NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

FEASABILITY STUDY FINAL REPORT

Wantagh Cleaners Site
Site No. 1-30-064
Hempstead, New York

January 2016

Prepared by
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Certification

I, Christopher Gurr, certify that I am currently a New York State (NYS) registered professional engineer and that this Feasibility Study 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).

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11/11/2015
Date

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Acronyms and Abbreviations

°F	degrees Fahrenheit
%	percent
amsl	above mean sea level
AS	air sparge
ASTM	ASTM International
BASE	Building Assessment and Survey Evaluation
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	contaminant of concern
CSM	conceptual site model
CVOCs	chlorinated volatile organic compounds
DCE	dichloroethene
DHC	Dehalococcoides
DNAPL	dense non-aqueous phase liquid
DPE	dual-phase extraction
DPT	direct push technology
EAB	enhanced anaerobic bioremediation
EC	Electrical conductivity
EDR	Environmental Data Resources Inc.
EPA	United States Environmental Protection Agency
ERH	electrical resistivity heating
EZVI	emulsified zero-valent iron
Fenley & Nicol	Fenley & Nicol Environmental, Inc.
FRI	Focused Remedial Investigation
FS	Feasibility Study
ft	feet
GC	gas chromatograph
GCW	groundwater circulation well
GPR	ground penetrating radar
GRA	General Response Action
GWQS	Groundwater Quality Standards
H&S	health and safety
IC	institutional control
ICE	internal combustion engine
IRM	interim remedial measure
ISCO	*in situ* chemical oxidation
ISTR	*in-situ* thermal remediation
IVS	in-well vapor stripper
LPGAC	Liquid-Phase Granular Carbon
MEE	methane, ethane, ethene

mg/kg	milligram per kilogram
mg/L	milligrams per Liter
mg/m^3	milligrams per meters cubed
MIP	membrane interface probe
MNA	monitored natural attenuation
msl	mean sea level
MTBE	methyl tertiary butyl ether
mV	millivolts
NCDOH	Nassau County Department of Health
NCDPW	Nassau County Department of Public Works
NCP	National Contingency Plan
NFA	No Further Action
NYCRR	New York Code, Rules and Regulations
NYPDES	New York Pollutant Discharge Elimination System
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	operations & maintenance
ORP	oxidation reduction potential
OSHA	Occupational Safety and Health Administration
OVA	organic vapor analyzer
PCE	tetrachloroethylene
PDI	pre-design investigation
POTW	Publically Owned Treatment Works
PRAP	Proposed Remedial Action Plan
PRB	permeable reactive barrier
PRP	potentially responsible party
PRR	periodic review reporting
PSA	Preliminary Site Assessment
RA	remedial action
RAO	Remedial Action Objective
RI	remedial investigation
RIR	Remedial Investigation Report
ROD	Record of Decision
SCG	standard, criteria and guidance
SCO	Soil Cleanup Objectives
SVE	soil vapor extraction
SVOC	Semi-volatile organic compounds
T/M/V	toxicity, mobility, or volume
TAGM	Technical and Administrative Guidance Memorandum
TAL	Target Analyte List
TCA	Trichloroethane
TCE	trichloroethylene

TOC	total organic carbon
TOGS	Technical and Operational Guidance Series
µg/kg	micrograms per kilogram
µg/L	microgram per liter
µg/m^3	microgram per cubic meter
USGS	United States Geological Survey
UST	underground storage tank
VC	vinyl chloride
VI	vapor intrusion
VOC	volatile organic compounds
VPGAC	Vapor-Phase Granular Activated Carbon
ZVI	zero-valent iron

Appendices

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Section 1

Introduction

This Feasibility Study (FS) Report is for the Wantagh Cleaners Site (herein referred to as the "Site") located at 920 Wantagh Avenue, Village of Wantagh, Hempstead, Nassau County, New York. It was prepared by CDM Smith for the New York State Department of Environmental Conservation (NYSDEC) under the Engineering Services for Investigation and Design, Standby Contract No. D007621, Work Assignment D007621-18. The Site is an active dry cleaning facility which previously used chlorinated solvents during on-site operations. Site investigation activities performed between 2007 and 2014 identified soil, groundwater, and soil vapor contamination on and off site. The FS report was developed in accordance with the New York State guidance entitled "DER-10 Technical Guidance for Site Investigation and Remediation", dated May 2010 (NYSDEC 2010) and "Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York", dated October 2006 (NYSDOH 2006).

1.1 Purpose

The objective of this FS is to develop and present remedial alternatives that are appropriate for addressing site contamination as defined in the February 2015 Remedial Investigation Report (RIR) Addendum. The FS serves as the mechanism for development, screening, and detailed evaluation of remedial alternatives. It includes:

- Developing remedial action objectives (RAOs) for site-related contamination
- Developing site-specific remedial action criteria
- Identifying, screening, and selecting remedial technologies and process options applicable to the contamination associated with the Site
- Assembling the retained technologies and process options into remedial alternatives for evaluation and comparative analysis

1.2 Organization of Feasibility Study Report

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

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

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

Section 3: Summary of Site Conditions provides a description of physical characteristics of the Site, nature and extent of contamination, the conceptual site (CSM) model and contaminant fate and transport.

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

Section 5: General Response Actions (GRA) presents actions that, alone or in combination, satisfy the remedial action objectives (RAOs) for the identified media by reducing the concentrations of hazardous substances or reducing the likelihood of contact with hazardous substances.

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

Section 7: Remedial Action Alternatives presents the remedial alternatives developed by combining the feasible technologies and process options from Section 6. This section also provides detailed descriptions and preliminary design assumptions regarding the alternatives that were retained. This information is used to develop the cost estimates for each alternative. This section also provides a detailed analysis of each alternative with respect to the following eight criteria:

- overall protection of public health and the environment;
- compliance with SCGs;
- long-term effectiveness and permanence;
- reduction of toxicity, mobility, or volume with treatment;
- short-term effectiveness;
- implementability;
- cost; and
- community acceptance.

An overall comparison between the various remedial alternatives is also presented in this section.

Section 8: Detailed Analysis of Remedial Action Alternatives evaluates the remedial alternatives against the remedial action criteria.

Section 9: Recommended Remedy provides the recommended remedy for each medium that would meet the remedial goals and RAOs.

Section 10: References is complete list of the citations in the FS Report.

Section 2

Site Description and History

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

2.1 Site Description

The Site is located at 920 Wantagh Avenue in the Town of Hempstead, Nassau County, New York at the intersection of Wantagh Avenue and Sand Hill Road (**Figures 2-1 and 2-2**). The property is bounded by Sand Hill Road to the south, Wantagh Avenue to the east, a gasoline service station to the north, and a convenience store to the west. The Site occupies approximately 0.26 acres and consists of a single story building and a paved parking lot. The entire Site is covered with an impervious surface, more specifically a one-story building and asphalt pavement. An intermittent creek is located to the west of the Site, and a drainage ditch is located across from the Site on the southerly boundary of Sand Hill Road.

The surrounding area consists of mixed residential and commercial properties. The Southern State Parkway is located directly south of the Site. Groundwater contamination emanating from the Site has been identified south of the Southern State Parkway, within a densely populated residential neighborhood. Commercial properties are located south of the residential neighborhood, along Wantagh Avenue near Jerusalem Avenue. Twin Lakes Preserve is located approximately 1.6 miles southwest of the Site.

2.2 Operational and Remedial History

Information on the Site operations and previous remedial investigations were provided in the following documents:

- *Supplement to Focused Remedial Investigation Revised Report,* dated November 1998, prepared by Fenley & Nicol Environmental, Inc. (Fenley & Nicol Environmental, Inc).
- *Soil and Groundwater Remediation by Air Sparging and Soil Vapor Extraction, Interim Remedial Measure, Project Manual,* dated December 1998, prepared by Fenley & Nicol.
- *Soil and Groundwater Remediation by Air Sparging and Soil Vapor Extraction, Interim Remedial Measure, Design Report,* dated December 1998, prepared by Fenley & Nicol.
- *Proposed Remedial Action Plan, Wantagh Cleaners Site, Village of Wantagh, Town of Hempstead, Nassau County, New York, Site Number 1-30-064*, dated February 1999, prepared by NYSDEC.
- *Record of Decision, Wantagh Cleaners Site, Village of Wantagh, Town of Hempstead, Nassau County, New York, Site Number 1-30-064*, dated February 1999, prepared NYSDEC.

- *Final Site Characterization Report, Soil Vapor Intrusion Evaluation, Wantagh Cleaners Site,* dated June 2009, prepared CDM Smith.
- *Final Remedial Investigation Report, Wantagh Cleaners Site (Site No. 1-30-064), Town of Hempstead, New York* dated October 2012, prepared by CDM Smith.
- *Draft Remedial Investigation Report Addendum, Wantagh Cleaners Site (Site No. 1-30-064), Hempstead, New York* dated February 2015, prepared by CDM Smith.

2.2.1 Operational History

The previous owner, Mr. Kleinfield, owned the subject property since 1984. He leased the building to Wantagh Cleaners as a dry cleaning facility in May of 1991. The previous occupant was Coral Cleaners, but it is not known for how long. The Site has been the location of a dry cleaning facility from at least 1974 to the present. Mr. Kleinfield is now deceased and the owner of the property is currently owned by KMN Realty Associates.

Site contamination was caused by the discharge of dry cleaning process fluid containing tetrachloroethylene (PCE) into two on-site leaching pits: LP-1 and LP-2. Primary dry cleaning process wastewater was discharged into LP-1 and overflow discharged into LP-2. A third on-site leaching pit, LP-3, was used for septic wastewater disposal. The discharged wastewater seeped to the surrounding soils through the bottom of the leaching pits. The base of LP-1 was approximately 15 feet below grade; the base of LP-2 was approximately 11 feet below grade; and the base of LP-3 was approximately 7 feet below grade. **Figure 2-2** displays the leaching pit locations. The groundwater table is approximately 9 feet below ground surface (bgs).

During the supplemental Remedial Investigation (RI) field event, the current tenant provided additional information on previous disposal activities at the Site. A floor drain in the shape of a trench was formerly located inside the building along the western and southern walls. The floor drain discharged directly to LP-1. The approximate location of the floor drain (trench) is shown on **Figure 2-2**.

In November of 1988, the Nassau County Department of Health (NCDOH) notified the potentially responsible party (PRP), Mr. Kleinfield, that the facility should have been connected to the public sewer system in May of 1985. The notification also required that all on-site cesspools, leaching pits, and septic tanks be emptied, cleaned, and backfilled.

In November of 1990, NCDOH notified the PRP that the facility still had not been connected to the public sewer system and was therefore in violation of County ordinance. The PRP was requested to provide the NCDOH with a schedule of compliance for the ordinance issued.

In March of 1991, the facility was connected to the public sewer system and discharges to the leaching pits ceased.

In January of 1992, leaching pits LP-1 and LP-2 were emptied, pressure washed, backfilled with clean sand, and capped with cement. There is no record indicating leaching pit LP-3 was cleaned; however, documentation indicates LP-3 was backfilled. The details of the 1992 pit treatments are described below in Section 2.2.2. The floor drain located inside the building was also cleaned out and filled with cement during this time.

In July of 1994, a 1,000-gallon underground fuel oil storage tank, located just south of the boiler room, was emptied and filled with clean sand. The location of the tank is shown on **Figure 2-2**.

2.2.2 1991 & 1994 Preliminary Assessments

In January of 1991, the PRP hired a consultant to evaluate alternatives for the disposal of sediments from the leaching pits. Samples from LP-1, LP-2, and LP-3 were collected and analyzed for volatile organic compounds (VOCs) and metals. Based on analytical results, and with approval of the NCDOH and the Nassau County Department of Public Works (NCDPW), the contents of leaching pits LP-1 and LP-2 were disposed at the Bay Park Scavenger Waste Facility. The concentrations of VOCs and metals measured in the disposal sediments were not documented.

In April 1991, "soil/sludge" samples were collected from approximately 2 feet beneath the base of LP-1 and LP-3. Toluene, PCE, trichloroethylene (TCE), and 1,1,2-trichloroethane (TCA) were detected in soil samples at both locations. VOCs detected above New York State Technical and Administrative Guidance Memorandum (NYS TAGM) soil cleanup criteria were PCE (196,000 micrograms per kilogram [µg/kg]) and TCE (10,600 µg/kg) both at LP-1.

In September 1991, soil samples were collected from two feet below the "sediment surface (bottom)" at LP-1, four feet below bottom at LP-2, and five feet below bottom at LP-3. PCE was only detected in the soil sample collected from LP-3, however the concentration was below NYS TAGM. Methylene chloride concentrations exceeded NYS TAGM at all three leaching pit locations at concentrations ranging from 400 to 820 µg/kg.

The NYS TAGM soil cleanup criteria referenced above include:

- PCE: 1,400 µg/kg
- TCE: 700 µg/kg
- Toluene: 1,500 µg/kg
- Methylene chloride: 100 µg/kg

In January of 1992, liquid and sediments from LP-1 and LP-2 were pumped out below the base of each leach pit to a depth of 17 feet below grade. The pits were then pressure washed. LP-3 was not reported to have been emptied or cleaned. All three leaching pits were then backfilled with clean sand and capped with concrete.

In March of 1994, NYSDEC took the lead on the Site investigation and hired a consultant to complete a Phase 1 Preliminary Site Assessment (PSA). In April of 1994, the Site was listed under Class 2a in the Registry of Inactive Hazardous Waste Disposal Sites. A Class 2a is a temporary classification assigned to a site for which additional data are necessary for final classification.

Between June and November of 1994, NYSDEC's consultant conducted further investigations at the Site as part of a Phase 2 PSA. This work was conducted to determine if the Site should be reclassified from a Class 2a to a Class 2 site. A Class 2 site presents a significant threat to the public health or to the environment and action is required. Soil and groundwater samples were collected and analyzed for VOCs, semi-volatile organic compounds (SVOCs), and Target Analyte

List (TAL) inorganics. Soil borings were advanced adjacent to each leaching pit and soil samples were collected from 11.5 to 15.5 feet bgs. All VOCs, SVOCs, and metals concentrations were below NYS TAGM levels in the soil samples collected.

Groundwater samples were collected from three former monitoring wells, MW-1, MW-2 and MW-3, located 5 to 10 feet downgradient of each former leaching pit. The monitoring well locations are shown on *Figure 2 of the Record of Decision (ROD)* (provided in **Appendix A)**. Monitoring wells were screened from two feet above to eight feet below the water table (approximately 9 to 19 feet bgs). The following VOCs were detected at concentrations above NYSDEC Class GA Standards:

- MW-1 (LP-1): PCE (39 micrograms per liter [µg/L]), TCE (99 µg/L), 1,2,-dichloroethene (DCE) (9,200 µg/L), and vinyl chloride (VC) (300 µg/L)
- MW-2 (LP-2): PCE (30,000 µg/L), TCE (8,300 µg/L), 1,2-DCE (7,200 µg/L), 1,1-DCE (10 µg/L), and VC (380 µg/L)
- MW-3 (LP-3): PCE (19 µg/L) and TCE (8 µg/L)

The NYSDEC Class GA Standards for the chlorinated VOCs referenced above is 5 µg/L, except for VC which is 2 µg/L.

In May 1995, NYSDEC reclassified the Site from Class 2a to Class 2 based on the groundwater VOC results from the Phase 2 PSA.

On September 17, 1996, the PRP entered into an Order of Consent with NYSDEC to complete a Focused Remedial Investigation/Feasibility Study (FRI/FS) and institute interim remedial measures (IRMs).

2.2.3 1997 & 1998 Focused Remedial Investigation

In August and September of 1997, the PRP's consultant Fenley & Nicol conducted a FRI to define the nature and extent of contamination resulting from previous on-site disposal activities. A supplemental FRI was conducted in July of 1998, to further delineate the extent of site related contamination across Sand Hill Road and downgradient of the Site. A site plan exhibiting the previous consultant's sampling locations is presented in *Figure 2 of the ROD* (provided in **Appendix A**).

Soil samples were collected directly downgradient of the three former leaching pits and the decommissioned oil tank at two foot intervals from ground surface to the water table. Of the six samples analyzed, one soil sample (S4 just downgradient of LP-2 at a depth 2 to 4 feet bgs) exhibited concentrations which exceeded NYS TAGM Soil Cleanup Objectives: 1,2-DCE at 80 µg/kg and 2-butanone at 440 µg/kg. *Table 1 of the ROD* (provided in **Appendix A**) presents the soil sampling results during the August and September 1997 FRI.

Three sediment samples were collected from an intermittent creek west of the Site. Three sediment samples were also collected from the drainage ditch just south of Sand Hill Road. No VOCs were detected in any of the water body sediment samples. Surface water sample collection was planned for both the creek west of the Site and the drainage ditch just south of Sand Hill

Road. At the time of the sampling event both waterways were dry. Therefore, the existing sediment data were used to characterize the surface water. It was concluded that surface water did not pose a risk to environmental or human health.

Groundwater samples were collected from the three on-site monitoring wells (MW-1, MW-2, and MW-3). VOC concentrations detected in all three wells exceeded New York State (NYS) groundwater standards. The following VOCs were detected at concentrations above NYSDEC Class GA Standards:

- MW-1 (LP-1): PCE at 46 μg/L, TCE at 52 μg/L, and 1,2-DCE at 8,000 μg/L.
- MW-2 (LP-2): PCE at 35,000 μg/L, TCE at 3,300 μg/L, 1,2-DCE at 4,500 μg/L, and methylene chloride at 270 μg/L.
- MW-3 (LP-3): PCE at 12 μg/L.

The NYSDEC Class GA Standards for the chlorinated VOCs referenced above is 5 μg/L.

Groundwater samples were also collected from three off-site monitoring wells, screened at 11 feet, 35 feet, and 55 feet bgs (DW-11, DW-35, and DW-55 respectively). This well cluster was located on the southern side of Sand Hill Road at the intersection with Wantagh Avenue. None of the groundwater samples collected from the DW-designated wells exhibited concentrations of contaminants exceeding NYS Groundwater Standards. The off-site monitoring well locations are shown on *Figure 3 of the ROD* (**provided in Appendix A**).

In July 1998, groundwater grab samples were collected at five locations just south of Sand Hill Road using direct push technology (DPT) drilling methods. Two groundwater samples were collected from each location: one from a depth of 10 to 12 feet bgs (at the groundwater table), and one from a depth of 50 feet bgs. Of the ten groundwater samples, only one sample collected from 11 feet bgs at boring GB-3, located downgradient of LP-1 and MW-1, exhibited concentrations above NYS Class GA Groundwater Standards (PCE at 73 μg/L; TCE at 28 μg/L; and cis-1,2-DCE at 32 μg/L). Groundwater samples collected from 10 to 12 feet bgs at borings GB-1 and GB-2, located downgradient of LP-2 and MW-2, yielded chlorinated VOCs (CVOCs) at concentrations below NYS Class GA Groundwater Standards. *Figure 2 and Table 2 of the ROD* (provided in **Appendix A)** present the groundwater sampling locations and results during August 1997, September 1997, and July 1998.

2.2.4 Interim Remedial Measure: Air Sparge/Soil Vapor Extraction

Following the FRI, an air sparge/soil vapor extraction (AS/SVE) system was installed in 1998/1999 as an IRM in response to the concentrations of contaminants in soil and groundwater. *Figure 3 of the ROD* (provided in **Appendix A**) shows the location of the AS/SVE wells. Effluent air monitoring was conducted to track system parameters and overall performance. Air sampling was also conducted using an organic vapor analyzer/gas chromatograph (OVA/GC) at a minimum of once per week during the first month of system operations, and monthly or on an as-needed basis thereafter. Air samples were collected from the vapors entering and exiting the carbon filters. Groundwater samples were also collected at the three on-site monitoring wells and the deep well cluster. Air and groundwater data from the operation and maintenance monitoring were not found during CDM Smith's background records search.

In May 1999, based upon the apparent success of the IRM, NYSDEC selected No Further Action (NFA) with continuation of the AS/SVE system as the remedy for this Site. The Site was also reclassified in the Registry of Inactive Hazardous Waste Disposal Sites contingent upon the successful operation of the AS/SVE system.

Presently, the AS/SVE system is not in operation. According to the Wantagh Cleaners manager, the system is no longer in place at the site and equipment previously stored in the AS/SVE equipment shed was stolen. The date that the system was decommissioned is unknown. Monitoring wells (MW-1 through MW-3, DW-11, DW-35, and DW-55) installed during the FRI have also been decommissioned.

2.2.5 2007 Site Investigation and Vapor Intrusion Evaluation

In May 2007, NYSDEC reopened the Site to conduct a vapor intrusion (VI) evaluation due to the updated standards on soil vapor and human health established in the New York State Department of Health (NYSDOH) *Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York* (October 2006).

In December 2007, CDM Smith conducted site investigation activities on behalf of NYSDEC to evaluate the potential for VI. The investigation included soil gas and groundwater sampling via DPT, sub-slab vapor and indoor air sampling within the Wantagh Cleaners building, and outdoor (ambient) air sampling. The 2007 sample locations and associated results are shown on **Figures 2-3 and 2-4**. Field operations and analytical results are summarized below.

Seven DPT permanent soil gas sampling ports were installed at approximately 2 feet above the water table (approximately 10 feet bgs). Soil gas concentrations of PCE ranged from 23 micrograms per cubic meter (μg/m^3) to 160,000 μg/m^3, and TCE ranged from 1.8 to 59,000 μg/m^3. The soil gas samples on the southern side of the building (downgradient for groundwater) contained significantly higher levels of chlorinated solvents than the samples from the northeastern side (upgradient groundwater). These results suggested that the source of vapor contamination is likely beneath the building.

One indoor air sample and two sub-slab soil vapor samples were collected from within and beneath the Wantagh Cleaners building. Elevated PCE concentrations detected in sub-slab vapor ranged from 110,000 to 450,000 μg/m^3. The indoor air sample contained 220 μg/m^3 of PCE. TCE levels ranging from 7,000 to 18,000 μg/m^3 were observed in the sub-slab samples, and 64 μg/m^3 of TCE was observed in the indoor air sample. Based on the vapor monitoring results, the NYSDOH *Sub-Slab Vapor/Indoor Air Matrices 1 and 2* suggests that mitigation is needed to minimize potential exposures associated with VI. The NYSDOH mitigation action limits for PCE and TCE in sub-slab vapor are 1,000 and 250 μg/m^3, respectively.

Carbon tetrachloride was not detected in the sub-slab vapor but was detected in indoor air at a concentration of 0.6 μg/m^3. 1,1,1-TCA was detected at a concentration of 82 μg/m^3 in one sub-slab sample, but was not detected in the indoor air.

Two outdoor ambient air samples were collected, one for each day of sampling. One sample, which was collected over a 2-hour period, contained no VOC exceedances. The second sample, collected over a 24-hour period, contained PCE and TCE at concentrations of 220 and 18 μg/m^3, respectively. These detections exceeded the PCE and TCE ambient air guideline values of 100 and 5 μg/m^3, respectively. Ambient air guideline values are based on *NYSDOH Guidance Appendix C Table C2- EPA 2001 Building Assessment and Survey Evaluation (BASE) Database, SUMMA canister method, 90th percentile (EPA BASE 90th Percentile)*.

A NYSDOH Indoor Air Quality Questionnaire and Building Inventory form was completed during the 2007 VI Evaluation. The on-site facility is currently using Exxon DF-2000 dry cleaning fluid, which is a synthetic hydrocarbon material containing no chlorinated solvents. CDM Smith and NYSDEC are unaware of the current storage and disposal procedures for this new Exxon dry cleaning fluid. CDM Smith did not observe any potential PCE sources inside the building.

Seven groundwater samples were collected within a four-foot interval starting at the water table interface (approximately 10 to 14 feet bgs). Several compounds were detected above NYSDEC Class GA Groundwater Quality Standards (GWQS) in six out of the seven sample locations. Elevated concentrations for PCE and its degradation products were observed at four of these six locations. Additionally, elevated concentrations of methylene chloride were detected at two of the six locations. Chlorobenzene, 1,2-dichlorobenzene, and methyl tertiary butyl ether (MTBE) were detected at elevated concentrations at isolated locations. The presence of MTBE suggests groundwater may be impacted from the gasoline fueling station adjacent to the Site. Potential sources of the chlorobenzenes contamination are unknown.

Based on data collected during the 2007 investigation, CDM Smith recommended that a vapor mitigation system be installed on site to minimize potential exposures associated with VI. In addition to the continued monitoring of vapor, further delineation of the groundwater, soil, and soil vapor was recommended to identify the on-site source and delineate the extent of contamination on and off site.

2.2.6 2011 through 2014 Remedial Investigation

From 2011 to 2014, CDM Smith performed RI activities at the Site. The investigation was performed in two phases, with the first phase focused on characterizing on-site contamination and the second phase (i.e., RI Addendum) focused on delineating the extent of contamination on and off site. The field investigation included the following:

RI Phase I - November 3, 2011 through November 29, 2011

- Geophysical survey utilizing ground penetrating radar (GPR) and electrical conductivity (EC) was conducted at the Site to identify underground utilities, water lines, underground storage tanks (USTs) and/or any large anomalies such as conduits.
- Membrane interface probe (MIP) screening at 14 locations (MIP-01, MIP-02, MIP-03, MIP-04, MIP-06, MIP-07, MIP-08, MIP-09, MIP-10, MIP-11, MIP-13, MIP-14, MIP-16 and MIP-17).
- Advancement and sampling of 7 on-site (MIP-01, MIP-07 through MIP-11, and MIP-16) and 8 off-site (MIP-12 through MIP-15, and MIP-18 through MIP-21) DPT soil borings. A total of

16 soil samples were submitted for VOC analysis by United States Environmental Protection Agency (EPA) Method 8260B.

- Advancement and sampling of 7 onsite (MIP-01, MIP-07 through MIP-11, and MIP-16) and 8 offsite (MIP-12 through MIP-15, and MIP-18 through MIP-21) DPT groundwater vertical profiling locations. A total of 45 groundwater samples were submitted for VOC analysis by EPA Method 8260B.

- Installation of one onsite sub-slab port, one offsite sub-slab port, and 5 outdoor soil gas ports.

- Sampling of 2 onsite sub-slab vapor ports (SB-01 and SB-02), 1 offsite sub-slab vapor port (SB-02), 1 onsite indoor air (IA-01), 1 offsite indoor air (IA-02), 8 onsite soil gas ports (SV-01 through SV-08), 3 offsite soil gas ports (SV-09 through SV-11) and 1 ambient (outdoor) air location for VOC analysis by EPA Method TO-15.

RI Phase II (Addendum) - December 9, 2013 through September 25, 2014

- Geophysical survey by GPR and EC was conducted on and offsite to identify underground utilities, water lines, USTs and/or any large anomalies such as conduits.

- Sampling of sub-slab, indoor air, and outdoor air at two residences east and one residence north of the Wantagh Avenue Dry Cleaners property for VOC analysis by EPA Method TO-15.

- Advancement of DPT groundwater, soil, and soil gas screening points at 49 boring locations:

  - At 47 of the 49 locations, groundwater screening samples for vertical profiling were collected. A total of 286 samples (excluding quality control samples) were submitted for VOC analysis by EPA Method 8260B.

  - At 31 of the 49 locations, lithologic logging was performed. At 3 of the 49 locations, soil samples were submitted for VOC analysis by EPA Method 8260B.

  - At 7 of the 49 locations, soil gas sampling was performed. Soil gas samples were submitted for VOC analysis by EPA Method TO-15.

- Soil gas sampling using DPT was performed at an additional four locations not co-located with any lithologic or groundwater screening boring. Soil gas samples were submitted for VOC analysis by EPA Method TO-15.

- Installation and development of six on-site monitoring wells. During well installation, a total of ten soil samples was submitted for VOC and grain size analyses by EPA Method 8260C and ASTM International (ASTM) Method D422, respectively.

- Sampling of the six newly installed monitoring wells. All groundwater samples were analyzed for VOCs by EPA Method 8260C, metals by EPA Method 6010C, hydrocarbons by EPA Method 8015, total organic carbon (TOC) by SM5310B, ammonia by EPA Method

350.1, nitrate/nitrite by EPA Method 353, sulfide by SM4500SF, chloride and sulfate by EPA Method 300.0, methane, ethane, ethene (MEE) by method RSK 175, and alkalinity by SM2320B. A Hach kit was used in the field to test the groundwater for ferrous iron and manganese.

- Performance of synoptic water level measurements and hydraulic conductivity testing at the six monitoring well locations.

The results of the RI and RI Addendum are detailed in the October 2012 Final RIR and February 2015 Draft RI Addendum. Results presented in both reports were used to determine the nature and extent of contamination discussed in Section 3.

Section 3

Summary of Site Conditions

The February 2015 RIR Addendum characterized the nature and extent of contamination migration and the exposure/risk assessment (CDM Smith, 2015). As indicated in Section 2, the field investigation for the RI was performed in two phases, with the first phase focused on characterizing on-site contamination and the second phase focused on delineating the extent of contamination on and off site. The first phase of the investigation occurred between November 3rd through 29th, 2011, while the second phase occurred between December 9, 2013 through September 25, 2013. This section presents a description of physical characteristics of the Site, a summary of study area investigation, summary of the nature and extent of contamination, a summary of the fate and transport, and a summary of the exposure/risk assessment.

3.1 Physical Characteristics of the Site

The physical characteristics of the Site and surrounding area are important to understanding the current nature and extent of contamination and future transport of contaminants. These characteristics can be described in terms of the demography and land use, meteorology, surface features and drainage, geology and hydrogeology.

3.1.1 Demography and Land Use

The Site is located in the Village of Wantagh, Hempstead, Nassau County, New York. Wantagh is located in central Nassau County, just north of the Southern State Parkway. According to the 2010 Census from the United States Census Bureau, 53,891 people reside in Hempstead, which covers a land area of 3.68 square miles. Therefore, Hempstead has a population density of 14,636.3 people per square mile. The Village of Wantagh lies in the Town of Hempstead, with a population of 18,871 people and a population density of 4,927.2 people per square mile. With 1,358,627 people residing in Nassau County and a land area of 284 square miles, the population density of Nassau County is 4,704 people per square mile.

Generally, north of the Site to the Hempstead Bethpage Turnpike and south of the Site to the Sunrise Highway, land use is primarily residential. Commercial properties are located sporadically along Wantagh Avenue, with concentrated areas at Jerusalem Avenue and Sunrise Highway.

3.1.2 Meteorology

Meteorological information was obtained from the nearest weather station location in Farmingdale, New York. The average annual temperature in Farmingdale, New York is 54 degrees Fahrenheit (°F). The coldest month, February, averages a monthly temperature of 22°F, while the warmest month, July, averages a monthly temperature of 77 °F.

Average monthly precipitation in Farmingdale is approximately 3.2 inches with the wettest months, on average, being June and August. The Phase I field investigation was performed during November 2011, which had a monthly precipitation of 2.47 inches and average temperatures ranging from 41 to 58 °F. The Phase II field investigation was performed from December 2013 through September 2014. The majority of the investigation was conducted during the winter, which had continuous snowfall throughout the season.

3.1.3 Surface Features

The Site is mostly occupied by a single-story building. The surface is relatively flat, with a very slight gradient from north to south. The building is surrounded by a paved parking lot to the east and south, and a narrow paved driveway along the northern boundary of the building. The western side of the building abuts the property boundary, which borders the adjacent convenience store.

3.1.4 Site Topography and Drainage

The on-site building is located at approximately 45 feet above mean sea level (amsl). The site topography declines slightly towards the southern boundary of the property. Surface water runoff drains into municipal sewer drains and infiltrates grass and vegetated areas. A drainage outfall is located south of Sand Hill Road, directly downgradient of the Site. The outfall area is densely vegetated, inaccessible, and appears to have a steep slope. An intermittent creek is located approximately 100 feet west of the Site. This creek is reported to flow approximately 1.2 miles south from the Site to Seaman Pond (i.e., Upper Twin Pond), located in Twin Lakes Preserve.

3.1.5 Site Geology

The Site is located within the Atlantic Coastal Plain Physiographic Province. A history of coastal submergence and emergence spanning the Cretaceous Period, significant differential erosion during the Cenozoic, and glaciation during the Quaternary is reflected in the present day geology of Long Island. The geology is characterized by a southeastward-thickening wedge of unconsolidated sediments overlying a gently-dipping basement bedrock surface. The wedge ranges in thickness from zero feet where it outcrops along the north shore in Queens, up to about 2,000 feet along the south shore barrier islands.

A series of geologic cross-sections were constructed, from descriptions of lithology at individual well and boring locations, to present a general model of subsurface stratigraphy in the study area. Cross-section locations are shown on **Figure 3-1**. **Figures 3-2 through 3-6** present the cross-sections. Three general units were encountered during the Wantagh RI: fill, Upper Glacial sands, and Upper Magothy sands.

Fill: Fill material was encountered in the general vicinity of the Site. The fill, consisting of brown, dark brown, or black silts, with traces of anthropogenic material (e.g., wood) and gravel, was generally observed to depths of approximately about 9 feet bgs, where the water table was encountered. Fill material was also observed sporadically in off-site borings.

Upper Glacial Sands: Upper Glacial deposits at the Site, consisted of yellow to yellowish-brown fine to medium sand from the water table interface to a depth of approximately 45 feet bgs. Deposits of sand and gravel, and thin, discontinuous gravel beds were observed within the sandy layer. Off-site, the Upper Glacial deposits generally consisted of brown to orange-yellow silt, silty sand and sand to depths of about 10 feet bgs. The surficial deposits were underlain by a yellowish brown to brownish yellow sand, and sand and gravel with thin, discontinuous gravel beds interspersed within the two deposits.

Upper Magothy Sands: The Magothy Formation was encountered below the Upper Glacial sands at about 40 feet bgs in the vicinity of the Site. At monitoring well MW-04I, located at the intersection of Sand Hill Road and Wantagh Avenue, the unit was observed as grayish brown, very dense, medium to coarse quartz sand, with some gravel from 40 to 51 feet bgs. Clay layers with trace silt, a few inches thick, were encountered at 51 and 53 feet bgs. Fine to medium quartz sand was interbedded and underlies the clay layers. Moving off site to the south, the same grayish brown, very dense, fine sand and silt was encountered at approximately 45 to 55 feet bgs.

3.1.6 Hydrogeology

The hydrogeology of Long Island has been well documented over the years by the United States Geological Survey (USGS) and others. Three major aquifers are present on Long Island: the Upper Glacial aquifer, the Magothy aquifer and the Lloyd aquifer. Groundwater contours prepared for Nassau County's Groundwater Monitoring Program, based on water levels collected in public wells in 2001, 2002, and 2003 indicate that the groundwater in the Upper Glacial aquifer (water table) in the Site area generally flows to the southwest toward the south shore of Long Island.

Five shallow monitoring wells were installed in the Upper Glacial Aquifer and two intermediate monitoring wells were installed in the upper Magothy Formation in the immediate vicinity of the site. The off-site investigation was performed using direct push methods and permanent wells were not installed. Estimates of groundwater flow direction, hydraulic gradient and hydraulic conductivity were based on these on-site wells. Actual values for flow direction, gradient and hydraulic conductivity in off-site/downgradient areas may vary from our estimates.

Groundwater Flow

Groundwater elevation data collected in September 2014 shows shallow groundwater in the Upper Glacial Aquifer, in the vicinity of the site, moves in a south/southwesterly direction (**Figure 3-7**). Monitoring wells were only installed at the site, therefore off site flow direction is inferred, based on groundwater screening observations and expected regional groundwater flow.

The groundwater table was encountered within the Upper Glacial Aquifer at an approximate elevation of 36 feet amsl at the Site (approximately 9 feet bgs). Downgradient from the site, the groundwater table was found as deep as 17 feet bgs at boring location DT1-F. Further downgradient as groundwater migrates towards Twin Lakes Preserve, the groundwater table is encountered at shallower depths ranging from 12 to 13 feet bgs at borings DT3-A and DT2-E, and as shallow as 3.5 feet bgs (boring DT3-H) and 5 feet bgs (boring DT2-N) in borings advanced at the edge of the vegetated buffer area outside the preserve. These observations suggest shallow groundwater is discharging to these surface water bodies.

Water level information within the Upper Magothy is limited due to well control. The groundwater flow direction within this unit is inferred to be similar to flow within the Upper Glacial Aquifer.

During downgradient groundwater screening, the observed contamination plume was consistent with the expected regional flow patterns, as suggested by CDM Smith internal regional flow models. The downgradient portion of the shallower part of the plume migrates to the southwest and may discharge to surface water at the Twin Lakes Preserve. Deeper groundwater contamination appears to migrate in a more southerly direction. Based on regional flow patterns, the ultimate discharge point may be the East Bay (Atlantic Ocean).

The horizontal hydraulic gradient, measured between shallow wells completed in the Upper Glacial Aquifer, was approximately 0.0023 feet per feet (ft/ft), and the measured vertical gradient between the Upper Glacial Aquifer and upper Magothy Formation wells is minimal. Based on the measured hydraulic conductivity/ observed lithology, there may be limited vertical migration of groundwater between the Upper Glacial Aquifer and upper Magothy Formation in the immediate vicinity of the site. This typically is not the case between the Upper Glacial and Magothy formations when confining layers are absent and is likely an artifact of the limited number of monitoring points.

Hydraulic Conductivity

Slug testing performed in the shallow (Upper Glacial Aquifer) and intermediate (upper Magothy Formation) wells provided the following estimates of hydraulic conductivity:

- Shallow Wells (Upper Glacial Aquifer) – Range of 67 to 116.3 feet/day, with a mean value of 85 feet/day
- Intermediate Wells (transitional zone between the Upper Glacial aquifer and upper Magothy Formation) – Range of 5.5 to 7.4 feet/day with a mean value of 6.5 feet/day

Using the estimated hydraulic conductivity of the Upper Glacial aquifer and the horizontal gradient across the Site, the average linear velocity was estimated as follows:

$$V = \frac{Ki}{n}$$

Where: V = linear velocity (groundwater flow rate)

K = hydraulic conductivity: 85 feet/day

i = gradient: 0.0023 ft/ft

n = effective porosity: assumed to be 35 percent (%) or 0.35

Using these values, linear V is calculated as 0.56 ft/day.

The estimated hydraulic properties within the Upper Glacial Aquifer are comparable to those measured at the nearby Solvent Finishers NYSDEC Site. However, in the downgradient portion of the plume, as groundwater approaches its regional discharge area, hydraulic gradient and therefore groundwater velocity likely increases.

Groundwater Impacts

It appears likely that shallow groundwater is discharging to the Twin Lakes Preserve and eventually to the East Bay; and the deeper groundwater within the upper Magothy Formation is likely discharging to the East Bay (Atlantic Ocean).

The closest public supply wells to the Site are located approximately one mile southwest (N-09514 and N-10195) and 1.5 miles southeast (N-05767 and N-09910) of the Site, outside the footprint of the observed plume. In addition, public supply well N-08031 is located on the southwestern side of Twin Lakes Preserve, approximately 1.6 miles from the Site. Well N-08031 is screened from -368 to -489 feet mean sea level (msl). The footprint of the groundwater contamination has been horizontally delineated only to the northeastern side of Twin Lakes Preserve; therefore, it is unknown whether the plume encountered the screen interval of the public supply Well N-08031.

3.2 Nature and Extent of Contamination

This section describes the findings of the remedial investigation for all environmental media that were investigated. The following material summarizes the main contaminants of concern in each environmental medium at the Site. **Tables 3-1** and **3-3** present the summary of the RI Phase I results for soil and groundwater, respectively. **Tables 3-2** and **3-4** present the summary of the RI Phase II (Addendum) results for soil and groundwater, respectively. **Table 3-5** provides the results of the soil gas, sub-slab vapor, and indoor air sampling conducted on site and at the adjacent convenience store property performed in 2011. **Tables 3-6 through 3-8** provides the results of the sub-slab vapor and indoor air sampling conducted at off-site residential locations.

Several VOCs exceed regulatory standards in unsaturated and saturated soil, groundwater and soil vapor at the Site, and groundwater, soil, and soil vapor off site. The primary contaminant of concern is PCE. The analytical results identified the presence of a long, narrow plume extending in the direction of groundwater flow from the center of the on-site building and former leaching pits to Twin Lakes Preserve, located approximately 1.6 miles southwest of the Site. The complete horizontal and vertical extent of the plume was not delineated during the RI. However, potential receptor pathways have been evaluated on and offsite to support this FS.

The following is a summary of the nature and extent of contamination.

CVOCs are considered to have medium-to-high mobility in water depending on their degree of chlorination. Transport in groundwater from contaminant sources is expected to be the dominant migration pathway.

The dominant degradation processes are hydrolysis and biodegradation. However, based on the anaerobic environment and absence of TOC at the shallow groundwater on site, biodegradation is expected to be slow in these subsurface environments. Therefore, the CVOCs may persist in groundwater for some time if left untreated.

Anaerobic conditions were observed in the Upper Glacial Aquifer at on-site monitoring wells MW-02S, MW-03S, and MW-04S. At MW-02S, located immediately downgradient of LP-1, the groundwater is sulfate-reducing. The positive oxidation reduction potential (ORP) at this location suggests conditions may be only weakly sulfate-reducing, indicating biotic PCE dechlorination to less chlorinated by-products is possible. At MW-03S, located immediately downgradient of LP-2, the groundwater has a negative ORP of -419 millivolt (mV) and depleted sulfate, indicating more strongly reducing conditions. The absence of TOC in the on-site shallow groundwater at both monitoring well locations is likely a limiting factor keeping reductive dechlorination from being a major process. Groundwater conditions at MW-04S measured during fieldwork for this RI Addendum, downgradient/slightly side-gradient of the site, are only slightly reducing and organic carbon limited. These conditions indicate that sustained PCE reductive dechlorination is unlikely.

Aerobic conditions were observed at the upgradient monitoring well (MW-01S) and at monitoring wells screened within the upper Magothy Formation on-site (MW-02I and MW-04I). Reductive dechlorination of PCE would not be favored at these locations, but direct oxidation of cis-1,2-DCE and VC may be possible.

Under sulfate-reducing conditions, many CVOCs can undergo microbially mediated reductive dechlorination via sequential replacement of chlorine atoms by hydrogen atoms. Chlorinated ethenes and ethanes can be biodegraded by this process to yield ethene and ethane as final breakdown products. Ethene and ethane were not detected at the method detection limit of 1 milligrams per liter (mg/L) in any of the monitoring well groundwater samples collected during the supplemental RI field event. The absence of detected ethene and ethane may suggest that any reductive dechlorination occurring on site is stalling at *cis*-1,2-DCE. However, the high detection limit for these compounds may also indicate lower but still appreciable concentrations below 1 mg/L may be present. VC was detected in unsaturated soils beneath the on-site building and at MW-02I only. Otherwise, VC was also detected in only one groundwater sample collected from the downgradient portion of the plume, within the residential neighborhood south of the Southern State Parkway. The minimal presence of VC further supports the predominance of anaerobic biodegradation stalling at the *cis*-1,2-DCE daughter product.

In reductive dechlorination, the bacteria utilize a separate carbon source for food and they degrade (via respiration) the CVOCs, which serve as terminal electron acceptors much like oxygen serves aerobic bacteria (or animals). No measureable concentrations of organic carbon were detected on site indicating no available carbon source to fuel reductive dechlorination. Thus, biodegradation is not expected to be a dominant process affecting CVOC fate on site. Under the site shallow groundwater's predominant mildly sulfate-reducing conditions and absence of available TOC, any microbial breakdown of PCE is expected to stop at the *cis*-1,2-DCE intermediate, which can accumulate as it is produced. The presence of DCE may indicate that there was previously a carbon source at the Site that was consumed, and once consumed brought reductive dechlorination to a halt.

