Feasibility Study Report

Beau Brummel Cleaners
Commack, New York
Site # 152211
Work Assignment # D-007618-28

February 2016

ARCADIS Design & Consultancy for natural and built assets

I, Daniel J. Loewenstein, certify that I am currently a NYS registered professional engineer and that this Report was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the DER Technical Guidance for Site Investigation and Remediation (DER-10) and that all activities were performed in full accordance with the DER approved work plan and any DER approved modifications.

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Site # 152211

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List of Acronyms

1,1,1-TCA	1,1,1-Trichloroethane
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-Dichloroethene
bgs	Below Ground Surface
BTEX	Benzene, toluene, ethylbenzene, and xylene
C&D	Construction and Demolition
CCl4	Carbon Tetrachloride
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/sec	centimeters per second
CO2	Carbon Dioxide
COC	Chemical Compounds of Concern
CVOCs	Chlorinated Volatile Organic Compounds
DER	Division of Environmental Remediation
DHE	Dehalococcoides ethanogenes
DO	Dissolved Oxygen
DW	Dry Well
Earth Tech	Earth Tech, Inc.
ESI	Expanded Site Investigation
ESTCP	Environmental Security Technology Certification Program
ETI	Environmental Technology, Inc.
GRAs	General Response Actions
GSA	General Services Administration
ISCO	In-situ chemical oxidation
KMnO4	Potassium permanganate
MCLs	Maximum Contaminant Levels
MNA	Monitored Natural Attenuation

MnO_2	Manganese dioxide
MTBE	Methyl tertiary-butyl ether
MW	Monitoring Well
$NaMnO_4$	Sodium permanganate
NAPLs	Non-aqueous Phase Liquids
NOM	Natural Organic Matter
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O & M	Operation and Maintenance
PAHs	Polycyclic aromatic hydrocarbons
PCE	Tetrachloroethene
ppm	part-per-million
PRBs	Permeable Reactive Barriers
PSA	Preliminary Site Assessment
RAGS	Risk Assessment Guidance for Superfund
RAOs	Remedial Action Objectives
$S_2O_8^{2-}$	Persulfate anion
SAT	Site Assessment Team
SCG	Standards, Criteria, and Guidance
$SO_4^{2-\bullet}$	Sulfate free radical
SSD	Sub-Slab Depressurization
SVE	Soil Vapor Extraction
TCE	Trichloroethene
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency
UV	Ultraviolet

VC	Vinyl Chloride
VOCs	Volatile Organic Compound

1. Introduction

This Feasibility Study Report has been developed to screen and evaluate remedial alternatives for contaminants in groundwater and off-site soil vapor in the vicinity of the Beau Brummel Cleaners site in Commack, New York (Figure 1). The purpose of this report is to:

- Identify potentially feasible technologies to remediate the dissolved-phase volatile organic compound (VOC) plume in the vicinity of the Beau Brummel site;
- Identify potentially feasible soil vapor intrusion remedial technologies for the adjacent property at 2045 Jericho Turnpike;
- Evaluate whether other off-site buildings are being impacted, or have the potential to be impacted by site related contamination;
- Evaluate these technologies based on eight evaluation criteria; and
- Compare remedial measure alternatives that could be implemented to meet Remedial Action Objectives (RAOs) and provide site-specific information on performance of the remedial technology.

The remedy for the groundwater contaminant plume to the northeast, east and south of the site, and soil vapor intrusion at 2045 Jericho Turnpike and other off-site properties that are found to be impacted will not be selected until this evaluation, and subsequent NYSDEC assessments, have been thoroughly reviewed and presented to the public. The goals of this remedy are discussed in Section 2.1. This Feasibility Study (FS) was completed in accordance with NYSDEC Division of Environmental Remediation (DER) Technical Guidance for Site Investigation and Remediation (DER-10), NYSDEC DER program policy for Presumptive/Proven Remedial Technologies (DER-15), and other appropriate NYSDEC guidance.

1.1 Site Location and Description

The Beau Brummel Cleaners site is located in a mixed commercial and residential area in Commack, New York. The site address is 2049 Jericho Turnpike and it is located in the Town of Smithtown in Suffolk County. The site consists of an approximately 0.25-acre parcel with a one-story building. Paved parking areas surround the building to the north, west, and south. The property is bordered to the west by the Commack Beverage Center (2055 Jericho Turnpike), to the east by a 7-Eleven convenience store (2045 Jericho Turnpike), to the north by a church (10 Beechwood Lane), and to the south by Jericho Turnpike. There are commercial properties south of Jericho Turnpike. An aerial photograph is included as Figure 2.

Dissolved-phase VOCs, primarily tetrachloroethene (PCE) are present in groundwater beneath the Beau Brummel Cleaners property and extend off-site approximately 420 feet to the east and 180 feet to the south across Jericho Turnpike. Soil vapor contamination by VOCs also extends off-site, although the extent of this impact has not been completely delineated.

1.2 Site History

Previous remedial investigations at the Beau Brummel site include the following activities:

- In April 1998, elevated levels of PCE were detected in a sludge sample during a routine inspection of a sanitary system by the Suffolk County Department of Health Services (SCDHS). Remediation of the sanitary system was completed in July 1998 as a result of these findings.

- In December 2004, PCE was detected at elevated levels in groundwater samples collected at the service station located east of the site across Beechwood Lane (2039 Jericho Turnpike). A 1,000-gallon storage tank that contained #2 fuel oil was also removed from the Beau Brummel site during this time. A 140-gallon above ground storage tank containing organic solvents had also been removed from the site in 1996.

- In March 2005, soil samples were collected from the site and found to contain PCE. These soil samples were collected in close proximity to where water had been discovered to be leaking from a misting spray unit that was used to evaporate treated water from the site.

- In February 2007, the NYSDEC designated the Beau Brummel Cleaners site as a potential Hazardous Waste Disposal Site. ID # 152211 was assigned to the site.

- In 2009, a Site Characterization (SC) Report was completed by AECOM. The SC indicated that PCE was the primary contaminant of concern (COC) in groundwater at and in the vicinity of the site. PCE concentrations detected in groundwater were the highest in on-site shallow wells MW-3S and MW-2S at concentrations of 370 micrograms per liter (µg/L) and 130 µg/L, respectively Other compounds detected in groundwater included TCE (detected in monitoring well MW-3S at a concentration of 18 µg/L), cis-1,2-DCE (detected in on-site monitoring wells MW-3S and MW-2S [68 µg/L and 6.30 µg/L] respectively and at offsite locations MW-6S and MW-6I [35 µg/L and 6.4 µg/L] respectively), and benzene (4.8 µg/L at MW-4D). Acetone and aromatics were also detected in soil samples collected during monitoring well installations. PCE and TCE were detected in soil vapor and outdoor air samples collected during the SC, in addition to cis-1,2-DCE and xylenes.

- Soil samples collected at the site during the Site Characterization in 2009 indicated the presence of PCE, acetone, chlorobenzene, ethylbenzene and xylenes in soil, however, none of these compounds were detected above the Soil Cleanup Objectives for Unrestricted Use Criteria.

- Between March and October 2014, Hydrotech installed a Soil Vapor Extraction/Sub-slab Depressurization System (SVE/SSDS) as part of an Interim Removal Measure at the site. A pilot test well in the northern portion of the site was converted to an SVE well (PT-1), and another SVE well was installed in the southern portion of the site (PT-2). A sub-slab suction pit was also installed in the central area of the building (SD-1). All three of these extraction points are connected to a system blower in the northeast corner of the building. As-builts are provided in the IRM Construction Completion Report (Hydrotech, 2015). The system was started on October 17, 2014. Biannual system monitoring as well as groundwater monitoring is ongoing.

1.3 Conceptual Site Model

Information obtained during the RI and previous investigations was used to develop a conceptual site model, which summarizes the site-specific geology, the depth and flow of groundwater, and the potential CVOC sources. This model is used herein to facilitate the evaluation of potential CVOC source areas and migration pathways and provide an organizational structure for data collected during multiple investigations. These data include site-specific information on CVOCs in soil, groundwater, soil gas, sub-slab vapor, indoor and outdoor air and the geologic and hydrogeologic characteristics that affect the distribution, fate, and migration of the CVOCs. A summary of the analytical results from samples collected during the RI is provided in Appendix A. A summary of VOCs detected during the RI in groundwater and soil vapor is provided in Figure 3 (groundwater) and Figure 4 (soil vapor).

According to previous investigations, surface soil in the vicinity of the site generally consists of coarse to fine gravel with sand. Subsurface soil consists of coastal plain deposits of silty clay, sandy clay, and sand and gravel, known as the Magothy Formation. The site is located at an elevation of approximately 150 feet above mean sea level (AMSL) in northern Suffolk County (Figure 1). Regional topography consists of irregular inland highlands that slope toward water bodies. Groundwater is typically encountered at approximately 100 feet below ground surface (bgs). Regional groundwater flow in the vicinity of the site is generally to the east toward the Nissequogue River.

The hydraulic gradient is predominantly horizontal at and near the site.

Analytical data indicate that groundwater contains PCE and that the dissolved-phase VOC plume has migrated from the site to the east, northeast, and south. PCE concentrations in groundwater sampled during the RI at multiple depths from monitoring wells ranged from 3.6 to 99 µg/L. Degradation products of PCE include TCE, cis-1,2 DCE, and vinyl chloride (VC), and were generally not detected in groundwater, indicating that little natural attenuation of PCE is occurring within the aquifer. VOCs were detected in shallow-, intermediate- and deep-zone groundwater. This indicates that the VOCs within the plume have not only migrated laterally from Beau Brummel Cleaners site, but also migrated vertically downwards.

Analytical data indicate that sub-slab vapor and indoor air contain VOCs at the following properties: 2055 Jericho Turnpike, 2045 Jericho Turnpike, and two apartment complexes at 51 Mayfair Gardens. Consistent with groundwater quality, PCE was the primary CVOC present in the sub-slab vapor and indoor air samples. The highest concentration of PCE was detected to the east of the site at 253 $\mu g/m^3$, in a sub-slab vapor sample at 2045 Jericho Turnpike. PCE and TCE were also found in soil vapor to the east, across Jericho Turnpike at 330 $\mu g/m^3$ and 54 $\mu g/m^3$ respectively. Based on a review of the relevant information and analytical data from the residences and businesses where samples were collected, the NYSDEC and NYSDOH recommended monitoring and/or mitigation (installation of a sub-slab depressurization system) at 2045 Jericho Turnpike, which is located over the dissolved-phase VOC plume, and additional off-site investigation to determine if more buildings are impacted by site related soil vapor contamination.

1.3.1 Groundwater Exposure Pathway Assessment

No complete direct contact groundwater exposure pathways exist. Groundwater is not used for potable, commercial, agricultural, or industrial purposes at or near the site, and such uses are not planned. Groundwater use restrictions will be part of the site environmental covenant.

1.3.2 Soil Vapor Exposure Pathway Assessment

The basic model for soil vapor intrusion is vertical migration of vapors containing VOCs from a subsurface source to indoor air through cracks, foundation joints, or other openings in the floor. Understanding the migration of sub-slab soil vapors and indoor air movement is important in evaluating the potential soil vapor intrusion pathway. Even if VOCs are present in both sub-slab soil vapor and indoor air in the same building, a direct soil vapor intrusion pathway may not be conclusively determined because of air movement between buildings. Therefore, the sub-slab materials and the building construction need to be accounted for when evaluating corrective measures.

Potential human receptors include people in the adjacent building to the east of the site and in buildings to south and east. Potentially complete exposure pathways for on-site workers and occupants of off-site buildings related to soil vapor intrusion include inhalation of indoor air.

1.4 Current Remedial Actions

An SSD/SVE system was constructed by the property owner to remediate chlorinated VOCs in the source area soil and any soil vapor intrusion beneath the site, primarily PCE. This Feasibility Study does not evaluate remedies for the on-site source zone at the Beau Brummel Cleaners site, but does take into account the impacts of the continued operation of the SVE/SSDS.

2. Remedial Action Objectives and Evaluation Criteria

For the purposes of this feasibility study, and based on the results of previous site investigations, the remedial goal for the Beau Brummel Cleaners investigation area is to eliminate, to the extent practicable, exposures to VOCs in groundwater and indoor air, and to restore groundwater to pre-disposal conditions.

2.1 Remedial Action Objectives

RAOs are goals set for environmental media, such as soil, groundwater, sediment, surface water, soil vapor, and indoor air, which are intended to provide protection for human health and the environment. RAOs form the basis for the FS by providing overall goals for site remediation. The RAOs are considered during the identification of appropriate remedial technologies and formulation of alternatives for each site, and later during the evaluation of remedial alternatives. RAOs are based on engineering judgment, and potentially applicable or relevant and appropriate SCGs.

- Eliminate, to the extent practicable, exposures to VOCs in groundwater and indoor air;
- Minimize the migratory potential of the contaminants;
- Minimize the potential for human exposure to in-situ contaminated media; and
- Reduce the magnitude and extent of contamination in the affected media.

2.2 Evaluation Criteria

In accordance with DER-10 Technical Guidance for Site Investigation and Remediation (DER-10) (NYSDEC, 2010), the remedial measure alternatives developed in this Feasibility Study will be screened based on an evaluation of the following criteria:

- Overall Protection of Human Health and the Environment;
- Compliance with Standards, Criteria, and Guidance (SCGs);
- Long-term Effectiveness and Permanence;
- Reduction of Toxicity, Mobility, and Volume;
- Short-term Effectiveness;
- Implementability;

- Cost;
- Land Use;
- Community Acceptance.

2.2.1 Overall Protection of Human Health and the Environment

This criterion serves as a final check to assess whether each alternative meets the requirements that are protective of human health and the environment. The overall assessment of protection is based on a composite of factors assessed under other evaluation criteria; especially long-term effectiveness and performance, short-term effectiveness, and compliance with SCGs. This evaluation focuses on how a specific alternative achieves protection over time and how site risks and human exposures are reduced. The analysis includes how each source of contamination is to be eliminated, reduced or controlled for each alternative.

2.2.2 Compliance with SCGs

This evaluation criterion determines how each alternative complies with SCGs, as discussed and identified in Sections 3 and 4 of this Report. The actual determination of which requirements are applicable or relevant and appropriate is made by NYSDEC and in consultation with NYSDOH. If a SCG is not met, the basis for one of the four waivers allowed under 6 NYCRR Part 375-1.10(c)(i) is discussed. If an alternative does not meet the SCGs and a waiver is not appropriate or justifiable, such an alternative should not be considered further. The identification of potential SCGs is documented in Table 1.

This evaluation criterion assesses how each alternative complies with the following SCGs:

General:

6 NYCRR Part 375 – Environmental Remediation Programs, including the Inactive Hazardous Waste Disposal Site Remedial Program

6 NYCRR Part 371 – Identification and Listing of Hazardous Wastes

Water:

6 NYCRR Part 700-705, Water Quality Regulations for Surface Water and Groundwater

NYSDEC Division of Water TOGS 1.1.1 – Ambient Water Quality Standards and Groundwater Effluent Limitations

Air:

NYSDEC Division of Air Resources Policy DAR-1 – Guidelines for Control of Toxic Ambient Air Contaminants

NYSDOH October 2006 Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York

2.2.3 Long-term Effectiveness and Permanence

This evaluation criterion addresses the results of a remedial action in terms of its permanence and quantity/nature of waste or residual remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the waste or residual remaining at the site and operating system necessary for the remedy to remain effective. The factors being evaluated include the permanence of the remedial alternative, magnitude of the remaining risk, adequacy of controls used to manage residual waste, and reliability of controls used to manage residual waste.

2.2.4 Reduction of Toxicity, Mobility, and Volume

This evaluation criterion assesses the remedial alternative's use of the technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous wastes as their principal element. The NYSDEC's policy is to give preference to alternatives that eliminate any significant threats at the site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in the contaminants mobility, or reduction of the total volume of contaminated media. This evaluation includes: the amount of the hazardous materials that would be destroyed or treated, the degree of expected reduction in toxicity, mobility, or volume measured as a percentage, the degree in which the treatment would be irreversible, and the type and quantity of treatment residuals that would remain following treatment.

2.2.5 Short-term Effectiveness

This evaluation criterion assesses the effects of the alternative during the construction and implementation phase. Alternatives are evaluated with respect to the effects on human health and the environment during implementation of the remedial action. The aspects evaluated include: protection of the community during remedial actions, environmental impacts as a results of remedial actions, time until the remedial response objectives are achieved, and protection of workers during the remedial action.

2.2.6 Implementability

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. The evaluation includes: feasibility of construction and operation; the reliability of the technology; the ease of undertaking additional remedial action; monitoring considerations; activities needed to coordinate with other offices or agencies; availability of adequate off-site treatment, storage, and disposal services; availability of equipment; and the availability of services and materials.

2.2.7 Cost

Cost estimates are prepared and evaluated for each alternative. The cost estimates include capital costs, operation and maintenance (O&M) costs, and future capital costs. A cost sensitivity analysis is performed which includes the following factors: the effective life of the remedial action, the O&M costs, the duration of the cleanup, the volume of contaminated material, other design parameters, and the discount rate. Cost estimates developed at the detailed analysis of alternatives phase of a feasibility study generally have an exposed accuracy range of -30 to +50 percent (USEPA, 2000).

2.2.8 Community Acceptance

Following submission of this report and the generation of the Proposed Remedial Action Plan (PRAP) by the NYSDEC, a summary of the proposed remedial action will be sent to the project's contact list, which will include the date, time, and location of the public meeting, and announcement of the 30-day period for submission of written comments from the public. A Responsiveness Summary will be prepared to address public comments on the PRAP. After the submission of Responsiveness Summary, a final remedy will be selected and publicized. If the final remedy differs significantly from the proposed remedy, public notices will include descriptions of the differences and the reason for the changes.

2.2.9 Land Use

This criterion is an evaluation of the current, intended and reasonably anticipated future use of the site and its surroundings, as it relates to an alternative or remedy, when unrestricted levels would not be achieved.

3. Common Components of Remedial Alternatives

A Site Management Plan is a common element of the alternatives being evaluated for the Beau Brummel Cleaners investigation area (with the exception of the no action alternative) and is not discussed in the summary and evaluation of each alternative.

3.1 Site Management Plan

A Site Management Plan would guide future activities at the properties above the dissolved-phase VOC plume by developing requirements for periodic site management reviews. The periodic site management reviews would focus on evaluating these areas with regard to the continuing protection of human health and the environment as provided by information such as indoor air, soil vapor, sub-slab vapor, and groundwater monitoring results and documentation of field inspections. A sub-slab depressurization/soil vapor extraction (SSD/SVE) system is currently in use at the site. A long-term groundwater monitoring program that is associated with the SSD/SVE system is also in place. The Site Management Plan will likely mandate the ongoing monitoring of groundwater quality and/or the operation and maintenance of engineered mitigation systems, including the on-site SSD/SVE system, as well as prohibit the use of groundwater.

3.2 Institutional Controls

Groundwater use restrictions could be placed on the properties located above the dissolved-phase CVOC plume that would require compliance with the approved site management plan. No institutional controls, such as environmental easements or deed restrictions, are proposed for off-site properties. Costs for implementing institutional controls are not included in the remedial alternative cost estimates.

3.3 Soil Vapor Intrusion Action Plan

A Soil Vapor Intrusion (SVI) Action Plan would create guidance for monitoring soil vapor and indoor air COC concentrations in buildings located above the dissolved-phase CVOC plume and areas impacted by site-related soil vapor contamination. The SVI Action Plan will be developed and included in the final Site Management Plan (SMP)

3.4 General Response Actions

NYSDEC Program Policy DER-15: *Presumptive /Proven Remedial Technologies*, provides generally accepted presumptive remedies for various site media which comply with 6 NYCRR section 375-1.8. Presumptive remedies for VOC contaminated site media are presented in Section 4 of the DER-15 Guidance document. The purpose of the presumptive remedy approach is to streamline the remedy selection process by providing remedies that have been proven to be both feasible and cost-effective for specific site types and/or contaminants. In accordance with Section 4.2(a)3 of the NYSDEC Program Policy Draft DER-10: Technical Guidance for Site Investigation and Remediation, the use of presumptive remedies eliminates the need to screen the selected technologies and to proceed directly to the evaluation of the presumptive alternatives.

In accordance with DER-10 Section 4.2(a)3, general response actions (GRAs) have been identified which may be effective remedies for the remediation of soil vapor, groundwater, and/or surface water at the site. The GRAs identified include:

No Action - A no action response, required by the DER for the Feasibility Study (FS) process, provides a baseline for comparison with other alternatives.

