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Final Feasibility Study Report

Former Paul Miller Dry Cleaners Site
(Site No: 243018)
Port Richmond, New York

March 2013

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Section 1

Introduction

This Feasibility Study (FS) Report for Former Paul Miller Dry Cleaners Site (herein referred to as the "Site") located in Port Richmond; Richmond County, New York was prepared by Camp Dresser McKee & Smith (CDM Smith) for the New York State Department of Environmental Conservation (NYSDEC) under the Engineering Services for Investigation and Design, Standby Contracts No. D004437 and D007621. All background and site information used in the development of this FS report was furnished by NYSDEC. This information has been supplemented with data and information collected during a site remedial investigations (RI) conducted by CDM Smith between 2008 and 2012. This FS report was developed in accordance with New York State guidance *"Division of Environmental Remediation (DER)-10 Technical Guidance for Site Investigation and Remediation", dated June 2010*.

1.1 Purpose

The objective of this FS is to develop and present remedial alternatives that are appropriate for remediating site contamination as delineated in the RI report (CDM Smith, 2012). This FS is the mechanism to develop, screen and evaluate remedial alternatives for groundwater.

The objectives of the FS are to:

- Develop remedial action objectives (RAOs) for site-related contamination
- Develop site-specific remedial action criteria
- Identify, screen, and select remedial technologies and process options that will appropriately address contamination associated with the Site
- Assemble retained technologies and process options into remedial alternatives for evaluation and comparative analysis

1.2 Organization of Feasibility Study Report

This FS Report is comprised of nine sections. The following identifies the organization of the report and the contents of each section.

Section 1: Introduction. This section provides the background information regarding the purpose and the organization of this FS report.

Section 2: Site Description and History. This section provides the Site background including the Site location and description, description of physical characteristics of the site, site history, and summary of previous investigations.

Section 3: Summary of Remedial Investigation. This section provides the summary of field activities associated with each of the four phases comprising the field investigation for the RI/FS, nature and extent of contamination, contaminant fate and transport, and exposure/risk assessment.

Section 4: Remedial Goals and Remedial Action Objectives. This section presents a list of remedial goals and RAOs by considering the characterization of contaminants, the risk assessments, and compliance with standard, criteria, and guidance (SCGs).

Section 5: General Response Actions. This section identifies general response actions.

Section 6: Identification and Screening of Remedial Technologies. This section identifies and screens remedial technologies and process options for each medium.

Section 7: Development and Analysis of Remedial Alternatives. This section presents the remedial alternatives developed by combining the feasible technologies and process options. This section also provides detailed descriptions and preliminary design assumptions regarding the alternatives that were retained. This information is used to develop the cost estimates for each alternative. This section also provides a detailed analysis of each alternative with respect to the following eight criteria: overall protection of public health and the environment; compliance with SCGs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume with treatment; short-term effectiveness; implementability; cost; and community acceptance. An overall comparison between the various remedial alternatives is also examined in this section.

Section 8: Recommended Remedy. This section provides the recommended remedy.

Section 9: References. A complete list of the references cited in the FS Report is presented in this section.

Section 2

Site Description and History

The following sections describe the Site location and description, site history, and a summary of previous investigations.

2.1 Site Location and Description

Located in Port Richmond, New York, the Site occupies a 0.39 acre parcel in a commercial area, as depicted in Figure 2-1. The former dry cleaner building is currently being used as a fast food restaurant. The front (southern) portion of the building is slab on grade. The rear (northern) portion of the building has a basement, which is currently used for storage of extraneous equipment. The basement contains 4 rooms, which are reported to have been boiler room, two storage rooms and a fur vault. The Site is relatively flat with its entire surface area covered with concrete and/or asphalt. The Site grades topographically from approximately 28 feet amsl in the south to approximately 25 feet amsl in the north-northwest.

2.2 Site History

Historical documents, including aerial photographs and city directories indicate that the site was undeveloped until approximately 1960. Paul Miller Dry Cleaners operated at the site from approximately 1960 through 1995. As of 2000, the site has been a fast food restaurant.

2.3 Physical Characteristics of the Study Area

2.3.1 Topography

The Former Paul Miller Site lies at approximately 25 feet amsl and has been leveled and paved for development. Local topography slopes gently from the southwest to the northeast in the vicinity of the Site. Palmer's Run formerly flowed west to east and bisected the paved area just north of the site. The Site's former, natural topography, likely sloped towards Palmer's Run.

2.3.2 Site Geology and Hydrogeology

The Site is underlain by the unconsolidated glacial till of the Harbor Hill Formation, which has likely been reworked by Palmer's Run and its tributaries. The Harbor Hill Formation is estimated to be 100-150 feet thick at the site. Borings and wells did not extend below a depth of 100 feet bgs, so the total thickness was not confirmed.

Site stratigraphy was evaluated from lithologic descriptions collected during soil borings and the electrical conductivity (EC) investigation conducted during the RI. Lithologic logs indicate that the geologic deposits at the Site are predominantly fine to medium sand, with silty sand lenses, and local deposits of coarse sand and gravel (e.g. MW-11D). In some cases blow counts were low (e.g. a maximum of 15 blows per 6 inches at MW-15D), indicating fairly loose soils; in some cases the soils exhibited higher blow counts indicating more compact soils (e.g. blow counts generally at least 30 per six inches at MW-14S).

Generally, the upper 35 feet are a heterogenous mix of silt and sand. The silt and sand appear to be locally stratified, but the units are not continuous across boreholes. Below 35 feet bgs, the lithologic descriptions and the EC logs show a transition to well graded sand to the terminal depth of the borings at approximately 80 feet bgs. Figure 2-2 is a representative cross section of the site's general geology.

Slug tests were conducted on eight wells. The calculated hydraulic conductivities range from 0.05 ft/day (MW-14S) to 69 feet per day (MW-15D). The relative hydraulic conductivities generally compare favorably with the strata screened at each well: wells screened in sand had higher conductivities than wells screened in silty matrices.

The heterogeneity of the glacial overburden has created a very complex groundwater flow system. Figures 2-3, 2-4 and 2-5 show the potentiometric surfaces at the water table, 30 feet bgs and 70 feet bgs, respectively. These surfaces were calculated using the water levels measured in March 2012. The three potentiometric surfaces were plotted separately to illustrate how contaminant migration differs with depth at the site.

The water table potentiometric surface (Figure 2-3) was developed using the four wells at the site that are screened across the water table. This potentiometric surface shows a groundwater high at MW-3, which is likely related to the local geology or to a stormwater drainage feature. The groundwater flow at the water table is to both the north and south from MW-3.

The shallow potentiometric surface (Figure 2-4) represents groundwater flow at 30 feet bgs. This potentiometric surface was constructed using data from the shallow (S) wells. Groundwater flow from the Site in this interval is to the northwest overall, but it should also be noted that groundwater from the northeast of the site is flowing south-southwest and converging just north of the site. This flow pattern is likely influenced by the geology, given the likelihood of preferential flow paths in the till. Preferential flows paths are indicated by the hydraulic conductivity measurements, which vary by two orders of magnitude in the shallow wells. The shallow potentiometric surface is also consistent with the Site's former, natural topography, where groundwater in the immediate vicinity of the Site likely flowed towards Palmer's Run. Despite having been filled in, it is likely that the presence of the channel, and possibly its branches, still influence groundwater flow at the Site.

The deep potentiometric surface (Figure 2-5) represents groundwater flow at 70 feet bgs. This potentiometric surface was constructed using data from the deep (D) wells. Groundwater flow in this interval is to the north-northeast and is consistent with regional groundwater flow towards Kill Van Kull.

2.4 Summary of Previous Investigations

In 1994, the owner of the shopping center in which the Site is located conducted an environmental investigation at the Site. Subsequently, in May 2000, NYSDEC retained Lawler, Matusky & Skelly Engineers LLP (LMS) to conduct an Immediate Investigation Work Assignment (IIWA) of the Site.

CDM Smith performed a RI at the site in 2009. Subsurface soil samples were collected for volatile organic compound (VOC) and semi-volatile organic compound (SVOC) analysis; three of these samples were run for full list Target Compound List (TCL)/Target Analyte List (TAL) analysis. No residual source areas in unsaturated soils that may have been still contributing to groundwater contamination were detected. Tetrachloroethene (PCE) was only detected at concentrations slightly above the unrestricted use soil cleanup objectives at one location (MW-11S) from a depth of 15 to 15.5 feet below ground surface (bgs). PCE and its associated breakdown products were not detected in vadose zone soil samples collected during the RI. The RI determined that soil was not the primary media of concern.

Monitoring wells MW-8S, MW-9S/9D, MW-10S/10D, MW-11S/11D, MW-12S, MW-13S/13D, MW-14S, MW-15D, MW-16S were installed as part of this RI. Prior to groundwater sampling in monitoring wells, a synoptic round of groundwater levels was measured. Groundwater samples were analyzed for VOCs and SVOCs; three of these samples were also run for full list TCL/TAL analysis. Results showed groundwater contamination at the Site consists primarily of PCE and its associated breakdown products: trichloroethene (TCE), 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE), and vinyl chloride (VC). Chlorobenzene (CB) was also detected. Two well results and oil-water interface probe readings confirmed the likely presence of dense non-aqueous phase liquid (DNAPL) at MW-12S and MW-14S. Since MW-15D functions as a deep well paired with MW-14S and concentrations in MW-15D were not indicative of the presence of DNAPL, it was concluded that DNAPL has perched atop the low permeability layers encountered at MW-14S. DNAPL is also suspected atop low permeability layers in the vicinity of MW-12S.

A soil vapor investigation was conducted in order to determine if vapor phase contaminants are present at concentrations that could impact indoor air quality. The investigation included collecting four sub-slab soil vapor samples, five indoor air samples, one duplicate sample of each, and two ambient air samples for VOC analysis. TCE and PCE were detected at concentrations exceeding guidance values in an indoor air sample in Building A (the building onsite). This sample also showed the presence of vinyl chloride, cis-1,2-DCE, chloroform, and toluene at concentrations above background values.

The RI concluded that it is likely any PCE released at the Site has since migrated vertically through the vadose and saturated zones to ultimately accumulate atop low permeability layers. PCE NAPL has continued to migrate along these layers, functioning as a source for dissolved phase PCE groundwater contamination. The RI found evidence of reductive dechlorination taking place in the aquifer at the Site as there are detections of degradation products (trans- and cis-1,2-DCE and VC), and oxidation-reduction potentials in groundwater indicate that conditions are slightly reducing.

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Section 3

Summary of Remedial Investigation

3.1 Introduction

This section summarizes the results of the field investigation conducted in accordance with the *Remedial Investigation and Feasibility Study Work Plan* (RI/FS Work Plan) dated September 2009. This RI report was developed in accordance with the "State Superfund Standby Contract Work Assignment D004437-35, RI/FS, former Paul Miller Dry Cleaners, Site No. 243018." The Work Plan and this RI follow the guidelines set forth in the "*Division of Environmental Remediation (DER)-10 Technical Guidance for Site Investigation and Remediation" (*NYSDEC, 2010).

3.2 Summary of Field Investigation

The objective of the Remedial Investigation (RI) for the Site was to characterize the horizontal and vertical extent of groundwater contamination and characterize the groundwater flow.

Field activities for the RI consisted of:

- Electrical Conductivity (EC) / Membrane interface probe (MIP) Investigation
- MIP confirmatory soil samples
- MIP confirmatory groundwater samples
- Sub-slab soil sampling
- Sub-slab groundwater sampling
- Monitoring well rehabilitation and piezometer abandonment
- Monitoring well sampling
- Indoor air sampling
- Slug tests; and
- Two rounds of synoptic water levels.

3.3 Nature and Extent of Contamination

3.3.1 Approach to the Evaluation of Contamination

The characterization and evaluation of the nature and extent of contamination was focused on those constituents identified as representative contaminants.

3.3.1.1 Selection of Screening Criteria

The soil analytical results were compared to the Unrestricted Use Soil Cleanup Objectives (6 NYCRR Part 375-6.8 (a), December 14, 2006). The groundwater analytical results were compared to the New York State Standards and Guidance Values for Class GA Groundwater (NYSDEC TOGS 1.1.1).

The 2006 NYSDOH Vapor Intrusion guidance indicates that the State of New York does not have any standards, criteria or guidance values for subsurface soil vapor. However, Table 3-1 of the guidance document provides guidance values for indoor and outdoor air against which methylene chloride, PCE, and TCE may be compared. Additionally, background concentrations derived from background studies are available in Appendix C of the guidance document. In the case of the Site, the 90th percentile values presented in Table C2, "EPA 2001: Building assessment and survey evaluation (BASE) database," are appropriate for comparison to the Site's indoor and outdoor air sample results. This value is 100 $\mu g/m^3$ for PCE

3.3.1.2 Representative Contaminants

The Site is located in an urbanized area which has been developed for approximately 50 years and operated as a dry cleaners from approximately 1960 – 1995. Based on this analysis, it was determined that PCE and its degradation products, TCE, cis-1,2-DCE, and VC were most representative of site related contamination .

3.3.2 Nature and Extent of Contamination

The shallow portion of the aquifer (above 35 ft bgs) consists of unconsolidated glacial till comprised of gravel, silty sands, silt, and clay. The deep aquifer consists of mostly silty sand and well-graded sand. The MIP investigation results, groundwater screening results, and monitoring well sampling results from the RI are presented in Figures 3-1, 3-2, and 3-3, respectively.

3.3.2.1 Groundwater

The groundwater investigation successfully characterized the boundaries of the plume area. PCE results exceeding 1,500 µg/L (1% of the solubility for PCE) were found in seven locations, indicating the potential presence of DNAPL. The highest concentrations were detected on the east side of the site building. PCE was detected at 100,000 D µg/L at MW-14S. In general, detections of PCE and its degradation products TCE, cis-1,2-DCE, and VC were limited to the shallow glacial till portion of the aquifer above 35 feet bgs in an area around the former Paul Miller Dry Cleaners building. Estimated isopleths of the total chlorinated ethenes in the shallow portion of the aquifer are presented in Figure 3-4. There was only one detection of PCE in a monitoring well screened in the deep aquifer, 5 µg/L in MW-15D. The analytical results from the groundwater screening samples and monitoring well sampling are detailed on Tables 3-1, 3-2, and 3-3.

MIP investigation results to the northeast of the site building indicate potential commingling of the former Paul Miller dry cleaners plume with a neighboring plume, Charlton Cleaners. It is currently unknown to what extent each plume is contributing contaminant mass to this area.

3.3.2.2 Indoor Air Investigation

Air quality sampling was conducted in 2008, 2009 and 2011. In 2008, sub-slab and indoor air samples were collected at the former Paul Miller dry cleaners site building, the adjacent bank and an adjacent fast food restaurant. Concentrations detected in each building corresponded with monitoring/mitigation guidance values. Additional sampling for PCE, using passive sampling badges, was conducted in 2009. Air quality sampling badges for PCE were placed in two locations in and around the former Paul Miller dry cleaners and the bank building to the west of the former Paul Miller Dry Cleaners. No sampling was conducted at the other adjacent building, the fast food restaurant to the east, because the property owner refused access.

At the former Paul Miller dry cleaners building, TCE and PCE were detected at concentrations exceeding guidance values in an indoor air samples. This samples also showed the presence of vinyl chloride, cis-1,2-DCE, chloroform, and toluene at concentrations above background values. Concentrations detected inside the building were approximately four orders of magnitude greater than the concentrations in the sub-slab samples. Therefore, the indoor air concentrations were attributed to contaminated materials within the building, rather than the penetration of sub-slab vapors. Monitoring will continue in this building as well as the two adjacent buildings.

3.4 Contaminant Fate and Transport

3.4.1 Summary of the Evaluation of Natural Attenuation

Across the site, the presence of cis-1,2-DCE and VC indicates that dechlorination of PCE has at least occurred at some point in the past. Based on the 2012 round of data, it appears that the more favorable conditions for natural attenuation of PCE and TCE are present in the shallowest parts of the aquifer. Moving deeper into the aquifer and also downgradient, conditions become more oxidizing. This means that conditions are not very suitable for microbial degradation of the parent products, but potentially the daughter products cis-1,2-DCE and VC can be degraded in these areas to non-toxic byproducts. A summary of natural attenuation in different zones of the site is presented in Table 3-4.

The relative lack of organic carbon and the less reducing conditions in the more contaminated depths of the aquifer indicate that further microbial reductive dechlorination of PCE and TCE could be limited. Given the finite amount of carbon in the pre-release subsurface, one would expect declining rates of attenuation over time as the available carbon was utilized. Dilution and dispersion also lead to decreasing concentrations. Volatilization and abiotic degradation are other attenuation mechanisms that may be causing the observed concentration reductions.

The monitoring data from 2008 and from 2012 indicate that dissolved phase concentrations in subsurface areas lateral, downgradient, and vertical to the source area are decreasing. More data would be needed to determine if these decreasing concentrations are a temporal trend.

3.4.2 Conceptual Site Model

Physical Setting

Groundwater at the site is found at an elevation of approximately 19 feet amsl, which corresponds to a relatively thin vadose zone of between three and nine feet thick. The geology at the site is characterized by a heterogeneous mix of soil types above 35 feet bgs, and a relatively homogenous sand or silty sand below 35 feet bgs. The top heterogeneous unit consists of glacial deposits of various permutations of clay, silt, and sand. The unit has relatively low hydraulic conductivity (less than 0.5 feet per day). Due to its more sandy composition, the unit below 35 feet bgs has much higher hydraulic conductivity (greater than 30 feet per day). In the shallow stratum, groundwater flows in a north/northwestern direction from the former Paul Miller building; in the deeper stratum, groundwater flows to the northeast.

Contaminant Sources, Migration Pathways, and Fate

High concentrations of VOCs indicative of DNAPL (e.g., aqueous concentrations greater than 1% of the solubility of PCE) were found at multiple locations around the former Paul Miller drycleaners building. Waste PCE from the drycleaners may have been disposed of onto the ground in multiple locations around the building.

Once in the subsurface, much of the PCE moved by gravity as DNAPL downward through the vadose and saturated zones. Further downward NAPL travel was impeded by the less permeable clays and tight silts in the glacial deposits in the upper 35 feet. NAPL accumulated on top of and between these deposits and is likely still present. NAPL also spilled over the edges of the deposits and continued to travel deeper into the aquifer. Over time, the following processes have likely occurred:

- a portion of the contaminant mass diffused into the clay and silt matrices in the top 35 feet;
- a portion volatilized and rose into the vadose zone and to the surface;
- a portion dissolved into groundwater in the top 35 feet; and
- a portion continued to travel downward into the more homogenous sand below 35 feet, and potentially down to bedrock.

The sum of these actions has resulted in a decrease in the mass of DNAPL in the subsurface below the points of disposal over time.

Since the geology is heterogeneous in the top 35 feet, dissolved phase contamination migrates along preferential pathways with higher hydraulic conductivity. Dissolution of the residual DNAPL and back-diffusion of dissolved contaminants from the silt and clay matrices are serving as continual sources of dissolved phase groundwater contamination. The mass flux at different elevations in the top 35 feet and rates of diffusion into and out of the less permeable soils will vary considerably.

DNAPL that continued downward would either be dissolved in groundwater in the sandy stratum, or sink further until another low-permeability layer such as bedrock was encountered. Bedrock is expected in this area and the depth to bedrock is estimate to be 150 feet. DNAPL may be present underneath the site on top of bedrock. Groundwater travels northeast in this stratum. Dissolved contamination will be carried downgradient by advection. Minimal retardation is expected given the low expected fraction organic carbon in this sandy unit.

Biodegradation has occurred to varying degrees across the site. The presence of degradation byproducts of PCE indicate that microbial degradation has occurred at some point in the past. The measured geochemistry of the site indicates that the most favorable conditions for natural attenuation of PCE and TCE are present in the shallowest parts of the aquifer (methanogenic conditions and available carbon). Moving deeper in the glacial deposits and into the deeper sand stratum, conditions become more oxidizing and less conducive to microbial degradation. Further hindering biodegradation at the site is the lack of available carbon for microbial growth. Overall, sample results from 2012 appeared to show a decrease in concentrations across most of the wells compared to samples collected in 2008. This observed reduction is likely due to a combination of biodegradation, volatilization, and dilution/dispersion.

PCE has also been observed in groundwater at a neighboring site. The former Charlton Cleaners building is approximately 300 feet northeast of the former Paul Miller drycleaners building. Based on the Charlton Cleaners RI (LBG 2006), the southwestern extent of Charlton Cleaners contamination does not appear to be fully delineated, especially in the heterogeneous soil above 35ft bgs. The two PCE plumes may potentially comingle in the immediate vicinity northeast of the Paul Miller site.

Receptors

No users have been identified of groundwater potentially impacted by releases from the former Paul Miller drycleaners. Indoor air sampling has not linked observed PCE and TCE vapors to the subsurface contamination at the former Paul Miller Dry Cleaners building, and no contaminant vapors were detected at the building to the west. It is unknown if workers at the neighboring Kentucky Fried Chicken restaurant are impacted by site related contaminant vapor. There does not appear to be an imminent threat to receptors downgradient because either the receptors are far away from the existing plume (greater than 200 feet) or the plume is deep and vapors are not expected to be rising from these depths to impact receptors on the surface.

3.5 Conclusions and Recommendations

This section provides a summary of the major findings of the RI. Conclusions are drawn from the various investigations that were conducted to determine the nature and extent of contamination in soil, air and groundwater. Recommendations are also provided.

3.5.1 Conclusions

The significant findings of the RI are as follows:

- The Groundwater concentrations exceeding screening criteria at the site consist primarily of PCE and its associated daughter products: TCE, cis-1,2-DCE, and VC.
- Concentrations detected in samples from monitoring wells and groundwater screening samples east, south, and west of the building indicate the potential presence of NAPL.
- The extent of contamination has been delineated with either groundwater samples or MIP results in the four directions around the site building.
- The Paul Miller plume and the Charlton Cleaners plume may potentially be commingling in the area northeast of the site building.
- Indoor air monitoring at the former Paul Miller dry cleaners detected vinyl chloride, cis-1,2-DCE, chloroform, and toluene at concentrations above background values. Concentrations detected inside the building were approximately four orders of magnitude greater than the

concentrations in the sub-slab samples. The indoor air concentrations were attributed to contaminated materials within the building, rather than penetration of sub-slab vapors.

3.5.2 Recommendations

The following additional activities may be needed to complete a remedial design for the site:

- Continued monitoring of the indoor air for the former Paul Miller dry cleaners and the two adjacent buildings
- Additional delineation is recommended to characterize the potential commingling of the Charlton Cleaners plume and the former Paul Miller Dry Cleaners plume. A recommended approach to this activity would involve developing a potentiometric surface that encompasses both sites, compound-specific isotope analysis to differentiate the contributions of each source to mass in the commingling zone, and additional groundwater screening and/or monitoring well installation and sampling.

Section 4

Remedial Goals and Remedial Action Objectives

Remedial action objectives (RAOs) are media-specific goals for protecting human health and the environment that serve as guidance for the development of remedial alternatives. The process of identifying the RAOs follows the identification of affected media and contaminant characteristics; evaluation of exposure pathways, contaminant migration pathways and exposure limits; and the evaluation of chemical concentrations that will result in acceptable exposure. The RAOs are based on regulatory requirements that may apply to the various remedial activities being considered for the Site.

Remedial Goals (RGs) are target chemical concentrations that the remedial action needs to achieve in order to protect human health and the environment. RGs were selected based on federal or state promulgated standards, with consideration also given to criteria, guidance, background concentrations, and other requirements such as analytical detection limits. These RGs were then used as a benchmark in the technology screening, alternative development, and detailed evaluation of alternatives presented in the subsequent sections of the FS report.

4.1 Standards, Criteria, and Guidance

To determine whether the Site groundwater contains contamination at levels of concern, State and Federal standards, criteria, and guidance (SCGs) were assessed. The regulatory SCGs and the applicability of these SCGs to the Site are summarized in the following sections.

- Potential SCGs are divided into three groups:
- Chemical-specific SCGs
- Location-specific SCGs
- Action-specific SCGs

4.1.1 Chemical-Specific Standards, Criteria, and Guidance

Chemical-specific SCGs are health- or technology-based numerical values that establish concentration or discharge limits for specific chemicals or classes of chemicals. There are no chemical-specific Federal SCGs for cleanup of contaminated soil, but there is a State SCG for soil. Therefore, NYSDEC Unrestricted Use Soil Cleanup Objectives are applicable requirements according to NYSDEC Inactive Hazardous Waste Disposal Site Remedial Program under 6 NYRR Part 375 Subpart 375-2.

Groundwater at the Site currently is not being used as a source of drinking water, but NYSDEC classifies all fresh groundwater in the state as “Class GA fresh groundwater”, for which the assigned best usage is as a source of potable water supply. Therefore, although there are no known current users of groundwater at or near the Site, the groundwater is assumed to be a source of drinking water in the future. Therefore, New York State Groundwater Quality Standards are applicable requirements and the Federal and New York State primary drinking water standards are relevant and appropriate requirements if an action involves future use of groundwater as a public supply source.

4.1.1.1 Federal Standards, Criteria, and Guidance

Federal Drinking Water Standards

- National Primary Drinking Water Standards (40 CFR 141). It is a relevant and appropriate requirement since the groundwater is a potential drinking water source.

4.1.1.2 New York Standards, Criteria, and Guidance

Soil Standards and Criteria

- NYSDEC Inactive Hazardous Waste Disposal Site Remedial Program 6 NYCRR Part 375 Subpart 375-2, Environmental Remediation Programs, Unrestricted Use Soil Cleanup Objectives, December 14, 2006. Used as the primary basis for setting numerical criteria for soil cleanups.

Groundwater Standards and Guidance

- New York State Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (Technical and Operational Guidance Series (TOGS) 1.1.1). Used for setting numerical criteria for groundwater cleanups.

- New York State Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations (6 New York Environmental Conservation Rules and Regulations (NYCRR) Part 703). Applicable for assessing water quality at the Site during remedial activities.

Drinking Water Standards

- NYSDOH Drinking Water Standards (10 NYCRR Part 5). It is a relevant and appropriate requirement since the groundwater is a potential drinking water source.

Soil Vapor and Indoor Air Guidance

- Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (NYSDOH 2006) is considered relevant and appropriate to soil vapor and indoor air at and in the vicinity of the Site. The 2006 NYSDOH Vapor Intrusion guidance indicates that the State of New York does not have any standards, criteria, or guidance values for subsurface vapors. The guidance is appropriate for evaluation of indoor air and sub-slab soil vapor contamination due to soil vapor intrusion and determination of appropriate course(s) of action to follow to reduce exposure to the chemical(s) in the air.

4.1.2 Location-specific Standards, Criteria, and Guidance

Location-specific SCGs are those which are applicable or relevant and appropriate due to the location of the Site or area to be remediated. Based on the historic site information there is no location specific criteria that could be applicable.

4.1.3 Action-specific Standards, Criteria, and Guidance

Action-specific SCGs are requirements which set controls and restrictions to particular remedial actions, technologies, or process options. These regulations do not define Site cleanup levels but do affect the implementation of specific remedial technologies. These action-specific SCGs are considered in the screening and evaluation of various technologies and process options in subsequent sections of this report.

4.1.3.1 Federal Standards, Criteria, and Guidance

General - Site Remediation

- Occupational Safety and Health Administration (OSHA) Worker Protection (29 CFR 1904, 1910, 1926)
- OSHA General Industry Standards (29 CFR 1910)
- OSHA Construction Industry standards (29 CFR 1926)
- Resource Conservation and Recovery Act (RCRA): Identification and Listing of Hazardous Waste (40 CFR 261); Standards Applicable to Generators of Hazardous Waste (40 CFR 262); Standards for Owners/Operators of permitted hazardous waste facilities (40 CFR 264.10-264.19)

Off-Gas Management

- Clean Air Act (CAA) - National Ambient Air Quality Standards (NAAQS) (40 CFR 50)
- Standards of Performance for New Stationary Sources (40 CFR 60)
- National Emission Standards for Hazardous Air Pollutants (40 CFR 61)

Discharge of Groundwater

- Federal Clean Water Act - National Pollutant Discharge Elimination System (40 CFR 100 et seq.); Effluent Guidelines and Standards for the Point Source Category (40 CFR 414); Ambient Water Quality Criteria (40 CFR 131.36)
- Federal Safe Drinking Water Act - Underground Injection Control Program (40 CFR 144, 146)

Transportation of Hazardous Waste

- Department of Transportation (DOT) Rules for Transportation of Hazardous Materials (49 CFR 107, 171, 172, 177, and 179)
- RCRA Standards Applicable to Transporters of Hazardous Waste (40 CFR 263)

Waste Disposal

- RCRA Land Disposal Restrictions (40 CFR 268)
- RCRA Hazardous Waste Permit Program (40 CFR 270)

4.1.3.2 New York Standards, Criteria, and Guidance

New York Solid and Hazardous Waste Management Regulations (6 NYCRR)

- Hazardous Waste Management System - General (Part 370)
- Solid Waste Management Regulations (Part 360)
- Identification and Listing of Hazardous Waste (Part 371)

Disposal of Hazardous Waste (6 NYCRR)

- Standards for Universal Waste (Part 374-3)
- Land Disposal Restrictions (Part 376)

Discharge of Groundwater (6 NYCRR)

- State Pollutant Discharge Elimination System (SPDES) (Part 750-757)
- Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations (6 NYCRR Part 703)
- Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (TOGS 1.1.1)

Air Quality Management

- New York General Provisions (6 NYCRR Part 211)
- New York Air Quality Standards (6 NYCRR Part 257)
- New York State Department of Environmental Conservation (DAR-1) Air Guide 1, Guidelines for the Control of Toxic Ambient Contaminants
- New York State Department of Health Generic Community Air Monitoring Plan

4.2 Remedial Action Objectives

The recommended remedial action objectives (RAOs) for groundwater at the Site are as follows:

<u>RAOs for Public Health Protection</u>

- Prevent ingestion of groundwater with contaminant levels exceeding drinking water standards.
- Prevent contact with, or inhalation of volatiles, from contaminated groundwater.
- Mitigate impacts to public health resulting from existing, or the potential for, soil vapor intrusion into buildings at a site.