As the plume moves away from the source with the flow of groundwater, it dilutes, resulting in reduced contaminant concentrations immediately downgradient of the Site. Direct oxidation of *cis*-1,2-DCE and VC may be occurring. However, elevated chlorinated solvent concentrations (e.g., PCE concentrations ranging from 52 to 170 µg/L) are present as isolated hot spots throughout the horizontal and vertical extent of the plume. PCE and TCE are unlikely to degrade under aerobic conditions with minimal organic carbon; abiotic degradation of these compounds may be possible, but this pathway has not been evaluated. The presence of isolated PCE hotspots may be a result of multiple discharge events and unknown preferential flow pathways. Gravel layers interspersed within the sand layers of the Upper Glacial Aquifer and upper Magothy Formation may have also influenced the distribution of chlorinated solvents throughout the footprint of the plume.

3.3 Fate and Transport

Soil

Elevated concentrations of CVOCs were observed within the unsaturated zone beneath the on-site building (Borings E and F) and directly downgradient of the leaching pits LP-1 and LP-2 at soil borings MW-02I and MW-03S, respectively. The highest concentrations of CVOCs within unsaturated soils were observed beneath the on-site slab at soil Borings E (PCE at 7,800 µg/kg) and F (PCE at 850 µg/kg, *cis*-1,2-DCE at 280,000 µg/kg, and VC at 8,900 µg/kg). In addition, an elevated PCE concentration of 26,000 µg/kg was observed in the unsaturated zone directly above the water table at the MIP-01 location, located on site, directly upgradient of the building.

The source of CVOCs in unsaturated soils beneath the building slab and directly upgradient is most likely the former floor drain located along the western and southern perimeter of the building. In addition, the restroom is located in the northwest corner of the building, adjacent to the MIP-01 location. The presence of former drains in this area is unknown; therefore, CVOCs within the soils at MIP-01 may be associated with previous poor housekeeping practices in the restroom area.

The sources of CVOCs within unsaturated soils at MW-02I and MW-03S are former leaching pits LP-1 and LP-2, respectively. The former floor drain discharged primary dry cleaning process wastewater to LP-1 and overflow discharged into LP-2.

Groundwater

The solubility limit for PCE is 206 mg/L, which concentration would be indicative of the presence of dense non-aqueous phase liquid (DNAPL). Chlorinated solvents are denser and typically less viscous than water, and are referred to as dense NAPL or DNAPL. Upon release to the ground surface, a DNAPL will migrate vertically under the force of gravity, both within the unsaturated and saturated zones, until a physical barrier is encountered. PCE concentrations indicative of DNAPL were not observed during the supplemental RI field event and previous sampling events. However, 20 mg/L of PCE was observed at one on-site vertical profiling location, indicating a residual saturation level of PCE may be present at the water table acting as a continuous source. The vertical extent of PCE has not been delineated due to encountering refusal with the DPT rig at the upper Magothy Formation. Therefore, there is an unknown potential for undetected product and/or higher concentrations of PCE and its degradation products at deeper depths than characterized to date.

Advective migration of dissolved phase contamination from the source area appears to be the dominant transport pathway at the Site. Data collected during the RI identifies a long narrow plume approximately 8,550 feet long extending southwest from the on-site building and former leaching pits. During downgradient groundwater screening, the observed contaminant plume mimicked expected regional flow patterns. In the Upper Glacial Aquifer, the downgradient portion of the plume is approximately 150 to 600 feet wide, migrates to the southwest, and appears to discharge into the Twin Lakes Preserve. Deeper, within the upper Magothy Formation, the plume is approximately 150 to 1,500 feet wide and migrates in a more southerly direction, likely discharging to the East Bay (Atlantic Ocean). The wider part of the deep groundwater contamination is observed in close proximity to Twin Lakes Preserve.

The Site has been used as a dry cleaner since the early 1970s. Based on historical aerial photographs (provided in *Appendix K of the 2015 RIR Addendum*), the property was vacant prior to 1966. For chlorinated solvent plumes, generally the contaminant mass moves with the groundwater flow, but is influenced by adsorptive retardation. Based on the average groundwater seepage velocity calculated for the on-site Upper Glacial Aquifer (0.56 ft/day), and a retardation factor of 2.29, a release from the Site in 1970 would yield a plume approximately 3,900 feet long (*as presented in Section 5.3 Transport of Contaminants in the 2015 RIR Addendum, assuming fraction organic carbon of 0.001*). The observed plume length is 8,550 feet, and may be longer, since the plume has been characterized only as far as Twin Lakes Preserve. The discrepancy between calculated and observed plume length may be due to unknown preferential flow pathways and variability in related parameters as groundwater flows downgradient. The absence of monitoring wells within the downgradient plume footprint is a limiting factor in drawing conclusions regarding off-site conditions. However, gravel layers were observed interspersed within the sand layers of the Upper Glacial Aquifer and upper Magothy Formation on and off site, which may have transported chlorinated solvents further off site than anticipated.

During groundwater transport, the dissolved contaminants may interact with aquifer solids encountered along the flow path via adsorption, partitioning, ion-exchange reactions, and other physical, chemical, and biological processes. These interactions distribute the contaminant between the aqueous phase and the aquifer solids, diminish concentrations of the contaminants in the aqueous phase, and retard the movement of the contaminant relative to groundwater flow (MacKay et al. 1985). The Wantagh Cleaner's plume shows little lateral dispersion. The leading edge of the plume most likely discharges at the Twin Lakes Preserve, which in turn discharges to the East Bay.

Soil Vapor

Diffusion of vapors from groundwater sources occurs as a result of a concentration gradient between the source and the surrounding area. Thus, vapors can migrate upward or laterally through the vadose zone, and are further influenced by pressure gradients and preferential pathways. Since the site groundwater contains elevated levels of constituents (maximum PCE concentration of 20,000 µg/L), upward diffusion due to the concentration gradient between the contaminated groundwater and the unsaturated zone is most likely occurring.

The horizontal and vertical movement of vapors located near the building foundations are affected by advective transport mechanisms. Volatilized chemicals are drawn into the each building under the influence of negative pressure inside the building compared to sub-slab vapors. Vapor migration can occur more rapidly via man made or natural preferential pathways, such as interspersed gravel layers or utility corridors.

Based on the 2011 RI field event, sub-slab vapor collected from the on-site building has PCE concentrations up to 517 milligrams per meters cubed (mg/m^3). The sub-slab vapor collected from the adjacent convenient store detected PCE at 4 mg/m^3. The highest PCE concentration observed in soil gas samples was 147 mg/m3 from SV-02, located along the southern edge of the site building and upgradient of the former leaching pits. Based on soil vapor and indoor air analytical results from the 2011 VI event, NYSDOH suggests mitigation should be implemented at both properties to reduce risk of exposures to PCE and TCE.

Based on the results of the 2014 off-site residential VI sampling event, NYSDOH guidance recommends taking reasonable and practical actions to identify source(s) and reduce exposures to PCE at 921 Wantagh Avenue (RES-03) and 10 Old Jerusalem Road (RES-04). Based on an environmental records search report prepared by Environmental Data Resources Inc. (EDR), current and historic non-site related sources of chlorinated solvents could not be identified in the area, so observations at these two addresses are attributed to Site-related contamination.

During the supplemental RI field event, PCE and TCE concentrations above or equal to site-specific groundwater vapor intrusion screening criteria of 8 µg/L and 2 µg/L, respectively, were observed in shallow groundwater throughout the footprint of the plume. These site-specific groundwater criteria represent PCE and TCE concentrations that could contribute to VI within structures above the plume. Soil gas sampling was conducted at eleven locations within the footprint of the downgradient plume, in order to assess the potential human and environmental exposure from contaminated soil vapor. VOC concentrations observed in soil gas samples were not detected above NYSDOH air guideline values. However, in accordance with NYSDOH Guidance, soil vapor results cannot be used to rule out the potential for vapor intrusion to occur at nearby buildings. Therefore, the potential for VI within the downgradient plume is currently unknown.

Summary of Constituent Fate and Transport

The following summarizes the most significant fate and transport processes for the Site:

- Concentrations indicative of DNAPL were not observed within the Upper Glacial Aquifer or the upper Magothy Formation. However, the potential for residual DNAPL was observed at the water table from one on-site groundwater vertical profiling boring located in the vicinity of the former leaching pits. The vertical extent of the plume on-site was not delineated.

- Little lateral dispersion is occurring, resulting in a long, narrow plume that migrates southwest from the Site. The vertical extent and southern edge of the plume off site was not delineated. However, internal regional modeling indicates the leading edge of the plume flows into the Twin Lakes Preserve, which discharges to the East Bay.

- The greatest potential for transport of contaminants at the Site is via groundwater migration. CVOCs (PCE, TCE, *cis*-1,2-DCE) have been detected throughout the groundwater plume indicating their ongoing transport.

- Based on groundwater quality parameter screening, conditions within the Upper Glacial Aquifer on site are anaerobic. Reductive dechlorination of PCE may have stalled at the *cis*-

1,2-DCE intermediate due at least in part to the absence of an available carbon source or of microbes capable of fully dechlorinating PCE. Aerobic conditions were observed within the upper Magothy Formation, and therefore reductive dechlorination of PCE is not expected within this unit, although direct oxidation of *cis*-1,2-DCE and VC may be occurring.

- Dilution appears to be the primary mechanism for concentration reductions on site. Dechlorination daughter products of PCE and TCE are not identified throughout the footprint of the plume. Concentrations of CVOCs decrease with groundwater flow. Groundwater conditions off site do not show reductive dechlorination conditions.
- Volatilization from the water table is considered significant based on the results of the soil gas and sub-slab vapor results on site and off site.

3.4 Conceptual Site Model

The Site is located in a mixed use residential/commercial area. Commercial properties border the northern side (i.e., gasoline service station) and western side (i.e., convenience store) of the Site. The Jonas E. Salk Middle School and Gen Douglas MacArthur Senior High School are located north of the gasoline service station. Wantagh Avenue and residences are located on the eastern side of the Site. South of the Site is the Southern State Parkway and a densely populated residential/commercial area.

Based upon the data collected to date, elevated concentrations of CVOCs were identified in the unsaturated zone, at the water table interface, in groundwater beneath the on-site building slab, and in the vicinity of the former floor drain and leaching pits (LP-1 and LP-2). Dissolved CVOCs were also found in the groundwater below these areas. The source of the contamination is likely from seepage of dry cleaning process drainage fluid from the former on-site floor drain along the western and southern perimeters of the building, as well as the former leaching pits. VOC concentrations indicative of residual DNAPL were identified on-site, in close proximity to the former leaching pits. However, the complete vertical extent of the dissolved CVOC contamination has not been delineated to date. There is the potential for residual contamination to be present at deeper depths since the sources (former leaching pits and floor drain) have been present for many years, dating back to 1974.

Groundwater data from the RI shows a long, relatively narrow plume, consisting primarily of PCE, approximately 8,550 feet long (1.6 miles) extending south/southwest (downgradient) from the Site. Shallow groundwater contamination (**Figure 3-8a**) is approximately 150 to 600 feet wide and migrates southwest within the Upper Glacial Aquifer towards the Twin Lakes Preserve. The lateral extent of shallow groundwater contamination has been delineated. Deep groundwater contamination (**Figure 3-8b**) is approximately 150 to 1,500 feet wide and migrates south within the upper Magothy Formation towards the Twin Lakes Preserve and the East Bay. The lateral extent of deep groundwater contamination has not been delineated. Furthermore the southern extent of both the shallow and deep groundwater contamination has not been delineated. Regional groundwater modeling shows shallow groundwater flows from the Site toward the Twin Lakes Preserve, which eventually discharges to the East Bay. The shallow and deep PCE, TCE and *cis*-1,2-DCE concentrations presented on **Figures 3-8a and 3-8b** are indicative of the highest concentrations of each VOC observed at a specific sampling location. This current CSM is consistent with the expected flow path of the plume. However, the observed length of the off-site plume does not agree with the PCE linear velocity calculated for on-site groundwater conditions. The absence of monitoring wells installed within the footprint of the downgradient extent of the plume is a limiting factor in drawing conclusions on off-site conditions. However, gravel layers were observed interspersed within the sand layers of the Upper Glacial Aquifer and upper Magothy Formation, which may have transported chlorinated solvents further off-site than anticipated.

Figures 3-1 through 3-6 present cross sections of site constituents on site and off site.

At the Site, high levels of VOC concentrations are present within the unsaturated zone just upgradient of the on-site building, beneath the building slab, and in the vicinity of LP-1 and LP-2 (**Figures 3-4 through 3-6**). The former floor drain within the on-site building discharged to LP-1, and any overflow at LP-1 discharged to LP-2. The base of LP-1 was approximately 15 feet below grade; and the base of LP-2 was approximately 11 feet below grade. The CVOC detections just upgradient of the on-site building, at location MIP-01, are likely from seepage of dry cleaning processing fluid from the former drain located along the western side of the building. VOCs were not detected below 17 feet bgs at MIP-01. Upgradient locations MIP-21, Boring B, and MW-01S did not show any site-related VOCs. High levels of CVOCs were detected in subsurface soil beneath the base of LP-2

The vertical extent of dissolved CVOC contamination beneath the building is unknown, since the drill rig encountered refusal within the upper Magothy Formation. The CVOC detections beneath the building slab, at Borings E and F, are likely from seepage of dry cleaning processing fluid from the former drain located along the western and southern sides of the building. In addition, overflow from the former floor drain and leaching pits (LP-1 and LP-2) may have contributed to contamination observed beneath the building. VC is present in the unsaturated zone indicating that at least reductive dechlorination has occurred in the past above the water table. The elevated concentrations of VOCs within the unsaturated zone and at the water table are most likely contributing to vapor intrusion within the on-site building and the adjacent convenience store directly to the west.

Figures 3-2 and 3-4 show vertical profile groundwater samples that were collected from Boring A located external to the building, just upgradient of LP-1 and LP-2. The highest PCE concentration in groundwater (20,000 µg/L) was detected at the water table interface at Boring A. CVOC concentrations were variable throughout the rest of the Upper Glacial zone, and CVOCs were also detected within the upper Magothy Formation (PCE at 290 µg/L) and at the terminal depth of the boring (PCE at 55 µg/L, 85 feet bgs). The variability of CVOC concentrations along the vertical extent of groundwater contamination on site suggests the possibility of multiple discharge events.

Figures 3-2 and 3-3 present cross sections of PCE concentrations on site and off site. As shown on the figures, the narrow, long plume is migrating with groundwater flow by advection in a southwesterly direction. Relatively little lateral horizontal dispersion is occurring. Vertical transport of CVOCs from the Upper Glacial Aquifer to the Magothy Formation is occurring. CVOC concentrations are variable throughout the footprint of the plume, similar to the variable concentrations observed at vertical profiling Boring A on site. Sporadic detections of elevated

VOC concentrations are illustrated by the 50 µg/L contour line on **Figures 3-2 and 3-3**. Off site, elevated VOC concentrations are observed within the Upper Glacial Aquifer and are encountered at deeper intervals as the plume migrates downgradient. Elevated VOC concentrations were detected within the upper Magothy Formation at the downgradient-most boring, DT2-N. The variability of CVOC concentrations along the horizontal extent of the plume suggests multiple discharge events, complex hydrogeological flow paths (e.g., from interspersed gravel layers) and/or the possible presence of non-site related sources within the footprint of the plume. CDM Smith did not identify any historic or current non-site related source area(s) based on the review of an environmental records search report.

TCE and *cis*-1,2-DCE, the primary and secondary dechlorination products of PCE, are present throughout the vertical and horizontal extent of the plume. Degradation products *trans*-1,2-DCE and VC were only detected on site during the RI investigation. The concentrations of VC have decreased over time from the 1998 FRI, to the 2007 Site Characterization, to the 2011/2014 RI. The historical presence of VC suggests reductive dechlorination was once occurring on site; the decrease in concentrations suggest that VC may be naturally attenuating, potentially via direct oxidation pathways. In addition, benzene and MTBE were detected at low concentrations on site during the 2007 Site Characterization. Historically, benzene and possibly related petroleum hydrocarbon co-contamination (not measured) may have acted as a carbon source for bacteria promoting reductive dechlorination at the Site. The gasoline service station located upgradient of the Site could be a potential source for the benzene and MTBE observed in groundwater. Based on an initial assessment of groundwater quality parameters from the investigation, shallow groundwater on site is generally under anaerobic conditions. However, the absence of an available carbon source and lack of bacteria capable of complete dechlorination may currently be stalling any anaerobic dechlorination at *cis*-1,2-DCE. The presence of VC in on-site unsaturated soils and one isolated off-site groundwater sample suggests that TOC may have been available at one time to facilitate anaerobic dechlorination beyond *cis*-1,2-DCE.

3.5 Summary of Qualitative Human Health Exposure Assessment

A qualitative human health exposure assessment was included in the 2015 RIR Addendum. This assessment included an evaluation of potential risks associated with exposure to contaminants of concern (COCs) in soil, groundwater, or air for each receptor through comparison of the maximum detected concentration with the applicable standard or guidance value. The results of this evaluation are summarized in **Table 3-9**. The following are conclusions and recommendations from the assessment.

1,1-DCE, c*is*-1,2-DCE, PCE, *trans*-1,2-DCE, TCE, and VC were identified as COCs in groundwater at the Site, the right-of-way south of Sand Hill Road, and at the downgradient locations adjacent to the Southern Parkway and within the residential neighborhood. Benzene, chloroform, MTBE, iron and sodium were also identified as COCs in groundwater at the Site when screened against GWQS, however these are not site-related contaminants. PCE and TCE were identified as COCs in sub-slab soil vapor at the Site and at the adjacent convenience store building. *cis*-1,2-DCE was identified as a COC in sub-slab soil vapor at the Site only. Concentrations of PCE in indoor air exceeded air guidelines at the Wantagh Cleaners Building only. Therefore, PCE was identified as a COC in indoor air at the Site.

Carbon tetrachloride concentrations in sub-slab soil vapor and indoor air exceeded screening levels in samples collected below the Wantagh Cleaners Building and the adjacent convenience store. However, at both locations carbon tetrachloride was detected at a higher concentration in indoor air than the in sub-slab soil vapor. Additionally, carbon tetrachloride was not detected in soil and groundwater. Thus, carbon tetrachloride is not site-related and the presence of carbon tetrachloride inside the building is unlikely to be related to subsurface VI. The source of carbon tetrachloride inside the building should be identified and isolated or removed to reduce exposures.

PCE and TCE were identified as COCs in soil vapor samples collected beneath the parking lot of the Wantagh Cleaners Building and the adjacent convenience store, as well as in the soil vapor sample collected in the right-of-way south of Sand Hill Road. If construction were to occur in the future and either building be expanded, or in the event that a structure is placed in the right-of-way, further investigation of vapor intrusion into enclosed structures would have to be evaluated separately.

PCE was identified as a COC in soil vapor samples collected from the off-site residences at 921 Wantagh Avenue and 10 Jerusalem Road. However, at both locations PCE was detected at a higher concentration in indoor air than the in sub-slab soil vapor, which suggests there may be an additional source of PCE not related to the sub-slab vapor.

Based on the risk assessment evaluation, a vapor mitigation system should be installed at the Site to minimize current exposure. A vapor mitigation system should also be implemented at the adjacent convenience store to reduce potential exposure. Additionally, based on analytical results, it is recommended that indoor air and subsurface soil vapor quality be further investigated at the residences located south of the Site, within the downgradient footprint of the plume.

Section 4

Remedial Goals and Remedial Action Objectives

RAOs are media-specific goals for protecting human health and the environment that serve as guidance for the development of remedial alternatives. The process of identifying the RAOs follows the identification of affected media and contaminant characteristics; evaluation of exposure pathways, contaminant migration pathways and exposure limits; and the evaluation of chemical concentrations that will result in acceptable exposure. The RAOs are based on regulatory requirements that may apply to the various remedial activities being considered for the site. This section of the FS reviews the affected media and contaminant exposure pathways and identifies Federal, State, and local regulations that may affect remedial actions.

Cleanup objectives were selected based on federal or state SCGs, background concentrations, and with consideration also given to other requirements such as analytical detection limits. Near term goals to reduce the mass discharge of the source area to stabilize the downgradient plume and protect receptors were also considered in the cleanup objectives. These objectives were then used as a benchmark in the technology screening, alternative development, and detailed evaluation of alternatives presented in the subsequent sections of the FS report.

4.1 Remedial Action Objectives

Based on the evaluation of the nature and extent of contamination in soil, groundwater and vapor, the following preliminary RAOs were developed:

4.1.1 Remedial Action Objectives for Groundwater

The recommended NYSDEC RAOs for groundwater at the Site are as follows:

- Prevent ingestion of groundwater with contaminant levels exceeding drinking water standards
- Prevent contact with or inhalation of volatiles from contaminated groundwater
- Restore ground water aquifer to pre-disposal conditions, to the extent practicable
- Prevent the discharge of groundwater contaminants to surface water
- Remove the source of groundwater contamination to the extent practicable
- Prevent inhalation of or exposure from contaminants volatizing in groundwater

4.1.2 Remedial Action Objectives for Soil

The recommended NYSDEC RAOs for soil at the Site are as follows:

- Prevent inhalation of or exposure from contaminants volatizing in soil

4.1.3 Remedial Action Objectives for Soil Vapor

The recommended RAOs for soil vapor at the Site are as follows:

- Mitigate impacts to public health resulting from soil vapor intrusion into buildings at or near the Site

4.2 Standards, Criteria, and Guidance

To determine whether the soil, groundwater, and soil vapor contain contamination at levels of concern, State and Federal SCGs were assessed for each medium. The regulatory SCGs identified for each medium and the applicability of these SCGs to the Site are summarized in the following sections.

Potential SCGs are divided into three groups:

- Chemical-specific SCGs
- Location-specific SCGs
- Action-specific SCGs

4.2.1 Chemical-specific Standards, Criteria, and Guidance

Chemical-specific SCGs are health- or technology-based numerical values that establish concentration or discharge limits for specific chemicals or classes of chemicals.

4.2.1.1 Federal Standards, Criteria, and Guidance

Federal Drinking Water Standards

- National Primary Drinking Water Standards (40 CFR 141). Potentially applicable if an action involves future use of groundwater as a public supply source.

4.2.1.2 New York Standards, Criteria, and Guidance

Soil Standards and Criteria

- NYSDEC 6 NYCRR Part 375 Subpart 375-6, Environmental Remediation Programs, Unrestricted Use Soil Cleanup Objectives (SCOs), December 14, 2006. Used as the primary basis for setting numerical criteria for soil cleanups.
- NYSDEC CP-51 Supplemental SCOs are utilized when there are no Part 375 SCOs.

Groundwater Standards and Guidance

- New York State Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (Technical and Operational Guidance Series (TOGS) 1.1.1). Used for setting numerical criteria for groundwater cleanups.
- New York State Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations (NYCRR Part 703). Applicable for assessing water quality at the Site during remedial activities.

Drinking Water Standards

- NYSDOH Drinking Water Standards (10 NYCRR Part 5). Potentially applicable if an action involves future use of groundwater as a public supply source.

Soil Vapor Guidance

- Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (NYSDOH 2006) is considered relevant and appropriate to soil vapor at the Site. The 2006 NYSDOH Vapor Intrusion guidance indicates that the State of New York does not have any standards, criteria, or guidance values for subsurface vapors.

4.2.2 Location-specific Standards, Criteria, and Guidance

Location-specific SCGs are those which are applicable or relevant and appropriate due to the location of the Site or area to be remediated. Based on the historic site information there are no location specific criteria that could be applicable. If a location specific criterion exists, it may be superseded by chemical specific or action specific criteria listed in this section.

4.2.3 Action-specific Standards, Criteria, and Guidance

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

4.2.3.1 Federal Standards, Criteria, and Guidance

General - Site Remediation

- Occupational Safety and Health Administration (OSHA) Worker Protection (29 CFR 1904, 1910, 1926)

- Federal Resource Conservation and Recovery Act - Identification and Listing of Hazardous Waste (40 CFR 261); Standards Applicable to Generators of Hazardous Waste (40 CFR 262); Standards Applicable to Owners and Operators of Treatment, Storage, and Disposal Facilities (40 CFR 264)

Transportation of Hazardous Waste

- Hazardous Materials Transportation Regulations (49 CFR 107, 171, 172, 177, and 179)

- Federal Resource Conservation and Recovery Act - Standards Applicable to Transporters of Hazardous Waste (40 CFR 263)

Disposal of Hazardous Waste

- Federal Resource Conservation and Recovery Act - Land Disposal Restrictions (40 CFR 268)

Discharge of Groundwater

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

Off-Gas Management

- Federal Clean Air Act - National Ambient Air Quality Standards (40 CFR 50); National Emission Standards for Hazardous Air Pollutants (40 CFR 61)
- Federal Directive - Control of Air Emissions from Superfund Air Strippers (OSWER Directive 9355.0-28)

4.2.3.2 New York Standards, Criteria, and Guidance

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

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

Transportation of Hazardous Waste (6 NYCRR)

- Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities (Part 372)
- Waste Transporter Permit Program (Part 364)

Disposal of Hazardous Waste (6 NYCRR)

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

Discharge of Groundwater (6 NYCRR)

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

Off-Gas Management

- New York General Provisions (6 NYCRR Part 211)

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

4.3 Cleanup Objectives

Cleanup objectives were selected based on federal or state promulgated SCGs, background concentrations, and with consideration also given to other requirements such as analytical detection limits and guidance values. There are no chemical-specific Federal SCGs for cleanup of contaminated soil, but there are State SCGs for soil. Therefore, NYSDEC Restricted Use Soil Cleanup Objectives are applicable requirements according to NYSDEC Site Remedial Program under 6 NYCRR Part 375 Subpart 375-6. Groundwater at the Site currently is not being used as a source of drinking water, but NYSDEC classifies fresh groundwater in the state as "Class GA fresh groundwater", for which the assigned best usage is as a source of potable water supply. Therefore, although there are no known current users of groundwater at or near the Site, the groundwater is assumed to be a source of drinking water in the future. Therefore, New York State Groundwater Quality Standards are applicable requirements and the Federal and New York State primary drinking water standards are applicable if an action involves future use of groundwater as a public supply source. The primary site-related constituents of concern are chlorinated VOCs particularly PCE. **Table 4-1** identifies the cleanup objectives for the contaminants of concern at the site in soil and groundwater.

4.3.1 Groundwater Cleanup Objectives

Groundwater cleanup objectives are based on New York State Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (TOGS 1.1.1) for Class GA water.

While the long term goal will be to reduce groundwater concentrations to groundwater cleanup objectives, the near term goal is to protect key receptors and stabilize the plume. The source zone treatment will initially focus on substantial mass removal to reduce contaminant discharge to the downgradient contaminant plume.

4.3.2 Soil Cleanup Objectives

Soil cleanup objectives are based on the NYSDEC Restricted Use Soil Cleanup Objectives (Protection of Groundwater) 6 NYCRR 375-6.

4.3.3 Soil Vapor Cleanup Objectives

The Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (NYSDOH 2006) is considered relevant and appropriate to soil vapor at the Site. The 2006 NYSDOH Vapor Intrusion guidance indicates that the State of New York does not have any standards, criteria, or guidance values for subsurface vapors. However, air guideline values and the sub-slab vapor/indoor air matrices in the 2006 NYSDOH Vapor Intrusion guidance are compared to soil vapor concentrations that do not have a set standard, in order to identify if soil gas and sub-slab vapor should be mitigated.

4.4 Target Remediation Zones

Given the distribution of contamination at the Site, a single technology would not be appropriate or sufficient to address the entire site. To effectively pair the appropriate treatment technologies to the various levels of contamination in soil and groundwater, Site contamination has been separated into three zones as follows:

- **On-site vadose zone**, expected to be the source of elevated vapor concentrations in the Wantagh Cleaners building and the neighboring convenience store.
- **The groundwater source zone.** Given that Wantagh Avenue is a busy highway, the most practicable area to conduct active remediation is west of Wantagh Avenue. This area encompasses the majority of the contaminant mass at the site. Thus the horizontal extent of the groundwater source zone is defined as the contaminated aquifer from the northern boundary of the site to west of Wantagh Avenue; the vertical extent is limited to the thickness of aquifer from the top of the water table to a depth of ten feet below the water table.
- **The dilute plume**. This zone consists of deeper groundwater directly beneath the source zone, as well as the downgradient aquifer containing concentrations above SCGs, under and along Wantagh Avenue further south of the Site.

In the vadose zone, concentrations of up to 288 milligram per kilogram (mg/kg) of total VOCs were recorded directly underneath the Wantagh Cleaners building. The maximum groundwater concentration recorded in the source zone was 26 mg/L total VOCs at groundwater screening location A.

The dilute plume has been identified as that portion of the plume with low concentrations that might be amenable to a monitored natural attenuation approach.

Section 5

General Response Actions

Based on the established RAOs and site conditions, GRAs were identified. GRAs are those actions that, alone or in combination, satisfy the RAOs for the identified media by reducing the concentrations of hazardous substances or reducing the likelihood of contact with hazardous substances. The GRAs appropriate for addressing contamination at the Site are described in the sections below.

5.1 No Further Action

The National Contingency Plan (NCP) and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) require the evaluation of a NFA alternative as a basis for comparison with other remedial alternatives. Under the NFA alternative, remedial actions are not implemented, the current status of the Site remains unchanged, and no further action would be taken to reduce the potential for exposure to contamination.

5.2 Institutional/Engineering Controls

Institutional/Engineering Controls typically are restrictions placed to minimize access (e.g., fencing) or future use of the site (e.g., well drilling restriction). These limited measures are implemented to provide some protection of human health and the environment from exposure to site contaminants. They are also used to continue monitoring contaminant migration (e.g., long-term monitoring). Institutional/Engineering Controls are generally used in conjunction with other remedial technologies; alone they are not effective in preventing contaminant migration or reducing contamination.

5.3 Monitored Natural Attenuation

Monitored Natural Attenuation (MNA) is a response action by which the volume and toxicity of contaminants are reduced by naturally occurring processes. Processes which reduce the apparent contamination levels in groundwater include dilution, diffusion, dispersion, volatilization, adsorption, biodegradation, and chemical reactions. This naturally occurring attenuation, under the right circumstances, might be expected to reduce contaminant levels to the cleanup objectives within a reasonable timeframe and/or within a reasonable physical boundary.

5.4 Containment

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

5.5 Removal/Extraction

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

5.6 Treatment

Treatment involves the destruction of contaminants in the affected media, transfer of contaminants from one medium to another, or alteration of the contaminants thereby making them innocuous. The result is a reduction in toxicity, mobility, or volume of the contaminants. Treatment technologies vary among environmental media and can consist of chemical, physical, and biological processes. Treatment can occur in place or above ground, which would require coupling with removal/extraction. This GRA is usually preferred unless site- or contaminant-specific characteristics make it infeasible from an engineering or implementation perspective.

5.7 Disposal/Discharge

Discharge response actions for groundwater involve the discharge of extracted groundwater via on-site injection, on-site surface recharge, surface water discharge or discharge to a publically owned treatment works (POTW), following treatment to meet regulatory discharge and disposal requirements. Disposal of soils after removal or in conjunction with removal and treatment requires compliance with State and Federal Hazardous Waste Transportation and Disposal regulations, if levels present in media require such compliance.

Section 6

Identification and Screening of Remedial Technologies

Potential remedial technologies and process options associated with each general response action for groundwater and soil are identified and screened in this section. Representative remedial technologies and process options that have been retained are used to develop remedial action alternatives.

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

Effectiveness

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

Implementability

This evaluation criterion encompasses both the technical and administrative feasibility of the technology or process option. It includes an evaluation of pretreatment requirements, residuals management, and the relative ease or difficulty in performing the operation and maintenance (O&M) requirements. Process options that are clearly not executable at the site are eliminated by this criterion.

Relative Cost

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

Retained remedial technologies and process options are used to develop remedial action alternatives, either alone or in combination with other technologies. Lists of the remedial technologies evaluated for the groundwater source zone are provided in **Table 6-1,** for the dilute plume in **Table 6-2**, and for the on-site vadose zone in **Table 6-3**.

6.1 Groundwater

6.1.1 No Further Action

The NFA alternative is not a technology; rather it is considered as a basis for comparison.

Effectiveness - The NFA alternative is used as a baseline against which other technologies may be compared. It does not provide measures that would comply with SCGs, or otherwise meet RAOs.

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

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

Conclusion – The NFA alternative is retained for further consideration.

6.1.2 Institutional/Engineering Controls

Institutional Controls do not reduce the toxicity, mobility, or volume of contamination, but can be implemented to reduce the probability of exposure to contaminants. Institutional controls consist of administrative actions which control use of the site (e.g., well drilling restrictions) to reduce direct human contact with contaminated water. Institutional controls generally require long term monitoring of contaminant concentrations. Periodic review reporting (PRR) in accordance with Section 6.3 of *DER-10 Technical Guidance for Site Investigation and Remediation* (NYSDEC 2010) will also be completed as required by the selected remedy. Typical institutional controls are discussed below.

6.1.2.1 Deed Restrictions

Deed restrictions are regulatory actions that are used to prevent certain types of uses for properties where exposure pathways to contaminants may be created as a result of those uses. Deed restrictions may be used to prevent intrusive activities within the contamination plume.

Effectiveness - Deed restrictions can effectively minimize or eliminate the human exposure pathway to contaminated groundwater. However, they will not reduce the migration and the associated environmental impact of the contaminant plume.

Implementability - Deed restrictions are implementable if the local municipalities and site property owners allow them to be instituted. Implementation may be more difficult in off-site areas of the dilute plume and there may be objections from off-site property owners. They may also be implemented in conjunction with other technologies, as a protective measure to prevent exposure to contaminants during remediation.

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

Conclusion – Deed restrictions will be retained for further consideration.

6.1.2.2 Well Drilling/Water Use Restrictions

Well drilling restrictions are regulatory actions that are used to restrict installation of groundwater drinking water wells, and are referred to in New York State as an Environmental Easement.

Effectiveness – Environmental easements may effectively meet RAOs through restriction of future site uses or activities which would create human exposure pathways to contaminated groundwater. These restrictions, however, will not reduce the migration and the associated environmental impact of the contaminated groundwater.

Implementability - Implementation is possible based on the existing permitting process and may be implemented, in addition to remediation activities, as a protective measure to prevent future exposure to contaminants during remediation.

Relative Cost - The cost to implement environmental easements is low.

Conclusion – Environmental easements will be retained for further consideration.

6.1.2.3 Long-term Monitoring

Long-term monitoring includes periodic sampling and analysis of groundwater samples as well as site inspection and maintenance and associated PRRs as required by Section 6.3 of the NYSDEC DER 10 Guidance. This program would provide an indication of the movement of the contaminants and/or of the progress of remedial activities.

Effectiveness - Long-term monitoring alone would not be effective in meeting the RAOs. It would not alter the effects of the contamination on human health and the environment. Monitoring is a proven and reliable process for tracking the migration and attenuation of contaminants during and following treatment and is often coupled with additional technologies to determine their effectiveness.

Implementability - Long-term monitoring could be easily implemented. Monitoring wells are easily accessible for sample collection. Equipment, material, and sampling procedures are readily available. Site inspection, monitoring and reporting are easily implementable.

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

Conclusion - Long-term monitoring will be retained for further consideration to track the impact of the chosen remedial alternatives.

6.1.3 Monitored Natural Attenuation

MNA refers to the remedial action that relies on naturally occurring attenuation processes to achieve site-specific RAOs within a reasonable time frame compared to other options. Natural attenuation processes that reduce contaminant concentrations in groundwater include destructive (biodegradation and chemical reactions with other subsurface constituents) and nondestructive mechanisms (dilution, dispersion, volatilization, and adsorption). Biodegradation is often the most significant destructive attenuation mechanism for chlorinated solvents if the appropriate microorganisms are present and there is sufficient organic carbon available to fuel their growth. PCE and TCE biodegrade predominantly by reductive dechlorination under anaerobic conditions, while cis-1,2-DCE and VC can biodegrade under both anaerobic and aerobic conditions. Abiotic degradation of these compounds may be possible, but this pathway has not been evaluated.

While degradation byproducts of PCE were observed in site groundwater during the RI, the TOC data indicate that there is not sufficient organic carbon available to sustain a population of dechlorinating bacteria for complete dechlorination of PCE. This is true in groundwater on site as well as off site.

Given the absence of evidence for a destructive attenuation mechanism in site groundwater, an evaluation of the effectiveness of MNA hinges on the ability of non-destructive processes, dilution and dispersion, to achieve RAOs within a reasonable timeframe compared to other technologies. Slug tests performed during the RI showed hydraulic conductivity in the Upper Glacial Aquifer ranged from 67 to 116 feet per day. The high permeability of the aquifer indicate that dilution and dispersion can be expected to be significant in the plume. The length of the plume (over 8,000 linear feet) attests to this.

Effectiveness - Based on the data collected during the RI, complete dechlorination of PCE is unlikely at the source and in the dilute plume due to the lack of significant organic carbon source and potential absence of bacteria capable of complete dechlorination.

Dilution and dispersion are likely reducing concentrations in the dilute plume. However, MNA generally requires the demonstration that attenuation processes are resulting in a stable or shrinking contaminant plume to ensure that there is no threat to receptors. Plume stability is evaluated using trend analysis and/or modelling to evaluate contaminant concentrations over time in monitoring wells within the source area(s) and contaminant plume. Additional data would need to be collected to evaluate/verify the feasibility/effectiveness of MNA.

If there is uncertainty about the effectiveness of MNA, contingency planning may be required to initiate some additional measures if monitoring indicates that the technology is not working effectively towards achieving goals or if it is determined a receptor is threatened.

The effectiveness of MNA, as part of a multi-technology remedial strategy, can be improved if remediation of the source results in significant decreases in contaminant mass discharge (i.e., loading) to the contaminant plume or technologies accelerate removal mechanisms (e.g., biodegradation). Often, active treatment technologies cannot achieve stringent cleanup objectives and so will reduce contaminant levels to some intermediate level and then rely on MNA for further reductions to achieve goals.

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

Relative Cost - MNA involves low capital cost and low O&M cost for long term monitoring and periodic reassessment.

Conclusion - MNA may be used in conjunction with other treatment technologies and will be retained for further consideration.

6.1.4 Containment

Containment technologies are implemented to prevent direct contact to contaminants and to reduce contaminant mobility. Containment does not directly impact contaminant toxicity and volume. By reducing contaminant mobility, exposures to human and ecological receptors are minimized or eliminated. Containment technologies are typically accompanied by a long-term O&M and monitoring program to verify that the containment measures continue to be effective. Commonly used containment technologies include barrier walls.

6.1.4.1 Slurry, Sheet or Secant Piling Walls

The walls would be constructed using slurry grout, sheet or secant piling to the top of a low permeability layer. Barrier walls can be used in combination with a groundwater extraction system; the walls would minimize the amount of pumping required to maintain hydraulic control by acting as a physical barrier, restricting clean groundwater inflow from side-gradient areas into the capture zone.

Slurry walls are constructed by pumping a low permeability slurry, typically consisting of either a soil-bentonite or cement-bentonite mixture, into an excavated trench. Excavation can be completed using a long-arm excavator and a clam shovel to meet the required depth. The slurry would be pumped into the hole during the course of excavation to keep the sidewalls from collapsing. Sheet pile retaining walls are usually used in soft soils and tight spaces. Sheet pile barriers are constructed by driving or vibrating sections of steel sheet piling into the ground. Secant pile walls employ bored piling techniques, typically auger or rotary piles.

Effectiveness – Containment walls would not effectively achieve hydraulic control on their own. Such technologies would need to be coupled with additional hydraulic control via pumping. The wall would effectively retard continued migration of contamination off site, but would have no impact on plume migration beyond the containment wall. Upgradient of the wall, this technology would reduce only the mobility of the contamination and would not reduce the toxicity or volume of contamination. In addition, containment walls have limited effectiveness on vertically migrating contamination.

Implementability – Slurry, sheet, and secant pile walls are implementable because both depth of the groundwater table and contamination are shallow. However, because of the presence of a currently occupied building and parking lot on site, installing the walls on site may be complicated by existing building operations. Similarly, main roads located on the off-site portion of the contaminant source zone may pose major restrictions in wall implementation due to potential disruption of traffic flow.

Relative Cost – Slurry, sheet, and secant pile walls involve high capital costs and low to no O&M costs.

Conclusion - Containment walls will not be retained for further consideration due to difficulties with effectiveness and implementability.

6.1.5 Removal/ Extraction

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

6.1.5.1 Vertical Extraction Wells

This technology generally involves the installation of groundwater extraction wells within areas of contamination to provide hydraulic control and capture of contaminants. Additionally, extraction wells may be installed as part of an extraction-injection well network for *ex situ* or *in situ* treatment systems. The specific extraction well locations would be determined through groundwater modeling and/or pilot testing.

Effectiveness - Extraction wells are effective in limiting plume migration for sites where the hydrogeology is well understood and the pumping rate necessary to achieve the required radius of influence is sustainable. Pump tests and groundwater modeling must be conducted to confirm whether extraction wells will be effective for containing the contamination plume. Additionally, the extracted groundwater will require treatment to remove the contaminants and will need to be coupled with additional technologies to be effective at achieving RAOs. Preliminary groundwater quality investigations in the Remedial Investigation Addendum report indicate groundwater concentrations of dissolved iron (ferrous iron) ranges from 0.05-0.95 mg/L. Iron fouling in the extraction wells is not expected to be a problem at these low concentrations.

Implementability – Because of the presence of a currently occupied building on site, implementation of extraction wells and associated aboveground treatment on site may be restricted due to potential disruption of existing building operation. Similarly, a main road located on the off-site portion of the contaminant source zone may also restrict off-site locations available for extraction well installation due to potential disruption of heavy traffic flow. Trenching would be required to connect wells to a treatment unit which would be disruptive to existing surface structures and may require repaving of parking areas and heavily traveled roads. Also, *ex situ* treatment of groundwater will require additional space for installation and operation, as well as a method for disposing of the pumped water.

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

Conclusion - Groundwater extraction wells will not be retained for further consideration due to difficulties with implementability.

6.1.5.2 Dual Phase Extraction

This technology involves the removal of groundwater coupled with the removal of soil vapor in the unsaturated zone. The dual phase extraction wells will provide hydraulic control and capture contaminants. See section 6.2.4.3 for a detailed evaluation of this technology. Dual phase extraction wells will not be retained for further consideration due to difficulties with implementability.

6.1.5.3 Extraction Trenches

This technology involves construction of a trench perpendicular to the direction of groundwater flow to intercept and prevent down gradient migration of a contaminant plume. A bio-polymer slurry is used temporarily to support the sidewalls of the trench, preventing collapse of the trench sidewalls. The trench is typically backfilled with material of higher permeability than the native aquifer (e.g., gravel) to create a zone of preferential flow, and perforated piping or well screens are typically installed in the trench to collect the intercepted groundwater. After the piping and backfill have been installed, an additive is pumped into the trench to break down the slurry to simple sugars and water, thus re-establishing hydraulic connection to the aquifer. Extracted groundwater is then treated as necessary to meet discharge requirements. Extraction trenches are generally used for contamination at shallow depth. One-pass trenching can excavate and backfill with sand at the same time.