Institutional Controls - Institutional controls are applied when active remedial measures do not achieve cleanup limits. Potential human exposure is reduced by limiting public access to site contaminants. Institutional controls such as environmental easements can also apply through an extended remediation period, or to sites where cleanups are completed up to feasible levels but still leave residual contamination greater than background levels.

Monitored Natural Attenuation (MNA) - MNA, also known as intrinsic remediation, bioattenuation, or intrinsic bioremediation, refers to the use of natural processes, such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials, as part of overall site remediation. MNA is a non-engineered remedial technique, which involves the degradation of the VOCs in the groundwater by naturally occurring processes (i.e., biodegradation). Such degradation is monitored over time under a long-term monitoring program.

In-situ Treatment - In-situ treatment for groundwater uses various technologies including biological, thermal, and reactive materials. In-situ treatment is effective in treating source areas of contamination but can be prohibitively expensive for treatment of large areas of groundwater contamination.

Removal Measures - Removal measures provide for the removal of contaminants or contaminated materials from their existing location for treatment (on-site or off-site) or disposal. Groundwater extraction systems are typically used to remove groundwater and are combined with various ex-situ treatment technologies including UV oxidation, air stripping, and granular activated carbon. The effluent treated water is often returned to the subsurface through injection wells, released to surface water bodies, or released to the local Publicly-Owned Treatment Works (POTW).

Containment/Barrier - Containment of groundwater includes remedial measures that contain or isolate contaminants on-site. Containment prevents migration of contaminants from the site or to downgradient areas and attempts to prevent direct human and ecological exposure to contaminated media. Examples of containment technologies are grout slurry walls, sheet piling, hydraulic control by pumping, and reactive barriers. Containment technologies are often combined with other treatment technologies to remove contamination.

4. Identification and Screening of Technologies

In this section selected technologies are described in general and are screened for their implementability and applicability to the site. Based on this screening, remedial technologies are retained or not retained for further consideration.

Technology types include such general categories as treatment or containment, whereas process options are specific processes within the general technology types (e.g., treatment via chemical oxidation, or containment using a treatment barrier). This section develops a list of potential technology types and process options for treatment and/or containment of groundwater impacted by VOCs at the sites. The retained technologies and process options are subsequently evaluated based on the evaluation criteria discussed in Section 2.2.Remedial strategies/technologies identified for screening include:

- No Further Action
- Long Term Monitoring
- Monitored Natural Attenuation
- In-situ Chemical Oxidation
- In-Situ Bioremediation
- Permeable Reactive Barriers
- Air Sparging/Soil Vapor Extraction
- Groundwater Extraction
- In-well Air Stripping
- Phytoremediation

Descriptions, evaluations, and screening of each of these potential remedial strategies/technologies are provided below.

GRAs for groundwater are limited to areas of PCE-impacted groundwater exceeding NYSDEC Class GA Standards. Impacts to groundwater are restricted to the source area near the on-site building south across Jericho Turnpike and northeastward across Beechwood Lane, an approximately one and one-half acre area (Figure 5) The PCE-impacted groundwater area is below several commercial properties, as well as a four-lane roadway.

4.1.1.1 No Further Action

The “no further action” option, by definition, involves no further institutional controls, environmental monitoring, or remedial action. The no further action option does not include groundwater or air monitoring to evaluate the effects of any natural attenuation processes at the site. Although the no further action option would be unable to meet the RAOs, in accordance with DER-10, it will be retained to provide a basis for comparison to other remedial alternatives.

4.1.1.2 Long-Term Monitoring

A long-term monitoring option would involve no active remediation in the Beau Brummel Cleaners Investigation area, but would monitor the plume stability and the natural reduction of the PCE contamination over time. If this option is selected for implementation, the dissolved-phase PCE plume would not be remediated other than with natural processes (i.e. dilution, dispersion, etc.). For this reason, this alterative alone would not be in compliance with SCGs, but would be effective in the short-term and protective of human health and the environment because groundwater is not used as a water supply and given the depth to groundwater, exposure to VOCs in groundwater is unlikely. The long-term monitoring option would not actively reduce the toxicity, mobility or volume of the dissolved-phase PCE plume, would require minimal effort to implement, and would have relatively low costs. Under the long-term monitoring option, the groundwater contamination plume would not be actively remediated, but groundwater VOC concentrations would be monitored periodically.

Groundwater samples would be collected semi-annually for 30 years (unless altered based on five-year reviews) from the entire monitoring well network (22 wells). Samples would be analyzed for VOCs to monitor contaminant concentrations and verify concentrations are not increasing or migrating into areas that previously had not exceeded NYSDEC GA Standards.

4.1.1.3 Monitored Natural Attenuation (MNA)

Consideration of this option usually requires evaluating contaminant degradation rates and pathways and predicting contaminant concentrations at downgradient receptor points. The primary objective of this evaluation would be to demonstrate that natural processes of contaminant degradation will reduce contaminant concentrations below regulatory standards or risk-based levels, before potential exposure pathways are completed. Long-term monitoring should be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives. A select group of existing monitoring wells would be monitored quarterly for the first year followed by annual sampling as needed.

Natural attenuation is not the same as no further action, although it often is perceived as such. The Comprehensive Environmental Response, Compensation, and Liability

Act (CERCLA) requires evaluation of a no further action alternative but does not require evaluation of natural attenuation. Natural attenuation is considered on a case-by-case basis. In all cases where natural attenuation is being considered, extensive site characterization and monitoring would be required, both before and after any potential implementation of this remedial option.

Compared with other remedial technologies, natural attenuation has the following advantages:

- Less generation or transfer of remediation wastes;
- Less intrusive;
- May be applied to all or part of a given site, depending on site conditions and cleanup objectives;
- May be used in conjunction with, or as a follow-up to, other (active) remedial measures; and
- Overall cost will likely be lower than active remediation.

Potential disadvantages of MNA include:

- Data used as input parameters for modeling need to be collected;
- Intermediate degradation products may be more mobile and more toxic than the original contaminant;
- Natural attenuation is not appropriate where imminent site risks are present;
- Contaminants may migrate before they are degraded;
- Institutional controls may be required, and the site may not be available for its highest reuse potential until contaminant levels are reduced;
- It is not meant to address source areas of relatively high contamination;
- There are long-term monitoring costs associated with this option; and

- Longer time frames would be required to achieve remedial objectives, compared to active remediation.

Analytical data indicates that natural biological degradation of the groundwater contamination in the Beau Brummel Cleaners investigation area is minimal. Because of this and the long time frame associated with natural attenuation processes, MNA will be not considered further. However, long-term groundwater monitoring will be considered as a remedial alternative.

4.1.1.4 In-situ Chemical Oxidation

In-situ chemical oxidation (ISCO) has been used since the early 1990s to treat environmental contaminants in groundwater, soil, and sediment. Many of these projects have focused on the treatment of chlorinated solvents (e.g., TCE and PCE), although several projects have also used the process to treat petroleum compounds [(i.e., benzene, toluene, ethylbenzene, and xylene (BTEX) and methyl tertiary-butyl ether (MTBE)] and semi-volatile organic compounds such as polycyclic aromatic hydrocarbons (PAHs) and pesticides (USEPA, 1998 and Siegrist, 2001).

ISCO is defined as the delivery and distribution of oxidants and other amendments into the subsurface to transform contaminants of concern into innocuous end products such as carbon dioxide (CO_2), water, and inorganic compounds. A chemical oxidant is injected in areas where a reduction in groundwater contaminant concentration is desired. Injection locations can be either permanently installed wells or temporary injection points installed using direct-push methods. When oxidants come in contact with chlorinated VOCs they are broken down into non-toxic components. However, contact between the oxidant and contaminant required to facilitate the reaction is the most important technical limitation of this technology, as it can be difficult to accomplish.

Accordingly, this remedial approach generally includes several injections over time accompanied by groundwater sampling and analysis. Numerous injections are typically required to remediate the treatment area. Given this and depending on the final contaminant concentration desired, the overall costs are typically medium to high relative to other technologies. Since the reaction with the contaminant and the chemical oxidant generally occurs over a relatively short period, treatment can be more rapid than other in-situ technologies. This technology does not generate large volumes of residual waste material that must be treated and/or disposed.

ISCO can be used to treat localized source areas and dissolved-phase plumes since it is capable of treating high concentrations of contaminants by adding more oxidants. ISCO typically becomes prohibitively expensive for large areas requiring treatment to low concentration endpoints.

Advantages of ISCO typically include:

- Relatively short remediation times in areas where groundwater flow does not introduce additional contaminants with time (typically one to two years);
- Limited long-term operation, maintenance, and monitoring (OM&M) costs in such settings;
- Treats both dissolved and sorbed contaminants concurrently;
- Treats compounds that are not readily biodegradable; and
- Breakdown of chlorinated VOCs without the generation of potentially more toxic degradation products (although not all chlorinated VOC mass may break down).

Disadvantages of ISCO include:

- Its application to areas with only the highest contaminant concentrations is typically most cost effective;
- The need to inject large volumes of oxidant (especially in areas where groundwater flow introduces additional contaminants over a long period of time from upgradient directions);
- The need for multiple injections;
- The difficulty of contacting oxidants with groundwater contaminants intended for destruction when injecting into low permeability or heterogeneous formations;
- Health and safety issues pertaining to field personnel associated with the handling and injection of oxidants and reagents;

- Relatively high costs per volume treated; and

- Naturally occurring carbon sources increase the oxidant demand in the treatment zone. The presence of carbonates can also add to the oxidant demand for certain ISCO chemicals.

The most common oxidants utilized for ISCO are hydrogen peroxide (Fenton's reagent), potassium and sodium permanganate, and sodium persulfate. A general summary of each of these oxidants is presented below.

<u>Fenton's Reagent (Hydrogen Peroxide)</u>

Hydrogen peroxide-based in-situ chemical oxidation is driven by the formation of a hydroxyl free radical in the presence of a metal catalyst. This reaction, known as the Haber-Weiss mechanism, was first utilized for the treatment of organic compounds in wastewater in the 1890s by H.J.H Fenton using an iron catalyst (Fenton's reagent). The hydroxyl free radical is a powerful oxidizer of organic compounds, thus many organic compounds in the subsurface that contact the chemical oxidant are readily degraded to innocuous compounds (e.g., water and carbon dioxide). Any residual hydrogen peroxide remaining after the reaction decomposes to water and oxygen. Soluble iron (ferrous iron), the transition metal catalyst added to the subsurface during injection of the oxidant mixture, is precipitated out of solution during conversion to ferric iron.

Typical hydrogen peroxide concentrations utilized for treatment with Fenton's reagent range from five to 50 percent by weight, however, concentrations less than 15 percent are utilized at a majority of sites. The hydrogen peroxide concentration used in the injection fluid is based on contaminant concentrations, subsurface characteristics, and treatment volume. Acids are also typically added to the injection solution to lower the pH of the contaminated zone if the natural pH is not low enough to promote the Fenton's reaction.

Compared to other oxidants, Fenton's reagent has a relatively short life once injected into the subsurface. Therefore, a larger number of Fenton's reagent injections would be required to sustain the oxidant in the subsurface compared to injections of other oxidants. For this reason, Fenton's reagent will not be retained for further consideration.

Sodium and Potassium Permanganate

Permanganate is an oxidizing agent with a unique affinity for oxidizing organic compounds with carbon-carbon double bonds (e.g., TCE and PCE), aldehyde groups or hydroxyl groups (alcohols). There are two forms of permanganate that are used for ISCO, potassium permanganate ($KMnO_4$) and sodium permanganate ($NaMnO_4$). Potassium permanganate has been used in drinking water and wastewater treatment for several decades to oxidize raw water contaminants, typically for odor control. Potassium permanganate is available as a dry crystalline material, while sodium permanganate is a liquid. Permanganate turns bright purple when dissolved in water; this purple color is an indicator of unreacted chemical. Reacted permanganate is black or brown, indicating the presence of a manganese dioxide (MnO_2) byproduct.

Sodium permanganate has a much higher solubility in water than potassium permanganate, allowing it to be used for ISCO at higher concentrations, compared to two to five percent for potassium permanganate. Since it is supplied in liquid form, the use of sodium permanganate commonly requires no on-site mixing. Sodium permanganate injections as a form of ISCO will be considered further.

Sodium Persulfate

Sodium persulfate is a strong oxidant that derives its oxidizing potential through the persulfate anion ($S_2O_8^{2-}$). The persulfate anion is capable of oxidizing a wide range of contaminants, including chlorinated ethenes, BTEX, phenols, MTBE, and low molecular weight PAHs. However, when catalyzed in the presence of heat (thermal catalyzation) or transition metals ions (i.e., ferrous iron), the persulfate ion is converted to the sulfate free radical ($SO_4^{2-}\bullet$), which is second only to Fenton's reagent in oxidizing potential. Sodium persulfate is supplied in an aqueous solution at concentrations up to 50 percent by weight. Sodium persulfate injections as a form of ISCO will not be considered further.

RegenOx®

RegenOx® is a proprietary mixture of oxidants used to treat VOCs in groundwater. A RegenOx® application will remove significant amounts of contamination from the subsurface and is typically applied using direct-injection techniques. The application process enables the two part product to be combined, then pressure injected into the zone of contamination and moved out into the aquifer media. Once in the subsurface, RegenOx® produces a cascade of efficient oxidation reactions via a number of mechanisms including: surface mediated oxidation, direct oxidation and free radical oxidation. These reactions eliminate contaminants and can be propagated in the presence of RegenOx® for periods of up to 30 days on a single injection. RegenOx® produces minimal heat and is highly compatible with follow-on enhanced bioremediation applications.

ISCO will not be retained for evaluation as a barrier remedial alternative because of the high cost and large number of injections that would be required to sustain a treatment wall/barrier. The multi-directional flow patterns in the vicinity of the Beau Brummel site make implementing ISCO as a barrier technology infeasible. However, as stated above, sodium permanganate will be considered further as a plume-wide ISCO treatment where a distribution of injection wells would be utilized within the plume.

4.1.1.5 Enhanced In-situ Bioremediation

Bioremediation (or enhanced biodegradation) is the controlled management of microbial processes in the subsurface. This differs from monitoring of bioremediation processes under monitored natural attenuation (MNA) by being an active, designed, and managed process. Some microorganisms, such as Dehalococcoides (DHC), break down VOCs to the end products ethane and ethene. Therefore, bioremediation can often be enhanced through biostimulation (substrates injected in-situ to promote microbial activity) or bioaugmentation (increasing of bioremediation by adding microbial cultures). Biostimulation is used to set the proper conditions for increased microbial activity and may be all that is needed for satisfactory remediation. Biostimulation is often focused in areas where microbial populations are marginal and/or under conditions that are insufficient to support practical biodegradation rates. Carbon sources used at anaerobic sites include molasses, edible oils, lactic acid, sodium benzoate, methane, and yeast extract.

The presence of Dehalococcoides bacteria can be quantified to evaluate if bioaugmentation with Dehalococcoides would be necessary to further facilitate chlorinated VOC degradation. If bacteria counts are low, additional cultures can be added to the subsurface to increase populations. However, where dechlorination end products (such as ethene) are already present in groundwater, it is likely that sufficient reductive dechlorinators are already present and bioaugmentation may not be necessary.

Favorable in-situ conditions must be present to ensure successful bioremediation. Subsurface heterogeneity can complicate the distribution of biostimulants. Chemically, bioremediation of chlorinated compounds works best under highly reducing conditions, with methanogenic conditions being the most favorable. Under sulfate-reducing conditions biodegradation commonly stalls at cis-dichloroethene (cis-DCE). Dechlorinators are also limited if the pH is outside the normal range (greater than 8 or less than 5).

Enhanced bioremediation vendors agree that this technology can effectively treat CVOCs, including PCE, TCE, 1,1,1-trichloroethane (1,1,1-TCA), and 1,1-DCE. Despite this, in-situ bioremediation pilot studies are often conducted to evaluate the applicability, effectiveness, and cost of this remedial technology. Pilot studies provide data to better evaluate remedial technologies, support the remedial design of a selected alternative, and reduce full-scale implementation cost and performance uncertainties.

A form of in-situ bioremediation is a biological barrier which acts as a passive control to dissolved-phase CVOC plume flow when microorganisms break down VOCs that pass by them in groundwater. Biological barriers have recently been installed using emulsified edible oil inserted into the soil with the help of chase water and an emulsifying agent (to reduce viscosity). This type of biological barrier does not require excavation; it can be installed by injecting the oil, chase water, and emulsifying agent into the subsurface through temporary injection points or permanent injection wells.

A disadvantage of a biological barrier is the possible increase of DCE and vinyl chloride (VC) downgradient of the treatment area. This is due to the PCE and TCE byproduct's (DCE and vinyl chloride) slower reduction rates. Heterogeneity in the soil can disrupt continuity of the wall resulting in gaps that can transmit contaminated water. Increased biofouling can also reduce the permeability of the barrier, potentially causing water to flow around the treatment zone. Additional byproducts of bioremediation may include increased methane and increased concentration of dissolved iron and manganese and occasionally other metals if the local pH is significantly lowered through biological activity.

In the right conditions, chlorinated ethenes can be degraded under anaerobic conditions through reductive dechlorination. Reductive dechlorination is a reaction catalyzed by microorganisms in which a hydrogen atom replaces the chlorine atom on CVOCs such as TCE. The resulting hydrogen is then used by reductive dehalogenators to strip the solvent molecules of their chlorine atoms which allows for further degradation. Though this can occur naturally, it may not happen within an adequate time frame to meet remedial goals. The injection of hydrogen-releasing compounds can be used to enhance dechlorination processes. Anaerobic conditions can be created through the introduction of large amounts of carbon sources, and monitored by measuring dissolved oxygen (DO) to determine if anaerobic conditions have been achieved.

Advantages of anaerobic degradation typically include:

- Effectively reducing CVOC concentrations under the right conditions;
- In-situ degradation of CVOCs; and
- Cost-effectiveness compared to other remedial technologies.

Disadvantages of anaerobic degradation typically include:

- The presence of DO at levels greater than 1 part per million (ppm) limit anaerobic degradation and would require the introduction of a carbon source to reduce DO levels;
- Depending on soil type, degree of heterogeneity, and groundwater depth, this technology may require closely spaced injection sites and can be cost prohibitive; and
- Bioaugmentation may be necessary if microbial populations are shown to be insufficient.

There is little evidence that natural degradation of CVOCs is occurring in groundwater in the Beau Brummel Cleaners investigation area. Degradation products of PCE are not present in groundwater. Field measurements of dissolved oxygen and reduction oxidation potential indicate that the water-table aquifer is under aerobic conditions (contains oxygen). Under these aerobic conditions, CVOCs degrade at a much slower rate than under anaerobic conditions. Altering the naturally aerobic conditions and sustaining a subsurface environment for enhanced reductive dechlorination would not be feasible or cost effective given the size of the CVOC plume, multiple groundwater flow directions, and access limitations for injection wells (or multiple injection events) that would be needed to implement this technology.

4.1.1.6 Permeable Reactive Barrier

Permeable Reactive Barriers (PRBs) are vertical zones of material (typically zero-valent iron, mulch, or some other reducing agent) that are installed in the subsurface to passively intercept groundwater flow. PRBs are installed in or down gradient of a dissolved-phase contaminant plume by excavating a trench across the path of a migrating dissolved-phase VOC plume and filling it with the appropriate reactive material (such as a mixture of sand and iron particles), or by injecting the reactive material into the ground as a mobile slurry using direct push technology or injection wells. Groundwater flowing passively under a hydraulic gradient through the PRB is treated as the contaminants in the dissolved-phase plume are broken down into byproducts or immobilized by precipitation or sorption after reacting with the substrate inside the PRB. Although PRBs are a remedial technology that requires no pumping, the rate of groundwater treatment can be accelerated by groundwater withdrawal or injection in the vicinity of the PRB. Groundwater monitoring systems are typically installed to monitor the effectiveness of a PRB (or other remedial technology) over the long term.

PRB systems have been used successfully to treat chlorinated organic compounds, including PCE and TCE at numerous full-scale applications. PRBs intended for groundwater containing VOCs are commonly constructed with zero-valent iron. Such PRBs can be constructed as a wall beneath the ground surface either by open trenching or with minimal disturbance to above-ground structures and property using trenchless injection technology. Another emerging PRB method utilizes an electrolysis process to break apart the VOC constituents. Probes are installed into the ground, which generate a current in the subsurface that degrades the VOC constituents. Both methods, in addition to mulch and chitin barriers, are discussed below.

