FINAL
Feasibility Study Report for the Farmingdale Plaza Cleaners Site, Operable Unit 2
Farmingdale, Nassau County, New York

Site No. 130107

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Prepared for:
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List of Abbreviations and Acronyms

A&P	The Great Atlantic and Pacific Tea Company, Inc.
AA	alternative analysis
AMSL	above mean sea level
ARAR	applicable or relevant and appropriate requirement
AS	air sparging
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMT	Continuous Multichannel Tubing
COC	contaminant of concern
CP-51	Final Commissioner Policy No. 51, Soil Cleanup Guidance
CRI	Continued Remedial Investigation
DCA	dichloroethane
DCE	dichloroethene
DCB	dichlorobenzene
EEEPC	Ecology and Environment Engineering, P.C.
EPA	(United States) Environmental Protection Agency
ESA	Environmental Site Assessment
FPC	Farmingdale Plaza Cleaners
FS	Feasibility Study
gpm	gallons per minute
HRC	hydrogen-releasing compound
IC	institutional control
LIFS	Liberty Industrial Finishing Site
LTM	long-term monitoring
µg/L	micrograms per liter
mg/L	milligrams per liter
MA	Magothy Aquifer
MEE	methane, ethane, ethene

List of Abbreviations and Acronyms (cont.)

MEK	methyl ethyl ketone
MPI	Malcolm Pirnie Inc.
MTBE	methyl tertiary butyl ether
NAPL	non-aqueous phase liquid
NCP	National Contingency Plan
NYCRR	New York Codes, Rules, and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OM&M	operations, monitoring, and maintenance
ORC	oxygen-releasing compound
ORP	oxidation reduction potential
OSHA	Occupational Safety and Health Administration
OU	operable unit
PCE	tetrachloroethene
PPE	personal protective equipment
PRB	permeable reactive barrier
PRP	potentially responsible party
qPCR	quantitative polymerase chain reaction
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	Record of Decision
RSCO	Recommended Soil Cleanup Objective
SCG	standards, criteria, and guideline
SPDES	State Pollutant Discharge Elimination System
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TAGM	Technical Administrative Guidance Memorandum
TBC	to be considered criteria
TCE	trichloroethene
TOC	total organic carbon
TOGS	Technical and Operational Guidance Series
UGA	Upper Glacial Aquifer

List of Abbreviations and Acronyms (cont.)

VC	vinyl chloride
VOC	volatile organic compound
YU	YU & Associates
ZVI	zero-valent iron

1 Introduction

1.1 Purpose and Organization

Ecology and Environment Engineering, P.C. (EEEPC) has completed a Feasibility Study (FS) for the Farmingdale Plaza Cleaners (FPC) site under contract to the New York State Department of Environmental Conservation (NYSDEC) (Work Assignment Number D004435-25). The FPC Site (Site No. 130107) is located in the village of Farmingdale, Town of Oyster Bay, Nassau County, New York (see Figure 1-1). The scope of this FS is to propose alternatives to address the groundwater contaminant plume associated with the FPC site, also identified as Operable Unit-2 (OU-2). Previous investigations and remedial efforts have addressed the on-site soil and soil-vapor contamination as part of Operable Unit 1 (OU-1).

This FS was developed using information from the following sources: the United States Environmental Protection Agency's (EPA's) *Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) (EPA 540/G-89/004) (EPA 1988a); EPA's *CERCLA Compliance with Other Laws Manual* (EPA 1988b); NYSDEC's Final Commissioner Policy No. 51 (CP-51), Soil Cleanup Guidance (NYSDEC 2010b); NYSDEC's DER-10, *Technical Guidance for Site Investigation and Remediation* (NYSDEC 2010a); New York State Department of Health's (NYSDOH's) *Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York* (NYSDOH 2006); and New York State Codes, Rules, and Regulations (NYCRR) Title 6, Part 375, *Environmental Remediation Programs* (NYSDEC 2006).