Effectiveness - Extraction trenches are effective in capturing groundwater to provide hydraulic control. To meet the RAOs, sufficient contaminant mass needs to be captured such that the cleanup objectives are met within a reasonable timeframe. Aquifers where matrix diffusion and slow desorption kinetics occur can be problematic, since groundwater will be continually fed by back-diffusion and desorption from the soils.

Implementability - The equipment and materials would be readily available. Source zone contamination has been relatively shallow. Therefore, an extraction trench is implementable. However, as mentioned in Section 6.1.4.1, existing surface structures may limit access and space for implementation. Trenching, especially will be disruptive to existing surface structures and may require repaving of parking areas and heavily traveled roads which will take additional time.

Relative Cost - Extraction trenches would involve moderate capital cost and O&M costs.

Conclusion - This technology will not be retained for further evaluation due to difficulties with implementability.

6.1.5.4 Air Sparging

Air sparging involves the injection of air into the contaminated aquifer. Injected air strips organic contaminants *in situ* and helps to flush the contaminants into the unsaturated zone. If the mass of VOCs is great enough, SVE may be implemented in conjunction with air sparging to remove the vapor-phase contamination from the vadose zone by vacuum extraction and, if required, vapor treatment to mitigate impacts to surface receptors. See Section 6.2.4.2 for more information on SVE.

Effectiveness – Air sparging is generally most effective for removal of volatile, relatively insoluble organics from a highly permeable, relatively uniform sandy aquifer (Bass, 2000). The brown silty sand in the saturated zone at the Site is well suited for air sparging. A pilot test would be necessary to confirm effectiveness.

Implementability – Air sparging is potentially implementable at the site. However, potential clayey sand layers in the soil above the sparged zone may make it difficult to allow sparged air to vent to the atmosphere. Vents may need to be installed. Care would need to be taken to ensure that vapors do not contaminate nearby surface waters or increase risk of vapor intrusion inside buildings. In addition, as mentioned in Section 6.1.5.1, existing surface structures may limit access and space for implementation. However, this technology may be more implementable to those requiring *ex situ* water treatment because the required vapor treatment would use the same facility required for SVE, and not need a comparatively large water treatment and disposal train.

Relative Cost - This technology would involve moderate capital and O&M costs.

Conclusion - This technology will be retained for further evaluation for the on-site portion of the groundwater source zone but not the dilute plume.

6.1.6 *In Situ* Treatment

In situ treatment technologies intercept and immobilize or degrade contaminants in the subsurface passively, or mobilize and/or destroy contaminants in the subsurface aggressively and significantly shorten the required remediation time. Many of the passive technologies require little maintenance. The active technologies significantly speed up the removal rate of residual free phase or adsorbed contaminants, which would not be possible via pump-and-treat technology and other extraction technologies. *In situ* treatment also reduces the possibility of exposure of contaminants to the site worker. Several *in situ* treatment technologies were identified as potentially applicable at the Site, and are discussed below.

6.1.6.1 *In situ* Biotic and Abiotic Treatment

In Situ Bioremediation

Enhanced anaerobic bioremediation (EAB) is a technology that can remediate chlorinated VOC contamination in soil and groundwater through reductive dechlorination. EAB involves injection of organic substrate (electron donor) solution into the subsurface to stimulate the growth of native microorganisms to detoxify chlorinated VOC contaminants. The predominant degradation pathway is anaerobic reductive dechlorination as discussed in Section 6.1.3. In addition, the generation of ferrous iron and the possible formation of reduced iron minerals, such as ferrous sulfide, could degrade chlorinated VOC contaminants via abiotic degradation pathways (Adamson et al. 2011). The quantity of organic substrate injected into the subsurface is usually designed conservatively to ensure it would not be the limiting factor for EAB treatment.

For complete reductive dechlorination, the presence of a strain of the bacterium Dehalococcoides (DHC) is required. Lack of DHC typically results in the dechlorination progress stalling at cis-1,2-DCE. To achieve complete dechlorination at such sites, DHC bacteria can be injected after the establishment of anaerobic conditions in the aquifer. This is referred to as bioaugmentation.

EAB has been applied successfully to treat chlorinated solvent contaminated groundwater, even with residual DNAPL. It is applicable to a wide range of contaminant concentrations but may not be cost effective for a large dilute plume or a swiftly flowing aerobic plume. The median removal efficiency was found to be 95 percent for parent compounds and 62 percent for total chlorinated VOCs (ITRC 2011). The potential effectiveness of EAB for Site soil and groundwater contamination at the source areas is discussed below.

Effectiveness – This technology would be effective for source zone highly contaminated groundwater. However, the extent of success depends on site conditions, and the availability of the DHC bacteria (for complete reductive dechlorination of chlorinated solvents). If coupled with in situ thermal remediation, the increased groundwater temperature would also be beneficial to microbial growth. In addition, the relatively homogeneous silty sand characterizing the aquifer could support effective distribution of the organic substrate. However, detailed characterization of the lithology and possibly a pilot study would be critical for the design and implementation of successful EAB treatment.

Implementability – Implementation can be complicated by potential access limitations to the occupied building on site and public roads off site. Based on the method selected, multiple injections may be required and monitoring is necessary. Multiple applications may be necessary to achieve SCGs. A pilot study may be needed to collect site-specific implementation parameters.

Relative Cost – This technology would require moderate capital and moderate O&M costs over several years since multiple rounds of amendment injections may be necessary.

Conclusion – In situ bioremediation will be retained for further consideration for both the groundwater source zone and the dilute plume

In Situ Chemical Reduction

In situ chemical reduction (ISCR) is a process that uses a reductant to chemically transform the contaminants to non-hazardous compounds. The most widely used reductant for chlorinated hydrocarbons is zero-valent iron (ZVI). ZVI has been applied in several ways to remediate contaminants: in a permeable reactive barrier, in an injected slurry with nano-scale or micro-scale particles, or with hydraulic fracturing. Recently, ZVI has also been combined with organic carbon to promote contaminant degradation through both biodegradation and chemical reduction pathways, such as emulsified zero-valent iron (EZVI), a commercial product containing emulsified oil-coated ZVI, or EHC®, another commercial product, containing ZVI and controlled-release organic carbon in solid form.

ISCR is generally applied in saturated zones to treat contaminated plumes. There are a few cases where ISCR was applied to a residual DNAPL zone using an amendment combining ZVI and organics, and with in situ soil mixing for delivery and distribution (ITRC 2011).

Effectiveness – ISCR through ZVI can effectively treat contaminated groundwater aquifers containing PCE, TCE, and their degradation products if distributed effectively in the treatment zone. For this Site, evenly distributing ZVI-containing materials in the groundwater in the source zone is expected to be feasible due to the relative homogeneity of the silty sand aquifer. However, a pilot study would be necessary to collect site-specific implementation parameters.

Implementability – Equipment and experienced vendors would be available. Achieving adequate distribution of the ISCR amendment would be feasible. However, implementation can be complicated by potential access limitations to the occupied building on site and public roads off site. Based on the method selected, multiple injections may be required and monitoring is necessary. A field pilot study may be necessary to obtain design parameters.

Relative Cost – This technology would involve high capital cost. Depending on the delivery technology and the depth of contamination, the O&M cost could be minimal, mainly for monitoring.

Conclusion – ISCR will be retained for further consideration for both the onsite groundwater source zone and the dilute plume

In Situ Chemical Oxidation

In situ chemical oxidation (ISCO) involves the injection of chemical oxidants to destroy organic contaminants in the groundwater. Complete oxidation of contaminants results in their breakdown into innocuous compounds such as carbon dioxide, water, and chloride. In situ chemical oxidation can significantly increase the mass transfer between the residual contaminated soil and groundwater. A number of factors affect the performance of this technology, including oxidant delivery, oxidant type, dose of oxidant, contaminant type and concentration, and oxidant demand of the soil.

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

ISCO has been successfully applied to treat highly contaminated groundwater and in some cases with residual DNAPL. The median removal was found to be about 72 percent for total chlorinated VOCs (ITRC 2011).

Effectiveness - ISCO technology is proven to be effective when an adequate amount of the oxidant can be distributed evenly enough in the aquifer to ensure it contacts the contaminants. Native soils with high oxidant demand may also decrease the effectiveness of ISCO in treating contaminants since ISCO is a non-selective oxidation process. However, the native soil in the contaminant source zone is expected to have low oxidant demand based on site geology explored in the RI. In the dilute plume however, low concentrations of contaminants may encourage injected oxidants to be spent more on satisfying native oxidant demand than treating the contaminants. Long-lasting oxidants are preferred to treat contaminants from back diffusion. However, amendments may still be consumed too quickly to provide long-lasting treatment to the dilute plume.

Implementability – ISCO would be implementable. Equipment and vendors would be available for ISCO implementation. A field pilot study would be necessary to evaluate and develop a site-specific delivery strategy. Three to five rounds of application are typically necessary for sufficient mass reduction. As mentioned in Section 6.1.6.1, existing surface structures may limit access both on site and off site.

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

Conclusion - ISCO will be retained for further consideration for the groundwater source zone but not for the dilute plume

6.1.6.2 Permeable Reactive Barriers

Permeable reactive barriers (PRBs) provide *in situ* treatment of groundwater and are designed to intercept contaminated groundwater flow. An in-ground trench is backfilled with reactive media to provide passive treatment of the contaminated groundwater as it passes through the trench. These reactive barriers differ from highly impermeable barriers, such as slurry walls, or sheet pilings, which restrict the movement of a groundwater plume. PRBs can be installed as permanent, semi-permanent, or replaceable units which transect the plume flow path and act as a treatment wall. Natural hydraulic gradients transport contaminants through the strategically placed reactive media. When the contaminated groundwater passes through the reactive zone of the barrier, the contaminants are either immobilized or chemically degraded to less harmful product(s).

Effectiveness -PRBs have been effective in degrading chlorinated solvents. However, PRBs require periodic reactivation to retain effectiveness.

Implementability - PRBs are installed downgradient, perpendicularly intersecting the contaminated groundwater flow. Due to the shallow depth of groundwater and contamination, PRBs can be installed via trenching. However, as mentioned in Section 6.1.5.3, trenching will be disruptive to existing surface structures and may require repaving of parking areas and heavily traveled roads which will take additional time.

Relative Cost - PRBs involve moderate to high capital and low O&M costs. The replacement cost could be as high as the capital cost.

Conclusion - PRBs will not be retained for further consideration due to difficulties with implementability.

6.1.6.3 *In Situ* Thermal Remediation

ISTR facilitates the *in situ* thermal mobilization of chlorinated VOCs over a wide range of concentrations in groundwater and soil through desorption and volatilization. In this technology, heat is applied to the subsurface soils using technologies such as electrical resistivity heating (ERH), steam enhanced extraction, or thermal conductive heating. For chlorinated solvents, the vaporization is the driving mechanism for mass removal. This technology is typically applied in conjunction with SVE to remove the volatilized contaminants. ISTR is very effective in removing VOC contaminants in heterogeneous and low-permeability soils and generally requires shorter treatment times (months) than many other remedial technologies. However, *in situ* thermal treatment typically also involves an extensive drilling program, high energy usage, and high overall costs. This technology is evaluated for groundwater and soil below.

Effectiveness – Thermal treatment is very effective and fast in source areas for remediating VOC contamination as found at this Site. It will most likely also reduce contaminants to lower levels than other *in situ* treatments since its effectiveness is generally not as dependent on subsurface soil or biogeochemical conditions. However, it involves intensive energy use and increased temporary health and safety (H&S) risks. Heating would reduce the moisture content in the vadose zone soil and enhance the air flow for mass reduction through the SVE system.

Implementability – Implementing ISTR would be challenging at this Site for the following reasons: (1) it is an active operating facility with busy roads adjacent to the east and south. As a result, access to the contaminated area for installation of the remediation system would be restricted and available space as an exclusion zone during remediation would be limited. (2) Since contaminants are at or near the ground surface and much of soil and groundwater directly underneath the building is contaminated, heating would need to be conducted close to the ground surface. Insulation for protection of site workers would be critical. (3) Heating well installation may be limited to a DPT rig that can maneuver around the building. The depth such a rig can reach to install the borings for ISTR might be limited. Implementing ISTR would require temporary shutdown of the existing operation in the building which would be subject to approval from the property owner. ISTR would be even more difficult to implement in the dilute plume as the plume covers a large area mostly occupied by residential neighborhoods.

Relative Cost - ISTR involves high capital costs and high O&M costs for a relatively short period of time.

Conclusion - ISTR will be retained for further consideration for the groundwater source zone as a treatment to predisposal conditions but will not be retained for the dilute plume.

6.1.6.4 In-Well Vapor Stripping

In-well vapor stripping involves adding a sparge point inside a well. As the sparged gas rises through the well, it strips contaminants from the water, and the stripped contaminants are removed from the vapor stream above surface. The sparging creates hydraulic lift inside the well. The lifted water discharges out through an upper screen, and the resulting pressure difference allows water to be drawn in through a lower screen. Thus, in-well vapor stripping is in effect a recirculating *in situ* treatment system.

Effectiveness – The vadose zone generally must be thick enough and conductive enough to ensure circulated water can recharge out of the upper screen without mounding to the surface (United States Department of Energy, 2002). At the Site, the vadose zone is about 9 or 10 feet thick and is highly conductive sand, which is expected to achieve a relatively large and effective recirculation radius of influence for each stripping well.

Implementability – Due to existing surface structures on and off site as mentioned in Section 6.1.5.1, limited access may reduce implementability and also the number of wells that can be installed. Implementing in the dilute plume would be even more complicated as the size and the extent of the plume may require excessive amounts of recirculation and discharge.

Relative Cost – In-well vapor stripping involves high capital costs and medium O&M costs.

Conclusion – This technology will be retained for further consideration for the groundwater source zone but not for the dilute plume

6.1.7 *Ex situ* Treatment

Ex situ groundwater treatment options were not screened in this FS because no groundwater removal/extraction technologies were retained for the groundwater source zone.

6.1.8 Discharge

Options for discharge of treated groundwater were not screened in this FS because no groundwater removal/extraction technologies were retained for the groundwater source zone.

6.2 Soil

6.2.1 No Further Action

Effectiveness - NFA is used as a baseline against which other technologies may be compared. It does not provide measures that would comply with SCGs, or otherwise meet RAOs.

Implementability - NFA is implementable given there is no action required.

Relative Cost - NFA involves no capital or O&M costs.

Conclusion –NFA is retained for further consideration, but for comparison purposes only.

6.2.2 Institutional/Engineering Controls

Institutional controls consist of administrative actions which control use of the site (e.g., fencing and signage) to reduce direct human contact with contaminated soil. Typical institutional controls are discussed below. Engineering controls reduce human contact with contaminated soil through physical (engineered) methods.

6.2.2.1 Land-Use Controls

Land-use controls, also known as deed restrictions, are used to limit the way the land can be developed or used when contamination is allowed to remain at a site above the remediation goals. For example, deed restrictions can restrict subsurface intrusive activities (e.g., excavation).

Effectiveness – Land-use controls, such as restricting intrusive activities, would be effective in protecting human health from exposure to contaminated soil. However, the effectiveness is dependent on proper enforcement. Vapor intrusion is already occurring in the Wantagh Cleaners building and the adjacent convenience store. Land-use controls would help reduce or minimize additional site-related contamination exposure risk to current and future workers in these buildings and to potential future construction workers performing excavation at the site. However, it may need to be coupled with sub-slab depressurization to minimize health risks associated with existing vapor intrusion.

Implementability – Land-use controls would limit the current and future use of the contaminated properties and would require the local government to enforce and monitor the controls over the long term. This option is implementable.

Relative Cost – The cost to implement land-use controls is low. Some administrative, long-term monitoring and/or periodic assessment cost would be required.

Conclusion – Land-use controls will be retained for further consideration in combination with other remedial technologies.

6.2.2.2 Fencing and Signs

Fencing installed around contaminated areas limits access and minimizes direct human exposure to contaminated soil. Fencing is often installed with signs that indicate the risks. Fencing may also be used in combination with other remedial technologies to protect human health during remedial construction activities such as excavation/removal.

Effectiveness – Fencing and signs can be effective to minimize, not prevent, human contact with the contaminated materials or potential hazards during remedial action. However, fencing and signs would not reduce the toxicity, mobility, or volume (T/M/V) of contaminated soils nor prevent contaminants in the vadose zone from migrating to the groundwater.

Implementability – This option could be implemented. However, the presence of an existing business on site may make it difficult to limit access to certain areas. Fencing would also require periodic inspection and maintenance.

Relative Cost – This option has low capital cost and low O&M cost.

Conclusion – Fencing and signs will be retained for further consideration in combination with other remedial technologies.

6.2.2.3 Community Awareness

Community awareness involves information and education programs to educate the local community on potential hazards, available technologies capable of addressing the contamination, and the remediation progress.

Effectiveness – This option would be effective when combined with other technologies that could reduce exposure and T/M/V. Educational programs would protect human health by bringing increased awareness to the public of the contaminated conditions and would enhance implementation of other institutional controls or engineering controls (such as land-use controls) within the contaminated area.

Implementability – This option would be implementable.

Relative Cost – Community awareness would have low capital and operational costs.

Conclusion – Community awareness will be retained for further evaluation.

6.2.2.4 Subslab Depressurization

Subslab depressurization involves the installation of a negative pressure field directly under a building slab. The negative pressure field becomes a "sink" for any vapors present in the vicinity of the structure.

Effectiveness – This option would be effective for preventing or minimizing soil vapor intrusion into the building on-site and the adjacent convenient store where vapor intrusion has been identified as a an issue. *Implementability* – This option would be implementable.

Relative Cost – This option would have low capital and operational costs.

Conclusion – Subslab depressurization will be retained for further evaluation.

6.2.3 Containment

Containment technologies are implemented to prevent direct contact with contaminants and to reduce contaminant mobility. Containment does not directly impact contaminant toxicity and volume. By reducing contaminant mobility, exposures to human and ecological receptors are controlled and minimized. Containment technologies are typically accompanied by a long-term O&M and monitoring program to verify that the containment measures continue to be effective. The most commonly used containment technology for vadose zone soil is capping.

6.2.3.1 Capping

Capping can isolate contaminated media from direct contact with humans, biota, or surface runoff, which mitigates unacceptable risks to human and ecological receptors. Additionally, an impermeable surface cap can significantly reduce infiltration into contaminated soils by diverting rainwater away from the contaminated zone, thereby reducing the leaching of contaminants from the vadose zone into the groundwater.

Effectiveness – Capping would be effective in reducing the leaching of contaminants in the vadose zone to groundwater. The current pavement and building slab are acting like a cap for soil contamination below the pavement/slab. Capping would not eliminate contaminant migration due to volatilization and vapor phase diffusion and would not eliminate the migration of VOC vapors into buildings unless it was installed with a vapor barrier. Capping also would not reduce the toxicity and volume of the contamination, but would reduce mobility into groundwater. Therefore, capping would not be an effective remedial technology alone. In addition, Long term effectiveness of the cap depends on proper maintenance; inspection and maintenance would be required as part of the long term monitoring.

Implementability – For this Site, capping could be implemented using conventional construction equipment in areas without pavement and by repairing the cracks in existing pavement and building slabs. Capping would limit future land use and would require a rigorous inspection and maintenance program. Inspection and maintenance of the existing asphalt cap is easily implementable within the Wantagh property. However, inspection and maintenance of the public paved roads may require permitting as well as any additional government restrictions. Similarly, paving landscaped public areas may be more difficult to implement and may be restricted.

Relative Cost – Capping involves moderate capital and low O&M costs.

Conclusion – Maintaining existing asphalt caps in the source zone is retained for further consideration with other remedial technologies.

6.2.4 Removal and Extraction

6.2.4.1 Excavation

Excavation uses standard earthwork equipment to remove contaminated soil for consolidation, treatment, and/or disposal. In general, heavy machinery (e.g., backhoes, bulldozers, and end-loaders) can be utilized to remove large quantities of soil; manual excavation is useful for removal of small amounts of soil at sensitive areas (e.g., next to utilities) or when heavy machinery cannot access certain areas. Excavation becomes more difficult and complicated with increasing depth due to accessibility, structural stability, and safety concerns. Dewatering would be required for excavations below the water table. Once excavated, the materials must be stored or stockpiled in a containment area to prevent the spread of contaminants prior to sampling, analysis, and disposal.

Effectiveness – Excavation is an effective technology at this Site for removing contaminant mass in the vadose zone, thus potentially controlling vapor intrusion and minimizing impacts to groundwater. Excavation would be an effective technology for the shallow vadose soil contamination. However, excavation of all contaminated soils in the unsaturated zone in the source area may not be possible due to the proximity to currently occupied buildings.

Implementability – Excavation is difficult to implement at this Site for vadose zone contaminated soils. Since the majority of the building footprint is contaminated, excavation underneath the building would be very complicated especially with an active business in the building. In addition, the Site is bordered by very busy streets. Obtaining access to entire sections of the roads for excavation work would also be very difficult.

Relative Cost – Excavation at shallow depths with structural support for buildings would involve moderate to high capital costs. Excavation would not require O&M costs.

Conclusion – Excavation will be not be retained due to implementability issues.

6.2.4.2 Soil Vapor Extraction

A SVE system creates a negative pressure zone in soil to enhance volatilization and remove volatilized contaminants. Vapor extraction can be conducted *ex situ* on excavated soil using perforated pipes in mounds or *in situ* with vapor extraction wells. The extraction systems are coupled with blowers or vacuum pumps to create a vacuum. Increased air flow through the soil allows enhanced mass transfer from adsorbed, dissolved, and free product phases in the soil to the vapor phase. An off-gas treatment system is often utilized to treat the contaminated vapor prior to discharge to the atmosphere. Depending on the depth of soil being remediated, vertical extraction wells, horizontal extraction pipes, or trenches may be used. Surface caps are often used in conjunction with SVE to reduce emissions of fugitive vapors, increase the vacuum radius of influence, prevent surface water infiltration, and prevent vertical short-circuiting of the air flow.

Effectiveness – An SVE system will be effective at this Site due to primarily sandy soils in the vadose zone which permit air flow. SVE would reduce contaminant concentrations in soil and soil vapor beneath the buildings. However, clayey sand layers at various depths in the unsaturated zone may lower permeability and interfere with the effectiveness of the vacuum system. A pilot study typically would be necessary prior to the design and implementation of an SVE system to measure the relevant parameters and determine effectiveness.

For initial mass reduction, an SVE system likely would be effective. As vapor phase contaminants are removed from the more transmissive soils, contaminants in the tighter zones very slowly partition into the air channels through diffusion, and the effectiveness and efficiency of an SVE system greatly decreases.

Implementability – SVE is implementable at this Site. A permit for off-gas treatment and discharge also would be required to implement an SVE system. SVE systems are typically operated in continuous mode at the beginning of the remedial action then switched to pulsed mode until concentrations in the extracted vapors either drop to non-detectable levels or to asymptotic levels. A cost-effectiveness analysis generally is conducted before the system is shut down.

Relative Cost – SVE would involve low to moderate capital and moderate O&M costs when run for a long time.

Conclusion – SVE will be retained for further consideration, especially for the soil contamination underneath the buildings and/or in conjunction with thermal remediation.

6.2.4.3 Dual-Phase Extraction

Dual-phase extraction (DPE) involves the combined extraction of soil vapor and groundwater utilizing extraction wells screened across both the saturated and unsaturated zones. A pump is utilized to extract groundwater while a vacuum is applied to the wellhead to extract soil gas. Both aqueous and vapor streams would require *ex situ* treatment. Contaminant vaporization and recovery is facilitated by increasing pressure and concentration gradients. Groundwater extraction would depress the water table and expose more soils to the applied vacuum for mass removal in the expanded vadose zone. DPE is considered an effective technology for mass reduction of VOC contamination from groundwater and contaminated soils. This technology has been evaluated for soil and groundwater below.

Effectiveness – DPE would be effective for reducing the mass of contaminants in groundwater and soil. However, the extracted groundwater and vapor will require treatment. The silty sandy lithology is suitable permeability for DPE. A pilot study typically would be necessary prior to the design and implementation of a DPE system to measure relevant variables and determine effectiveness.

Implementability – Dual phase extractions wells may have the same access restrictions as vertical extraction wells (mentioned in Section 6.1.5.1). In particular, *ex situ* treatment of groundwater will require additional space for installation and operation which may not be feasible with the Site's space limitations.

Relative Cost - Installation of DPE wells involves moderate capital costs and O&M costs.

Conclusion – This technology will not be retained for further consideration due to implementability issues.

6.2.5 *In Situ* and *Ex Situ* Treatment

6.2.5.1 *In Situ* Thermal Remediation

In situ thermal technologies heat the subsurface soil and groundwater, resulting in desorption and volatilization of contaminants. The evaluation of this technology has been discussed for groundwater and soil in Section 6.1.6.4, and has been retained for further consideration.

6.2.5.2 *Ex situ* Treatment for Extracted Vapor

The contaminated soil vapor extracted from SVE, ISTR, or air stripping would require treatment prior to discharge to the atmosphere. These *ex situ* treatment technologies are presented below.

Liquid/Vapor-Phase Granular Activated Carbon

Vapor-Phase Granular Activated Carbon (VPGAC) is usually used to remove contaminants from the gas phase in combination with an SVE system, *in situ* thermal remediation, or air strippers in the treatment train. Contaminants in the vapor phase or off-gas are adsorbed onto VPGAC and removed from the air flow prior to discharge to the atmosphere. Contaminants in the groundwater or condensed water are absorbed onto the Liquid-Phase Granular Carbon (LPGAC) and removed from the water prior to discharge. The used GAC can be either regenerated after contaminants break through or disposed in an appropriate manner. This technology is evaluated for soil and groundwater below.

Effectiveness – Activated carbon adsorption would be effective in removing PCE, TCE, and cis-1,2-DCE. However, it is less effective in the removal of vinyl chloride. An additional treatment method, such as potassium permanganate oxidation, would be required to remove vinyl chloride which was detected during the RI under the on-site building in the vadose zone (8,900 µg/kg diluted and estimated concentration).

Implementability – Implementation of a VPGAC/LPGAC treatment train is possible, this technology would also need to be coupled with one of the discharge options, as well as appropriate disposal or regeneration of the fouled media at the end of its useful life cycle. Vapor-phase GAC can be used directly for an SVE system or in the treatment train for off-gas management in the DPE or ISTR remedy. Liquid-phase GAC can be used to treat contaminated groundwater from DPE. This technology would be implementable, and the equipment and materials would be readily available. This technology generally does not require a treatability study. Due to limited access and space, smaller GAC vessels might be suitable at this site. Discharging the treated gas would generally require a permit.

Relative Cost – This technology would involve moderate capital and O&M costs. O&M costs would be high if used on high concentration vapor streams. Treatment is more economical when used as a polishing step following treatment by air stripper.

Conclusion – This technology will be retained for further consideration.

Thermal Oxidation

Thermal oxidation systems are typically used for SVE off-gas treatment. These treatment systems destroy contaminants in vapor streams at elevated temperatures through combustion or oxidization. Types of thermal oxidation include direct-flame thermal oxidation, flameless thermal oxidation, catalytic oxidation, hybrid thermal/catalytic oxidation, and internal combustion engines (ICEs).

Effectiveness – Thermal oxidation is more effective for treating off-gases with high concentrations of vapor contaminants. This is usually done in the initial stages of treatment. After concentrations have been reduced, thermal oxidation is usually replaced with carbon adsorption treatment (i.e., GAC).

Implementability – This technology would be implementable, and the equipment and materials would be readily available. It can be used for vapor contaminants from SVE, DPE, and/or ISTR remedies. However, the presence of chlorinated VOCs like TCE at the site may lead to the formation of acid gases during vapor combustion which will require acid resistant materials in the treatment system. These acid gases may also require further treatment. Due to limited access and space, smaller treatment systems might be more suitable at this site. Discharging the treated gas would generally require a permit.

Relative Cost – This technology would involve high capital and O&M costs.

Conclusion – This technology will not be retained for further consideration due to potential issues with acid gases.

Potassium Permanganate Oxidation

When vinyl chloride is present in the extracted soil vapor or treatment system off-gas, potassium permanganate can be used for both neutralization and oxidation. Typically, an ion exchange resin (zeolite) is impregnated with a solution of potassium permanganate. Potassium permanganate will react to form three compounds: potassium hydroxide, manganese tetraoxide, and manganese dioxide. The manganese tetraoxide will oxidize vinyl chloride into potassium chloride and carbon dioxide. The potassium chloride will remain in the pore structure of the substrate that contains the hydrated potassium permanganate.

Effectiveness – Potassium permanganate oxidation would be effective in removing vinyl chloride from the off-gas.

Implementability – The equipment and materials would be readily available through vendors. This technology could be implemented with SVE or ISTR technologies and/or as part of the off-gas treatment in a DPE remedy. It can also be used as a second treatment step after GAC. This technology generally does not require a treatability study.

Relative cost – This technology would involve moderate capital and O&M costs.

Conclusion – This technology will be retained for further consideration.

6.2.6 Disposal

Disposal response actions for soil are not screened herein because excavation and disposal of soil was not retained.

Section 7

Remedial Action Alternatives

The objective of this section is to develop and describe remedial action alternatives for the three Site treatment zones defined in Section 4.4 above: on-site vadose zone, shallow groundwater source zone, and dilute plume. To address the site-specific RAOs, alternatives have been developed by combining the technologies and process options retained in Sections 5 and 6.

7.1 Development of Remedial Action Alternatives

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

In order to provide a cost-effective remedy, alternatives are constructed as combinations of technologies that are suitable for different site-specific hydrogeologies and levels of contamination.

The five alternatives developed for the on-site contaminated vadose zone soil, source zone contaminated groundwater, and dilute plume are listed below:

- Alternative 1 – No further action
- Alternative 2 – SVE, i*n situ* treatment, long-term monitoring and institutional controls (IC)
- Alternative 3 – SVE, recirculating in-well air stripping, *in situ* treatment, long-term monitoring and IC
- Alternative 4 – SVE, air sparging, *in situ* treatment, long-term monitoring and IC
- Alternative 5 – SVE, ISTR, *In situ* treatment, and IC

7.2 Key Assumptions Affecting the Development of Remedial Action Alternatives

Key assumptions made during the development of remedial actions were:

1. Access can be obtained to the interior of the building occupied by Wantagh Cleaners and the associated parking lot for implementation of the designs beneath the building. These activities may impact the business operations at the facility. Access can also be obtained to Sand Hill Road south of the property, and the landscaped area south of Sand Hill Road for design implementation.
2. The geographic scope of the FS includes both the on-site property and the downgradient off-site distal plume. Therefore, at least one alternative would consist of large-scale active treatment to consider restoring the entire aquifer to unrestricted use.

3. Mitigation of potential vapor intrusion into off-site properties south of the Southern State Parkway is not required.

7.3 Description of Remedial Action Alternatives

7.3.1 Common Elements of the Remedial Alternatives

The common elements of the remedial alternatives (excluding NFA) are described in this subsection.

Pre-Design Investigation

Prior to the completion of the remedial design and the subsequent implementation, a pre-design investigation (PDI) would be performed to confirm and finalize the remediation target zones and to evaluate the site characteristics for the remedial design.

On-site Vadose Zone SVE

Soil vapor extraction wells would be installed to target the contaminated vadose zone. For cost-estimating purposes, it is assumed 10 SVE wells would be installed on site. Vapor monitoring wells also would be installed to monitor the progress of contaminant removal and the changes in soil vapor pressure. Piping for transferring the extracted soil vapor to the above ground treatment system would be routed underground, along walls, or overhead to minimize impact to routine building operations. For cost estimating purposes, it is assumed that the SVE system would operate for up to five years.

The above ground treatment system would be installed in a pre-fabricated building brought on Site to treat the extracted soil vapor prior to discharge to the atmosphere. This system likely would consist of a blower, compressors, piping, an air-water separator or knockout tank, and oxidation to destroy the collected vapors. An air permit would be obtained.

For cost-estimating purposes, it is assumed the SVE system would be operated continuously for the first three years and intermittently for the following two years. The air flow rate (vacuum) and concentrations of contaminants, oxygen, and carbon dioxide in the extracted vapor would be monitored regularly. Additional sampling and analysis would also be conducted in order to meet the air emission permit requirements. An evaluation of residual contamination would be conducted prior to shutdown of the system.

A pilot study would be performed as part of the PDI to collect the design parameters for the SVE system.

Vapor Mitigation for Adjacent Convenience Store

Each alternative would use SVE to control vapor intrusion into the Wantagh Cleaners Building. However, as a common element of each alternative, a sub-slab depressurization system (SSDS) would be installed under the adjacent convenience store to induce a negative pressure field directly under the building slab. The negative pressure field becomes a "sink" for any vapors present in the vicinity of the structure, thereby intercepting them before they have the opportunity to migrate inside the building.

Monitoring of Surface Water and Soil Vapor

Monitoring of VOCs in surface water at the Twin Lakes Preserve and soil vapor above the dilute plume would be conducted annually. It is assumed that two grab samples of surface water would be collected, and soil vapor would be measured through six permanent monitoring points distributed throughout the length of the plume. It is assumed that monitoring would be conducted annually for 20 years.

Institutional Controls

Institutional controls, such as groundwater use restrictions that restrict the installation and use of wells in the contaminated aquifer, would be implemented to minimize human exposure to contaminated groundwater. Community awareness measures, such as hand delivery of fact sheets related to the Site contamination, may also be performed.

7.3.2 Alternative 1 – No Further Action

The NFA alternative is considered in accordance with DER-10 requirements and provides a baseline for comparison with the other alternatives. Under this alternative, no further action would be undertaken, and the current status of the impacted areas would remain unchanged. Contaminated groundwater would continue to migrate in the subsurface to areas further downgradient. This alternative does not include any institutional controls or monitoring.

7.3.3 Alternative 2 – SVE, *in Situ* Treatment, Long-Term Monitoring and IC

This remedial alternative would consist of the following major components.

- Treatability study and pilot study
- Remedial design
- *In situ* treatment to address contamination in groundwater source zone
- *In situ* treatment reactive barrier to restrict further migration into the dilute plume
- Long-term monitoring in the dilute plume
- Performance Monitoring

Conceptual designs of the elements of this alternative (other than the common elements detailed above) are described below and shown on **Figure 7-1**.

Treatability Study and Pilot Study

A treatability study would be performed using soil and groundwater from the treatment areas to help determine the specific amendment and quantities of chemicals required for the injection. Amendments such as lactate, emulsified vegetable oil, chemical reduction agents such as zero valent iron or a combination thereof to promote biological, chemical and/or biogeochemical processes that result in transformation of contaminants would be considered under this alternative.

A pilot study would be performed at the site to develop site-specific input parameters for the design, including expected radius of influence for the distribution of amendments via injection and the need for additional amendments such as bioaugmentation or shear-thinning fluids. A pilot study would also be used to develop the radius of influence of SVE points. Results of the pilot test would help predict performance for the full-scale remediation.

***In Situ* Treatment**

For cost-estimating purposes, a preliminary conceptual approach is described below. The actual approach would be determined during the remedial design. It should also be noted that *in situ* EAB is selected to be the representative *in situ* treatment technology option in this alternative. However, a different *in situ* treatment may be considered depending on the information collected in the PDI.

For cost-estimating purposes, it is assumed that a soluble amendment would be injected using direct push technology in borings immediately upgradient of the building, on site around the former leach pit area, and across the street along Sand Hill Road. Advection would carry the soluble amendment under the building and downgradient to provide treatment in these areas.

Rows of DPT injections of a low solubility amendment (slow-release formulation) would be installed as a biobarrier perpendicular to the groundwater flow direction at the downgradient edge of the groundwater source zone (along the north side of the on-ramp to Highway 28S: Southern State Parkway) and along the cloverleaf opposite Wantagh Avenue to impede further migration from the source zone. These biobarriers would provide longer-lasting treatment of any continuing discharge from the source zone (**Figure 7-1**). All injection points would be spaced approximately 20 to 30 feet apart based on an assumed radius of influence of 10 to 15 feet. The amendments would be injected in the 10 to 20 feet bgs interval. It is assumed two rounds of treatment would be conducted two years apart.

Long-Term Monitoring

A total of six groundwater monitoring wells would be installed in the dilute plume to for monitoring purposes. Permanent soil vapor monitoring points would also be installed in the same locations. It is assumed that monitoring would be conducted annually for 20 years.

Performance Monitoring

Monitoring wells will be installed downgradient of the treatment zone to evaluate treatment effectiveness in the active groundwater treatment zone. MW-01S would be used for performance monitoring upgradient of the treatment zone. For cost-estimating purposes, a total of 6 monitoring wells would be installed for performance monitoring. Final locations of the monitoring wells would be determined during the remedial design. Three vapor monitoring points would be installed in the on-site contaminated vadose zone. In addition to monitoring during treatment, groundwater and soil samples would be collected prior to treatment and post treatment to evaluate the effectiveness of the active treatment. The results from this monitoring would be used to evaluate the need for additional active remediation, an eventual transition to passive remediation and, ultimately, site closure. It is assumed that annual sampling would be conducted for ten years.

Site Restoration

After the completion of the remedial action (RA) all equipment and materials would be removed from the Site. The Site would be restored to pre-RA conditions to the extent possible such as repairing the building slab and pavement. Select monitoring wells would be retained for future use as appropriate.

7.3.4 Alternative 3 – SVE, recirculating in-well air stripping, Long-Term Monitoring and IC

This remedial alternative would consist of the following major components.

- Treatability study and pilot study
- Remedial design
- 3-in-1 groundwater circulation/in-well vapor stripping/SVE to address contamination in the on-site vadose zone and groundwater source zone
- *In situ* treatment reactive barrier to restrict further migration into the dilute plume
- Long-term monitoring in the dilute plume
- Performance monitoring

Conceptual designs of the elements of this alternative (other than the common elements detailed above) are described below and shown on **Figure 7-2**.

Groundwater Circulation Well/In-Well Vapor Stripping/Soil Vapor Extraction

A 3-in-1 groundwater circulation well, in-well vapor stripper, and SVE (GCW/IVS/SVE) system would treat both the contaminated vadose zone and the groundwater source zone. One such well would be installed on site in the area of the former leach pit (**Figure 7-2**).

There would be two screens for the well. The first would be across the water table, and the second would be at a depth below the water table, approximately 30 feet bgs to capture the target remediation zone. Nitrogen gas would be generated above ground and injected through a sparge point installed down the middle of the well (nitrogen would be used to avoid iron fouling). As the gas bubbles up through the well, it strips contaminant vapor from the water in the well, and at the same time creates hydraulic lift. The lifted water spills out through the top screen to the top of the water table, and the gas containing the stripped contaminants is then captured in the vadose zone by placing a vacuum on this portion of the well. Due to the hydraulic lift created by the in-well sparge, water is actively brought into the well through the lower screen, thus creating recirculation of groundwater. It is assumed that this well would have a 30 foot radius of influence, equal to twice the distance between the upper and lower screens.

The SVE system will be installed as described in the Common Elements section. However, it will be installed with only 9 wells instead of 10 (**Figure 7-2**). In place of an SVE well in the former leach pit area, a groundwater circulation well with in-well air stripping will be installed instead.

For cost-estimating purposes, it is assumed that the system would run for five years. Needed equipment would include a compressor, nitrogen gas, piping, valves, manifolds, condensate separator, vacuum extraction blower, and a vapor treatment system.

Treatability Study and Pilot Study

A treatability study and pilot study would be performed as described in Alternative 2.

In Situ Treatment

In situ treatment would be conducted in a manner similar to that described in Alternative 2. However, under this alternative, the *in situ* injection points in the former leach pit area would not be installed as they would be replaced by the in well air stripper. Amendment would still be emplaced upgradient of the on-site building, along the south side of Sand Hill Road, along the north side of the on-ramp to Highway 28S: Southern State Parkway, and along the cloverleaf opposite Wantagh Avenue.

Performance Monitoring

Performance monitoring would be conducted as described under Alternative 2 above.

Long-Term Monitoring

Long-term monitoring in the dilute plume would be conducted as described in Alternative 2.

Site Restoration

Site restoration would be conducted as described in Alternative 2.

7.3.5 Alternative 4 – SVE, air sparging, *in situ* treatment, long-term monitoring and IC

This remedial alternative would consist of the following major components.

- Treatability study and pilot study
- Remedial design
- Air sparging to address contamination in the on-site groundwater source zone
- *In situ* treatment biobarrier to restrict further migration into the dilute plume
- Long-term monitoring in the dilute plume
- Performance monitoring

Conceptual designs of the elements of this alternative (other than the common elements detailed above) are described below and shown on **Figure 7-3**.

Treatability Study and Pilot Study

A treatability study and pilot study would be performed as described in Alternative 2.

Additionally, the radius of influence of air sparge points would be identified during the pilot study.

Air Sparging

Five sparge points would be installed next to the SVE wells on site except inside the building. An additional two sparge points would be installed around the leach pit area. Three more points would be installed around the downgradient corner of the building with angled drilling to access areas beneath the building (**Figure 7-3**) for a total of 10 sparge points. The collected vapor would be piped to the vapor treatment system on site. The ambient air blower/compressor would be in the same building as the SVE treatment system.

In Situ Treatment

In situ treatment would be conducted in a manner similar to that described in Alternative 2. However, under this alternative, only the biobarriers using a slow-release formulation along the north side of the on-ramp to Highway 28S: Southern State Parkway and on the cloverleaf opposite Wantagh Avenue would be emplaced since AS/SVE would be conducted on site.

Performance Monitoring

Performance monitoring would be conducted as described under Alternative 2 above.

Long-term monitoring

Long-term monitoring in the dilute plume would be conducted as described in Alternative 2.

Site Restoration

Site restoration would be conducted as described in Alternative 2.

7.3.6 Alternative 5 – SVE, ISTR, *in situ* treatment, and IC

This alternative would consist of the following major components:

- Treatability study and pilot study
- Remedial design
- *In situ* thermal remediation to address contamination in both the on-site vadose zone and groundwater source zone
- *In situ* treatment to address contamination in the groundwater source zone and in the dilute plume
- Performance monitoring

This alternative seeks to restore the impacted soil and groundwater to pre-disposal conditions (contaminant concentrations below SCGs) through active treatment. Conceptual designs of the elements of this alternative (other than the common elements detailed above) are described below and shown on **Figure 7-4**.

In Situ Thermal Remediation

ISTR would be applied to the former leach pit area on site. ISTR would be coupled with the SVE treatment system on site (**Figure 7-4**) to capture vapor generated by the thermal treatment. This approximately 5,400 square foot treatment zone is located in the southern portion of the Site alongside the southernmost corner of the on-site building. The zone is entirely outside of the building to ensure no health and safety risks to occupants of the building. The treatment depth is generally targeted to be between 5' and 20' bgs to address both vadose zone and saturated source zone contamination.

For cost estimating purposes, it is assumed ERH would be conducted. The radius of influence of each heating point is expected to be seven feet. Triangular electrode arrays supplied with three-phase power would be installed throughout the treatment zone to pass current between the electrodes. The soils are naturally resistant to the flow of electrical current, thus heating the surrounding soils and groundwater. This heating results in the volatilization of contaminants from the soil and groundwater. SVE would be combined with ERH to remove the contaminated vapors produced. Vapors would be piped to the SVE treatment system prior to discharge to the atmosphere. Achieving predisposal conditions is expected to take about 100 days of heating (total implementation duration of 8-12 months) based on ISTR applications at similar sites.

Temperature monitoring points would be installed to monitor the progress of heating in the soil.

Soil vapor extraction wells would be installed as described in the Common Elements section. However, these wells will be of stainless steel construction to minimize corrosion and maximize durability associated with ISTR implementation.