<u>Zero-valent Iron</u>

The most common PRB technology utilizes zero-valent iron particles, typically in granular (macro-scale) form, to completely degrade chlorinated VOCs via abiotic reductive dehalogenation. As the iron is oxidized, a chlorine atom is removed from the compound using electrons supplied by the oxidation of iron. As the groundwater containing CVOCs flows through the reactive material, a number of reactions occur that indirectly or directly lead to the reduction of the chlorinated solvents. One mechanism is the reaction of iron filings with oxygen and water, which produces hydroxyl radicals. The hydroxyl radicals in turn oxidize the contaminants. During this process, the chloride in the compound is replaced by hydrogen, resulting in the complete transformation of CVOCs to byproducts (ethene, ethane, and chloride ions). Since degradation rates using the process are several orders of magnitude greater than under natural conditions, any intermediate degradation byproducts formed during treatment (e.g., VC) are also reduced to byproducts in a properly designed treatment zone. The use of zero-valent iron to treat CVOCs has been well documented, and is covered under several patents, depending on the installation method.

PRB longevity using zero-valent iron is dependent on contaminant concentration, groundwater flow velocity, and the geochemical makeup of the groundwater. The oldest full-scale PRB was installed in February 1995 at a site in Sunnyvale, California. This PRB has successfully reduced the concentrations of TCE, DCE, VC, and Freon through 11 years of operation (ETI, 2006). Since the age of the oldest PRB is only approximately 16 years, bench scale studies using reactive iron columns (from both cores obtained from emplaced reactive walls and from virgin reactive iron) have been conducted to evaluate long-term PRB longevity. These tests have shown that, although the reactivity of the iron declines with long-term exposure to groundwater, conditions promoting the dehalogenation of chlorinated solvents are maintained over the long term. Based on these studies, the expected life of a typical reactive wall (where life is defined as the period over which the reactivity of the iron declines by a factor of two) is approximately 30 years (ESTCP, 2003). However, these studies also indicated that groundwater geochemistry, specifically the concentration and resulting flux of natural organic matter (NOM), total dissolved solids (TDS), and carbonate, along with the distribution of VOC concentrations, greatly influences the lifetime of the reactive iron and should be considered in the reactive wall design process (Klausen et al., 2003).

Zero-valent iron PRBs can be installed by direct-injection of iron or iron substrate into a series of injection wells or boreholes along the barrier alignment. The iron particles are injected into the subsurface to form a continuous barrier between the wells/boreholes. During injection, the barrier geometry can be monitored in real-time to ensure fracture coalescence or overlap using resistivity sensors in the subsurface. Once installed, the hydraulic continuity of the PRB can also be verified using hydraulic pulse interference testing. This test involves a cyclic injection of fluid into a source well on one side of the PRB and high precision measurement of the pressure pulse using a receiver transducer in an observation well on the other side of the PRB. The time delay and attenuation of the hydraulic pulse is used to evaluate the hydraulic effectiveness and continuity of the wall. PRBs have been installed to depths exceeding 100 feet below grade and barrier lengths exceeding 1,000 feet. This trenchless method generates almost no waste that would require disposal or treatment.

In contrast, PRB installation using trenching installation technologies are typically physically limited to approximately 60 feet below grade, although a trenched PRB is rarely installed to a depth of more than 30 feet below grade. Also, trenching results in larger volumes of waste in the form of soil that must be disposed of or otherwise treated. Also, trenching technology can create significant disruption to surrounding communities and infrastructure, and is generally limited to areas where underground utilities are not present or, if present, can be disturbed.

Advantages of zero-valent iron PRBs typically include:

- Passive method of treatment, resulting in low long-term OM&M costs that remain low as long as no adjustments need to be made to the barrier;
- Barrier technologies (such as zero-valent iron PRBs) can be an effective method of dissolved-phase plume control; and
- PRB installation using direct injection technology is not constrained by utilities and is typically a relatively low-impact method for PRB installation.

Disadvantages of zero-valent iron PRBs typically include:

- Installation of a PRB using conventional trenching methods can be complicated if underground utilities are present;
- Once installed the PRB is expensive to adjust, re-locate or remove;
- A high groundwater flow rate would decrease the contact time between CVOCs and zero-valent iron, thereby reducing the PRB effectiveness;
- Changes in groundwater direction or velocity, though unlikely, can reduce the PRB effectiveness; and
- Relatively high capital costs.

Because of the deep depth to groundwater containing CVOCs and space constraints related to the highly populated area above the dissolved-phase CVOC plume, the installation of a PRB using ZVI will not be considered further.

Mulch and Chitin Barriers

A form of in-situ bioremediation is a biological barrier which acts as a passive control to dissolved-phase plume flow when microorganisms break down VOCs that pass by them in groundwater. A biological barrier treats VOC containing groundwater biologically, which is different than most PRB technologies where a chemically reactive treatment barrier is utilized. As with chemical barriers, care must be taken to ensure the wall is constructed to the correct thickness so that the dissolved-phase contaminant plume has enough time to biodegrade. Biological barriers can be constructed with a variety of materials including mulch and chitin (though inexpensive, mulch and chitin are limited in the depth to which they can be emplaced) and food waste products such as cheese whey. A mulch or chitin barrier cannot be installed without excavation. Mulch can be used to turn aquifers anaerobic and provide a source of electron donors for reductive dechlorination of CVOCs. Mulch is inexpensive, long-lasting, and is naturally present in the environment. Given the depth to groundwater at the site and required trenching depths, mulch/chitin barrier will not be considered further for treatment of the dissolved-phase CVOC plume.

Electrically-induced Redox Barrier

Application of this technology involves the insertion of closely spaced permeable electrodes through the groundwater plume. A low voltage direct current drives the oxidation of CVOCs. An electrically-induced redox barrier is an effective method for reduction of CVOCs in groundwater.

Advantages of an electrically-induced redox barrier typically include:

- Like other passive technologies, an electrically induced barrier has low long-term OM&M costs, mostly relating to power usage; and

- The electronic barrier has the potential to control mineral accumulation common on other barriers by periodic reversal of electrode potentials, thereby minimizing potential problems related to decreasing permeability.

Disadvantages of an electrically-induced redox barrier typically include:

- This is a relatively new concept with only limited field testing (conducted by Environmental Security Technology Certification Program and Colorado State University at F.E. Warren Air Force Base);

- A trench and fill system is the only way to initially install the barrier making it impractical in deep aquifers or urban/suburban areas; and

- The barrier needs to equilibrate with the dissolved-phase contaminant plume for a few months before implementing the charge.

Although an electrically-induced redox barrier may be feasible for site treatment, it will not be retained for future consideration. This technology is unproven and would be difficult to implement due to the depth to groundwater.

4.1.1.7 Air Sparging/Soil Vapor Extraction

Air sparging with soil vapor extraction involves injecting air into groundwater to volatilize contaminants and enhance aerobic biodegradation. A series of injection wells are installed into the saturated zone and soil vapor extraction wells are installed into the vadose zone. After air is injected, air rises in channels through pores in sand and silt with the lowest air-entry pressure (usually the coarser materials) and the contaminants are removed (stripped) from the groundwater and are carried up into the unsaturated zone. A soil vapor extraction system is usually installed to remove vapors from the unsaturated zone.

The system would be designed so that the area of influence of the systems overlap, ensuring that all areas are treated. Pilot tests are often performed to evaluate the most effective distance between injection wells. An injection pump and vacuum extractor would be located above ground. The extracted soil vapor may be treated on-site prior to release to the atmosphere.

- Advantages of air sparging with soil vapor extraction typically include:

- Can be installed relatively easily with readily available equipment;

- Can be installed at a relatively low cost.

Disadvantages of air sparging with soil vapor extraction typically include:

- Heterogeneities or stratified soils would cause air flow to not flow uniformly through the subsurface causing some zones to be less treated;

- Ex-situ vapor treatment is commonly required, resulting in the need to properly manage granular activated carbon including disposal of spent granular activated carbon;

- Surface treatment, vapor extraction, manifold, piping, and injection structures are needed;

- Effective vapor extraction is needed to prevent fugitive vapors; and

- Cannot be used for treating confined aquifers.

Air sparging with soil vapor extraction will not be retained for further evaluation because of the space constraints related to the highly populated area above the dissolved-phase CVOC plume and extensive above ground infrastructure and operations and maintenance required.

4.1.1.8 Groundwater Extraction and Treatment

Groundwater extraction and treatment, also referred to as pump and treat, would involve the removal of contaminant-containing groundwater through the use of pumping wells. The extracted water would be treated and returned to the subsurface, a surface water body, or sewer system. Groundwater pumping systems can also be used to control dissolved-phase plume migration.

Site characteristics, such as hydraulic conductivity, will determine the range of groundwater extraction remedial options possible. To assess if groundwater extraction is appropriate for the Beau Brummel Cleaners investigation area, the following information is needed to design an effective groundwater pumping strategy:

- Properties of the subsurface; and

- The biological and chemical characteristics of the groundwater.

The advantages of groundwater extraction include:

- Pump and treat is an established and widely proven technique for controlling a large volume of contaminated groundwater;

- Using pumping wells to control groundwater flow and slow or reverse the spread of contaminants can be useful in managing large areas of groundwater contamination;

- Groundwater pumping can create a hydraulic barrier to control the spread of a dissolved-phase plume; and

- The extracted groundwater can be treated with relative ease once it is at the surface.

The following factors may limit the applicability and effectiveness of groundwater pumping as a remedial process and should be evaluated prior to implementation:

- It is possible that a long time may be necessary to achieve the remediation goal;

- Residual saturation of the contaminant in the soil pores cannot be removed by groundwater pumping. Contaminants tend to be sorbed in the soil or rock matrix. Groundwater pumping is not applicable to contaminants with high residual saturation, contaminants with high sorption capabilities, and aquifers with hydraulic conductivity less than 10^{-5} centimeters per second (cm/sec);

- Bio-fouling of the extraction wells, and associated treatment stream, is a common problem which can severely affect system performance;

- Hydraulic control systems require frequent, long-term maintenance;

- The cost of installing and operating treatment systems can be high. Additional cost may also be attributed to the disposal of spent carbon and the handling of other treatment residual and wastes;

- Pumping is typically not effective at reducing low contaminant concentrations in the subsurface due to tailing effects; and

- The cost-effectiveness of a groundwater pumping system typically decreases as the concentration in the groundwater decreases.

Surfactant-enhanced recovery may also be used to improve the effectiveness for contaminated sites with LNAPLs and DNAPLs. The following factors may limit the applicability and effectiveness of surfactant-enhanced recovery:

- Subsurface heterogeneities, as with most groundwater remediation technologies, present challenges to the successful implementation of this technology; and
- Off-site migration of contaminants due to the increased solubility achieved with surfactant injection.

Extracted groundwater is generally treated by granular activated carbon, air stripping, or ultraviolet (UV) oxidation. Extracted vapors may also need to be treated. A description of several ex-situ treatments is provided below:

Advanced Oxidation Process

Advanced oxidation processes are similar to in-situ chemical oxidation in that oxidants are used to degrade contaminants to carbon dioxide, water, and simple organic and inorganic compounds. The process typically uses ozone, hydrogen peroxide, and ultraviolet light (UV) in some combination to form hydroxyl radicals (OH^-). Hydroxyl radicals have the highest oxidation potential and readily breakdown contaminants such as TCE.

Advanced oxidation processes are available in many forms and are generally used in treatment systems for groundwater that contain higher concentrations of VOCs. The most widely used products are systems using hydrogen peroxide/UV, ozone/UV, and hydrogen peroxide/ozone. For evaluation purposes, the hydrogen peroxide/ozone system has been selected. This system is effective in treating VOCs and is not significantly affected by turbidity as are processes using UV due to the need to keep UV lamps clean. Ozone is readily mixed with groundwater in the controlled environment of the treatment piping. Oxidation is effective at treating a wide variety of compounds but typically has high costs relative to granular activated carbon and air stripping.

Air Stripping/Aeration

Air stripping is a form of aeration, which is a widely used technology for environmental remediation. Aeration promotes volatilization and biological degradation by increasing the contact between contaminated media and air. Aeration can promote biodegradation in systems where the oxygen-rich air has time to nourish bacteria. Aeration methods include activated sludge, rotating biological contactors, trickling filters, air stripping, air sparging, bioventing, packed towers, diffused aeration, tray aeration, venturi aeration, and spray aeration.

Air stripping involves the mass transfer of VOCs from water to air. In the air stripping process, VOCs are partitioned from extracted groundwater by increasing the surface area of the water containing VOCs exposed to air. Air stripping is most appropriate for VOCs that are easily evaporated from water. Compounds which are highly soluble, such as alcohols and ketones, are difficult to remove with air stripping.

For groundwater remediation, the most widely used air stripping process typically involves use of a packed tower or tray aeration. The typical packed tower air stripper includes a spray nozzle at the top of the tower to distribute water containing VOCs over the packing in the column, a fan to force air countercurrent to the water flow, and a sump at the bottom of the tower to collect treated water. Packed tower air strippers can be installed as either permanent structures on concrete pads or as temporary structures on a skid or trailer, mainly depending on the volume of water treated. Low-profile air strippers, or tray aerators, include a number of trays in a very small chamber to maximize air-water contact. These systems are easier to install and operate than other air strippers, but have a somewhat larger footprint.

The off-gases may need to be treated if the aerated water contains high concentrations of VOCs. Air strippers commonly use vapor-phase activated carbon systems to capture VOCs in off-gases, especially in early stages of remediation when VOC concentrations are higher. Off-gas treatment is not feasible in some applications of this technology, such as spray irrigation. The effect of, and potential exposures related to, transferring VOCs from water to air must be assessed prior to implementing this technology. Air quality may need to be monitored if this treatment option is implemented.

Carbon Adsorption

Carbon adsorption is most appropriate for low concentrations and/or low flow rates of contaminated water. Liquid-phase carbon adsorption typically involves pumping groundwater through one or more vessels in series containing activated carbon to which dissolved VOCs adsorb. When the concentration of contaminants in the effluent from the treatment vessel exceeds a certain level, the carbon is typically removed and regenerated off site or disposed. The most common reactor configuration for carbon adsorption systems involving groundwater is the fixed bed approach with two vessels in series. The fixed-bed configuration is the most widely used for adsorption from liquids. The duration of operation and maintenance (O&M) is dependent upon the contaminant type, concentration, mass treated, other organics or metals that occupy adsorption sites, and the clean-up requirements. It should be noted that several compounds, including vinyl chloride, 1,1,1-TCA, DCA, chloroform, methylene chloride, and alcohols, have a poor affinity for carbon absorption.

Despite the potential drawbacks related to installation, operation, and maintenance, groundwater extraction with ex-situ treatment has the potential to quickly control dissolved-phase plume migration. Although it is effective at treating a wide variety of compounds, oxidation will not be considered further because of its high costs relative to granular activated carbon and air stripping. Following treatment, the water would be re-injected into the subsurface or discharged to a surface water body in accordance with SPDES requirements.

Groundwater extraction and treatment will not be considered further because of the space constraints related to the highly populated area above the dissolved-phase CVOC plume and extensive above ground infrastructure and operations and maintenance required.

4.1.1.9 In-well Air Stripping (a.k.a. Groundwater Recirculation)

An in-well air stripping system uses a series of groundwater circulation wells to recapture and re-circulate groundwater within an aquifer. The groundwater circulation well system creates in-situ vertical groundwater circulation cells by drawing groundwater from the aquifer through the lower screen of a double-screened well and discharging it through the upper screen section. No groundwater is removed from the ground. Air is injected into the well, releasing bubbles into the contaminated groundwater, which aerate the water and form an air-lift pumping system (due to an imparted density gradient) that causes groundwater to flow upward in the well.

As the bubbles rise, VOC contamination in the groundwater is transferred from the dissolved state to the vapor state through an air stripping process. The air/water mixture rises in the well until it encounters the dividing device within the inner casing, which is designed to maximize volatilization. The air/water mixture flows from the inner casing to the outer casing through the upper screen. A vacuum is applied to the outer casing, and contaminated vapors are drawn upward through the annular space between the two casings. The partially treated groundwater re-enters the subsurface through the upper screen and infiltrates back to the aquifer and the zone of contamination where it is eventually cycled back through the well, thus allowing groundwater to undergo sequential treatment cycles until the remedial objectives are met. Off gas from the stripping system is collected and treated, typically using granular activated carbon. Pilot testing and field measurements are generally required to determine the exact well and piping configuration.

In-well air stripping has been demonstrated to be effective and has been used or selected as a remedy at numerous sites, particularly in coarse media with little silt or clay lenses. As of January 2006, over 1,300 wells have been installed in more than 75 sites, including federal sites, in 24 states (NYSDEC DER-15). Only a limited number of vendors are available to design and construct an in-well air stripping system.

In general, in-well air strippers are most effective at sites containing high concentrations of dissolved contaminants. The effectiveness of in-well air stripping systems may be limited in shallow aquifers. These systems are typically more cost-effective for remediating groundwater at sites with deep water tables because the groundwater does not need to be brought to the surface. To prevent smearing the contaminants in the area immediately above the water table, this technology should not be used at sites containing non-aqueous phase liquids (NAPLs).

In-well air stripping will not be retained for further evaluation because there would be significant space constraints related to the densely populated area above the dissolved-phase CVOC plume and extensive above ground infrastructure and operations and maintenance required.

4.1.1.10 Phytoremediation

Phytoremediation is a bioremediation process that uses plants to remove, transfer, stabilize, and/or destroy contaminants in the soil and groundwater. Phytoremediation is used for the remediation of metals, radionuclides, pesticides, explosives, fuels, VOCs and semi-volatile organic compounds (SVOCs). Phytoremediation mechanisms include:

Rhizosphere biodegradation - Natural substances are released through the plant's roots, supplying nutrients to microorganisms in the soil, which enhances biological degradation.

Phyto-accumulation (also called phyto-extraction) - Phyto-accumulation is used primarily for remediation of soil and groundwater containing metals. Contaminant mass is absorbed through the plant roots and stored in the plant's shoots and leaves, which are harvested and either smelted for potential metal recycling/recovery or are disposed of as a hazardous waste.

Hydroponic Systems for Treating Water Streams (Rhizofiltration) - Rhizofiltration is similar to phyto-accumulation, but the plants are grown in greenhouses with their roots in water. This system can be used for ex-situ treatment, where groundwater is pumped to the surface to irrigate these plants. The plants are harvested and disposed of after they become saturated with contaminants.

Phyto-stabilization - Chemical compounds produced by the plant immobilize contaminants, rather than degrade them.

Phyto-degradation. In this process, plants metabolize and destroy contaminants within plant tissues.

Phyto-volatilization. A process where plants absorb contaminants and release them into the atmosphere through their leaves.

Hydraulic Control. In this process, trees indirectly assist with remediation of groundwater by controlling groundwater movement by uptaking water and lowering the water table.

The advantages of phytoremediation include:

- Lower cost than many traditional remedial technologies;
- Vegetation can be easily monitored;
- Potential recovery and re-use of valuable metals ("phytomining"); and
- Uses naturally occurring organisms/vegetation and preserves the natural state of the environment.

The following factors may limit the applicability and effectiveness of phytoremediation:

- The area and depth of the treatment zone is dictated by plant root spread and depth. In most cases, it is limited to shallow soils, streams, and groundwater although deeper groundwater can be treated by pumping it to the surface to irrigate plantations of trees;

- Phytoremediation is generally limited to treatment of lower contaminant concentrations and contamination in shallow soils, streams, and groundwater;

- Climatic factors influence the effectiveness of phytoremediation and its success may be seasonal, depending on location;

- The success of remediation depends in establishing the selected plant community, which may require several seasons of irrigation, potentially increasing the mobilization of contaminants in the soil and groundwater;

- Requires a long-term commitment because of slow growth and low biomass;

- Plant survival is affected by the toxicity and concentrations of the contaminants and the general condition of the soil.

- Plants may not be able to live if contaminant concentrations are too high;

- Phytoremediation may transfer contamination across media (e.g., from soil to air);

- Phytoremediation is not effective for strongly sorbed contaminants such as polychlorinated biphenyls (PCBs); and

- Phytoremediation requires large areas of land.