<u>RAOs for Environmental Protection</u>

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

4.3 Remediation Goals

The remediation goals (RG) were developed based on the State promulgated soil and groundwater standards, with consideration also given to background concentrations and other requirements such as analytical detection limits and guidance values. The primary site-related constituents of concern are chlorinated VOCs. The remedial goals are the unrestricted use soil cleanup objectives (6 NYCRR Part

375 Subpart 375-6.3) and the New York State Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (TOGS 1.1.1).

Soil concentration goals for the constituents of concern are as follows:

- Tetrachloroethene: 1,300 µg/kg
- Trichloroethene: 470 µg/kg
- Cis-1,2-dichloroethene: 250 µg/kg
- Vinyl chloride: 20 µg/kg

Groundwater concentration goals are:

- Tetrachloroethene: 5 µg/L
- Trichloroethene: 5 µg/L
- Cis-1,2-dichloroethene: 5 µg/L
- Vinyl chloride: 2 µg/L

4.4 Target Treatment Zone

The target treatment zone is presented in Figure 4-1. According to DER-10, a source area typically includes the portion of the site where a substantial amount of DNAPL is present. DNAPL is suspected to be present in groundwater where the concentration of a contaminant is equal to or greater than 1% of the water solubility of the contaminant (NYSDEC, 2010). The "Target Treatment Zone" shown on Figure 4-1 comprises the source zone and the downgradient plume to a PCE concentration of approximately 200 µg/L. It is not cost effective and many times technically infeasible to treat lower concentrations. The plume extent beyond the target treatment zone comprises the areal extent of glacial till groundwater where PCE is expected or was observed above the groundwater remedial goal (5 µg/L). This area will be addressed through natural attenuation and long-term monitoring.

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Section 5

General Response Actions

General response actions (GRAs) were identified based on the established RAOs and site conditions. GRAs are those actions that, individually or in combination, satisfy the RAOs for the identified media by reducing the concentrations of hazardous substances or reducing the likelihood of contaminant exposure by receptors. Potentially applicable GRAs at the Site include no action, institutional/engineering controls, monitored natural attenuation, containment, removal/extraction, treatment, and disposal/discharge.

5.1 No Action

The National Contingency Plan (NCP) and CERCLA require the evaluation of a No Action alternative as a basis for comparison with other remedial alternatives. A No Action alternative will be evaluated at this New York site. Under the No Action alternative, remedial actions are not implemented, the current status of the Site remains unchanged, and no action would be taken to reduce the potential for exposure to contamination.

5.2 Environmental Easement / Site Management Plan

Institutional/Engineering Controls typically are measures that minimize access (e.g., fencing) or restrict future use of the Site (e.g., restrictions on the use of groundwater). These limited measures are implemented to provide some protection of human health and the environment from exposure to site contaminants. An environmental easement is required for projects where the remedy requires institutional and/or engineering controls. Institutional/Engineering Controls are generally used in conjunction with other remedial technologies; alone they are not effective in preventing contaminant migration or reducing contamination. They are also used to continue monitoring contaminant migration (e.g., long-term monitoring).

5.3 Monitored Natural Attenuation

Monitored Natural Attenuation (MNA) is a response action by which the mass and toxicity of contaminants are reduced by naturally occurring processes in the groundwater. Processes which reduce contamination levels in groundwater include dilution, dispersion, volatilization, adsorption, biodegradation, and abiotic chemical reactions with other subsurface constituents. As this GRA relies on naturally occurring processes, the effectiveness of MNA must be demonstrated by data collected from a regular monitoring schedule. Data would need to show that naturally occurring attenuation processes would be expected to reduce contaminant levels to the RGs within a reasonable timeframe and/or within a reasonable physical boundary.

5.4 Containment

Containment actions use physical or hydraulic control methods, such as low permeability barriers and/or groundwater extraction wells, to minimize or eliminate contaminant migration and potential exposure to receptors. Containment technologies do not involve treatment to reduce the toxicity or mass of contaminants. The response actions require long-term monitoring to determine whether containment actions are performing successfully. The NCP does not prefer containment response actions since they do not provide permanent remedies.

5.5 Removal/Extraction

Removal response actions refer to methods typically used to excavate and handle soil, sediment, waste, and/or other solid materials. An extraction-based response action provides reduction in mobility and volume of contaminants by removing the contaminated groundwater from the subsurface using such means as groundwater extraction wells or interceptor trenches. Groundwater extraction is typically used in conjunction with other technologies to achieve the RAOs for the removed media, such as treatment or disposal options. Groundwater extraction can also provide hydraulic containment to prevent migration of dissolved contaminants. The extraction response action does not reduce the concentrations of contaminants in groundwater. It merely transfers the contaminants to be managed under another response action.

5.6 Treatment

Treatment involves the destruction of contaminants in the affected media, transfer of contaminants from one media to another, or molecular transformation of the contaminants. The result is a reduction in toxicity, mobility, or volume of the contaminants. Treatment technologies vary among environmental media and can consist of chemical, physical, thermal, and biological processes. Treatment in place can be used to meet concentration reduction goals; treatment above ground must be coupled with removal/extraction in order to meet goals. The treatment GRA is usually preferred unless site- or contaminant-specific characteristics inhibit feasibility from an engineering, implementation, or cost perspective.

5.7 Disposal/Discharge

Following extraction, groundwater must be managed appropriately. Extracted groundwater that meets regulatory standards (by treatment, if necessary) can be disposed of or discharged via on-site injection into the subsurface, on-site surface recharge of the underlying aquifer, discharge to a publically owned treatment works, or discharge to surface water bodies.

Section 6

Identification and Screening of Remedial Technologies

Potential remedial technologies and process options associated with each GRA are identified and screened in this section. Representative remedial technologies and process options that are retained will be used to develop remedial action alternatives in the following section.

The technology screening approach is based upon the procedures outlined in *DER-10 Technical Guidance for Site Investigation and Remediation* (NYSDEC 2010). The evaluation process uses three criteria: Effectiveness, Implementability, and Relative Cost. Among these three, the effectiveness criterion outweighs the implementability and relative cost criteria. These criteria are described below:

Effectiveness
This evaluation criterion focuses on the effectiveness of process options to reduce the toxicity, mobility, or volume of contamination for long term protection and for meeting the RAOs and RGs. It also evaluates the potential impacts to human health and the environment during construction and implementation, and how proven and reliable the process is with respect to site-specific conditions.

Implementability
This evaluation criterion encompasses both the technical and administrative feasibility of the technology or process option. It includes an evaluation of pretreatment requirements, residuals management, and the relative ease or difficulty in performing the operation and maintenance (O&M) requirements. Process options that are clearly ineffective or unworkable at the site are eliminated by this criterion.

Relative Cost
Cost plays a limited role in the screening process. Both capital costs as well as O&M costs are considered. The cost analysis is based on engineering judgment and each process is evaluated as to whether costs are low, moderate, or high relative to the other options within the same technology type.

Retained remedial technologies and process options are used to develop remedial action alternatives, either alone or in combination with other technologies.

6.1 Remedial Technologies

6.1.1 No Action

The No Action alternative is not a technology. The No Action alternative is considered as a basis for comparison.

Effectiveness - The No Action alternative is used as a baseline against which other technologies may be compared. It generally does not provide measures that would comply with SCGs, or otherwise meet RAOs. The No Action alternative does not reduce the impacts to human health and the environment.

Implementability - The No Action alternative is implementable given there is no action required.

Relative Cost - The No Action alternative involves no capital or O&M costs.

Conclusion – The No Action alternative is retained for further consideration.

6.1.2 Long-term Monitoring

Long-term monitoring includes periodic sampling and analysis of groundwater samples. This program would provide an indication of the movement of the contaminants and/or of the progress of remedial activities, including monitored natural attenuation.

Effectiveness - Long-term monitoring alone would not be effective in meeting the RAOs. It would not alter the effects of the contamination on human health and the environment. Monitoring is a proven and reliable process for tracking the migration of contaminants during and following treatment.

Implementability - Long-term monitoring could be easily implemented. All monitoring wells are easily accessible for sample collection and additional wells can be installed. Equipment, material, and sampling procedures are readily available.

Relative Cost - Long-term monitoring involves low capital and moderate O&M cost.

Conclusion - Long-term monitoring will be retained for further consideration.

6.1.3 Institutional Controls

Institutional Controls do not reduce the toxicity, mobility, or volume of contamination, but can be implemented to reduce the probability of exposure to contaminants. Institutional controls consist of administrative actions which control use of the site (e.g., restrictions on the use of groundwater) to reduce direct human contact of contaminated water. Institutional controls generally require long term monitoring of contaminant concentrations. Typical institutional controls are discussed below.

6.1.3.1 Environmental Easements

Environmental easements are regulatory actions that are used to restrict certain types of uses for properties where exposure pathways to contaminants may be created as a result of those uses. Environmental easements may be used to restrict or minimize intrusive activities within the contamination plume without certain controls in place.

Effectiveness - Environmental easements could effectively restrict or eliminate use of contaminated groundwater, thereby reducing risks to human health. Environmental easements would not reduce the migration and the associated environmental impact of the contaminated groundwater.

Implementability – The difficulty of implementing environmental easements depends on the needs of the local government and its enforcement system.

Relative Cost - The cost to implement environmental easements is low. Some administrative, long-term monitoring and periodic assessment cost would be required.

Conclusion – Environmental easements will be retained for further consideration.

6.1.3.2 Restrictions on the Use of Groundwater

Groundwater use restrictions are regulatory actions that are used to regulate installation of groundwater wells and other uses of groundwater.

Effectiveness - Groundwater use restrictions would reduce the potential for human exposure pathways to contaminated groundwater. Groundwater use restrictions will not reduce the migration and the associated environmental impact of the contaminated groundwater.

Implementability - Implementation would be easy via the existing permitting process. Groundwater use restrictions may also be implemented, in addition to remediation activities, as a protective measure to prevent future exposure to contaminants during remediation.

Relative Cost - The cost to implement groundwater use restrictions is low.

Conclusion - Groundwater use restrictions will be retained for further consideration.

6.1.4 Monitored Natural Attenuation

Monitored natural attenuation (MNA) refers to the remedial action that relies on naturally occurring attenuation processes to achieve RAOs within a reasonable time frame. Monitoring groundwater quality over time is necessary to demonstrate that the expected attenuation processes are actually occurring. Natural attenuation processes that reduce contaminant concentrations in groundwater include destructive (biodegradation and chemical reactions with other subsurface constituents) and non-destructive mechanisms (dilution, dispersion, volatilization, and adsorption).

Dilution and biodegradation are typically the most significant attenuation mechanisms. PCE and TCE biodegrade predominantly by reductive dechlorination under anaerobic conditions. Breakdown products *cis*-1,2-DCE, VC, and ethane biodegrade under both anaerobic and aerobic conditions. The primary anaerobic reductive dechlorination pathway for PCE to ethene is given below:

$$\text{PCE} \rightarrow \text{TCE} \rightarrow \text{cis-1,2-DCE} \rightarrow \text{VC} \rightarrow \text{Ethene}$$

Reductive dechlorination is a process requiring an adequate supply of electron donors (the chlorinated solvent molecule is the electron acceptor). The existence of other electron acceptors—oxygen, nitrate/nitrite, ferric iron, or sulfate—can compete with the chlorinated solvent molecule as the preferred electron acceptor and inhibit or limit the dechlorination process. The highest reductive dechlorination rates for PCE have been observed under anaerobic, highly reducing conditions associated with methanogenic reactions. By analyzing biogeochemistry data, including distribution of electron acceptors (e.g. nitrate/nitrite, ferric iron, and sulfate concentrations), metabolic by-products, and the contaminant distribution and time trends, it is possible to determine whether active biotransformation of the chlorinated solvents is occurring.

Effectiveness - MNA is an effective remediation approach for sites where natural mechanisms can be demonstrated to minimize or prevent the further migration of elevated contaminant concentrations. Destructive mechanisms such as biotic or abiotic degradation are preferred over non-destructive mechanisms (dilution, dispersion, volatilization, matrix diffusion). The following key points summarize the conclusions about destructive mechanisms at the site:

- Contaminant concentrations generally decreased from 2008 – 2012 in both the source and the downgradient areas of the plume;
- The existence of degradation byproducts of PCE and appropriate reducing conditions in some areas of the site indicate that destructive biodegradation has occurred in the past and may have contributed to the observed decrease. Given the lack of organic carbon across most of the site (except MW-03), further biodegradation appears unlikely in the future;
- The available data does not indicate whether or not other destructive mechanisms (abiotic degradation, aerobic co-metabolism) can account for the observed decrease in concentrations in the downgradient plume, or if the concentration is due to non-destructive mechanisms. Further investigation would be required to identify these processes, determine whether or not they are likely to continue degrading contamination in the future, and if so at what rate.

Given the uncertainty around attenuation mechanisms, it is unknown whether or not MNA would effectively meet the remedial goals downgradient of the source within a reasonable timeframe. It should be noted, though, that there does not appear to be an imminent threat to receptors downgradient. MNA will not be effective inside the source zone without first removing the NAPL.

Implementability - Natural attenuation is considered to be easily implementable. Materials and services necessary to model and monitor the contaminant dynamics are readily available. Site restrictions and/or institutional controls may be required as long-term control measures as part of the MNA alternative.

Relative Cost - Modeling and monitoring for MNA involves low capital cost and moderate O&M cost.

Conclusion – MNA will not be retained.

6.1.5 Containment

Low-permeability vertical barrier walls could be installed downgradient of source areas or plumes to control contaminant migration. The walls would be constructed using slurry or sheet piling to the top of a low permeability layer. Barrier walls would only be effective in areas of the Site where a high water table and shallow depth of the aquifer and confining clay unit are found. Within these areas, both types of barrier walls (i.e., slurry or sheet pile) would be effective for redirecting contaminated groundwater flow. Barrier walls can be used in combination with a groundwater extraction system; the walls would minimize the amount of pumping required to maintain hydraulic control by acting as a physical barrier, restricting clean groundwater inflow from side-gradient areas into the capture zone.

Effectiveness – No confining unit has been detected at the site that a containment wall would be keyed into. Containment is not effective.

Implementability - Slurry walls and sheet pile barriers are implementable in general, and the construction materials and services are readily available. However, the depth to the confining layer where an effective wall would be based exceeds the potential depths of trench excavation. Implementation would be difficult.

Relative cost – Moderate capital cost

Conclusion – Containment is not retained.

6.1.6 Groundwater Extraction Wells

Groundwater extraction involves placing extraction wells to intercept the flow of contaminated groundwater and hydraulically prevent contamination from migrating downgradient. This technology is also used for dewatering when it is necessary to lower the water table to facilitate installation/operation of other remedial technologies. The extracted groundwater is typically treated ex-situ and disposed of on-site or off site.

Effectiveness - Extraction wells are effective in providing hydraulic control and contaminant removal for sites where the hydrogeology is well understood and the pumping rate necessary to maintain hydraulic control is sustainable. Generally not effective for contaminant removal from heterogeneous low permeability materials such as silt and/or clay, which are present at the site. However, extraction wells can provide hydraulic control to prevent offsite migration.

Implementability - Extraction wells are implementable and the equipment and materials are readily available. However, the extracted groundwater may require treatment prior to discharge or re-injection to remove the site contaminants. Due to space constraints and discharge limitations, implementability would be reduced if large treatment vessels are required (i.e., high groundwater extraction flow rate).

Relative Cost - Installation of extraction wells involves moderate capital costs and O&M costs could be high if the extraction system needs to be operated for several decades.

Conclusion – Groundwater extraction is retained.

6.1.7 Vapor Extraction Wells

A vacuum is applied through wells installed in the vadose zone to extract vapor in this zone. Extracted vapor is then treated as necessary to remove contamination from the vapor stream before being released to the atmosphere. The increased air flow through the subsurface can also stimulate biodegradation of some of the contaminants, especially those that are less volatile. Wells may either be vertical or horizontal. In areas of high groundwater levels, water table depression pumps may be required to offset the effect of upwelling induced by the vacuum.

Effectiveness - At the site, effectiveness of vapor extraction may be enhanced by the pavement covering the site since short circuiting from the atmosphere will be reduced. More energy is needed to draw vapor through tight silts and clays than sand or gravel. Effectiveness may be limited by the presence of silts and clays in the vadose zone.

Implementability - Implementable across most of the site. Vendors and equipment are readily available to install both horizontal and vertical vapor extraction wells. However, given the shallow water table, the vadose zone may be too thin underneath the building (or potentially non-existent) to install a well.

Relative Cost - Installation of vapor extraction wells involves moderate capital costs and moderate O&M costs

Conclusion – Vapor extraction is retained as a supplemental technology, especially for use with in-situ thermal remediation.

6.1.8 Dual Phase Extraction Wells

A vacuum is applied to wells screened across the water table to extract both vapor and groundwater. Dual phase extraction differs from vapor or groundwater extraction mainly in the above ground treatment train. For dual phase, a treatment train is needed that separates the extracted vapors and water and treats each stream separately.

Effectiveness - Dual phase extraction can ehance contaminant removal in areas where the water table is shallow by exposing more vadose zone for vapor extraction and directly removing contaminated groundwater and potentially NAPL. The strength of the vacuum can be adjusted during system operation to optimize contaminant extraction. Effectiveness may be limited by the presence of silts and clays in the vadose zone.

Implementability - Implementable across most of the site. Vendors and equipment are readily available to install both horizontal and vertical dual phase extraction wells.

Relative Cost - Installation of dual phase extraction wells involves moderate capital costs and moderate-high O&M costs

Conclusion – Dual phase extraction is retained as a supplemental technology, especially for use with in-situ thermal remediation.

6.1.9 Soil Extraction

Contaminated soil is excavated and either transported to a disposal site or treated. The excavated volume would be backfilled with either clean fill or the treated soil. Soil extraction would involve removing the building on-site, extracting and backfilling, and reconstructing the building.

Effectiveness - Excavation and off-site disposal is highly effective in addressing the contamination at the site. All contamination is physically removed from the site and disposed of in a permitted landfill where the potential for migration of contamination is minimal. This alternative would virtually eliminate the on-site risks associated with exposure pathways and would meet the RAOs. This alternative would not reduce the toxicity or volume. However, mobility would be reduced via off-site disposal and on-site risks would be reduced.

Implementability - Several factors impact the implementability of this alternative. The most significant technical factor is the limited space availability on-site, which presents challenges with regards to stockpiling and management of the excavated materials, loading and unloading operations, traffic management in the site vicinity and the health and safety issues that arise from these activities. Other technical challenges to implementation include the nature of subsurface material at the site (glacial till) which make handling difficult and the dewatering requirements during the remedial activities. Administrative challenges include the necessity of access agreements that may need to be executed with adjacent properties prior to implementation.

Relative Cost – Very high.

Conclusion – Removal must be retained in order to develop the pre-disposal alternative.

6.1.10 Ex-Situ Treatment

Ex-situ treatment technologies remove contaminants from environmental media extracted from the subsurface, for example via groundwater extraction or soil vapor extraction. As such, these technologies must be combined with a method to bring the contaminants above ground in order to meet the RAOs and RGs. Several ex-situ treatment technologies were identified as potentially applicable at the Site, and are discussed below.

6.1.10.1 Air Stripping

Air stripping is a physical mass transfer process that uses clean air to remove dissolved volatile organic compounds (VOCs) from water by increasing the surface area of the groundwater exposed to air. In general, the water stream exiting the air stripper can be discharged to surface water or groundwater. The vapor effluent would likely require treatment (e.g., carbon adsorption or via thermal or catalytic oxidation) before discharge to the atmosphere.

Effectiveness - Effective in removing the site contaminants from water because of their high Henry's law constants. Contaminants extracted from any of the contamination zones could be effectively treated.

Implementability - Implementable. Vendors and equipment are readily available to provide air strippers for groundwater VOC removal. Typically used in the above groundwater treatment system for in-situ thermal remediation.

Relative Cost – Low capital and O&M costs.

Conclusion – retained as a polishing technology or as a secondary technology to address the liquid waste from dewatering.

6.1.10.2 Liquid Phase Granular Activated Carbon (LPGAC) Adsorption

Contaminants in groundwater are adsorbed by passing the extracted groundwater through a series of reactor vessels containing granular activated carbon (GAC). When the concentration of contaminants in the effluent exceeds a pre-established value, the GAC is removed for regeneration or disposal.

Effectiveness - Effective in removing contaminants with moderate or high organic carbon partition coefficients (K_{oc}) from groundwater, which include trichloroethene (TCE) and tetrachloroethene (PCE). Not effective in removing VC, which does not effectively adsorb to carbon. Not very effective in removing cis-1,2-DCE which has the tendency to break through quickly. The process is susceptible to biological and inorganic fouling and may require pretreatment steps such as pH adjustment and suspended solids removal.

Implementability - The equipment and materials are readily available. Needs to be combined with groundwater extraction and discharge technologies or in-situ thermal remediation.

Relative Cost – Medium capital and O&M costs

Conclusion – Retained as a polishing technology or as a secondary technology to address the liquid waste from dewatering.

6.1.10.3 Vapor Phase Granular Activated Carbon (VPGAC) Adsorption

Carbon adsorption can be used to treat vapor phase contamination. The contaminated effluent from a soil vapor extraction (SVE) system is drawn through vessel(s) containing GAC to which contaminants are adsorbed. When the concentration of contaminants in the effluent exceeds a pre-established value, the GAC is removed for regeneration or disposal.

Effectiveness - Effective in removing contaminants with moderate or high organic carbon partition coefficients (Koc) from groundwater, which include trichloroethene (TCE) and tetrachloroethene (PCE). Not effective in removing VC, which does not effectively adsorb to carbon. Not very effective in removing cis-1,2-DCE or vinyl chloride which have the tendency to break through quickly. The process is susceptible to biological and inorganic fouling and may require pretreatment steps such as pH adjustment and suspended solids removal.

Implementability - The equipment and materials are readily available. Can be implemented with groundwater extraction and discharge technologies or in-situ thermal remediation technologies.

Relative Cost – Medium capital and O&M costs

Conclusion – Retained as a polishing technology or as a secondary technology to address the liquid waste from dewatering.

6.1.10.4 Condensation and Cooling

The contaminated effluent from a soil vapor extraction (SVE) system is delieverd to an air compressor. Water vapor is removed from the steam at the air-to-air heat exchangers as it is cooled to ambient temperature. The vapor stream is further cooled in refrigerated heat exchangers, where VOCs are condensed and separated from the vapor stream. The vapor stream is then sent to an adsorber such as GAC to polish it off.

Effectiveness - Effective in recovering volatile organic compounds, including PCE, TCE, VC, and cis-1,2-DCE from the vapor stream of SVE or dual-phase extraction (DPE) systems.

Implementability - Implementable. Vendors and equipment are readily available. Can be implemented with groundwater extraction and discharge technologies or in-situ thermal remediation technologies.

Relative Cost – Medium capital and O&M costs

Conclusion – Retained as a polishing technology or as a secondary technology to address the liquid waste from dewatering.

6.1.10.5 Ultraviolet (UV) /Oxidation

Using UV/Oxidation, organic contaminants are destroyed through chemical oxidation/reduction reactions. This process option is used when destruction of contaminants is preferred or when contaminants cannot be removed with GAC or air stripping.

Effectiveness - Effective in destroying the chlorinated VOCs found at the Site. Effectiveness can be inhibited by turbidity.

Implementability - Implementable. Vendors and equipment are readily available. Can be implemented with groundwater extraction and discharge technologies or in-situ thermal remediation technologies.

Relative Cost – High capital and O&M costs. Generally, more costly as compared to LPGAC or VPGAC unit. Requires more electricity to operate.

Conclusion – Retained as a polishing technology or as a secondary technology to address the liquid waste from dewatering.

6.1.11 In-Situ Treatment

In-situ treatment technologies either intercept and immobilize or degrade contaminants in the subsurface passively (for example: phytoremediation and permeable reactive barriers), or mobilize and/or destroy contaminants in the subsurface aggressively and significantly shorten the required remediation time (such as in situ chemical oxidation and in situ bioremediation). Many of the passive technologies require little maintenance but do not remove contamination rapidly. The active technologies significantly speed up the removal rate—including the residual free phase or adsorbed contaminants where pump-and-treat technology and other extraction technologies are less effective. In-situ treatment also reduces the possibility of contaminant exposure to the site worker. Several in-situ treatment technologies were identified as potentially applicable at the Site, and are discussed below.

6.1.11.1 In-Situ Chemical Reduction

In-situ chemical reduction (ISCR) involves the injection of reductants such as zero valent iron (ZVI) particles, iron minerals, or a mixture to incite abiotic and or biotic reduction of the contaminants to non-hazardous compounds.

Effectiveness - The effectiveness of ISCR, such as ZVI and the proprietary mixture EHC, in treating contaminated groundwater is proven for the site contaminants. Many amendments for ISCR are long-lasting in the subsurface, making them attractive for this site, where slow diffusion from the low permeability soils is likely to sustain high groundwater concentrations in the more permeable soils for a long time. Treatability and pilot-scale testing will be required to identify the most effective amendment.

Implementability – Vendors and equipment for in-situ injection are readily available. May result in secondary water quality changes like increase in concentrations of iron and manganese in the groundwater. Achieving uniform delivery of reductant and adequate contact of reductant with contaminants are critical for effective treatment. Emplacement via fracturing is necessary in low permeability silts and clays. The necessity of fracturing makes ISCR less implementable at the site.

Relative Cost - Medium to high capital cost. Low O&M costs.

Conclusion – ISCR will be retained for further consideration.

6.1.11.2 In-Situ Chemical Oxidation

In-situ chemical oxidation (ISCO) is an active approach that involves the injection into the subsurface of chemical oxidants that destroy organic contaminants in groundwater. Complete oxidation of contaminants results in their breakdown into innocuous compounds such as carbon dioxide, water, and chloride. A number of factors affect the performance of this technology, including effectiveness of oxidant delivery to the contaminated zone, oxidant type, dose of oxidant, contaminant type and concentration, and non-contaminant oxidant demand.

Commonly used oxidants include ozone, Fenton's Reagent, potassium permanganate, activated sodium persulfate, catalyzed percarbonate, etc. Permanganate can oxidize PCE, TCE, DCE and VC effectively, generating manganese dioxide precipitation in the subsurface. Fenton's Reagent, activated persulfate, and catalyzed percarbonate generate radicals to oxidize contaminants. Radicals can oxidize a wide variety of contaminants, but they are non-selective and have extremely short lifetimes. Therefore, effectively delivering the oxidants into the contaminant zones and ensuring that the radicals come into contact with contaminants is a challenge.

Effectiveness - ISCO is capable of reducing contaminant mass as long as there is adequate contact between oxidants and contaminants. The effectiveness of the treatment is questionable due to the heterogeneity of the soil in the target treatment zone. Furthermore, since the oxidant only last for a short time period, back-diffusion from the silts and clays would likely create rebound in groundwater concentrations.

Implementability – Equipment and vendors are readily available. However, proper implementation of ISCO treatment is critical for this Site as chemical delivery can be challenging in heterogeneous formations. Subsurface heterogeneities can affect delivery of the oxidant. Poor application can result in large pockets of untreated contaminants and the oxidant can be consumed by the natural oxidant demand of the soil.

Relative Cost - ISCO involves high capital and low O&M costs.

Conclusion - ISCO will not be retained for further consideration due to the soil heterogeneity.

6.1.11.3 Air Sparging

Air sparging (AS) is a technology in which air is injected into the groundwater for the purpose of removing organic contaminants by volatilization and stripping. As air moves up through the groundwater, VOCs partition into the gas phase and are transported to the vadose zone. Soil vapor extraction (SVE) is typically used in conjunction with air sparging to eliminate off-site migration of vapors. The AS/SVE combined system would employ a number of AS wells, with SVE trenches, wells, or blankets placed among the AS wells to extract the sparge vapors. An off-gas treatment system using vapor phase carbon adsorption and permanganate may be necessary to limit the release of captured vapors to the atmosphere.

Effectiveness - Air sparging is effective for removal of volatile, relatively insoluble organics from highly permeable, relatively uniform sandy aquifer. Oxygen added to the contaminated groundwater can enhance aerobic biodegradation of contaminants below and above the water table. The shallow zone of the aquifer, where a majority of the contamination exists, is characterized by sandy silts, silts, and clay which decreases the effectiveness of air sparging because of low permeability.

Implementability – An air sparge system would require off-gas treatment to address air emissions. The presence of low permeability soils would likely require a high number of sparging and SVE wells to be installed. This technology is widely available and implementable at the site.

Relative Cost - AS/SVE involves high capital and moderate O&M costs.

Conclusion - AS/SVE will not be retained for further consideration due to the low permeability soils.

6.1.11.4 In-situ Bioremediation

In-situ bioremediation is designed to facilitate the in-situ biological destruction of chlorinated VOCs over a wide range of concentrations in groundwater. It involves the injection of organics, nutrients, and potentially microorganisms into the subsurface to stimulate the growth of natural microorganisms to detoxify chlorinated solvent contamination in the subsurface.

Effectiveness - Both aerobic and anaerobic bioremediation has been successfully applied at many Sites. Geochemistry at the site is favorable for reductive dechlorination (anaerobic bioremediation). There is evidence suggesting that reductive dechlorination is already occurring at the site. Introduction of a suitable electron donor would create reducing conditions across target treatment zone thereby enhancing reductive dechlorination.

Implementability - Effectively delivering the amendment into the contaminated soil matrix is critical for the success of in situ treatment. Limitations include: delivery method for nutrients, presence of nutrients in the subsurface, carbon source, and type of microorganisms present in the subsurface. Injection vendors and technology are widely available.

Relative Cost – In-situ bioremediation involves medium to high capital and low O&M cost.

Conclusion – Bioremediation will be retained for further consideration.

6.1.11.5 In-Situ Thermal Remediation

The temperature of the contaminated area is increased by electrical resistivity heating (ERH), thermal conduction heating or steam injection, causing groundwater and VOCs to vaporize, increasing the diffusion rate and solubility of contaminants, and potentially enhancing abiotic degradation or even biological degradation of contaminants. The resulting vapors are extracted by a vadose zone soil vapor extraction system or dual phase extraction wells and then treated in an above ground treatment system.

Effectiveness – Successfully applied in removing contamination sources in silty or clayey soils such as the glacial till found at the site. Contaminant vapor would be captured using vertical or horizontal SVE wells or dual phase extraction. Residual heat would also be capable of stimulating accelerated biodegradation of remaining low-concentration contaminants. If too much unheated water enters the treatment zone from upgradient, it can create a significant heat sink and decrease efficiency. However, with the slow groundwater velocity in the target treatment zone, this is not expected to be a factor.

Implementability - Implementable by specialty vendors. The technology requires a significant, reliable source of electrical power or natural gas to run the system. The business on the site would need to be shut down during installation and operations, including the cool-down phase.

Relative Cost - High capital and O&M costs over a short period, approximately one year.

Conclusion - ISTR will be retained for further consideration due to its effectiveness at removing contamination from the glacial till at the site.

6.1.12 Discharge

Any groundwater extracted from the subsurface will need to be discharged on-site or off-site. Potential on-site and off-site discharge options for groundwater are evaluated below.

6.1.12.1 On-Site Injection

Treated groundwater is injected into the aquifer on-site through a series of wells. Injection requires that the groundwater be treated to meet applicable groundwater standards prior to disposal to the subsurface.

Effectiveness - The aquifer that is injected into must be transmissive enough to receive the volume of water injected. The lower sandy stratum at the site (below 35 feet bgs) is transmissive; the glacial till above 35 feet bgs is not transmissive). Injection would need to be limited to the sandy stratum to be effective.