Several studies have been completed to characterize the nature and extent of the groundwater contaminant plume associated with the FPC Site. This includes the. *Final Plume B Source Investigation Report* prepared by Earth Tech, Inc. (2004), the *Final Immediate Investigation Report* prepared by YU & Associates, Inc. (2009), and, most recently, the *Remedial Investigation Report for the Farmingdale Plaza Cleaners Site, Operable Unit 2* prepared by EEEPC (2013).

This FS describes the technologies proposed and evaluated to address the groundwater contaminant plume. The FS report is divided into the following six sections:

- Section 1 describes the purpose for the study and discusses site background information;
- Section 2 presents the process used to identify the appropriate standards, criteria, and guidance (SCG) values applicable to the various contaminants found in the groundwater and provides insight into the development of appropriate remedial action objectives (RAOs) to protect human health and the environment;
- Section 3 evaluates various technologies that may be appropriate for remediating the groundwater contamination;
- Section 4 presents combinations of these technologies as remedial alternatives, and provides detailed analyses of these alternatives along with supporting rationale and preliminary cost estimates for each of the proposed alternatives;
- Section 5 presents a comparative analysis of the proposed remedial alternatives; and
- Section 6 presents a list of the references cited in this report.

1.2 Background Information

1.2.1 Site Description and Surrounding Land Uses

The FPC Site is located at 450 Main Street in the village of Farmingdale, town of Oyster Bay, Nassau County, New York (see Figure 1-1). The Site is situated on a 4-acre parcel that includes a 33,000-square-foot one-story masonry structure and an associated parking lot (Section 49: Block 102, Lots 245, 250, and 269). The masonry structure building is broken up for several businesses and the former occupants of the structure include the Waldbaum's Supermarket and Farmingdale Plaza Cleaners. At the time of this report, the only remaining businesses are Main Street Cards and Gifts and Lucky House Chinese Restaurant. The plaza site is bordered by Prospect Street to the north, Fulton Street/Long Island Railroad to the south, Main Street to the east, and Weiden Street to the west. The surrounding area is a mixed neighborhood of restaurants, houses, apartment complexes, and retail businesses. The nearest surface water body to the site is Massapequa Creek, a small ephemeral stream, that originates about 4,500 feet south-southeast of the site.

1.2.2 Site History/Previous Investigations

FPC began operation at the Farmingdale Plaza in 1983, which was reportedly constructed the same year. In the 1990s, environmental investigations began near the FPC site in an effort to investigate the nearby Liberty Industrial Finishing Site (LIFS). LIFS is a National Priority List designated site located approximately 1,000 feet to the south (downgradient) of the FPC site at 55 Motor Avenue. In 2000, a Continued Remedial Investigation (CRI) was conducted for the United States Environmental Protection Agency (EPA) at the LIFS indicated that the

Farmingdale area had been impacted by two contaminant plumes (designated as Plume A and Plume B) (URS 2000). Plume A was determined to originate from the LIFS (see Section 1.2.3 below), while the tetrachloroethene (PCE)-dominated Plume B was identified to originate from an upgradient source that was later identified as the FPC site and possibly unknown source(s) north of the FPC site. Since then, the FPC site has been the subject of a number of environmental investigations. The following paragraphs describe the results of these investigations. However, it should be noted that all investigation work performed by the potentially responsible party's (PRP's) consultants (Malcolm Pirnie Inc. [MPI] and Whitestone Associates) was not done under the NYSDEC supervision, nor did NYSDEC review any of the PRP's work plans and/or results as this work was not performed under an Order on Consent.

In 2000, MPI completed a Phase I Environmental Site Assessment (ESA) on behalf of the PRP (The Great Atlantic and Pacific Tea Company, Inc. [A&P]). The report did not identify any major areas of concern (MPI 2000). In 2001, MPI conducted a Phase II ESA on behalf of the PRP (MPI 2001). Although both benzene and PCE were detected in the groundwater samples, MPI proposed that the identified contaminants were related to an off-site contaminant source, but NYSDEC did not concur with the proposed conclusion.