The following should be considered prior to selecting phytoremediation as a remedy:

- The toxicity and bioavailability of biodegradation products is not always known;

- Degradation by-products may be mobilized in groundwater or bio-accumulated in animals;

- It is unclear whether contaminants that collect in the leaves and wood of trees are released when the leaves fall in the autumn or when the tree is used for firewood or mulch;

- Contaminants may bio-accumulate in plants which then pass into the food chain;

- Plants may contain high levels of heavy metals, making disposal of harvested plants problematic; and

- The ecological impact of introducing new plant species should be evaluated prior to implementation and monitored following implementation.

A phytoremediation system often includes the use of plants suited to conditions at the site to degrade and/or remove contaminants. Vegetation may not need to be imported as native vegetation may be sufficient. The previously existing ecosystem could be altered into a phytoremediation system (such as a constructed wetland) or enhanced to provide the desired treatment design.

To be effective, phytoremediation systems must be properly designed, constructed, operated, and maintained. Once completed, a phytoremediation system requires regular monitoring to ensure proper operation. As with any remedial technology these systems may require enhancements or modifications in addition to routine management to maintain optimum performance.

Because of the depth to groundwater and the uncertainties regarding its effectiveness at the Beau Brummel Cleaners investigation area, phytoremediation will not be retained for further evaluations.

4.2 Remedial Alternatives

Based upon the site characteristics, the GRAs, and technology screening presented above, the following remedial alternatives were developed for groundwater treatment of the off-site dissolved phase CVOC plume and soil vapor intrusion at 2045 Jericho Turnpike:

4.2.1 Groundwater

Alternative 1: No Further Action

Alternative 2: No Further Action with Long-Term Monitoring

Alternative 3: Targeted In-Situ Chemical Oxidation

Alternative 4: Restoration to Achieve Pre-Disposal Conditions

5. Remedial Alternative Analysis

This section presents an analysis of the potential remedial alternatives for remediation of the Beau Brummel Cleaners dissolved phase CVOC plume and off-site soil vapor intrusion at 2045 Jericho Turnpike in accordance with the criteria described in Section 2.2.

5.1 Groundwater

5.1.1 Alternative 1: No Further Action

A no further action alternative would involve no active remediation of the Beau Brummel Cleaners dissolved phase CVOC plume. The SVE/SSD system currently operating at the site would be deactivated. If this alternative is selected for implementation, the CVOC plume would not be remediated other than with natural processes (i.e. dilution, dispersion, natural attenuation, etc.). For this reason, this alternative alone would not be in compliance with SCGs or effective in the short-term. The no further action alternative would not reduce the toxicity, mobility or volume of the dissolved-phase CVOC plume, would require no effort to implement, and would have minimal costs. Under the no further action alternative, the dissolved phase CVOC plume would not be actively remediated.

The no further action alternative would not include the site management plan, institutional controls, or the SVI Action Plan described in Section 3.1.

Overall Protection of Human Health and the Environment

Although the no further action alternative does not include groundwater treatment, it would be protective of human health and the environment because groundwater containing site-related CVOCs is not being used as a water supply.

Compliance with SCGs

Because there is no active groundwater remediation included in this alternative, it would not be in compliance with SCGs.

Long-term Effectiveness and Permanence

Because there is no active groundwater remediation included in this alternative, it would not be effective in the long-term.

Reduction of Toxicity, Mobility, and Volume

The no further action alternative would not reduce the toxicity, mobility or volume of the dissolved-phase CVOC plume other than with natural processes (i.e. dilution, dispersion, natural attenuation, etc.).

Short-term Effectiveness

The no further action alternative would be effective in the short term because groundwater at the site is not used as a water supply. In addition, as there would be no construction or implementation phase, there would also be no potential for exposure to workers, the community or the environment in the short term.

Implementability

The components of this alternative are readily implementable and would require minimal effort.

Cost

The no further action alternative would have no capital or OM&M costs (Table B-6).

Land Use

The implementation of this remedy would have no impact on the current and future use of the Beau Brummel Cleaners site or the properties located above the dissolved-phase CVOC plume.

5.1.2 Alternative 2: No Further Action with Long-Term Monitoring

The no further action with long-term monitoring alternative would include the site management plan, institutional controls, and SVI Action Plan described in Section 3.1 and continued operation of the SVE System. This alternative would rely on a long-term monitoring program to monitor plume stability and the natural reduction of the CVOC contamination over time, in part due to source treatment. Monitoring would verify that contaminant flux in not occurring. Groundwater samples would be collected semi-annually for 30 years (unless altered based on five-year reviews) at all wells in the monitoring well network (22). Samples would be analyzed for VOCs to verify decreasing VOC concentrations and to assess if groundwater containing site-related compounds is migrating to the locations where PCE was previously undetected or detected below the NYSDEC GA Standard.

Overall Protection of Human Health and the Environment

Although the long-term monitoring alternative does not include groundwater treatment, it would be protective of human health and the environment because groundwater containing site-related CVOCs is not being used as a water supply.

Compliance with SCGs

This remedy of no further action with monitoring would, in the long-term, come into compliance with the SCGs. Through natural diffusion and dispersion of the contaminants in groundwater the concentration of the COCs will decrease over time. Concentrations of COCs would be monitored for significant changes and thus eventually for compliance with the SCGs.

Long-term Effectiveness and Permanence

There is active source treatment by the SVE system, which through partitioning of the contaminant from soil to water and then through natural dispersion and diffusion should decrease the concentration of contaminant in the groundwater in the long-term.

Reduction of Toxicity, Mobility, and Volume

The long-term monitoring alternative would not reduce the toxicity, mobility or volume of the dissolved-phase CVOC plume other than with natural processes (i.e. dilution, dispersion, natural attenuation, etc.).

Short-term Effectiveness & Impacts

The long-term monitoring alternative would be effective in the short term because groundwater is not used as a water supply. In addition, as there would be no construction phase, there would also be no exposure to workers, the community or the environment in the short term.

Implementability

The components of this alternative are readily implementable and would require minimal effort.

Cost

The long-term monitoring alternative would have no capital costs associated with construction or installation of a remedial alternative, but would incur OM&M costs similar to those associated with the remedial alternatives that include active treatment of the dissolved-phase CVOC plume. Costs are based on semi-annual, long-term groundwater quality monitoring, and creation of site management and soil vapor intrusion action plans.

The opinion of probable cost for this remedial alternative, with an expected accuracy range of –30 to +50 percent, is presented in Table B-1. The cost opinion is based on collecting 22 groundwater samples per year for 30 years. Capital costs including the first year of OM&M and creation of the site management and soil vapor intrusion action plans would be approximately $48,000. Annual OM&M costs are estimated to be $34,000 including two groundwater sampling events and laboratory analysis. The total present value of this alternative based on a 2.3% discount rate over a 30-year period is approximately $762,000.

Land Use

The implementation of this remedy would have little to no impact on the current and future use of the Beau Brummel Cleaners site or the properties located above the dissolved-phase CVOC plume.

5.1.3 Alternative 3: Targeted In-situ Chemical Oxidation

Sodium permanganate will be considered in the following alternative. Implementation of a targeted ISCO treatment program would include the following:

- Bench-scale laboratory testing to evaluate the effectiveness of ISCO treatment and the amount of oxidant required for treatment.
- Implementation and evaluation of a field pilot test to evaluate oxidant distribution and persistence in the subsurface.
- Injection of oxidant into temporary direct-push injection points into the subsurface.
- Post-injection groundwater monitoring to evaluate treatment effectiveness.

Groundwater would be treated throughout the dissolved-phase VOC plume area through the injection of sodium permanganate to promote ISCO of contaminants. Specifically, Alternative 3 includes the installation of 65 temporary ISCO injection points down to a depth of approximately 115 feet below ground surface, or 15 feet below the top of the water table. The approximate area of the dissolved-phase VOC plume area is 1.5 acres and is shown on Figure 5. Points would be utilized for a one-time direct push oxidant injection of sodium permanganate to drive ISCO of the contaminants. Based upon preliminary calculations, it is estimated that approximately 15,000 gallons of premixed oxidant solution would be needed, per injection, to address groundwater beneath the entire site. Alternative 3 would be capable of achieving the RAOs as it adequately addresses the groundwater RAOs for each media. Groundwater monitoring upgradient, downgradient, and within the treatment area would be required to evaluate the effectiveness of the ISCO injections at reducing contaminant concentrations. ISCO injections would treat the plume as the affected groundwater flows through the treatment area. However, areas of the plume downgradient of the treatment area would continue to migrate away from the site. For cost evaluation purposes, it is estimated that post-injection groundwater monitoring would continue annually for 30 years.

Since ISCO relies on direct contact between the oxidant solution and the contaminant, the success of the ISCO treatment would be highly dependent on the ability to effectively distribute the oxidant through the treatment area. If such distribution can be achieved, it is anticipated that the ISCO treatment is capable of meeting the RAOs for targeted areas within the off-site dissolved phase CVOC plume area.

In addition, development and implementation of Site Management and Soil Vapor Intrusion Action plans would be included in this alternative.

Overall Protection of Human Health and the Environment

The implementation of the ISCO alternative would be protective of human health by reducing concentrations of VOCs in groundwater, although a single injection is not likely to sustain the oxidants in the subsurface in order to prevent rebound of PCE groundwater concentrations. However, groundwater containing site-related CVOCs is not being used as a water supply and exposures relating to soil vapor intrusion are actively being addressed at the source.

Compliance with SCGs

The implementation of ISCO as a remedy would be in compliance with SCGs within the treatment area. Groundwater contamination downgradient of the treatment area would also decrease through dilution and contaminant flux.

Long-term Effectiveness and Permanence

ISCO is considered to be effective in the long-term because further migration of the dissolved phase plume could be minimized and the groundwater VOC concentrations in the treatment area would be reduced. The limiting factor to the long-term effectiveness of ISCO is the number of injections necessary to maintain the oxidant in the subsurface and treating a sufficient volume of contaminated groundwater, including the source area.

Reduction of Toxicity, Mobility, and Volume

ISCO is considered to be effective at reducing the toxicity, mobility, or volume of the plume because ISCO can convert the VOCs to non-toxic byproducts if sufficient contact can be achieved.

Short-term Effectiveness

ISCO would be effective in the short-term since ISCO treatment oxidizes VOCs almost immediately upon contact. However, ISCO is ineffective at treating groundwater upgradient and downgradient of the ISCO injection locations. Implementation and initial operation of this alternative is not expected to pose significant risk to the community. Risks to workers, which include potential exposure to oxidants and to contaminated groundwater during injection point and equipment installation, are readily controlled using standard work practices and engineering controls. Since it is supplied in liquid form, the use of sodium permanganate commonly requires no on-site mixing, thereby minimizing risk to workers.

Implementability

ISCO treatment could be implemented using readily available technologies and is considered easy to implement. However, the success of the treatment would be dependent on the degree to which the oxidant solution is able to come into contact with the contaminants and the number of injections required. Additionally, ISCO treatment would require injections in roadways and active parking lots, which would lead to significant disruption of traffic patterns in the area. ISCO injections do not generate significant waste, so treatment and disposal considerations are negligible. Utility clearance confirmation is necessary prior to conducting any subsurface drilling.

Land Use

The implementation of this remedy would have little to no impact on the current and future use of the Beau Brummel Cleaners site or the properties located above the dissolved-phase CVOC plume. Potential negative land use impacts if this alternative is implemented include institutional controls such as restrictions on groundwater use.

Cost

The cost for this remedial alternative, with an expected accuracy range of –30 to +50 percent, is presented in Table B-2. The estimated capital cost including the first year of O&M is approximately $1.11 million. Annual O&M cost are estimated to be approximately $34,000. The total present value of this alternative based on a 2.3% discount rate over a 30-year period is approximately $1.83 million. One injection event would be conducted during the first year with 30 years of semi-annual groundwater monitoring. These costs assume that 65 temporary injection points will be installed over the VOC dissolved phase plume. These costs also assume that 10% pore volume of oxidant would be injected through a 15-foot screen to a distance of 15 feet from the well.

5.1.4 Alternative 4: Restoration to Achieve Pre-Disposal Conditions

ISCO could be employed during multiple events to restore the Beau Brummel Cleaners off-site dissolved phase CVOC plume to pre-disposal conditions by reducing groundwater contaminant concentrations to be in compliance with SCGs. Oxidants would be injected over an approximately 1.5 acre area at 65 injection points, as discussed in Section 4.1.1.4. This alternative is identical to Alternative 3 with the exception of number of injection events would continue until the contamination levels in sampled media were reduced to pre-disposal conditions. It is assumed that a minimum of four injection events, commonly three to six months apart, would be needed to restore the groundwater quality to pre-release conditions.

As discussed in Section 3.1, development and implementation of Site Management, Institutional Controls, and Soil Vapor Intrusion Action Plan would be included in this alternative. Performance monitoring would be implemented as a secondary component of this alternative and would involve periodic sampling and analysis of groundwater. For costing purposes, it is assumed that 22 groundwater samples would be collected from the monitoring well network semi-annually for 30 years.

Overall Protection of Human Health and the Environment

The implementation of multiple ISCO injections as a remedy would be protective of human health by reducing concentrations of VOCs in groundwater, and sustaining the oxidants in the subsurface with multiple injections in order to prevent rebound of PCE groundwater concentrations. Additionally, groundwater containing site-related CVOCs is not being used as a water supply and exposures relating to soil vapor intrusion are actively being addressed at the source.

Compliance with SCGs

The implementation of multiple ISCO injections as a remedy would be in compliance with SCGs within the treatment area. Groundwater contamination downgradient of the treatment area would also decrease through dilution and contaminant flux.

Long-term Effectiveness and Permanence

ISCO is considered to be effective in the long-term because further migration of the dissolved phase plume could be minimized and the groundwater VOC concentrations in the treatment area would be reduced. The limiting factor to the long-term effectiveness of ISCO is the number of injections necessary to maintain the oxidant in the subsurface and treating a sufficient volume of contaminated groundwater, including the source area. Since this alternative requires four injections, the oxidants in the subsurface have a higher probability of being sustained.

Reduction of Toxicity, Mobility, and Volume

ISCO is considered to be effective at reducing the toxicity, mobility, or volume of the plume because ISCO can convert the VOCs to non-toxic byproducts if sufficient contact can be achieved.

Short-term Effectiveness

Multiple ISCO injections would be effective in the short-term since ISCO treatment oxidizes VOCs almost immediately upon contact. However, ISCO is ineffective at treating groundwater upgradient and only moderately effective at treating groundwater downgradient of the ISCO injection locations. Implementation and initial operation of this alternative is not expected to pose significant risk to the community. Risks to workers, which include potential exposure to oxidants and to contaminated soils and groundwater during well and equipment installation, are readily controlled using standard work practices and engineering controls. Since it is supplied in liquid form, the use of sodium permanganate commonly requires no on-site mixing, thereby minimizing risk to workers.

Implementability

ISCO treatment could be implemented using readily available technologies and is considered easy to implement. However, the success of the treatment would be dependent on the degree to which the oxidant solution is able to come into contact with the contaminants and the number of injections required. Additionally, ISCO treatment would require injections in active roadways and parking lots, which would lead to significant disruption of traffic patterns in the area. ISCO injections do not generate significant waste, so treatment and disposal considerations are negligible. Utility clearance confirmation is necessary prior to conducting any subsurface drilling.

Land Use

The implementation of this remedy would have little to no impact on the current and future use of the Beau Brummel Cleaners site or the properties located above the dissolved-phase CVOC plume. Potential negative land use impacts if this alternative is implemented include institutional controls such as restrictions on groundwater use.

Cost

The cost for this remedial alternative, with an expected accuracy range of –30 to +50 percent, is presented in Table B-3. The estimated capital cost including the first year of O&M is approximately $4.2 million. Annual O&M cost are estimated to be approximately $34,000. The total present value of this alternative based on a 2.3% discount rate over a 30-year period is approximately $4.9 million. Four injection event would be conducted during the first year with 30 years of semi-annual groundwater monitoring. These costs assume that 65 temporary injection points will be installed over the VOC dissolved phase plume. These costs also assume that 10% pore volume of oxidant would be injected through a 15-foot screen to a distance of 15 feet from the well.

6. Comparative Evaluation of Alternatives

The following four groundwater remedial alternatives were evaluated below relative to each other and the criteria summarized in Section 2.2.

- No Further Action;
- No Further Action with Long-Term Monitoring;
- Targeted Enhanced In-situ Chemical Oxidation; and
- Restoration to Achieve Pre-Disposal Conditions.

The known source area still exists at the Beau Brummel Cleaners site. This source area is currently being remediated with a SVE system in the building at 2049 Jericho Turnpike. Since it does not fully control or remediate the entire investigation area, the no further action alternative would not be effective at meeting RAOs. The alternative would not require any costs, would not be in compliance with SCGs, or reduce toxicity, mobility or volume of the dissolved-phase CVOC plume. Both the no further action and the long-term monitoring alternatives would be protective to human health and the environment since groundwater is not used as a water supply in this area. The long-term monitoring alternative would be easy to implement with moderate costs, but would not be in compliance with SCGs or as effective in the long term as the targeted ISCO or pre-disposal conditions alternatives.

The targeted ISCO and pre-disposal conditions alternatives could be used to enhance or accelerate the decrease in concentrations downgradient of the suspected source areas; however, these alternatives may be difficult to implement given the large number of injections necessary over a busy, high traffic area.

The pre-disposal conditions alternative would have significantly higher costs than other alternatives, but would be in compliance with SCGs, effective in both the short term and long term, and would reduce the toxicity, mobility and volume of the dissolved-phase CVOC plume. A comparison of each remedial alternative relative to each evaluation criteria is provided below and in Table 2.

6.1.1 Overall Protection of Human Health and the Environment

The ISCO and restoration to pre-disposal conditions alternatives would be effective at minimizing groundwater CVOC concentrations by chemically degrading VOCs to non-toxic byproducts (e.g., ethane, ethene, and/or chloride ions). As the RAOs would be met, these remedial alternatives would be protective of human health and the environment. However, the single-injection ISCO would be minimally more protective of human health and the environment relative to the no action and long-term monitoring alternatives because a single injection ISCO would not effectively prevent rebound of PCE concentrations and would likely not treat the entire plume. The no action and long-term monitoring alternatives are less protective of human health and the environment than the single and multiple injection ISCO because they do not include active groundwater remediation. However, groundwater containing site-related CVOCs is not being used as a water supply.

6.1.2 Compliance with SCGs

The ISCO and restoration to pre-disposal condition alternatives would treat contaminated groundwater throughout the dissolved phase CVOC plume. However, the single injection alternative would only treat initial concentrations and not be effective in treating rebounding VOC concentrations. The no action and long-term monitoring alternatives would not actively treat the dissolved-phase CVOC plume and would take significantly longer (decades) to be in compliance with SCGs.

6.1.3 Short-Term Effectiveness

Once the single and multiple injection ISCO alternatives are implemented, contaminant concentrations will begin to be reduced within the treatment area. The restoration to pre-disposal conditions ISCO alternative would be more effective in the short-term than the single injection ISCO assuming sufficient distribution of injected material and uniform treatment is achieved. The short-term effectiveness of each remedial alternative, with the exception of no further action, would be assessed using standard groundwater monitoring wells to evaluate upgradient and downgradient (treated) groundwater adjacent to the treatment area.

Implementation and operation of these alternatives is not expected to pose significant risk to the community. Risks to workers, which include potential exposure to oxidants and to contaminated soils and groundwater during well and equipment installation, are readily controlled using standard work practices and engineering controls. Air emissions, which could impact the community during implementation are also monitored and can be controlled within acceptable levels with standard work practices and engineering controls. As many of the ISCO injection points are in active roadways, a traffic control plan would reduce risks to workers during injections.

6.1.4 Long-Term Effectiveness and Permanence

Each of the groundwater treatment remedial alternatives are considered to be effective in the long-term because VOC concentrations in groundwater would be reduced within the treatment area. The no action and long-term monitoring alternatives would be less effective in the long term than the ISCO alternatives because the rate of degradation of contaminants through natural processes would be considerably slower.

The ISCO alternatives would effectively reduce groundwater VOC concentrations quickly. However, multiple injection events may be necessary if there is incomplete treatment or rebounding of VOC concentrations after the initial injection. The spacing of the injection wells would need to be designed so as to achieve uniform treatment across the width of the dissolved-phase CVOC plume. The potential for incomplete contaminant degradation would be evaluated using available data, including those from pilot studies.

6.1.5 Reduction of Toxicity, Mobility, or Volume

The no action and long-term monitoring alternatives would not reduce the toxicity, mobility, or volume of the dissolved-phase CVOC plume other than with natural processes (i.e. dilution, dispersion, natural attenuation, etc.). In contrast, the groundwater treatment remedial alternatives would reduce the mobility of the plume by treating the groundwater within the treatment area. These alternatives would limit plume migration and reduce contaminant concentrations in the treatment area, thereby reducing the toxicity, mobility, and volume of the plume.