Implementability - Implementable, given that standard construction methods and materials would be utilized. Some implementability problems can arise during long-term operation of injection wells, such as clogging of screen packs with precipitates or microbial fouling, particularly in high iron conditions. These can be overcome by proper removal of suspended solids and excess iron from the treated water, periodic chlorination of the injected water, and redevelopment and cycling on/off of wells.

Relative Cost - Medium capital costs. Medium to high O&M costs if well rehabilitation needs to be performed periodically.

Conclusion - This technology will be retained for further consideration

6.1.12.2 On-site Surface Recharge

Treated groundwater can be disposed on-Site using a surface recharge system such as a drain field or a recharge basin. Recharge basins are shallow ponds that allow water to infiltrate into the ground gradually, and depending on the permeability of the soil, generally require large surface areas.

Effectiveness - Not effective for this Site because the shallow zone of the aquifer is characterized by low hydraulic conductivity.

Implementability - Easily implementable using available construction resources. Would be required to meet substantive requirements of NYSDEC permit for discharge.

Relative Cost - Low capital and O&M costs.

Conclusion - This technology will not be retained.

6.1.12.3 Off-Site Handling

Assuming the pumped groundwater could be piped to an appropriate off-site location, the same on-site technology described above could be installed on an off-site property as well. Additionally, it may be possible to discharge water to the publically owned treatment works (POTW) that handles municipal wastewater.

Effectiveness - Effective if there are storm sewers in the vicinity of the Site and treated water meets NYSDEC discharge permit requirements.

Implementability - Implementable; requires NYSDEC discharge permit and coordination with local authority. Additional investigation of the implementability of discharging to storm sewer should be evaluated prior to the remedial action.

Relative Cost - This technology involves moderate capital and high O&M costs.

Conclusion - This technology will be retained for further consideration.

6.2 Summary of Remedial Technology Screening

Remedial alternatives are described briefly in Table 6-1. The retained technologies and process options include the following:

- No Action;
- Institutional/Engineering Control: environmental easements, groundwater use restrictions, long term monitoring;
- Soil Vapor Extraction
- Dual Phase Extraction
- Soil Extraction;
- In-situ Chemical Reduction
- In-situ bioremediation;
- In-situ Thermal Remediation.

Section 7

Development and Analysis of Remedial Alternatives

Representative remedial technologies and process options that have been retained during the screening in Section 6 were used to develop the remedial action alternatives described in this section.

7.1 Evaluation Criteria for Detailed Screening of Technologies

The technology screening approach is based upon the procedures outlined in "*DER-10 Technical Guidance for Site Investigation and Remediation"* (NYSDEC 2010). These criteria are classified into the following three groups and are described below:

Threshold Criteria: Threshold criteria are requirements that each alternative must meet in order to be considered for selection.

- **Overall Protection of Human Health and the Environment**. This criterion is an evaluation of the remedy's ability to protect public health and the environment, assessing how risks posed through each existing or potential pathway of exposure are eliminated, reduced or controlled through removal, treatment, engineering controls or institutional controls. The remedy's ability to achieve each of the RAOs is evaluated.

- **Compliance with New York State Standards, Criteria, and Guidance (SCGs)**. Compliance with SCGs addresses whether a remedy will meet environmental laws, regulations, and other standards and criteria. In addition, this criterion includes the consideration of guidance which the Department has determined to be applicable on a case-specific basis.

Primary Balancing Criteria: These criteria are used to distinguish the relative effectiveness of each alternative so that decision makers compare the positive and negative aspects of each of the remedial strategies.

- **Long-term Effectiveness and Permanence**. This criterion evaluates the long-term effectiveness of the remedial alternatives after implementation. If wastes or treated residuals remain on-site after the selected remedy has been implemented, the following items are evaluated: 1) the magnitude of the remaining risks, 2) the adequacy of the engineering and/or institutional controls intended to limit the risk, and 3) the reliability of these controls.

- **Reduction of Toxicity, Mobility or Volume**. Preference is given to alternatives that permanently and significantly reduce the toxicity, mobility or volume of the wastes at the site.

- **Short-term Effectiveness**. The potential short-term adverse impacts of the remedial action upon the community, the workers, and the environment during the construction and/or implementation are evaluated. The length of time needed to achieve the remedial objectives is also estimated and compared against the other alternatives.

- **Implementability**. The technical and administrative feasibility of implementing each alternative is evaluated. Technical feasibility includes the difficulties associated with the construction of the remedy and the ability to monitor its effectiveness. For administrative feasibility, the availability of the necessary personnel and materials is evaluated along with potential difficulties in obtaining specific operating approvals, access for construction, institutional controls, and so forth.

- **Cost-Effectiveness**. Capital costs and annual operation, maintenance, and monitoring costs are estimated for each alternative and compared on a present worth basis. Although cost-effectiveness is the last balancing criterion evaluated, where two or more alternatives have met the requirements of the other criteria, it can be used as the basis for the final decision.

Modifying Criterion: This criterion is taken into account after evaluating those above. It is evaluated after public comments on the FS and Proposed Remedial Action Plan (PRAP) have been received. This criterion is not evaluated in this FS.

- **Community Acceptance**. Concerns of the community regarding the RI/FS reports and the PRAP are evaluated. A responsiveness summary will be prepared that describes public comments received and the manner in which the Department will address the concerns raised. If the selected remedy differs significantly from the proposed remedy, notices to the public will be issued describing the differences and reasons for the changes.

Note that “Land Use” is not an applicable criterion since the remedial goal is unrestricted use.

7.2 Development and Detailed Analysis of Remedial Action Alternatives

Remedial action alternatives have been developed based on the potential for these alternatives to meet the SCGs, RAOs, and RGs described in Section 4. In Section 6, a preliminary screening of available remedial action technologies was performed. The technologies and processes retained are used to develop remedial action alternatives in this Section.

7.2.1 Assumptions and Common Components

The RI concluded that the source of contamination is between 25 and 35 feet bgs in glacial till geology consisting of a heterogeneous mix of clay, silt, and sand lenses and fingers. Below this target source zone is a more transmissive sandy stratum. In order to meet the RG of source removal, the technologies and process options retained after the screening step were combined into the following four alternatives. Conceptual designs for these alternatives were developed and costed, and are presented in this section.

- Alternative 1 – No Action

- Alternative 2 – Return to pre-disposal conditions

- Alternative 3 – In situ thermal remediation
- Alternative 4 – In situ biological and/or abiotic remediation
- Alternative 5 – Combined technologies

The No Action alternative was retained in accordance with DER-10 to serve as a baseline for comparison with the other alternatives for the site. Additionally, Alternative 2, excavation and disposal, was retained to comply with the DER-10 requirement to develop an alternative that returns the site to "pre-disposal conditions."

Some alternatives may require pre-design investigations, modeling, Site-specific treatability studies, and/or pilot studies to confirm that selected technologies will adequately address contamination.

It is assumed that the common elements listed below will be included as part of each of the remedial alternatives (except Alternatives 1 and 2):

Monitoring – Periodic monitoring of Site groundwater can be implemented when contaminants remain above levels that allow for unrestricted use and unlimited exposure. The monitoring program should continue until concentrations have stabilized or met remedial goals.

Institutional controls – Institutional controls such as environmental easements would restrict the future use of the Site and groundwater. They would require precautions to be taken to protect human health in the event remedial measures are disturbed.

7.3.1 Alternative 1 – No Action

The No Action alternative was retained for comparison purposes as required by DER-10. No remedial actions would be implemented as part of the No Action alternative. Groundwater would continue to migrate and the contamination would continue to attenuate through dilution, dispersion, limited biodegradation, etc. This alternative does not include institutional controls or long-term groundwater monitoring.

Overall Protection of Human Health and the Environment

The No Action alternative does not provide overall protection of human health and the environment and does not meet the RAOs. Currently, contaminated groundwater is not used as drinking water. However, this alternative does not prevent future use of contaminated groundwater, which poses potential human risks above EPA threshold values through direct contact, ingestion, and inhalation. Because no remedial action would be implemented under this alternative, no means would be available to prevent current and future exposure.

Compliance with SCGs

Due to the presence of chlorinated VOCs above the groundwater quality standards and drinking water standards, this alternative would not comply with the chemical-specific SCGs for groundwater for a sustained period. As this alternative involves no action, location- and action-specific SCGs are not applicable.

Long-term Effectiveness and Permanence
The No Action alternative is not considered a permanent remedy. The contaminants would not be destroyed, yet concentrations would be reduced only gradually through natural dispersion and dilution. This alternative, however, would not provide adequate control of risks to human health or the environment because there are no mechanisms to prevent current and future exposure. Under this alternative there would be no mechanism in place to prevent future risk to human health; therefore, this alternative would not be considered effective in the long term.

Reduction of Toxicity, Mobility or Volume through Treatment

The implementation of this alternative would not affect the toxicity, mobility, or volume of the contamination.

Short-term Effectiveness
This alternative would not include a remedial action. Therefore, it would have no short-term impact to workers or the community. There would be no adverse environmental impacts to habitats or vegetation.

Implementability
This alternative is easily implemented, since no services or permits would be required.

Cost
There would be no cost under this alternative.

7.3.2 Alternative 2 – Return to Pre-Disposal Conditions

This alternative has been included in accordance with DER-10 Section 4.4 (b) 3 (ii), which states that one or more alternatives capable of achieving cleanup to pre-disposal or unrestricted condition must be developed as part of the FS. Hence, the cleanup goal for this alternative is not the same as the other alternatives in this FS.

Under Alternative 2, cleanup to pre-disposal or unrestricted condition at the site is achieved through removal of contaminated materials by excavation and off-site disposal. All contaminated soils in the impacted footprint in the top 35 feet (the glacial till), covering an area of 98,361 square feet (as shown in Figure 7-1) would be excavated; any residual mass in the lower sandy stratum would naturally attenuate. For cost estimating purposes, it is assumed that the soils from the contaminated depth intervals between 25 feet to 35 feet bgs would require disposal in an approved offsite facility. The remainder of the excavated soils along with certified clean fill would be used to backfill the excavated areas. The removal of all contaminated soils would be confirmed by performing post-excavation sampling in the excavated areas. Prior to commencement of the excavation activities, the building and the asphalt paving in the footprint of the contaminated area would be demolished. Once the excavation, disposal and backfilling activities are completed, the building would be rebuilt and the asphalt area would be re-paved to restore the original conditions at the site. During excavation and backfill activities, dewatering would be performed in order to maintain the water levels below the depths of excavation/backfill activities. The contaminated water generated during the dewatering activities would be treated either by removal through Granular Activated Carbon (GAC) or an air stripper. The contaminated soils that are classified as hazardous would be disposed of in an appropriate Subtitle C landfill. The remainder of the contaminated materials that are classified as non-hazardous would be disposed of in a Subtitle D landfill. The determination of whether the contaminated material is hazardous or non-hazardous would be based on TCLP analysis of the excavated soils. For purposes of cost estimation, this FS assumes that 10% of the materials disposed of offsite would be classified as hazardous.

Overall Protection of Human Health and the Environment
This alternative would protect human health and the environment by removing the contamination from the site and disposing of it in a secure, permitted landfill. This alternative would meet the RAOs since the source would be removed.

Compliance with SCGs
This alternative would achieve chemical-specific SCGs in the target treatment zone because the contamination would be excavated and removed, and replaced with clean fill.

Long-term Effectiveness and Permanence
Excavation and disposal would be permanent and effective over the long-term since the contamination will be removed and disposed of in a secure, permitted landfill. Confirmation sampling would be conducted at the bottom of the excavated pit to ensure that no residual contamination above SCGs remained.

Reduction of Toxicity, Mobility or Volume through Treatment
The toxicity, volume and mobility of contamination at the site would be reduced significantly since the contamination would be excavated and removed from the site.

Short-term Effectiveness
This alternative would include significant site work and would cause disruption to the workers and surrounding businesses. The on-site building would be demolished. Demolition and excavation would require approximately 14 months; there would be additional time for re-construction of the site building. Use of personal protective equipment (PPE) by workers during groundwater sampling would minimize contaminant exposure.

Implementability
Access agreements with neighboring properties may be needed to have enough space for stockpiling soils, loading and unloading, etc. Excavation must be combined with engineering controls during implementation—including vapor emissions control--to provide protection to workers and the environment. Dewatering would be necessary, and treatment of the water extracted for dewatering would also be required. The heterogeneous nature of the glacial till would increase the difficulty of handling the soils.

Cost
The total present worth cost for Alternative 2 is approximately $23,300,000. Detailed cost estimates are presented in Appendix A

7.3.3 Alternative 3 – In-Situ Thermal Remediation

In-Situ Thermal Remediation (ISTR) applies heat to the source zone in order to partition the contaminants into the vapor phase. The targeted zone must be heated to greater than the boiling point of the contaminants of concern. Once this temperature is reached, it will not matter whether the contaminant is present as NAPL, dissolved phase, or sorbed to soil: the contaminant mass will undergo a phase-shift to become heated vapor that will rise vertically through pore space. Steam generated from boiling groundwater will also steam-strip contamination.

The Paul Miller site is characterized by contamination in both high and low permeability soils in the glacial till. NAPL is likely present, and significant mass of contamination has likely diffused into the clay and silts in the till. A principle benefit of ISTR is that this technology targets soils regardless of permeability: it can remove NAPL that diffused into the low permeability matrices as well as dissolved phase contamination in the high permeability sand. This limits the “rebound” effect seen with other technologies that preferentially target high permeability matrices.

In the most common application of ISTR, the aquifer from the depth of the source zone to the surface is heated above the contaminant boiling point, and the contaminant vapor is then captured in the vadose zone with a soil vapor extraction system. The heating is usually done with either injected steam, electrical resistive heating (ERH), or thermal conductive heating (TCH). ERH and TCH are the most common methods for chlorinated solvent contamination. Both ERH and TCH are anticipated to be effective at the site.

For costing purposes, it is assumed that TCH will be used. In this application, heating wells are installed down to the source zone. The well casings are usually steel. An internal heating mechanism (such as electricity or the burning of natural gas) heats up the steel casing. The heat spreads outward into the aquifer via conduction. With an appropriate number of heating wells regularly spaced (to be determined during design), the aquifer can be heated to over 100 degrees Celsius – more than enough to cause the phase-shift of contaminants and generate steam.

The aquifer can be heated to the target temperature in a matter of months by the TCH system. The target temperature must then be maintained for a period of months. When remediation is complete, the heating apparatus is removed, the wells are abandoned, and the subsurface slowly returns to ambient temperature. It is important to note that since the remediation will be taking place immediately around and under the site building, it would be prudent to suspend business operations in the on-site building while the thermal remediation is in progress due to the health and safety risks of the remediation, potentially for over a year.

The target treatment zone will be heated by either installing the heater wells at an angle from the exterior of the building, or by drilling through the slab from the inside of the building. Temperature probes are installed at various depths in the aquifer to monitor heating. The heated vapor that rises must be captured and treated. For costing purposes, it is assumed that the heating wells would be spaced 10 feet apart and one in every ten heater wells would have a co-located vapor extraction well (Figure 7-2). If necessary, additional dual phase extraction wells to extract liquids would be installed near the high-impact areas. The vapors generated due to heating would be routed to a treatment/recovery system consisting of carbon units and heat exchangers. The heated vapors extracted from the SVE wells would first be passed through a knockout tank, where most of the moisture is cooled down to ambient temperature and separated. The remaining vapors are passed through a refrigerated heat exchanger system where the vapors are further cooled to a temperature of about -40 degrees Fahrenheit, thus condensing the chemical constituents in the vapor. Any remaining vapors are passed through regenerative carbon adsorbers that remove any remaining fugitive VOCs prior to discharge into atmosphere. The water recovered from the knockout tank would either be treated with carbon and discharged or disposed of at an appropriate off-site facility. The condensate recovered from the heat exchanger system would be disposed of at an appropriate off-site facility. The existing pavement at the site will be retained since it serves to inhibit both heat and vapor loss from the subsurface.

A pre-design investigation is proposed to delineate the area to be treated. No pilot study is anticipated for this alternative.

Overall Protection of Human Health and the Environment

This alternative would provide protection of human health and conditional protection of the environment. The vaporized contaminant mass in the treatment zone would rise into the vadose zone, where it would be collected and removed from the environment using a dual phase extraction and treatment system. This alternative would meet the RAOs across the site.

Compliance with SCGs

This alternative is desgined to achieve chemical-specific SCGs in the target treatment zone by vaporizing and steam-stripping contaminants from soil and groundwater and allowing residual contamination to naturally attenuate. Since ISTR heats both soils and groundwater, it will be more effective at achieving unrestricted soil criteria than other technologies that focus on groundwater. This process is expected to take on the order of months.

Long-term Effectiveness and Permanence

The alternative would provide long-term effectiveness and permanence. The treatment will take on the order of months before SCGs are met in the target treatment zone. The bulk of the mass of contamination in the subsurface—dissolved, sorbed, and NAPL—will be permanently removed by ISTR. Remaining contamination at very low concentrations would decrease over time through natural processes.

Reduction of Toxicity, Mobility or Volume through Treatment

The toxicity, volume and mobility of contamination at the site would be reduced significantly since ISTR would remove the chlorinated VOCs from the subsurface. The recovered contaminants would be collected in the vadose zone, removed from the site and transferred to a permitted disposal facility.

Short-term Effectiveness

This alternative would include substantial site work and would cause impacts to the workers and surrounding communities. ISTR will require that the operations area be controlled during remedial operations. The business operating on the site will need to be shut down during operations to protect employees and customers, potentially for over a year. Use of personal protective equipment (PPE) by workers during remedial operations and groundwater sampling would minimize contaminant exposure. If the target treatment zone is successfully heated above the boiling points of the contaminants, the vaporized contaminants will rise into the vadose zone on the order of months.

Implementability

In-situ thermal remediation is a well known process based on the simple principle of heating the contaminants above their boiling points to free them from the aqueous or sorbed phases. With the depth of the target treatment zone (approximately 35 feet bgs), the slow moving groundwater at the site, the presence of pavement to act as a vapor barrier, and the existing parking lot, the implementability of ISTR is generally favorable for the site. Existing site operations and infrastructure may inhibit the optimal layout of the remediation system. In particular, implementing ISTR underneath the building on-site—heating the subsurface as well as collecting vapors that rise under the building—could be a challenge. These challenges would be overcome by angled drilling, well installation through the slab of the building, and/or dual phase extraction. New York City Department of Environmental Protection maps of water and sewer infrastructure did not show any such infrastructure in the treatment zone. Remediation under the building will require that the building's operations be shut down during the remediation, potentially over a year. Identifying acceptable discharge/disposal options for the captured contaminants may also be problematic, as will the need to secure the large amounts of energy to run the thermal system.

Cost

The total present worth for Alternative 3 is $13,451,000. The estimated capital cost is $11,609,000. The estimated monitoring cost over 30 years is $1,842,000. Detailed cost estimates are presented in Appendix A.

7.3.5 Alternative 4 – In-situ Biological and/or Abiotic Remediation

Under this alternative, amendments would be injected into the subsurface in the contaminated zones to promote biological and abiotic reactions that reductively dechlorinate PCE/TCE to harmless daughter products. These amendments consist of a mixture of a carbon source along with ZVI or other suitable amendments. Due to the solid nature of the material, zero valent iron (ZVI) is not as easily injectible as other amendments. Hence, fracturing and emplacement would be required if ZVI is a component of the amendment. This method would have the benefit of introducing amendments into both the low permeability matrices where contaminants have diffused as well as the higher permeability sands and gravels. This method would allow a more comprehensive attack on the entirety of the source zone.

Effective implementation of fracturing would increase conductivity in the low-permeability zones in glacial till. Boreholes would be advanced into the glacial till of the target treatment zone, and a network of fracture planes would be created through application of hydraulic pressure. By injecting under pressure, the amendments will mix into the sand of the till, and also enter into the fractures in the silts and clays. Once in the fractures, the amendments will permeate into the microporous structure of the low permeability matrices to contact and destroy the VOC contaminants. Fracturing and injection would be performed at different depths in one borehole, and in multiple boreholes across the site. However, it should be noted that the direction of the fractures cannot be completely controlled, so there is the risk that fractures may not provide adequate distribution of the amendment, and some contamination would remain untreated.

The amendments would enter the more permeable sections in the vicinity of the fractures, as well as the fractures themselves. Degradation will be relatively rapid here once bioreactivity is established. As degradation proceeds, a chemical gradient will be established between the zones of reactivity and the adjacent low-permeability silt and clay. This will expedite the back-diffusion of contamination out of the silts and clays, drawing mass into the permeable, reactive zones. Contaminant mass in both the permeable and low permeable geologies will be reduced as this process continues. The overall rate of destruction of contaminants at the site will be kinetically limited by the rate of VOC desorption from the clay and into the reactive degradation zones.

Identifying the correct type of amendment and an effective way to inject the amendment into the source are key tasks. A bench scale study and field scale pilot study to test the efficacy of amendments as well as injection methods is recommended. The ability of the amendments to address any DNAPL impacts would also be evaluated during the pilot study. The full extent of the treatment zone would be determined during a pre-design investigation.

For cost estimating purposes, emplacement or injection following hydraulic fracturing would be conducted every 30 feet (Figure 7-3). It is assumed that a second round of fracturing and emplacement will be needed in 25% of the target treatment zone in year five. The exact mixture of amendments would be finalized during the design stage. Quarterly monitoring would be conducted for the first two years and annually after that for a total of 10 years. A review of site conditions would be conducted every five years. The review would include an evaluation of the extent of contamination and effectiveness of treatment. If contamination remains, the review would also include an assessment of contaminant migration and attenuation over time.

Overall Protection of Human Health and the Environment

This alternative would provide protection of human health and the environment by destroying contaminants by biological or abiotic mechanisms in-situ. The remaining very low contaminant concentrations are expected to be reduced through natural processes such as dilution, dispersion, and degradation in the subsurface. This alternative would meet RAOs.

Compliance with SCGs

This alternative would meet the chemical-specific SCGs by destroying contamination *in-situ*. The remaining contaminant concentrations in groundwater would be reduced through natural attenuation processes. The RGs are anticipated to be achieved within 10 years based on two injection rounds of amendments followed by natural attenuation of any residual contamination.

Long-term Effectiveness and Permanence

In order to be effective and permanent over the long term, the alternative will need to accomplish two tasks:

- The emplaced amendment will need to be distributed across all the areas in the source zone where contamination exists, and
- Reactive degradation conditions need to be maintained until enough contamination has been degraded to meet the RGs.

Without these accomplishments, contaminant mass will remain in the subsurface after treatment. These risks would be mitigated by conducting multiple fractures across both the aereal and the vertical extent of the treatment zone, and injecting a long-lived amendment. However, fracturing is known to work best in more consolidated material such as clay and tight silts, and not as well in loose sand. In the heterogeneous geology of the glacial till where clay, silt, sand and gravel are found in varying mixtures, pockets of contamination may remain after treatment because fractures initiated in less consolidated material fail to propagate.

Reduction of Toxicity, Mobility or Volume through Treatment

In-situ treatment would reduce the toxicity and volume of contamination in the treatment zone. Chlorinated VOCs would be transformed to ethene, ethane, and carbon dioxide. Intermediates, such as DCEs, DCA, and VC, would be closely monitored. Since emplacement of the amendment would be by fracturing, and fracturing increases the porosity of the subsurface, there is the possibility that mobility of the contamination would increase. However, under this alternative the fractures would be filled with amendment and become reactive zones; thus the purpose of increasing porosity in the subsurface is to open more pathways for contaminant destruction, and not for increasing mobility.

Short-term Effectiveness

This alternative would include substantial site work and would cause impacts to the workers and surrounding communities during the amendment emplacement phase. The on-site business would likely need to be shut down for a temporary time (up to a month) when fracturing and emplacing amendment in the immediate vicinity. Use of personal protective equipment (PPE) by workers during activities would minimize contaminant exposure.

Implementability

This alternative is technically implementable. The processes that govern degradation reactions are well understood, and technical feasibility of biological and abiotic remediation has been established at numerous sites. Despite this, bioremediation and abiotic remediation are still considered innovative technologies. They would require bench and pilot scale testing prior to implementation. In general, no significant technical difficulties are anticipated. No difficulty in obtaining a permit for the emplacement of amendments into groundwater is anticipated.

Existing site operations and infrastructure may inhibit the optimal layout of the remediation system. Additionally, two rounds of fracturing and emplacement injections would be expected over a timeframe on the order of years (estimated at two rounds over 10 years for costing purposes).

Cost

The total present worth for Alternative 4 is $6,034,000. The estimated capital cost is $4,192,000 and the monitoring cost over 30 years is $1,842,000. Detailed cost estimates are presented in Appendix A

7.3.5 Alternative 5 – Combined Technologies Alternatives

This alternative combines the technologies of Alternatives 3 and 4. In situ thermal remediation would be implemented in the most heavily contaminated portions of the source zone to the east of the site building, and in situ biological and/or abiotic treatment would be utilized to emplace amendment in the remaining area (Figure 7-4). For cost estimating purposes, emplacement or injection following hydraulic fracturing would be conducted every 30 feet across approximately 80% of the source zone, and heating wells for ISTR would be installed 10 feet apart in the remaining area. The fracturing and emplacement would be conducted during the cool-down period of the ISTR in order to take advantage of the residual heat that would be conducive to biological growth.

A bench scale study and pilot study would be needed to identify the most effective amendment and emplacement method. A pre-design investigation is proposed to delineate the area to be treated. For cost estimating purposes, it is anticipated that a second round of fracturing and emplacement would be needed in 25% of the treatment area after five years.

Overall Protection of Human Health and the Environment
This alternative would provide protection of human health and the environment by destroying contaminants by biological or abiotic mechanisms in-situ, or by vaporizing and collecting contaminant mass at the surface. The remaining very low contaminant concentrations are expected to be reduced through natural processes such as dilution, dispersion, and biodegradation in the subsurface. This alternative would meet RAOs.

Compliance with SCGs
This alternative would meet the chemical-specific SCGs by destroying contamination *in-situ* and by vaporizing and steam stripping contaminants from soil and groundwater. The remaining contaminant concentrations in groundwater would be reduced through natural attenuation processes. The RGs are anticipated to be achieved within 5 years with one round of amendment emplacement and thermal remediation, followed by natural attenuation of any residual contamination.

Long-term Effectiveness and Permanence
For the area to be treated with ISTR, the bulk of the mass of contamination in the subsurface—dissolved, sorbed, and NAPL—will be permanently removed by ISTR.

In order for the remaing area treated by biological and/or abiotic remediation to be effective and permanent over the long term, the alternative will need to accomplish two tasks:

- The emplaced amendment will need to be distributed across all the areas in the source zone where contamination exists, and
- Reactive degradation conditions need to be maintained until enough contamination has been degraded to meet the RGs.

Without these accomplishments, contaminant mass will remain in the subsurface after treatment. These risks would be mitigated by conducting multiple fractures across both the aereal and the vertical extent of the treatment zone, and injecting a long-lived amendment. However, fracturing is known to work best in more consolidated material such as clay and tight silts, and not as well in loose sand. In the heterogeneous geology of the glacial till where clay, silt, and sand are found in varying mixtures, pockets of contamination may remain after treatment because fractures initiated in less consolidated material fail to propagate.

Reduction of Toxicity, Mobility or Volume through Treatment
ISTR would reduce the toxicity, mobility, and volume of chlorinated VOCs in the subsurface by thermally desorbing the contaminants from the soil and extracting them using an SVE system, where they would be removed from the vapor stream and disposed of.

In-situ biological and/or abiotic treatment would reduce the toxicity and volume of contamination in the treatment zone. Chlorinated VOCs would be transformed to ethene, ethane, and carbon dioxide. Intermediates, such as DCEs, DCA, and VC, would be closely monitored. Since emplacement of the amendment would be by fracturing, and fracturing increases the porosity of the subsurface, there is the possibility that mobility of the contamination would increase. However, under this alternative the fractures would be filled with amendment and become reactive zones; thus the purpose of increasing porosity in the subsurface is to open more pathways for contaminant destruction, and not for increasing mobility.

Short-term Effectiveness
This alternative would include substantial site work and would cause impacts to the workers and surrounding communities. ISTR will require that the operations area be controlled during remedial operations. The business operating on the site will need to be shut down during operations to protect employees and customers, potentially for over a year. The on-site business would also likely need to be shut down for a temporary time (up to a month) when fracturing and emplacing amendment in the immediate vicinity. Use of personal protective equipment (PPE) by workers during activities would minimize contaminant exposure.

Implementability
In-situ thermal remediation is a well known process based on the simple principle of heating the contaminants above their boiling points to free them from the aqueous or sorbed phases. With the depth of the target treatment zone (approximately 35 feet bgs), the slow moving groundwater at the site, the presence of pavement to act as a vapor barrier, and the existing parking lot, the implementability of ISTR is generally favorable for the site. Existing site operations and infrastructure may inhibit the optimal layout of the remediation system. In particular, implementing ISTR underneath the building on the site—heating the subsurface as well as collecting vapors that rise under the building—could present challenges. These challenges would be overcome by angled drilling, well installation through the slab of the building, and/or dual phase extraction. New York City Department of Environmental Protection maps of water and sewer infrastructure did not show any such infrastructure in the treatment zone. Remediation under the building will require that the building's operations be shut down during the remediation, potentially over a year. Identifying acceptable discharge/disposal options for the captured contaminants may also be problematic, as will the need to secure the large amounts of energy to run the thermal system.

Biological and/or abiotic remediation is implementable in the remaining area. The processes that govern degradation reactions are well understood, and technical feasibility of biological and abiotic remediation has been established at numerous sites. Despite this, bioremediation and abiotic remediation are still considered innovative technologies. They would require bench and pilot scale testing prior to implementation. In general, no significant technical difficulties are anticipated. No difficulty in obtaining a permit for the emplacement of amendments into groundwater is anticipated.

The potential risks are that there are a limited number of vendors capable of doing environmental fracturing and emplacement of amendment. Additionally, existing site operations and infrastructure may inhibit the optimal layout of the remediation system. One round of fracturing and emplacement would be expected over a timeframe on the order of years (estimated five years for costing purposes).

Cost

The total present worth for Alternative 4 is $8,814,000. The estimated capital cost is $6,972,000 and the monitoring cost over 30 years is $1,842,000. Detailed cost estimates are presented in Appendix A

7.3.6 Comparative Analysis of Alternatives

The four alternatives for groundwater are:

- Alternative 1 – No Action
- Alternative 2 – Return to pre-disposal conditions
- Alternative 3 – In situ thermal remediation
- Alternative 4 – In situ biological and/or abiotic remediation
- Alternative 5 – Combined technologies

7.3.6.1 Overall Protection of Human Health and the Environment

Alternative 1, the no-action alternative, would not provide protection of human health and the environment since contamination would remain in place and no mechanism would be implemented to prevent exposure. The remaining alternatives are active treatment methods that either destroy mass in-situ or remove contamination from the subsurface, thereby meeting the RAOs and providing protection to human health and the environment. The main difference between the four is the speed of remediation and therefore time period for abating exposure risks. Excavation and in-situ thermal remediation would be rapid, and eliminate exposure pathways within a year. Alternative 4 and 5 would require time for the degradation processes from the emplacement of amendment to occur—at least five years.

