVI)	Pounds	1,000	$ 0.25	$ 250.00
10	Management and disposal of derived wastes based on subcontractors means and methods[2]	Drum	3	$ 250.00	$ 750.00
11	Standby Time	Hour	8	$ 750.00	$ 6,000.00
12	Value Engineering/Consulting services (design input)	Hour	20	$ 185.00	$ 3,700.00
13	Report Preparation	Lump Sum	1	$ 4,830.00	$ 4,830.00
Total Costs					$ 141,565.82

Authorized Signature: Robert L. Kelley

Name: Robert L. Kelley

Title: VP of Business and Technology Development

Company: ARS Technologies, Inc.

Address: 98 Ward St., New Brunswick, NJ

Phone: 908-510-3835

Footnotes:

1. Unit rates must include all environmental and recovery fees, taxes, surcharges, and markups.
2. Quantity to be proposed by Subcontractor based on former experience.