If one of the active treatment alternatives are implemented, VOCs would be chemically degraded to non-toxic byproducts (e.g., ethane, ethene, and/or chloride ions), which do not pose significant risk to human health or the environment. The amount of reduction of the toxicity, mobility, or volume of the plume is dependent on the degree to which uniform treatment is achieved within the treatment area, which is primarily related to the area of influence and spacing of the injection wells.

6.1.6 Implementability

It is expected that it would take approximately one year to design and implement each of the alternatives that include active remediation. The remedial alternatives are all technically feasible and may be affected differently by site-specific geologic and hydrogeologic characteristics. As such, pre-design studies and/or pilot tests are recommended prior to remedy implementation to evaluate the feasibility of the selected remedial alternative and to finalize design of the remedy.

The ISCO and restoration to pre-disposal conditions alternatives are capable of reducing groundwater VOC concentrations while eliminating the need for ex-situ treatment facilities and minimizing disposal issues. These alternatives do not generate significant waste, so ex-situ treatment and disposal considerations are negligible.

It is anticipated that the necessary equipment, personnel, and materials would be available to meet an appropriate schedule for implementation of each of the remedial alternatives using readily available technologies. There does not appear to be significant obstacles to implementing these remedial technologies, although obtaining permits and access will be necessary for the groundwater treatment alternatives. Drilling and installing injection points in the roadways is feasible but would be logistically challenging as the streets located above the dissolved-phase CVOC plume are busy and narrow. Utility clearance confirmation is necessary prior to conducting any subsurface drilling. There would be minimal disruptions to Beau Brummel Cleaners site activities during implementation of these alternatives because no surface structures, other than possibly injection wells, are needed.

6.1.7 Land Use

None of the alternatives would have more than a minimal impact on land use at properties above the dissolved-phase CVOC plume. Targeted ISCO and restoration to pre-disposal conditions alternatives could impact land use by placing restrictions on groundwater use in this area.

6.1.8 Cost

A summary of opinion of probable costs for each remedial alternative is provided in Tables B-6 and B-7. A graph of the probable present value of each of the alternatives is included in Appendix B. The relative order of probable present value for the four alternatives over a 30-year period are, from least to most expensive:

- No further action;
- No further action with long-term monitoring;
- ISCO;
- Restoration to pre-disposal conditions.

The no further action alternative would cost significantly less than any of the alternatives that include monitoring or active groundwater remediation. Restoration to achieve pre-disposal conditions a very costly.

6.2 Remedial Alternative Advantages and Disadvantages

A list of select advantages and disadvantages for the groundwater alternatives is below:

No further action alternative advantages:

- No cost;
- Can be easily and quickly implemented.

No further action alternative disadvantages:

- Includes no active groundwater remediation;
- Groundwater VOC concentrations would not be reduced, other than with natural processes;
- SCGs would not be attained in a reasonable time frame.

No further action with long-term monitoring alternative advantages:

- Low cost;
- Includes the SVE system that is already in place
- Easy to implement.

No further action with long-term monitoring alternative disadvantages:

- Includes no active groundwater remediation;
- SCGs would not be attained in a reasonable time frame.

Targeted ISCO alternative advantages:

- Limited long-term OM&M costs;
- No above-ground structures needed;
- Treats both dissolved and sorbed contaminants concurrently;
- Treats compounds that are not readily biodegradable;
- Breakdown of chlorinated VOCs without the generation of potentially more toxic degradation products;
- Can convert VOCs to non-toxic byproducts if sufficient contact can be achieved;
- Meets the RAOs because ISCO treatment oxidizes VOCs almost immediately upon contact.

Targeted ISCO alternative disadvantages:

- ISCO treatment success is highly dependent on the ability to effectively distribute the oxidant through the treatment area;
- Multiple injections are typically required to sustain the oxidants in the subsurface, commonly 3 to 6 months apart;

- Subsurface conditions may dictate the need for closely spaced injection wells;
- Relatively high costs per volume treated;
- Subsurface conditions (i.e. soil type, degree of heterogeneity, and groundwater depth) may dictate the need for closely spaced injection wells;
- Injection logistics are complicated by space constraints as a result of the highly populated area above the dissolved-phase CVOC plume;
- Oxidants must be handled with care.

Restoration to pre-disposal conditions alternative advantages include all Targeted ISCO advantages plus:

- Multiple injections reduce likelihood of VOC concentration rebound in the groundwater.

Restoration to pre-disposal conditions alternative disadvantages include all Targeted ISCO disadvantages plus:

- Very costly;
- Numerous interruptions to traffic patterns on busy roads over the plume.

6.3 Remedial Alternatives Summary

Implementing an alternative with active remediation of VOCs in groundwater in the Beau Brummel Cleaners investigation area poses several problems. Injection logistics are complicated by space constraints as a result of the highly populated area with crowded, busy streets above the dissolved-phase CVOC plume. Traffic patterns would be disrupted for an extended period of time, with lane shutdowns and/or restrictions affecting major roadways. These issues reduce the potential for installing injection points in desired locations.

The no further action alternative and no further action with long-term monitoring alternatives are the least expensive and easiest to implement but do not include active groundwater treatment. However they do treat the source area of the contamination with the IRM – the SVE System. Groundwater CVOC concentrations would eventually reach compliance with SCGs under these alternatives in several years. Groundwater containing site-related CVOCs is not being used as a water supply and soil vapor intrusion pathways are addressed through mitigation at the source.

The targeted ISCO and restoration to pre-disposal condition alternatives would be effective at minimizing groundwater CVOC concentrations across the entire plume area. These alternatives would each be protective of human health and the environment, would be in compliance with SCGs in the treatment areas, and would reduce the toxicity, mobility, and volume of the plume. Assuming uniform treatment of the dissolved phase plume can be achieved, the targeted ISCO and restoration to pre-disposal conditions would be effective in the long- and short-term. However, as multiple injections may be required to prevent rebounding of CVOC concentrations, the single injection targeted ISCO alternative would likely be less effective in the long-term.

The targeted ISCO and restoration to pre-disposal conditions alternatives can be costly as injections are required at a large number of locations to distribute and sustain oxidant in the subsurface. ISCO is most effective when treating a source area or area of relatively high concentrations. The costs associated with ISCO injections throughout the widespread dissolved-phase CVOC plume make this alternative infeasible because of space constraints, the need for multiple injection events, and the costs associated with sustaining the oxidant in the subsurface.

The restoration to pre-disposal conditions alternative would be the most effective, most protective of human health and the environment, and most likely to produce uniform plume treatment but its high capital cost and logistical constraints make this alternative infeasible.

None of the remedial alternatives require above-ground structures and extensive O&M efforts. The implementation of the targeted ISCO and restoration to pre-disposal conditions alternatives would require pre-design studies to finalize the design of the remedy. A pilot test would be performed to evaluate the feasibility of the selected remedial alternative at the Beau Brummel Cleaners investigation area and to design the remedy.

The public's comments, concerns and overall perception of the proposed remedial alternative will be evaluated by NYSDEC following issuance of a Proposed Remedial Action Plan (PRAP) in a format that responds to all questions that are raised. Community acceptance of the proposed remedy for the Beau Brummel Cleaners investigation area would be evaluated after the public comments have been received.

7. References

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Figures

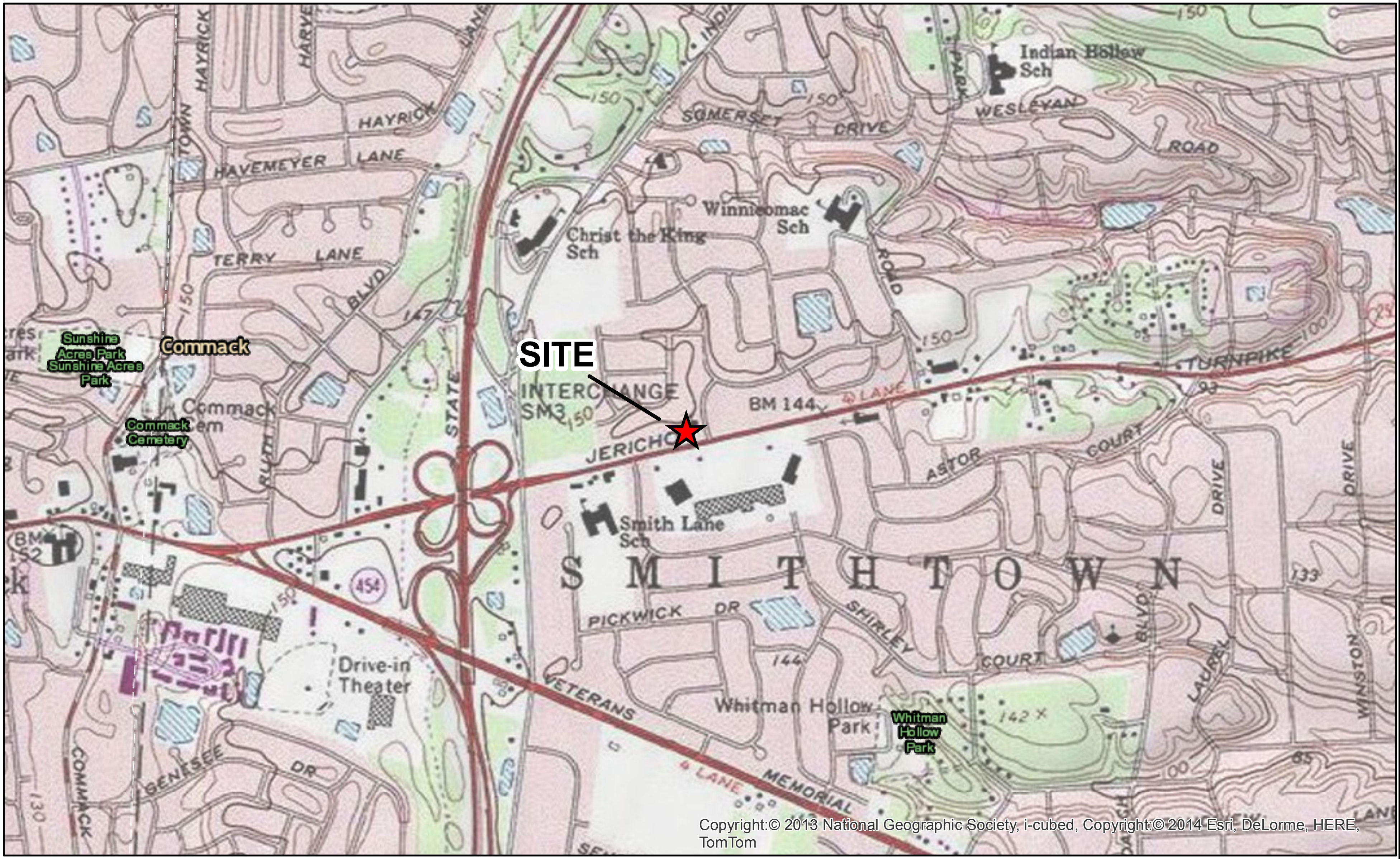
Tables

Appendix A

Analytical Data

Appendix B

Remedial Alternatives Cost Estimates



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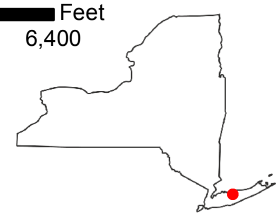

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NYSDEC Site No. 152211
Beau Brummel Cleaners
2049 Jericho Turnpike, Commack, New York

FEASIBILITY STUDY

SITE LOCATION

ARCADIS

FIGURE
1

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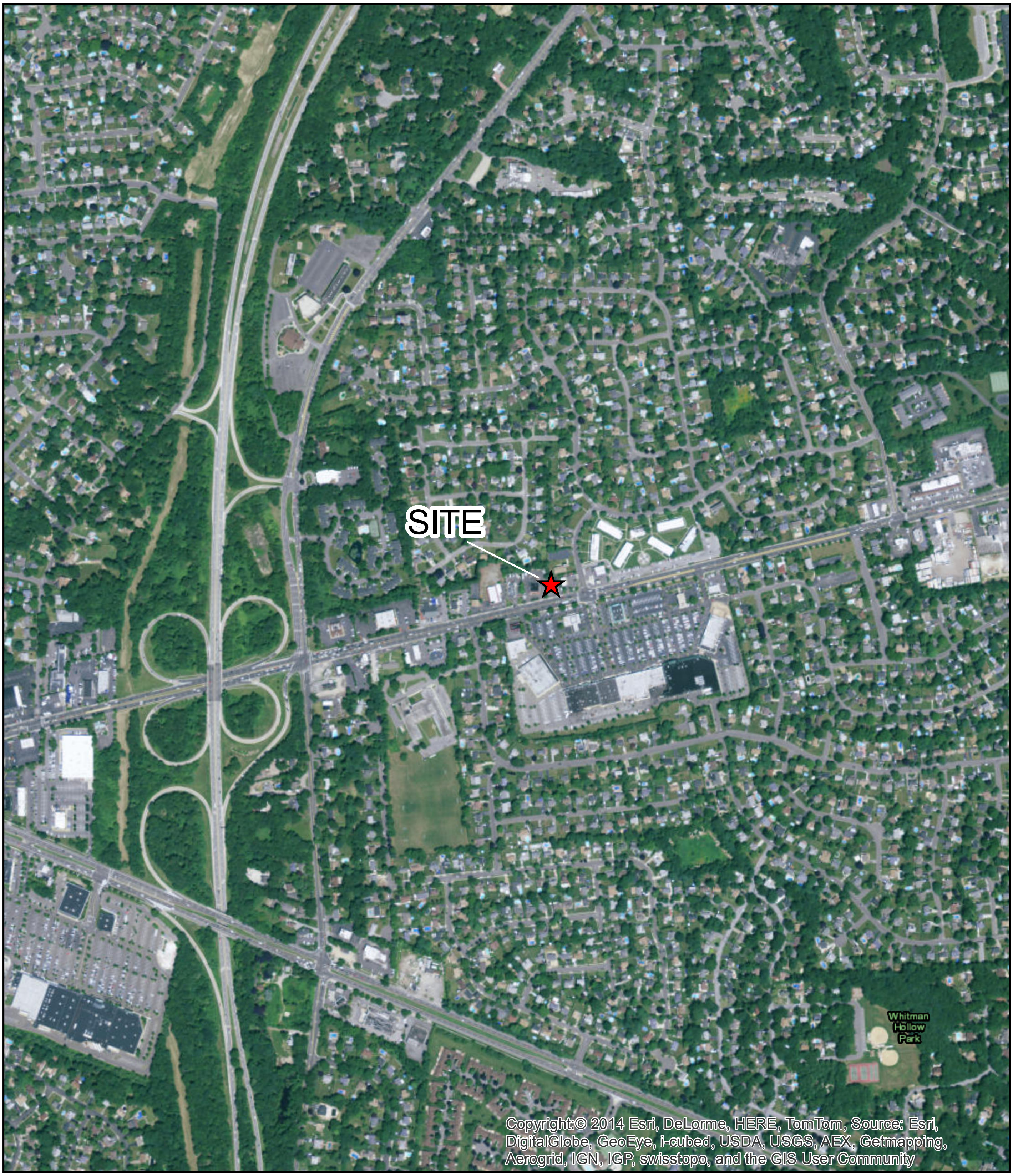

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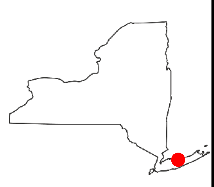

NYSDEC Site No. 152211
Beau Brummel Cleaners
2049 Jericho Turnpike, Commack, New York
FEASIBILITY STUDY

AERIAL PHOTOGRAPH

ARCADIS

FIGURE
2

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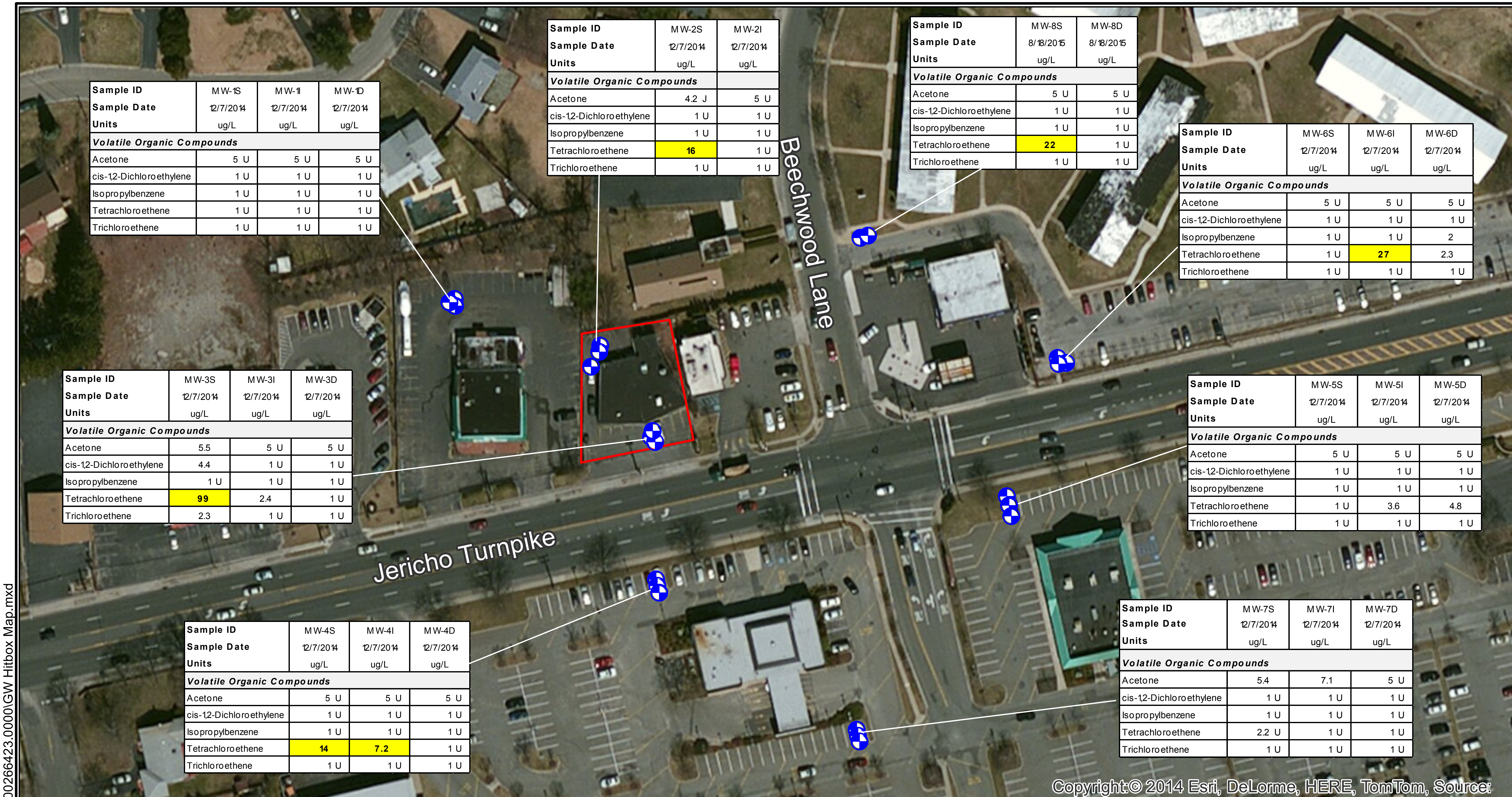


Sample ID	MW-1S	MW-1I	MW-1D
Sample Date	12/7/2014	12/7/2014	12/7/2014
Units	ug/L	ug/L	ug/L
Volatile Organic Compounds			
Acetone	5 U	5 U	5 U
cis-1,2-Dichloroethylene	1 U	1 U	1 U
Isopropylbenzene	1 U	1 U	1 U
Tetrachloroethene	1 U	1 U	1 U
Trichloroethene	1 U	1 U	1 U

Sample ID	MW-2S	MW-2I
Sample Date	12/7/2014	12/7/2014
Units	ug/L	ug/L
Volatile Organic Compounds		
Acetone	4.2 J	5 U
cis-1,2-Dichloroethylene	1 U	1 U
Isopropylbenzene	1 U	1 U
Tetrachloroethene	16	1 U
Trichloroethene	1 U	1 U