7.3.6.2 Compliance with SCGs

The no-action alternative would not meet SCGs. The remaining four active remedy alternatives are designed to meet SCGs; the main differentiator is the amount of time required for cleanup. Alternatives 2 and 3 would be rapid, followed by alternatives 5 (approximately five years) and alternative 4 (approximately ten years).

7.3.6.3 Long-term Effectiveness and Permanence

The no-action alternative is not considered to be an effective or permanent remedy in that the magnitude of the remaining risks would be unknown. Alternatives 2 and 3, excavation and in-situ thermal remediation, respectively, would provide the greatest opportunity for long-term effectiveness and permanence. Alternative 4 would also be effective and permanent; however, there is less certainty that this would be the case when compared to excavation and in-situ thermal remediation. There are a few reasons for this:

- Alternative 4 requires widespread delivery of the amendment to the subsurface. Given that the fracturing pattern and success of emplacing the amendment in the heterogeneous geology of the glacial till is unknown until it is actually implemented, there is the potential that areas of contamination would not be treated.

- The emplaced amendment would create degrading conditions in groundwater. Thus, soil would be indirectly treated by creating a concentration gradient that would draw contamination out of soil and into the degrading conditions in groundwater. In contrast, in-situ thermal remediation would directly treat both soil and groundwater by raising the temperature of both matrices. Excavation also removes both soil and groundwater.

- For Alternative 4, sufficient amendment would need to be emplaced such that reactive conditions and the concentration gradient are maintained long enough for contaminant degradation to occur. Given the heterogeneous geology in the glacial till, it is uncertain if the amendment could be distributed to every location in the subsurface where necessary.

Alternative 5 is a combination of thermal remediation and fracturing and emplacement. As such, the respective discussion above applies to the area treated by each technology (Figure 7-4).

7.3.6.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The no-action alternative would not reduce toxicity, mobility, or volume of contamination through treatment. Alternatives 2 and 3, excavation and ISTR, would involve removing the contamination from the subsurface and transferring it to a permitted disposal facility, where it would be secured. Thus toxicity, mobility, and volume in the subsurface at this site would be reduced through revmoal. Alternative 4 would reduce toxicity and volume through in-situ treatment. There is the possibility that mobility would be increased due to the amendment emplacement method (hydraulic fracturing). But overall, mobility would be reduced as long as the contamination in the groundwater was effectively degraded due to the emplaced amendments. Alternative 5 is a combination of thermal remediation in the area of highest concentration and fracturing and emplacement in the remaining treatment zone. The respective discussion above applies to the area treated by each technology.

7.3.6.5 Short-term Effectiveness

Alternative 1 would have no short-term impact to workers or the community since remedial actions would not be performed. The key element that differentiates Alternatives 2, 3, 4 and 5 for short-term effectiveness is the amount of time that operations would require the on-site business to suspend operations. These time periods are:

- Alternative 2 – Excavation: Approximately 14 months

- Alternative 3 – ISTR: Approximately 12 months

- Alternative 5 – Combined technologies: Approximately 12 months

- Alternative 4 – In situ treatment: Approximately one month

7.3.6.6 Implementability

Alternative 1 is easily implemented since no services or permits would be required.

Overall, Alternative 4 will be the easiest to implement because no above-ground treatment is needed, the disruption to the current occupants would be the shortest timeframe, and no off-site disposal of contaminated materials would be needed. Alternatives 2 and 3 would both require off-site disposal of materials and require much longer-term disruption to the current occupants (up to a year for Alternative 3). Environmental fracturing (Alternative 4) and thermal remediation (Alternative 3) are specialized technologies relative to excavation; procuring experienced contractors will be relatively more difficult. The combined technologies Alternative 5 would be difficult to implement since it would require designing, procuring, and operating two different technologies.

7.3.6.7 Cost

A comparative summary table of the cost estimates for each alternative is shown below.

Alternative	Capital Costs	Monitoring Costs
1 – No Action	$0	$0
2 – Return to Pre-Disposal Conditions	$23,300,000	$0
3 – In-Situ Thermal Remediation	$11,609,000	$1,842,000
4 – In-situ Biological and/or Abiotic Remediation	$4,192,000	$1,842,000
5 – Combined technologies	$6,972,000	$1,842,000

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Section 8

Recommended Alternative

Alternative 4, In-situ Biological and/or Abiotic Remediation, is the recommended alternative. Alternative 4 will be the easiest to implement because it will achieve the RGs without the need for any above-ground treatment, disruption to the current occupants would be the shortest timeframe, and no off-site disposal of contaminated materials would be needed. It will take the longest of the proposed alternatives to meet the remedial goals (approximately ten years). But during the remediation, no imminent threat to receptors via groundwater is expected, and a vapor mitigation system can be operated at the on-site building.

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Section 9

References

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CDM Smith. 2012. Remedial Investigation Report (Site No.: 2-43-018), Port Richmond, New York. September.

Leggette, Brashears & Graham, Inc (LBG), 2006. Remedial Investigation Report for the Former Charlton Cleaners Facility. June.

New York State Department of Environmental Conservation (NYSDEC). 2010. *DER-10 Technical Guidance for Site Investigation and Remediation*. June

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Tables

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Table 3-1
MIP Groundwater Screening Data - Detections
Former Paul Miller Dry Cleaners Site
Port Richmond, Richmond County, New York

	Sample ID	80230-GW-MIP5-15		80230-GW-MIP5-15-DUP		80230-GW-MIP5-28		80230-GW-MIP6-15		80230-GW-MIP6-33.5	
	Sample Location	MIP5		MIP5		MIP5		MIP6		MIP6	
	Depth	15				28		15		33.5	
	Sampling Date	05/24/2011		05/24/2011		05/24/2011		05/23/2011		05/23/2011	
Chemical	**NEW YORK STATE CLASS GA**	Result		Result		Result		Result		Result	
Volatiles (µg/L)											
1,1,2-Trichloroethane	**1**										
1,1-Dichloroethene	**5**										
1,2-Dichlorobenzene	3										
1,4-Dichlorobenzene	3										
2-Butanone (Mek)	NL										
Acetone	NL										
Carbon Disulfide	60										
Chlorobenzene	5										
Chloroform	7										
Chloromethane	5										
Cis-1,2-Dichloroethene	**5**	**780**				1.7	J	**21**		**11**	
Methyl Tert-Butyl Ether (MTBE)	NL							1.7	J		
Tetrachloroethene	**5**	**32000**	**D**	**33000**		**150**		**2100**	**D**	**380**	**D**
Toluene	5										
Trans-1,2-Dichloroethene	**5**										
Trichloroethene	**5**					2.3	J	**9**		**8.7**	
Vinyl Chloride	**2**										
Semi-Volatiles (µg/L)											
Bis(2-Ethylhexyl)Phthalate	5			1.7	J						
Diethylphthalate	NL	1.1	J								
Inorganics (µg/L)											
Aluminum	NL	516		489		492		249		714	
Barium	1000	81	B	79.2	B	92.6	BEJ	153	BEJ	114	BEJ
Calcium	NL	101000		98000		120000		111000		168000	
Chromium	50	2.4	B	2.2	B	4	B	1.9	B	11	B
Cobalt	NL	7.2	B	7.4	B	1.7	B	4.8	B	4.8	B
Copper	200	4.1	B	4	B					4.5	B
Iron	**300**	**1700**		**1600**		**1410**		**747**		**2660**	
Magnesium	NL	38100		37200		32900		64700		59100	
Manganese	**300**	**2320**		**2250**		202		**1100**		**479**	
Nickel	**100**	38.6	B	37.5	B	16.9	B	31.2	B	**118**	
Potassium	NL	6800		6790		3840		5540		4570	
Sodium	NL	138000		138000		62400		277000		120000	
Vanadium	NL	1.9	B	2.2	B	1.9	B	1.2	B	2.3	B
Zinc	NL	39.1	B	38.5	B	23.6	B	32	B	29.2	B

Notes:
ID - identification
µg/kg - milligrams per kilogram
mg/kg - milligrams per kilogram
NL - not listed
Indicates exceedance

(1) NYSDEC. June 1998. TOGS 1.1.1. Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations

Laboratory Data Qualifiers
J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater. The concentration given is an approximate value.

B - The analyte was found in the laboratory blank as well as the sample. This indicates possible laboratory contamination of the environmental sample.
P - For dual column analysis, the percent difference between the quantitated concentrations on the two columns is greater than 40%.
* - For dual column analysis, the lowest quantitated concentration is being reported due to coeluting interference.
E (Organics) - Indicates the analyte ‘s concentration exceeds the calibrated range of the instrument for that specific analysis.
D - The reported value is from a secondary analysis with a dilution factor. The original analysis exceeded the calibration range.
R - The reported value was rejected.

Table 3-2
Sub-slab Groundwater Screening Data - Detections
Former Paul Miller Dry Cleaners Site
Port Richmond, Richmond County, New York

		Sample ID	PM-GWS-1A-110311		PM-GWS-1A-110311-DUP		PM-GWS-1B-1122011		PM-GWS-2-1122011		PM-GWS-5-110311		PM-GWS-6-110311		PM-GWS-7-1122011	
		Sample Location	PM-GWS-1A		PM-GWS-1A-DUP		PM-GWS-1B		PM-GWS-2		PM-GWS-5		PM-GWS-6		PM-GWS-7	
		Approximate Depth	8-9		8-9		8-9		8-9		8-9		8-9		12.5	
		Sampling Date	11/03/2011		11/03/2011		11/02/2011		11/02/2011		11/03/2011		11/03/2011		11/02/2011	
Chemical	**CAS#**	**NEW YORK STATE CLASS GA**	Result		Result		Result		Result		Result		Result		Result	
Volatiles (µg/L)																
1,1,2-Trichloroethane	79-00-5	**1**														
1,1-Dichloroethene	75-35-4	**5**														
1,2-Dichlorobenzene	95-50-1	3														
1,4-Dichlorobenzene	106-46-7	3														
2-Butanone (Mek)	78-93-3	NL													140	J
Acetone	67-64-1	NL			4.5	J							8.3	J	89	J
Carbon Disulfide	75-15-0	60													2.1	J
Chlorobenzene	108-90-7	5														
Chloroform	67-66-3	7														
Chloromethane	74-87-3	5														
Cis-1,2-Dichloroethene	156-59-2	**5**	**11**		**12**		**12**	**J**	**90**	**J**	**15**	**J**	**12**	**J**	**27**	**J**
Ethane	74-84-0	NL														
Ethene	74-85-1	NL														
Methane	74-82-8	NL														
Methyl Tert-Butyl Ether (MTBE)	1634-04-4	NL														
Tetrachloroethene	127-18-4	**5**	**53**		**57**		**17**	**J**	**150**	**J**	**51**		**11**	**J**	**18**	**J**
Toluene	108-88-3	5	2.2	J	2.5	J										
Trans-1,2-Dichloroethene	156-60-5	**5**														
Trichloroethene	79-01-6	**5**	**5.2**		**5.5**		2.8	J	**16**		**14**		4.3	J	3.1	J
Vinyl Chloride	75-01-4	**2**							**2.1**	**J**						

Notes:
ID - identification
µg/kg - milligrams per kilogram
mg/kg - milligrams per kilogram
NL - not listed
Indicates exceedance

(1) NYSDEC. June 1998. TOGS 1.1.1. Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations.

Laboratory Data Qualifiers
J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater. The concentration given is an approximate value.

B - The analyte was found in the laboratory blank as well as the sample. This indicates possible laboratory contamination of the environmental sample.
P - For dual column analysis, the percent difference between the quantitated concentrations on the two columns is greater than 40%.
* - For dual column analysis, the lowest quantitated concentration is being reported due to coeluting interference.
E (Organics) - Indicates the analyte ‘s concentration exceeds the calibrated range of the instrument for that specific analysis.
D - The reported value is from a secondary analysis with a dilution factor. The original analysis exceeded the calibration range.
R - The reported value was rejected.

Table 3-3
Monitoring Well Data - Detections
Former Paul Miller Dry Cleaners Site
Port Richmond, Richmond County, New York

		Sample ID	80230-MW01-030612	80230-MW02-030612	80230-MW03-030712	80230-MW04-030612	80230-MW08S-030712	80230-MW09D-030512	80230-MW09S-030512	80230-MW10D-030512	80230-MW10S-030512
		Sample Location	MW01	MW02	MW03	MW04	MW08S	MW09D	MW09S	MW10D	MW10S
		Depth	13	9	10	9	30	65	30	65	27
		Sampling Date	03/06/2012	03/06/2012	03/07/2012	03/06/2012	03/07/2012	03/05/2012	03/05/2012	03/05/2012	03/05/2012
Chemical	CAS#	New York State Standards and Guidance Values for Class GA Groundwater (1)	Result	Result	Result	Result	Result	Result	Result	Result	Result
Volatiles (µg/L)											
1,1,2-Trichloroethane	79-00-5	1	0.6 J				**1.1 J**				
1,1-Dichloroethene	75-35-4	5	2.8 J						0.65 J		
1,2-Dichlorobenzene	95-50-1	3									
1,4-Dichlorobenzene	106-46-7	3									
2-Butanone (MEK	78-93-3	NL									
Acetone	67-64-1	NL									
Carbon Disulfide	75-15-0	60									
Chlorobenzene	108-90-7	5	1.1 J								
Chloroform	67-66-3	7					0.81 J		0.66 J		
Chloromethane	74-87-3	5		0.58 J				0.92 J			
Cis-1,2-Dichloroethene	156-59-2	5	**4300 D**	**22**	**38**		**26**		**17**		**140**
Ethane	74-84-0	NL	310								3.2
Ethene	74-85-1	NL	700								
Methane	74-82-8	NL	1400	960	130	1500			2.1		45
Methyl Tert-Butyl Ether (MTBE)	1634-04-4	NL									0.76 J
Tetrachloroethene	127-18-4	5	**750 D**				**1300 D**		**34**		**6.1**
Toluene	108-88-3	5	2 J								
Trans-1,2-Dichloroethene	156-60-5	5	**98**								
Trichloroethene	79-01-6	5	**130**				**10**		**16**		2.6 J
Vinyl Chloride	75-01-4	2	**1200 JD**	**11 J**		**2.8 J**			0.58 J		1.3 J
Miscellaneous (mg/L)											
Alkalinity, Total (as CaCO3)	ALK	NL	260	300	600	420	170	210	230	130	1000
Ammonia as N	7664-41-7	2	R	R							
Chloride	16887-00-6	250	**860**	230	130	**430**	71	90	72	88	150
Hardness As CaCO3	CACOA-H	NL	120	300	440	230	230	320	320	330	620
Nitrate-NO3	14797-55-8	10	0.82	0.65			5.1	5.8	3.3	4.2	
Nitrite-NO2	14797-65-0	1									
Nitrogen, Kjeldahl	KN	NL	R	R	R	R		R	R		
Sulfate	14808-79-8	NL	45	57	2.1 J	15	35	45	44	48	61
Sulfide	18496-25-8	NL	0.4		0.056		0.048		0.083		0.046
Total Dissolved Solids	TDS	NL	1800	800	910	1000	360	370	390	420	690
Total Organic Carbon	TOC	NL	12	12	45	11					5.7 J
Total Suspended Solids	TSS	NL	140	40	80	21	95	68	540	87	230

Notes:
ID - identification
µg/kg - milligrams per kilogram
mg/kg - milligrams per kilogram
NL - not listed
Indicates exceedance

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Laboratory Data Qualifiers
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D - The reported value is from a secondary analysis with a dilution factor. The original analysis exceeded the calibration range.

R - The reported value was rejected.

Table 3-3
Monitoring Well Data - Detections
Former Paul Miller Dry Cleaners Site
Port Richmond, Richmond County, New York

		Sample ID	80230-MW11D-030812	80230-MW11S-030812	80230-MW12S-030812	80230-MW12S-030812-DUP	80230-MW13D-030712	80230-MW13S-030712	80230-MW14S-030812	80230-MW15D-030712	80230-MW16S-030612
		Sample Location	MW11D	MW11S	MW12S	MW12S	MW13D	MW13S	MW14S	MW15D	MW16S
		Depth	65	30	30	--	65	30	29	65	30
		Sampling Date	03/08/2011	03/08/2011	03/08/2012	03/08/2012	03/07/2012	03/07/2012	03/08/2012	03/07/2012	03/06/2012
Chemical	**CAS#**	**New York State Standards and Guidance Values for Class GA Groundwater (1)**	Result	Result	Result	Result	Result	Result	Result	Result	Result
Volatiles (µg/L)											
1,1,2-Trichloroethane	79-00-5	**1**									
1,1-Dichloroethene	75-35-4	**5**		**15**				**9.4**			
1,2-Dichlorobenzene	95-50-1	3		2.2 J				1.1 J			
1,4-Dichlorobenzene	106-46-7	3						0.92 J			
2-Butanone (MEK	78-93-3	NL									
Acetone	67-64-1	NL									
Carbon Disulfide	75-15-0	60									
Chlorobenzene	108-90-7	5		2.6 J				3.1 J			
Chloroform	67-66-3	7									
Chloromethane	74-87-3	5									
Cis-1,2-Dichloroethene	156-59-2	**5**		**11000 D**	**350 J**	**380 J**		**7000 D**	**850**	1.3 J	**34**
Ethane	74-84-0	NL		10	3.7	4.3		9.3	90		
Ethene	74-85-1	NL						41	33		
Methane	74-82-8	NL		170	31	35		95	39	2	
Methyl Tert-Butyl Ether (MTBE)	1634-04-4	NL		2.1 J				3.1 J			
Tetrachloroethene	127-18-4	**5**		**9000 D**	**71000 D**	**72000 D**		**2500 D**	**100000 D**	**5**	**2200 D**
Toluene	108-88-3	5									
Trans-1,2-Dichloroethene	156-60-5	**5**		**8.9**				**160**			
Trichloroethene	79-01-6	**5**		**2400 D**				**950 D**	**1300**		**64**
Vinyl Chloride	75-01-4	**2**		**37 J**				**210 JD**			
Miscellaneous (mg/L)											
Alkalinity, Total (as CaCO3)	ALK	NL	300	360	200	210	330	270	350	310	400
Ammonia as N	7664-41-7	2									R
Chloride	16887-00-6	**250**	88	**280**	98	97	91	**250**	**290**	99	**480**
Hardness As CaCO3	CACOA-H	NL	390	550	290	300	340	560	760	360	600
Nitrate-NO3	14797-55-8	10	4.5	0.32	5.4	5.1	4.8			5	1.9
Nitrite-NO2	14797-65-0	1			0.12 J	0.13 J					
Nitrogen, Kjeldahl	KN	NL									R
Sulfate	14808-79-8	NL	47	94	33	33	46	120	100	47	52
Sulfide	18496-25-8	NL	0.096	0.095	0.034	0.033			0.1	0.11	0.038
Total Dissolved Solids	TDS	NL	590	1000	570	590	520	730	1200	400	1200
Total Organic Carbon	TOC	NL		2.9 J	2 J			6.1 J	3.3 J		
Total Suspended Solids	TSS	NL	420	190	120	100	190	24	180	260	60

Notes:
ID - identification
µg/kg - milligrams per kilogram
mg/kg - milligrams per kilogram
NL - not listed
Indicates exceedance

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B - The analyte was found in the laboratory blank as well as the sample. This indicates possible laboratory contamination of the environmental sample.

P - For dual column analysis, the percent difference between the quantitated concentrations on the two columns is greater than 40%.

* - For dual column analysis, the lowest quantitated concentration is being reported due to coeluting interference.

E (Organics) - Indicates the analyte 's concentration exceeds the calibrated range of the instrument for that specific analysis.

D - The reported value is from a secondary analysis with a dilution factor. The original analysis exceeded the calibration range.

R - The reported value was rejected.

Table 3-4
Natural Attenuation Analysis
Former Paul Miller Dry Cleaners Site
Port Richmond, Richmond County, New York

	Wells screened at the water table (MW-02, MW-03, MW-04)	**Under suspected primary discharge** (MW-11S, MW-12S, MW-13S, MW-14S)	**Under suspected additional discharge** (MW-01 and MW-16S)	**Downgradient** (MW-09S)	**Cross-gradient** (MW-08S)	**Deep Wells** (MW-09D, MW-10D, MW-11D, MW-13D, MW-15D)
Degradation Byproducts	Yes	Yes	Yes – more so in MW-01 than MW-16S	Yes	*Cis*-1,2-DCE, but no VC. Relatively little compared to parent products	N/A except for MW15D, which has *cis*-1,2-DCE
ReDox conditions	Methanogenic	Aerobic to nitrate reducing	MW-01 is methanogenic; MW-16S is aerobic	Nitrate reducing	Aerobic	Aerobic to nitrate reducing
Available carbon	Carbon limited, except for MW-03	Carbon limited	Carbon limited	Carbon limited	Carbon limited	Carbon limited

Table 6-1
Remediation Technology Screening
Former Paul Miller Drycleaners
Port Richmond, NY

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Technical Implementability	Relative Cost	Retained
No Action	None	None	The No Action alternative is retained as a baseline for comparison with other alternatives as required by DER-10. No remedial actions would be implemented. The Site-wide groundwater contamination would remain in its existing condition.	The No Action Response is not effective. It does not prevent human exposure to contaminated groundwater. It does not protect the environment. It does not meet the remedial action objectives (RAOs).	Implementable. Minor administrative action may be needed.	No capital, operation, or maintenance costs.	Yes
Long-Term Monitoring	Long-Term Monitoring	Long-Term Monitoring	Periodic environmental monitoring to determine extent of contaminant plume.	Not effective in reducing contamination levels by itself. Would not alter the risk to human health or the effect on the environment. Effective in providing information on Site conditions.	Easily implementable. Comprehensive monitoring well network needs to be installed for the long-term monitoring program.	Medium capital cost if monitoring well network needs to be established. Medium operation and maintenance (O&M) costs.	Yes
Institutional/Engineering Controls	Institutional Controls	Environmental Easements	Environmental easements are used to prevent certain types of uses for properties where exposure pathways to contaminants may be created as a result of those uses. They may be used to require the installation of a vapor mitigation system; or prevent well drilling activities within the contamination plume. They are generally administrated by local government.	Effective in reducing risks to human health posed by groundwater contamination by restricting or eliminating use of contaminated groundwater. The effectiveness depends on proper enforcement. Would not reduce the migration and environmental impact of the contaminated groundwater in any of the contaminant areas.	May not be easy to implement. Depends on the local government and its enforcement system.	Implementation cost is low. Some administrative, long-term monitoring and periodic assessment cost would be required.	Yes
		Well Drilling Restrictions	This process involves regulatory actions that regulate the installation of wells. NYSDEC has the administrative authority to prevent installation of drinking water wells in contaminated areas.	Effective for protection of human health by preventing direct contact with contaminated groundwater at the site. Would not reduce migration or environmental impact of the contaminated groundwater.	Implementable via the existing permitting process. May be combined with other remediation activities as a protective measure to prevent exposure to contaminants during and post remediation.	Implementation cost is low.	Yes
	Engineering Controls	Fencing	Fences would limit access to contaminanted areas. Can also be used to limit health and safety risks during remedial action at the Site.	Effective for protection of human health if any above-ground treatment system pose hazards to untrained personnel during the remedial action. May also minimize property loss or damage during investigation or remediation. Would not reduce the migration and environmental impact of the contaminated groundwater in any of the contaminant areas.	Easily implementable.	Low capital and operational costs.	Yes
	Community Awareness	Information and Education Programs	Community information and education programs would be undertaken to enhance awareness of potential hazards, available technologies capable to address the contamination, and remediation progress to the local community.	Educational programs would protect human health by creating awareness and would enhance the implementation of environmental easements within the contaminated aquifer.	Implementable.	Low capital cost and operational costs.	Yes
Monitored Natural Attenuation (MNA)	MNA	MNA	Relies on natural destructive (biodegradation and abiotic degradation) and nondestructive mechanisms (dilution, dispersion, volatilization, and adsorption) to reduce contaminant levels within a reasonable time frame. Implemented with a long term monitoring program. Under favorable conditions, these physical, chemical, or biological processes act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater within a reasonable timeframe.	Effective for sites where multiple years of data have demonstrated that the contaminant plume is contained or shrinking; attenuation mechanisms are active and responsible for containing the plume; and sufficient evidence exists that these mechanisms would persist for the required time of plume management. Given the likely presence of DNAPL in the glacial till, MNA will not be effective within a reasonable timeframe in the source areas because attenuation rates are slow relative to the amount of mass present as DNAPL. Additional data would need to be collected in the plume to confirm occurrence of MNA.	Materials and services necessary to monitor attenuation are readily available and implementable at the site. Institutional/engineering controls would be required to minimize human exposure.	Low to medium capital costs because additional monitoring wells would be suggested. Medium to high O&M cost since monitoring would continue for many years.	No.

Table 6-1
Remediation Technology Screening
Former Paul Miller Drycleaners
Port Richmond, NY

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Technical Implementability	Relative Cost	Retained
Containment	Vertical Barrier	Slurry Walls	Slurry walls are constructed by making low-permeability slurry (typically either a soil-bentonite mixture or a cement-bentonite mixture) into an excavated trench. Excavation can be completed using a long-arm excavator and a clam shovel to achieve the required depth. Slurry would be pumped into the hole during the course of excavation to keep the sidewalls from collapsing.	Eliminates migration of contaminated groundwater horizontally. Mobility of the plume may be reduced. Slurry wall barriers are effective in preventing additional groundwater contamination from migrating offsite or for diverting uncontaminated groundwater around a contaminant source. Use of this technology does not guarantee that further remediation may not be necessary and there is potential for the slurry wall to degrade or deteriorate over time. Effectiveness is limited at this site because contaminated groundwater would likely short-circuit underneath the barrier to the more conductive zone below the target treatment zone.	Slurry walls are constructible at this Site. Construction materials and services are readily available. Typical slurry wall applications reach installation depths of about 30 to 40 feet below grade surface (bgs), based upon practical limitations associated with excavator trenching. Slurry walls can be installed to depths of 100 feet bgs using a clam shovel at a higher unit cost.	Moderate capital cost.	No
		Sheet Pile Barriers	Sheet pile barriers are constructed by driving or vibrating sections of steel sheet piling into the ground. Each sheet pile section is interlocked at its edges, and the seams are often grouted to prevent leakage. Upon completion of remedial activities, the sheet piles can be vibrated out of the ground, disassembled, and removed from the Site, provided that the sheeting and joints are still of good structural integrity at the time of removal. Otherwise, the sheets would be cut off below ground surface, and the walls would continue to influence groundwater flow patterns on a localized scale.	Eliminates migration of contaminated groundwater horizontally. Mobility of the plume may be reduced. If good joints are installed, the sheet piling may be effective in preventing additional groundwater contamination from migrating offsite or for diverting uncontaminated groundwater around a contaminant source. Effectiveness is limited if poor joints are installed. Use of this technology does not guarantee that further remediation in the future may not be necessary. Effectiveness is limited at this site because contaminated groundwater would likely short-circuit underneath the barrier to the more conductive zone below the target treatment zone.	Sheet piles have been widely used in the heavy construction industry, particularly for groundwater control and slope stability. Construction materials and services are readily available. Typical sheet pile wall applications reach installation depths of about 80 feet bgs, based upon practical limitations associated with installation. Completely watertight joints are nearly impossible to install. Sheetpile walls may be difficult to implement at the site due to the presence of boulders in the glacial till.	Moderate capital cost.	No

Table 6-1
Remediation Technology Screening
Former Paul Miller Drycleaners
Port Richmond, NY

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Technical Implementability	Relative Cost	Retained
Extraction	Groundwater Extraction	Extraction Wells	Installation of groundwater extraction wells to provide hydraulic control and capture of contaminant migration. Effective when combined with other treatment and discharge technologies. Potential scenarios for extraction wells include containment of source area groundwater, containment of the leading edge of the high concentration plume, or preventing contaminated groundwater from migrating offsite.	Effective in providing hydraulic control and removal at sites where the soil is highly permeable, hydrogeology is well understood and the pumping rate necessary to maintain hydraulic control is sustainable. Reduces migration of contaminated groundwater and reduces concentrations of contaminants in groundwater over time. Generally not effective for contaminant removal from heterogeneous low permeability materials such as silt and/or clay. The Site soils in the first 35 ft bgs vary between silty sand, silt and clay.	Implementable. Necessary equipment and materials are readily available.	Medium to high capital cost due to depth of drilling. Medium O&M cost due to prolonged period of operation generally required.	No
	Vapor Extraction	Vapor Extraction Wells	A vacuum is applied through wells installed in the vadose zone to extract vapor in this zone. Extracted vapor is then treated as necessary to remove contamination from the vapor stream before being released to the atmosphere. The increased air flow through the subsurface can also stimulate biodegradation of some of the contaminants, especially those that are less volatile. Wells may either be vertical or horizontal. In areas of high groundwater levels, water table depression pumps may be required to offset the effect of upwelling induced by the vacuum.	At the site, effectiveness of vapor extraction may be enhanced by the pavement covering the site since short circuiting from the atmosphere will be reduced. More energy is needed to draw vapor through tight silts and clays than sand or gravel. Effectiveness may be limited by the presence of silts and clays in the vadose zone.	Implementable across most of the site. Vendors and equipment are readily available to install both horizontal and vertical vapor extraction wells. However, given the shallow water table, the vadose zone may be too thin underneath the building (or potentially non-existent) to install a well.	Medium capital costs. Medium O&M costs.	Yes
	Dual Phase Extraction	Dual phase extraction wells	A vacuum is applied to wells screened across the water table to extract both vapor and groundwater. Dual phase extraction differs from vapor or groundwater extraction mainly in the above ground treatment train. For dual phase, a treatment train is needed that separates the extracted vapors and water and treats each stream separately.	Dual phase extraction is particularly effective in areas where the water table elevation may fluctuate, leaving more vadose zone exposed. The strength of the vacuum can be adjusted during system operation to optimize contaminant extraction.	Implementable across most of the site. Vendors and equipment are readily available to install both horizontal and vertical dual phase extraction wells.	Medium capital costs. Medium-high O&M costs.	Yes
	Soil Extraction	Excavation and backfill	Contaminated soil is excavated and either transported to a disposal site or treated. The excavated are would be backfilled with either clean fill or the treated soil.	Protects human receptors by eliminating surface exposure of contaminants and reducing subsurface contaminants. Effective technique for removing contaminated soil from the site. May be combined with transport, disposal, and/or treatment technologies.	Difficult to implement due to depth of excavation. Will require extensive dewatering due to the shallow water table.	High capital costs. Low O&M costs.	Yes (retained as pre-disposal alternative in accordance with DER-10)

Table 6-1
Remediation Technology Screening
Former Paul Miller Drycleaners
Port Richmond, NY

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Technical Implementability	Relative Cost	Retained
Treatment	Ex-situ Treatment	Air Stripping	Air stripping is a physical mass transfer process that uses clean air to remove dissolved volatile organic compounds (VOCs) from water by increasing the surface area of the groundwater exposed to air. In general, the water stream exiting the air stripper can be discharged to surface water or groundwater. The vapor effluent would likely require treatment (e.g., carbon adsorption or via thermal or catalytic oxidation) before discharge to the atmosphere.	Effective in removing the site contaminants from water because of their high Henry's law constants. Contaminants extracted from any of the contamination zones could be effectively treated.	Implementable. Vendors and equipment are readily available to provide air strippers for groundwater VOC removal. Typically used in the above groundwater treatment system for in-situ thermal remediation.	Low capital and O&M costs.	Retained as a polishing technology or as a secondary technology to address the liquid waste from dewatering.
		Liquid Phase Granular Activated Carbon (LPGAC) Adsorption	Contaminants in groundwater are adsorbed by passing the extracted groundwater through a series of reactor vessels containing granular activated carbon (GAC). When the concentration of contaminants in the effluent exceeds a pre-established value, the GAC is removed for regeneration or disposal.	Effective in removing contaminants with moderate or high organic carbon partition coefficients (K_{oc}) from groundwater, which include trichloroethene (TCE) and tetrachloroethene (PCE). Not effective in removing VC, which does not effectively adsorb to carbon. Not very effective in removing cis-1,2-DCE which has the tendency to break through quickly. The process is susceptible to biological and inorganic fouling and may require pretreatment steps such as pH adjustment and suspended solids removal.	Implementable. The equipment and materials are readily available. Needs to be combined with groundwater extraction and discharge technologies or in-situ thermal remediation.	Medium capital and O&M costs.	Retained as a polishing technology or as a secondary technology to address the liquid waste from dewatering.
		Vapor Phase Granular Activated Carbon (VPGAC) Adsorption	Carbon adsorption can be used to treat vapor phase contamination. The contaminated effluent from a soil vapor extraction (SVE) system is drawn through vessel(s) containing GAC to which contaminants are adsorbed. When the concentration of contaminants in the effluent exceeds a pre-established value, the GAC is removed for regeneration or disposal.	Effective in removing contaminants with moderate or high organic carbon partition coefficients (K_{oc}) from groundwater, which include trichloroethene (TCE) and tetrachloroethene (PCE). Not effective in removing VC, which does not effectively adsorb to carbon. Not very effective in removing cis-1,2-DCE or vinyl chloride which have the tendency to break through quickly. The process is susceptible to biological and inorganic fouling and may require pretreatment steps such as pH adjustment and suspended solids removal.	Implementable. The equipment and materials are readily available. Can be implemented with groundwater extraction and discharge technologies or in-situ thermal remediation technologies.	Medium capital and O&M costs.	Retained as a polishing technology; would not be effective for cis-1,2-DCE or vinyl chloride.
		Condensation and Cooling	The contaminated effluent from a soil vapor extraction (SVE) system is delievered to an air compressor. Water vapor is removed from the steam at the air-to-air heat exchangers as it is cooled to ambient temperature. The vapor stream is further cooled in refrigerated heat exchangers, where VOCs are condensed and separated from the vapor stream. The vapor stream is then sent to an adsorber such as GAC to polish it off.	Effective in recovering volatile organic compounds, including PCE, TCE, VC, and cis-1,2-DCE from the vapor stream of SVE or dual-phase extraction (DPE) systems.	Implementable. Vendors and equipment are readily available. Can be implemented with groundwater extraction and discharge technologies or in-situ thermal remediation technologies.	Medium capital and O&M costs.	Yes.
		Ultraviolet (UV) /Oxidation	Using UV/Oxidation, organic contaminants are destroyed through chemical oxidation/reduction reactions. This process option is used when destruction of contaminants is preferred or when contaminants cannot be removed with GAC or air stripping.	Effective in destroying the chlorinated VOCs found at the Site. Effectiveness can be inhibited by turbidity.	Implementable. Vendors and equipment are readily available. Can be implemented with groundwater extraction and discharge technologies or in-situ thermal remediation technologies.	High capital and O&M costs. Generally, more costly as compared to LPGAC or VPGAC unit. Requires more electricity to operate.	Yes.