The heated vapors extracted from the SVE wells would first pass through a knockout tank where most of the moisture is cooled down to ambient temperature and separated. The vapors would then pass through a refrigerated heat exchanger system where the vapors are further cooled, thus, condensing the chemical constituents from the vapor. The vapors would then pass through carbon absorbers or an oxidation system that would remove any remaining fugitive VOCs prior to discharge into the atmosphere. The water recovered from the knockout tank would either be treated with carbon and discharged or disposed of at an appropriate off-site facility. The condensate recovered from the heat exchanger system would be disposed of at an appropriate off-site facility. The existing pavement at the Site would be retained since it serves to inhibit both heat and vapor loss from the subsurface.

Heating of the soils is anticipated to take approximately 100 days, during which the SVE system would be operated to remove volatilized contaminants. The air flow rate, vacuum, and concentrations of contaminants, oxygen, and carbon dioxide in the extracted air would be monitored regularly. Additional sampling and analysis would also be conducted in order to meet the air permit requirements. After heating, an approximately 100-day soil cool down period would be needed prior to removal of the system. The SVE system would be operated during the cool down period or longer as necessary.

After the completion of the project, confirmatory soil and groundwater VOC analysis would be conducted. After completion of the ISTR event, the remedy would transition to passive remediation if concentrations remain above SCGs.

Treatability Study and Pilot Study

A treatability study and pilot study would be performed as described in Alternative 2.

In Situ Treatment

In situ treatment would be applied as detailed in Alternative 2, with two major exceptions:

1. No injections would be conducted in the on-site zone near the former leach pits. ISTR would be applied instead (as described above).
2. Four additional slow-release formulation biobarriers would be installed in the dilute plume to provide treatment of groundwater as advection carries contamination through each biobarrier. Each biobarrier would be approximately 400 feet long to encompass the width of the dilute plume, and would have an approximately 20 foot thick treatment zone.

The residual heat from the ISTR system may be conducive to the growth of microbes and enhance the effectiveness of the biobarriers immediately downgradient of the ISTR treatment zone.

Performance Monitoring

The effectiveness of ISTR in the vadose zone soil would be evaluated by collecting soil samples using a DPT rig. The effectiveness of ISTR and *in situ* treatment would be evaluated by collecting groundwater samples from monitoring wells and soil borings. Groundwater samples from the treatment zone and nearby monitoring wells would be analyzed for VOCs. In addition to groundwater monitoring during treatment, groundwater and soil samples would be collected prior to treatment and post treatment to evaluate the effectiveness of the active treatment. The results from this monitoring would be used to evaluate the need for additional active treatment, transition to passive remediation and, ultimately, site closure.

It is assumed that 12 monitoring wells would be installed for performance monitoring, and six rounds of sampling would be conducted.

Site Restoration

Site restoration would be conducted as described in Alternative 2.

Section 8

Detailed Analysis of Remedial Action Alternatives

The remedial alternatives described in Section 7 are evaluated in this section against the criteria described below.

8.1 Evaluation Criteria

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

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

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

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

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

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

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

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

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

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

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

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

8.2 Detailed Analysis of Remedial Alternatives

This section provides detailed analysis of the remedial alternatives developed in Section 7. Table 7-1 presents a summary of the alternatives evaluation.

8.2.1 Detailed Analysis of Alternative 1

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

Overall Protection of Human Health and the Environment

The no further action alternative does not provide overall protection of human health and the environment and does not meet the RAOs. This alternative does not prevent future use of contaminated groundwater, and does not mitigate vapor intrusion impacts above the plume. Because no further remedial action would be implemented under this alternative, no means would be available to identify and prevent current and future exposure. This alternative relies on natural attenuation processes to restore groundwater quality; however, the effects of natural attenuation would not be monitored to evaluate their impact on the plume.

Compliance with SCGs

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

Long-term Effectiveness and Permanence

NFA is not considered to be a permanent remedy. The contaminants would not be destroyed, except by gradual reductions through natural dispersion and dilution. Decrease in contaminants levels via dispersion would be expected at some portions of the Site. This alternative, however, would not provide adequate control of risks to human health or the environment because there are no mechanisms to prevent current and future exposure. Under this alternative there would be no mechanism in place to prevent future risk to human health; therefore, this alternative would not be considered effective in the long term.

Reduction of Toxicity, Mobility or Volume through Treatment

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

Short-term Effectiveness

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

Implementability

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

Cost

There would be no cost under this alternative.

8.2.2 Detailed Analysis of Alternative 2

Overall Protection of Human Health and the Environment

This alternative would achieve the RAOs. Active remediation of groundwater in the source zone, institutional controls, and monitoring of soil vapor, surface water, and the monitoring of dilute contamination in the plume would ensure that human health and the environment are protected. Additionally, SVE and vapor mitigation for the on-site and nearby building would ensure that occupants are protected from vapor contamination.

Compliance with SCGs

This alternative will be able to meet SCGs pursuant to DER-10 / Technical Guidance for Site Investigation and Remediation.

Long-Term Effectiveness and Permanence

The technologies under this alternative have been proven to be effective and result in a permanent remedy at several sites due to either removal of contamination from the subsurface or destruction *in situ*. Permanent attenuation will occur in the dilute plume over time. Effectiveness of these technologies are heavily dependent on site conditions. However, when designed and implemented properly, they are expected to be highly effective and permanent over the long-term.

Reduction of T/M/V through Treatment

SVE and *in situ* treatment would reduce T/M/V through treatment. The contaminants would be removed from the extracted vapor stream with either oxidation or another appropriate technology. *In situ* treatment would destroy the contaminants in the subsurface.

Short-Term Effectiveness

The short-term impacts due to Alternative 2 are not expected to be significant. Impacts to site safety due to activities under this alternative are minimal. However activities such as installation of wells, injection of amendments, and operation of the SVE system can potentially result in inconveniences to the local community through noise, temporary disruption to traffic etc. There are also health and safety risks for workers when drilling and driving to and from the site. These impacts can be minimized if proper procedures and protocols are followed during the implementation of this alternative.

Implementability

To implement this alternative, it is assumed that access agreements could be obtained by NYSDEC to perform the pre-design investigation and the remediation as necessary. To implement this alternative, space would be required for the remedial action inside and around the site building for drill rigs, piping, and equipment. Traffic may need to be temporarily controlled or re-routed on the nearby streets. Given that drilling and injection would be conducted in one location at a time, it is unlikely that operations of the dry cleaner would need to be substantially disrupted for an extended duration.

Cost

The estimated capital cost for Alternative 2 is $2,215,000. The estimated present worth of annual O&M and monitoring is $938,000. The total present worth is estimated to be $3,153,000.

8.2.3 Detailed Analysis of Alternative 3

Overall Protection of Human Health and the Environment

This alternative would achieve the RAOs. Active remediation of groundwater in the source zone, institutional controls, and monitoring of soil vapor, surface water, and monitoring of dilute contamination in the plume would ensure that human health and the environment are protected. Additionally, SVE and vapor mitigation for the on-site and nearby building would ensure that occupants are protected from vapor contamination.

Compliance with SCGs

This alternative will be able to meet SCGs pursuant to DER-10 / Technical Guidance for Site Investigation and Remediation.

Long-Term Effectiveness and Permanence

The technologies under this alternative have been proven to be effective and result in a permanent remedy at several sites due to either removal of contamination from the subsurface or destruction *in situ*. Permanent attenuation will occur in the dilute plume over time. Effectiveness of these technologies are heavily dependent on site conditions. However, when designed and implemented properly, they are expected to be highly effective and permanent over the long-term.

Reduction of T/M/V through Treatment

SVE and recirculating in well air strippers would reduce T/M/V through treatment. The contaminants would be removed from the extracted vapor stream with either oxidation or another appropriate technology.

Short-Term Effectiveness

The short-term impacts due to Alternative 3 are not expected to be significant. Impacts to site safety due to activities under this alternative are minimal. However activities such as installation of wells and operation of the systems can potentially result in inconveniences to the local community through noise, temporary disruption to traffic etc. These impacts can be minimized if proper procedures and protocols are followed during the implementation of this alternative.

Implementability

To implement this alternative, it is assumed that access agreements could be obtained by NYSDEC to perform the pre-design investigation and the remediation as necessary. Space would be required for the remedial action inside and around the site building for drill rigs, piping, and equipment. Traffic may need to be temporarily controlled on the nearby streets. Operations of the dry cleaner will be slightly—though not completely—curtailed during installation of the system. However, the business will likely not be impacted during operations. With the conceptual design detailed in this alternative, air lines and extracted vapor lines would need to be run from the treatment system on site across Sand Hill Road to the downgradient recirculating in well air stripper. Depending on the depths of utilities on Sand Hill Road and local regulations, it may be difficult to implement this conceptual design.

Cost

The estimated capital for Alternative 3 is $2,095,000. The estimated present worth of annual O&M and monitoring is $1,113,000. The total present worth is estimated to be $3,208,000.

8.2.4 Detailed Analysis of Alternative 4

Overall Protection of Human Health and the Environment

This alternative would achieve the RAOs. Active remediation of groundwater in the source zone, institutional controls, and monitoring of soil vapor, surface water, and monitoring of dilute contamination in the plume would ensure that human health and the environment are protected. Additionally, SVE and vapor mitigation for the on-site and nearby building would ensure that occupants are protected from vapor contamination.

Compliance with SCGs

This alternative will be able to meet SCGs pursuant to DER-10 / Technical Guidance for Site Investigation and Remediation.

Long-Term Effectiveness and Permanence

The technologies under this alternative have been proven to be effective and result in a permanent remedy at several sites with similar geology and contamination due to either removal of contamination from the subsurface or destruction *in situ*. Permanent attenuation will occur in the dilute plume over time. Effectiveness of these technologies can sometimes depend on site conditions. However, when designed and implemented properly, they are expected to be highly effective and permanent over the long-term.

Reduction of T/M/V through Treatment

Air sparge, SVE, and *in situ* treatment would reduce T/M/V through treatment. The contaminants would be removed from the extracted vapor stream with either oxidation or another appropriate technology. *In situ* treatment would destroy contamination in place.

Short-Term Effectiveness

The short-term impacts due to Alternative 4 are not expected to be significant. Impacts to site safety due to activities under this alternative are minimal. However activities such as installation of sparge points and operation of the systems can potentially result in inconveniences to the local community through noise, temporary disruption to traffic etc. These impacts can be minimized if proper procedures and protocols are followed during implementation.

I**mplementability**

To implement this alternative, it is assumed that access agreements could be obtained by NYSDEC to perform the pre-design investigation and the remediation as necessary. Space would be required for the remedial action inside and around the site building for drill rigs, piping, and equipment. Traffic may need to be temporarily controlled on the nearby streets. Operations of the dry cleaner will be curtailed during installation of the system. However, the Cleaner's business will likely not be impacted during operations since the sparge points, SVE, and piping would be buried under the parking lot.

Cost

The estimated capital for Alternative 4 is $1,995,000. The estimated present worth of annual O&M and monitoring is $924,000. The total present worth is estimated to be $2,919,000.

8.2.4 Detailed Analysis of Alternative 5

Overall Protection of Human Health and the Environment

This alternative would achieve the RAOs. Active remediation of groundwater in both the source zone and dilute plume, monitoring of soil vapor and surface water, and institutional controls would ensure that human health and the environment are protected. Additionally, SVE and vapor mitigation for the on-site and nearby building would ensure that occupants are protected from vapor contamination.

Compliance with SCGs

This alternative will be able to meet SCGs pursuant to DER-10 / Technical Guidance for Site Investigation and Remediation.

Long-Term Effectiveness and Permanence

The technologies under this alternative have been proven to be effective and result in a permanent remedy at several sites with similar geology and contamination due to either removal of contamination from the subsurface or destruction *in situ*. Effectiveness of these technologies can are heavily dependent on site conditions. However, when designed and implemented properly, they are expected to be highly effective and permanent over the long-term.

Reduction of T/M/V through Treatment

ISTR, SVE, and *in situ* treatment would reduce T/M/V through treatment. The contaminants would be removed from the extracted vapor stream with either oxidation or another appropriate technology. *In situ* treatment would destroy contamination in place.

Short-Term Effectiveness

The short-term impacts due to Alternative 5 will be significant since ISTR will involve monopolizing space on-site for over six months. Site safety due to activities under this alternative will need to be properly controlled due to the heating of the subsurface and the aboveground equipment required for ISTR. For the *in situ* treatments, injection of amendments can potentially result in inconveniences to the local community through noise, temporary disruption to traffic etc. These impacts can be minimized if proper procedures and protocols are followed during the implementation.

Implementability

To implement this alternative, it is assumed that access agreements could be obtained by NYSDEC to perform the pre-design investigation and the remediation as necessary. Space would be required for the remedial action inside and around the site building for drill rigs, piping, and equipment. Traffic may need to be temporarily controlled on the nearby streets. Operations of the dry cleaner will be curtailed during installation and operation of the ISTR system for up to six months. Off-site, the installation of the treatment barriers is expected to be implementable since they can be installed on city streets, sidewalks, or grass strips.

Cost

The estimated capital for Alternative 5 is $8,601,000. The estimated present worth of annual O&M and monitoring is $889,000. The total present worth is estimated to be $9,490,000.

8.3 Comparative Analysis of Alternatives

Overall Protection of Human Health and the Environment

Under the protectiveness criterion, Alternative 1 is not rated as it does not meet the criteria. The remaining alternatives all entail monitoring of soil vapor and surface water quality in order to identify any impacts to human health and environment as they may arise. Alternative 5 is expected to be the most protective since the source zone treatment (ISTR) is the most thorough amongst the technologies considered in the alternatives, and the downgradient biobarrier would minimize any potential discharges to surface water. Alternatives 2, 3 and 4 are less aggressive in comparison especially with no active remediation in the dilute plume and thus may be less protective if rates of attenuation are slow.

Compliance with SCGs

Alternative 1 does not meet the criteria. However, all other alternatives are expected to eventually meet SCGs. Alternative 5 will be the fastest in complying with SCGs due to the aggressive thermal treatment and active treatment in the dilute plume. The remaining alternatives may achieve compliance in a similar amount of time.

Long-term Effectiveness and Permanence

Alternative 1 does not meet the criteria. With regards to long-term effectiveness and permanence, all other alternatives are expected to meet this criteria.

Reduction of Toxicity, Mobility or Volume through Treatment

Alternative 1 does not reduce the T/M/V through treatment. Alternative 5 will have the most reduction of T/M/V, especially since it would involve active treatment in the dilute plume. Alternative 2, 3, and 4 would be less effective in comparison because there is no active remediation in the dilute plume, and might be expected to rank from most to least effective as Alt 4 > Alt 2 > Alt 3, depending on response to treatment.

Short-term Effectiveness

Alternative 1 will have the least short-term impact under the NFA alternative, however the risks due to the site contaminants would remain. All other alternatives will have an SVE system and a treatment shed, which will be disruptive during installation and require space on site. Among the other alternatives, Alternative 5 will have the most impact on the site building and the on-site business due to the ISTR component, which would be the most disruptive and have the highest health risk to on-site workers. Alternative 3 and 4 would require slightly more space on site during operation compared to Alternative 2 due to the expanded vapor treatment requirements.

Implementability

Alternative 1 is the most easily implementable but it would not meet the threshold and primary balancing criteria. All other alternatives will have an SVE system for which building access will be required for installation. On-site business will inevitably be disrupted. Alternative 5 will be the least implementable as it will require shutting down most of the on-site business and parking lot for ISTR installation, and possibly protective measures for workers on-site. However, some of these challenges can be overcome with proper design prior to implementation and careful coordination with the property owners/renters during implementation. Alternatives 2 is expected to have the least complications with implementability since it will not require continued operations and maintenance of a system (e.g. in-well air stripper for Alt 3, and air sparge system for Alt 4). Additionally, Alternative 2 will not require the disruption to the site business from the heavy equipment used to bury air/vapor lines, as would be the case for Alt 3 and 4.

Cost

Alternative 1 is not associated with any cost since it does not involve any remedial action or monitoring. Other than the NFA alternative, Alternative 4 is the least costly followed by Alternatives 2, 3, and 5 in that order.

Section 9

Recommended Remedy

Upon NYSDEC review of the Draft FS Report, a recommended remedy will be provided in the Final FS. In addition, a sustainable remediation evaluation will be conducted on the recommended remedy to identify best management practices that can be implemented to reduce environmental, economic, and social impacts from remedy implementation.

Section 10

References

Adamson, D.T., McGuire, T.M., Newell, C.J., Stroo, H., 2011. "Sustained Treatment: Implications for Treatment Timescales Associated With Source-Depletion Technologies." *Remediation*, Spring 2011.

CDM Smith. 2015. Remedial Investigation Report Addendum, Wantagh Cleaners Site. April.

______. 2011. Final Work Plan Amendment – Remedial Investigation, Wantagh Cleaners Site. May.

______. 2009. Final Site Characterization Report, Soil Vapor Intrusion Evaluation, Wantagh Cleaners Site. June.

Fenley & Nicol Environmental, Inc. (Fenley & Nicol). 1998. Supplement to Focused Remedial Investigation Revised Report. November.

_______. 1998. Soil and Groundwater Remediation by Air Sparging and Soil Vapor Extraction, Interim Remedial Measure, Project Manual. December.

_______. 1998. Soil and Groundwater Remediation by Air Sparging and Soil Vapor Extraction, Interim Remedial Measure, Design Report. December.

Interstate Technology Regulatory Council (ITRC). 2011. Integrated DNAPL Site Strategy. November.

New York State Department of Environmental Conservation (NYSDEC). 2010. Final DER-10 Technical Guidance for Site Investigation on Remediation. May.

_______. 1999. Proposed Remedial Action Plan, Wantagh Cleaners Site, Village of Wantagh, Town of Hempstead, Nassau County, New York, Site Number 1-30-064. February.

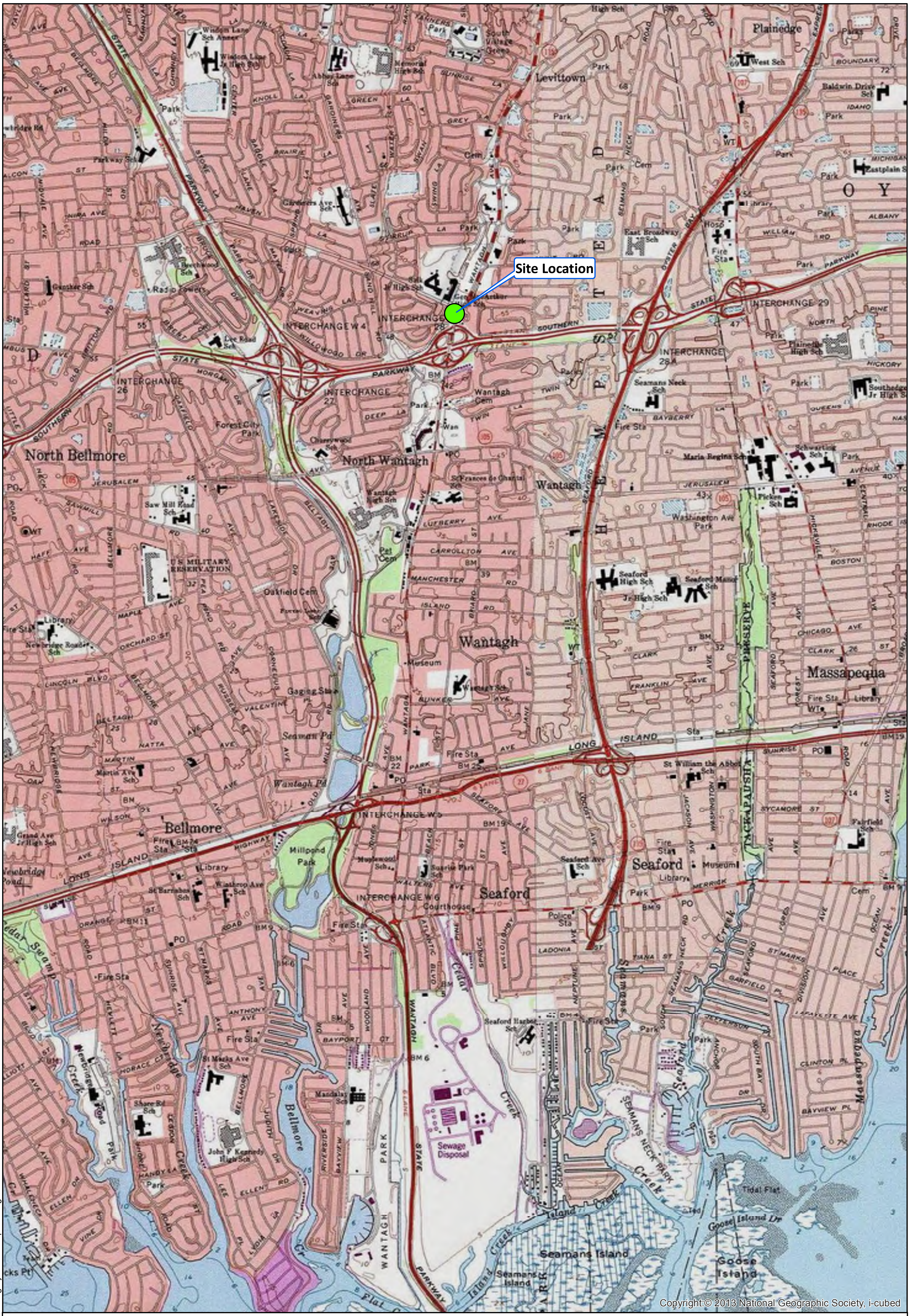
_______. 1999. Record of Decision, Wantagh Cleaners Site, Village of Wantagh, Town of Hempstead, Nassau County, New York, Site Number 1-30-064. May.

New York State Department of Health (NYSDOH). 2006. Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York. October.

United States Census Bureau. State and County QuickFacts. http://quickfacts.census.gov/qfd/states/36/36059.html. Last Revised: May 29, 2015. Accessed August 18, 2015.

United States Department of Energy (USDOE). 2002. In-Well Vapor Stripping Technology: Innovative Technology Summary Report. https://clu-in.org/download/techfocus/gwcirc/US-DOE-EM-0626-In-Well-Vapor-Stripping-Technology.pdf

Figures



N
W E
S

Feet
0 1,000 2,000 4,000

Figure 2-1
Site Location

Wantagh Cleaners Site
920 Wantagh Avenue
Hempstead, New York

CDM Smith

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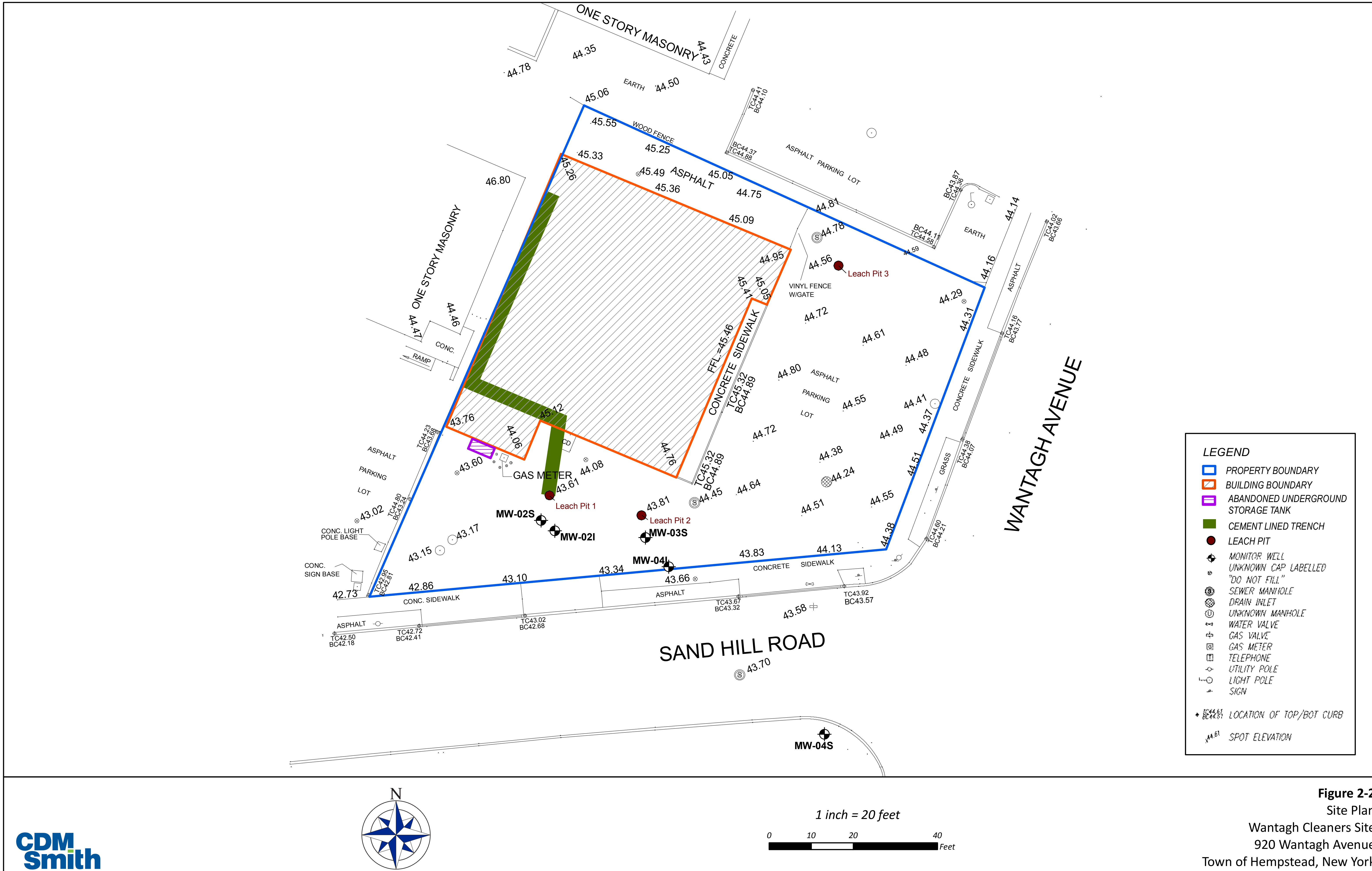

Figure 2-2
Site Plan
Wantagh Cleaners Site
920 Wantagh Avenue
Town of Hempstead, New York

CDM Smith

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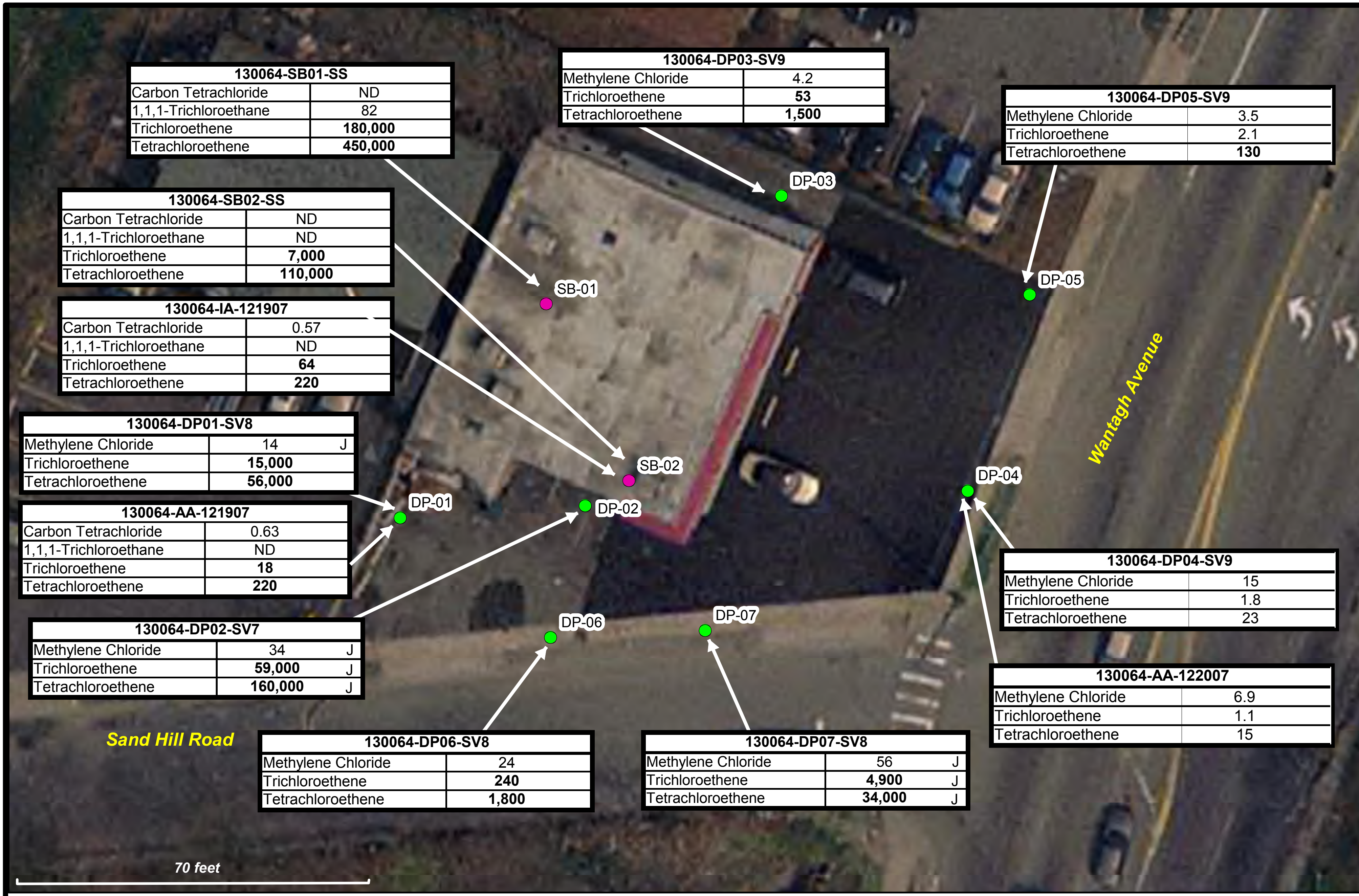


130064-SB01-SS	
Carbon Tetrachloride	ND
1,1,1-Trichloroethane	82
Trichloroethene	**180,000**
Tetrachloroethene	**450,000**

130064-SB02-SS	
Carbon Tetrachloride	ND
1,1,1-Trichloroethane	ND
Trichloroethene	**7,000**
Tetrachloroethene	**110,000**

130064-IA-121907	
Carbon Tetrachloride	0.57
1,1,1-Trichloroethane	ND
Trichloroethene	**64**
Tetrachloroethene	**220**

130064-DP01-SV8		
Methylene Chloride	14	J
Trichloroethene	**15,000**	
Tetrachloroethene	**56,000**	

130064-AA-121907	
Carbon Tetrachloride	0.63
1,1,1-Trichloroethane	ND
Trichloroethene	**18**
Tetrachloroethene	**220**

130064-DP02-SV7		
Methylene Chloride	34	J
Trichloroethene	**59,000**	J
Tetrachloroethene	**160,000**	J

130064-DP03-SV9	
Methylene Chloride	4.2
Trichloroethene	**53**
Tetrachloroethene	**1,500**

130064-DP05-SV9	
Methylene Chloride	3.5
Trichloroethene	2.1
Tetrachloroethene	**130**

130064-DP04-SV9	
Methylene Chloride	15
Trichloroethene	1.8
Tetrachloroethene	23

130064-AA-122007	
Methylene Chloride	6.9
Trichloroethene	1.1
Tetrachloroethene	15

130064-DP06-SV8	
Methylene Chloride	24
Trichloroethene	**240**
Tetrachloroethene	**1,800**

130064-DP07-SV8		
Methylene Chloride	56	J
Trichloroethene	**4,900**	J
Tetrachloroethene	**34,000**	J

Legend

All units in µg/m3

- Direct Push (DP) Groundwater and Soil Vapor Location
- Sub-slab (SB) Vapor Sample

Note: CDM rounded values to two significant digits.

NYSDOH Air Guidelines (ug/m^3)	
Tetrachloroethene	100
Trichloroethene	5
Methylene Chloride	60

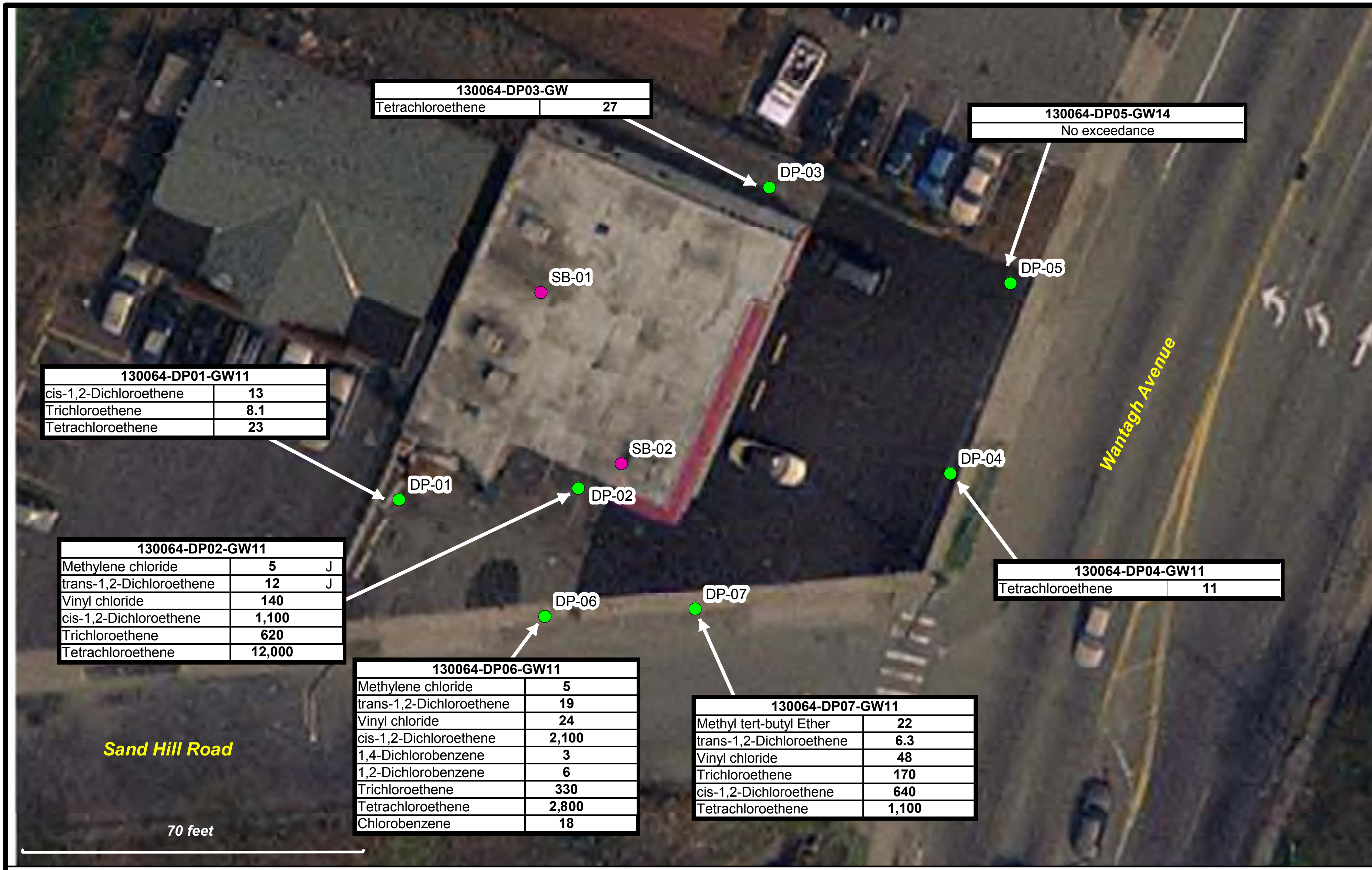
Values in bold indicate samples that exceeded NYSDOH Air Guidelines.

J: Concentration given as approximate

ND: Not detected

CDM Smith

Figure 2-3
2007 Soil Vapor and Sub-Slab Vapor Detections
Wantagh Cleaners Site
920 Wantagh Avenue
Town of Hempstead, New York



Legend
All units in µg/L
Direct Push (DP) Groundwater and Soil Vapor Location
Sub-slab (SB) Vapor Sample
J: Concentration given as approximate

Site-Specific Groundwater Delineation Criteria (SSGWDC)	
Methylene chloride	5
trans-1,2-Dichloroethene	5
Vinyl chloride	2
cis-1,2-Dichloroethene	5
Trichloroethene	5
Tetrachloroethene	5
Methyl tert-butyl Ether	10
1,4-Dichlorobenzene	3
1,2-Dichlorobenzene	3
Chlorobenzene	5

N

Figure 2-4
2007 Groundwater Grab Exceedances
Wantagh Cleaners Site
920 Wantagh Avenue
Town of Hempstead, New York

Figure 3-1
Cross Section Location Map
Wantagh Cleaners Site
Hempstead, New York

CDM Smith

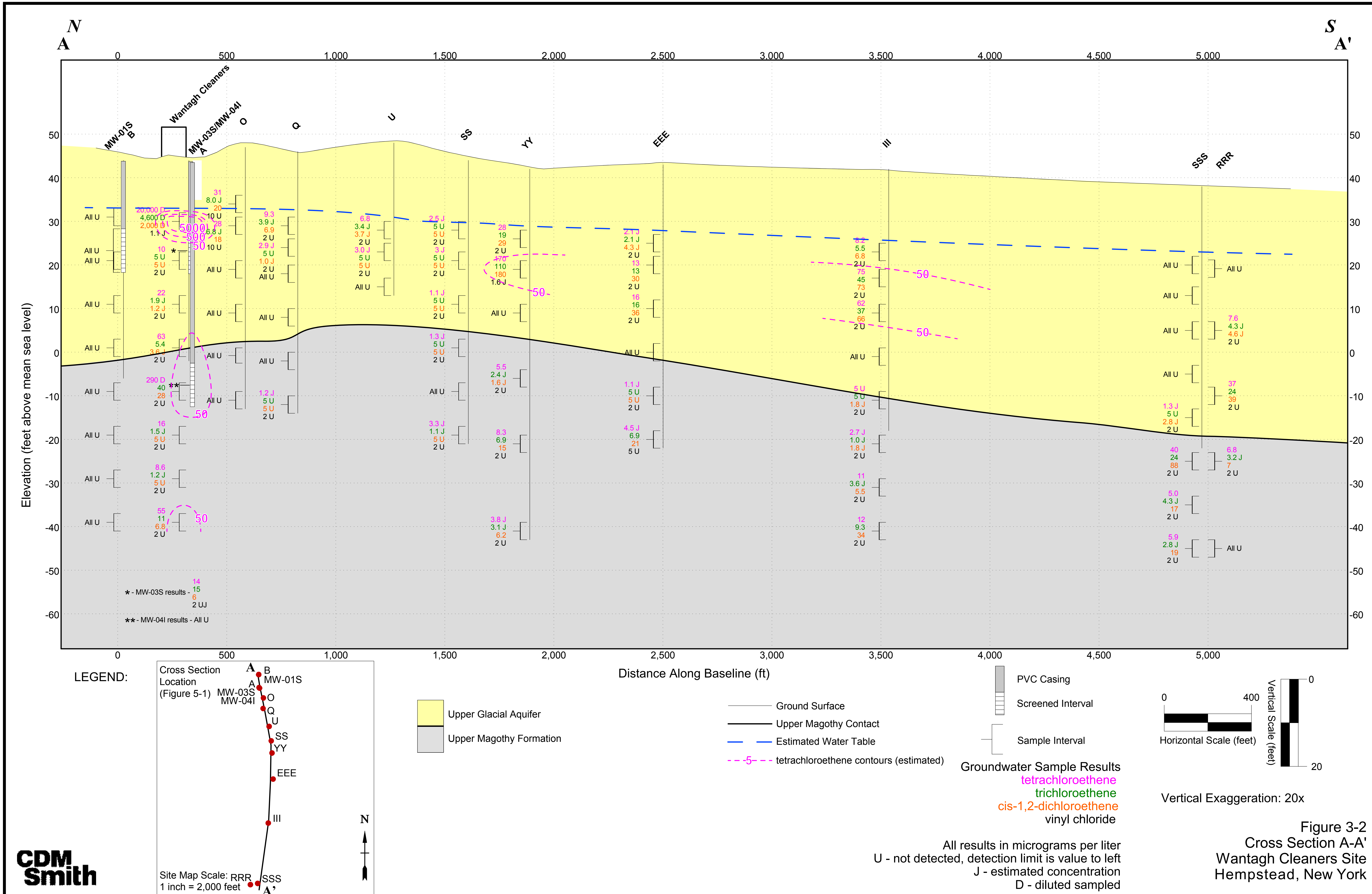


Figure 3-2
Cross Section A-A'
Wantagh Cleaners Site
Hempstead, New York

STANDARD CROSS SECTION: WANTAGH WANTAGH_2014.GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 12/4/14 REV.