Sample ID	MW-8S	MW-8D
Sample Date	8/18/2015	8/18/2015
Units	ug/L	ug/L
Volatile Organic Compounds		
Acetone	5 U	5 U
cis-1,2-Dichloroethylene	1 U	1 U
Isopropylbenzene	1 U	1 U
Tetrachloroethene	22	1 U
Trichloroethene	1 U	1 U

Sample ID	MW-6S	MW-6I	MW-6D
Sample Date	12/7/2014	12/7/2014	12/7/2014
Units	ug/L	ug/L	ug/L
Volatile Organic Compounds			
Acetone	5 U	5 U	5 U
cis-1,2-Dichloroethylene	1 U	1 U	1 U
Isopropylbenzene	1 U	1 U	2
Tetrachloroethene	1 U	27	2.3
Trichloroethene	1 U	1 U	1 U

Sample ID	MW-3S	MW-3I	MW-3D
Sample Date	12/7/2014	12/7/2014	12/7/2014
Units	ug/L	ug/L	ug/L
Volatile Organic Compounds			
Acetone	5.5	5 U	5 U
cis-1,2-Dichloroethylene	4.4	1 U	1 U
Isopropylbenzene	1 U	1 U	1 U
Tetrachloroethene	99	2.4	1 U
Trichloroethene	2.3	1 U	1 U

Sample ID	MW-5S	MW-5I	MW-5D
Sample Date	12/7/2014	12/7/2014	12/7/2014
Units	ug/L	ug/L	ug/L
Volatile Organic Compounds			
Acetone	5 U	5 U	5 U
cis-1,2-Dichloroethylene	1 U	1 U	1 U
Isopropylbenzene	1 U	1 U	1 U
Tetrachloroethene	1 U	3.6	4.8
Trichloroethene	1 U	1 U	1 U

Sample ID	MW-4S	MW-4I	MW-4D
Sample Date	12/7/2014	12/7/2014	12/7/2014
Units	ug/L	ug/L	ug/L
Volatile Organic Compounds			
Acetone	5 U	5 U	5 U
cis-1,2-Dichloroethylene	1 U	1 U	1 U
Isopropylbenzene	1 U	1 U	1 U
Tetrachloroethene	14	7.2	1 U
Trichloroethene	1 U	1 U	1 U

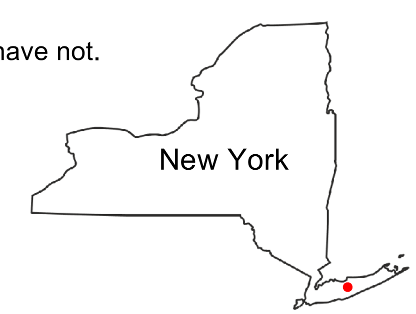
Sample ID	MW-7S	MW-7I	MW-7D
Sample Date	12/7/2014	12/7/2014	12/7/2014
Units	ug/L	ug/L	ug/L
Volatile Organic Compounds			
Acetone	5.4	7.1	5 U
cis-1,2-Dichloroethylene	1 U	1 U	1 U
Isopropylbenzene	1 U	1 U	1 U
Tetrachloroethene	2.2 U	1 U	1 U
Trichloroethene	1 U	1 U	1 U

Note: Highlighted concentrations exceed the respective NYSDEC Class GA Standard.
December 2014 and February 2015 results have been validated by a third party validation service while the August 2015 (MW-8 cluster) results have not.

Legend

Monitoring Well

Approximate Site Boundary



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NYSDEC Site No. 152211
Beau Brummel Cleaners
2049 Jericho Turnpike, Commack, New York

FEASIBILITY STUDY

CONCENTRATIONS OF DETECTED VOCS IN GROUNDWATER

ARCADIS

FIGURE 3

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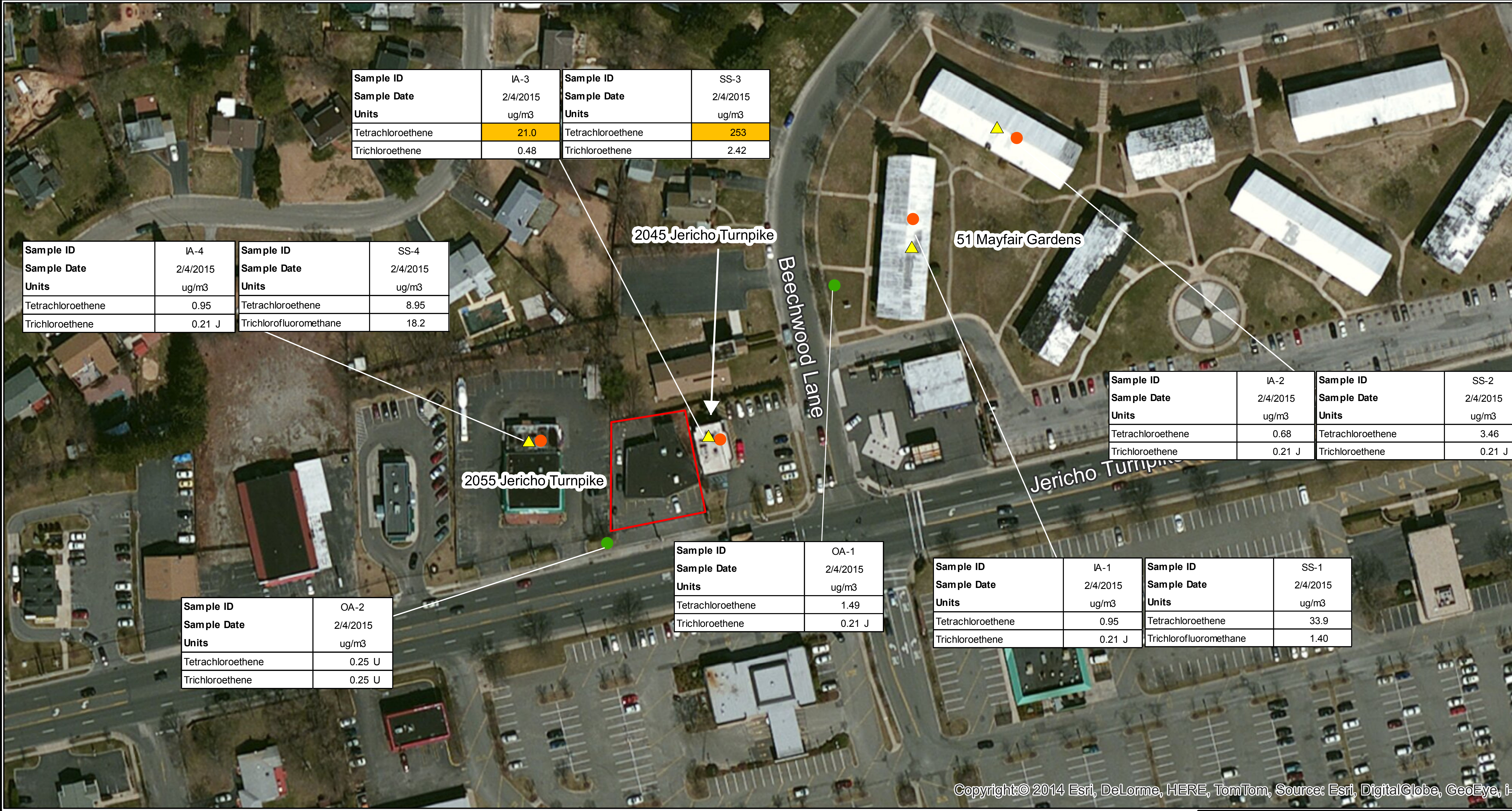

Sample ID	IA-3
Sample Date	2/4/2015
Units	ug/m3
Tetrachloroethene	21.0
Trichloroethene	0.48

Sample ID	SS-3
Sample Date	2/4/2015
Units	ug/m3
Tetrachloroethene	253
Trichloroethene	2.42

Sample ID	IA-4
Sample Date	2/4/2015
Units	ug/m3
Tetrachloroethene	0.95
Trichloroethene	0.21 J

Sample ID	SS-4
Sample Date	2/4/2015
Units	ug/m3
Tetrachloroethene	8.95
Trichlorofluoromethane	18.2

Sample ID	IA-2
Sample Date	2/4/2015
Units	ug/m3
Tetrachloroethene	0.68
Trichloroethene	0.21 J

Sample ID	SS-2
Sample Date	2/4/2015
Units	ug/m3
Tetrachloroethene	3.46
Trichloroethene	0.21 J

Sample ID	OA-1
Sample Date	2/4/2015
Units	ug/m3
Tetrachloroethene	1.49
Trichloroethene	0.21 J

Sample ID	IA-1
Sample Date	2/4/2015
Units	ug/m3
Tetrachloroethene	0.95
Trichloroethene	0.21 J

Sample ID	SS-1
Sample Date	2/4/2015
Units	ug/m3
Tetrachloroethene	33.9
Trichlorofluoromethane	1.40

Sample ID	OA-2
Sample Date	2/4/2015
Units	ug/m3
Tetrachloroethene	0.25 U
Trichloroethene	0.25 U

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DRAFT

0 100 200 400 600 800 Feet

New York

N

Legend

- SubSlab
- OutdoorAir
- IndoorAir
- Approximate Site Boundary
- Mitigation potentially required based on NYSDOH recommendations

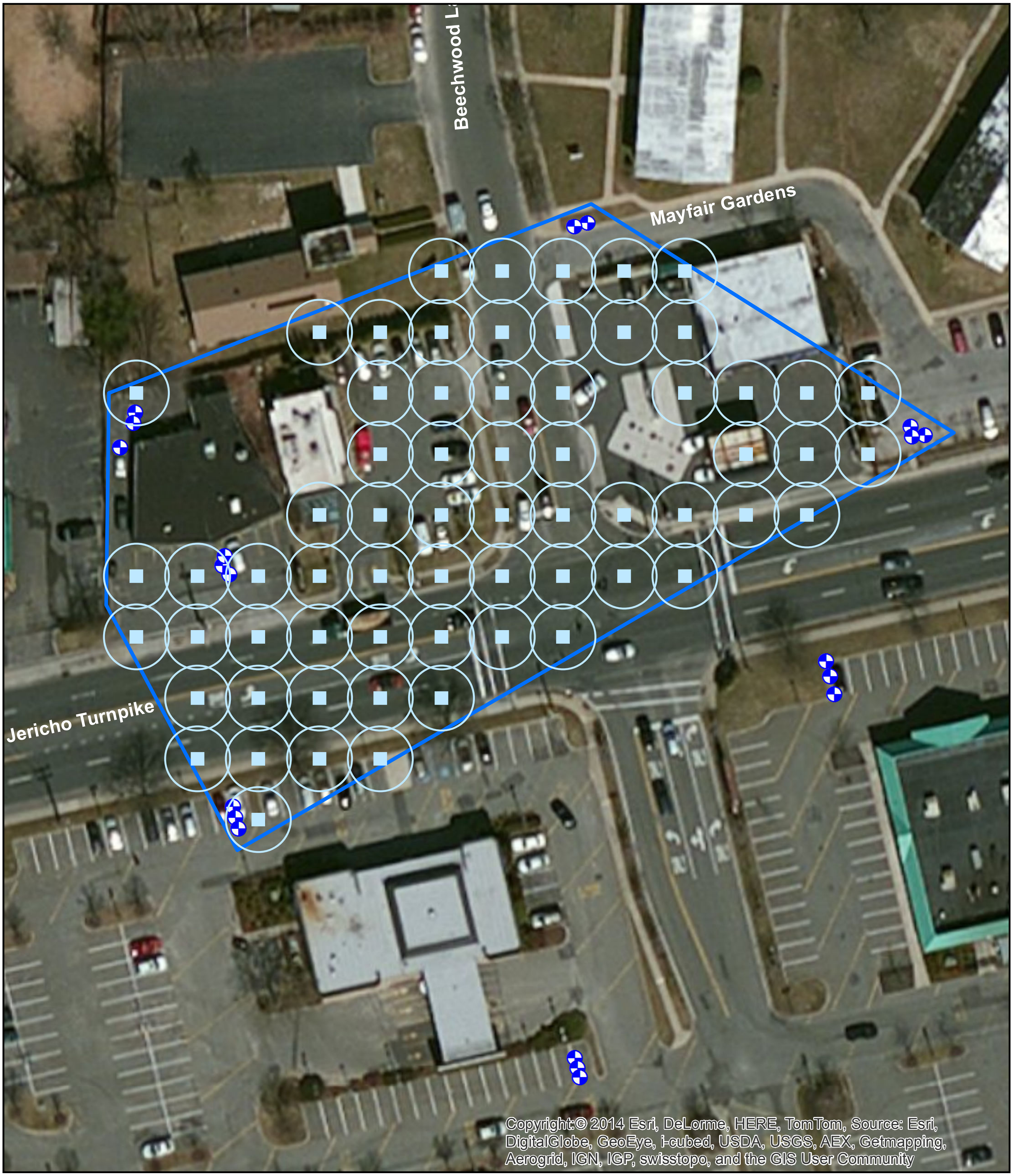
NYSDEC Site No. 152211
Beau Brummel Cleaners
2049 Jericho Turnpike, Commack, New York

FEASIBILITY STUDY

CONCENTRATIONS OF CONTAMINANTS OF CONCERN IN SOIL VAPOR INTRUSION SAMPLES

ARCADIS

FIGURE 4



0 20 40 80 120 160 200 Feet

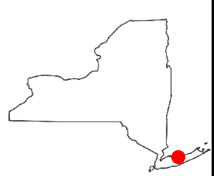
N

Legend

Injection Point, 15-ft radius

Approximate Dissolved Phase VOC Plume Area

Monitoring Well



NYSDEC Site No. 152211
Beau Brummel Cleaners
2049 Jericho Turnpike, Commack, New York
FEASIBILITY STUDY

PROPOSED ISCO INJECTION POINTS

ARCADIS

FIGURE
5

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Table 1
EVALUATION OF POTENTIAL SCGs
Beau Brummel Cleaners
(NYSDEC SITE 152211)
Commack, New York

Medium/Location/Action	Citation	Requirements	Comments	Potential SCG
Potential chemical-specific SCGs				
Ground water	6 NYCRR 703 - Class GA ground water quality standards	Promulgated state regulation that requires that fresh ground waters of the state must attain Class GA standards	Potentially applicable to site ground water.	Yes
Indoor Air	NYSDOH - Guidance for Evaluating Soil Vapor Intrusion	Guidance that discusses generic levels for monitoring potential exposures, as well as for mitigating current or potential exposures.	Potentially applicable to all occupied structures affected by soil vapor intrusion as a result of the dissolved-phase CVOC plume.	Yes
Potential location-specific SCGs				
Wetlands	6 NYCRR 633 - Freshwater wetland permit requirements	Actions occurring in a designated freshwater wetland (within 100 ft) must be approved by NYSDEC of its designee. Activities occurring adjacent to freshwater wetlands must: be compatible with preservation, protection, and conservation of wetlands and benefits; result in no more than insubstantial degradation to or loss of any part of the wetland; and be compatible with public health and welfare.	No applicable because wetlands will not be destroyed or modified.	No
	Executive Order 11990 - Protection of Wetlands	Activities occurring in wetlands must avoid, to the extent possible, the long- and short-term adverse impacts associated with the destruction or modification of wetlands. The procedures also require USEPA to avoid direct or indirect support of new construction in wetlands wherever there are practicable alternatives or minimal potential harm to wetlands when there are no practicable alternatives.	No applicable because wetlands will not be destroyed or modified.	No
100-year flood plain	6 NYCRR 373-2.2 - Location standards for hazardous waste treatment, storage, and disposal facilities - 100-yr floodplain	Hazardous waste treatment, storage, or disposal facilities located in a 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of hazardous waste during a 100-yr flood.	Not applicable or relevant and appropriate as no activities will be conducted within a flood plain.	No
	Executive Order 11988 - Floodplain Management	EPA is required to conduct activities to avoid, to the extent possible, the long- and short- term adverse impacts associated with the occupation or modification of floodplain. The procedures also require EPA to avoid direct or indirect support of floodplain development wherever there are practicable alternatives and minimize potential harm to floodplains when there are no practicable alternatives.	Not applicable or relevant and appropriate as no flood plains will be occupied or modified.	No
Within 61 meters (200 ft) of a fault displaced in Holocene time	40 CFR Part 264.18	New treatment, storage, or disposal of hazardous waste is not allowed.	Not applicable or relevant and appropriate. Site is not located within 200 ft of a fault displaced in Holocene time, as listed in 40 CFR 264 Appendix VI.	No
River or stream	16 USC 661 - Fish and Wildlife Coordination Act	Required protection of fish and wildlife in a stream when performing activities that modify a stream or river.	Not applicable or relevant and appropriate as no streams or rivers will be modified.	No
Habitat of an endangered or threatened species	6 NYCRR 182	Provides requirements to minimize damage to habitat of an endangered species.	Not applicable; threatenced species are not known to be present.	No
Habitat of an endangered or threatened species	Endangered Species Act	Provides a means for conserving various species of fish, wildlife, and plants that are threatened with extinction.	Not applicable; threatenced species are not known to be present.	No

Table 1
EVALUATION OF POTENTIAL SCGs
Beau Brummel Cleaners
(NYSDEC SITE 152211)
Commack, New York

Medium/Location/Action	Citation	Requirements	Comments	Potential SCG
Historical property or district	National Historic Preservation Act	Remedial actions are required to account for the effects of remedial activities on any historic properties included on or eligible for inclusion on the National Register of Historic Places.	Not applicable or relevant and appropriate. Site not identified as a historic property and no properties will be impacted.	No
Potential action-specific SCGs				
Treatment actions	6 NYCRR 373- Hazardous waste management facilities	Provides requirements for managing hazardous wastes.	Not applicable. No hazardous waste anticipated to be produced.	No
Construction	29 CFR Part 1910 - Occupational Safety and Health Standards - Hazardous Waste Operations and Emergency Response	Remedial activities must be in accordance with applicable OSHA requirements.	Applicable for construction and monitoring phase of remediation.	Yes
	29 CFR Part 1926 - Safety and Health Regulations for Construction	Remedial construction activities must be in accordance with applicable OSHA requirements.	Applicable for construction and monitoring phase of remediation.	Yes
Transportation	6 NYCRR 364 - Waste Transporter Permits	Hazardous waste transport must be conducted by a hauler permitted under 6 NYCRR 364.	Not applicable. Hazardous waste is not anticipated to be generated.	No
	6 NYCRR Part 372- Hazardous Waste Manifest System and Related Standards for Generators, Transporters, and Facilities	Substantive hazardous waste generator and transportation requirements must be met when hazardous waste is generated for disposal. Generator requirements include obtaining an EPA Identification Number and manifesting hazardous waste for disposal.	Not applicable. Hazardous waste is not anticipated to be generated.	No
	49 CFR 172-174 and 177-179 - Department of Transportation Regulations	Hazardous waste transport to offsite disposal facilities must be conducted in accordance with applicable DOT requirements.	Not applicable. Hazardous waste is not anticipated to be generated.	No
Generation of air emissions	NYS Air Guide 1	Provides annual guideline concentrations (AGCs) and short-term guideline concentrations (SGCs) for specific chemicals. These are property boundary limitations that would result in no adverse health effects.	Not applicable. No air emisions expected.	No
	NYS TAGM 4031- Dust Suppressing and Particle Monitoring at Inactive Hazardous Waste Disposal Sites	Provides limitations on dust emissions.	Potentially applicable. Dust emissions, specifically during drilling activities, may be anticipated depending on remedy selected.	Yes
Construction storm water management	NYSDEC General permit for storm water discharges associated with construction activities. Pursuant to Article 17 Titles 7 and 8 and Article 70 of the Environmental Conservation Law.	The regulation prohibits discharge of materials other than storm water and all discharges that contain hazardous substance in excess of reportable quantities established by 40 CFR 117.3 or 40 CFR 302.4, unless a separate NPDES permit has been issued to regulate those discharges. A permit must be acquired if activities involve the disturbance of 5 acres or more. If the project is covered under the general permit, the following are required: development and implementation of a monitoring program; all records must be retained for a period of at least 3 years after construction is complete.	Not applicable. Construction disturbances will not exceed the limits.	No
Underground Injection	40 CFR 144 and 146 USEPA Underground Injection Control Regulations	This regulation sets forth minimum requirements for the UIC program promulgated under Part C of the Safe Drinking Water Act and describes the technical standards to follow when implementing the UIC program.	Applicable for the installation of injection points.	Yes

Table 2
GROUNDWATER REMEDIAL ALTERNATIVES EVALUATION CRITERIA COMPARISON
Beau Brummel Cleaners
(NYSDEC SITE 152221)
Commack, New York