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Technical Implementability	Relative Cost	Retained
Treatment	In-situ Treatment	In-situ Thermal Remediation	The temperature of the contaminated area is increased by electrical resistivity heating (ERH), thermal conduction heating or steam injection, causing groundwater and VOCs to vaporize, increasing diffusion rate and solubility of contaminants, and potentially enhancing abiotic degradation or even biological degradation of contaminants. The resulting vapors are extracted by vadose zone soil vapor extraction system or dual phase extraction wells and then treated in an above ground treatment system.	Successfully applied in removing contamination sources in silty or clayey soils such as the glacial till found at the site. Contaminant vapor would be captured using vertical or horizontal SVE wells or dual phase extraction. Residual heat would also be capable of stimulating accelerated biodegradation of remaining low-concentration contaminants. If too much unheated water enters the treatment zone from upgradient, it can create a significant heat sink and decrease efficiency. However, with the slow groundwater velocity in the target treatment zone, this is not expected to be a factor.	Implementable by specialty vendors. The technology requires a significant, reliable source of electrical power or natural gas to run the system. The business on site would need to be shut down during installation and operations, including the cool-down phase.	High capital and O&M costs over a short period, approximately one year.	Yes.
		Air Sparging	Air or oxygen is injected into the contaminated aquifer. Injected air strips VOCs into the unsaturated zones. SVE is usually implemented in conjunction with air sparging.	Air sparging is effective for removal of volatile, relatively insoluble organics from highly permeable, relatively uniform sandy aquifer. Oxygen added to the contaminated groundwater can enhance aerobic biodegradation of contaminants below and above the water table. The shallow zone of the aquifer, where a majority of the contamination exists, is characterized by sandy silts, silts, and clay which decreases the effectiveness of air sparging.	Implementable. System would require off-gas treatment to address air emissions. The presence of low permeability soils would likely require a high number of sparging and SVE wells to be installed.	Moderate capital and O&M costs.	No, lack of effectiveness due to silty and clayey soils
		In-situ Chemical Reduction (ISCR)	In-situ chemical reduction involves the injection of reductants such as zero valent iron (ZVI) particles, iron minerals, or a mixture (EHC) to reduce the contaminants to non-hazardous compounds.	The effectiveness of in-situ chemical reduction, such as ZVI and EHC, in treating contaminated groundwater is proven for the site contaminants. Treatability and pilot-scale testing will be required to identify the most effective amendment.	Vendors and equipment for in-situ injection are readily available. May result in secondary water quality changes like increase in concentrations of iron and manganese in the groundwater. Achieving uniform delivery of reductant and adequate contact of reductant with contaminants are critical for effective treatment. Emplacement via fracturing is necessary in low permeability silts and clays. The necessity of fracturing makes ISCR less implementable at the site.	Medium to high capital cost. Low O&M costs.	Yes

Table 6-1
Remediation Technology Screening
Former Paul Miller Drycleaners
Port Richmond, NY

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Technical Implementability	Relative Cost	Retained
Treatment	In-situ Treatment	In-situ Chemical Oxidation (ISCO)	ISCO involves the injection of chemical oxidants (e.g., catalyzed hydrogen peroxide) into the subsurface to destroy organic contaminants in groundwater. Complete oxidation of contaminants results in their breakdown into non-toxic compounds, such as carbon dioxide, water, and minerals. Repeat application of oxidant is generally required due to mass transfer from areas of low permeability into areas of higher permeability.	ISCO is capable of reducing contaminant mass as long as there is adequate contact between oxidants and contaminants. The effectiveness of the treatment is questionable due to the heterogeneity of the soil in the target treatment zone. Furthermore, since the oxidant only last for a short time period, back-diffusion from the silts and clays would likely create rebound in groundwater concentrations.	Equipment and vendors are readily available. However, proper implementation of ISCO treatment is critical for this Site as chemical delivery can be challenging in heterogeneous formations. Subsurface heterogeneities can affect delivery of the oxidant. Poor application can result in large pockets of untreated contaminants and the oxidant can be consumed by the natural oxidant demand of the soil.	High capital costs. Low O&M costs.	No, lack of effectiveness
		In-situ Bioremediation	In-situ bioremediation is designed to facilitate the in-situ biological destruction of chlorinated VOCs over a wide range of concentrations in groundwater. It involves the injection of organics, nutrients, and potentially microorganisms into the subsurface to stimulate the growth of natural microorganisms to detoxify chlorinated solvent contamination in the subsurface.	Both aerobic and anaerobic bioremediation has been successfully applied at many Sites. Geochemistry at the site is favorable for reductive dechlorination (anaerobic bioremediation). There is evidence suggesting that reductive dechlorination is already occurring at the site. Introduction of a suitable electron donor would create reducing conditions across target treatment zone thereby enhancing reductive dechlorination.	Effectively delivering the amendment into the contaminated soil matrix is critical for the success of in situ treatment. Limitations include: delivery method for nutrients, presence of nutrients in the subsurface, carbon source, and type of microorganisms present in the subsurface. Injection vendors and technology are widely available.	Medium to high capital costs. Low O&M costs.	Yes
Discharge	On-Site Discharge	On-Site Injection	Treated groundwater is injected into the aquifer on Site through a series of wells. Injection requires that the groundwater be treated to meet applicable groundwater standards prior to disposal to the subsurface.	The aquifer that is injected into must be transmissive enough to receive the volume of water injected. The lower sandy stratum at the site (below 35 ft bgs) is transmissive; the glacial till above 35 ft bgs is not transmissive). Injection would need to be limited to the sandy stratum to be effective.	Implementable, given that standard construction methods and materials would be utilized. Some implementability problems can arise during long-term operation of injection wells, such as clogging of screen packs with precipitates or microbial fouling, particularly in high iron conditions. These can be overcome by proper removal of suspended solids and excess iron from the treated water, periodic chlorination of the injected water, and redevelopment and cycling on/off of wells.	Medium capital costs. Medium to high O&M costs if well rehabilitation needs to be performed periodically.	Yes
		On-Site Surface Recharge	Treated groundwater can be disposed on-Site using a surface recharge system such as a drain field or a recharge basin. Recharge basins are shallow ponds that allow water to infiltrate into the ground gradually, and depending on the permeability of the soil, generally require large surface areas.	Not effective for this Site because the shallow zone of the aquifer is characterized by low hydraulic conductivity.	Easily implementable using available construction resources. Would be required to meet substantive requirements of NYSDEC permit for discharge.	Low capital and O&M costs.	No, due to lack of effectiveness.
	Off-Site Discharge	Discharge to Storm Sewer	Treated groundwater is discharged directly to a storm sewer if available.	Effective if there are storm sewers in the vicinity of the Site and treated water meets NYSDEC discharge permit requirements.	Implementable; requires NYSDEC discharge permit and coordination with local authority. Additional investigation of the implementability of discharging to storm sewer should be evaluated prior to the remedial action.	Low capital costs. Medium O&M costs.	Yes

Note:
ft = feet
bgs = below ground surface
Highlighted rows indicate technology eliminated from further evaluation

Figures

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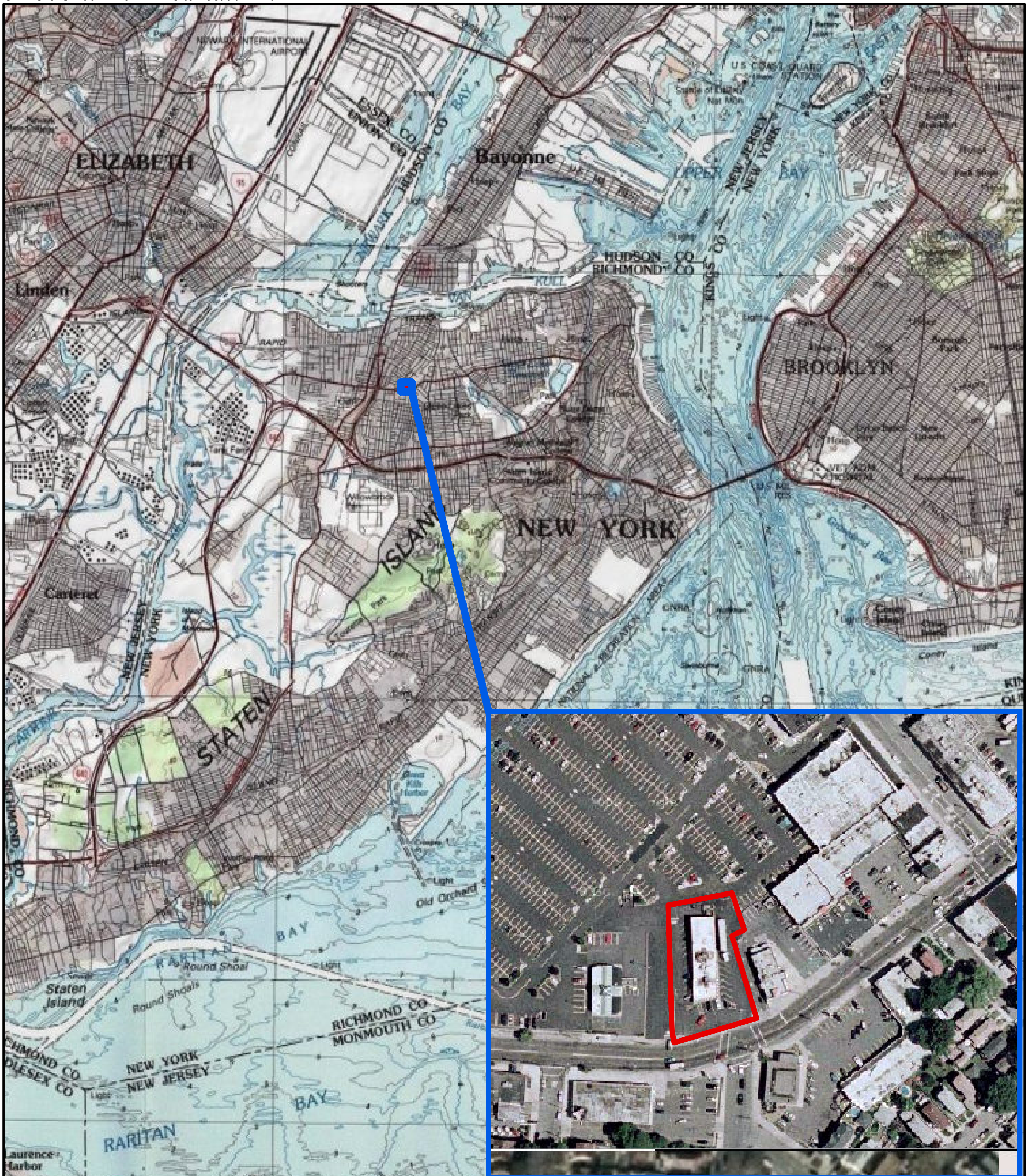
C:\IMS\GIS\Paul Miller\MXD\Site Location.mxd



Site Boundary

N

0 1 2 4 Miles

Figure 2-1
Site Location
Former Paul Miller Dry Cleaners
Port Richmond, NY

CDM Smith

Map source: USGS

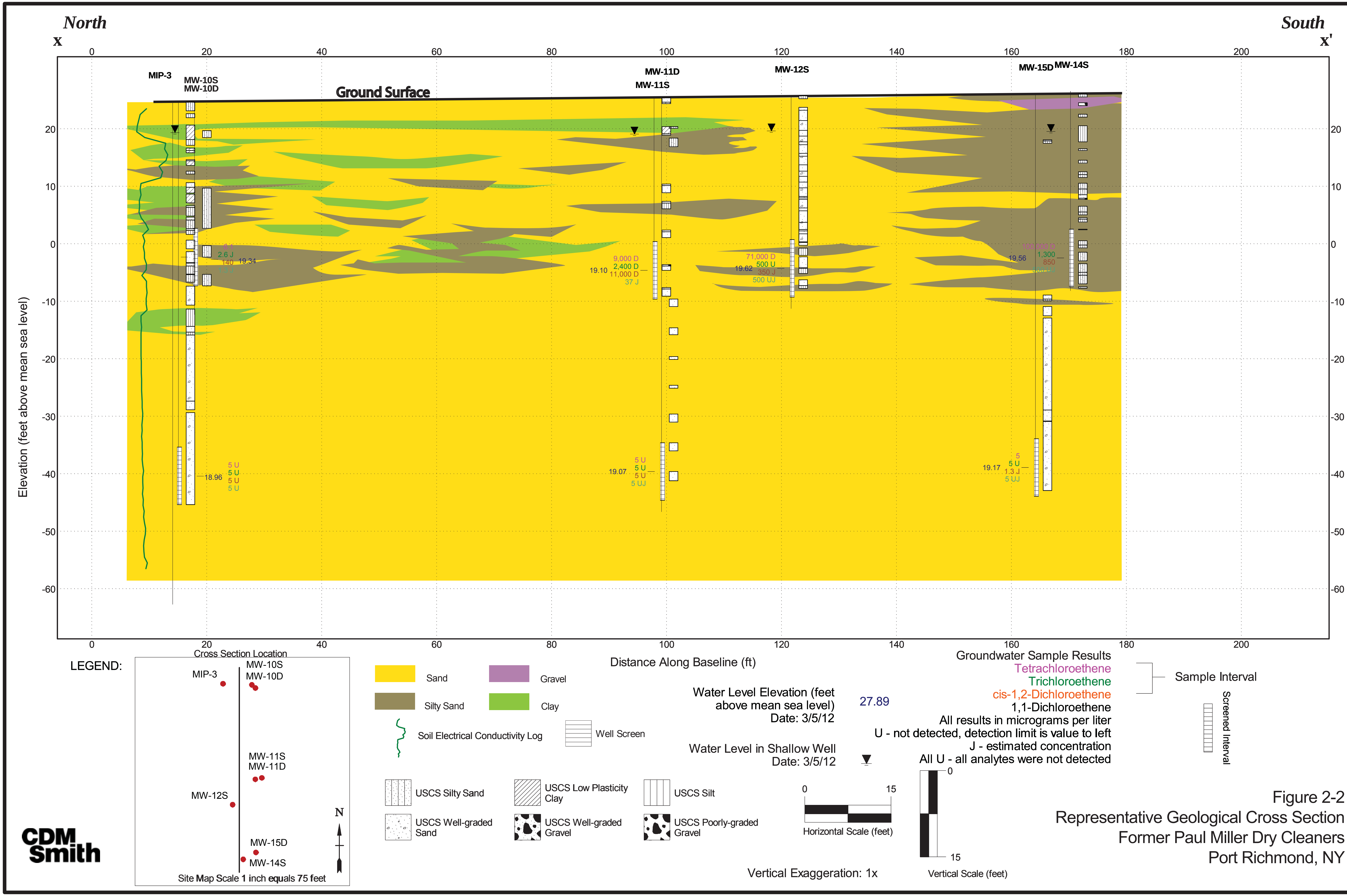


Figure 2-2
Representative Geological Cross Section
Former Paul Miller Dry Cleaners
Port Richmond, NY

Figure 2-3

Potentiometric Surface at the Water Table

Former Paul Miller Dry Cleaners
Port Richmond, NY

N

Note: This potentiometric surface affects the wells shown.
Elevations measured on 3/5/12.

0 10 20 30 40
Feet

CDM Smith

GURRC C:\IMS\GIS\Paul Miller\MXD\Figure 3-1 Potentiometric Surface at the Water Table.mxd 6/28/2012

Potentiometric Surface at 30 ft bgs

Note: This potentiometric surface affects the wells shown. Elevations measured on 3/5/12.

0 10 20 30 40 Feet

N

Figure 2-4

Former Paul Miller Dry Cleaners

Port Richmond, NY

CDM Smith

GURRC C:\IMS\GIS\Paul Miller\MXD\Figure 3-2 Potentiometric Surface at the 30 ft bgs Table.mxd 6/28/2012

N

Potentiometric Surface at 70 ft bgs

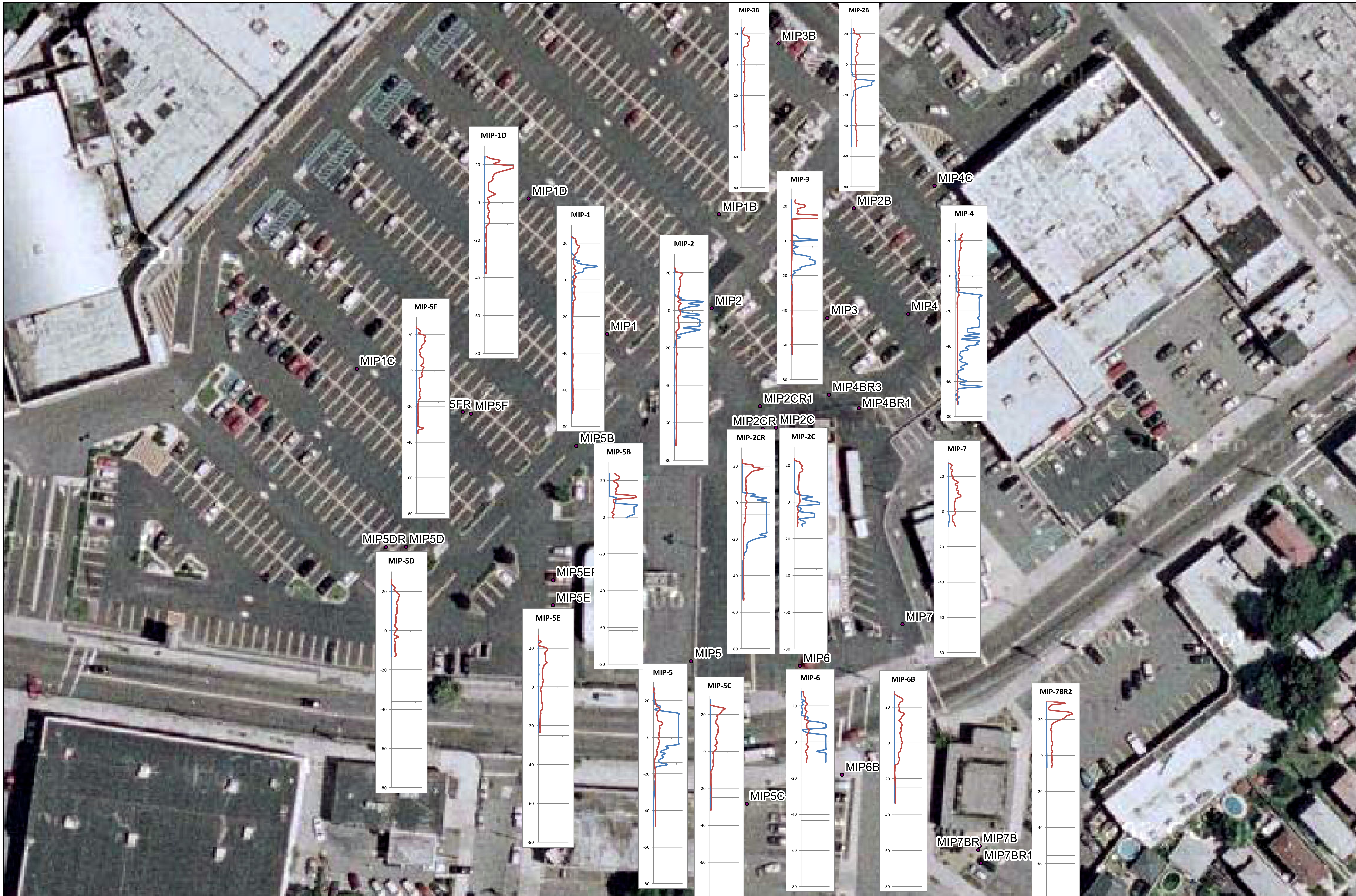
Figure 2-5
Former Paul Miller Dry Cleaners
Port Richmond, NY

Note: This potentiometric surface affects the wells shown. Elevations measured 3/5/12.

0 10 20 30 40 Feet

CDM Smith

GURRC C:\IMS\GIS\Paul Miller\MXD\Figure 3-3 Potentiometric Surface at the 70 ft bgs Table.mxd 6/28/2012



N

Legend

MIP Locations

NOTES:
1) Y axis units are feet above mean sea level.
2) Data collected between May and June, 2011.
3) Red line presents relative Soil Conductivity. HIGHER results indicate MORE fine grain sizes (such as silt and clay). LOWER results indicate MORE sand.
4) Blue line presents Electron Capture Detector (ECD) results. HIGHER results indicate HIGHER detections of VOCs in the soil or aquifer.

MIP Results

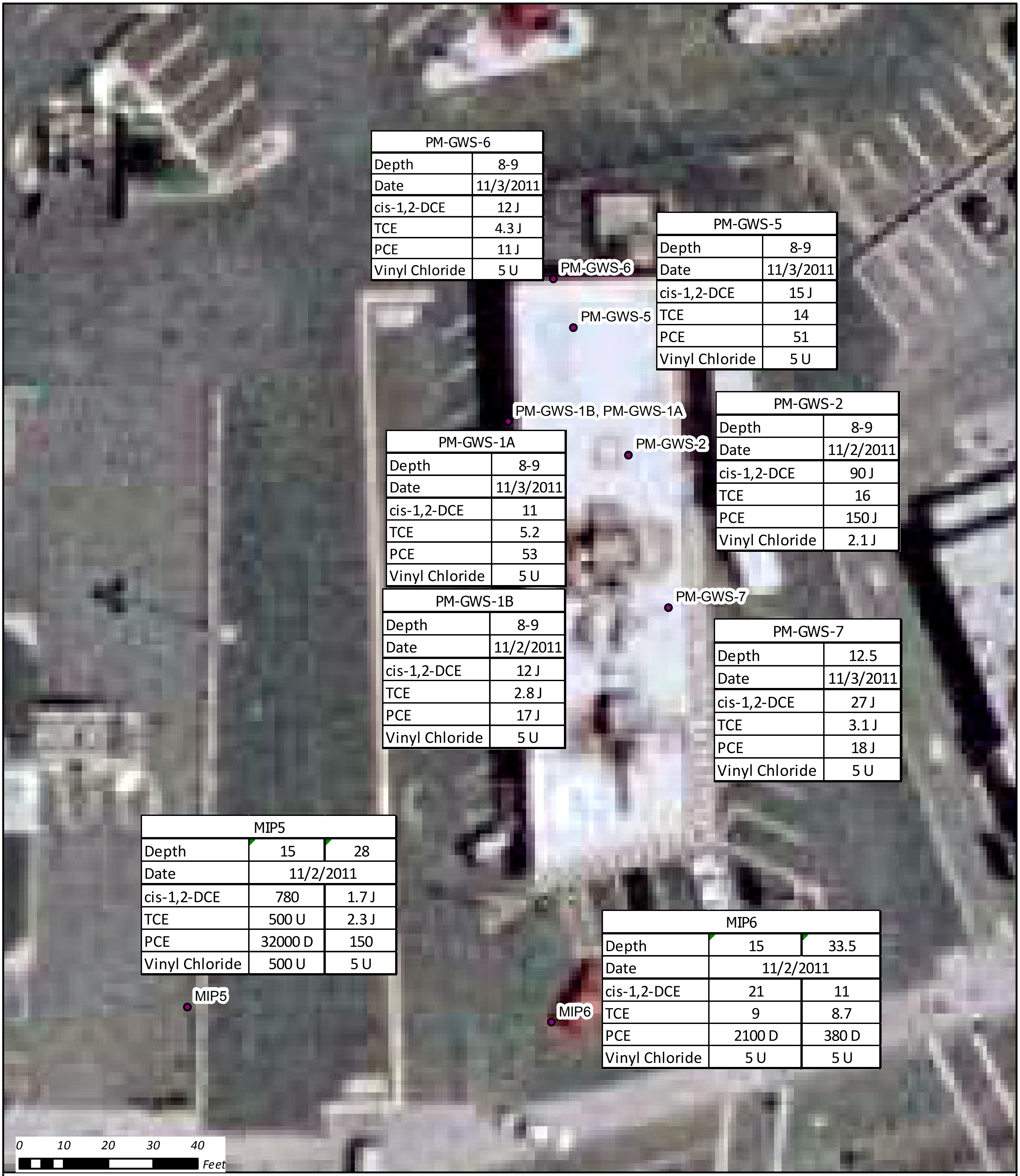
0 25 50 100 150 200 Feet

Figure 3-1

Former Paul Miller Drycleaners

Port Richmond, NY

CDM Smith



PM-GWS-6	
Depth	8-9
Date	11/3/2011
cis-1,2-DCE	12 J
TCE	4.3 J
PCE	11 J
Vinyl Chloride	5 U

PM-GWS-5	
Depth	8-9
Date	11/3/2011
cis-1,2-DCE	15 J
TCE	14
PCE	51
Vinyl Chloride	5 U

PM-GWS-2	
Depth	8-9
Date	11/2/2011
cis-1,2-DCE	90 J
TCE	16
PCE	150 J
Vinyl Chloride	2.1 J

PM-GWS-1A	
Depth	8-9
Date	11/3/2011
cis-1,2-DCE	11
TCE	5.2
PCE	53
Vinyl Chloride	5 U

PM-GWS-1B	
Depth	8-9
Date	11/2/2011
cis-1,2-DCE	12 J
TCE	2.8 J
PCE	17 J
Vinyl Chloride	5 U

PM-GWS-7	
Depth	12.5
Date	11/3/2011
cis-1,2-DCE	27 J
TCE	3.1 J
PCE	18 J
Vinyl Chloride	5 U

MIP5		
Depth	15	28
Date	11/2/2011	
cis-1,2-DCE	780	1.7 J
TCE	500 U	2.3 J
PCE	32000 D	150
Vinyl Chloride	500 U	5 U

MIP6		
Depth	15	33.5
Date	11/2/2011	
cis-1,2-DCE	21	11
TCE	9	8.7
PCE	2100 D	380 D
Vinyl Chloride	5 U	5 U

N

Legend

● Sample_Locations

Depth units are feet bgs.
Analyte units are ug/L.