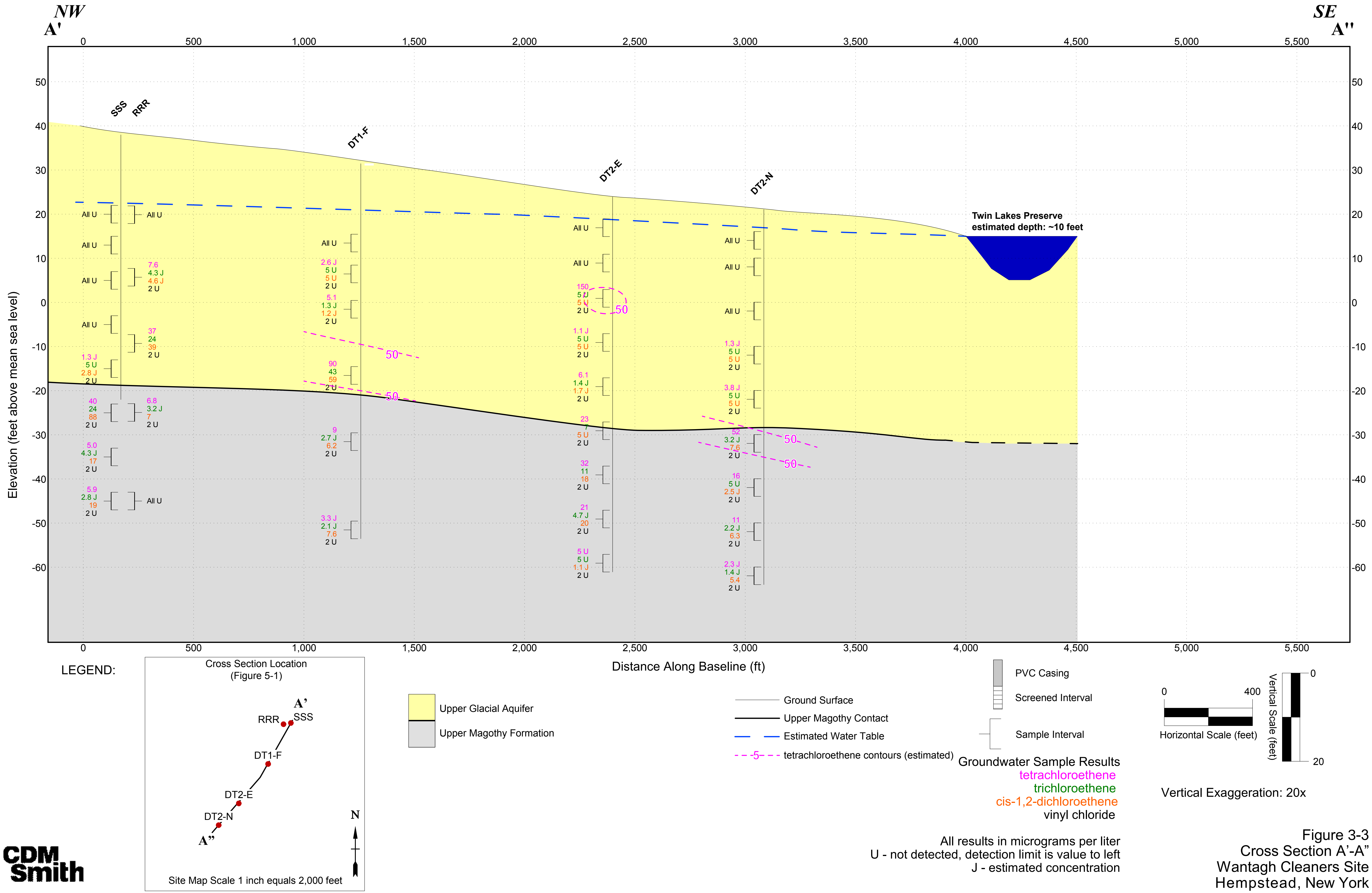


Figure 3-3
Cross Section A'-A"
Wantagh Cleaners Site
Hempstead, New York

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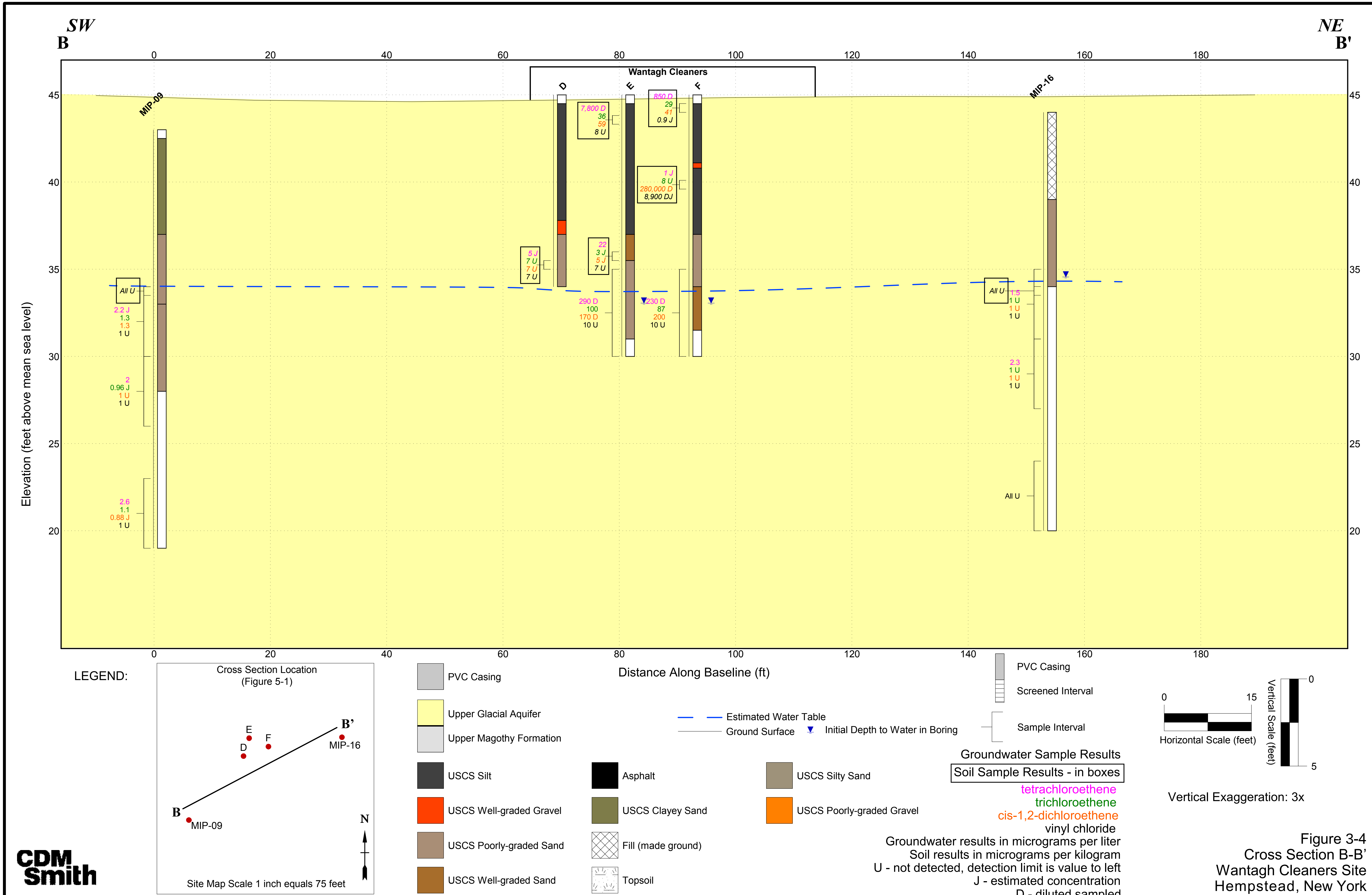

Figure 3-4
Cross Section B-B'
Wantagh Cleaners Site
Hempstead, New York

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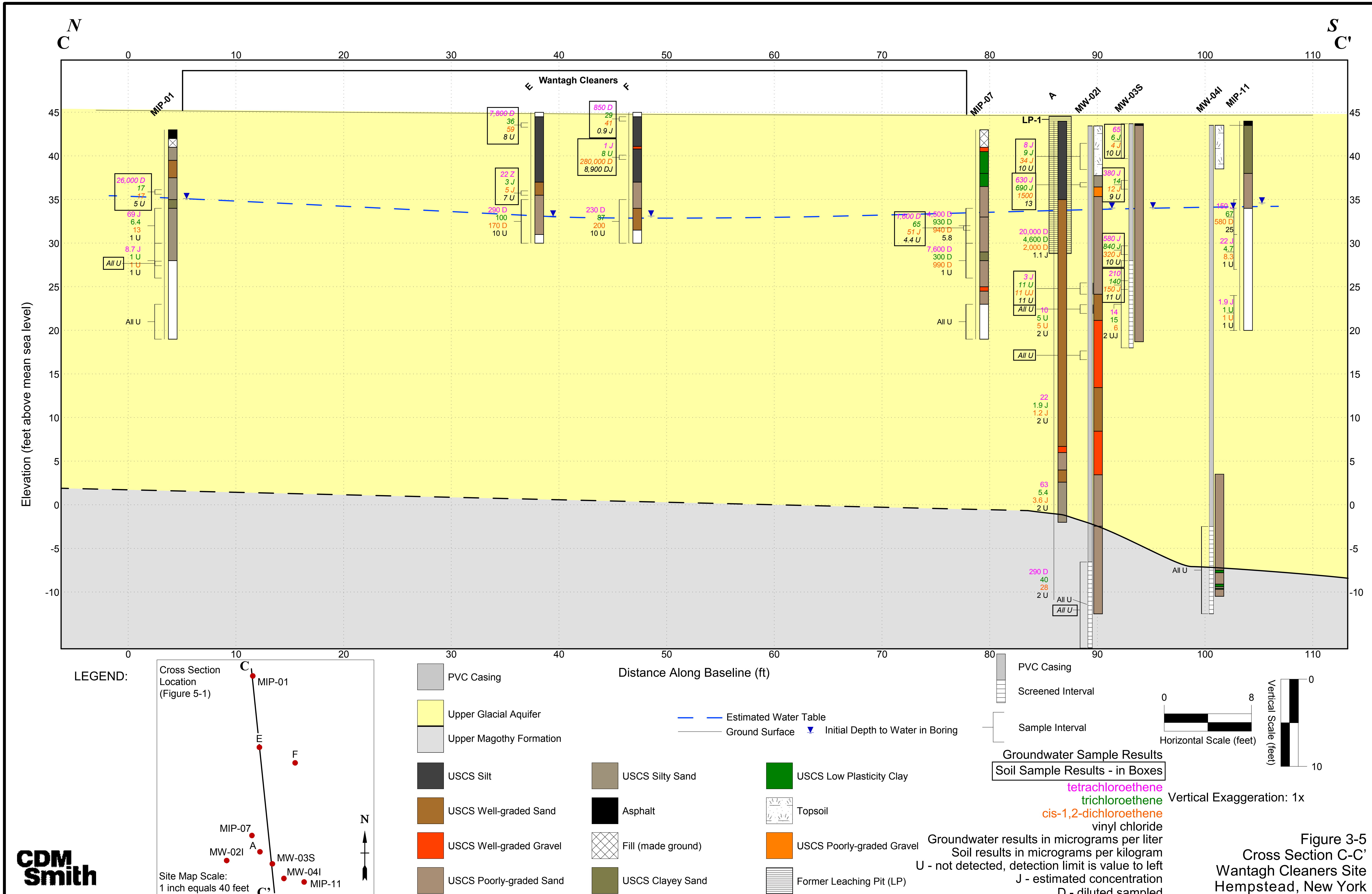


Figure 3-5
Cross Section C-C'
Wantagh Cleaners Site
Hempstead, New York

STANDARD CROSS SECTION: WANTAGH WANTAGH_2014.GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 12/5/14 REV.

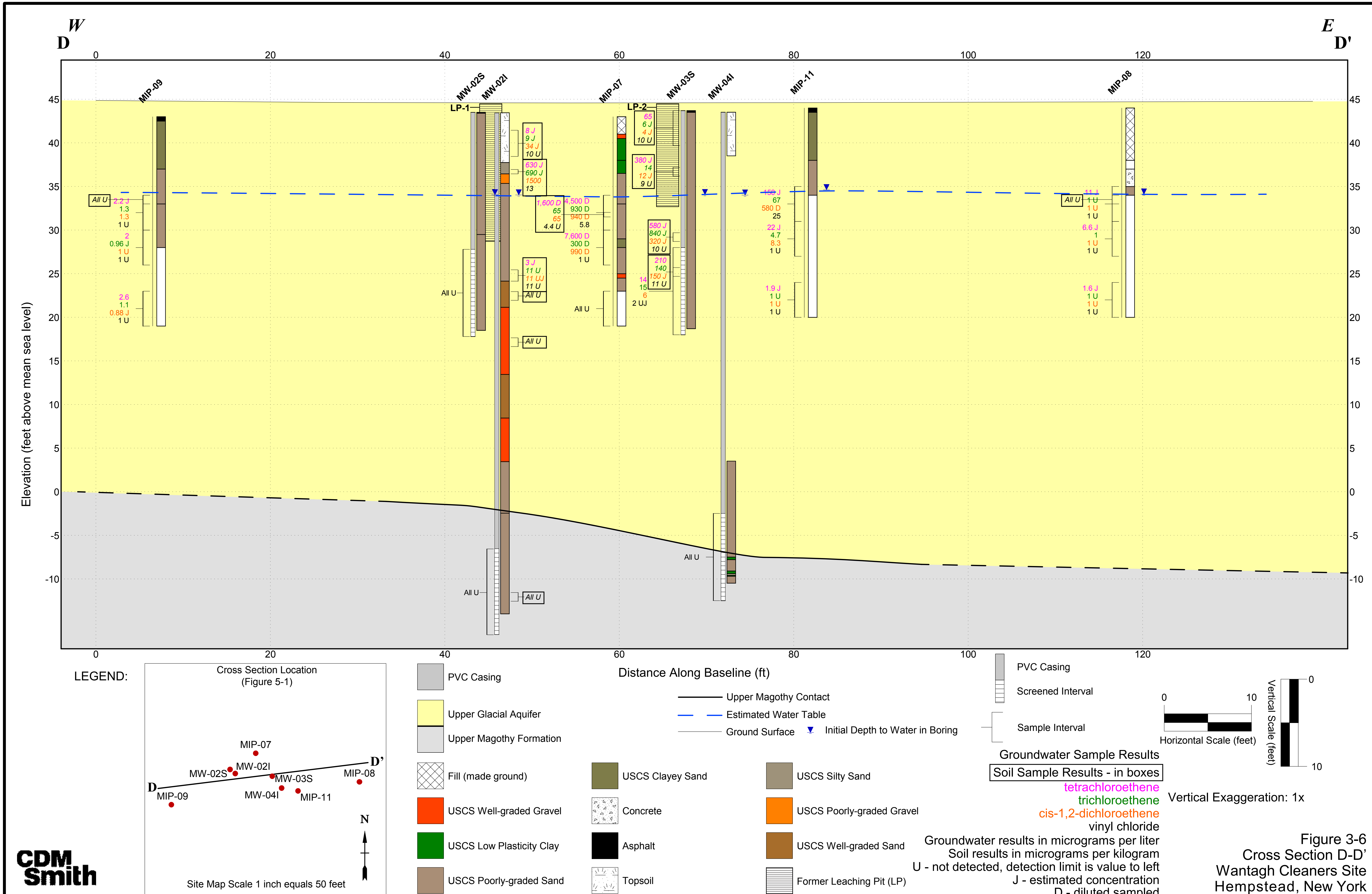


Figure 3-6
Cross Section D-D'
Wantagh Cleaners Site
Hempstead, New York

STANDARD CROSS SECTION: WANTAGH WANTAGH_2014.GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 12/5/14 REV.

Shallow Well

Intermediate Well

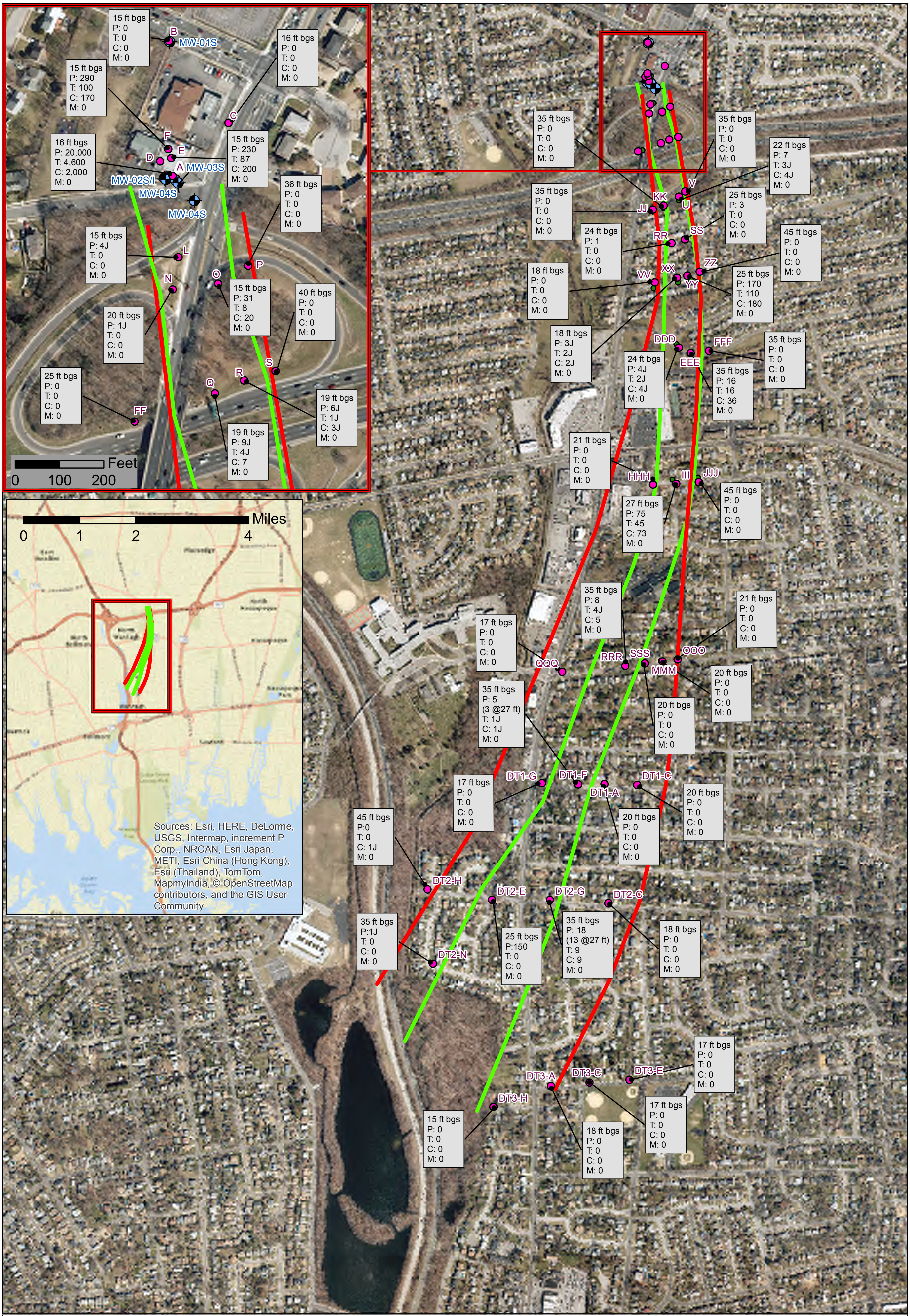
Shallow Groundwater Elevation Contours (feet amsl)

Notes:

1. Groundwater elevation measurements (in feet amsl) presented were collected on September 12, 2014.
2. Intermediate zone groundwater elevation measurementas are presented but were not utilized to generate the shallow groundwater elevation contours.

Figure 3-7
Shallow Groundwater Elevation Contour Map
Wantagh Cleaners Site
Hempstead, New York

CDM Smith



Soil Boring/Groundwater Location (RI Phase II)

Monitoring Well

Estimated Plume Shallow

Estimated Plume Deep

Screening Results (units in µg/l)

16	PCE
16	TCE
36	CIS-1,2-DCE
0	MTBE

N S E W

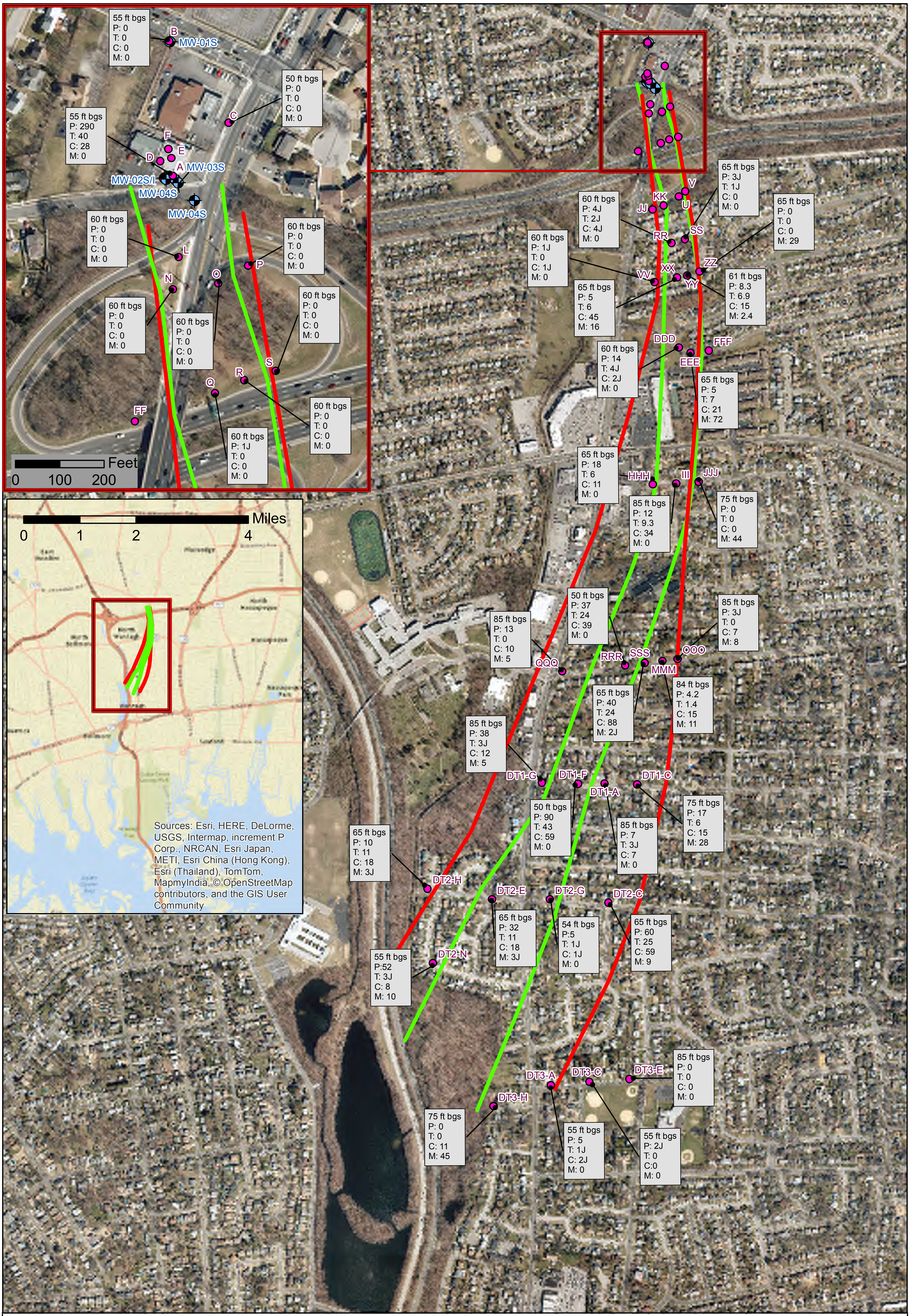
Feet

0 350 700 1,400

Notes:
VOC concentrations represent the highest detection for that compound.
A result of 0 µg/L = non-detect at reporting limit

Figure 3-8a
Shallow Groundwater Screening Results
Wantagh Cleaners Site
Hempstead, New York

CDM Smith



- Soil Boring/Groundwater Location (RI Phase II)
- Monitoring Well
- Estimated Plume Shallow
- Estimated Plume Deep

Screening Results (units in ug/l)

16	PCE
16	TCE
36	CIS-1,2-DCE
0	MTBE

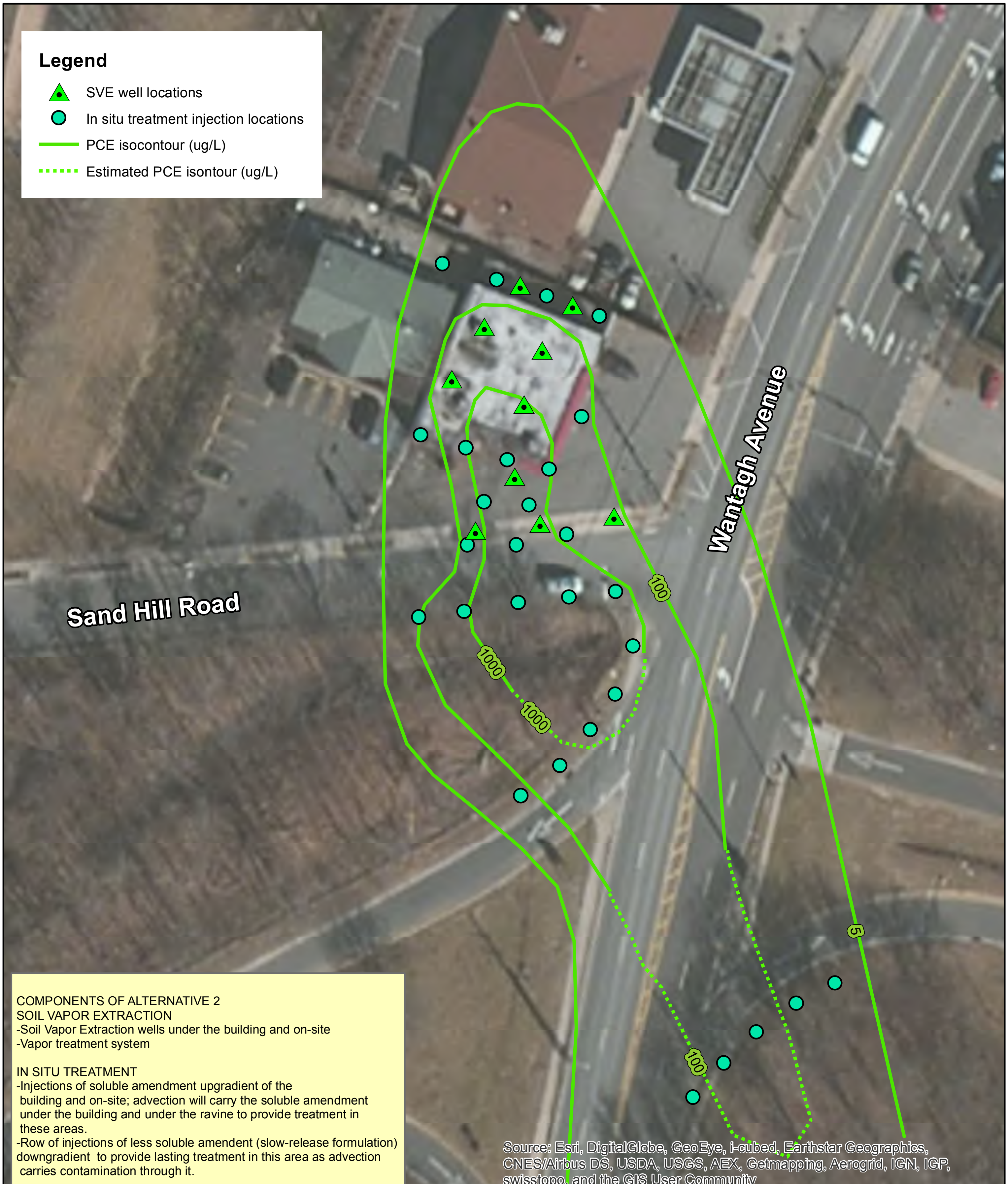
N W E S

Feet
0 350 700 1,400

Figure 3-8b
Deep Groundwater Screening Results
Wantagh Cleaners Site
Hempstead, New York

Notes:
VOC concentrations represent the highest detection for that compound.
A result of 0 µg/L = non-detect at reporting limit

CDM Smith



0 25 50 100 Feet

Figure 7-1
Alternative 2
Wantagh Cleaners Site
920 Wantagh Avenue
Hempstead, New York

CDM Smith

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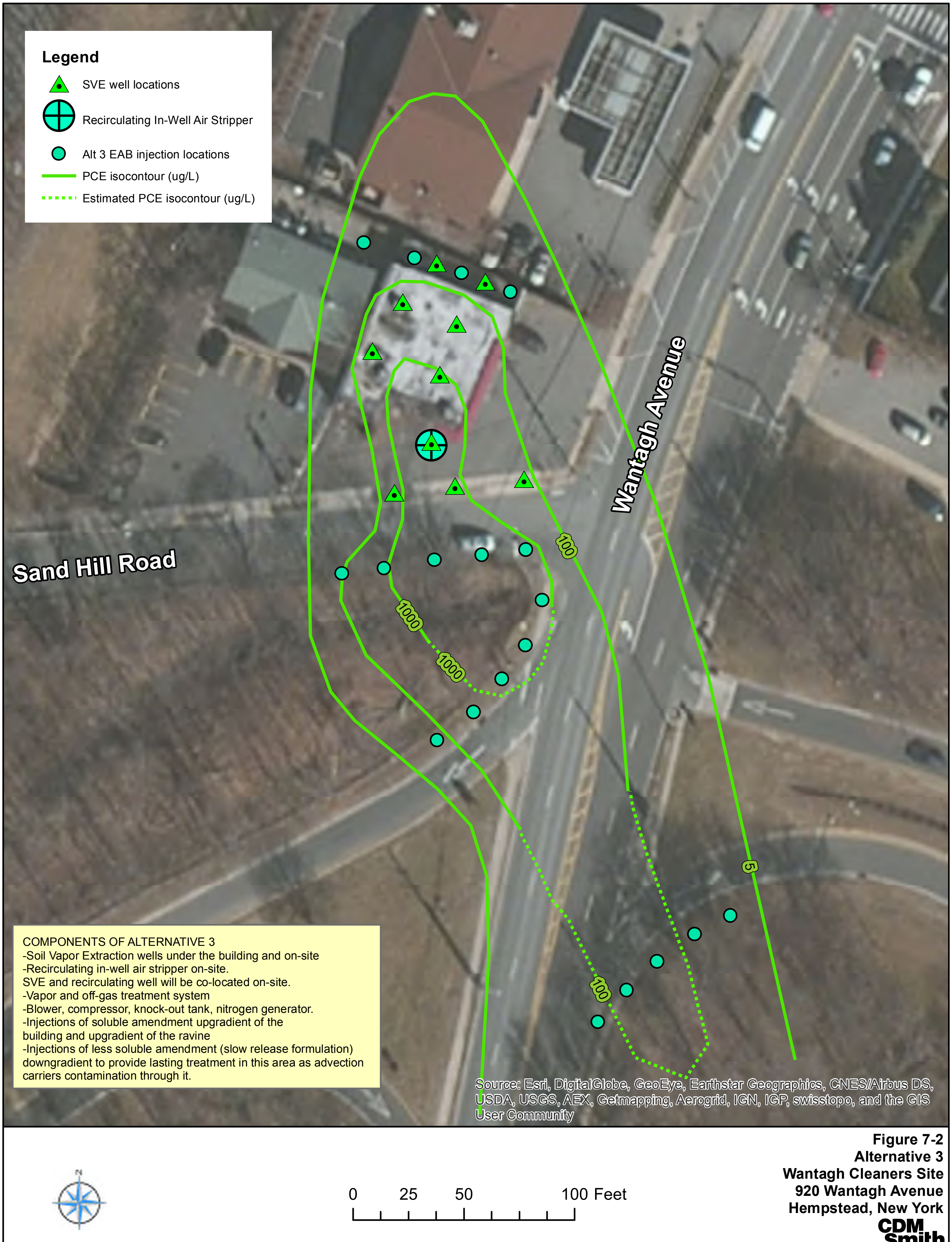

Figure 7-2
Alternative 3
Wantagh Cleaners Site
920 Wantagh Avenue
Hempstead, New York

CDM Smith

\\nysvr1\IMS\GIS\100023_Wantagh\DATA\MXD\FS\Figurew 7-2 Alternative 3.mxd 11/11/2015 liuy2

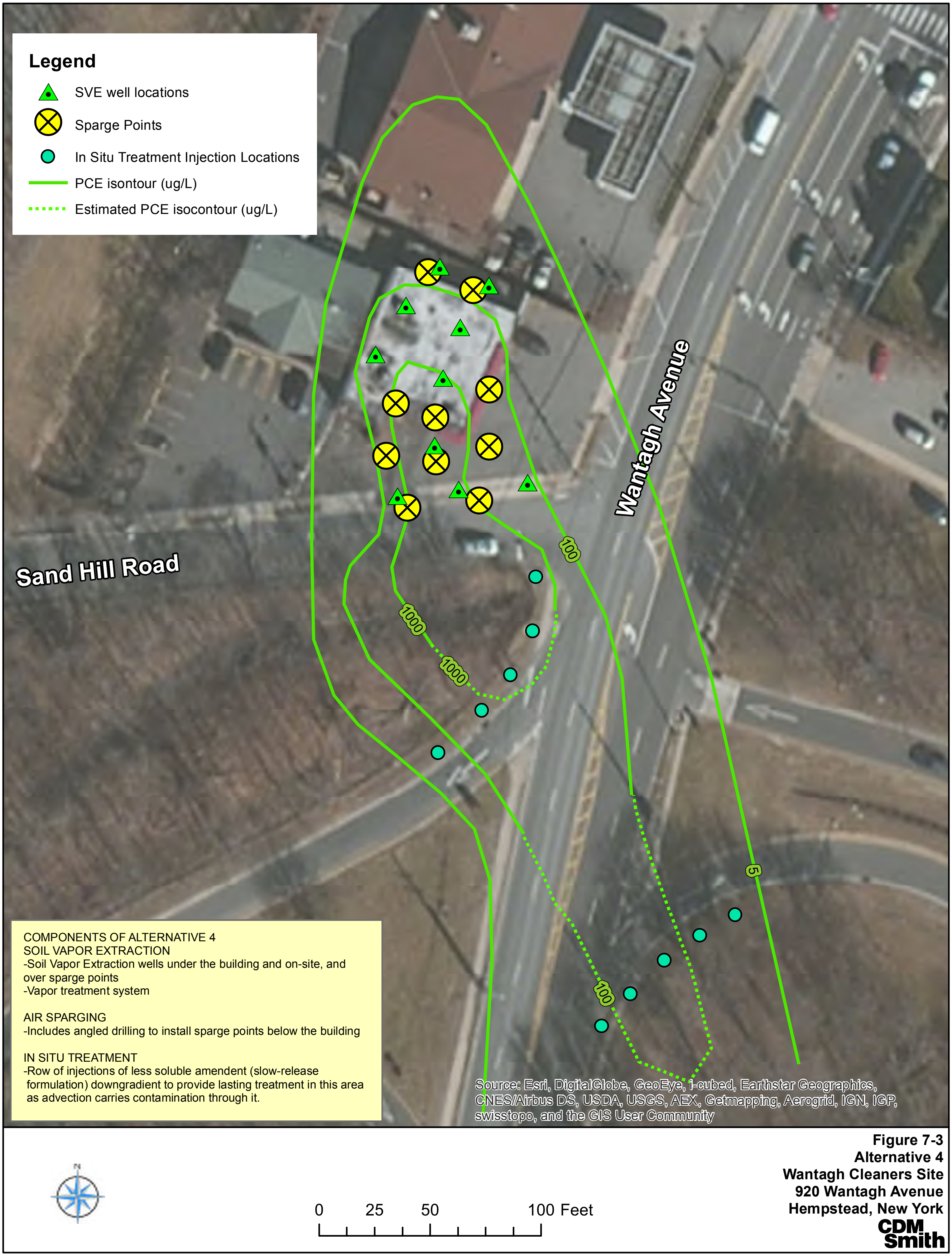

Figure 7-3
Alternative 4
Wantagh Cleaners Site
920 Wantagh Avenue
Hempstead, New York

CDM Smith

\ysvr1\IMS\GIS\100023_Wantagh\DATA\MXD\FS\Figurew 7-3 Alternative 4.mxd 11/9/2015 GURRC

COMPONENTS OF ALTERNATIVE 5
- Soil Vapor Extraction wells under the building and on-site
- Vapor and off-gas treatment system
- In situ thermal remediation in Leach Pit area (on-site parking lot)
- Injections of soluble amendment upgradient of the building and on-site; advection will carry the soluble amendment under the building and under the ravine to provide treatment in these areas.
- Rows of injections of in situ treatment amendent perpendicular groundwater flow direction

N
W E
S

Feet
0 350 700 1,400

Figure 7-4
Alternative 5
Wantagh Cleaners Site
Hempstead, New York

CDM Smith

Tables

Table 3-1
Summary of Chemicals of Concern in Soil
Remedial Investigation Phase I
Wantagh Cleaners Site
Hempstead, New York

Chemical	CAS No	Detection Frequency	Maximum Concentration (mg/kg)	Location of Maximum Concentration	375-6.8(b): Restricted Use Soil Cleanup Objectives - Commercial[1] (mg/kg)	COC? Yes/No
Volatile Organic Compounds						
1,1,1-Trichloroethane	71-55-6	1 / 16	0.42 JD	MIP-01	500	No
1,2-Dichloroethane	107-06-2	1 / 16	0.0051	MIP-01	30	No
Acetone	67-64-1	7 / 16	0.025 J	MIP-09	500	No
cis-1,2-Dichloroethene	156-59-2	6 / 16	0.3 JD	MIP-14	500	No
Methylene Chloride	75-09-2	5 / 16	0.01 J	MIP-19	500	No
Tetrachloroethene	127-18-4	5 / 16	26 D	MIP-01	150	No
trans-1,2-Dichloroethene	156-60-5	1 / 16	0.002 J	MIP-14	500	No
Trichloroethene	79-01-6	5 / 16	0.065	MIP-07	200	No

COC - chemical of concern
mg/kg - milligrams per kilogram
J - Analyte detected below quantitation limits
D - Compound is identified at a secondary dilution factor
Notes:
1. NYSDEC Subpart 375-6: Table 375-6.8(a): Restricted Use Soil Cleanup Objectives - Commercial, http://www.dec.ny.gov/regs/15507.html#15513 (375). December 14, 2006.

Table 3-2
Summary of Chemicals of Concern in Soil
Remedial Investigation Phase II (Addendum)
Wantagh Cleaners Site
Hempstead, New York

Chemical	CAS No	Detection Frequency	Maximum Concentration (mg/kg)		Location of Maximum Concentration	375-6.8(b): Restricted Use Soil Cleanup Objectives - Commercial[1] (mg/kg)	COC? Yes/No
Volatile Organic Compounds							
1,1-Dichloroethene	75-35-4	1 / 15	0.0009	J	Boring F	500	No
2-Butanone (MEK)	78-93-3	9 / 15	0.024		MW-02I	500	No
Acetone	67-64-1	10 / 15	0.18	J	MW-02I	500	No
Carbon Disulfide	75-15-0	5 / 15	0.031		MW-03S	NL	No
Chlorobenzene	108-90-7	1 / 15	0.016		MW-02I	500	No
cis-1,2-Dichloroethene	156-59-2	10 / 15	280		Boring F	500	No
Methylene Chloride	75-09-2	3 / 15	0.001	J	Boring D/ Boring E/ Boring F	500	No
Tetrachloroethene	127-18-4	11 / 15	7.8	J	Boring E	150	No
Toluene	108-88-3	3 / 15	0.001	J	MW-02I	500	No
trans-1,2-Dichloroethene	156-60-5	4 / 15	0.023	J	MW-02I	500	No
Trichloroethene	79-01-6	9 / 15	0.84	J	MW-03S	200	No
Vinyl Chloride	75-01-4	2 / 15	8.9	J	Boring F	13	No

COC - chemical of concern
mg/kg - milligrams per kilogram
J - Analyte detected below quantitation limits
Notes:
1. NYSDEC Subpart 375-6: Table 375-6.8(a): Restricted Use Soil Cleanup Objectives - Commercial, http://www.dec.ny.gov/regs/15507.html#15513 (375). December 14, 2006.

Table 3-3
Summary of Chemicals of Concern in Groundwater
Remedial Investigation Phase I
Wantagh Cleaners Site
Hempstead, New York

Chemical	CAS No	Detection Frequency	Maximum Concentration (µg/L)	Location of Maximum Concentration	NYSDEC Standards and Guidance Values for Class GA Groundwater [1] (µg/L)	COC? Yes/No
Volatile Organic Compounds						
1,1-Dichloroethene	75-35-4	5 / 45	8.4	MIP-15	5	**Yes**
Chloroethane	75-00-3	1 / 45	0.68 J	MIP-18	5	No
Chloromethane	74-87-3	28 / 45	1.8 J	MIP-11	5	No
cis-1,2-Dichloroethene	156-59-2	17 / 45	2600 D	MIP-14	5	**Yes**
Isopropylbenzene	98-82-8	3 / 45	1.6	MIP-18	5	No
Tetrachloroethene	127-18-4	36 / 46	7600 D	MIP-07	5	**Yes**
trans-1,2-Dichloroethene	156-60-5	11 / 46	61 J	MIP-14	5	**Yes**
Trichloroethene	79-01-6	18 / 46	1300 D	MIP-07	5	**Yes**
Vinyl Chloride	75-01-4	11 / 48	110 D	MIP-15	2	**Yes**

COC - chemical of concern
µg/L - micrograms per liter
J - Analyte detected below quantitation limits
D - Compound is identified at a secondary dilution factor

Notes:
1. NYSDEC. June 1998. TOGS 1.1.1. Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations.
Includes April 2000 and June 2004 Addendum values. (http://www.dec.ny.gov/regulations/2652.html)
Includes revisions in Part 703 effective February 16, 2008.

Table 3-4
Summary of Chemicals of Concern in Groundwater
Remedial Investigation Phase II (Addendum)
Wantagh Cleaners Site
Hempstead, New York

Chemical	CAS No	Detection Frequency	Maximum Concentration (µg/L)	Location of Maximum Concentration	NYSDEC Standards and Guidance Values for Class GA Groundwater [1] (µg/L)	COC? Yes/No
Volatile Organic Compounds						
1,1-Dichloroethane	75-34-3	21 / 292	5	Boring DT1-C	5	No
1,1-Dichloroethene	75-35-4	1 / 292	1 J	Boring XX	5	No
2-Butanone (MEK)	78-93-3	3 / 292	2 J	Boring A	50	No
Acetone	67-64-1	11 / 292	3 J	Boring VV	50	No
Benzene	71-43-2	1 / 292	7	Boring DT1-G	1	**Yes**
Chlorobenzene	108-90-7	2 / 292	1 J	Boring DT2-E	5	No
Chloroform	67-66-3	4 / 292	11	Boring B	7	**Yes**
Chloromethane	74-87-3	6 / 292	4 J	Boring DT1-F	5	No
cis-1,2-Dichloroethene	156-59-2	93 / 292	2000	Boring A	5	**Yes**
Dichlorodifluoromethane	75-71-8	1 / 292	4 J	Boring DT1-C	5	No
Isopropylbenzene	98-82-8	1 / 292	2 J	Boring A	5	No
Methyl tert-butyl ether (MTBE)	1634-04-4	45 / 292	72	Boring EEE	10	**Yes**
Tetrachloroethene	127-18-4	122 / 292	20000	Boring A	5	**Yes**
trans-1,2-Dichloroethene	156-60-5	4 / 292	28	Boring A	5	**Yes**
Trichloroethene	79-01-6	78 / 292	4600	Boring A	5	**Yes**
Vinyl Chloride	75-01-4	2 / 292	2	Boring YY	2	No
Metals						
Iron	7439-89-6	6 / 6	990	MW-02I	300	**Yes**
Sodium	7440-23-5	6 / 6	43300	MW-02I	20000	**Yes**

COC - chemical of concern
µg/L - micrograms per liter
J - Analyte detected below quantitation limits

Notes:

1. NYSDEC. June 1998. TOGS 1.1.1. Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations. Includes April 2000 and June 2004 Addendum values. (http://www.dec.ny.gov/regulations/2652.html) Includes revisions in Part 703 effective February 16, 2008.