		Evaluation Criteria Alternatives						
		Overall Protection of Public Health and the Environment	**Compliance with Standards, Criteria, and Guidance (SCGs)**	**Long-term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility or Volume**	**Short-Term Effectiveness**	**Implementability**	**Cost**
Remedial Alternatives	**No Action**	Protective because groundwater is not used as water supply	Non-Compliant	Not as effective in the long term as Targeted ISCO or restoration to pre-disposal conditions.	Would not reduce toxicity, mobility or volume of dissolved phase CVOC plume other than with natural processes.	Effective in short term since groundwater is not used as a water supply	Easy to implement	No Cost
	Long-Term Monitoring	Protective because groundwater is not used as water supply	Non-Compliant	Not as effective in the long term as Targeted ISCO or restoration to pre-disposal conditions .	Would not reduce toxicity, mobility or volume of dissolved phase CVOC plume other than with natural processes.	Effective in short term since groundwater is not used as a water supply	Easy to implement	Moderate Costs
	Targeted In-Situ Chemical Oxidation	Protective by reducing concentrations of VOCs in groundwater. Groundwater is not used as a water supply.	Compliant within and downgradient of treatment areas.	Effective in long term as further migration of plume can be minimized and CVOC concentrations reduced.	Reduction of toxicity and mobility achieved within the treatment area.	Effective in short term since injection points are installed in small diameter borings with little to no worker contact with contaminated groundwater	Alternative is considered easy to implement, however, significant interruptions to roadways and parking lots will be necessary due to the location of injection points.	High Costs
	Restoration to Achieve Pre-disposal Conditions	Protective by reducing concentrations of VOCs in groundwater and sustaining oxidants in the subsurface with multiple injections.	Compliant with SCGs	Effective in long term as further migration of plume can be minimized and CVOC concentrations reduced to below standards with multiple injections.	Reduction of toxicity and mobility achieved.	Effective in short term since injection points are installed in small diameter borings with little to no worker contact with contaminated groundwater	Alternative is considered easy to implement, however, significant interruptions to roadways and parking lots will be necessary due to the location of injection points.	Prohibitively Expensive

Table 3
GROUNDWATER REMEDIAL ALTERNATIVES EVALUATION CRITERIA COMPARISON
Beau Brummel Cleaners
(NYSDEC SITE 152221)
Commack, New York

		Evaluation Criteria Alternatives						
		Overall Protection of Public Health and the Environment	**Compliance with Standards, Criteria, and Guidance (SCGs)**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility or Volume**	**Short-term Effectiveness**	**Implementability**	**Cost**
Remedial Alternatives	**No Action**	No protection	Non Compliant	Not effective in the long term because there would be no active soil vapor intrusion monitoring or mitigation.	Not effective at reducing toxicity, mobility or volume	Not effective in theshort because there would be no active soil vapor intrusion mitigation.	Easy to implement	No Cost
	Long-Term Monitoring	Protective by monitoring concentrations over time to verifty they are not increasing.	Compliant by addressing the NYSDOH recommendation of monitoring.	Effective in the long-term by verfying VOC concentrations are not increasing.	There would be no reduction of toxicity, mobility or volume, other than through natural processes.	Effective in the short-term by verfying VOC concentrations are not increasing.	Considered easy to implement with minimal disruption to site activities, however, success of treeatment is dependent upon the degree at which the oxidant is in contact with contamination, and the number of injections needed.	Moderate Costs
	Sub-slab Depressurization System	Protective by mitigating soil vapor intrusion in the building and to some extent reducing concentrations in sub-slab vapor.	Compliant by addressing the NSDOH recommendation of monitoring/mitigation.	Effective in the long-term by mitigating soil vapor intrusion.	Reduction of toxicity, mobility and volume by remedical action to reduce VOC concentrations.	Effective in the short-term by immediately reducing indoor air contaminant concentrations. SSD system installation poses minimal risks to workers.	Alternative can be implented without many obstacles and with minimal disruption to site activities. Space constraints are primary obstacle to implementation.	Moderate Costs

Table 2
Summary of Validated Groundwater Analytical Results - VOCs
Beau Brummel Cleaners
Commack, New York
Site # 152211

Sample ID	NYSDEC	MW-1S	MW-1I	MW-1D	MW-2S	MW-2I	MW-2D	MW-3S	MW-3I	MW-3D	MW-4S	MW-4I	MW-4D
Sample Date	Class GA	12/7/2014	12/7/2014	12/7/2014	12/7/2014	12/7/2014	2/4/2015	12/7/2014	12/7/2014	12/7/2014	12/7/2014	12/7/2014	12/7/2014
Units	Standard (ug/L)	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Volatile Organic Compounds													
Acetone	50	5 U	5 UJ	5 U	5 U	4.2 J	5 U	5.5	5 U	5 U	5 U	5 U	5 U
cis-1,2-Dichloroethylene	5	1 U	1 U	1 U	1 U	1 U	1 U	4.4	1 U	1 U	1 U	1 U	1 U
Isopropylbenzene	5	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Tetrachloroethene	5	1 U	1 U	1 U	**16**	1 U	1 U	**99**	2.4	1 U	**14**	**7.2**	1 U
Trichloroethene	5	1 U	1 U	1 U	1 U	1 U	1 U	2.3	1 U	1 U	1 U	1 U	1 U
m,p-Xylene	5	2 U	2 U	2 U	2 U	2 U	1.4 J	2 U	2 U	2 U	2 U	2 U	2 U
o-Xylenes	5	1 U	1 U	1 U	1 U	1 U	0.88 J	1 U	1 U	1 U	1 U	1 U	1 U

Sample ID	NYSDEC	MW-5S	MW-5I	MW-5D	MW-6S	MW-6I	MW-6D	MW-7S	MW-7I	MW-7D	MW-8S	MW-8D
Sample Date	Class GA	12/7/2014	12/7/2014	12/7/2014	12/7/2014	12/7/2014	12/7/2014	12/7/2014	12/7/2014	12/7/2014	8/18/2015	8/18/2015
Units	Standard (ug/L)	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Volatile Organic Compounds												
Acetone	50	5 U	5 U	5 U	5 U	5 U	5 U	5.4	7.1	5 U	5 U	5 U
cis-1,2-Dichloroethylene	5	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Isopropylbenzene	5	1 U	1 U	1 U	1 U	1 U	2	1 U	1 U	1 U	1 U	1 U
Tetrachloroethene	5	1 U	3.6	4.8	1 U	**27**	2.3	2.2	1 U	1 U	**22**	1 U
Trichloroethene	5	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
m,p-Xylene	5	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
o-Xylenes	5	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U

NOTES:

U = Compound not detected; laboratory reporting limit shown

J = Value is estimated

(yellow highlight) Exceeds NYSDEC Class GA Standard or Guidance Value

Table 8
Summary of Validated Sub-Slab Vapor, Indoor Air, and Outdoor Air Analytical Results
Beau Brummel Cleaners
Commack, New York
Site # 152211

	Mayfair Gardens				2045 Jericho Turnpike			2055 Jericho Turnpike			
Sample ID	IA-1	SS-1	IA-2	SS-2	IA-3	DUP-01	SS-3	IA-4	SS-4	OA-1	OA-2
Sample Date	2/4/2015	2/4/2015	2/4/2015	2/4/2015	2/4/2015	2/4/2015	2/4/2015	2/4/2015	2/4/2015	2/4/2015	2/4/2015
Units	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
TO-15											
1,1,1-Trichloroethane	1.09 U	1.09 U	1.09 U	**2.73**	1.09 U	1.09 U	1.09 U	1.09 U	**0.55 J**	1.09 U	1.09 U
1,1,2,2-Tetrachloroethane	1.37 U	1.37 U	1.37 U	1.37 U	1.37 U	1.37 U	1.37 U	1.37 U	1.37 U	1.37 U	1.37 U
1,1,2-Trichloro-1,2,2-trifluoroethane	1.53 U	1.53 U	1.53 U	**0.84 J**	1.53 U	1.53 U	1.53 U	1.53 U	1.53 U	1.53 U	1.53 U
1,1,2-Trichloroethane	1.09 U	1.09 U	1.09 U	1.09 U	1.09 U	1.09 U	1.09 U	1.09 U	1.09 U	1.09 U	1.09 U
1,1-Dichloroethane	0.81 U	0.81 U	0.81 U	**3.44**	0.81 U	0.81 U	0.81 U	0.81 U	0.81 U	0.81 U	0.81 U
1,1-Dichloroethene	0.79 U	0.79 U	0.79 U	**0.83**	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U
1,2,4-Trichlorobenzene	1.48 UJ	1.48 UJ	1.48 UJ	1.48 UJ	1.48 UJ	1.48 UJ	1.48 UJ	1.48 UJ	1.48 UJ	1.48 UJ	1.48 UJ
1,2,4-Trimethylbenzene	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
1,2-Dibromoethane	1.54 U	1.54 U	1.54 U	1.54 U	1.54 U	1.54 U	1.54 U	1.54 U	1.54 U	1.54 U	1.54 U
1,2-Dichlorobenzene	1.20 UJ	1.20 UJ	1.20 UJ	1.20 UJ	1.20 UJ	1.20 UJ	1.20 UJ	1.20 UJ	1.20 UJ	1.20 UJ	1.20 UJ
1,2-Dichloroethane	0.81 U	0.81 U	0.81 U	0.81 U	0.81 U	0.81 U	0.81 U	**0.45 J**	0.81 U	0.81 U	0.81 U
1,2-Dichloroethene	0.79 U	0.79 U	0.79 U	**0.83**	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U
1,2-Dichloroethene	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U	0.79 U
1,2-Dichloropropane	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
1,2-Dichlorotetrafluoroethane	1.40 U	1.40 U	1.40 U	1.40 U	1.40 U	1.40 U	1.40 U	1.40 U	1.40 U	1.40 U	1.40 U
1,3,5-Trimethylbenzene	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
1,3-Dichlorobenzene	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U
1,3-Dichloropropene	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U
1,3-Dichloropropene	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U
1,3-Hexachlorobutadiene	2.13 U	2.13 U	2.13 U	2.13 U	2.13 U	2.13 U	2.13 U	2.13 U	2.13 U	2.13 U	2.13 U
1,4-Dichlorobenzene	1.20 U	1.2 U	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U
Acetone	0.48 U	**2.38**	0.48 U	**2.95**	**90.5**	**92.9**	**7.34**	0.48 U	**24.1**	0.48 U	0.48 U
Benzene	**1.57**	0.64 U	**2.08**	0.64 U	**1.18**	**1.18**	**1.63**	**1.95**	**1.28**	**1.76**	**0.99**
Bromodichloromethane	1.34 U	1.34 U	1.34 U	**0.67 J**	1.34 U	1.34 U	1.34 U	1.34 U	1.34 U	1.34 U	1.34 U
Bromoform	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U
Bromomethane	0.78 U	0.78 U	0.78 U	0.78 U	0.78 U	0.78 U	0.78 U	0.78 U	0.78 U	0.78 U	0.78 U
Carbon disulfide	0.62 U	**0.34 J**	0.62 U	**0.75**	0.62 U	0.62 U	**0.47 J**	0.62 U	**1.56**	0.62 U	0.62 U
Carbon tetrachloride	**0.50**	**0.31**	**0.57**	**0.44**	**0.50**	**0.63**	**0.44**	**0.50**	0.25 U	**0.50**	**0.57**
Chlorobenzene	0.92 U	0.92 U	0.92 U	0.92	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Chloroethane	0.53 U	0.53 U	0.53 U	0.53 U	0.53 U	0.53 U	0.53 U	0.53 U	0.53 U	0.53 U	0.53 U
Chloroform	**0.98**	**0.88 J**	0.98 U	**3.76**	**5.42**	**5.86**	**6.40**	0.98 U	0.98 U	0.98 U	0.98 U
Chloromethane	**0.91**	0.41 U	**0.99**	0.41 U	**1.90**	**2.02**	0.41 U	**1.16**	0.41 U	**1.09**	**1.09**
Dibromochloromethane	1.70 U	1.70 U	1.70 U	1.70 U	1.70 U	1.70 U	1.70 U	1.70 U	1.70 U	1.70 U	1.70 U
Dichlorodifluoromethane	**2.52**	**1.09**	**2.52**	**1.04**	**2.42**	**2.62**	**2.72**	**8.11**	**6.23**	**2.62**	**2.67**
Ethylbenzene	**0.48 J**	0.87 U	**0.78 J**	0.87 U	**0.61 J**	**0.61 J**	0.87 U	**1.04**	0.87 U	**0.61 J**	0.87 U
Methyl butyl ketone	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U
Methyl ethyl ketone	**0.68**	**1.24**	**1.59**	**1.09**	**86.9**	**82.3**	**3.54**	**0.80**	**5.93**	**0.74**	**0.74**
Methyl isobutyl ketone	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U	0.82 U
Methyl tert-butyl ether	0.72 U	0.72 U	0.72 U	0.72 U	0.72 U	0.72 U	0.72 U	0.72 U	0.72 U	0.72 U	0.72 U
Methylene chloride	**1.32**	**0.85**	**0.97**	**1.16**	**2.14**	**2.06**	**0.50 J**	**0.89**	**0.82**	**1.09**	**0.82**
Styrene	0.85 U	0.85 U	0.85 U	0.85 U	**1.15**	**1.02**	**0.68 J**	0.85 U	0.85 U	0.85 U	0.85 U
Tetrachloroethene	**0.95**	**33.9**	**0.68**	**3.46**	**21.0**	**21.0**	**253**	**0.95**	**8.95**	**1.49**	0.25 U
Toluene	**2.71**	**0.79**	**4.26**	**4.07**	**12.8**	**12.2**	**0.75**	**5.35**	**1.17**	**2.67**	**1.73**
Trichloroethene	**0.21 J**	0.25 U	**0.21 J**	**0.21 J**	**0.48**	**0.43**	**2.42**	**0.21 J**	0.25 U	**0.21 J**	0.25 U
Trichlorofluoromethane	**1.24**	**1.40**	**1.24**	**1.40**	**1.29**	**1.46**	**1.57**	**16.0**	**18.2**	**1.40**	**1.35**
Vinyl acetate	0.70 U	0.70 U	0.70 U	0.7 U	0.70 U	0.70 U	0.70 U	0.70 U	0.70 U	0.70 U	0.70 U
Vinyl chloride	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
Xylenes (m&p)	**1.82**	0.87 U	**2.56**	0.87 U	**2.00**	**1.91**	0.87 U	**3.30**	0.87 U	**1.69**	**0.78 J**
Xylenes (o)	**0.61 J**	0.87 U	**0.83 J**	0.87 U	**0.78 J**	**0.78 J**	0.87 U	**1.13**	0.87 U	**0.65 J**	0.87 U

Notes:

Mitigation required based on NYSDOH requirements

Mitigation potentially required based on NYSDOH requirements

Bold = the concentration was detected at the indicated concentration

U = Compound not detected; laboratory reporting limit shown

J = Estimated value

DUP-01 collected at IA-3 location

Table B-1
Remedial Alternative Opinion of Probable Cost

Alternative GW-2
LONG-TERM MONITORING

OPINION OF PROBABLE COST SUMMARY

Site: Beau Brummel Cleaners
Location: Commack, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2015
Date: November 24, 2015

Description: Alternative GW-2 consists of no remedial action with 30 years of semi-annual groundwater monitoring. Capital costs and first year O&M costs occur in Year 1. Annual O&M costs occur in Years 1-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Report Preparation					
Site Management Plan	60	hours	$100.00	$6,000	
Soil Vapor Intrusion Action Plan	40	hours	$100.00	$4,000	
SUBTOTAL				$10,000	
SUBTOTAL				$10,000	
Contingency	25%			$2,500	10% scope + 15% Bid
SUBTOTAL				$12,500	
Project Management*	10%			$1,250	Planning, reporting, and administration.
Remedial Design*	0%			$0	Design analysis, plans, specs, costing, and scheduling.
Construction Management*	0%			$0	Submittal review, design modifications, construction oversight.
First year operation and maintenance	1	lump sum		$34,000	See cost breakdown below
TOTAL CAPITAL COST				$48,000	

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Groundwater Sampling	96	hours	$80.00	$7,680	2 people, 2 days, 2 times/year
Passive Diffusion Bags and Weights	52	bags	$40.00	$2,080	
Groundwater Laboratory Analysis	52	samples	$100.00	$5,200	VOC analysis: 25 samples+ trip blank semi-annually
Data Validation	52	samples	$30.00	$1,560	
Data Compliation and Evaluation	60	hours	$100.00	$6,000	30 hours/event
SUBTOTAL				$22,520	
SUBTOTAL				$22,520	
Contingency	25%			$5,630	
SUBTOTAL				$28,150	
Project Management*	10%			$2,815	
Technical Support*	10%			$2,815	
TOTAL ANNUAL O&M COST				$34,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	PRESENT VALUE	NOTES
Capital	1	$48,000	$48,000	$48,000	
Annual O&M	2-5	$136,000	$34,000	$128,526	
		$184,000		$176,526	5 years, 2.3 %
TOTAL PRESENT VALUE OF ALTERNATIVE FOR FIVE YEARS				$177,000	
Capital	1	$48,000	$48,000	$48,000	
Annual O&M	2-30	$986,000	$34,000	$713,796	
		$1,034,000		$761,796	30 years, 2.3 %
TOTAL PRESENT VALUE OF ALTERNATIVE FOR THIRTY YEARS				$762,000	

** Per USEPA 540-R-00-002, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study". July 2000.*

Table B-2
Remedial Alternative Opinion of Probable Cost

Alternative GW-3
TARGETED IN-SITU CHEMICAL OXIDATION

OPINION OF PROBABLE COST SUMMARY

Site: Beau Brummel Cleaners
Location: Commack, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2015
Date: November 24, 2015

Description: Alternative GW-3 consists of in-situ chemical oxidation to treat the area of the plume with the highest concentrations. Assumes a one-time direct-push oxidant injection event over a 15 foot vertical thickness where VOC concentrations exceed standards in year 1 and semi-annual groundwater sampling for 30 years. Capital costs and first year O&M costs occur in Year 1. Annual O&M costs occur in Years 1-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Report Preparation					
Site Management Plan	60	hours	$100.00	$6,000	
Soil Vapor Intrusion Action Plan	40	hours	$100.00	$4,000	
SUBTOTAL				$10,000	
Pre- and Post-injection Performance Monitoring					
Groundwater Sampling	96	hours	$80.00	$7,680	2 people, 2 days, 2 times
Passive Diffusion Bags and Weights	52	bags	$40.00	$2,080	
Groundwater Laboratory Analysis	52	samples	$100.00	$5,200	VOC analysis: 15 samples+ trip blank/event
Data Validation	52	samples	$30.00	$1,560	
Data Compliation and Evaluation	60	hours	$100.00	$6,000	30 hours/event
SUBTOTAL				$22,520	
Direct-Push Borings and Injections					
Drilling and Injection Mobilization	1	lump sum	$30,000.00	$30,000	
Decon Pad	1	lump sum	$500.00	$500	Assuming injecting at 5 gallons per minute, 1 day to achieve depth
Direct-Push Drilling/injecting	65	days	$3,500.00	$227,500	1 day to inject per point, 65 injection points
Oxidant Solution, premixed tanker	975,000	pounds	$0.30	$292,500	65 injection points, 15,000 pounds per injection point
Drums	5	Drums	$55.00	$275	
Traffic Control and Permits	1	lump sum	$65,000.00	$65,000	$1,000 per day estimate
SUBTOTAL				$615,775	
SUBTOTAL				$648,295	
Contingency	25%			$162,074	10% scope + 15% Bid
SUBTOTAL				$810,369	
Project Management*	8%			$64,830	Planning, reporting, and administration.
Remedial Design*	15%			$121,555	Design analysis, plans, specs, costing, and scheduling.
Construction Management*	10%			$81,037	Submittal review, design modifications, construction oversight.
First year operation and maintenance	1	lump sum		$34,000	See cost breakdown below
TOTAL CAPITAL COST				$1,112,000	