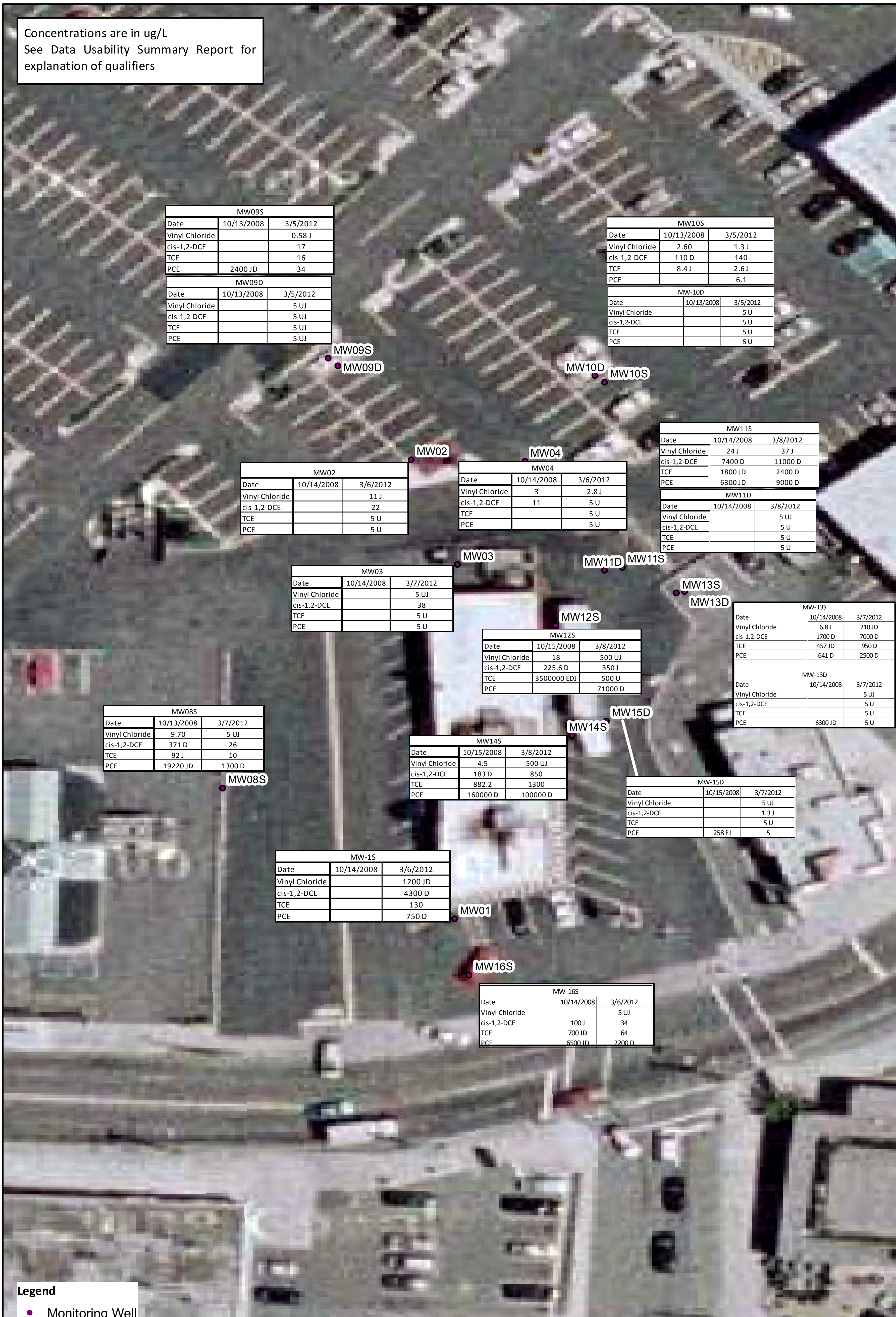
Groundwater Screening Results

Figure 3-2
Former Paul Miller Dry Cleaners
Port Richmond, NY

CDM Smith

GU RRC C:\IMS\GIS\Paul Miller\MXD\Figure 4-3 GWS Boxmap.mxd 6/21/2012

Concentrations are in ug/L
See Data Usability Summary Report for explanation of qualifiers



MW09S		
Date	10/13/2008	3/5/2012
Vinyl Chloride		0.58 J
cis-1,2-DCE		17
TCE		16
PCE	2400 JD	34

MW09D		
Date	10/13/2008	3/5/2012
Vinyl Chloride		5 UJ
cis-1,2-DCE		5 UJ
TCE		5 UJ
PCE		5 UJ

MW10S		
Date	10/13/2008	3/5/2012
Vinyl Chloride	2.60	1.3 J
cis-1,2-DCE	110 D	140
TCE	8.4 J	2.6 J
PCE		6.1

MW-10D		
Date	10/13/2008	3/5/2012
Vinyl Chloride		5 U
cis-1,2-DCE		5 U
TCE		5 U
PCE		5 U

MW11S		
Date	10/14/2008	3/8/2012
Vinyl Chloride	24 J	37 J
cis-1,2-DCE	7400 D	11000 D
TCE	1800 JD	2400 D
PCE	6300 JD	9000 D

MW11D		
Date	10/14/2008	3/8/2012
Vinyl Chloride		5 UJ
cis-1,2-DCE		5 U
TCE		5 U
PCE		5 U

MW02		
Date	10/14/2008	3/6/2012
Vinyl Chloride		11 J
cis-1,2-DCE		22
TCE		5 U
PCE		5 U

MW04		
Date	10/14/2008	3/6/2012
Vinyl Chloride	3	2.8 J
cis-1,2-DCE	11	5 U
TCE		5 U
PCE		5 U

MW03		
Date	10/14/2008	3/7/2012
Vinyl Chloride		5 UJ
cis-1,2-DCE		38
TCE		5 U
PCE		5 U

MW-13S		
Date	10/14/2008	3/7/2012
Vinyl Chloride	6.8 J	210 JD
cis-1,2-DCE	1700 D	7000 D
TCE	457 JD	950 D
PCE	641 D	2500 D

MW-13D		
Date	10/14/2008	3/7/2012
Vinyl Chloride		5 UJ
cis-1,2-DCE		5 U
TCE		5 U
PCE	6300 JD	5 U

MW12S		
Date	10/15/2008	3/8/2012
Vinyl Chloride	18	500 UJ
cis-1,2-DCE	225.6 D	350 J
TCE	3500000 EDJ	500 U
PCE		71000 D

MW08S		
Date	10/13/2008	3/7/2012
Vinyl Chloride	9.70	5 UJ
cis-1,2-DCE	371 D	26
TCE	92 J	10
PCE	19220 JD	1300 D

MW14S		
Date	10/15/2008	3/8/2012
Vinyl Chloride	4.5	500 UJ
cis-1,2-DCE	183 D	850
TCE	882.2	1300
PCE	160000 D	100000 D

MW-15D		
Date	10/15/2008	3/7/2012
Vinyl Chloride		5 UJ
cis-1,2-DCE		1.3 J
TCE		5 U
PCE	258 EJ	5

MW-1S		
Date	10/14/2008	3/6/2012
Vinyl Chloride		1200 JD
cis-1,2-DCE		4300 D
TCE		130
PCE		750 D

MW-16S		
Date	10/14/2008	3/6/2012
Vinyl Chloride		5 UJ
cis-1,2-DCE	100 J	34
TCE	700 JD	64
PCE	6500 JD	2200 D

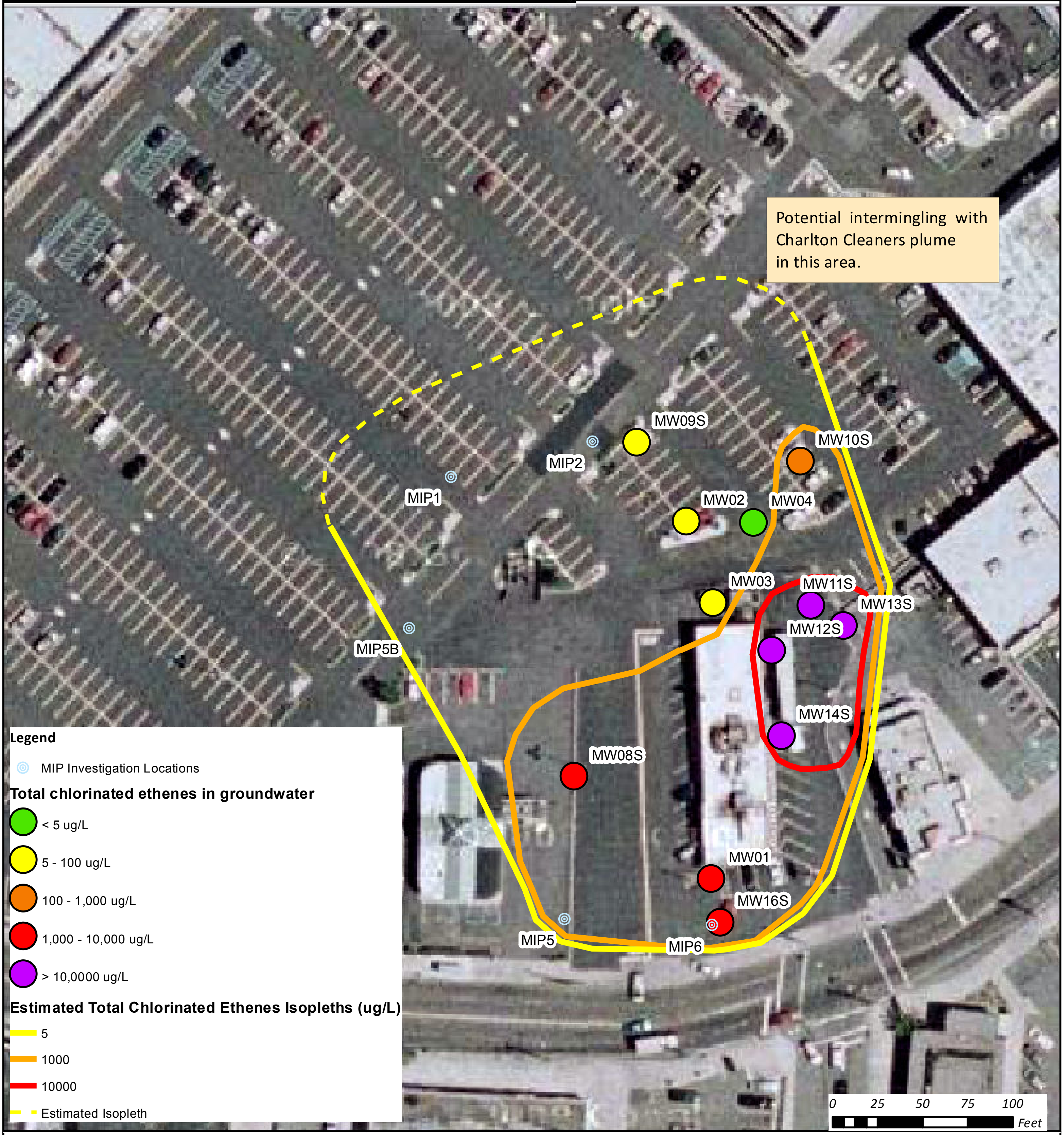
Groundwater Exceedances

Figure 3-3

Former Paul Miller Dry Cleaners

Port Richmond, NY

CDM Smith



N

Shallow Groundwater - Total Chlorinated Ethenes Isopleths

Figure 3-4
Former Paul Miller Dry Cleaners
Port Richmond, NY

CDM Smith

Note:
1) Shallow groundwater gradient is north/northwest
2) Shallow groundwater is less than 35 feet bgs

GURRC C:\IMS\GIS\Paul Miller\MXD\FS\Figure 4-1 Target Treatment Zone.mxd 12/17/2012

N

Legend

- MIP locations and Monitoring Wells
- Estimated Plume Extent
- Target Treatment Zone

Target Treatment Zone

0 25 50 75 100 *Feet*

Figure 4-1

Former Paul Miller Dry Cleaners

Port Richmond, NY

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N

Legend

- MIP locations and Monitoring Wells
- Estimated Excavation Extent

0 25 50 75 100 Feet

Alternative 2 - Excavation Area

Figure 7-1

Former Paul Miller Dry Cleaners
Port Richmond, NY

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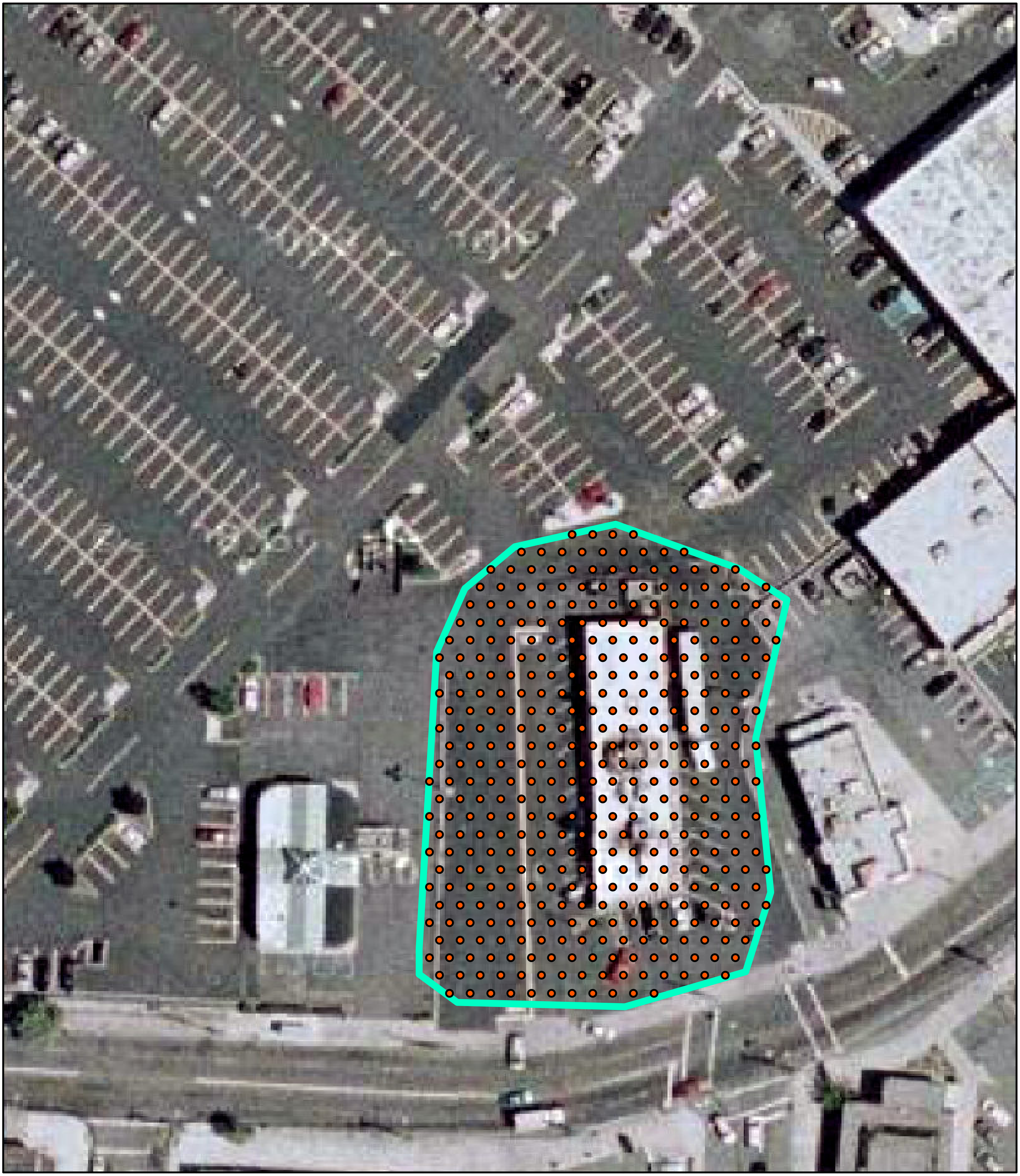

Figure 7-2

Alternative 3 - Heating Well Locations

Former Paul Miller Dry Cleaners
Port Richmond, NY

N

Legend

Heating Well Locations

Source Target Treatment Zone

0 25 50 75 100 Feet

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GURRC C:\IMS\GIS\Paul Miller\MXD\FS\Figure 7-2_Heating well locations.mxd 11/27/2012

Alternative 4 - Fracturing and Emplacement Locations

Figure 7-3
Former Paul Miller Dry Cleaners
Port Richmond, NY

N

Legend

- Fracturing and Emplacment Locations
- Source Target Treatment Zone

0 25 50 75 100 *Feet*

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GURBC C:\IMS\GIS\Paul Miller\MXD\FS\Figure 7-3_Fracturing and Emplacement Locations.mxd 11/27/2012

Alternative 5 - Combined Technologies

Figure 7-4
Former Paul Miller Dry Cleaners
Port Richmond, NY

N

Legend

- Fracturing and Emplacement Locations
- Heating well locations
- Treatment Zone

0 20 40 60 80 *Feet*

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GLIBBC C:\IMS\GIS\Paul Miller\MXD\FS\Figure 7-4_Combined Technologies alternative.mxd 11/29/2012

Appendix A

Cost Estimates

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Cost Estimate for Alternative 2 (Pre-Disposal Alternative)
Excavation and Off-site Disposal
Former Paul Miller Dry Cleaners Site
Port Richmond, New York

No.	Description	Cost
	Design Costs	
	Pre-Design Investigation (based on Alternative 4)	$300,000
	Remedial Design (Allowance)	$500,000
		$800,000
	RA COSTS	
	General Requirements	**Cost**
1	General Conditions	$1,454,000
2	Permits (Allowance)	$20,000
3	Safety and Health Requirements	$372,000
4	Temporary Facilities and Utilities	$188,000
5	Security	$320,000
6	Surveying	$316,000
7	Erosion Control	$50,000
8	Decontamination	$108,000
	Site Preparation	
9	Site Preparation (allowance)	$20,000
	Excavation and Sampling	
10	Excavation	$1,279,000
11	Waste Characterization Sampling	$168,000
12	**Transportation and Disposal**	$8,652,000
13	**Backfill and Restoration**	$3,372,000
	Closure Documents	
14	RA Report and As-Built Drawings (Allowance)	$50,000
	Subtotal RA Costs	**$16,369,000**
	Bond (1.5%)	$246,000
	TOTAL RA COSTS	**$16,615,000**

Cost Estimate for Alternative 2 (Pre-Disposal Alternative)
Excavation and Off-site Disposal
Former Paul Miller Dry Cleaners Site
Port Richmond, New York

No.	Description	Cost
	ENGINEERING SUPPORT SERVICES DURING CONSTRUCTION	
	Engineering Support Services (10%)	$1,661,500
	TOTAL ENGINEERING SUPPORT COSTS	**$1,662,000**
	PROJECT CAPITAL COST	
	DESIGN COSTS	$800,000
	TOTAL RA COSTS	$16,615,000
	ENGINEEERING SUPPORT COSTS	$1,662,000
	SUBTOTAL PROJECT CAPITAL COST	**$19,077,000**
	Escalation (2%)	$382,000
	Contingency (20%)	$3,816,000
	TOTAL PROJECT CAPITAL COST	**$23,300,000**

Note: The project cost presented herein represents only feasibility study level, and is thus subject to change pending the results of the pre-design investigation, which is intended to collect sufficient data to assist in the development of remedial design and associated detailed cost estimate. Expected accuracy range of the cost estimate is -30% to +50%.

Description: FS Cost Estimate for Pre-Disposal Alternative 2 - Excavation and Off-site Disposal - Individual Cost Item Backup

0001 - General Conditions

General conditions to include the project-dedicated site supervisory staff, development of work plans, site photographs/videos, project signs, insurance, mobilization/demobilization, and costs not covered elsewhere.

Estimate assumes that following the remedial design, the RA Contractor will mobilize to the site and complete the remedial action including the site preparation, excavation/removal, off-site transportation and disposal, backfill and compaction, final grading, and site restoration prior to project end.

Project Schedule

Assume the following project schedule:

Pre-Construction Work Plans and Meetings (RA Work)	4	weeks		
Field Trailer Compound Establishment	2	weeks		
Site Preparation (Decon areas, stockpile areas, clearing)	3	weeks		
Remedial Excavation	29	weeks		
Tranportation and Disposal (T & D)	20	weeks		
Backfill and Compaction (concurrent to T & D)	15	weeks		
Final Site Restoration and Demob	10	weeks		
Total Construction Duration	60	weeks		
	15	months		
Project Closeout	3	months		
Total Project Duration	**18**	**months**	**78**	**weeks**

General Condition Costs

A) Site Supervisory Staff

Project Manager	$160	per hour	
Project Engineer	$110	per hour	
Procurement staff (20 hours per week)	$95	per hour	
Total for office support	**$570,000**		

Assume the following Site Supervisory Staff for duration of construction (see labor/equipment backup page for rates):

Site Superintendent	$100	per hour	
Construction Foreman	$80	per hour	
Environmental Technician (QC)	$85	per hour	
Pickup Truck #1	$13	per hour	
Pickup Truck #2	$13	per hour	
per diem for superintendant and QC engineer	$0	per day	
	$291	per hour	
	$50,440	per month	
Total Site Supervisory Staff for Construction Duration			**$757,000**

B) Work Plan Preparation

Estimated # of Pre-Construction Work Plans Required:			3 work plans
Estimated # of Engineer Hours Required per Work Plan:			80 hours
Professional Engineer	$110	per hour	
Project Manager	$160	per hour	
Total Work Plan Preparation Cost:			**$64,800**

C) Mobilization/Demobilization Fees

Assume 10 large pieces of equipment to be used throughout remedial action.

Per MEANS 01-54-36.50-0100 Mobilization, 50-mile round trip

Total Mobilization/Demobilization Cost: **$12,000**

D) Project Insurance

Per MEANS 01-31-13.30-0020 Builder's Risk Insurance, 0.24% of job cost. Allow $50,000 based on project size.

Estimated Project Insurance Cost: **$50,000**

TOTAL GENERAL CONDITION COST: **$1,454,000**

Description: FS Cost Estimate for Pre-Disposal Alternative 2 - Excavation and Off-site Disposal - Individual Cost Item Backup

03 - Safety and Health Requirements

Safety and Health Requirements to include the Site Health and Safety Officer, personnel protective equipment and supplies, and additional safety and air monitoring equipment/testing.

Total Construction Duration:	60	weeks	
	300	work days	

A) Site Health and Safety Officer

Full time SHSO During Construction

Industrial Hygienist (SHSO)	$125	per hour	
			$300,000

B) PPE Costs

Assume PPE required for 10 people per work day for duration of demolition and construction.	
Estimate $20 per day per worker for PPE and incidental safety equipment/testing.	$60,000

C) Additional Safety and Air Monitoring Equipment

Add 20% to PPE Costs for additional safety and air monitoring equipment:	$12,000

TOTAL SAFETY AND HEALTH REQUIREMENTS COST:	**$372,000**

Description: FS Cost Estimate for Pre-Disposal Alternative 2 - Excavation and Off-site Disposal - Individual Cost Item Backup

04 - Temporary Facilities

Temporary Facilities to include the field trailers, utilities, cleaning services, and office equipment and supplies.

A) Field Trailers

Assume a total of 3 project trailers required (2 for Contractor and 1 shower trailer).

The trailer compound will be mobilized at project start and will be used for entire project duration (not just the construction).

Total Duration for Field Portion of Project: 60 weeks

MEANS 01-52-13.20-0550 Field Trailer Rental, 50' x 12', furnished	$405
MEANS 01-52-13.20-0700 Add for Air Conditioning	$46
	$451

Field Trailer Rental Cost per Trailer :	$7,000
Installation of Utility Connections (allowance):	$10,000
Total Field Trailer Rental Cost for 3 trailers:	**$31,000**

B) Utilities and Cleaning Services for Field Trailers

Assume following utilities per month per trailer:

Electricity	$600	per month per trailer
Phone/Internet	$80	per month per trailer
Water	$40	per month per trailer
Sewer	$30	per month per trailer
Cleaning Services	$50	per month per trailer
	$800	per month per trailer

Total Utilities and Cleaning Services for 3 trailers: **$144,000**

C) Miscellaneous Office Supplies

Item	QTY	UOM	Unit Cost	Extended Cost
Computers	3	each	$2,000	$6,000
Fax Machines	3	each	$300	$900
Printers	3	each	$500	$1,500
Office Supplies	15	months	$300	$4,500

Total Miscellaneous Office Equipment/Supplies: **$13,000**

TOTAL COST FOR TEMPORARY FACILITIES: **$188,000**

Description: FS Cost Estimate for Pre-Disposal Alternative 2 - Excavation and Off-site Disposal - Individual Cost Item Backup

05 - Security

Assume for duration of construction requires 16-hour security guard for weekdays and 24-hour security guard for weekends.

Total Field Duration:	60 weeks		
	7,680 hours		

A) Security Guard

Security Guard	$40	per hour

Total Security Guard Cost: **$308,000**

B) Security Trailer

MEANS 01-52-13.20-1100 Portable Office, prefab on skids, 8' x 12'	$119

Total Security Trailer Cost : **$11,500**

TOTAL COST FOR SITE SECURITY: **$320,000**

06 - Surveying

Assume surveying will be required for the following tasks/durations:

Existing Conditions Survey prior to Site Preparation	2	weeks
Excavation and Backfill Period (for depth verification, quantity measurement, waste char. samples, final grading)	44	weeks

Total Surveying Duration:	46	weeks
	231	work days

Survey Cost

Assume full-time 2-person survey team for the surveying work:

Surveyor #1	$80	per hour
Surveyor #2	$80	per hour
	$160	per hour
	$1,280	per day
As-built Drawing Preparation	$20,000	LS

TOTAL COST FOR SURVEYING: **$316,000**

Description: FS Cost Estimate for Pre-Disposal Alternative 2 - Excavation and Off-site Disposal - Individual Cost Item Backup

07 - Erosion Control

Total Field Duration: 60 weeks

A) Installation and Maintenance of Erosion Control Devices

Assume 2 laborers for 4 hours per week to install, maintain, and remove erosion control devices throughout construction:

Laborer (Foreman)	$100	per hour
Laborer	$55	per hour
	$155	per hour

Total Cost for Erosion Control Installation: **$38,000**

B) Erosion Control Devices/Materials

MEANS 31-25-13.10-1100 Silt Fence, 3' high, adverse conditions	$0.96	per LF
MEANS 31-25-13.10-1250 Hay Bales, stacked	$6.60	per LF
	$7.56	per LF

Assume silt fence and hay bales installed around outer site perimeter (assume 340 feet x 275 feet area)

Perimeter of excavation area	1230	LF
add 25% for material replacement	1537.5	LF

Total Cost for Erosion Control Devices/Materials: **$12,000**

TOTAL COST FOR EROSION CONTROL: $50,000

08 - Decontamination

Assume decontamination pad required during construction duration only.

A) Construct Decontamination Pad

Allowance for Construction of Decontamination Pad: **$15,000**

B) Decon Pad Operations

Assume 2 laborers for 2 hours per day to perform equipment decontamination on-site, including T&D trucks:

Laborer (Foreman)	$100	per hour
Laborer	$55	per hour
	$155	per hour

2 hours per day, 5 days a week

Total Cost for Decon Pad Operations: **$93,000**

TOTAL COST FOR DECONTAMINATION: $108,000

Description: FS Cost Estimate for Pre-Disposal Alternative 2 - Excavation and Off-site Disposal - Individual Cost Item Backup

10 - Excavation and Dewatering

A) Total Excavation/Removal Volume (Based on Figure 1)

Excavation Area	98,361	square feet
Excavation Depth	35	feet
Excavation Volume	127,505	CY
Contaminated Depth Interval	25 to 35	feet bgs
Contaminated zone vertical thickness	10	feet
Contaminated material volume	36,430	CY
Building Area	3,900	square feet
Building Length	130	feet
Building Width	30	feet
Building Height	25	feet
Building Demolition Volume (Assume 5% hazardous)	1,350	CY
Asphalt Debris Volume (assume 6" thick)	1,830	CY
Soil - Total	36,430	Bank Cubic Yards (BCY)
Debris	3,180	BCY

B) Excavation Duration

Assume 420 SY/day production rate for pavement demolition per RS Means item # 02.41.1317.5050
and 20,100 CF/day production rate for building demolition per RS Means item # 02.41.1613.0100
Assume 1100 CY/day production rate for excavation of soil (glacial till material) per RS Means item #
31.23.1646.6080 assuming clayey material and 150 feet haul.

Building demolition period, workdays	5	days		
Pavement demolition period, workdays	25	days		
Demolition Period (building and asphalt pavement), workdays			30	DAYS
Excavation Period, workdays			116	DAYS
Total Demo & Excavation Period, workdays			146	DAYS
Total Demo & Excavation Period, work hours (8 hours per day)			1,168	HOURS
Total Demo & Excavation Period, work weeks			29	WEEKS
Total Demo & Excavation Period, months			7	MONTHS

C) Demolition and Excavation Labor/Equipment Costs

Total Building Demolition Costs	$41,000
(Per RS Means 02.41.1613.0100)	
Total Pavement Demolition Costs	$112,400
(Per RS Means 02.41.1317.5050)	
Total Excavation Costs	$726,800
(Per RS Means 31.23.1646.6080)	

D) Dewatering Costs

Dewatering System weekly rental allowance	$8,000
(assume air stripper treatment with all associated equipment and carbon polish treatment)	
Utilities & Carbon Usage Costs (weekly allowance)	$1,000
Total dewatering cost	$398,000
(during excavation and backfill periods only)	

TOTAL DEMOLITION AND EXCAVATION COST **$1,279,000**

Description: FS Cost Estimate for Pre-Disposal Alternative 2 - Excavation and Off-site Disposal - Individual Cost Item Backup			
11 - Waste Characterization Sampling			
To check whether TCLP requirements are met:			
1 sample per 500 CY of total volume - soil, concrete and non-concrete debris			
A) Estimated # of Waste Characterization Samples			
Total # of samples:	80 samples		
Add 20% for QC samples for duplicates:	**100 samples**		
B) Laboratory Analysis Fees			
Waste Characterization Analytical Cost per sample		**$1,200**	
Total Laboratory Analysis Costs:		**$120,000**	
C) Waste Characterization Sample Collection			
Assume 1 hour per sample for an environmental technician to collect each sample			
Environmental Technician	$85 per hour	**$8,500**	
D) Sample Packaging and Shipping Costs			
Assume shipping cost is 5% of analytical cost:		**$6,000**	
E) Data Validation of Waste Characterization Samples			
Assume waste characterization samples will be used as clean final verification samples requiring validation.			
# of samples requiring validation :			100 samples
Assume 1 hour per sample for data validation by a chemist			100 hours
Add 200 hours for QCSR report:			200 hours
Total Chemist Hours:			300 hours
Chemist	$110 per hour	**$33,000**	
TOTAL WASTE-CHARACTERIZATION SAMPLING:	**$168,000**		

Description: FS Cost Estimate for Pre-Disposal Alternative 2 - Excavation and Off-site Disposal - Individual Cost Item Backup

12 - Transportation and Disposal

A) Transportation and Disposal Costs

a) Quantity Calculation at time of FS based on existing data (see Figure 1)

b) Add 25% additional volume to account for bulking between bank and loose cubic yards for soil.

c) Assumes 1.6 tons per CY soil density, 2 tons per CY for debris.