Table 3-5
Vapor Intrusion and Soil Gas Detections
Remedial Investigation Phase I
Wantagh Cleaners Site
Hempstead, New York

			Sample Location	Wantagh Cleaners Indoor Air (IA) & Sub-Slab Vapor (SB)			
			Sample ID	IA-01	SB-01	SB-101 (Duplicate)	SB-02
			Sampling Date	11/29/2011	11/29/2011	11/29/2011	11/29/2011
			Unit	ug/m^3	ug/m^3	ug/m^3	ug/m^3
Volatile Organic Compounds	**EPA Indoor Air[1]**	**EPA Outdoor Air[2]**	**NYSDOH Soil Vapor Standards[3]**				
Carbon Tetrachloride	1.3	0.7	NL	**0.5**	0.25 U	**0.31**	0.25 U
cis-1,2-Dichloroethene	1.9	1.8	NL	**2.14 [c,d]**	**749.35 D[d]**	**642.3 D[d]**	**36,357.46 D[c]**
Styrene	1.9	1.3	NL	0.43 U	0.43 U	**1.45**	**0.34 J**
Tetrachloroethene	15.9	6.5	100	**112.57 D[e]**	**20,953.87 D[e]**	**17,834.52 D[e]**	**517,404.50 EDJ[e]**
Trichloroethene	4.2	1.3	5	**3.28 [a]**	**1,886.36 D[a]**	**1,531.66 D[a]**	**27,784.79 D[a]**

Table 3-5
Vapor Intrusion and Soil Gas Detections
Remedial Investigation Phase I
Wantagh Cleaners Site
Hempstead, New York

			Sample Location	711 Indoor Air (IA) & Sub-Slab Vapor (SB)		Ambient Air (AA)
			Sample ID	IA-02	SB-03	AA
			Sampling Date	11/29/2011	11/29/2011	11/29/2011
			Unit	ug/m^3	ug/m^3	ug/m^3
Volatile Organic Compounds	**EPA Indoor Air[1]**	**EPA Outdoor Air[2]**	**NYSDOH Soil Vapor Standards[3]**			
Carbon Tetrachloride	1.3	0.7	NL	**0.5** [b]	**0.38** [b]	**0.44**
cis-1,2-Dichloroethene	1.9	1.8	NL	**1.55**	**2.93**	0.4 U
Styrene	1.9	1.3	NL	**2.38**	**0.81**	0.43 U
Tetrachloroethene	15.9	6.5	100	**67.07** [c]	**3,783.90** D[c]	**0.34**
Trichloroethene	4.2	1.3	5	**3.06** [a]	**72.55** D[a]	**0.59**

Table 3-5
Vapor Intrusion and Soil Gas Detections
Remedial Investigation Phase I
Wantagh Cleaners Site
Hempstead, New York

			Sample Location	Direct Push Soil Gas			
			Sample ID	SV-01	SV-02	SV-03	SV-04
			Sampling Date	11/28/2011	11/28/2011	11/28/2011	11/28/2011
			Unit	ug/m^3	ug/m^3	ug/m^3	ug/m^3
Volatile Organic Compounds	**EPA Indoor Air[1]**	**EPA Outdoor Air[2]**	**NYSDOH Soil Vapor Standards[3]**				
Carbon Tetrachloride	1.3	0.7	NL	0.25 U	0.25 U	**0.38**	**0.38**
cis-1,2-Dichloroethene	1.9	1.8	NL	**8127.89 D**	**38,657.06 D**	0.4 U	0.4 U
Styrene	1.9	1.3	NL	**0.6**	0.43 U	0.43 U	0.43 U
Tetrachloroethene	15.9	6.5	100	**19,733.25 D**	**147151.74 EDJ**	**1.9**	**2.58**
Trichloroethene	4.2	1.3	5	**3,847.95 D**	**40,897.91 D**	**0.27**	**0.54**

Table 3-5
Vapor Intrusion and Soil Gas Detections
Remedial Investigation Phase I
Wantagh Cleaners Site
Hempstead, New York

			Sample Location	**Direct Push Soil Gas**			
			Sample ID	**SV-05**	**SV-06**	**SV-07**	**SV-08**
			Sampling Date	**11/28/2011**	**11/28/2011**	**11/28/2011**	**11/28/2011**
			Unit	**ug/m^3**	**ug/m^3**	**ug/m^3**	**ug/m^3**
Volatile Organic Compounds	**EPA Indoor Air[1]**	**EPA Outdoor Air[2]**	**NYSDOH Soil Vapor Standards[3]**				
Carbon Tetrachloride	1.3	0.7	NL	0.25 U	0.25 U	**0.38**	**0.38**
cis-1,2-Dichloroethene	1.9	1.8	NL	**58.28**	**84,450.80 EDJ**	**3.29**	0.4 U
Styrene	1.9	1.3	NL	0.43 U	**0.55**	0.43 U	0.43 U
Tetrachloroethene	15.9	6.5	100	**888.34 D**	**103,074.03 EDJ**	**84.76**	**0.75**
Trichloroethene	4.2	1.3	5	**137.58 D**	**31,493.01 D**	**12.04**	0.21 U

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Table 3-5
Vapor Intrusion and Soil Gas Detections
Remedial Investigation Phase I
Wantagh Cleaners Site
Hempstead, New York

			Sample Location	Direct Push Soil Gas		
			Sample ID	SV-09	SV-10	SV-11
			Sampling Date	11/28/2011	11/28/2011	11/28/2011
			Unit	ug/m3	ug/m3	ug/m3
Volatile Organic Compounds	**EPA Indoor Air[1]**	**EPA Outdoor Air[2]**	**NYSDOH Soil Vapor Standards[3]**			
Carbon Tetrachloride	1.3	0.7	NL	0.25 U	0.25 U	0.25 U
cis-1,2-Dichloroethene	1.9	1.8	NL	**1,050.68 D**	**7.45**	0.4 U
Styrene	1.9	1.3	NL	**0.68**	**0.51 J**	0.43 U
Tetrachloroethene	15.9	6.5	100	**51.33**	**667.95 D**	**35.26**
Trichloroethene	4.2	1.3	5	**1,907.85 D**	**24.56**	**0.97**

Table 3-5
Vapor Intrusion and Soil Gas Detections
Remedial Investigation Phase I
Wantagh Cleaners Site
Hempstead, New York

Notes:

1 - Results compared against final New York State Department of Health Soil Vapor Intrusion Guidance, October 2006. Appendix C Table C2 - EPA 2001: Building assessment and survey evaluation (BASE) database, SUMMA® canister method, 90th perce

2 - Results compared against final New York State Department of Health Soil Vapor Intrusion Guidance, October 2006. Appendix C Table C2 - EPA 2001: Building assessment and survey evaluation (BASE) database, SUMMA® canister method, 90th perce

3 - Results compared against final New York State Department of Health Soil Vapor Intrusion Guidance, October 2006. Table 3.1 Air Guideline Values Derived by the NYSDOH.

a - Per the NYSDOH Soil Vapor/Indoor Air Matrix 1 - subslab concentrations greater than 50 ug/m ^{3} and indoor air between 1 and less than 5 ug/m ^{3} - Mitigation Required

b - Per the NYSDOH Soil Vapor/Indoor Air Matrix 1 - subslab concentrations less than 5 ug/m ^{3} and indoor air between 0.25 to less than 1 ug/m ^{3} - Action to Identify Source(s) and Reduce Exposures

c - Per the NYSDOH Soil Vapor/Indoor Air Matrix 2 - subslab concentrations above 1000 ug/m ^{3} and indoor air less than 3 ug/m ^{3}- Mitigation Required

d - Per the NYSDOH Soil Vapor/Indoor Air Matrix 2 - subslab concentrations between 100 and 1000 ug/m ^{3} and indoor air less than 3 ug/m ^{3} - Monitoring Required

e - Per the NYSDOH Soil Vapor/Indoor Air Matrix 2 - indoor air concentrations greater than or equal to 100 ug/m ^{3} and subslab concentrations greater than or equal to 1000 ug/m ^{3} - Mitigation Required

Result exceeded screening criteria and/or NYSDOH Sub-Slab/Indoor Air Matrix

EPA - Environmental Protection Agency

NYSDOH - New York State Department of Health

ug/m^3 - microgram per cubic meter

NL - No listed

VOCs - volatile organic compounds

Table 3-6
Vapor Intrusion Sampling Results: RES-02
Remedial Investigation Phase II (Addendum)
Wantagh Cleaners Site
Hempstead, New York

			Sample Location	**IA1-RES-02**		**IA2-RES-02**	**SS-RES-02**		**OA-RES-02**
			Sample Identification	IA1-RES-02	IA1D-RES-02	IA2-RES-02	SS-RES-02	SS-RESD-02	OA-RES-02
			Sampling Date	01/28/2014	01/28/2014	01/29/2014	01/28/2014	01/28/2014	01/29/2014
			Matrix	Indoor Air	Indoor Air	Indoor Air	Sub-slab Vapor	Duplicate	Outdoor Air
Volatile Organic Compounds (VOCs)	**EPA Indoor Air[1]**	**EPA Outdoor Air[2]**	**NYSDOH Soil Vapor Standards[3]**	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
2-Butanone (MEK)	12	11.3	NL	0.59 U	**0.68**	0.59 U	0.59 U	0.59 U	0.59 U
Acetone	98.9	43.7	NL	**8.77**	**10.1**	0.48 U	**2.38**	**1.83**	**5.51**
Benzene	9.4	6.6	NL	**1.6**	**1.85**	0.64 U	0.64 U	0.64 U	**1.09**
Chloroform	1.1	0.6	NL	0.98 U	**2.64**	0.98 U	0.98 U	0.98 U	0.98 U
Chloromethane	3.7	3.7	NL	**1.3**	**1.24**	0.41 U	0.41 U	0.41 U	**1.2**
Dichlorodifluoromethane	16.5	8.1	NL	**2.77**	**2.77**	0.99 U	**1.88**	**2.18**	**2.67**
m,p-Xylene (Sum Of Isomers)	NL	NL	NL	**1.87**	**1.95**	3.78 U	**1**	**0.91**	3.78 U
Methylene Chloride	10	6.1	60	**3.34 J**	**28.2 J**	**0.85**	**2.68**	**0.97**	**1.48**
Tetrachloroethene	15.9	6.5	100	1.36 U	1.36 U	1.36 U	**1.97**	**1.9**	1.36 U
Toluene	43	33.7	NL	**3.01**	**3.5**	0.75 U	**0.87**	0.75 U	**1.32**
Trichlorofluoromethane	18.1	4.3	NL	**1.46**	**1.69**	1.12 U	**1.4**	**1.35**	**1.35**

Notes:

1 - Results compared against final New York State Department of Health Soil Vapor Intrusion Guidance, October 2006. Appendix C Table C2 - EPA 2001: Building assessment and survey evaluation (BASE) database, SUMMA® canister method, 90th percentile for indoor air.

2 - Results compared against final New York State Department of Health Soil Vapor Intrusion Guidance, October 2006. Appendix C Table C2 - EPA 2001: Building assessment and survey evaluation (BASE) database, SUMMA® canister method, 90th percentile for outdoor air.

3 - Results compared against final New York State Department of Health Soil Vapor Intrusion Guidance, October 2006. Table 3.1 Air Guideline Values Derived by the NYSDOH.

Bold value indicates detected result

Acronyms:

J - Estimated Value   NL - not listed   U - Non-Detect

µg/m³ - micrograms per Liter cubed

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Table 3-7
Vapor Intrusion Sampling Results: RES-03
Remedial Investigation Phase II (Addendum)
Wantagh Cleaners Site
Hempstead, New York

Volatile Organic Compounds (VOCs)	EPA Indoor Air[1]	EPA Outdoor Air[2]	NYSDOH Soil Vapor Standards[3]	IA1-RES-03	IA2-RES-03	SS-RES-03	OA-RES-03
			Sample Location	**IA1-RES-03**	**IA2-RES-03**	**SS-RES-03**	**OA-RES-03**
			Sample Identification	IA1-RES-03	IA2-RES-03	SS-RES-03	OA-RES-03
			Sampling Date	12/09/2013	12/09/2013	12/10/2013	12/09/2013
			Matrix	Indoor Air	Indoor Air	Subslab Vapor	Outdoor Air
				µg/m3	µg/m3	µg/m3	µg/m3
1,2,4-Trimethylbenzene	9.5	5.8	NL	0.98 U	0.98 U	**1.38**	0.98 U
2-Butanone (MEK)	12	11.3	NL	**0.68**	**0.74**	**1.15**	**0.68**
Acetone	98.9	43.7	NL	**11.5**	**12.7**	**9.76**	0.48 U
Benzene	9.4	6.6	NL	**1.05**	**1.09**	0.64 U	**1.15**
Chloromethane	3.7	3.7	NL	**1.14**	**1.2**	0.41 U	**1.03**
Dichlorodifluoromethane	16.5	8.1	NL	**2.03**	**2.03**	0.99 U	**2.03**
m,p-Xylene (Sum Of Isomers)	NL	NL	NL	**1.17**	**1.04**	**1.82**	**1.26**
Methylene Chloride	10	6.1	60	**1.59**	**1.59**	**2.25**	**4.12**
Tetrachloroethene	15.9	6.5	100	**1.49** [a]	**8.21** [a]	**6.24** [a]	**47.5**
Toluene	43	33.7	NL	**2**	**2.11**	**1.47**	**2.26**
Trichlorofluoromethane	18.1	4.3	NL	**1.24**	**1.18**	**1.18**	**1.12**

Notes:

1 - Results compared against final New York State Department of Health Soil Vapor Intrusion Guidance, October 2006. Appendix C Table C2 - EPA 2001: Building assessment and survey evaluation (BASE) database, SUMMA® canister method, 90th percentile for indoor air.

2 - Results compared against final New York State Department of Health Soil Vapor Intrusion Guidance, October 2006. Appendix C Table C2 - EPA 2001: Building assessment and survey evaluation (BASE) database, SUMMA® canister method, 90th percentile for outdoor air.

3 - Results compared against final New York State Department of Health Soil Vapor Intrusion Guidance, October 2006. Table 3.1 Air Guideline Values Derived by the NYSDOH.

a - NYSDOH Sub-Slab Vapor/Indoor Air Matrix 2 suggests reasonable and practical actions to identify source(s) and reduce exposures

Result exceeded EPA Outdoor Air screening criteria

Bold value indicates detected result

Acronyms:

NL - not listed

U - Non-Detect

µg/m3 - micrograms per Liter cubed

CDM Smith

Table 3-8
Vapor Intrusion Sampling Results: RES-04
Remedial Investigation Phase II (Addendum)
Wantagh Cleaners Site
Hempstead, New York

			Sample Location	**IA1-RES-04**	**IA2-RES-04**	**SS-RES-04**	**OA-RES-04**
			Sample Identification	IA1-RES-04	IA2-RES-04	SS-RES-04	OA-RES-04
			Sampling Date	03/05/2014	03/05/2014	03/05/2014	03/05/2014
			Matrix	Indoor Air	Indoor Air	Subslab Vapor	Outdoor Air
Volatile Organic Compounds (VOCs)	**EPA Indoor Air[1]**	**EPA Outdoor Air[2]**	**NYSDOH Soil Vapor Standards[3]**	μg/m³	μg/m³	μg/m³	μg/m³
1,1,2-Trichloro-1,2,2-Trifluoroethane	NL	NL	NL	**0.77 J**	1.53 U	**0.77 J**	1.53 U
1,2,4-Trimethylbenzene	9.5	5.8	NL	0.98 U	0.98 U	**0.98**	0.98 U
2-Butanone (MEK)	12	11.3	NL	**1.95**	**3.33**	**2.48**	**0.53 J**
4-Methyl-2-Pentanone (MIBK)	6	1.9	NL	0.82 U	0.82 U	**0.61 J**	0.82 U
Acetone	98.9	43.7	NL	**4.63**	**14.1**	**13.2**	**4.77**
Benzene	9.4	6.6	NL	**0.73**	**0.83**	**0.86**	**0.64**
Chloroform	1.1	0.6	NL	0.98 U	**0.63 J**	**0.44 J**	0.98 U
Chloromethane	3.7	3.7	NL	**1.09**	**1.34**	**0.33 J**	**1.12**
Dichlorodifluoromethane	16.5	8.1	NL	**2.62**	**2.47**	**1.38**	**2.42**
Ethylbenzene	5.7	3.5	NL	0.87 U	0.87 U	**0.56 J**	0.87 U
m,p-Xylene (Sum Of Isomers)	NL	NL	NL	**0.52 J**	**0.61 J**	**1.52**	3.78 U
Methylene Chloride	10	6.1	60	**4.35**	**6.87**	**4**	**16.7**
o-Xylene	7.9	4.6	NL	0.87 U	0.87 U	**0.74 J**	0.87 U
Tetrachloroethene	15.9	6.5	100	**0.68 J**[a]	**19** [a]	**1.42** [a]	1.36 U
Toluene	43	33.7	NL	**0.87**	**1.54**	**1.96**	**0.75**
Trichlorofluoromethane	18.1	4.3	NL	**1.46**	**1.4**	**1.63**	**1.29**

Notes:

1 - Results compared against final New York State Department of Health Soil Vapor Intrusion Guidance, October 2006. Appendix C Table C2
- EPA 2001: Building assessment and survey evaluation (BASE) database, SUMMA® canister method, 90th percentile for indoor air.

2 - Results compared against final New York State Department of Health Soil Vapor Intrusion Guidance, October 2006. Appendix C Table C2
- EPA 2001: Building assessment and survey evaluation (BASE) database, SUMMA® canister method, 90th percentile for outdoor air.

3 - Results compared against final New York State Department of Health Soil Vapor Intrusion Guidance, October 2006. Table 3.1 Air Guideline Values Derived by the NYSDOH.

a - NYSDOH Sub-Slab Vapor/Indoor Air Matrix 2 suggests reasonable and practical actions to identify source(s) and reduce exposures

Result exceeded EPA Outdoor Air screening criteria

Result exceeded EPA Indoor Air screening criteria

Bold value indicates detected result

Acronyms:

NL - not listed

U - Non-Detect

μg/m³ - micrograms per Liter cubed

CDM Smith

Table 3-9

Summary of Current and Potential Exposure Pathways

Wantagh Cleaners Site

Hempstead, New York

Condition	Area of Concern	Receptors	Environmental Media & Exposure Route	Exposure Pathway	Rationale
Current	Wantagh Cleaners	Workers and visitors	Groundwater - ingestion, dermal contact	Incomplete	Groundwater is not used as a drinking water source.
			Subsurface soil - ingestion, dermal contact	Incomplete	No COCs identified in subsurface soils
			Indoor air - inhalation	Complete	Receptors may be exposed to contamination in indoor air.
	Adjacent Convenience Store	Workers and visitors	Groundwater - ingestion, dermal contact	Incomplete	Groundwater is not used as a drinking water source.
			Subsurface soil - ingestion, dermal contact	Incomplete	No COCs identified in subsurface soils
			Indoor air - inhalation	Complete	Receptors may be exposed to contamination in indoor air.
	Offsite Residences	Residents	Groundwater - ingestion, dermal contact	Incomplete	Groundwater is not used as a drinking water source.
			Subsurface soil - ingestion, dermal contact	Incomplete	No COCs identified in subsurface soils
			Indoor air - inhalation	Complete	Receptors may be exposed to contamination in indoor air.
Future	Wantagh Cleaners	Workers and visitors	Groundwater - ingestion, dermal contact	Incomplete	Groundwater is not used as a drinking water source.
			Subsurface soil - ingestion, dermal contact	Incomplete	No COCs identified in subsurface soils
			Indoor air - inhalation	Complete	Receptors may be exposed to contamination in indoor air.
		Construction Workers	Groundwater - ingestion, dermal contact, inhalation of vapor	Complete	Groundwater is present at a depth of approximately 9 feet. Therefore construction workers may come in contact with volatile organic contaminants in groundwater.
	Adjacent Convenience Store	Workers and visitors	Groundwater - ingestion, dermal contact	Incomplete	Groundwater is not used as a drinking water source.
			Subsurface soil - ingestion, dermal contact	Incomplete	No COCs identified in subsurface soils
			Indoor air - inhalation	Complete	Receptors may be exposed to contamination in indoor air.
	Right of Way South of Sandhill Road	Construction Workers	Groundwater - ingestion, dermal contact, inhalation of vapor	Complete	Groundwater is present at a depth of approximately 9 feet. Therefore construction workers may come in contact with volatile organic contaminants in groundwater.
	Adjacent to Southern Parkway/Residential Neighborhood	Construction Workers	Groundwater - ingestion, dermal contact, inhalation of vapor	Complete	Groundwater is present at a depth of approximately 9 feet. Therefore construction workers may come in contact with volatile organic contaminants in groundwater.
	Offsite Residences	Construction Workers	Groundwater - ingestion, dermal contact, inhalation of vapor	Complete	Groundwater is present at a depth of approximately 9 feet. Therefore construction workers may come in contact with volatile organic contaminants in groundwater.
		Residents	Groundwater - ingestion, dermal contact	Incomplete	Groundwater is not used as a drinking water source.
			Indoor air - inhalation	Complete	Receptors may be exposed to contamination in indoor air.

Table 4-1
Preliminary Remediation Goals
Wantagh Cleaners
Hempsted, New York

Contaminant of Concern	Groundwater (µg/L)	Soil (mg/kg)
cis-1,2-Dichloroethene	5	0.25
Tetrachloroethene	5	1.3
Trichloroethene	5	0.47
Vinyl Chloride	2	0.02

Notes:

µg/L - microgram per liter

mg/kg - miligram per kilogram

Groundwater criteria - NYSDEC TOGS 1.1.1 Class GA Water

Soil cleanup objectives - NYSDEC Unrestricted Use Soil Cleanup Objectives 6 NYCRR 375-6(a)

*NYSDEC CP-51 Protection of Groundwater SCO

Table 6-1
Groundwater Source Zone Technology Screening Table
Wantagh Cleaners Site Hempstead, New York

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Implementability	Relative Cost[a]	Retained
No Action	None	No Action	No action would be taken. The source area and site-wide contamination will remain in their existing conditions.	Ineffective. No Action alternative retained as baseline for comparison with other alternatives.	Easily implementable. No significant administrative difficulties anticipated.	No capital, operation, or maintenance costs. Would require some long-term costs for periodic reassessment.	Retained (as per DER-10)
Institutional and Engineering Controls	Deed Restriction	Government and Proprietary Controls	Regulatory actions utilized to prevent certain types of uses for properties where exposure pathways to contaminants may be created as a result of those uses.	Likely to be effective from a human health standpoint through restriction of future site uses or activities which may result in direct contact with contaminated groundwater. The effectiveness of deed restrictions is dependent on proper enforcement. Deed restrictions, however, will not reduce the migration and the associated environmental impact of the contaminant plume.	Implementable if the local municipalities and site property owners allow them to be instituted. Deed restrictions may be implemented, in addition to remediation activities, as a protective measure to prevent exposure to contaminants during remediation.	Low capital costs. Some administrative, long-term monitoring and periodic assessment cost would be required.	Retained
	Well Drilling/Water Use Restrictions	Government and Proprietary Controls	Regulatory actions utilized to restrict the installation of groundwater drinking water wells.	Well drilling and water use restrictions may effectively meet some RAOs through restriction of future site uses or activities which would create human exposure pathways to contaminated groundwater. These restrictions however will not reduce the migration and associated environmental impact of the contaminated groundwater.	Implementation is possible based on the existing permitting process. Well drilling restrictions may also be implemented in addition to remediation activities, as a protective measure to prevent future exposure to contaminants during remediation.	Low capital costs. No associated O&M costs are anticipated.	Retained
	Long Term Monitoring	Groundwater Sampling and Monitoring, Site Inspection, Maintenance & Reporting	Periodic sampling and analysis of groundwater samples to monitor contamination. Periodic Review reports (PRRs) will be completed in accordance with DER 10 Section 6.3, as required by the selected remedy.	Long-term monitoring alone would not alter the effects of the contamination on human health and the environment. Monitoring is a proven and reliable process for tracking the migration of contaminants during and following treatment.	Easily implementable. A long-term commitment would be required to implement a long-term monitoring program. More analysis would have to be conducted to choose sampling locations.	Low capital costs. Low operation and maintenance costs.	Retained
Monitored Natural Attenuation	Monitored Natural Attenuation	Monitored Natural Attenuation	Reliance on natural destructive (biodegradation and chemical reactions) and nondestructive mechanisms (dilution, dispersion, volatilization, and adsorption) to reduce contaminant levels in the context of a long term monitoring program. Under favorable conditions, these physical, chemical, or biological processes act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in the groundwater.	Effective for sites that have demonstrated to be utilizing natural mechanisms to minimize or prevent the further migration of groundwater contamination. Based on the lack of total organic carbon in the source zone explored in the remedial investigation (RI), biodegradation does not appear to be a dominant process affecting the contaminants. However, dilution and dispersion may be more important contributors to attenuation.	Easily implementable. Materials and services necessary to model and monitor the contaminant dynamics are readily available. Site restrictions and/or institutional controls may be required as long-term control measures as part of the MNA alternatives.	Low capital costs and moderate O&M costs for long-term monitoring, and periodic reassessment costs.	Retained
Containment	Containment Wall	Secant Pile, Sheet Pile Barrier, or Slurry Wall	Retardation of groundwater and plume flow via a containment wall to minimize exposures to human and/or ecological receptors and allow more time for extraction or contact time for in-situ remedies.	Unlikely to be effective at achieving hydraulic control on its own. Would need to be coupled with hydraulic control via pumping. Would be effective at retarding continued migration off site but will have no impact on plume migration beyond the containment wall.	Not easily implementable. Depth to groundwater and extent of contamination is shallow enough for wall installation. However, implementation may be complicated by existing surface structures including an occupied building and parking lot onsite and congested main roads offsite. Also, wall installation may require repaving of parking areas and roads which will take additional time.	High capital cost, low to no O&M costs.	Not Retained
Extraction	Collection/ Hydraulic Control	Vertical Extraction Well(s)	Removal of groundwater to provide hydraulic control and capture of contaminants. Additionally, extraction wells may be installed as part of an extraction-injection well network for ex-situ or in-situ treatment systems. The specific extraction well locations would be determined through groundwater modeling and/or pilot testing.	Effective for limiting plume migration. Pump tests and groundwater modeling must be conducted to confirm whether extraction wells will be effective in removing contaminants in the source zone. Additionally, the extracted groundwater will require treatment to remove the contaminants and will need to be coupled with additional technologies to be effective at achieving RAOs.	Not easily implementable. Necessary equipment and materials are readily available. However, implementation may be complicated by existing surface structures including an occupied building and parking lot onsite and congested main roads offsite. Trenching will be required to connect wells to a treatment unit which will be disruptive also. *Ex situ* treatment of groundwater will require additional space for installation and operation.	Moderate capital costs and moderate O&M costs.	Not Retained
		Dual Phase Extraction (DPE)[b]	Combined extraction of soil and groundwater utilizing extraction wells screened across the saturated and unsaturated zones. A pump is utilized to extract groundwater while a vacuum is applied to the wellhead to extract soil gas. Both aqueous and vapor streams would require ex situ treatment.	Effective for reducing mass of contaminants in groundwater and soil. However, the extracted groundwater and vapor will require treatment to remove the contaminants and will therefore need to be coupled with additional technologies to be effective at achieving RAOs. The silty sandy lithology in the saturated zone is suitable permeability for DPE. A pilot study typically would be necessary prior to the design and implementation of a DPE system to measure relevant variables and determine effectiveness.	Implementable. Necessary equipment and materials are readily available. However, implementation may be complicated by existing surface structures including an occupied building and parking lot onsite and congested main roads offsite.Trenching will be required to connect wells to a treatment unit which will be disruptive also. *Ex situ* treatment of groundwater will require additional space for installation and operation.	Moderate capital costs and moderate O&M costs.	Not Retained
		Extraction Trenches	Removal of groundwater to provide hydraulic control and capture contaminants at shallow depths. The specific extraction trench location would be determined through groundwater modeling and/or pilot testing.	Effective for capturing groundwater to provide hydraulic control. To meet the RAOs, sufficient contaminant mass needs to be captured such that the cleanup objectives are met within a reasonable timeframe.	Not easily implementable. Necessary equipment and materials are readily available. Trenching will be disruptive to existing surface structures and utilities and may require repaving of parking areas and roads which will take additional time.	Moderate capital costs and moderate O&M costs.	Not Retained
		Air Sparging/Soil Vapor Extraction (AS/SVE)	Injection of air into the contaminated groundwater aquifer. Volatile organic contaminants partition into the air stream as it is flushed into the unsaturated zone. Soil vapor extraction (SVE) may be implemented in conjunction with air sparging to remove the vapor-phase contamination from the vadose zone by vacuum extraction and vapor treatment to mitigate impacts to surface receptors.	Likely to be effective. Air sparging is generally most effective for removal of volatile, relatively insoluble organics from a highly permeable, relatively uniform sandy aquifer (Bass 2000). The brown silty sand in the saturated zone is well suited for air sparging at the Site. A pilot test would be necessary to confirm effectiveness.	Implementable. However, care would need to be taken to ensure that vapors do not contaminate nearby surface waters or increase risk of vapor intrusion inside buildings. In addition, existing surface structures may limit access and space for implementation. However, this technology may be more implementable if limited to on-site installation.	Moderate capital and O&M costs.	Retained

Table 6-1
Groundwater Source Zone Technology Screening Table
Wantagh Cleaners Site Hempstead, New York

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Implementability	Relative Cost[a]	Retained
In Situ Treatment	*In Situ* Biological Treatment	Enhanced Anaerobic Bioremediation (EAB)	Injection of an additive into the contaminated aquifer to promote the biodegradation of contaminants by naturally occurring microorganisms called *Dehalococcoides* (DHC) under reducing conditions.	Likely to be effective. However, extent of success depends on site conditions, availability of the DHC bacteria (for complete reductive dechlorination of chlorinated solvents). The relatively homogeneous silty sand characterizing the shallow aquifer in the site area will support the distribution of a substrate. However, detailed characterization of the lithology would be critical for the design and implementation of successful EAB treatment. A pilot study would be needed to collect site-specific design parameters and determine effectiveness.	Implementable. However, implementation can be complicated by potential access limitations to the occupied building onsite and public roads offsite. Based on the method selected, multiple injections may be required and monitoring is necessary. An organic substrate with multiple-year longevity would be preferred. Multiple applications may be necessary due to back diffusion.	Moderate capital and moderate O&M costs. May be over several years if multiple rounds of amendment injections are necessary.	Retained
		Aerobic Cometabolic Bioremediation (ACB)	Injection of oxygen and/or primary substrate into the contaminated aquifer to promote cometabolism of contaminants in conjunction with the metabolism of a primary substrate (such as methane), which aerobic microorganisms use for carbon source and/or energy. PCE is not considered to be biodegradable under aerobic conditions.	May be effective for biodegradation of TCE, cis-1,2-DCE, and vinyl chloride. However, ACB will not be effective in treating the main contaminant, PCE.	Implementable. However, implementation can be complicated by potential access limitations to the occupied building onsite and public roads offsite.	Moderate capital and moderate O&M costs.	Not Retained
	In Situ Biogeochemical Transformation	Permeable Reactive Barrier (PRB)[a,b]	Installation of an in-ground trench backfilled with reactive media to provide passive treatment of contaminated groundwater as it passes through the trench. Can be installed as permanent, semi-permanent, or replaceable units which transect the plume flow path and act as a treatment wall.	Effective in degrading chlorinated solvents. However, PRBs require periodic reactivation to retain effectiveness.	Not easily implementable. Due to the shallow depth of groundwater and contamination, PRBs can be installed via trenching. However, trenching will be disruptive to existing surface structures and utilities and may require repaving of parking areas and roads which will take additional time.	Moderate to high capital and low O&M costs. The replacement cost could be as high as the capital cost.	Not Retained
	In Situ Chemical Treatment	In-Situ Chemical Oxidation (ISCO)[b]	Injection of strong chemical oxidants (e.g., H_2O_2, S_2O_8, $KMnO_4$, and/or O_3) into the contaminated aquifer to oxidize organic contaminants. Complete oxidation of contaminants results in their breakdown into innocuous compounds such as carbon dioxide, water, and chloride.	Potentially effective but only when an adequate amount of the oxidant is injected to react with the contaminants. However, this process could result in the release of contaminants trapped in the absorbed phase into the dissolved phase. This could lead to increasing the size of the contaminant source zone if an insufficient amount of oxidant is added. Native soil in the contaminant source zone is expected to have low oxidant demand based on site geology explored in the RI Addendum. However, a pilot study would be necessary to collect site-specific design parameters and determine effectiveness.	Implementable. Equipment and vendors would be available. In addition, a long-lasting oxidant, such as permanganate, would be preferred compared to the oxidants that rely on the oxidation power of radicals in order to be able to treat contaminants that may be diffused out of the soil. It usually requires three to five rounds of application for mass reduction. Existing surface structures may limit access both onsite and offsite.	High capital and moderate O&M costs. More cost effective for source areas.	Retained
		In-Situ Chemical Reduction (ISCR)[b]	Injection of a reductant to chemically reduce contaminants to non-hazardous compounds. The most widely used reductant for reducing chlorinated hydrocarbons is zero-valent iron (ZVI).	Potentially effective. ZVI and the associated proprietary products (such as EHC® or EZVI) can effectively treat contaminated groundwater aquifers containing PCE, TCE, and their degradation products if distributed effectively in the treatment zone. For this Site, evenly distributing ZVI or the proprietary products in the groundwater is expected to be feasible due to the relative homogeneity of the silty sandy aquifer. However, a pilot study would be necessary to collect site-specific design parameters and determine effectiveness.	Implementable. Equipment and experienced vendors would be available. Achieving adequate distribution of the ISCR amendment would be feasible. However, implementation can be complicated by potential access limitations to the occupied building onsite and public roads offsite. Based on the method selected, multiple injections may be required and monitoring is necessary.	High capital costs. Depending on the delivery technology and the depth of contamination, the O&M cost could be minimal, mainly for monitoring.	Retained
	In Situ Physical Treatment	In-Situ Thermal Remediation (ISTR)	Application of heat to subsurface soils and groundwater using technologies such as electrical resistivity heating (ERH), steam enhanced extraction, or electro thermal dynamic stripping process. Vaporized chlorinated solvents are usually extracted by an SVE system.	Very effective in source areas, but also involves intensive energy use and increased temporary health and safety (H&S) risks for on-site workers which can be addressed through proper engineering controls and other H&S measures.	Not easily implementable. Heating well installation may be limited inside the currently occupied on-site building. Implementing ISTR might require modification or temporary shutdown of the existing operation in the building and temporary shutdown of the nearby roads which would be subject to approval from the property owner and the municipality respectively.	High capital costs. High O&M costs for a relatively short period of time.	Retained
		In-Well Vapor Stripping	Installation of groundwater recirculation cells in the contaminated aquifer to strip contaminants from the aqueous to vapor phase. Stripped contaminants are treated above surface while groundwater is recirculated back into the cells.	Potentially effective. The brown silty sand in the saturated zone is well suited for air sparging at the site. However, a pilot study would be necessary to collect site-specific design parameters and determine effectiveness.	Implementable. However, implementation can be complicated by potential access limitations to the occupied building onsite and public roads offsite.	High capital and low O&M costs.	Retained

Table 6-1
Groundwater Source Zone Technology Screening Table
Wantagh Cleaners Site Hempstead, New York

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Implementability	Relative Cost[a]	Retained
Ex-situ Treatment of Contaminated Groundwater	These options were not explored as no groundwater removal/extraction technologies were retained for the groundwater source zone.						
Disposal/ Discharge							

Notes:
* Denotes an innovative technology.
a Relative costs presented in this table are determined based on judgement, previous experience and preliminary quotations from vendors.
b Pilot scale testing may be required.

Table 6-2
Dilute Plume Technology Screening Table
Wantagh Cleaners Site Hempstead, New York

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Implementability	Relative Cost[a]	Retained
No Action	None	No Action	No action would be taken. The source area and site-wide contamination will remain in their existing conditions.	Ineffective. No Action alternative retained as baseline for comparison with other alternatives.	Easily implementable. No significant administrative difficulties anticipated.	No capital, operation, or maintenance costs. Would require some long-term costs for periodic reassessment.	Retained (as per DER-10)
Institutional and Engineering Controls	Deed Restriction	Government and Proprietary Controls	Regulatory actions utilized to prevent certain types of uses for properties where exposure pathways to contaminants may be created as a result of those uses.	May be effective from a human health standpoint through restriction of future site uses or activities which may result in direct contact with contaminated groundwater. The effectiveness of deed restrictions is dependent on proper enforcement. Deed restrictions, however, will not reduce the migration and the associated environmental impact of the dilute plume.	Not easily implementable. Implementation may be difficult in offsite areas of the dilute plume as there may be objections from offsite property owners. Deed restrictions may be implemented, in addition to remediation activities, as a protective measure to prevent exposure to contaminants during remediation.	Implementation cost is low. Some administrative, long-term monitoring and periodic assessment cost would be required.	Retained
	Well Drilling/Water Use Restrictions	Government and Proprietary Controls	Regulatory actions utilized to regulate the installation of groundwater drinking water wells.	Well drilling and water use restrictions may effectively meet some RAOs through restriction of future site uses or activities which would create human exposure pathways to contaminated groundwater. These restrictions however will not reduce the migration and associated environmental impact of the contaminated groundwater.	Implementation is possible based on the existing permitting process. Well drilling restrictions may also be implemented in addition to remediation activities, as a protective measure to prevent future exposure to contaminants during remediation.	The cost to implement well drilling restrictions is low. No associated O&M costs are anticipated.	Retained
	Long Term Monitoring	Groundwater Sampling and Monitoring, Site Inspection, Maintenance & Reporting	Periodic sampling and analysis of groundwater samples to monitor dilute plume. Periodic Review reports will be completed in accordance with DER 10 Section 6.3, as required by the selected remedy.	Long-term monitoring alone would not alter the effects of the contamination on human health and the environment. Monitoring is a proven and reliable process for tracking the migration of contaminants during and following treatment.	Implementable. A long-term commitment would be required to implement a long-term monitoring program. More analysis would have to be conducted to choose sampling locations.	Moderate capital costs due to size and extent of dilute plume. Moderate operation and maintenance costs.	Retained
Monitored Natural Attenuation	Monitored Natural Attenuation	Monitored Natural Attenuation	Reliance on natural destructive (biodegradation and chemical reactions) and nondestructive mechanisms (dilution, dispersion, volatilization, and adsorption) to reduce contaminant levels in the context of a long term monitoring program. Under favorable conditions, these physical, chemical, or biological processes act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in the groundwater.	Effective for sites that have demonstrated to be utilizing natural mechanisms to minimize or prevent the further migration of groundwater contamination. Similar concentration ratios for PCE and daughter products encountered throughout the downgradient plume suggest that biodegradation is not a dominant process affecting the contaminants. However, dilution and dispersion may be more important contributors to attenuation.	Implementable. Materials and services necessary to model and monitor the contaminant dynamics are readily available. Site restrictions and/or institutional controls may be required as long-term control measures as part of the MNA alternatives.	Low capital costs. Low operation and maintenance costs.	Retained
Containment	Containment Wall	Secant Pile, Sheet Pile Barrier, or Slurry Wall	Retardation of groundwater and plume flow via a containment wall to minimize exposures to human and/or ecological receptors and allow more time for extraction or contact time for in-situ remedies.	Unlikely to be effective at achieving hydraulic control on its own. Would need to be coupled with hydraulic control via pumping. Would be effective at retarding continued migration off site.	Difficult to implement. The contamination reaches depths up to 60 feet bgs in the dilute plume which may make wall installation difficult. The plume width also expands to over 700 feet which may be impractical to contain with a barrier wall. In addition, trenching will be disruptive to existing surface structures and may require repaving of excavated roads which will take additional time.	High capital cost, low to no O&M costs.	Not Retained
Extraction	Collection/ Hydraulic Control	Vertical Extraction Well(s)	Removal of groundwater to provide hydraulic control and capture of contaminants. Additionally, extraction wells may be installed as part of an extraction-injection well network for ex-situ or in-situ treatment systems. The specific extraction well locations would be determined through groundwater modeling and/or pilot testing.	Effective for limiting plume migration. Pump tests and groundwater modeling must be conducted to confirm whether extraction wells will be effective in containing the dilute plume. Additionally, the extracted groundwater will require treatment to remove the contaminants and will need to be coupled with additional technologies to be effective at achieving RAOs.	Not easily implementable. Necessary equipment and materials are readily available. However, implementation may be complicated by existing buildings and roads over areas of the dilute plume. In addition, the size and extent of the plume may require excessive amounts of pumping, treatment, and discharge.	High capital costs due to size and extent of dilute plume. Moderate O&M costs.	Not Retained
		Extraction Trenches	Removal of groundwater to provide hydraulic control and capture contaminants at shallow depths. The specific extraction trench location would be determined through groundwater modeling and/or pilot testing.	Effective for capturing groundwater to provide hydraulic control. To meet the RAOs, sufficient contaminant mass needs to be captured such that the cleanup objectives are met within a reasonable timeframe. Multiple extraction trenches may need to be installed to effectively address the full extent of the plume.	Not easily implementable. Necessary equipment and materials are readily available. However, the contamination reaches depths up to 60 feet bgs in the dilute plume which may make trenching impractical. The plume width also expands to over 700 feet which may be a difficult length to trench. In addition, trenching will be disruptive to existing surface structures and utilities and may require repaving of excavated roads which will take additional time.	High capital costs and moderate O&M costs.	Not Retained
		Air Sparging/Soil Vapor Extraction (AS/SVE)	Injection of air into the contaminated groundwater aquifer. Volatile organic contaminants partition into the air stream as it is flushed into the unsaturated zone. Soil vapor extraction (SVE) may be implemented in conjunction with air sparging to remove the vapor-phase contamination from the vadose zone by vacuum extraction and vapor treatment to mitigate impacts to surface receptors.	Likely to be effective. Air sparging is generally most effective for removal of volatile, relatively insoluble organics from a highly permeable, relatively uniform sandy aquifer (Bass 2000). The brown silty sand in the saturated zone is well suited for air sparging in the dilute plume. A pilot test would be necessary to confirm effectiveness.	Not easily implementable. The dilute plume runs through mostly residential areas which may contain sensitive receptors and require detailed care to limit risk of vapor intrusion in the residential buildings. In addition, existing surface structures and public roads may limit access and space for implementation.	High capital costs due to size and extent of dilute plume. Moderate O&M costs.	Not Retained

Table 6-2
Dilute Plume Technology Screening Table
Wantagh Cleaners Site Hempstead, New York

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Implementability	Relative Cost[a]	Retained
In-situ Treatment	In-Situ Biological Treatment	Enhanced Anaerobic Bioremediation (EAB)[b]	Injection of an additive into the contaminated aquifer to promote the biodegradation of contaminants by naturally occurring microorganisms called D*ehalococcoides* (DHC) under reducing conditions. Additives may include common substrates like sodium lactate, molasses, or proprietary amendments with liquid activated carbon.	Likely to be effective. However, extent of success depends on site conditions, availability of the DHC bacteria (for complete reductive dechlorination of chlorinated solvents). The relatively homogeneous silty sand characterizing the contaminated aquifer in the dilute plume area will support the distribution of a substrate. However, detailed characterization of the lithology would be critical for the design and implementation of successful EAB treatment. A pilot study would be needed to determine effectiveness.	Implementable. However, implementation can be complicated by existing surface structures and public roads. Based on the method selected, multiple injections may be required and monitoring is necessary. A substrate with multiple-year longevity would be preferred. Multiple applications may be necessary due to back diffusion.	Moderate to high capital and moderate O&M costs. May be over several years if multiple rounds of amendment injections are necessary.	Retained
		Aerobic Cometabolic Bioremediation (ACB)	Injection of oxygen and/or primary substrate into the contaminated aquifer to promote cometabolism of contaminants in conjunction with the metabolism of a primary substrate (such as methane), which aerobic microorganisms use for carbon source and/or energy. PCE is not considered to be biodegradable under aerobic conditions.	May be effective for biodegradation of TCE, cis-1,2-DCE, and vinyl chloride. However, ACB will not be effective in treating the main contaminant, PCE.	Implementable. However, implementation can be complicated by potential access limitations to existing surface structures and public roads.	Moderate capital and moderate O&M costs.	Not Retained
	In-Situ Biogeochemical Transformation	Permeable Reactive Barrier (PRB)[a,b]	Installation of an in-ground trench backfilled with reactive media to provide passive treatment of contaminated groundwater as it passes through the trench. Can be installed as permanent, semi-permanent, or replaceable units which transect the plume flow path and act as a treatment wall.	Effective in degrading chlorinated solvents. However, PRBs require periodic reactivation to retain effectiveness. In addition, multiple PRBs may need to be installed to effectively address the full extent of the plume.	Difficult to implementable. The contamination reaches depths up to 60 feet bgs in the dilute plume which may make PRB installation difficult. The plume width also expands to over 700 feet which may be impractical to address with PRBs. In addition, trenching will be disruptive to existing surface structures and utilities and may require repaving of parking areas and roads which will take additional time.	Moderate to high capital and low O&M costs. The replacement cost could be as high as the capital cost.	Not Retained
	In-Situ Chemical Treatment	In-Situ Chemical Oxidation (ISCO)[b]	Injection of strong chemical oxidants (e.g., H_2O_2, S_2O_8, $KMnO_4$, and/or O_3) into the contaminated aquifer to oxidize organic contaminants. Complete oxidation of contaminants results in their breakdown into innocuous compounds such as carbon dioxide, water, and chloride.	Not likely to be effective. Due to the low concentrations of contaminants in the dilute plume, injected oxidants may be spent more on satisfying native oxidant demand than treating the contaminants. Also, amendments will be consumed too quickly to provide long-lasting treatment to the dilute plume.	Implementable. Equipment and vendors would be available. In addition, a long-lasting oxidant, such as permanganate, would be preferred compared to the oxidants that rely on the oxidation power of radicals in order to be able to treat contaminants that may be diffused out of the soil. It usually requires three to five rounds of application for mass reduction. Existing surface structures may limit access in the dilute plume.	Very high capital costs due to size and extent of dilute plume. Moderate O&M costs. Not as cost effective in the plume as in source areas.	Not Retained
		In-Situ Chemical Reduction (ISCR)[b]	Injection of a reductant to chemically reduce contaminants to non-hazardous compounds. The most widely used reductant for reducing chlorinated hydrocarbons is zero-valent iron (ZVI).	Potentially effective. ZVI and the associated proprietary products (such as EHC® or EZVI) can effectively treat contaminated groundwater aquifers containing PCE, TCE, and their degradation products if distributed effectively in the treatment zone. For the dilute plume, evenly distributing ZVI or the proprietary products in the groundwater is expected to be largely feasible due to the relative homogeneity of the silty sandy aquifer. However, a pilot study would be necessary to collect site-specific design parameters and determine effectiveness.	Implementable. Equipment and experienced vendors would be available. Achieving adequate distribution of the ISCR amendment would be feasible. However, implementation may be complicated by the presence of existing surface structures and public roads. Based on the method selected, multiple injections may be required and monitoring is necessary. A field pilot study may be necessary to obtain design parameters.	Very high capital costs due to size and extent of dilute plume. Depending on the delivery technology and the depth of contamination, the O&M cost could be minimal, mainly for monitoring.	Retained
	In-Situ Physical Treatment	In-Situ Thermal Remediation (ISTR)	Application of heat to subsurface soils and groundwater using technologies such as electrical resistivity heating (ERH), steam enhanced extraction, or electro thermal dynamic stripping process. Vaporized chlorinated solvents are usually extracted by an SVE system.	Not likely to be as effective in the dilute plume as in source areas. Also involves intensive energy use and increased temporary health and safety (H&S) risks for people.	Difficult to implement. Since the dilute plume runs through mostly residential neighborhoods, this technology will pose H&S risks to residents and is largely impractical to implement in the dilute plume.	Very high capital costs. High O&M costs for a relatively short period of time.	Not Retained
		In-Well Vapor Stripping	Installation of groundwater recirculation cells in the contaminated aquifer to strip contaminants from the aqueous to vapor phase. Stripped contaminants are treated above surface while groundwater is recirculated back into the cells.	Effectiveness dependent on site conditions. A shallow vadose zone like at the Site may limit system effectiveness due to limited space for reinfiltration or circulation. In addition, the shallow vadose zone may limit the radius of the treatment zone and require more treatment wells than typically used.	Not easily implementable. However, implementation can be complicated by potential access limitations to existing surface structures and public roads. In addition, the size and extent of the plume may require excessive amounts of recirculation and discharge.	High capital and low O&M costs.	Not Retained

Table 6-2
Dilute Plume Technology Screening Table
Wantagh Cleaners Site Hempstead, New York

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Implementability	Relative Cost[a]	Retained
Ex-situ Treatment of Contaminated Groundwater	These options were not explored as no groundwater removal/extraction technologies were retained for the dilute plume.						
Disposal/ Discharge							

Notes:
* Denotes an innovative technology.
a Relative costs presented in this table are determined based on judgement, previous experience and preliminary quotations from vendors.
b Pilot scale testing may be required.