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Groundwater Sampling	96	hours	$80.00	$7,680	2 people, 2 days, 2 times/year
Passive Diffusion Bags and Weights	52	bags	$40.00	$2,080	
Groundwater Laboratory Analysis	52	samples	$100.00	$5,200	VOC analysis: 25 samples+ trip blank semi-annually
Data Validation	52	samples	$30.00	$1,560	
Data Compliation and Evaluation	60	hours	$100.00	$6,000	30 hours/event
SUBTOTAL				$22,520	
SUBTOTAL				$22,520	
Contingency	25%			$5,630	
SUBTOTAL				$28,150	
Project Management*	10%			$2,815	
Technical Support*	10%			$2,815	
TOTAL ANNUAL O&M COST				$34,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	PRESENT VALUE	NOTES
Capital	1	$1,112,000	$1,112,000	$1,112,000	
Annual O&M	2-5	$136,000	$34,000	$128,526	
		$1,248,000		$1,240,526	5 years, 2.3 %
TOTAL PRESENT VALUE OF ALTERNATIVE FOR FIVE YEARS				$1,241,000	
Capital	1	$1,112,000	$1,112,000	$1,112,000	
Annual O&M	2-30	$986,000	$34,000	$713,796	
		$2,098,000		$1,825,796	30 years, 2.3 %
TOTAL PRESENT VALUE OF ALTERNATIVE FOR THIRTY YEARS				$1,826,000	

** Per USEPA 540-R-00-002, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study". July 2000.*

Table B-3
Remedial Alternative Opinion of Probable Cost

Alternative GW-4
RESTORATION TO ACHIEVE PRE-DISPOSAL CONDITIONS

OPINION OF PROBABLE COST SUMMARY

Site: Beau Brummel Cleaners
Location: Commack, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2015
Date: November 24, 2015

Description: This alternative consists of injecting an oxidant into the subsurface to treat groundwater throughout the dissolved-phase CVOC plume and restore the site to pre-disposal conditions. Assumes four direct-push chemical oxidation injection events as part of the capital costs. Capital costs and first year O&M costs occur in Year 1. Annual O&M costs occur in Years 1-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Report Preparation					
Site Management Plan	60	hours	$100.00	$6,000	
Soil Vapor Intrusion Action Plan	40	hours	$100.00	$4,000	
SUBTOTAL				$10,000	
Pre- and Post-injection Performance Monitoring					
Groundwater Sampling	96	hours	$80.00	$7,680	2 people, 2 days, 2 times
Passive Diffusion Bags and Weights	52	bags	$40.00	$2,080	
Groundwater Laboratory Analysis	52	samples	$100.00	$5,200	VOC analysis: 15 samples+ trip blank/event
Data Validation	52	samples	$30.00	$1,560	
Data Compliation and Evaluation	60	hours	$100.00	$6,000	30 hours/event
SUBTOTAL				$22,520	
Direct-Push Borings and Injections					
Drilling and Injection Mobilization	4	lump sum	$30,000.00	$120,000	
Decon Pad	4	lump sum	$500.00	$2,000	Assuming injecting at 5 gallons per minute, 1 day to achieve depth
Direct-Push Drilling/injecting	260	days	$3,500.00	$910,000	1 day to inject per point, 65 injection points, 4 events
Oxidant Solution, premixed tanker	3,900,000	pounds	$0.30	$1,170,000	65 injection points, 15,000 pounds per injection point, 4 events
Drums	10	Drums	$55.00	$550	
Traffic Control and Permits	1	lump sum	$260,000.00	$260,000	$1,000 per day
SUBTOTAL				$2,462,550	
SUBTOTAL				$2,495,070	
Contingency	25%			$623,768	10% scope + 15% Bid
SUBTOTAL				$3,118,838	
Project Management*	8%			$249,507	Planning, reporting, and administration.
Remedial Design*	15%			$467,826	Design analysis, plans, specs, costing, and scheduling.
Construction Management*	10%			$311,884	Submittal review, design modifications, construction oversight.
First year operation and maintenance	1	lump sum		$34,000	See cost breakdown below
TOTAL CAPITAL COST				$4,182,000	

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Groundwater Sampling	96	hours	$80.00	$7,680	2 people, 2 days, 2 times/year
Passive Diffusion Bags and Weights	52	bags	$40.00	$2,080	
Groundwater Laboratory Analysis	52	samples	$100.00	$5,200	VOC analysis: 25 samples+ trip blank semi-annually
Data Validation	52	samples	$30.00	$1,560	
Data Compliation and Evaluation	60	hours	$100.00	$6,000	30 hours/event
SUBTOTAL				$22,520	
SUBTOTAL				$22,520	
Contingency	25%			$5,630	
SUBTOTAL				$28,150	
Project Management*	10%			$2,815	
Technical Support*	10%			$2,815	
TOTAL ANNUAL O&M COST				$34,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	PRESENT VALUE	NOTES
Capital	1	$4,182,000	$4,182,000	$4,182,000	
Annual O&M	2-5	$136,000	$34,000	$128,526	
		$4,318,000		$4,310,526	5 years, 2.3 %
TOTAL PRESENT VALUE OF ALTERNATIVE FOR FIVE YEARS				$4,311,000	
Capital	1	$4,182,000	$4,182,000	$4,182,000	
Annual O&M	2-30	$986,000	$34,000	$713,796	
		$5,168,000		$4,895,796	30 years, 2.3 %
TOTAL PRESENT VALUE OF ALTERNATIVE FOR THIRTY YEARS				$4,896,000	

** Per USEPA 540-R-00-002, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study". July 2000.*

Table B-4
Remedial Alternative Opinion of Probable Cost

Alternative VI-2
LONG-TERM MONITORING

OPINION OF PROBABLE COST SUMMARY

Site: Beau Brummel Cleaners
Location: Commack, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2015
Date: November 24, 2015

Description: Alternative VI-2 consists of no remedial action with 30 years of annual vapor intrusion monitoring. Capital costs and first year O&M costs occur in Year 1. Annual O&M costs occur in Years 1-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Report Preparation					
Site Management Plan	60	hours	$100.00	$6,000	
Soil Vapor Intrusion Action Plan	40	hours	$100.00	$4,000	
SUBTOTAL				$10,000	
SUBTOTAL				$10,000	
Contingency	25%			$2,500	10% scope + 15% Bid
SUBTOTAL				$12,500	
Project Management*	10%			$1,250	Planning, reporting, and administration.
Remedial Design*	0%			$0	Design analysis, plans, specs, costing, and scheduling.
Construction Management*	0%			$0	Submittal review, design modifications, construction oversight.
First year operation and maintenance	1	lump sum		$12,000	See cost breakdown below
TOTAL CAPITAL COST				$26,000	

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Air and Sub-Slab Vapor Sampling	48	hours	$85.00	$4,080	2 people, 2 days, 1 time/year
Air Laboratory Analysis	6	samples	$300.00	$1,800	VOC TO-15 analysis: 6 samples - annually
Data Validation	6	samples	$30.00	$180	
Data Compliation and Evaluation	20	hours	$100.00	$2,000	20 hours/event
SUBTOTAL				$8,060	
SUBTOTAL				$8,060	
Contingency	25%			$2,015	
SUBTOTAL				$10,075	
Project Management*	10%			$1,008	
Technical Support*	10%			$1,008	
TOTAL ANNUAL O&M COST				$12,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	PRESENT VALUE	NOTES
Capital	1	$26,000	$26,000	$26,000	
Annual O&M	2-5	$48,000	$12,000	$45,362	
		$74,000		$71,362	5 years, 2.3 %
TOTAL PRESENT VALUE OF ALTERNATIVE FOR FIVE YEARS				$71,000	
Capital	1	$26,000	$26,000	$26,000	
Annual O&M	2-30	$348,000	$12,000	$251,928	
		$374,000		$277,928	30 years, 2.3 %
TOTAL PRESENT VALUE OF ALTERNATIVE FOR THIRTY YEARS				$278,000	

** Per USEPA 540-R-00-002, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study". July 2000.*

Table B-5
Remedial Alternative Opinion of Probable Cost

Alternative VI-3
SUB-SLAB DEPRESSURIZATION

OPINION OF PROBABLE COST SUMMARY

Site: Beau Brummel Cleaners
Location: Commack, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2015
Date: November 24, 2015

Description: Alternative VI-3 consists of sub-slab depressurization with 30 years of annual indoor air sampling and system operations and maintenance. Capital costs and first year O&M costs occur in Year 1. Annual O&M costs occur in Years 1-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Report Preparation					
Site Management Plan	60	hours	$100.00	$6,000	
Soil Vapor Intrusion Action Plan	40	hours	$100.00	$4,000	
SUBTOTAL				$10,000	
SSD Installation					
SSD Installation Subcontractor	1	building	$4,000.00	$4,000	
Installation oversight	40	hours	$85.00	$3,400	
SUBTOTAL				$7,400	
SUBTOTAL				$17,400	
Contingency	25%			$4,350	10% scope + 15% Bid
SUBTOTAL				$21,750	
Project Management*	10%			$2,175	Planning, reporting, and administration.
Remedial Design*	10%			$2,175	Design analysis, plans, specs, costing, and scheduling.
Construction Management*	10%			$2,175	Submittal review, design modifications, construction oversight.
First year operation and maintenance	1	lump sum		$7,000	See cost breakdown below
TOTAL CAPITAL COST				$35,000	

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Indoor Air Sampling	24	hours	$85.00	$2,040	1 person, 2 days, 1 time/year
Air Laboratory Analysis	1	samples	$300.00	$300	VOC analysis: 1 sample - annually
Data Validation	1	samples	$30.00	$30	
Data Compliation and Evaluation	20	hours	$100.00	$2,000	20 hours/event
SUBTOTAL				$4,370	
SUBTOTAL				$4,370	
Contingency	25%			$1,093	
SUBTOTAL				$5,463	
Project Management*	10%			$546	
Technical Support*	10%			$546	
TOTAL ANNUAL O&M COST				$7,000	

PERIODIC COSTS IN YEARS 10 and 20:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Fan Replacement					
Fan Replacement	1	fan	$150.00	$150	
Subcontractor Installation	1	lump sum	$1,200.00	$1,200	
Installation Oversight	12	hours	$85.00	$1,020	
SUBTOTAL				$2,370	
Contingency	25%			$593	10% scope + 15% Bid
SUBTOTAL				$2,963	
Project Management*	10%			$296	
Technical Support*	20%			$593	
TOTAL PERIODIC COST FOR FAN REPLACEMENT				$3,900	

Note:
Expected life of a fan is 5 to 15 years.
Assume fan is replaced every 10 years.
Replace fans in nine systems at year 10 and year 20 to get usable fans to year 30.

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	PRESENT VALUE	NOTES
Capital	1	$35,000	$35,000	$35,000	
Annual O&M	2-5	$28,000	$7,000	$26,461	
		$63,000		$61,461	5 years, 2.3 %
TOTAL PRESENT VALUE OF ALTERNATIVE FOR FIVE YEARS				$61,000	
Capital	1	$35,000	$35,000	$35,000	
Periodic Cost	10	$3,900	$3,900	$3,178	
Periodic Cost	20	$3,900	$3,900	$2,532	
Annual O&M	2-30	$203,000	$7,000	$146,958	
		$245,800		$187,668	30 years, 2.3 %
TOTAL PRESENT VALUE OF ALTERNATIVE FOR THIRTY YEARS				$188,000	

** Per USEPA 540-R-00-002, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study". July 2000.*

Table B-6
Remedial Alternatives Opinion of Probable Cost Summary

OPINION OF PROBABLE COST SUMMARY

Site: Beau Brummel Cleaners
Location: Commack, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2015
Date: November 24, 2015

Soil Vapor Intrusion Remedial Alternatives

Alternative	Description	Capital Costs	Annual OM&M Costs	Total Present Value
Alternative VI-1	NO ACTION	$0	$0	$0
Alternative VI-2	LONG-TERM MONITORING	$26,000	$12,000	$278,000
Alternative VI-3	SUB-SLAB DEPRESSURIZATION	$35,000	$7,000	$188,000

Groundwater Remedial Alternatives

Alternative	Description	Capital Costs	Annual OM&M Costs	Total Present Value
Alternative GW-1	NO ACTION	$0	$0	$0
Alternative GW-2	LONG-TERM MONITORING	$48,000	$34,000	$762,000
Alternative GW-3	TARGETED IN-SITU CHEMICAL OXIDATION	$1,112,000	$34,000	$1,826,000
Alternative GW-4	RESTORATION TO ACHIEVE PRE-DISPOSAL CONDITIONS	$4,182,000	$34,000	$4,896,000

Notes:
Total Present Value costs assume implementation of each alternative for 30 years.
Periodic, non-annual O&M costs are not listed above but are included in the the Total Present Value costs.

Table B-7
Remedial Alternatives 30-Year Cost Summary

OPINION OF PROBABLE COST SUMMARY

Site: Beau Brummel Cleaners
Location: Commack, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2015
Date: November 24, 2015

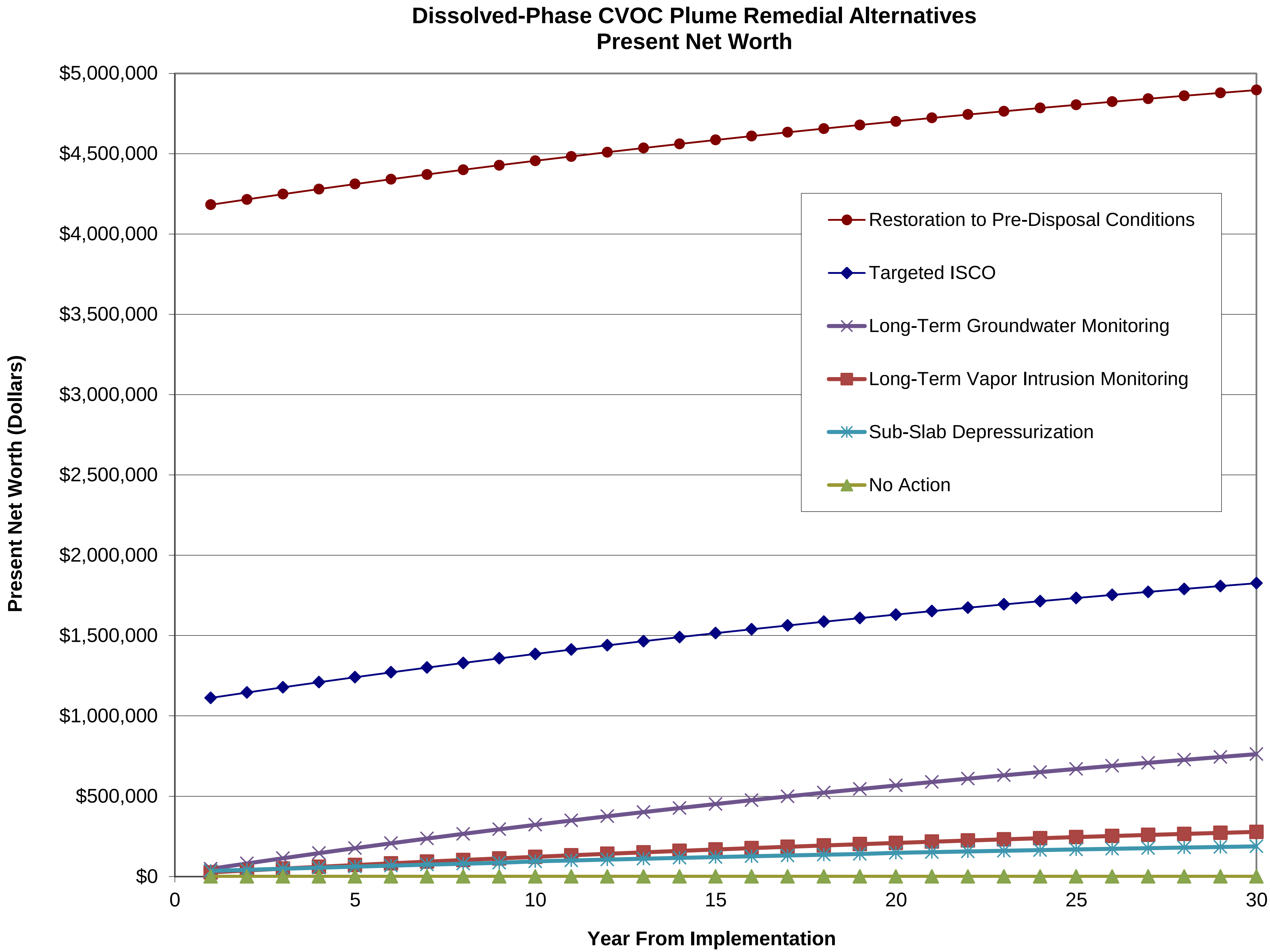
	Soil Vapor Intrusion Remedial Alternatives			**Groundwater Remedial Alternatives**			
	VI-1	VI-2	VI-3	GW-1	GW-2	GW-3	GW-4
Alternative	No Action	Long-Term Vapor Intrusion Monitoring	Sub-Slab Depressurization	No Action	Long-Term Groundwater Monitoring	Targeted ISCO	Restoration to Pre-Disposal Conditions
Capital Cost	$0	$26,000	$35,000	$0	$48,000	$1,112,000	$4,182,000
Annual O&M	$0	$12,000	$7,000	$0	$34,000	$34,000	$34,000
Periodic Cost Year 10	$0	$0	$3,900	$0	$0	$0	$0
Periodic Cost Year 20	$0	$0	$3,900	$0	$0	$0	$0
Year							
1	$0	$26,000	$35,000	$0	$48,000	$1,112,000	$4,182,000
2	$0	$37,730	$41,843	$0	$81,236	$1,145,236	$4,215,236
3	$0	$49,197	$48,531	$0	$113,724	$1,177,724	$4,247,724
4	$0	$60,405	$55,070	$0	$145,482	$1,209,482	$4,279,482
5	$0	$71,362	$61,461	$0	$176,526	$1,240,526	$4,310,526
6	$0	$82,072	$67,709	$0	$206,872	$1,270,872	$4,340,872
7	$0	$92,542	$73,816	$0	$236,535	$1,300,535	$4,370,535
8	$0	$102,776	$79,786	$0	$265,532	$1,329,532	$4,399,532
9	$0	$112,780	$85,622	$0	$293,877	$1,357,877	$4,427,877
10	$0	$122,559	$94,504	$0	$321,585	$1,385,585	$4,455,585
11	$0	$132,119	$100,081	$0	$348,669	$1,412,669	$4,482,669
12	$0	$141,463	$105,532	$0	$375,145	$1,439,145	$4,509,145
13	$0	$150,597	$110,860	$0	$401,025	$1,465,025	$4,535,025
14	$0	$159,526	$116,068	$0	$426,324	$1,490,324	$4,560,324
15	$0	$168,254	$121,160	$0	$451,054	$1,515,054	$4,585,054
16	$0	$176,786	$126,137	$0	$475,227	$1,539,227	$4,609,227
17	$0	$185,126	$131,002	$0	$498,858	$1,562,858	$4,632,858
18	$0	$193,279	$135,758	$0	$521,957	$1,585,957	$4,655,957
19	$0	$201,248	$140,406	$0	$544,536	$1,608,536	$4,678,536
20	$0	$209,038	$147,482	$0	$566,608	$1,630,608	$4,700,608
21	$0	$216,653	$151,924	$0	$588,184	$1,652,184	$4,722,184
22	$0	$224,097	$156,267	$0	$609,275	$1,673,275	$4,743,275
23	$0	$231,373	$160,511	$0	$629,891	$1,693,891	$4,763,891
24	$0	$238,486	$164,660	$0	$650,044	$1,714,044	$4,784,044
25	$0	$245,439	$168,716	$0	$669,744	$1,733,744	$4,803,744
26	$0	$252,236	$172,681	$0	$689,001	$1,753,001	$4,823,001
27	$0	$258,879	$176,556	$0	$707,825	$1,771,825	$4,841,825
28	$0	$265,374	$180,345	$0	$726,226	$1,790,226	$4,860,226
29	$0	$271,722	$184,048	$0	$744,213	$1,808,213	$4,878,213
30	$0	$277,928	$187,668	$0	$761,796	$1,825,796	$4,895,796

Notes:

Present Net Worth is based on a 2.3% discount rate.

Capital costs, which include the first year of O&M, occur in year 1.

Assumes O&M costs incurred at the end of each year.



Dissolved-Phase CVOC Plume Remedial Alternatives
Present Net Worth
Present Net Worth (Dollars)
$5,000,000
$4,500,000
$4,000,000
$3,500,000
$3,000,000
$2,500,000
$2,000,000
$1,500,000
$1,000,000
$500,000
$0
0
5
10
15
20
25
30
Year From Implementation
Restoration to Pre-Disposal Conditions
Targeted ISCO
Long-Term Groundwater Monitoring
Long-Term Vapor Intrusion Monitoring
Sub-Slab Depressurization
No Action