Waste Category	In-place Quantity (BCY)	Quantity after Excavation (LCY)	Quantity (tons)	Disposal Type
Hazardous Waste - Soil (assumed 10% of total soil)	3,700	4,700	6,000	Subtitle C Landfill
Non-Hazardous Waste - Soil (assumed 90% of total soil)	32,800	41,000	52,500	Subtitle D Landfill
Subtotal Waste Volume	**36,500**	**45,700**	**58,500**	

Waste Category	Quantity (LCY)	Quantity (tons)	Transportation Unit Costs (per ton)	Disposal Unit Costs (per ton)	Extended Costs
Hazardous Waste - Soil (vendor quote)	4,700	6,000	$131	$85	$1,125,700
Non-Hazardous Waste - Soil (vendor quote)	41,000	52,500	$75	$64	$7,298,000
Hazardous Waste - Debris (vendor quote)	2,900	5,800	$195	$150	$1,566,000
Non-Hazardous Waste - Debris (vendor quote)	400	800	$80	$95	$140,000
Subtotal T&D Cost	**45,700**	**58,500**			**$8,423,700**

B) Labor and equipment costs for loading the truck for offsite disposal

Assume 20 trucks per day for offsite shipment (each truckload is 25 CY)

Time for loading the material for offsite disposal	98	days
Excavator, Hydraulic, 2 CY	$100	per hour
Equip. Op. Heavy	$80	per hour
Laborer (Semi-Skilled)	$55	per hour
Laborer (Semi-Skilled)	$55	per hour
Total rate per day	$2,320	per day
Total Cost	**$227,400**	

Total Transportation and Disposal Costs	**$8,652,000**

Description: FS Cost Estimate for Pre-Disposal Alternative 2 - Excavation and Off-site Disposal - Individual Cost Item Backup			
13 - Backfill and Restoration			
Total Excavation Volume	127,505 BCY		
(Bulking factor 0.25)	159,381 Loose Cubic Yards (LCY)		
Backfill & Restoration Duration			
Assume backfill has a production rate of 2150 CY/day per 31.23.2314.5210			
Total Backfill Period, workdays			75 DAYS
Total Backfill Period, work hours (8 hours per day)			600 HOURS
Total Backfill Period, work weeks			15 WEEKS
Total Backfill Period, months			4 MONTHS
Total Asphalt Restoration Period (concurrent to building construction), days			50 DAYS
A) Backfill Labor/Equipment Costs			
Backfill Labor & Equipment Unit Rate	$1.45 per LCY		
(RS Means 31.23.2314.5210)			
Total Backfill Labor and Equipment Cost	**$231,200**		
B) Backfill Material Costs			
Backfill Material Costs (assume portion of excavated material is used as backfill):			
Common Fill Unit Cost (RS Means 31.23.2316.0035)	$32 per CY		
Fresh Backfill Material Quantity (with 0.25 bulking factor)		45,538 LCY	
Backfill hauling unit cost	$13.55 per LCY		
(RS Means 31.23.2320.9114)			
Total backfill hauling costs	$617,033		
Backfill Material Cost	$1,457,200		
Total Backfill Material Costs:	**$2,074,300**		
C) Backfill Material Testing			
Requires one sample for every 5,000 cubic yards imported to the site, analyzed for full parameters including sieve analyses, moisture content, chemical compounds, and Ra-226:			
Assume $1500 per sample analysis fee			
# of Backfill Material Samples Required:		10 samples	
Backfill Testing Cost:	**$15,000**		
D) Soil Density Testing			
Assume $500 per visit by soil density testing technician, 2 visits per week, during backfill operations.			
# of Backfill Visits Required:		30 visits	
Soil Density Testing Cost:	**$15,000**		
E) Asphalt Restoration Costs			
Area of asphalt restoration	94,500 square feet		
Unit costs for asphaltic concrete paving at parking lots and driveways			$4.77 per SF
(RS Means 32.12.1614.1180)			
Asphalt Restoration Costs	**$450,800**		
F) Building Construction Costs			
Building Area	3,900 square feet		
Unit cost (assumption)	$150		
Reconstruction of Demolished Building (allowance)	**$585,000**		
TOTAL BACKFILL AND RESTORATION COST:	**$3,372,000**		

Alternative 3
In-situ Thermal Remediation
Cost Estimate Summary
Former Paul Miller Dry Cleaners
Port Richmond, NY

Item No.	Item Description	Extended Cost
CAPITAL COSTS		
1.	Pre-design Investigation	$ 295,000
2.	Remedial Design	$ 338,000
3.	In-situ Thermal Remediation	$ 9,041,000
	Subtotal	**$ 9,674,000**
	Contingency (20%)	$ 1,935,000
	TOTAL CAPITAL COSTS	**$ 11,609,000**
OPERATION & MAINTENANCE (O&M) COSTS		
Annual O&M Costs		
4	Long Term Monitoring (Quarterly year 1 and 2, annually year 3 - 30)	$ 99,000
PRESENT WORTH OF 30 YEAR COSTS (with discounting)		
6.	Total Capital Costs	$ 11,609,000
7.	Monitoring Costs	$ 1,842,000
	TOTAL PRESENT WORTH OF 30 YEAR COSTS	**$ 13,451,000**

Notes:

1. Present worth calculation assumes 7% discount rate after inflation is considered.

CDM Smith

Description: Individual Cost Item Backup for Alternative 3

		Quantity	Unit	Unit Cost		Extended Cost
No. 1	**Pre-design Investigation**					
1a.	**Project Management and Office Support**					
	Include project management, subcontractor procurement, preparation of QAPP and HASP					
	Project Manager	20	hr	$160	=	$3,200
	Project Engineer	80	hr	$110	=	$8,800
	Geologist	80	hr	$110	=	$8,800
	Chemist	40	hr	$110	=	$4,400
	Procurement Specialist	40	hr	$110	=	$4,400
	Total Project Management and Office Support					$29,600
1b.	**Groundwater Screening**					
	Number of Locations	40	locations			
	Samples per location	1	samples			
	End depth at each location	40	ft			
	Locations per day	2	locations			
	Number of direct push days	20	Days			
	Drilling					
	GeoProbe mob/demob	1	LS	$8,000	=	$8,000
	GeoProbe and operators	20	days	$1,500	=	$30,000
	Decon pad	1	LS	$1,000	=	$1,000
	Decon of equipment	5	hr	$100	=	$500
	Drum	20	ea	$120	=	$2,400
	Drum disposal/sampling	20	ea	$200	=	$4,000
	Field Sampling Labor					
	Persons	2	persons			
	12-hour days	20	days			
	Mob/demob	20	hr	$110	=	$2,200
	Sampling	480	hr	$110	=	$52,800
	Travel Expense and per Diem					
	Van and car rental	40	day	$95	=	$3,800
	Sampling Equipment, Shipping, Consumable Supplies					
	Equipment & PPE	1	ea	$4,000	=	$4,000
	Shipping	20	day	$100	=	$2,000
	Misc	20	day	$100	=	$2,000
	Sample Analysis					
	VOCs	40	ea	$120	=	$4,800
	Metals	40	ea	$120	=	$4,800
	Data Validation					
	Assume samples validated @ 0.5 hr per sample					
	Samples management/validation	20	hr	$110	=	$2,200
	Total Groundwater Screening					$124,500
1c.	**Well Installation**					
	Monitoring Wells to install	4	wells			
	Well depth	45	ft			
	Screen length	10	ft			
	Drilling					
	Driller mob/demob	1	LS	$10,000	=	$10,000
	Boring 6 inch mud rotary	180	ft	$35	=	$6,300
	4-inch PVC screen	40	ft	$15	=	$600
	4-inch PVC casing	140	ft	$15	=	$2,100
	Well completion materials	180	ft	$8	=	$1,440
	Well development	20	hr	$110	=	$2,200
	Drums	4	LS	$50	=	$200
	Drum transport	4	LS	$200	=	$800
	Field Geologist					
	Mob/demob	10	hr	$110	=	$1,100
	Well drilling and development	44	hr	$110	=	$4,840
	Travel Expense and per Diem					
	Van and car rental	4	day	$95	=	$380
	Misc	4	day	$75	=	$300
	IDW Disposal					
	Drum	4	ea	$120	=	$480
	Drum disposal/sampling	4	ea	$200	=	$800
	Subtotal for Monitoring Wells installation					$31,540

1d.	**Synoptic Water Level and Groundwater Sampling**					
	Monitoring Wells to sample	21	wells			
	Number of samplers	2	people			
	Number of 12 hour workdays	7	days			
	Field Sampling Labor					
	Mob/demob	20	hr	$95	=	$1,900
	Well Sampling	168	hr	$95	=	$15,960
	Travel Expense and per Diem					
	Van and car rental	7	day	$95	=	$665
	Sampling Equipment, Shipping, Consumable Supplies					
	Equipment & PPE	1	ea	$3,500	=	$3,500
	Shipping	7	day	$200	=	$1,400
	Misc	7	day	$75	=	$525
	Sampling Analysis					
	VOCs	31	ea	$120	=	$3,720
	MEE	31	ea	$120	=	$3,720
	TOC	31	ea	$30	=	$930
	Nitrate	31	ea	$25	=	$775
	Sulfate	31	ea	$25	=	$775
	Ferrous Iron	31	ea	$18	=	$558
	Chloride	31	ea	$15	=	$465
	Alkalinity	31	ea	$20	=	$620
	Metals	31	ea	$120	=	$3,720
	Dehalococcoides	21	ea	$450	=	$9,450
	Data Management and Validation					
	Assume samples validated @ 0.5 hr per sample per analyte					
	Samples management/validation	150	hr	$110	=	$16,500
	Total Synoptic Water Level and Groundwater Sampling					$65,183
1e.	**Pre-design Investigation Report**					
	Assume include the data evaluation and management during sampling					
	Project Manager/Senior Reviews	40	hr	$160	=	$6,400
	Project Engineer	120	hr	$110	=	$13,200
	Project Geologist	120	hr	$110	=	$13,200
	Chemist	50	hr	$110	=	$5,500
	Data Management	50	hr	$110	=	$5,500
	Total Pre-design Investigation Report					$43,800
	TOTAL PRE-DESIGN INVESTIGATION:					**$295,000**

Description:	Individual Cost Item Backup for Alternative 3					
		Quantity	Unit	Unit Cost		Extended Cost
No. 3	**Remedial Design**					
	To include the analysis of investigation results and existing data, preparation of the remedial design including draft, pre-final, and final design packages consisting of specifications, drawings, design analysis report, and construction cost estimate.					
	Prices are estimated based on CDM Smith's experience on similar projects; hourly rate is for design engineer					
	Project management and meetings	400	hr	$160	=	$64,000
	Site visits	3	LS	$150	=	$450
	Prepare for draft submittal	1000	hr	$110	=	$110,000
	Cost estimate	80	hr	$110	=	$8,800
	Value engineering	120	hr	$110	=	$13,200
	Prepare for final submittal	1000	hr	$110	=	$110,000
	Prepare for final cost estimate	80	hr	$110	=	$8,800
	Post final engineering support	200	hr	$110	=	$22,000
	TOTAL REMEDIAL DESIGN COST:					**$338,000**

Description: Individual Cost Item Backup for Alternative 3

		Quantity	Unit	Unit Cost		Extended Cost
No. 4	**In-situ Thermal Remediation**					
4a.	**Construction Management & Operations - General Conditions**					
	Timeperiods are calculated in 5b below					
	Construction time period	27	weeks			
	Operations Timeperiod	21	weeks			
	Cooldown and Well Abandonment Time period	15	weeks			
	TOTAL CONSTRUCTION AND OPERATIONS TIME	64	weeks			
	Pre-Mobilization Work Plans					
	Project Manager	20	hr	$160	=	$3,200
	Environmental Engineer	60	hr	$110	=	$6,600
	Scientist	60	hr	$110	=	$6,600
	Admin Clerk	10	hr	$75	=	$750
	Permit Applications					
	Project Manager	40	hr	$160	=	$6,400
	Environmental Engineer	240	hr	$110	=	$26,400
	Scientist	240	hr	$110	=	$26,400
	Permit Fees for Gas, Power, Air & Water Discharge					$40,000
	Subcontractor Procurement					
	Assume procurement of driller, IDW, laboratory, thermal remediation subcontractors					
	Project Manager	60	hr	$160	=	$9,600
	Environmental Engineer	40	hr	$110	=	$4,400
	Geologist	30	hr	$110		$3,300
	Scientist	30	hr	$110	=	$3,300
	Procurement specialist	50	hr	$110	=	$5,500
	During Construction and Cooldown/Well Abandonment					
	Project Manager (10 hrs/wk)	429	hr	$160	=	$68,667
	Engineer (16 hrs/wk)	687	hr	$110	=	$75,533
	Site Superintendent (70 hrs/wk)	429	hr	$100	=	$42,917
	Site Trucks (2 per work days)	43	week	$250	=	$10,729
	Per Diem (2 people per work days)	86	day	$323	=	$27,724
	Health and Safety Engineer (16 hrs/wk)	687	hr	$125	=	$85,833
	Admin Clerk (assume 4 hrs/wk)	172	hr	$75	=	$12,875
	Subcontract management (10 hrs/week)	429	hr	$75	=	$32,188
	Meetings	18	LS	$500	=	$9,000
	Weekly calls	43	per	$500	=	$21,458
	Two Trailers with utilities	1	LS	$60,000	=	$60,000
	During Operations					
	Project Manager (10 hrs/wk)	214	hr	$160	=	$34,286
	Engineer (16 hrs/wk)	343	hr	$110	=	$37,714
	Site Superintendent (70 hrs/wk)	1,500	hr	$100	=	$150,000
	Site Trucks (2 per work days)	21	week	$250	=	$5,357
	Per Diem (2 people per work days)	0	day	$323	=	$0
	Health and Safety Engineer (16 hrs/wk)	343	hr	$125	=	$42,857
	Admin Clerk (assume 4 hrs/wk)	86	hr	$75	=	$6,429
	Subcontract management (10 hrs/week)	214	hr	$75	=	$16,071
	Meetings	18	LS	$500	=	$9,000
	Weekly calls	21	per	$500	=	$10,714
	Two Trailers with utilities	1	LS	$60,000	=	$60,000
	Site Security					
	Assume full time security guard, 12 hours during the weekday and 24 hours per day on weekend					
	Security guard	27	wk	$4,320	=	$118,656
	Remedial Action Reports					
	Project Manager	40	hr	$160	=	$6,400
	Environmental Engineer	240	hr	$110	=	$26,400
	Scientist	80	hr	$110	=	$8,800
	Admin Clerk	40	hr	$75	=	$3,000
	Geologist	120	hr	$110	=	$13,200
	Total for Construction Management					**$1,139,000**

		Quantity	Unit	Unit Cost			Extended Cost
4b.	**ISTR Implementation**						
	Assume thermal conductive heating with gas-fired heating wells						
	Drilling costs						
	Treatment area	45,000	SF				
	Heating well Radius of Influence	5.0	ft				
	Number of heating wells (from vendor)	573	wells				
	Total depth of heating wells	35	ft bgs				
	Temperature monitoring points	45	points				
	Total number of 8 inch borings	618	borings				
	Number of Drill Rigs	3	rigs				
	Installations per rig per day	1.5	points per day				
	Days for drilling	137	days				
	weeks for drilling	27	weeks				
	Number of soil vapor extraction wells	68	borings	(same borings as heating wells)			
	Total depth of SVE wells	7	ft				
	Boring total	21,630	ft	$40	=	$	865,200
	Drill cuttings per drilled foot	2.6	gal/ft				
	Drill cuttings waste	56238	gal		=	$	-
	Drilling mud waste	56238	gal				
	Barrels of waste	2812	barrels	$250	=	$	702,975
	TOTAL DRILLING COSTS					**$**	**1,569,000**
	Natural Gas Costs for Heating Wells						
	Average natural gas usage per well per day	1.46	mcf/day				
	Total heating treatment time	150	days				
	Total natural gas usage	125,139	mcf				
	Design remediation energy	125,139	mcf	$7	=	$	875,975
	TOTAL ENERGY COSTS					**$**	**876,000**
	Disposal and Other Costs - non-TCH vendors						
	Water Collection and Disposal	$300,000	LS			$	300,000
	Vapor Insulation Cover	$120,000	LS			$	120,000
	TOTAL DISPOSAL/MISCELLANEOUS COSTS					**$**	**420,000**
	TCH Subcontractor costs						
	Design, workplan, permits	$75,000	LS			$	75,000
	Mobilization and Materials	618	heating wells	$1,000	=	$	618,000
	Subsurface Installation	618	heating wells	$4,000	=	$	2,472,000
	Surface Installation and Startup	618	heating wells	$1,250	=	$	772,500
	System operation - control unit and labor	150	days	$2,000		$	300,000
	Vapor Extraction and Treatment	$100,000	LS				$100,000
	Demobilization and Final Report	$50,000	LS				$50,000
	Well Abandonment						
	Well abandonment (grouting)	21,630	ft	$30	=	$	648,900
	Wells abandoned per day	8	wells				
	Days for abandonment	77	days				
	Weeks for abandonment	15	weeks				
	TOTAL SUBCONTRACTOR COSTS					**$**	**5,036,400**
					ISTR Total		**$9,041,000**

Description: Individual Cost Item Backup for Alternative 3

		Quantity	Unit	Unit Cost		Extended Cost
No. 3	**Long Term Monitoring**					
	Monitoring Wells to sample	20	wells			
	Soil Vapor Samples	5	samples			
	Number of samplers	2	people			
	Number of 12 hour workdays	7	days			
	Sampling Project Planning (e.g., Staffing, Lab Procurement, Obtaining Equipment)					
	Project Manager	16	hr	$160	=	$2,560
	Geologist	50	hr	$110	=	$5,500
	Procurement Specialist	40	hr	$110	=	$4,400
	Field Sampling Labor					
	Mob/demob	60	hr	$110	=	$6,600
	Sampling	168	hr	$110	=	$18,480
	Travel Expense and per Diem					
	Van and car rental	7	day	$95	=	$665
	Sampling Equipment, Shipping, Consumable Supplies					
	Equipment & PPE	1	ea	$3,500	=	$3,500
	Shipping	7	day	$200	=	$1,400
	Misc	7	day	$75	=	$525
	Sampling Analysis					
	VOCs (TO-15 vapor)	5	ea	$190	=	$950
	VOCs (groundwater)	29	ea	$80	=	$2,320
	MEE	29	ea	$120	=	$3,480
	TOC	29	ea	$30	=	$870
	Nitrate	29	ea	$25	=	$725
	Sulfate	29	ea	$25	=	$725
	Ferrous Iron	29	ea	$18	=	$522
	Chloride	29	ea	$15	=	$435
	Alkalinity	29	ea	$20	=	$580
	Metals	29	ea	$120	=	$3,480
	Data Validation					
	Assume samples validated @ 1 hr per sample					
	Samples management/validation	261	hr	$110	=	$28,710
	Sampling Report					
	Project Manager	16	hr	$160	=	$2,560
	Environmental Engineer	40	hr	$110	=	$4,400
	Geologist	40	hr	$110	=	$4,400
	Admin Clerk	16	hr	$75	=	$1,200
	TOTAL GROUNDWATER SAMPLING COST PER EVENT					**$ 99,000**

Description: Individual Cost Item Backup for Alternative 3

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

This is a problem of the form find (P given A, i, n) or (P/A,i,n)

P = Present Worth

A= Annual amount

i = interest rate

$$P = A \times \frac{(1+i)^n - 1}{i(1+i)^n}$$

A. Long Term Monitoring - year 3- 30

Multiplier is (P/A) for five years minus (P/A) for year 1)

n =	30
i =	7%
The multiplier for $(P/A)_2$ =	**12.409**
n =	2
i =	7%
The multiplier for $(P/A)_2$ =	**1.808**
Net	**10.601**

Alternative 4
In-situ Biological and/or Abiotic Remediation
Cost Estimate Summary
Former Paul Miller Dry Cleaners
Port Richmond, NY

Item No.	Item Description	Extended Cost
CAPITAL COSTS		
1.	Pre-design Investigation	$ 297,000
2.	Microcosm Study	$ 60,000
3.	Pilot Study	$ 400,000
4.	Remedial Design	$ 338,000
5.	In-situ Treatment	$ 2,398,000
	Subtotal	**$ 3,493,000**
	Contingency (20%)	$ 699,000
	TOTAL CAPITAL COSTS	**$ 4,192,000**
OPERATION & MAINTENANCE (O&M) COSTS		
Annual O&M Costs		
6	Long Term Monitoring (quarterly yr 1-2, annually yr 3 - 10)	$ 99,000
PRESENT WORTH OF 30 YEAR COSTS (with discounting)		
7.	Total Capital Costs	$ 4,192,000
8.	Monitoring Cost	$ 1,842,000
	TOTAL PRESENT WORTH OF 30 YEAR COSTS	**$ 6,034,000**

Notes:

1. Present worth calculation assumes 7% discount rate after inflation is considered.

Description: Individual Cost Item Backup for Alternative 4

		Quantity	Unit	Unit Cost		Extended Cost
No. 1	**Pre-design Investigation**					
1a.	**Project Management and Office Support**					
	Include project management, subcontractor procurement, preparation of QAPP and HASP					
	Project Manager	20	hr	$160	=	$3,200
	Project Engineer	80	hr	$110	=	$8,800
	Geologist	80	hr	$110	=	$8,800
	Chemist	40	hr	$110	=	$4,400
	Procurement Specialist	40	hr	$110	=	$4,400
	Total Project Management and Office Support					$29,600
1b.	**Groundwater Screening**					
	Number of Locations	40	locations			
	Samples per location	1	samples			
	End depth at each location	40	ft			
	Locations per day	2	locations			
	Number of direct push days	20	Days			
	Drilling					
	GeoProbe mob/demob	1	LS	$8,000	=	$8,000
	GeoProbe and operators	20	days	$1,500	=	$30,000
	Decon pad	1	LS	$1,000	=	$1,000
	Decon of equipment	5	hr	$100	=	$500
	Drum	20	ea	$120	=	$2,400
	Drum disposal/sampling	20	ea	$200	=	$4,000
	Field Sampling Labor					
	Persons	2	persons			
	12-hour days	20	days			
	Mob/demob	20	hr	$110	=	$2,200
	Sampling	480	hr	$110	=	$52,800
	Travel Expense and per Diem					
	Van and car rental	40	day	$95	=	$3,800
	Sampling Equipment, Shipping, Consumable Supplies					
	Equipment & PPE	1	ea	$4,000	=	$4,000
	Shipping	20	day	$100	=	$2,000
	Misc	20	day	$100	=	$2,000
	Sample Analysis					
	VOCs	40	ea	$120	=	$4,800
	Metals	40	ea	$120	=	$4,800
	Data Validation					
	Assume samples validated @ 1 hr per sample					
	Samples management/validation	40	hr	$110	=	$4,400
	Total Groundwater Screening					$126,700
1c.	**Well Installation**					
	Monitoring Wells to install	4	wells			
	Well depth	45	ft			
	Screen length	10	ft			
	Drilling					
	Driller mob/demob	1	LS	$10,000	=	$10,000
	Boring 6 inch mud rotary	180	ft	$35	=	$6,300
	4-inch PVC screen	40	ft	$15	=	$600
	4-inch PVC casing	140	ft	$15	=	$2,100
	Well completion materials	180	ft	$8	=	$1,440
	Well development	20	hr	$110	=	$2,200
	Drums	4	LS	$50	=	$200
	Drum transport	4	LS	$200	=	$800
	Field Geologist					
	Mob/demob	10	hr	$110	=	$1,100
	Well drilling and development	44	hr	$110	=	$4,840
	Travel Expense and per Diem					
	Van and car rental	4	day	$95	=	$380
	Misc	4	day	$75	=	$300
	IDW Disposal					
	Drum	4	ea	$120	=	$480
	Drum disposal/sampling	4	ea	$200	=	$800
	Subtotal for Monitoring Wells installation					$31,540

1d.	**Synoptic Water Level and Groundwater Sampling**					
	Monitoring Wells to sample	21	wells			
	Number of samplers	2	people			
	Number of 12 hour workdays	7	days			
	Field Sampling Labor					
	Mob/demob	20	hr	$95	=	$1,900
	Well Sampling	168	hr	$95	=	$15,960
	Travel Expense and per Diem					
	Van and car rental	7	day	$95	=	$665
	Sampling Equipment, Shipping, Consumable Supplies					
	Equipment & PPE	1	ea	$3,500	=	$3,500
	Shipping	7	day	$200	=	$1,400
	Misc	7	day	$75	=	$525
	Sampling Analysis					
	VOCs	31	ea	$120	=	$3,720
	MEE	31	ea	$120	=	$3,720
	TOC	31	ea	$30	=	$930
	Nitrate	31	ea	$25	=	$775
	Sulfate	31	ea	$25	=	$775
	Ferrous Iron	31	ea	$18	=	$558
	Chloride	31	ea	$15	=	$465
	Alkalinity	31	ea	$20	=	$620
	Metals	31	ea	$120	=	$3,720
	Dehalococcoides	21	ea	$450	=	$9,450
	Data Management and Validation					
	Assume samples validated @ 0.5 hr per sample per analyte					
	Samples management/validation	150	hr	$110	=	$16,500
	Total Synoptic Water Level and Groundwater Sampling					$65,183
1e.	**Pre-design Investigation Report**					
	Assume include the data evaluation and management during sampling					
	Project Manager/Senior Reviews	40	hr	$160	=	$6,400
	Project Engineer	120	hr	$110	=	$13,200
	Project Geologist	120	hr	$110	=	$13,200
	Chemist	50	hr	$110	=	$5,500
	Data Management	50	hr	$110	=	$5,500
	Total Pre-design Investigation Report					$43,800
	TOTAL PRE-DESIGN INVESTIGATION:					**$297,000**

Description: Individual Cost Item Backup for Alternative 4

		Quantity	Unit	Unit Cost		Extended Cost
No. 3	**Remedial Design**					
	To include the analysis of investigation results and existing data, preparation of the remedial design including draft, pre-final, and final design packages consisting of specifications, drawings, design analysis report, and construction cost estimate.					
	Prices are estimated based on CDM Smith's experience on similar projects; hourly rate is for design engineer					
	Project management and meetings	400	hr	$160	=	$64,000
	Site visits	3	LS	$150	=	$450
	Prepare for draft submittal	1000	hr	$110	=	$110,000
	Cost estimate	80	hr	$110	=	$8,800
	Value engineering	120	hr	$110	=	$13,200
	Prepare for final submittal	1000	hr	$110	=	$110,000
	Prepare for final cost estimate	80	hr	$110	=	$8,800
	Post final engineering support	200	hr	$110	=	$22,000
	TOTAL REMEDIAL DESIGN COST:					**$338,000**

Description:	Individual Cost Item Backup for Alternative 4a						
		Quantity	Unit	Unit Cost			Extended Cost
No. 4a	**In-situ treatment**						
4a.	**Construction Management & Operations - General Conditions**						
	Timeperiods are calculated in 5b below						
	Drilling, Fracturing and Injection time period	13	weeks				
	TOTAL CONSTRUCTION AND OPERATIONS TIME	13	weeks				
	Pre-Mobilization Work Plans						
	Project Manager	20	hr	$160	=		$3,200
	Environmental Engineer	60	hr	$110	=		$6,600
	Scientist	60	hr	$110	=		$6,600
	Admin Clerk	10	hr	$75	=		$750
	Permit Applications						
	Project Manager	40	hr	$160	=		$6,400
	Environmental Engineer	120	hr	$110	=		$13,200
	Scientist	120	hr	$110	=		$13,200
	Subcontractor Procurement						
	Assume procurement of driller, IDW, laboratory, drilling and injection subcontractors						
	Project Manager	60	hr	$160	=		$9,600
	Environmental Engineer	40	hr	$110	=		$4,400
	Geologist	30	hr	$110			$3,300
	Scientist	30	hr	$110	=		$3,300
	Procurement specialist	50	hr	$110	=		$5,500
	During Construction & Operations						
	Project Manager (10 hrs/wk)	128	hr	$160	=		$20,480
	Engineer (16 hrs/wk)	205	hr	$110	=		$22,528
	Site Superintendent (10 hrs/wk)	128	hr	$100	=		$12,800
	Site Trucks (2 per work days)	13	week	$250	=		$3,200
	Health and Safety Engineer (16 hrs/wk)	205	hr	$125	=		$25,600
	Admin Clerk (assume 4 hrs/wk)	51	hr	$75	=		$3,840
	Subcontract management (10 hrs/week)	128	hr	$75	=		$9,600
	Meetings	18	LS	$500	=		$9,000
	Weekly calls	13	per	$500	=		$6,400
	Two Trailers with utilities	1	LS	$35,000	=		$35,000
	Site Security						
	Assume full time security guard, 12 hours during the weekday and 24 hours per day on weekend						
	Security guard	13	wk	$4,320	=		$55,296
	Remedial Action Reports						
	Project Manager	40	hr	$160	=		$6,400
	Environmental Engineer	240	hr	$110	=		$26,400
	Scientist	80	hr	$110	=		$8,800
	Admin Clerk	40	hr	$75	=		$3,000
	Geologist	120	hr	$110	=		$13,200
	Total for Construction Management						**$338,000**
4b.	**Hydraulic Fracturing and Amendment Injection**						
	Area of treatment zone	45,000	ft^2				
	Radius of Influence	15.0	ft				
	Total depth	35	ft bgs				
	Treatment zone thickness	10	ft				
	Estimated total porosity	0.25	--				
	Assume soil bulk density	100	lb/ft^3				
	Mass of soil in treatment zone	45,000,000	lbs				
	Number of fracture/injection points	64	points				
	Treatment zone volume	450,000	ft^3				
	Volume pore space	112,500	ft^3				
5c.	**Fracturing and Injection Point Installation Details**						
	Number of Rigs	1	rigs				
	Mob/demob	1	LS	$30,000	=	$	30,000
	Fracture/Injection points completed per day	1	points per day				
	Direct Push/Fracture/Injection contractor	64	days	$15,000	=	$	960,000
	TOTAL FOR AMENDMENT INJECTION					**$**	**990,000**
5e.	**Amendment Details**						
	Percentage amendment by soil mass	0.50%	lb amendment/lb soil				
	Mass of amendment required	225,000	lbs	$1.90	=	$	427,500
	Truck delivery	1	LS	$20,000	=	$	20,000
	TOTAL FOR AMENDMENTS					**$**	**447,500**
5f.	**Vapor Mitigation System**						
	Mob/demob	1	ea	$5,000	=	$	5,000
	Installation by subcontractor of Vapor Mitigation System	1	LS	$35,000	=	$	35,000
	Total for Vapor Mitigation					**$**	**40,000**
	Subtotal for In-situ Chemical Reduction and Bioremediation					$	1,815,500
	Insurance and bond (5%)					$	91,000
	TOTAL IN-SITU TREATMENT					**$**	**1,907,000**