Table 6-3
On-Site Vadose Zone Technology Screening Table
Wantagh Cleaners Site Hempstead, New York

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Implementability	Relative Cost[a]	Retained
No Action	None	No Action	No action would be taken. The source area and site-wide contamination will remain in their existing conditions.	Ineffective. No Action alternative retained as baseline for comparison with other alternatives.	Implementable. No significant administrative difficulties anticipated.	No capital, operation, or maintenance costs. Would require some long-term costs for periodic reassessment.	Retained (as per DER-10)
Institutional and Engineering Controls	Land Use Controls	Government and Proprietary Controls	Restriction of intrusive activities such as future site construction and subsequent exposure to contaminated media in source areas.	Likely to be effective for reducing or minimizing additional site-related contamination exposure risk to current and future workers in affected buildings and to potential future construction workers performing excavation at the site. However, effectiveness is dependent on proper enforcement. Vapor intrusion is already occurring in the on-site building and the adjacent convenience store. Therefore, these controls may need to be coupled with sub-slab depressurization to minimize health risks associated with existing vapor intrusion. Also, these controls would not reduce the toxicity, mobility, or volume (T/M/V) of contaminated soils nor prevent contaminants in the vadose zone from migrating to the groundwater.	Implementable. Would require the local government to enforce and monitor the controls over the long term.	Low capital costs. Some administrative, long-term monitoring and/or periodic assessment cost would be required.	Retained
		Fencing and Signs	Installation of fences around contaminated areas to limit access and minimize direct human exposure to contaminated soil. Fencing is often installed with signs that indicate the risks.	Effective for minimizing, not preventing, human contact with the contaminated materials or potential hazards during remedial action. However, fencing and signs would not reduce the T/M/V of contaminated soils nor prevent contaminants in the vadose zone from migrating to the groundwater.	Implementable. However, the presence of an existing business on-site may make it difficult to limit access to certain areas. Fencing would also require inspection and maintenance.	Low capital and O&M costs.	Retained
	Community Awareness	Information and Education Programs	Bring awareness to local community of potential hazards, available technologies capable of addressing the contamination, and the remediation progress.	Effective for protecting human health by bringing increased awareness to the public of the contaminated conditions and enhancing implementation of other institutional controls or engineering controls (such as land-use controls) within the contaminated area.	Implementable.	Low capital and O&M costs.	Retained
	Subslab Depressurization System	SSDS	Installation of a negative pressure field directly under a building slab. The negative pressure field becomes a "sink" for any vapors present in the vicinity of the structure.	Effective for preventing or minimizing soil vapor intrusion. If implemented on-site, it would not reduce the migration and associated environmental impact of contaminated soil vapor in and around other off-site structures.	Easily implementable. Construction materials and services are readily available.	Moderate capital and low O&M costs.	Retained
Containment	Barriers	Asphalt/Concrete Cap	The surface of the contaminated area is paved with asphalt or concrete to eliminate direct contact and reduce infiltration and vapor intrusion.	Likely to be effective in reducing leaching of contaminants in the vadose zone to groundwater. However, the cap will not completely eliminate infiltration and vapor intrusion. Long term effectiveness will depend on proper maintenance.	Already implemented on-site with a building slab and asphalt paved roads and parking lot.	Low capital costs and low O&M costs.	Not Retained (Already Implemented)

Table 6-3
On-Site Vadose Zone Technology Screening Table
Wantagh Cleaners Site Hempstead, New York

General Response Action	Remedial Technology	Process Option	Description of Response Action	Effectiveness	Implementability	Relative Cost[a]	Retained
Removal/ Extraction	Excavation	Excavation	Excavation of contaminated soils for consolidation, treatment, and/or disposal.	Effective for removing contaminant mass in the vadose zone where vapor intrusion is present, thus significantly decreasing vapor intrusion and minimizing the impact to groundwater. May not be able to excavate all contaminated soils in the unsaturated zone in the source area due to the proximity to buildings.	Difficult to implement. Since the majority of the on-site building footprint is contaminated, excavation underneath the building would be very complicated especially with an active business in the building. In addition, the Site is bordered by densely populated roadways. Obtaining access to entire sections of the roads for excavation work would also be very difficult.	Moderate to high capital costs for excavation at shallow depths with structural support for buildings. No O&M costs.	Not Retained
	Soil Vapor Extraction (SVE)[b]	Soil Vapor Extraction (SVE)[b]	Installation of vapor extraction wells screened in the unsaturated zone to enhance volatilization and remove volatilized contaminants. The extraction systems are coupled with blowers or vacuum pumps to create a vacuum. Increased air flow through the soil allows enhanced mass transfer from adsorbed, dissolved, and free product phases in the soil to the vapor phase. An off-gas treatment system is often utilized to treat the contaminated vapor prior to discharge to the atmosphere.	Effective for preventing vapor intrusion and potentially addressing unsaturated zone impacts due to primarily sandy soils in the vadose zone which encourages air flow. SVE would reduce contaminant concentrations in soil and soil vapor beneath the buildings. A pilot study typically would be necessary prior to the design and implementation of an SVE system to measure relevant parameters and determine effectiveness.	Implementable. A permit for off-gas treatment and discharge also would be required to implement an SVE system.	Low to moderate capital and O&M costs.	Retained
	Dual Phase Extraction (DPE)[b]	Dual Phase Extraction (DPE)[b]	Combined extraction of soil vapor and groundwater utilizing extraction wells screened across the saturated and unsaturated zones. A pump is utilized to extract groundwater while a vacuum is applied to the wellhead to extract soil gas. Both aqueous and vapor streams would require ex-situ treatment.	Effective for reducing mass of contaminants in groundwater and soil. The extracted groundwater and vapor will require treatment. The silty sandy lithology in the vadose zone has a suitable permeability for DPE. A pilot study typically would be necessary prior to the design and implementation of a DPE system to measure relevant variables and determine effectiveness.	Implementable. Necessary equipment and materials are readily available. However, implementation may be complicated by existing surface structures including an occupied building and parking lot onsite and congested main roads offsite.	Moderate capital costs and moderate O&M costs.	Retained
In Situ Treatment	*In situ* Thermal Remediation (ISTR)	*In situ* Thermal Remediation (ISTR)	Application of heat to subsurface soils using technologies such as electrical resistivity heating (ERH), steam enhanced extraction, or electro thermal dynamic stripping process. Vaporized chlorinated solvents are usually extracted by an SVE system.	Very effective in source areas, but also involves intensive energy use and increased temporary health and safety (H&S) risks for on-site workers which can be addressed through proper engineering controls and other H&S measures.	Not easily implementable. Heating well installation may be limited inside the currently occupied on-site building. Implementing ISTR might require modification or temporary shutdown of the existing operation in the building and temporary shutdown of the nearby roads which would be subject to approval from the property owner and the municipality respectively.	High capital costs. High O&M costs for a relatively short period of time.	Retained
Ex Situ Treatment of Off-Gas and Vapors	Ex Situ Chemical Treatment	Chemical Oxidation	Neutralization and oxidation of contaminants in extracted soil vapor or treatment off-gas with a strong oxidant such as potassium permanganate.	Effective in removing contaminants from the off-gas.	Implementable. Equipment and materials would be readily available through vendors. This technology could be implemented with SVE or ISTR technologies and/or as part of the off-gas treatment in a DPE remedy. It can also be used as a second treatment step after carbon adsorption. This technology generally does not require a treatability study.	Moderate capital and O&M costs.	Retained
		Thermal Oxidation	Destruction of contaminants in vapor streams at elevated temperatures through combustion or oxidization. Types of thermal oxidation include direct-flame thermal oxidation, flameless thermal oxidation, catalytic oxidation, hybrid thermal/catalytic oxidation, heat recovery, and internal combustion engines (ICEs).	More effective for treating off-gases with high concentrations of vapor contaminants. This is usually done in the initial stages of treatment. After concentration has been reduced, thermal oxidation is usually replaced with carbon adsorption treatment.	Not easily implementable. Equipment and materials would be readily available. It can be used for vapor contaminants from SVE, DPE, and/or ISTR remedies. However, the presence of chlorinated VOCs like TCE at the site may lead to the formation of acid gases during vapor combustion which will require acid resistant materials in the treatment system. These acid gases may also require further treatment. Due to limited access and space, smaller treatment systems may be more suitable at this site. Discharging the treated gas would generally require a permit.	High capital and O&M costs.	Not Retained
	Ex Situ Physical Treatment	Carbon Adsorption	Adsorption of contaminants in vapor phase or off-gas onto an adsorbent (usually granular activated carbon) before discharging air into the atmosphere.	Effective in removing PCE, TCE, and cis-DCE. Less effective in the removal of vinyl chloride which have both been detected above regulatory limits in the on-site vadose zone under the on-site building.	Implementable. Equipment and materials would be readily available. Adsorption treatment can be used directly for an SVE system or in the treatment train for off-gas management in the DPE or ISTR remedy. This technology generally does not require a treatability study. Due to limited access and space, a smaller adsorption vessel may be suitable at this site. Discharging the treated gas would generally require a permit.	Moderate capital and O&M costs. O&M costs would be high if used on vapor treatment with high concentrations.	Retained

Notes:
a Relative costs presented in this table are determined based on judgement, previous experience and preliminary quotations from vendors.
b Pilot scale testing may be required.

Table 7-1
Summary of Alternatives Evaluation
Wantagh Cleaners Site Hempstead, New York

Evaluation Criterion	ALTERNATIVE 1 No Action	ALTERNATIVE 2 SVE, In Situ Treatment, MNA and IC	ALTERNATIVE 3 SVE, Recirculating In-Well Air Stripping, In Situ Treatment, MNA and IC	ALTERNATIVE 4 SVE, Air Sparging and In Situ Treatment, MNA and IC	ALTERNATIVE 5 SVE, ISTR, and In Situ Treatment
Summary of Components	None	- Remedial Design - Pre-Design Investigation - Soil Vapor Extraction - Vapor Mitigation - *In Situ* Treatment - Monitored Natural Attenuation - Performance Monitoring - Institutional Controls - Five Year Review	- Remedial Design - Pre-Design Investigation - Soil Vapor Extraction - Vapor Mitigation - Recirculating In-Well Air Stripping - *In Situ* Treatment - Monitored Natural Attenuation - Performance Monitoring - Institutional Controls - Five Year Review	- Remedial Design - Pre-Design Investigation - Soil Vapor Extraction - Vapor Mitigation - Air Sparging - *In Situ* Treatment - Monitored Natural Attenuation - Performance Monitoring - Institutional Controls - Five Year Review	- Remedial Design - Pre-Design Investigation - Soil Vapor Extraction - Vapor Mitigation - In Situ Thermal Remediation - *In Situ* Treatment - Monitored Natural Attenuation - Performance Monitoring - Institutional Controls - Five Year Review
Overall Protection of Human Health and the Environment	This alternative does not provide overall protection of human health and the environment and does not meet the RAOs. This alternative does not prevent future use of contaminated groundwater, nor does it mitigate vapor intrusion impacts above the plume.	This alternative provides protection through active groundwater remediation, monitoring, and institutional controls. Additionally, SVE and vapor mitigation for the on-site and nearby building would ensure that occupants are protected from vapor contamination. However it does not offer active remediation in the dilute plume and thus may be less protective (or take longer to provide full protection) if rates of attenuation are slow.	This alternative provides protection through active groundwater remediation, monitoring, and institutional controls. Additionally, SVE and vapor mitigation for the on-site and nearby building would ensure that occupants are protected from vapor contamination. However it does not offer active remediation in the dilute plume and thus may be less protective (or take longer to provide full protection) if rates of attenuation are slow.	This alternative provides protection through active groundwater remediation, monitoring, and institutional controls. Additionally, SVE and vapor mitigation for the on-site and nearby building would ensure that occupants are protected from vapor contamination. However it does not offer active remediation in the dilute plume and thus may be less protective (or take longer to provide full protection) if rates of attenuation are slow.	This alternative is expected to be the most protective as it involves active treatment in the source zone and the dilute plume, as well as monitoring and institutional controls.
Compliance with New York State SCGs	This alternative would not comply with the chemical-specific SCGs for groundwater.	This alternative is expected to eventually meet SCGs although high levels of contaminants currently observed requires proper design and implementation.	This alternative is expected to eventually meet SCGs although high levels of contaminants currently observed requires proper design and implementation.	This alternative is expected to eventually meet SCGs although high levels of contaminants currently observed requires proper design and implementation.	This alternative is expected to be the fastest in complying with SCGs due to the aggressive thermal treatment and active treatment in the dilute plume.
Long-Term Effectiveness and Permanence	This alternative is not considered to be a permanent remedy and will not provide adequate control of risk to human health or the environment.	This alternative is expected to meet this criteria fully.			
Reduction of Toxicity, Mobility, or Volume	The implementation of this alternative would not affect the toxicity, mobility, or volume of the contaminants.	SVE and in-situ treatment would reduce T/M/V through removal and destruction, respectively.	SVE, recirculating in-well air strippers, and in situ treatment would reduce T/M/V through removal and contaminant destruction.	Air sparging, SVE, and in-situ treatment would reduce T/M/V through removal or destruction.	ISTR, SVE, and in-situ treatment would reduce T/M/V through removal or destruction. This alternative is expected to have the most reduction of T/M/V due to active treatment in the dilute plume.
Short-term Effectiveness	This alternative would not include a remedial action. Therefore, it would have no short-term impacts on workers, the community, or the environment.	The short-term impacts of this alternative are not expected to be significant. However, activities such as installation of wells, injection of amendments, and operation of the SVE system can potentially result in inconveniences to the local community through noise, temporary disruption to traffic etc. These impacts can be minimized if proper procedures and protocols are followed during the implementation of this alternative.	The short-term impacts of this alternative are not expected to be significant. However, activities such as installation of wells and operation of the SVE system can potentially result in inconveniences to the local community through noise, temporary disruption to traffic etc. These impacts can be minimized if proper procedures and protocols are followed during the implementation of this alternative.	The short-term impacts of this alternative are not expected to be significant. However, activities such as installation of sparge points, injection of amendments, and operation of the SVE system can potentially result in inconveniences to the local community through noise, temporary disruption to traffic etc. These impacts can be minimized if proper procedures and protocols are followed during the implementation of this alternative.	This alternative is expected to have the highest short-term impacts. Activities such as installation of wells, injection of amendments and operation of the SVE system can potentially result in inconveniences to the local community through noise, temporary disruption to traffic etc. ISTR installation may also be a health risk to on-site workers. These impacts can be minimized if proper procedures and protocols are followed during the implementation of this alternative.
Implementability	This alternative is easily implemented, since no services or permits would be required.	Space would be required for the remedial action inside and around the site building for drill rigs, piping, and equipment. Traffic may need to be temporarily controlled on the nearby streets. Given that drilling and injection would be conducted in one location at a time, it is unlikely that operations of the dry cleaner would need to be substantially disrupted for an extended duration.	Space would be required for the remedial action inside and around the site building for drill rigs, piping, and equipment. Operations of the dry cleaner will be slightly curtailed during installation of the system. However, operations will likely not be impacted during operations.	Space would be required for the remedial action inside and around the site building for drill rigs, piping, and equipment. Traffic may need to be temporarily controlled on the nearby streets. Operations of the dry cleaner will be curtailed during installation of the system. However, the dry cleaner's business operations will likely not be impacted during operations since the sparge points, SVE, and piping would be buried under the parking lot.	This alternative is expected to be the least implementable as it would require curtailing the operation of the on-site dry cleaners during installation and operation of the ISTR system for at least six months. Space would be required for the remedial action inside and around the site building for drill rigs, piping, and equipment. Traffic may need to be temporarily controlled on the nearby streets. Off-site, the installation of the treatment barriers is expected to be implementable since they can be installed on city streets, sidewalks, or grass strips.
Present Worth with Discounting	$0	$3,153,000	$3,208,000	$2,919,000	$9,490,000

CDM Smith

Appendix A

Record of Decision (ROD) Tables and Figures

Table 1
Wantagh Cleaners Site
(1-30-064)
Soil Sampling Results
Samples Collected in August 1997 and September 1997

SAMPLE LOCATION:	On-Site							Soil Background Conditions	Soil Cleanup Objectives
SAMPLE DESIGNATION:	S1	S2	S3	S4	S5	S6	SD-1	SB-1	
SAMPLE DEPTH, FEET:	10-12'	4-6'	4-6'	2-4'	10-12'	2-4'	0-0.5'	0-3'	
UNITS:	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
VOCs:									
1,2-Dichlorethene	--	--	0.030	**0.800**	--	0.004	--	--	0.300
2-Butanone	--	--	--	**0.440**	--	--	--	--	0.300
Trichloroethene	--	--	0.011	--	--	--	0.003	0.003	0.700
Tetrachlorethene	--	--	0.110	--	--	0.007	0.014	0.170	1.400
Ethylbenzene	--	--	--	--	0.066	--	--	--	5.500
Xylene (total)	--	--	--	--	0.320	--	--	--	1.200
Toluene	--	--	--	--	--	--	0.008	--	1.5

-- Indicates that the analyte was not detected.
Detected Values that are greater than NYS TAGM soil cleanup objectives appear in **bold**.
S On site soil sampling locations
SD Storm Drain sediment sample (composite of four grab samples at a 6 inch depth)
SB Soil background conditions, collected from an unaffected on-site location near the northern property line.

Table 2
Wantagh Cleaners Site
(1-30-064)
Groundwater Sampling Results
Samples Collected in August 1997, September 1997, and July 1998

SAMPLE LOCATION:	On-Site			Off-Site														NYS Class GA
SAMPLE DESIGNATION:	MW-1	MW-2	MW-3	DW-11	DW-35	DW-55	GB-1	GB-1	GB-2	GB-2	GB-3	GB-3	GB-4	GB-4	GB-5	GB-5	Groundwater
SAMPLE DEPTH, FEET:	9-19'	9-19'	9-19'	10-12'	34-36'	54-56'	10-12'	50'	10-12'	50'	10-12'	50'	10-12'	50'	10-12'	50'	**Standard**
UNITS:	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
VOCs:																	
Vinyl Chloride	–	–	–	–	–	–	–	–	–	–	1.7	–	–	–	–	–	2
1,2-Dichloroethene	**8,000**	**4,500**	2.0	–	–	–	1.6	–	–	–	**32.0**	–	–	–	–	–	5
Bromodichloromethane	–	–	–	–	–	–	1.7	–	1.2	–	–	–	–	–	–	–	N/A
Methylene Chloride	–	**270**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
1,1-Dichloroethane	–	–	0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	5
1,1,1-Trichloroethane	–	–	0.6	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Ethylbenzene	–	–	–	–	0.4	–	–	–	–	–	–	–	–	–	–	–	5
Xylene	–	–	–	–	0.9	–	–	–	–	–	–	–	–	–	–	–	5
Trichloroethene	**52**	**3,300**	3.0	–	–	–	–	–	–	–	**28.0**	–	–	–	–	–	5
Tetrachloroethene	**46**	**35,000**	**12.0**	–	–	–	2.7	–	–	–	**73.0**	–	–	–	–	–	5

– Indicates that the analyte was not detected.

Detected Values that are greater than NYS TAGM soil cleanup objectives appear in bold.

MW On-site shallow monitoring wells sampled during the FRI.

DW Off-site deep monitoring well cluster, installed and sampled during the FRI.

GB Off-site geoprobe location, sampled during the Supplemental FRI.

Figure 2
Wantagh Cleaners Site
(1-30-064)
Site Plan and Sampling Locations

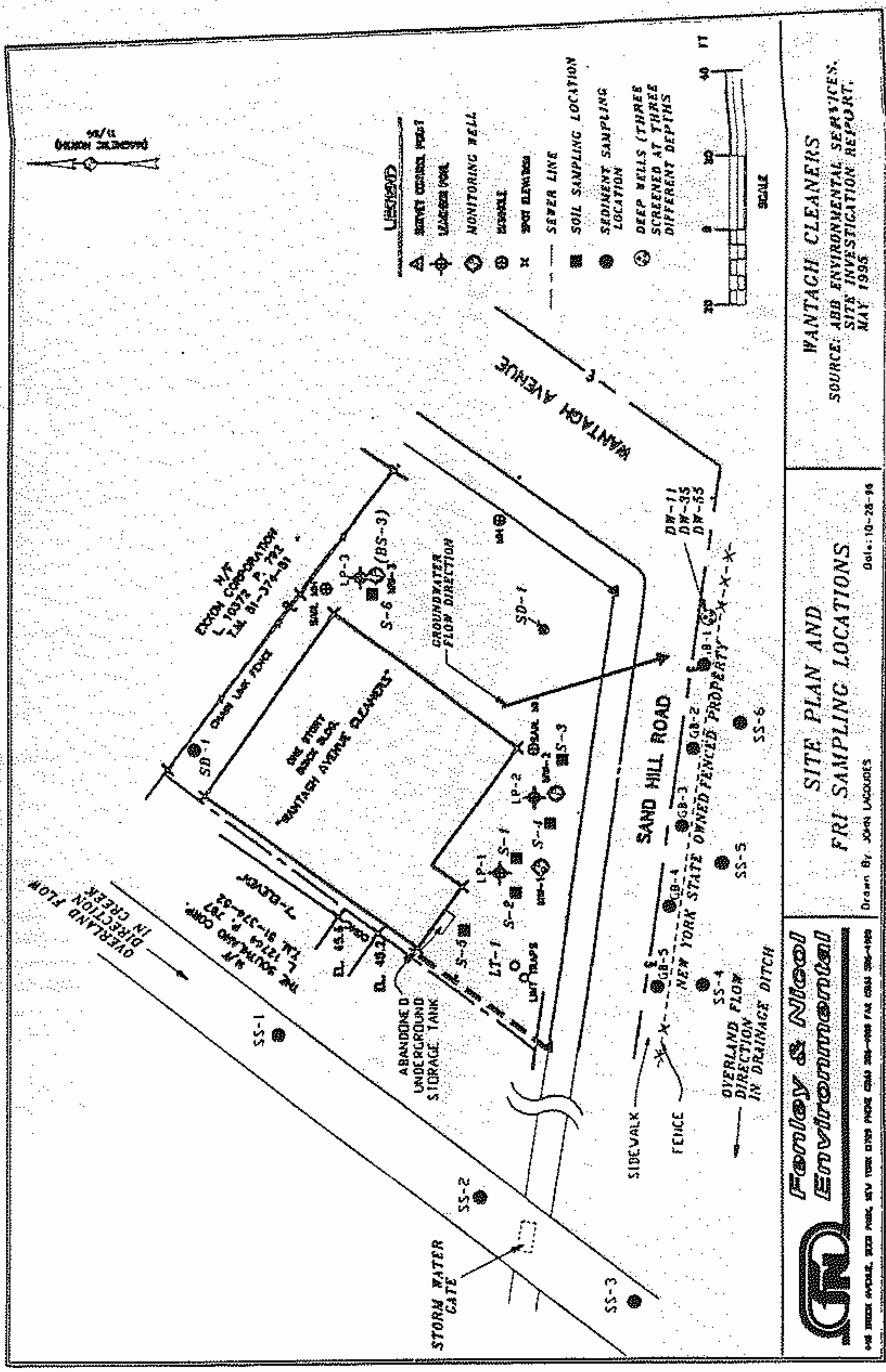
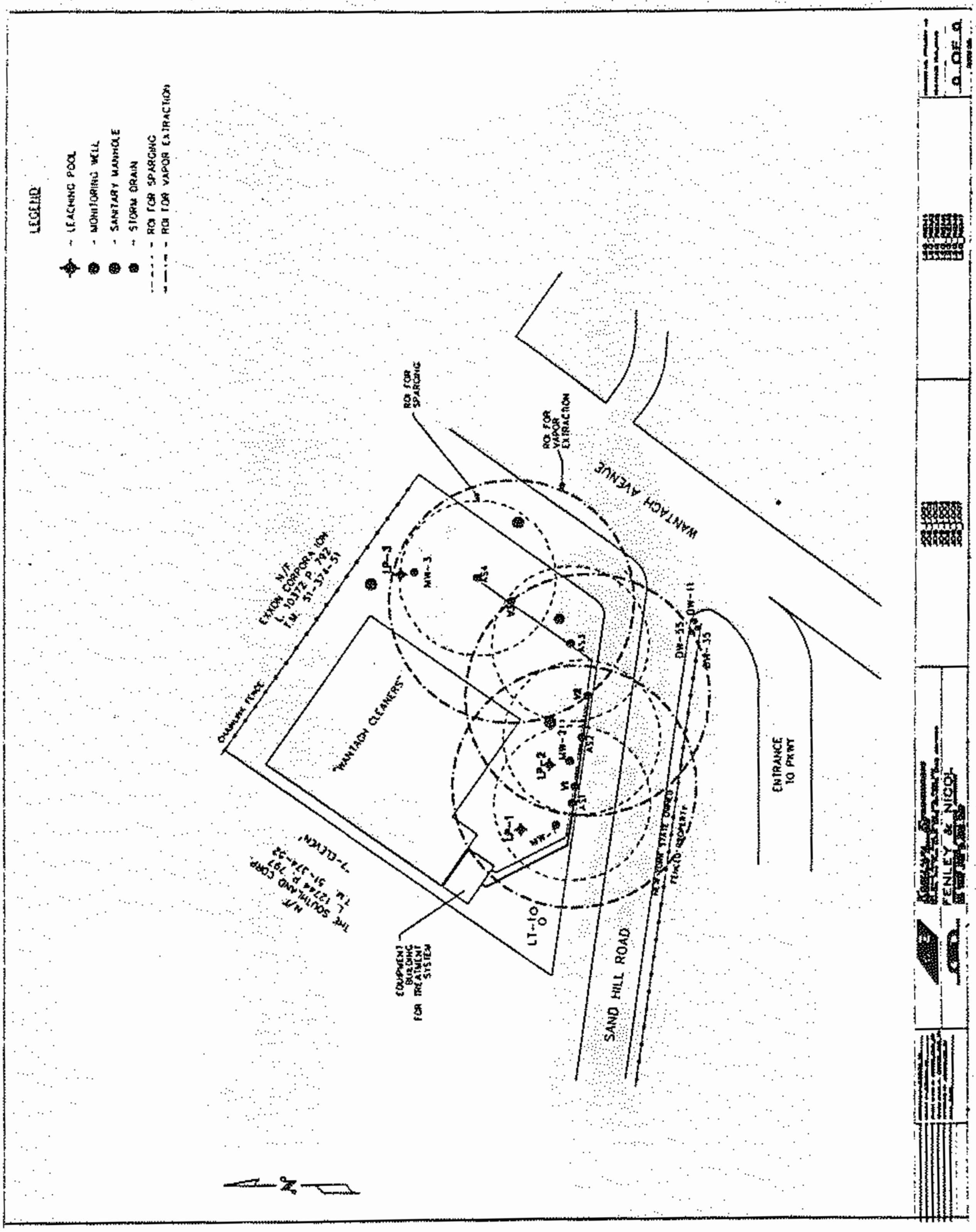


Figure 3
Wantagh Cleaners Site
(1-30-064)
IRM Design



Appendix B

Cost Details for Remedial Alternatives

Cost Estimate for Common Elements
Wantagh Cleaners Site
Hempstead, New York

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	
CLIENT:	NYSDEC			PAGE NO. :	

SUMMARY OF COSTS

Item Description	Extended Cost
CAPITAL COSTS	
Pre-Design Investigation	$ 129,000
Vapor Mitigation	$ 34,100
SVE System	$ 300,000
MONITORING COSTS PER EVENT	
Long Term Monitoring of soil vapor and surface water (20 years)	$ 16,000
PRESENT WORTH (with discounting)	
Total Capital Costs	$ 463,100
Total Monitoring Costs	$ 169,504
TOTAL PRESENT WORTH	**$ 633,000**

Present worth assumes a 7% discount rate

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	
CLIENT:	NYSDEC			PAGE NO. :	

Description: Common Elements

		Quantity	Unit	Unit Cost		Extended Cost
No. 1	**Pre-design Investigation**					
1a.	**Project Management and Office Support**					
	Include project management, subcontractor procurement, preparation of Work Plan and HASP					
	Project Manager	16	hr	$150	=	$2,400
	Project Engineer	40	hr	$100	=	$4,000
	Geologist	40	hr	$100	=	$4,000
	Administrative Assistant	10	hr	$80	=	$800
	Total Project Management and Office Support					**$11,200**
1b.	**Hollow Stem Auger and Geoprobe**					
	Source Zone Monitoring Wells to install	6	wells			
	Well depth	20	ft			
	Screen length	10	ft			
	Dilute Plume Monitoring Wells to install	6	wells			
	Well depth	40	ft			
	Screen length	10	ft			
	Total Linear Feet	360	ft			
	Drilling					
	Driller mob/demob	1	LS	$5,000	=	$5,000
	Utility Clearance, Permits & Soft Dig	1	LS	$2,500	=	$2,500
	Well Logs and Permits	12	each	$350	=	$4,200
	4" hollow stem auger drilling	360	ft	$22	=	$7,920
	Casing and mount	12	ea	$300		$3,600
	Well development	36	hr	$170	=	$6,120
	IDW disposal	1	LS	$5,000	=	$5,000
	Subtotal for Monitoring Wells installation					**$34,340**
	Groundwater Screening					
	Driller mob/demob	1	LS	$4,000	=	$4,000
	Utility Clearance, Permits & Soft Dig	1	LS	$2,500	=	$2,500
	Geoprobe	2	days	$2,000	=	$4,000
	Subtotal for Groundwater Screening					**$10,500**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
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Description: Common Elements

1c.	**Groundwater Samples**					
	Monitoring Wells to sample	18	wells			
	Groundwater screening	2	days			
	Groundwater screening samples	10	samples			
	Number of samplers	2	people			
	Number of 12 hour workdays	6.5	days			
		Quantity	Unit	Unit Cost		Extended Cost
	Field Sampling Labor					
	Mob/demob	10	hr	$95	=	$950
	Well Sampling	156	hr	$95	=	$14,820
	Travel Expense and per Diem					
	Van and car rental	6.5	day	$95	=	$618
	Sampling Equipment, Shipping, Consumable Supplies					
	Equipment & PPE	1	ea	$3,500	=	$3,500
	Shipping	6.5	day	$200	=	$1,300
	Misc	6.5	day	$75	=	$488
	Sampling Analysis					
	VOCs	37	ea	$80	=	$2,920
	MEE	12	ea	$120	=	$1,440
	TOC	12	ea	$30	=	$360
	Nitrate	12	ea	$25	=	$300
	Sulfate	12	ea	$25	=	$300
	Ferrous Iron	12	ea	$18	=	$216
	Chloride	12	ea	$15	=	$180
	Alkalinity	12	ea	$20	=	$240
	Metals	12	ea	$120	=	$1,440
	Dehalococcoides	6	ea	$450	=	$2,700
	Data Management and Validation					
	Assume samples validated @ 0.5 hr per sample per analyte					
	Samples management/validation	139	hr	$80	=	$11,080
	Total Synoptic Water Level and Groundwater Sampling					**$42,851**
1d.	**Pre-design Investigation Report**					
	Assume include the data evaluation and management during sampling					
	Project Manager/Senior Reviews	40	hr	$150	=	$6,000
	Project Engineer	120	hr	$100	=	$12,000
	Project Geologist	120	hr	$100	=	$12,000
	Total Pre-design Investigation Report					**$30,000**
	TOTAL PRE-DESIGN INVESTIGATION:					**$129,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
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Description: Common Elements - Subslab Depressurization System

SSDS Installation

To be used at adjacent convenient store for vapor intrusion impacts.

	Quantity	Units	Unit Cost		Total Cost
Labor Costs	1	LS	$6,400	=	$6,400
Subcontractors	1	LS	$26,100	=	$26,100
Subcontractor Management Fee	1	LS	$1,100	=	$1,100
Fixed Fee	1	LS	$500	=	$500
TOTAL FOR SSDS INSTALLATION				=	**$ 34,100**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
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Description: Common Elements

Treatment: SVE

Without a field test, the flow rate and vacuum for a conceptual design are not available. Therefore, costs of similar projects are used in this cost estimate.

	Quantity	Units	Unit Cost		Total Cost
Radius of Influence of SVE wells	15	Ft			
Total number of SVE wells	10				
Boring depth	10	Ft			
Mob/demob (one DPT rig)	1	LS	$4,000	=	$4,000
Decon pad	1	LS	$750	=	$750
Decon of equipment	10	Hr	$200	=	$2,000
Concrete coring	10	LS	$425	=	$4,250
Geoprobe	10	days	$2,000		$20,000
Exhaust Control and dust suppression	10	LS	$375	=	$3,750
PVC screen	50	Ft	$15	=	$750
PVC casing	50	Ft	$20	=	$1,000
Well surface completion	10	Ft	$500	=	$5,000
IDW handling	10	ea	$250	=	$2,500
IDW roll-off rental and disposal	1	LS	$15,000	=	$15,000
TOTAL FOR SVE WELL INSTALLATION					**$ 59,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
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Description: Common Elements

Above ground piping and treatment system installation

Assume the piping will convey the extracted vapor to an aboveground system housed nearby for treatment

SVE system

Assume each well air flow rate is 5 SCFM.

Assume system comes prepackaged in Conex box.

	Quantity	Units	Unit Cost		Total Cost
SVE prepackaged system (including VPGAC)	1	LS	$74,000	=	$74,000
Potassium permanganate impregnated zeolite	2	LS	$5,000	=	$10,000
SVE well head completion	10	LS	$1,260	=	$12,600
Plumbing and ducting	1	LS	$16,000	=	$16,000
Electrical Wiring and Controls	1	LS	$50,000	=	$50,000
TOTAL FOR SVE ABOVEGROUND SYSTEM AND YARD PIPING					**$ 152,600**

SVE system startup

Assume two weeks for initial startup testing, two engineers on site for two weeks, plumber and electrician onsite for two weeks

	Quantity	Units	Unit Cost		Total Cost
Electrician	80	hr	$110	=	$8,800
Plumber	80	hr	$110	=	$8,800
Project Engineer	180	hr	$110	=	$19,800
Environmental Engineer	180	hr	$100	=	$18,000
Vapor samples	100	ea	$330	=	$33,000
Shallow Soil Vapor Point Installation (0-8')	6	each	$80	=	$480
TOTAL FOR SVE SYSTEM START UP					**$ 88,400**

TOTAL SVE SYSTEM CONSTRUCTION AND START UP COSTS	**$300,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	
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Description: Common Elements

Groundwater Sampling					
Surface Water Samples	2	samples			
Soil Vapor Samples	6	samples			
Number of samplers	2	people			
Number of 12 hour workdays	2	days			
Field Sampling Labor					
Mob/demob	8	hr	$95	=	$760
Sampling	48	hr	$95	=	$4,560
Travel Expense and per Diem					
Van and car rental	2	day	$150	=	$300
Sampling Equipment, Shipping, Consumable Supplies					
Equipment & PPE	1	ea	$1,000	=	$1,000
Shipping	2	day	$150	=	$300
Misc	2	day	$75	=	$150
Sampling Analysis (including QC samples)					
VOCs aqueous	4	ea	$80	=	$320
VOCs, air (TO-15)	7	ea	$200	=	$1,400
Data Management and Validation					
Assume samples validated @ 0.5 hr per sample per analyte					
Samples management/validation	6	hr	$80	=	$440
Data management	11	hr	$95	=	$1,045
Reporting					
Annual Letter Report	1	ea	$5,000	=	$5,000
Total Monitoring Costs (per event)					**$16,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
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Description: Common Elements

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

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

P = Present Worth

A= Annual amount

i = interest rate

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

Long Term Monitoring

n =	20
i =	7%
The multiplier for $(P/A)_2$ =	**10.594**

Cost Estimate for Alternative 2
Wantagh Cleaners Site
Wantagh, New York

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	
CLIENT:	NYSDEC			PAGE NO. :	

SUMMARY OF COSTS	
Item Description	**Extended Cost**
CAPITAL COSTS	
Pilot Study	$ 255,000
Remedial Design and General Conditions	$ 284,000
In Situ Treatment (assume two events)	$ 596,000
Common Elements	$ 463,100
Subtotal	*$ 1,598,100*
Contingency (20%)	$ 319,620
Subtotal	*$ 1,917,720*
General Contractor Bond and Insurance (5%)	$ 95,886
Subtotal	*$ 2,013,606*
General Contractor Markup (profit - 10%)	$ 201,361
TOTAL CAPITAL COSTS	**$ 2,215,000**
OPERATION, MAINTENANCE AND MONITORING COSTS PER EVENT	
SVE Performance Monitoring (annual for five years)	$ 36,000
SVE Operations and Maintenance (annual for five years)	$ 74,000
In Situ treatment Performance Monitoring (annual for ten years)	$ 18,000
Monitored Natural Attenuation (annual for 20 years)	$ 18,000
Common Elements	$ 169,504
PRESENT WORTH (with discounting)	
Total Capital Costs	$ 2,215,000
Total Operations, Maintenance, and Monitoring Costs	$ 938,000
TOTAL PRESENT WORTH	**$ 3,153,000**

Present worth assumes a 7% discount rate

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	
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Description: Cost Estimate for Alternative 2 - Soil Vapor Extraction and In Situ Treatment - Pilot Study

	Quantity	Units	Unit Price	Total
Treatability study - laboratory	1	LS	$60,000	$60,000
Pilot study - In Situ Treatment and SVE				
Pilot study work plan	1	LS	$30,000	$30,000
Mobilization/Demobilization	1	LS	$5,000	$5,000
Subcontractor - DPT	10	days	$3,200	$32,000
Subcontractor - SVE	1	LS	$50,000	$50,000
Amendment	1	LS	$10,000	$10,000
Sampling	30	samples	$100	$3,000
Labor	300	hours	$100	$30,000
Equipment and supplies	1	LS	$5,000	$5,000
Prepare treatability/pilot study results report	1	LS	$30,000	$30,000
TOTAL TREATABILITY AND PILOT STUDY COSTS:				**$255,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	
CLIENT:	NYSDEC			PAGE NO. :	

Description: Cost Estimate for Alternative 2 - Soil Vapor Extraction and In Situ Treatment - General Requirements

	Quantity	Units	Unit Price	Total
Remedial Design				
Include preparation of plans, specifications, and bid documents				
Project Management and meetings	$150	hr	80	$12,000
Prepare bid package	$100	hr	800	$80,000
Cost estimate	$100	hr	80	$8,000
Prepare final bid pacakage	$100	hr	550	$55,000
Bid engineering support	$100	hr	100	$10,000
Total Remedial Design				**$165,000**
Construction Management				
Include preparation of work plans such as QAPP, health and safety plan, etc.				
Project Manager	$150	hr	120	$18,000
Environmental Engineer	$100	hr	400	$40,000
Total Construction Management				**$58,000**
Permits				
Project Manager	$150	hr	6	$900
Permitting Specialist	$100	hr	16	$1,600
Total Permit Costs				**$2,500**
Surveying				
Total Surveying Costs	$1	LS	6000	**$6,000**
Final Remedial Action Report (RAR)/Construction Completion Report (CCR)				
Project Manager	$150	hr	80	$12,000
Engineer	$100	hr	400	$40,000
Total RAR Costs				**$52,000**
TOTAL GENERAL CONDITION COST				**$284,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	
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Description: Cost Estimate for Alternative 2 - Soil Vapor Extraction and In Situ Treatment - Treatment Cost Items

Treatment: In Situ

Treatment Volume (per injection event)

Number of soluble formulation injection points	9		
Assumed ROI at each on-site DPT injection well	10	feet	(assumed)
Vertical thickness of on-site upgradient treatment zones	10	feet	(assumed based on screened length in each well)
Volume of treatment zone	28260	cubic feet	
Assumed porosity of treatment zone	0.3		
Volume of soluble formulation required	8478	cubic feet	
Number of slow-release formulation DPT injection points	20		
ROI	10	feet	(assumed)
Thickness of injection zone	10	feet	
Volume of treatment zone	62800	cubic feet	
Assumed porosity of treatment zone	0.3		
Volume of slow release formulation required	18840	cubic feet	
Total number of DPT injection wells	29		

Injection

	Quantity	Units	Unit Cost		Total Cost
Injection points completed	2	points per day			
Mobilization/Demobilization (1 DPT rig)	1	LS	5000	=	$ 5,000
Decon Pad	1	LS	750	=	$ 750
DPT drilling (rig, crew, equipment, decon)	15	days	$3,200	=	$ 48,000
Project management, planning, and oversight	280	hours	$100	=	$ 28,000
Total Injection Costs					**$81,750**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	
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Description: Cost Estimate for Alternative 2 - Soil Vapor Extraction and In Situ Treatment - Treatment Cost Items

Amendments

Soluble Amendment	Quantity	Units	Unit Cost		Total Cost
Injection Volume	8478	cubic feet			
Dilution factor (mass amendment: mass Water)	0.05				
Amendment costs	26451	lbs	$1.5	=	**$ 39,677**
Slow-release formulation					
Injection Volume	18840	cubic feet			
Dilution factor (mass amendment: mass Water)	0.10				
Amendment costs	117562	lbs	$1.5	=	**$ 176,342**
			TOTAL PER EVENT		**298,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	
CLIENT:	NYSDEC			PAGE NO. :	

Description Cost Estimate for Alternative 2 - Soil Vapor Extraction and In Situ Treatment - Treatment Cost Items

Peformance Monitoring for SVE system					
Number of samples	3	per month			
Number of 12 hour workdays	1	days			
Field Sampling Labor					
Mob/demob	4	hr	$95	=	$380
Summa Canister Sampling	12	hr	$95	=	$1,140
Travel Expense and per Diem					
Van and car rental	1	day	$200	=	$200
Sampling Equipment, Shipping, Consumable Supplies					
Equipment & PPE	1	ea	$100	=	$100
Shipping	1	day	$200	=	$200
Misc	1	day	$75	=	$75
Sampling Analysis					
VOCs (TO-15)	3	ea	$200	=	$600
Data Management and Validation					
Assume samples validated @ 0.5 hr per sample per analyte					
Samples management/validation	2	hr	$100	=	$150
Total SVE O & M sampling					$2,845
Annual Cost					$34,140
Annual Letter Report					$1,100
Total					**$36,000**
O&M					
SVE O&M Labor & Materials	1	LS	$60,000	=	$60,000
Vapor Treatment Media Replacement (Quarterly 500 lbs)	500	lbs	$2.00	=	$4,000
Vapor Treatment Media Transportation	4	trips	$500		$2,000
Utility Cost	12	months	$500		$6,000
Annual Letter Report					$1,100
Total Annual O&M					**$74,000**

In Situ Treatment Performance Monitoring					
Monitoring Wells to sample	12	wells			
Number of samplers	2	people			
Number of 12 hour workdays	3	days			
Field Sampling Labor					
Mob/demob	10	hr	$95	=	$950
Well Sampling	72	hr	$95	=	$6,840
Travel Expense and per Diem					
Van and car rental	3	day	$95	=	$285
Sampling Equipment, Shipping, Consumable Supplies					
Equipment & PPE	1	ea	$3,500	=	$3,500
Shipping	3	day	$150	=	$450
Misc	3	day	$75	=	$225
Sample Analysis including QC samples					
VOCs	16	ea	$80	=	$1,280
Dehalococcoides	4	ea	$450	=	$1,800
Data Management and Validation					
Assume samples validated @ 0.5 hr per sample per analyte					
Samples management/validation	8	hr	$80	=	$640
Data management	16	hr	$95	=	$1,520
Total In Situ Treatment Performance Monitoring (per event)					**$18,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	
CLIENT:	NYSDEC			PAGE NO. :	

Description: Cost Estimate for Alternative 2 - Soil Vapor Extraction and In Situ Treatment - MNA

Groundwater Sampling

Monitoring Wells to sample	6	wells			
Number of samplers	1	people			
Number of 12 hour workdays	3	days			
<u>Field Sampling Labor</u>					
Mob/demob	8	hr	$95	=	$760
Well Sampling	36	hr	$95	=	$3,420
<u>Travel Expense and per Diem</u>					
Van and car rental	3	day	$150	=	$450
<u>Sampling Equipment, Shipping, Consumable Supplies</u>					
Equipment & PPE	1	ea	$3,500	=	$3,500
Shipping	3	day	$150	=	$450
Misc	3	day	$75	=	$225
<u>Sampling Analysis</u>					
VOCs (including QC samples)	10	ea	$80	=	$800
<u>Data Management and Validation</u>					
Assume samples validated @ 0.5 hr per sample per analyte					
Samples management/validation	5	hr	$80	=	$400
Data management	10	hr	$95	=	$950
<u>Reporting</u>					
Annual Letter Report	1	ea	$7,000	=	$7,000
Total Monitoring Costs (per event)					**$18,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	
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Description: Present Worth Calculations

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

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

P = Present Worth

A= Annual amount

i = interest rate

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

SVE Performance Monitoring

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

SVE O&M

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

In Situ Treatment Performance Monitoring

n =	10
i =	7%
The multiplier for $(P/A)_2$ =	**7.024**

Monitored Natural Attenuation

n =	20
i =	7%
The multiplier for $(P/A)_2$ =	**10.594**

PROJECT: Wantagh Cleaners	COMPUTED BY : YL	CHECKED BY:	
JOB NO.:	DATE : 11/2/2015	DATE CHECKED:	
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Description: Wage rates assumptions for the professional and craft labor and equipment rates for use in FS cost estimate.

Number of work hours per year: **2080** *52 weeks x 40 hours per week*

Professional Labor	Rate
Labor Category	
Project Manager	**$150**
Site Superintendent	**$120**
Construction Foreman	**$120**
Environmental Engineer	**$100**
Engineer	**$95**
Environmental Technician	**$85**
Surveyor	**$80**
Drafter	**$75**
Chemist	**$100**
N2 Operator (Water Treatment)	**$95**
Industrial Hygienist (SHSO)	**$100**
Security Guard	**$50**
Laborer (Semi-Skilled)	**$50**
Geologist	**$100**
Data Management	**$85**
Administrative Staff	**$65**

Cost Estimate for Alternative 3
Wantagh Cleaners Site
Hempstead, New York

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	CG
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	11/9/2015
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SUMMARY OF COSTS - ALTERNATIVE 3

Item Description	Extended Cost
CAPITAL COSTS	
Pilot Study	$ 255,000
Remedial Design and General Conditions	$ 284,000
Recirculating Well (10 Years Operation)	$ 133,000
In situ treatment (assume two events)	$ 376,000
Common Elements	$ 463,100
Subtotal	*$ 1,511,100*
Contingency (20%)	$ 302,220
Subtotal	*$ 1,813,320*
General Contractor Bond and Insurance (5%)	$ 90,666
Subtotal	*$ 1,903,986*
General Contractor Markup (profit - 10%)	$ 190,399
TOTAL CAPITAL COSTS	**$ 2,095,000**
OPERATION, MAINTENANCE AND MONITORING COSTS PER EVENT	
SVE Performance monitoring (annual for eight years)	$ 36,000
SVE Operations and Maintenance (annual for eight years)	$ 74,000
In Well Air Stripper perf. monitoring (annual for eight years)	$ 16,000
Monitored Natural Attenuation (annual for 20 years)	$ 18,000
Common Elements	$ 169,504
PRESENT WORTH (with discounting)	
Total Capital Costs	$ 2,095,000
Total Operations, Maintenance, and Monitoring Costs	$ 1,113,000
TOTAL PRESENT WORTH	**$ 3,208,000**

Present worth assumes a 7% discount rate

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	CG
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Description: Cost Estimate for Alternative 3

	Quantity	Units	Unit Price	Total
Treatability study - laboratory	1	LS	$60,000	$60,000
Pilot study - In Situ Treatment and SVE				
Pilot study work plan	1	LS	$30,000	$30,000
Mobilization/Demobilization	1	LS	$5,000	$5,000
Subcontractor - DPT	10	days	$3,200	$32,000
Subcontractor - SVE	1	LS	$50,000	$50,000
Amendment	1	LS	$10,000	$10,000
Sampling	30	samples	$100	$3,000
Labor	300	hours	$100	$30,000
Equipment and supplies	1	LS	$5,000	$5,000
Prepare treatability/pilot study results report	1	LS	$30,000	$30,000
TOTAL TREATABILITY AND PILOT STUDY COSTS:				**$255,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	CG
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Description: Cost Estimate for Alternative 3

	Quantity	Units	Unit Price	Total
Remedial Design				
Include preparation of plans, specifications, and bid documents				
Project Management and meetings	$150	hr	80	$12,000
Prepare bid package	$100	hr	800	$80,000
Cost estimate	$100	hr	80	$8,000
Prepare final bid pacakage	$100	hr	550	$55,000
Bid engineering support	$100	hr	100	$10,000
Total Remedial Design				**$165,000**
Construction Management				
Include preparation of work plans such as QAPP, health and safety plan, etc.				
Project Manager	$150	hr	120	$18,000
Environmental Engineer	$100	hr	400	$40,000
Total Construction Management				**$58,000**
Permits				
Project Manager	$150	hr	6	$900
Permitting Specialist	$100	hr	16	$1,600
Total Permit Costs				**$2,500**
Surveying				
Total Surveying Costs	$6,000	LS	1	**$6,000**
Final Remedial Action Report (RAR)/Construction Completion Report (CCR)				
Project Manager	$150	hr	80	$12,000
Engineer	$100	hr	400	$40,000
Total RAR Costs				**$52,000**
TOTAL GENERAL CONDITION COST				**$284,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	CG
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Description: Cost Estimate for Alternative 3

Recirculating In Well Air Stripper Construction and Startup

Depth of wells		30	Ft			
Hollow Stem Auger mob/demob						
Mob/demob	1	LS	$6,000	=		$6,000
Decon pad	1	LS	$800	=		$800
TOTAL FOR MOB/DEMOB					**$**	**6,800**
Recirculating In Well Air Stripper Well installation						
Total number of recirculating wells	1	wells				
Decon of equipment	2	Hr	$200	=		$400
Hollow stem augering	30	Ft	$35	=		$1,050
4-inch carbon steel well casing	10	Ft	$30	=		$300
4-inch carbon steel well screen	20	Ft	$50	=		$1,000
Trenching	100	Ft	$11	=		$1,100
Plastic ground cover	0	SF	$1	=		$0
Well surface completion	1	Ft	$500	=		$500
TOTAL FOR SPARGE POINTS INSTALLATION					**$**	**4,350**
Investigation-Derived Waste (IDW) handling						
IDW disposal	1	LS	$3,000	=		$3,000
TOTAL FOR IDW					**$**	**3,000**

Air sparge system						
Electrical hookup	1	ea	$1,500	=	$	1,500
7.5 hp compressor	1	ea	$2,200	=	$	2,200
Control panel	1	ea	$5,000	=	$	5,000
PLC/Autodialer	1	ea	$5,000	=	$	5,000
Instrumentation	1	LS	$2,000	=	$	2,000
Piping	1	LS	$2,000	=	$	2,000
Wiring	1	LS	$5,000	=	$	5,000
Solenoid valves	20	ea	$100	=	$	2,000
Gauges	5	ea	$75	=	$	375
Flowmeters	5	ea	$150	=	$	750
Compressed air hose	1000	ft	$5	=	$	5,000
Security Fencing	100	ft	$30	=	$	3,000
Gates	1	ea	$1,000	=	$	1,000
Concrete Pad	0	sf	$15	=	$	-
Container	1	LS	$3,500	=	$	3,500
TOTAL FOR SYSTEM					**$**	**38,325**
Installation cost (100% of equipment cost)					**$**	**38,325**
Total System Cost					**$**	**76,650**
System Construction and Startup						
Assume two weeks for construction						
Assume two weeks for initial startup testing						
Project Engineer	160	hr	$110	=	$	17,600
Environmental Engineer	160	hr	$100	=	$	16,000
Equipment and consumables	1	LS	$2,000		$	2,000
Vapor samples	20	ea	$330	=	$	6,600
TOTAL FOR SYSTEM CONSTRUCTION AND START UP					**$**	**42,200**
TOTAL IN WELL AIR STRIPPER SYSTEM CONSTRUCTION AND START UP COSTS						**$133,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	CG
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	11/9/2015
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Description: Cost Estimate for Alternative 3

Treatment: In Situ

Treatment Volume (per injection event)

Number of soluble formulation injection points	9		
Assumed ROI at each on-site DPT injection well	10	feet	(assumed)
Vertical thickness of on-site upgradient treatment zones	10	feet	(assumed based on screened length in each well)
Volume of treatment zone	28260	cubic feet	
Assumed porosity of treatment zone	0.3		
Volume of soluble formulation required	8478	cubic feet	
Number of slow-release formulation DPT injection points	10		
ROI	10	feet	(assumed)
Thickness of injection zone	10	feet	
Volume of treatment zone	31400	cubic feet	
Assumed porosity of treatment zone	0.3		
Volume of slow release formulation required	9420	cubic feet	
Total number of DPT injection wells	19		

Injection

	Quantity	Units	Unit Cost		Total Cost
Injection points completed	2	points per day			
Mobilization/Demobilization (1 DPT rig)	1	LS	5000	=	$ 5,000
Decon Pad	1	LS	750	=	$ 750
DPT drilling (rig, crew, equipment, decon)	10	days	$3,200	=	$ 32,000
Project management, planning, and oversight	220	hours	$100	=	$ 22,000
Total Injection Costs					**$59,750**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	CG
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Description: Cost Estimate for Alternative 3

Amendments

Soluble Amendment	Quantity	Units	Unit Cost		Total Cost
Injection Volume	8478	cubic feet			
Dilution factor (mass amendment: mass Water)	0.05				
Amendment costs	26451	lbs	$1.5	=	**$ 39,677**
Slow-release formulation					
Injection Volume	9420	cubic feet			
Dilution factor (mass amendment: mass Water)	0.10				
Amendment costs	58781	lbs	$1.5	=	**$ 88,171**
			TOTAL PER EVENT		**188,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	CG
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	11/9/2015
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Description: Cost Estimate for Alternative 3

Peformance Monitoring for SVE system					
Number of samples	3	per month			
Number of 12 hour workdays	1	days			
Field Sampling Labor					
Mob/demob	4	hr	$95	=	$380
Summa Canister Sampling	12	hr	$95	=	$1,140
Travel Expense and per Diem					
Van and car rental	1	day	$200	=	$200
Sampling Equipment, Shipping, Consumable Supplies					
Equipment & PPE	1	ea	$100	=	$100
Shipping	1	day	$200	=	$200
Misc	1	day	$75	=	$75
Sampling Analysis					
VOCs (TO-15)	3	ea	$200	=	$600
Data Management and Validation					
Assume samples validated @ 0.5 hr per sample per analyte					
Samples management/validation	2	hr	$100	=	$150
Total SVE O & M sampling					$2,845
Annual Cost					$34,140
Annual Letter Report					$1,100
Total					**$36,000**
O&M					
System O&M Labor & Materials	1	LS	$60,000	=	$60,000
Vapor Treatment Media Replacement (Quart	500	lbs	$2.00	=	$4,000
Vapor Treatment Media Transportation	4	trips	$500		$2,000
Utility Cost	12	months	$500		$6,000
Annual Letter Report					$1,100
Total Annual O&M					**$74,000**
Recirculating In Well Air Strippers Performance Monitoring					
Monitoring Wells to sample	12	wells			
Number of samplers	2	people			
Number of 12 hour workdays	3	days			
Field Sampling Labor					
Mob/demob	10	hr	$95	=	$950
Well Sampling	72	hr	$95	=	$6,840
Travel Expense and per Diem					
Van and car rental	3	day	$95	=	$285
Sampling Equipment, Shipping, Consumable Supplies					
Equipment & PPE	1	ea	$3,500	=	$3,500
Shipping	3	day	$150	=	$450
Misc	3	day	$75	=	$225
Sample Analysis including QC samples					
VOCs	16	ea	$80	=	$1,280
Data Management and Validation					
Assume samples validated @ 0.5 hr per sample per analyte					
Samples management/validation	8	hr	$80	=	$640
Data management	16	hr	$95	=	$1,520
Total In Situ Treatment Performance Monitoring (per event)					**$16,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	CG
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	11/9/2015
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Description: ALTERNATIVE 3

Groundwater Sampling

Monitoring Wells to sample	6	wells			
Number of samplers	1	people			
Number of 12 hour workdays	3	days			
<u>Field Sampling Labor</u>					
Mob/demob	8	hr	$95	=	$760
Well Sampling	36	hr	$95	=	$3,420
<u>Travel Expense and per Diem</u>					
Van and car rental	3	day	$150	=	$450
<u>Sampling Equipment, Shipping, Consumable Supplies</u>					
Equipment & PPE	1	ea	$3,500	=	$3,500
Shipping	3	day	$150	=	$450
Misc	3	day	$75	=	$225
<u>Sampling Analysis</u>					
VOCs (including QC samples)	10	ea	$80	=	$800
<u>Data Management and Validation</u>					
Assume samples validated @ 0.5 hr per sample per analyte					
Samples management/validation	5	hr	$80	=	$400
Data management	10	hr	$95	=	$950
<u>Reporting</u>					
Annual Letter Report	1	ea	$7,000	=	$7,000
Total Monitoring Costs (per event)					**$18,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	CG
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	11/9/2015
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Description: Present Worth Calculation ALTERNATIVE 3

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

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

P = Present Worth

A= Annual amount

i = interest rate

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

SVE Performance Monitoring

n = 8

i = 7%

The multiplier for $(P/A)_2$ = **5.971**

O&M

n = 8

i = 7%

The multiplier for $(P/A)_2$ = **5.971**

Recirculating Well Performance Monitoring

n = 8

i = 7%

The multiplier for $(P/A)_2$ = **5.971**

Monitored Natural Attenuation

n = 20

i = 7%

The multiplier for $(P/A)_2$ = **10.594**

PROJECT: Wantagh Cleaners	COMPUTED BY : YL	CHECKED BY:	
JOB NO.:	DATE : 11/2/2015	DATE CHECKED:	
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Description: Wage rates assumptions for the professional and craft labor and equipment rates for use in FS cost estimate.

Number of work hours per year: **2080** *52 weeks x 40 hours per week*

Professional Labor	Rate
Labor Category	
Project Manager	**$150**
Site Superintendent	**$120**
Construction Foreman	**$120**
Environmental Engineer	**$100**
Engineer	**$95**
Environmental Technician	**$85**
Surveyor	**$80**
Drafter	**$75**
Chemist	**$100**
N2 Operator (Water Treatment)	**$95**
Industrial Hygienist (SHSO)	**$100**
Security Guard	**$50**
Laborer (Semi-Skilled)	**$50**
Geologist	**$100**
Data Management	**$85**
Administrative Staff	**$65**

Cost Estimate for Alternative 4
Wantagh Cleaners Site
Hempstead, New York

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	CG
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	11/9/2015
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SUMMARY OF COSTS - ALTERNATIVE 4	
Item Description	**Extended Cost**
CAPITAL COSTS	
Pilot Study	$ 255,000
Remedial Design and General Conditions	$ 284,000
Air Sparging System	$ 185,000
In Situ Treatment (assume two events)	$ 252,000
Common Elements	$ 463,100
Subtotal	*$ 1,439,100*
Contingency (20%)	$ 287,820
Subtotal	*$ 1,726,920*
General Contractor Bond and Insurance (5%)	$ 86,346
Subtotal	*$ 1,813,266*
General Contractor Markup (profit - 10%)	$ 181,327
TOTAL CAPITAL COSTS	**$ 1,995,000**
OPERATION, MAINTENANCE AND MONITORING COSTS PER EVENT	
SVE Performance Monitoring (annual for five years)	$ 36,000
SVE Operations and Maintenance (annual for five years)	$ 74,000
Air Sparging and In Situ treatment Performance Monitoring (annual for ten years)	$ 16,000
Monitored Natural Attenuation (annual for 20 years)	$ 18,000
Common Elements	$ 169,504
PRESENT WORTH (with discounting)	
Total Capital Costs	$ 1,995,000
Total Operations, Maintenance, and Monitoring Costs	$ 924,000
TOTAL PRESENT WORTH	**$ 2,919,000**

Present worth assumes a 7% discount rate

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Description: Cost Estimate for Alternative 4 - Soil Vapor Extraction, Air Sparge, and In Situ Treatment - Pilot Study

	Quantity	Units	Unit Price	Total
Treatability study - laboratory	1	LS	$60,000	$60,000
Pilot study - In Situ Treatment and AS/SVE				
Pilot study work plan	1	LS	$30,000	$30,000
Mobilization/Demobilization	1	LS	$5,000	$5,000
Subcontractor - DPT	10	days	$3,200	$32,000
Subcontractor - AS/SVE	1	LS	$50,000	$50,000
Amendment	1	LS	$10,000	$10,000
Sampling	30	samples	$100	$3,000
Labor	300	hours	$100	$30,000
Equipment and supplies	1	LS	$5,000	$5,000
Prepare treatability/pilot study results report	1	LS	$30,000	$30,000
TOTAL TREATABILITY AND PILOT STUDY COSTS:				**$255,000**

CDM Smith

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Description: Cost Estimate for Alternative 4 - Soil Vapor Extraction, Air Sparge and In Situ Treatment - Individual Cost Item Backup

	Quantity	Units	Unit Price	Total
Remedial Design				
Include preparation of plans, specifications, and bid documents				
Project Management and meetings	$150	hr	80	$12,000
Prepare bid package	$100	hr	800	$80,000
Cost estimate	$100	hr	80	$8,000
Prepare final bid pacakage	$100	hr	550	$55,000
Bid engineering support	$100	hr	100	$10,000
Total Remedial Design				**$165,000**
Construction Management				
Include preparation of work plans such as QAPP, health and safety plan, etc.				
Project Manager	$150	hr	120	$18,000
Environmental Engineer	$100	hr	400	$40,000
Total Construction Management				**$58,000**
Permits				
Project Manager	$150	hr	6	$900
Permitting Specialist	$100	hr	16	$1,600
Total Permit Costs				**$2,500**
Surveying				
Total Surveying Costs	$1	LS	6000	**$6,000**
Final Remedial Action Report (RAR)/Construction Completion Report (CCR)				
Project Manager	$150	hr	80	$12,000
Engineer	$100	hr	400	$40,000
Total RAR Costs				**$52,000**
TOTAL GENERAL CONDITION COST				**$284,000**

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Description: Cost Estimate for Alternative 4

Air Sparge System Construction and Startup

Without a field test, the flow rate for a conceptual design is not available. Therefore, costs of similar projects are used in this cost estimate.

Basis of Design

Radius of Influence of AS points	7	Ft
Depth of AS points	30	Ft
Air flowrate per point	20	scfm

Hollow Stem Auger mob/demob

Mob/demob	1	LS	$6,000	=	$6,000
Decon pad	1	LS	$800	=	$800
TOTAL FOR MOB/DEMOB					**$ 6,800**

AS points installation

Total number of AS points	10	points			
Decon of equipment	10	Hr	$200	=	$2,000
Hollow stem augering	300	Ft	$70	=	$21,000
4-inch carbon steel well casing	200	Ft	$30	=	$6,000
4-inch carbon steel well screen	100	Ft	$50	=	$5,000
Trenching	400	Ft	$11	=	$4,400
Plastic ground cover	0	SF	$1	=	$0
Well surface completion	10	Ft	$500	=	$5,000
TOTAL FOR SPARGE POINTS INSTALLATION					**$ 43,400**

Vapor Monitoring Points

Total number of monitoring points	3	wells			
Decon of equipment	5	Hr	$200	=	$1,000
Hollow stem augering	30	Ft	$35	=	$1,050
4-inch carbon steel well casing	6	Ft	$30	=	$180
4-inch carbon steel well screen	24	Ft	$50	=	$1,200
Well surface completion	3	Ft	$500	=	$1,500
TOTAL FOR VAPOR MONITORING POINT INSTALLATION					**$ 4,930**

Investigation-Derived Waste (IDW) handling

IDW handling	13	well or pt	$45	=	$585
IDW roll-off rental and disposal	1	LS	$15,000	=	$15,000
TOTAL FOR IDW					**$ 15,585**

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Description: Cost Estimate for Alternative 4

Air sparge system						
Electrical hookup	1	ea	$1,500	=	$	1,500
7.5 hp compressor	1	ea	$2,200	=	$	2,200
Control panel	1	ea	$5,000	=	$	5,000
PLC/Autodialer	1	ea	$5,000	=	$	5,000
Instrumentation	1	LS	$2,000	=	$	2,000
Piping	1	LS	$2,000	=	$	2,000
Wiring	1	LS	$5,000	=	$	5,000
Solenoid valves	20	ea	$100	=	$	2,000
Gauges	5	ea	$75	=	$	375
Flowmeters	5	ea	$150	=	$	750
Compressed air hose	500	ft	$5	=	$	2,500
Security Fencing	100	ft	$30	=	$	3,000
Gates	1	ea	$1,000	=	$	1,000
Concrete Pad	0	sf	$15	=	$	-
Container	1	LS	$3,500	=	$	3,500
TOTAL FOR AIR SPARGE SYSTEM					$	35,825
Installation cost (100% of equipment cost)					$	35,825
Total Air Sparge System Cost					$	71,650
Air sparge system Construction and Startup						
Assume two weeks for construction						
Assume two weeks for initial startup testing						
Project Engineer	160	hr	$110	=	$	17,600
Environmental Engineer	160	hr	$100	=	$	16,000
Equipment and consumables	1	LS	$2,000		$	2,000
Vapor samples	20	ea	$330	=	$	6,600
TOTAL FOR SYSTEM CONSTRUCTION AND START UP					$	42,200
TOTAL AIR SPARGE SYSTEM CONSTRUCTION AND START UP COSTS						**$185,000**

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Description: Cost Estimate for Alternative 4 - Soil Vapor Extraction, Air Sparge and In Situ Treatment - Treatment Cost Items

Treatment: In Situ
Treatment Volume (per injection event)

Number of slow-release formulation DPT injection	10		
ROI	10	feet	(assumed)
Thickness of injection zone	10	feet	
Volume of treatment zone	31400	cubic feet	
Assumed porosity of treatment zone	0.3		
Volume of slow release formulation required	9420	cubic feet	

Injection

	Quantity	Units	Unit Cost		Total Cost
Injection points completed	2	points per day			
Mobilization/Demobilization (1 DPT rig)	1	LS	5000	=	$ 5,000
Decon Pad	1	LS	750	=	$ 750
DPT drilling (rig, crew, equipment, decon)	5	days	$3,200	=	$ 16,000
Project management, planning, and oversight	160	hours	$100	=	$ 16,000
Total Injection Costs					**$37,750**

Slow-release formulation

Injection Volume	9420	cubic feet			
Dilution factor (mass amendment: mass Water)	0.10				
Amendment costs	58781	lbs	$1.5	=	**$ 88,171**

TOTAL PER EVENT **$126,000**

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Description: Cost Estimate for Alternative 4 - Soil Vapor Extraction, Air Sparge and In Situ Treatment - Treatment Cost Items

Peformance Monitoring for SVE system					
Number of samples	3	per month			
Number of 12 hour workdays	1	days			
Field Sampling Labor					
Mob/demob	4	hr	$95	=	$380
Summa Canister Sampling	12	hr	$95	=	$1,140
Travel Expense and per Diem					
Van and car rental	1	day	$200	=	$200
Sampling Equipment, Shipping, Consumable Supplies					
Equipment & PPE	1	ea	$100	=	$100
Shipping	1	day	$200	=	$200
Misc	1	day	$75	=	$75
Sampling Analysis					
VOCs (TO-15)	3	ea	$200	=	$600
Data Management and Validation					
Assume samples validated @ 0.5 hr per sample per analyte					
Samples management/validation	2	hr	$100	=	$150
Total SVE-AS O & M sampling					$2,845
Annual Cost					$34,140
Annual Letter Report					$1,100
Total					**$36,000**
Operations & Maintenance					
AS/SVE O&M Labor & Materials	1	LS	$60,000	=	$60,000
Vapor Treatment Media Replacement (Quar	500	lbs	$2.00	=	$4,000
Vapor Treatment Media Transportation	4	trips	$500		$2,000
Utility Cost	12	months	$500		$6,000
Annual Letter Report					$1,100
Total Annual O&M					**$74,000**
Air Sparging and In Situ Treatment Performance Monitoring					
Monitoring Wells to sample	12	wells			
Number of samplers	2	people			
Number of 12 hour workdays	3	days			
Field Sampling Labor					
Mob/demob	10	hr	$95	=	$950
Well Sampling	72	hr	$95	=	$6,840
Travel Expense and per Diem					
Van and car rental	3	day	$95	=	$285
Sampling Equipment, Shipping, Consumable Supplies					
Equipment & PPE	1	ea	$3,500	=	$3,500
Shipping	3	day	$150	=	$450
Misc	3	day	$75	=	$225
Sample Analysis including QC samples					
VOCs	16	ea	$80	=	$1,280
Data Management and Validation					
Assume samples validated @ 0.5 hr per sample per analyte					
Samples management/validation	8	hr	$80	=	$640
Data management	16	hr	$95	=	$1,520
Total In Situ Treatment Performance Monitoring (per event)					**$16,000**

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Description: Cost Estimate for Alternative 4 - Soil Vapor Extraction, Air Sparge, and In Situ Treatment - MNA

Groundwater Sampling

Monitoring Wells to sample	6	wells			
Number of samplers	1	people			
Number of 12 hour workdays	3	days			
Field Sampling Labor					
Mob/demob	8	hr	$95	=	$760
Well Sampling	36	hr	$95	=	$3,420
Travel Expense and per Diem					
Van and car rental	3	day	$150	=	$450
Sampling Equipment, Shipping, Consumable Supplies					
Equipment & PPE	1	ea	$3,500	=	$3,500
Shipping	3	day	$150	=	$450
Misc	3	day	$75	=	$225
Sampling Analysis					
VOCs (including QC samples)	10	ea	$80	=	$800
Data Management and Validation					
Assume samples validated @ 0.5 hr per sample per analyte					
Samples management/validation	5	hr	$80	=	$400
Data management	10	hr	$95	=	$950
Reporting					
Annual Letter Report	1	ea	$7,000	=	$7,000
Total Monitoring Costs (per event)					**$18,000**

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Description: Present Worth Calculation

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

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

P = Present Worth

A= Annual amount

i = interest rate

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

AS/SVE Performance Monitoring

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

SVE O&M

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

In Situ Treatment Performance Monitoring

n =	10
i =	7%
The multiplier for $(P/A)_2$ =	**7.024**

Monitored Natural Attenuation

n =	20
i =	7%
The multiplier for $(P/A)_2$ =	**10.594**

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Description: Wage rates assumptions for the professional and craft labor and equipment rates for use in FS cost estimate.

Number of work hours per year: **2080** *52 weeks x 40 hours per week*

Professional Labor	Labor Category	Rate
	Project Manager	**$150**
	Site Superintendent	**$120**
	Construction Foreman	**$120**
	Environmental Engineer	**$100**
	Engineer	**$95**
	Environmental Technician	**$85**
	Surveyor	**$80**
	Drafter	**$75**
	Chemist	**$100**
	N2 Operator (Water Treatment)	**$95**
	Industrial Hygienist (SHSO)	**$100**
	Security Guard	**$50**
	Laborer (Semi-Skilled)	**$50**
	Geologist	**$100**
	Data Management	**$85**
	Administrative Staff	**$65**

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SUMMARY OF COSTS - alternative 5

Item Description	Extended Cost
CAPITAL COSTS	
Pilot Study	$ 255,000
Remedial Design and General Conditions	$ 330,000
ISTR Treatment	$ 1,563,000
In Situ Treatment (assume two events)	$ 3,594,000
Common Elements	$ 463,100
Subtotal	*$ 6,205,100*
Contingency (20%)	$ 1,241,020
Subtotal	*$ 7,446,120*
General Contractor Bond and Insurance (5%)	$ 372,306
Subtotal	*$ 7,818,426*
General Contractor Markup (profit - 10%)	$ 781,843
TOTAL CAPITAL COSTS	**$ 8,601,000**
OPERATION, MAINTENANCE AND MONITORING COSTS PER EVENT	
SVE Performance Monitoring (annual for five years)	$ 36,000
SVE Operations and Maintenance (annual for five years)	$ 74,000
In Situ treatment Performance Monitoring (annual for ten years)	$ 24,000
Common Elements	$ 169,504
PRESENT WORTH (with discounting)	
Total Capital Costs	$ 8,601,000
Total Operations, Maintenance, and Monitoring Costs	$ 889,000
TOTAL PRESENT WORTH	**$ 9,490,000**

Present worth assumes a 7% discount rate

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Description: Cost Estimate for Alternative 5 - Soil Vapor Extraction, ISTR, and In Situ Treatment - Pilot Study

	Quantity	Units	Unit Price	Total
Treatability study - laboratory	1	LS	$60,000	$60,000
Pilot study - In Situ Treatment and SVE				
Pilot study work plan	1	LS	$30,000	$30,000
Mobilization/Demobilization	1	LS	$5,000	$5,000
Subcontractor - DPT	10	days	$3,200	$32,000
Subcontractor - SVE	1	LS	$50,000	$50,000
Amendment	1	LS	$10,000	$10,000
Sampling	30	samples	$100	$3,000
Labor	300	hours	$100	$30,000
Equipment and supplies	1	LS	$5,000	$5,000
Prepare treatability/pilot study results report	1	LS	$30,000	$30,000
TOTAL TREATABILITY AND PILOT STUDY COSTS:				**$255,000**

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Description: Cost Estimate for Alternative 5 - Soil Vapor Extraction, ISTR, and In Situ Treatment - Individual Cost Item Backup

	Quantity	Units	Unit Price	Total
Remedial Design				
Include preparation of plans, specifications, and bid documents				
Project Management and meetings	$150	hr	80	$12,000
Prepare bid package	$100	hr	1000	$100,000
Cost estimate	$100	hr	100	$10,000
Prepare final bid pacakage	$100	hr	700	$70,000
Bid engineering support	$100	hr	120	$12,000
Total Remedial Design				**$204,000**
Construction Management				
Include preparation of work plans such as QAPP, health and safety plan, etc.				
Project Manager	$150	hr	120	$18,000
Environmental Engineer	$100	hr	400	$40,000
Total Construction Management				**$58,000**
Permits				
Project Manager	$150	hr	6	$900
Permitting Specialist	$100	hr	16	$1,600
Total Permit Costs				**$2,500**
Surveying				
Total Surveying Costs	$8,000	LS	1	**$8,000**
Final Remedial Action Report (RAR)/Construction Completion Report (CCR)				
Project Manager	$150	hr	100	$15,000
Engineer	$100	hr	420	$42,000
Total RAR Costs				**$57,000**
TOTAL GENERAL CONDITION COST				**$330,000**

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Description: Cost Estimate for Alternative 5 - In situ treatment

Treatment: In Situ

Treatment Volume (per injection event)

Number of soluble formulation injection points	9		
Assumed ROI at each on-site DPT injection well	10	feet	(assumed)
Vertical thickness of on-site upgradient treatment zones	10	feet	(assumed based on screened length in each well)
Volume of treatment zone	28260	cubic feet	
Assumed porosity of treatment zone	0.3		
Volume of soluble formulation required	8478	cubic feet	
Number of slow-release formulation DPT injection points	100		
ROI	10	feet	(assumed)
Thickness of injection zone	17	feet	
Volume of treatment zone	533800	cubic feet	
Assumed porosity of treatment zone	0.3		
Volume of slow release formulation required	160140	cubic feet	
Total number of DPT injection wells	109		

Injection

	Quantity	Units	Unit Cost		Total Cost
Injection points completed	2	points per day			
Mobilization/Demobilization (1 DPT rig)	1	LS	5000	=	$ 5,000
Decon Pad	1	LS	750	=	$ 750
DPT drilling (rig, crew, equipment, decon)	55	days	$3,200	=	$ 176,000
Project management, planning, and oversight	760	hours	$100	=	$ 76,000
Total Injection Costs					**$257,750**

CDM Smith	PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	CG
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Description: Cost Estimate for Alternative 5 - In situ treatment

Amendments					
Soluble Amendment	Quantity	Units	Unit Cost		Total Cost
Injection Volume	8478	cubic feet			
Dilution factor (mass amendment: mass Water)	0.05				
Amendment costs	26451	lbs	$1.5	=	**$ 39,677**
Slow-release formulation					
Injection Volume	160140	cubic feet			
Dilution factor (mass amendment: mass Water)	0.10				
Amendment costs	999274	lbs	$1.5	=	**$ 1,498,910**
			TOTAL PER EVENT		**1,797,000**

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Description: Cost Estimate for Alternative 5 - ISTR

Treatment: ISTR - ERH and SVE Application

	Quantity	Units	Unit Price		Total
Drilling costs					
Heating well Radius of Influence	7.0	ft			
Area of Treatment Zone	5,400	sq ft			
Depth of Treatment Zone	20	ft bgs			
Number of combined heating/SVE wells	35	electrodes			
Total drilling depth of electrodes	700	ft bgs			
Temperature monitoring points	6	points			
Total number of 12 inch OD borings	35	borings			
Number of Drill Rigs	1	rigs			
Installations per rig per day	2	points per day			
Days for drilling	18	days			
Weeks for drilling	4	weeks			
Boring total	700	ft	$50	=	$ 35,000
Drilling mob	1	LS	$10,000	=	$ 10,000
Drill cuttings per drilled foot	0.02	CY/ft			
Drill cuttings non-haz waste disposal via 20CY rolloff	14	CY	$96	=	$ 1,314
Delivery and rental of 20CY rolloff	1	rolloff	$700	=	$ 700
TOTAL DRILLING COSTS					$ 60,000
Power Costs for ERH System Operation					
Average electrical heating power input per electrode	27.5	kW			
Total electrical heating power input	962.5	kW			
Total heating treatment time	100	days			
Design remediation energy	2310000	kWh	$0.14	=	$ 323,400
TOTAL ENERGY COSTS					$ 324,000
ERH Subcontractor costs					
Design, workplan, permits	$75,000	LS			$ 75,000
Electrical Permit and Utility Connection to controller	$30,000	LS			$ 30,000
Mobilization and Materials	35	heating wells	$12,500	=	$ 437,500
Subsurface Installation	35	heating wells	$4,000	=	$ 140,000
Surface Installation and Startup	35	heating wells	$7,000	=	$ 245,000
System operation - control unit and labor	100	days	$2,000		$ 200,000
Demobilization and Final Report	$50,000	LS			$ 50,000
Well Abandonment					
Well abandonment (grouting)	35	ft	$30	=	$ 1,050
Wells abandoned per day	8	wells			
Days for abandonment	4	days			
Weeks for abandonment	1	weeks			
Schedule Summary					
Well driling	4	weeks			
Setup	6	weeks			
Heat up	14	weeks			
Cool down	14	weeks			
Assumed schedule float	8	weeks			
Total Operation timeperiod	46	weeks			
TOTAL SUBCONTRACTOR COSTS					$ 1,178,550
TOTAL ISTR ZONE TREATMENT					**$ 1,563,000**

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Description: Cost Estimate for Alternative 5 - Soil Vapor Extraction, ISTR, and In Situ Treatment - Perf Monitoring

Peformance Monitoring for SVE system					
Number of samples	3	per month			
Number of 12 hour workdays	1	days			
Field Sampling Labor					
Mob/demob	4	hr	$95	=	$380
Summa Canister Sampling	12	hr	$95	=	$1,140
Travel Expense and per Diem					
Van and car rental	1	day	$200	=	$200
Sampling Equipment, Shipping, Consumable Supplies					
Equipment & PPE	1	ea	$100	=	$100
Shipping	1	day	$200	=	$200
Misc	1	day	$75	=	$75
Sampling Analysis					
VOCs (TO-15)	3	ea	$200	=	$600
Data Management and Validation					
Assume samples validated @ 0.5 hr per sample per analyte					
Samples management/validation	2	hr	$100	=	$150
Total SVE O & M sampling					$2,845
Annual Cost					$34,140
Annual Letter Report					$1,100
Total					**$36,000**
O&M					
SVE O&M Labor & Materials	1	LS	$60,000	=	$60,000
Vapor Treatment Media Replacement (Quart	500	lbs	$2.00	=	$4,000
Vapor Treatment Media Transportation	4	trips	$500		$2,000
Utility Cost	12	months	$500		$6,000
Annual Letter Report					$1,100
Total Annual O&M					**$74,000**

In Situ Treatment Performance Monitoring					
Monitoring Wells to sample	18	wells			
Number of samplers	2	people			
Number of 12 hour workdays	4.5	days			
Field Sampling Labor					
Mob/demob	10	hr	$95	=	$950
Well Sampling	108	hr	$95	=	$10,260
Travel Expense and per Diem					
Van and car rental	4.5	day	$95	=	$428
Sampling Equipment, Shipping, Consumable Supplies					
Equipment & PPE	1	ea	$3,500	=	$3,500
Shipping	4.5	day	$150	=	$675
Misc	4.5	day	$75	=	$338
Sample Analysis including QC samples					
VOCs	23.5	ea	$80	=	$1,880
Dehalococcoides	6	ea	$450	=	$2,644
Data Management and Validation					
Assume samples validated @ 0.5 hr per sample per analyte					
Samples management/validation	12	hr	$80	=	$940
Data management	24	hr	$95	=	$2,233
Total In Situ Treatment Performance Monitoring (per event)					**$24,000**

PROJECT:	Wantagh Cleaners	COMPUTED BY :	YL	CHECKED BY:	CG
JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	11/9/2015
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Description: Present Worth Calculations

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

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

P = Present Worth

A= Annual amount

i = interest rate

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

SVE Performance Monitoring

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

SVE O&M

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

In Situ Treatment Performance Monitoring

n =	10
i =	7%
The multiplier for $(P/A)_2$ =	**7.024**

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JOB NO.:		DATE :	11/2/2015	DATE CHECKED:	11/9/2015
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Description: Wage rates assumptions for the professional and craft labor and equipment rates for use in FS cost estimate.

Number of work hours per year: **2080** *52 weeks x 40 hours per week*

Professional Labor	**Rate**
Labor Category	
Project Manager	**$150**
Site Superintendent	**$120**
Construction Foreman	**$120**
Environmental Engineer	**$100**
Engineer	**$95**
Environmental Technician	**$85**
Surveyor	**$80**
Drafter	**$75**
Chemist	**$100**
N2 Operator (Water Treatment)	**$95**
Industrial Hygienist (SHSO)	**$100**
Security Guard	**$50**
Laborer (Semi-Skilled)	**$50**
Geologist	**$100**
Data Management	**$85**
Administrative Staff	**$65**

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