Description:	Individual Cost Item Backup for Alternative 4b					
		Quantity	Unit	Unit Cost		Extended Cost
No. 4b	**In-situ treatment**					
4a.	**Construction Management & Operations - General Conditions**					
	Timeperiods are calculated in 5b below					
	Drilling, Fracturing and Injection time period	3	weeks			
	TOTAL CONSTRUCTION AND OPERATIONS TIME	3	weeks			
	Pre-Mobilization Work Plans					
	Project Manager	20	hr	$160	=	$3,200
	Environmental Engineer	60	hr	$110	=	$6,600
	Scientist	60	hr	$110	=	$6,600
	Admin Clerk	10	hr	$75	=	$750
	Permit Applications					
	Project Manager	40	hr	$160	=	$6,400
	Environmental Engineer	120	hr	$110	=	$13,200
	Scientist	120	hr	$110	=	$13,200
	Subcontractor Procurement					
	Assume procurement of driller, IDW, laboratory, drilling and injection subcontractors					
	Project Manager	60	hr	$160	=	$9,600
	Environmental Engineer	40	hr	$110	=	$4,400
	Geologist	30	hr	$110		$3,300
	Scientist	30	hr	$110	=	$3,300
	Procurement specialist	50	hr	$110	=	$5,500
	During Construction & Operations					
	Project Manager (10 hrs/wk)	32	hr	$160	=	$5,120
	Engineer (16 hrs/wk)	51	hr	$110	=	$5,632
	Site Superintendent (10 hrs/wk)	32	hr	$100	=	$3,200
	Site Trucks (2 per work days)	3	week	$250	=	$800
	Health and Safety Engineer (16 hrs/wk)	51	hr	$125	=	$6,400
	Admin Clerk (assume 4 hrs/wk)	13	hr	$75	=	$960
	Subcontract management (10 hrs/week)	32	hr	$75	=	$2,400
	Meetings	18	LS	$500	=	$9,000
	Weekly calls	3	per	$500	=	$1,600
	Two Trailers with utilities	1	LS	$35,000	=	$35,000
	Site Security					
	Assume full time security guard, 12 hours during the weekday and 24 hours per day on weekend					
	Security guard	3	wk	$4,320	=	$13,824
	Remedial Action Reports					
	Project Manager	40	hr	$160	=	$6,400
	Environmental Engineer	240	hr	$110	=	$26,400
	Scientist	80	hr	$110	=	$8,800
	Admin Clerk	40	hr	$75	=	$3,000
	Geologist	120	hr	$110	=	$13,200
	Total for Construction Management					**$218,000**
4b.	**Hydraulic Fracturing and Amendment Injection**					
	Area of treatment zone	11,250	ft^2			
	Radius of Influence	15.0	ft			
	Total depth	35	ft bgs			
	Treatment zone thickness	10	ft			
	Estimated total porosity	0.25	--			
	Assume soil bulk density	100	lb/ft^3			
	Mass of soil in treatment zone	11,250,000	lbs			
	Number of fracture/injection points	16	points			
	Treatment zone volume	112,500	ft^3			
	Volume pore space	28,125	ft^3			
5c.	**Fracturing and Injection Point Installation Details**					
	Number of Rigs	1	rigs			
	Mob/demob	1	LS	$30,000	=	$ 30,000
	Fracture/Injection points completed per day	1	points per day			
	Direct Push/Fracture/Injection contractor	16	days	$15,000	=	$ 240,000
	TOTAL FOR AMENDMENT INJECTION					**$ 270,000**
5e.	**Amendment Details**					
	Percentage amendment by soil mass	0.50%	lb amendment/lb soil			
	Mass of amendment required	56,250	lbs	$1.90	=	$ 106,875
	Truck delivery	1	LS	$20,000	=	$ 20,000
	TOTAL FOR AMENDMENTS					**$ 126,875**
5f.	**Vapor Mitigation System**					
	Mob/demob	1	ea	$5,000	=	$ 5,000
	Installation by subcontractor of Vapor Mitigation System	1	LS	$35,000	=	$ 35,000
	Total for Vapor Mitigation					**$ 40,000**
	Subtotal for In-situ Chemical Reduction and Bioremediation					$ 654,875
	Insurance and bond (5%)					$ 33,000
	TOTAL IN-SITU TREATMENT					**$ 688,000**

Description: Individual Cost Item Backup for Alternative 4

		Quantity	Unit	Unit Cost		Extended Cost
No. 3	**Long Term Monitoring**					
	Monitoring Wells to sample	20	wells			
	Soil Vapor Samples	5	samples			
	Number of samplers	2	people			
	Number of 12 hour workdays	7	days			
	<u>Sampling Project Planning (e.g., Staffing, Lab Procurement, Obtaining Equipment)</u>					
	Project Manager	16	hr	$160	=	$2,560
	Geologist	50	hr	$110	=	$5,500
	Procurement Specialist	40	hr	$110	=	$4,400
	<u>Field Sampling Labor</u>					
	Mob/demob	60	hr	$110	=	$6,600
	Sampling	168	hr	$110	=	$18,480
	<u>Travel Expense and per Diem</u>					
	Van and car rental	7	day	$95	=	$665
	<u>Sampling Equipment, Shipping, Consumable Supplies</u>					
	Equipment & PPE	1	ea	$3,500	=	$3,500
	Shipping	7	day	$200	=	$1,400
	Misc	7	day	$75	=	$525
	<u>Sampling Analysis</u>					
	VOCs (TO-15 vapor)	5	ea	$190	=	$950
	VOCs (groundwater)	29	ea	$80	=	$2,320
	MEE	29	ea	$120	=	$3,480
	TOC	29	ea	$30	=	$870
	Nitrate	29	ea	$25	=	$725
	Sulfate	29	ea	$25	=	$725
	Ferrous Iron	29	ea	$18	=	$522
	Chloride	29	ea	$15	=	$435
	Alkalinity	29	ea	$20	=	$580
	Metals	29	ea	$120	=	$3,480
	<u>Data Validation</u>					
	Assume samples validated @ 1 hr per sample					
	Samples management/validation	261	hr	$110	=	$28,710
	<u>Sampling Report</u>					
	Project Manager	16	hr	$160	=	$2,560
	Environmental Engineer	40	hr	$110	=	$4,400
	Geologist	40	hr	$110	=	$4,400
	Admin Clerk	16	hr	$75	=	$1,200
	TOTAL GROUNDWATER SAMPLING COST PER EVENT					**$ 99,000**

Description: Individual Cost Item Backup for Alternative 4

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

This is a problem of the form find (P given A, i, n) or (P/A,i,n)

P = Present Worth

A= Annual amount

i = interest rate

$$P = A \times \frac{(1+i)^n - 1}{i(1+i)^n}$$

A. Long Term Monitoring - year 3- 30

Multiplier is (P/A) for five years minus (P/A) for year 1)

n =	30
i =	7%
The multiplier for $(P/A)_2$ =	**12.409**
n =	2
i =	7%
The multiplier for $(P/A)_2$ =	**1.808**
Net	**10.601**

B. Amendment Emplacement Round 2 in Year 5

Multiplier is (P/A) for five years minus (P/A) for four years)

n =	5
i =	7%
The multiplier for $(P/A)_2$ =	**4.100**
n =	4
i =	7%
The multiplier for $(P/A)_2$ =	**3.387**
Net	**0.713**

Alternative 5
Combined Technologies
Cost Estimate Summary
Former Paul Miller Dry Cleaners
Port Richmond, NY

Item No.	Item Description	Extended Cost
CAPITAL COSTS		
1.	Pre-design Investigation	$ 295,000
2.	Microcosm Study	$ 60,000
3.	Pilot Study	$ 400,000
4.	Remedial Design	$ 601,000
5.	In-situ Thermal Remediation	$ 2,329,000
6.	In-situ ISCR and EAB Round 1	$ 1,700,000
7.	In-situ ISCR and EAB Round 2 (with discounting)	$ 425,000
	Subtotal	**$ 5,810,000**
	Contingency (20%)	$ 1,162,000
	TOTAL CAPITAL COSTS	**$ 6,972,000**
OPERATION & MAINTENANCE (O&M) COSTS		
Annual O&M Costs		
8	Long Term Monitoring (quarterly yr 1-2, annually yr 3 - 30)	$ 99,000
PRESENT WORTH OF 30 YEAR COSTS (with discounting)		
9.	Total Capital Costs	$ 6,972,000
10.	Monitoring Costs	$ 1,842,000
	TOTAL PRESENT WORTH OF 30 YEAR COSTS	**$ 8,814,000**

Notes:

1. Present worth calculation assumes 7% discount rate after inflation is considered.

Description: Individual Cost Item Backup for Alternative 5

		Quantity	Unit	Unit Cost		Extended Cost
No. 1	**Pre-design Investigation**					
1a.	**Project Management and Office Support**					
	Include project management, subcontractor procurement, preparation of QAPP and HASP					
	Project Manager	20	hr	$160	=	$3,200
	Project Engineer	80	hr	$110	=	$8,800
	Geologist	80	hr	$110	=	$8,800
	Chemist	40	hr	$110	=	$4,400
	Procurement Specialist	40	hr	$110	=	$4,400
	Total Project Management and Office Support					$29,600
1b.	**Groundwater Screening**					
	Number of Locations	40	locations			
	Samples per location	1	samples			
	End depth at each location	40	ft			
	Locations per day	2	locations			
	Number of direct push days	20	Days			
	Drilling					
	GeoProbe mob/demob	1	LS	$8,000	=	$8,000
	GeoProbe and operators	20	days	$1,500	=	$30,000
	Decon pad	1	LS	$1,000	=	$1,000
	Decon of equipment	5	hr	$100	=	$500
	Drum	20	ea	$120	=	$2,400
	Drum disposal/sampling	20	ea	$200	=	$4,000
	Field Sampling Labor					
	Persons	2	persons			
	12-hour days	20	days			
	Mob/demob	20	hr	$110	=	$2,200
	Sampling	480	hr	$110	=	$52,800
	Travel Expense and per Diem					
	Van and car rental	40	day	$95	=	$3,800
	Sampling Equipment, Shipping, Consumable Supplies					
	Equipment & PPE	1	ea	$4,000	=	$4,000
	Shipping	20	day	$100	=	$2,000
	Misc	20	day	$100	=	$2,000
	Sample Analysis					
	VOCs	40	ea	$120	=	$4,800
	Metals	40	ea	$120	=	$4,800
	Data Validation					
	Assume samples validated @ 0.5 hr per sample					
	Samples management/validation	20	hr	$110	=	$2,200
	Total Groundwater Screening					$124,500
1c.	**Well Installation**					
	Monitoring Wells to install	4	wells			
	Well depth	45	ft			
	Screen length	10	ft			
	Drilling					
	Driller mob/demob	1	LS	$10,000	=	$10,000
	Boring 6 inch mud rotary	180	ft	$35	=	$6,300
	4-inch PVC screen	40	ft	$15	=	$600
	4-inch PVC casing	140	ft	$15	=	$2,100
	Well completion materials	180	ft	$8	=	$1,440
	Well development	20	hr	$110	=	$2,200
	Drums	4	LS	$50	=	$200
	Drum transport	4	LS	$200	=	$800
	Field Geologist					
	Mob/demob	10	hr	$110	=	$1,100
	Well drilling and development	44	hr	$110	=	$4,840
	Travel Expense and per Diem					
	Van and car rental	4	day	$95	=	$380
	Misc	4	day	$75	=	$300
	IDW Disposal					
	Drum	4	ea	$120	=	$480
	Drum disposal/sampling	4	ea	$200	=	$800
	Subtotal for Monitoring Wells installation					$31,540

1d.	**Synoptic Water Level and Groundwater Sampling**					
	Monitoring Wells to sample	21	wells			
	Number of samplers	2	people			
	Number of 12 hour workdays	7	days			
	Field Sampling Labor					
	Mob/demob	20	hr	$95	=	$1,900
	Well Sampling	168	hr	$95	=	$15,960
	Travel Expense and per Diem					
	Van and car rental	7	day	$95	=	$665
	Sampling Equipment, Shipping, Consumable Supplies					
	Equipment & PPE	1	ea	$3,500	=	$3,500
	Shipping	7	day	$200	=	$1,400
	Misc	7	day	$75	=	$525
	Sampling Analysis					
	VOCs	31	ea	$120	=	$3,720
	MEE	31	ea	$120	=	$3,720
	TOC	31	ea	$30	=	$930
	Nitrate	31	ea	$25	=	$775
	Sulfate	31	ea	$25	=	$775
	Ferrous Iron	31	ea	$18	=	$558
	Chloride	31	ea	$15	=	$465
	Alkalinity	31	ea	$20	=	$620
	Metals	31	ea	$120	=	$3,720
	Dehalococcoides	21	ea	$450	=	$9,450
	Data Management and Validation					
	Assume samples validated @ 0.5 hr per sample per analyte					
	Samples management/validation	150	hr	$110	=	$16,500
	Total Synoptic Water Level and Groundwater Sampling					$65,183
1e.	**Pre-design Investigation Report**					
	Assume include the data evaluation and management during sampling					
	Project Manager/Senior Reviews	40	hr	$160	=	$6,400
	Project Engineer	120	hr	$110	=	$13,200
	Project Geologist	120	hr	$110	=	$13,200
	Chemist	50	hr	$110	=	$5,500
	Data Management	50	hr	$110	=	$5,500
	Total Pre-design Investigation Report					$43,800
	TOTAL PRE-DESIGN INVESTIGATION:					**$295,000**

Description:	Individual Cost Item Backup for Alternative 5					
		Quantity	Unit	Unit Cost		Extended Cost
No. 2	**Remedial Design**					
	To include the analysis of investigation results and existing data, preparation of the remedial design including draft, pre-final, and final design packages consisting of specifications, drawings, design analysis report, and construction cost estimate.					
	Prices are estimated based on CDM Smith's experience on similar projects					
	Project management and meetings	700	hr	$160	=	$112,000
	Site visits	5	LS	$150	=	$750
	Prepare for draft submittal	1800	hr	$110	=	$198,000
	Cost estimate	140	hr	$110	=	$15,400
	Value engineering	200	hr	$110	=	$22,000
	Prepare for final submittal	1800	hr	$110	=	$198,000
	Prepare for final cost estimate	140	hr	$110	=	$15,400
	Post final engineering support	350	hr	$110	=	$38,500
	TOTAL REMEDIAL DESIGN COST:					**$601,000**

Description: Individual Cost Item Backup for Alternative 5

No.	Item	Quantity	Unit	Unit Cost		Extended Cost
No. 3	**In-situ Thermal Remediation**					
3a.	**Construction Management & Operations - General Conditions**					
	Timeperiods are calculated in 5b below					
	Construction time period	3	weeks			
	Operations Timeperiod	21	weeks			
	Cooldown and Well Abandonment Time period	2	weeks			
	TOTAL CONSTRUCTION AND OPERATIONS TIME	27	weeks			
	Pre-Mobilization Work Plans					
	Project Manager	20	hr	$160	=	$3,200
	Environmental Engineer	60	hr	$110	=	$6,600
	Scientist	60	hr	$110	=	$6,600
	Admin Clerk	10	hr	$75	=	$750
	Permit Applications					
	Project Manager	40	hr	$160	=	$6,400
	Environmental Engineer	240	hr	$110	=	$26,400
	Scientist	240	hr	$110	=	$26,400
	Permit Fees for Gas, Power, Air & Water Discharge					$40,000
	Subcontractor Procurement					
	Assume procurement of driller, IDW, laboratory, thermal remediation subcontractors					
	Project Manager	60	hr	$160	=	$9,600
	Environmental Engineer	40	hr	$110	=	$4,400
	Geologist	30	hr	$110		$3,300
	Scientist	30	hr	$110	=	$3,300
	Procurement specialist	50	hr	$110	=	$5,500
	During Construction and Cooldown/Well Abandonment					
	Project Manager (10 hrs/wk)	53	hr	$160	=	$8,444
	Engineer (16 hrs/wk)	84	hr	$110	=	$9,289
	Site Superintendent (70 hrs/wk)	53	hr	$100	=	$5,278
	Site Trucks (2 per work days)	5	week	$250	=	$1,319
	Per Diem (2 people per work days)	11	day	$323	=	$3,409
	Health and Safety Engineer (16 hrs/wk)	84	hr	$125	=	$10,556
	Admin Clerk (assume 4 hrs/wk)	21	hr	$75	=	$1,583
	Subcontract management (10 hrs/week)	53	hr	$75	=	$3,958
	Meetings	18	LS	$500	=	$9,000
	Weekly calls	5	per	$500	=	$2,639
	Two Trailers with utilities	1	LS	$60,000	=	$60,000
	During Operations					
	Project Manager (10 hrs/wk)	214	hr	$160	=	$34,286
	Engineer (16 hrs/wk)	343	hr	$110	=	$37,714
	Site Superintendent (70 hrs/wk)	1,500	hr	$100	=	$150,000
	Site Trucks (2 per work days)	21	week	$250	=	$5,357
	Per Diem (2 people per work days)	0	day	$323	=	$0
	Health and Safety Engineer (16 hrs/wk)	343	hr	$125	=	$42,857
	Admin Clerk (assume 4 hrs/wk)	86	hr	$75	=	$6,429
	Subcontract management (10 hrs/week)	214	hr	$75	=	$16,071
	Meetings	18	LS	$500	=	$9,000
	Weekly calls	21	per	$500	=	$10,714
	Two Trailers with utilities	1	LS	$60,000	=	$60,000
	Site Security					
	Assume full time security guard, 12 hours during the weekday and 24 hours per day on weekend					
	Security guard	3	wk	$4,320	=	$14,592
	Remedial Action Reports					
	Project Manager	40	hr	$160	=	$6,400
	Environmental Engineer	240	hr	$110	=	$26,400
	Scientist	80	hr	$110	=	$8,800
	Admin Clerk	40	hr	$75	=	$3,000
	Geologist	120	hr	$110	=	$13,200
	Total for Construction Management					**$703,000**

No.	Item	Quantity	Unit	Unit Cost			Extended Cost
3b.	**ISTR Implementation**						
	Assume thermal conductive heating with gas-fired heating wells						
	Drilling costs						
	Treatment area	6,000	SF				
	Heating well Radius of Influence	5.0	ft				
	Number of heating wells	70	wells				
	Total depth of heating wells	35	ft bgs				
	Temperature monitoring points	6	points				
	Total number of 8 inch borings	76	borings				
	Number of Drill Rigs	3	rigs				
	Installations per rig per day	1.5	points per day				
	Days for drilling	17	days				
	weeks for drilling	3	weeks				
	Number of soil vapor extraction wells	9	borings	(same borings as heating wells)			
	Total depth of SVE wells	7	ft				
	Boring total	2,660	ft	$40	=	$	106,400
	Drill cuttings per drilled foot	2.6	gal/ft				
	Drill cuttings waste	6916	gal		=	$	-
	Drilling mud waste	6916	gal				
	Barrels of waste	346	barrels	$250	=	$	86,450
	TOTAL DRILLING COSTS					**$**	**193,000**
	Natural Gas Costs for Heating Wells						
	Average natural gas usage per well per day	1.46	mcf/day				
	Total heating treatment time	150	days				
	Total natural gas usage	15,288	mcf				
	Design remediation energy	15,288	mcf	$7	=	$	107,013
	TOTAL ENERGY COSTS					**$**	**108,000**
	Disposal and Other Costs - non-TCH vendors						
	Water Collection and Disposal	$200,000	LS			$	200,000
	Vapor Insulation Cover	$80,000	LS			$	80,000
	TOTAL DISPOSAL/MISCELLANEOUS COSTS					**$**	**280,000**
	TCH Subcontractor costs						
	Design, workplan, permits	$75,000	LS			$	75,000
	Mobilization and Materials	76	heating wells	$1,000	=	$	76,000
	Subsurface Installation	76	heating wells	$4,000	=	$	304,000
	Surface Installation and Startup	76	heating wells	$1,250	=	$	95,000
	System operation - control unit and labor	150	days	$2,000		$	300,000
	Vapor Extraction and Treatment	$65,000	LS				$65,000
	Demobilization and Final Report	$50,000	LS				$50,000
	Well Abandonment						
	Well abandonment (grouting)	2,660	ft	$30	=	$	79,800
	Wells abandoned per day	8	wells				
	Days for abandonment	10	days				
	Weeks for abandonment	2	weeks				
	TOTAL SUBCONTRACTOR COSTS					**$**	**1,044,800**
					ISTR Total	**$**	**2,329,000**

Description:	Individual Cost Item Backup for Alternative 5						
		Quantity	Unit	Unit Cost			Extended Cost
No. 4a	**In-situ treatment**						
	Construction Management & Operations - General Conditions						
	Timeperiods are calculated in 5b below						
	Drilling, Fracturing and Injection time period	11	weeks				
	TOTAL CONSTRUCTION AND OPERATIONS TIME	11	weeks				
	Pre-Mobilization Work Plans						
	Project Manager	20	hr	$160	=		$3,200
	Environmental Engineer	60	hr	$110	=		$6,600
	Scientist	60	hr	$110	=		$6,600
	Admin Clerk	10	hr	$75	=		$750
	Permit Applications						
	Project Manager	40	hr	$160	=		$6,400
	Environmental Engineer	120	hr	$110	=		$13,200
	Scientist	120	hr	$110	=		$13,200
	Subcontractor Procurement						
	Assume procurement of driller, IDW, laboratory, drilling and injection subcontractors						
	Project Manager	60	hr	$160	=		$9,600
	Environmental Engineer	40	hr	$110	=		$4,400
	Geologist	30	hr	$110			$3,300
	Scientist	30	hr	$110	=		$3,300
	Procurement specialist	50	hr	$110	=		$5,500
	During Construction & Operations						
	Project Manager (10 hrs/wk)	112	hr	$160	=		$17,920
	Engineer (16 hrs/wk)	179	hr	$110	=		$19,712
	Site Superintendent (10 hrs/wk)	112	hr	$100	=		$11,200
	Site Trucks (2 per work days)	11	week	$250	=		$2,800
	Health and Safety Engineer (16 hrs/wk)	179	hr	$125	=		$22,400
	Admin Clerk (assume 4 hrs/wk)	45	hr	$75	=		$3,360
	Subcontract management (10 hrs/week)	112	hr	$75	=		$8,400
	Meetings	18	LS	$500	=		$9,000
	Weekly calls	11	per	$500	=		$5,600
	Two Trailers with utilities	1	LS	$35,000	=		$35,000
	Site Security						
	Assume full time security guard, 12 hours during the weekday and 24 hours per day on weekend						
	Security guard	11	wk	$4,320	=		$48,384
	Remedial Action Reports						
	Project Manager	40	hr	$160	=		$6,400
	Environmental Engineer	240	hr	$110	=		$26,400
	Scientist	80	hr	$110	=		$8,800
	Admin Clerk	40	hr	$75	=		$3,000
	Geologist	120	hr	$110	=		$13,200
	Total for Construction Management						**$318,000**
	Hydraulic Fracturing and Amendment Injection						
	Area of treatment zone	39,000	ft^2				
	Radius of Influence	15.0	ft				
	Total depth	35	ft bgs				
	Treatment zone thickness	10	ft				
	Estimated total porosity	0.25	--				
	Assume soil bulk density	100	lb/ft^3				
	Mass of soil in treatment zone	39,000,000	lbs				
	Number of fracture/injection points	56	points				
	Treatment zone volume	390,000	ft^3				
	Volume pore space	97,500	ft^3				
	Fracturing and Injection Point Installation Details						
	Number of Rigs	1	rigs				
	Mob/demob	1	LS	$30,000	=	$	30,000
	Fracture/Injection points completed per day	1	points per day				
	Direct Push/Fracture/Injection contractor	56	days	$15,000	=	$	840,000
	TOTAL FOR AMENDMENT INJECTION					**$**	**870,000**
	Amendment Details						
	Percentage amendment by soil mass	0.50%	lb amendment/lb soil				
	Mass of amendment required	195,000	lbs	$1.90	=	$	370,500
	Truck delivery	1	LS	$20,000	=	$	20,000
	TOTAL FOR AMENDMENTS					**$**	**390,500**
	Vapor Mitigation System						
	Mob/demob	1	ea	$5,000	=	$	5,000
	Installation by subcontractor of Vapor Mitigation System	1	LS	$35,000	=	$	35,000
	Total for Vapor Mitigation					**$**	**40,000**
	Subtotal for In-situ Chemical Reduction and Bioremediation					$	1,618,500
	Insurance and bond (5%)					$	81,000
	TOTAL IN-SITU TREATMENT					**$**	**1,700,000**

Description: Individual Cost Item Backup for Alternative 5						
	Quantity	Unit	Unit Cost			Extended Cost
No. 4b In-situ treatment						
Construction Management & Operations - General Conditions						
Timeperiods are calculated in 5b below						
Drilling, Fracturing and Injection time period	3	weeks				
TOTAL CONSTRUCTION AND OPERATIONS TIME	3	weeks				
Pre-Mobilization Work Plans						
Project Manager	20	hr	$160	=		$3,200
Environmental Engineer	60	hr	$110	=		$6,600
Scientist	60	hr	$110	=		$6,600
Admin Clerk	10	hr	$75	=		$750
Permit Applications						
Project Manager	40	hr	$160	=		$6,400
Environmental Engineer	120	hr	$110	=		$13,200
Scientist	120	hr	$110	=		$13,200
Subcontractor Procurement						
Assume procurement of driller, IDW, laboratory, drilling and injection subcontractors						
Project Manager	60	hr	$160	=		$9,600
Environmental Engineer	40	hr	$110	=		$4,400
Geologist	30	hr	$110			$3,300
Scientist	30	hr	$110	=		$3,300
Procurement specialist	50	hr	$110	=		$5,500
During Construction & Operations						
Project Manager (10 hrs/wk)	28	hr	$160	=		$4,480
Engineer (16 hrs/wk)	45	hr	$110	=		$4,928
Site Superintendent (10 hrs/wk)	28	hr	$100	=		$2,800
Site Trucks (2 per work days)	3	week	$250	=		$700
Health and Safety Engineer (16 hrs/wk)	45	hr	$125	=		$5,600
Admin Clerk (assume 4 hrs/wk)	11	hr	$75	=		$840
Subcontract management (10 hrs/week)	28	hr	$75	=		$2,100
Meetings	18	LS	$500	=		$9,000
Weekly calls	3	per	$500	=		$1,400
Two Trailers with utilities	1	LS	$35,000	=		$35,000
Site Security						
Assume full time security guard, 12 hours during the weekday and 24 hours per day on weekend						
Security guard	3	wk	$4,320	=		$12,096
Remedial Action Reports						
Project Manager	40	hr	$160	=		$6,400
Environmental Engineer	240	hr	$110	=		$26,400
Scientist	80	hr	$110	=		$8,800
Admin Clerk	40	hr	$75	=		$3,000
Geologist	120	hr	$110	=		$13,200
Total for Construction Management						**$213,000**
Hydraulic Fracturing and Amendment Injection						
Area of treatment zone	9,750	ft^2				
Radius of Influence	15.0	ft				
Total depth	35	ft bgs				
Treatment zone thickness	10	ft				
Estimated total porosity	0.25	--				
Assume soil bulk density	100	lb/ft^3				
Mass of soil in treatment zone	9,750,000	lbs				
Number of fracture/injection points	14	points				
Treatment zone volume	97,500	ft^3				
Volume pore space	24,375	ft^3				
Fracturing and Injection Point Installation Details						
Number of Rigs	1	rigs				
Mob/demob	1	LS	$30,000	=	$	30,000
Fracture/Injection points completed per day	1	points per day				
Direct Push/Fracture/Injection contractor	14	days	$15,000	=	$	210,000
TOTAL FOR AMENDMENT INJECTION					**$**	**240,000**
Amendment Details						
Percentage amendment by soil mass	0.50%	lb amendment/lb soil				
Mass of amendment required	48,750	lbs	$1.90	=	$	92,625
Truck delivery	1	LS	$20,000	=	$	20,000
TOTAL FOR AMENDMENTS					**$**	**112,625**
Subtotal for In-situ Chemical Reduction and Bioremediation					$	565,625
Insurance and bond (5%)					$	29,000
TOTAL IN-SITU TREATMENT					**$**	**595,000**

Description: Individual Cost Item Backup for Alternative 5

		Quantity	Unit	Unit Cost		Extended Cost
No. 5	**Long Term Monitoring**					
	Monitoring Wells to sample	20	wells			
	Soil Vapor Samples	5	samples			
	Number of samplers	2	people			
	Number of 12 hour workdays	7	days			
	Sampling Project Planning (e.g., Staffing, Lab Procurement, Obtaining Equipment)					
	Project Manager	16	hr	$160	=	$2,560
	Geologist	50	hr	$110	=	$5,500
	Procurement Specialist	40	hr	$110	=	$4,400
	Field Sampling Labor					
	Mob/demob	60	hr	$110	=	$6,600
	Sampling	168	hr	$110	=	$18,480
	Travel Expense and per Diem					
	Van and car rental	7	day	$95	=	$665
	Sampling Equipment, Shipping, Consumable Supplies					
	Equipment & PPE	1	ea	$3,500	=	$3,500
	Shipping	7	day	$200	=	$1,400
	Misc	7	day	$75	=	$525
	Sampling Analysis					
	VOCs (TO-15 vapor)	5	ea	$190	=	$950
	VOCs (groundwater)	29	ea	$80	=	$2,320
	MEE	29	ea	$120	=	$3,480
	TOC	29	ea	$30	=	$870
	Nitrate	29	ea	$25	=	$725
	Sulfate	29	ea	$25	=	$725
	Ferrous Iron	29	ea	$18	=	$522
	Chloride	29	ea	$15	=	$435
	Alkalinity	29	ea	$20	=	$580
	Metals	29	ea	$120	=	$3,480
	Data Validation					
	Assume samples validated @ 1 hr per sample					
	Samples management/validation	261	hr	$110	=	$28,710
	Sampling Report					
	Project Manager	16	hr	$160	=	$2,560
	Environmental Engineer	40	hr	$110	=	$4,400
	Geologist	40	hr	$110	=	$4,400
	Admin Clerk	16	hr	$75	=	$1,200
	TOTAL GROUNDWATER SAMPLING COST PER EVENT					**$ 99,000**

Description: Individual Cost Item Backup for Alternative 5

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

This is a problem of the form find (P given A, i, n) or (P/A,i,n)

P = Present Worth

A= Annual amount

i = interest rate

$$P = A \times \frac{(1+i)^n - 1}{i(1+i)^n}$$

A. Long Term Monitoring - year 3- 30

Multiplier is (P/A) for five years minus (P/A) for year 1)

n =	30
i =	7%
The multiplier for $(P/A)_2$ =	**12.409**
n =	2
i =	7%
The multiplier for $(P/A)_2$ =	**1.808**
Net	**10.601**

B. Amendment Emplacement Round 2 in Year 5

Multiplier is (P/A) for five years minus (P/A) for four years)

n =	5
i =	7%
The multiplier for $(P/A)_2$ =	**4.100**
n =	4
i =	7%
The multiplier for $(P/A)_2$ =	**3.387**
Net	**0.713**