In 2001, soil and groundwater samples were collected at the FPC site during an Environmental Site Investigation by Whitestone Associates (Whitestone 2001) for the PRP (A&P). Although no volatile organic compounds (VOCs) were reported in the soil samples above the Technical Administrative Guidance Memorandum (TAGM) Recommended Soil Cleanup Objectives (RSCOs), PCE, trichloroethene (TCE), cis-1,2-dichloroethene (DCE), and trans-1,2-DCE were detected in several groundwater samples. PCE was reported above the groundwater standard in five of six temporary well points to the east, south, and west, of the dry cleaner building, as well as in monitoring wells north of the plaza and in a monitoring well located at the southern access driveway to the plaza. Cis-1,2-DCE was also detected above the groundwater standard in the two westernmost samples.

In November 2003, Whitestone Associates conducted a Historical Site Use Investigation (Whitestone 2003) at the site on behalf of the PRP. This investigation found no VOCs present in soil above the TAGM RSCOs and identified groundwater contamination as unrelated to historic site activities. Groundwater flow was interpreted to have a northeasterly flexure. NYSDEC did not agree with the proposed conclusion. Subsequent investigations conducted by both EPA and NYSDEC have interpreted groundwater flow to generally be from north to south (YU 2009).

During the period from August 2000 to June 2003, Earth Tech, Inc., conducted an investigation for the EPA at the LIFS. Earth Tech concluded that groundwater flow was to the south in both the Upper Glacial Aquifer (UGA) and Magothy Aquifer (MA) and confirmed that Plume B originated from an off-site source in the vicinity of the FPC site (Earth Tech 2004). The highest concentrations of

PCE (and degradation products TCE and cis-1,2-DCE) were found in the UGA southwest of the FPC site. However, wells immediately north of the FPC plaza showed significantly less PCE (Earth Tech 2004). The highest PCE concentration detected was 3,600 micrograms per liter (µg/L) in well EPA-MW-4A during a sampling event performed in August 2000. In conjunction with the hydrogeologic investigation, the EPA conducted a soil vapor survey and identified elevated levels of PCE in areas immediately adjacent to and in the parking lot southeast of the FPC site (YU 2009).

In 2004, as a result of the Earth Tech investigation, Whitestone Associates conducted a Supplemental RI (Whitestone 2004) on behalf of the PRP. This report concluded that there was no evidence of a PCE source originating at the FPC site that would impact groundwater and that VOC detections were attributed to background groundwater contamination, but NYSDEC did not concur with these findings.

In 2007, O'Brien & Gere conducted an on-site remedial investigation (RI) at the FPC site for NYSDEC that identified PCE and degradation product contamination both upgradient and downgradient of the site (O'Brien & Gere 2007). The PCE plume north of the dry cleaner had a maximum concentration of 170 µg/L, but groundwater wells positioned between the upgradient PCE plume and the dry cleaner showed PCE concentrations were an order of magnitude lower (about 20 µg/L) than in the incoming plume. Wells downgradient of the dry cleaner had a maximum PCE concentration of 160 µg/L. The PCE concentration gap suggests that there is a possibility that there are two separate plumes. PCE was also reported above RSCOs in soil samples collected in the sub-slab area of the FPC building. The 2007 RI report recommended mitigation efforts to limit the impact of soil vapor intrusion for both the Farmingdale Plaza and the neighboring Garden Apartments. A soil vapor extraction system was installed by NYSDEC on site in November 2011 after the remedial design and pilot test were completed.

In 2008/2009, YU & Associates (YU), under contract to AECOM Technical Services Northeast, Inc., conducted an Immediate Investigation for NYSDEC related to the Plume B groundwater contaminant plume believed to originate from the FPC site and other upgradient sources (YU 2009). YU installed 10 Solinist Continuous Multichannel Tubing (CMT) multilevel wells, each with seven sampling zones, to depths up to 117 feet below ground surface. Six CMT wells were installed downgradient of the FPC site and upgradient of the LIFS, while four CMT wells were installed downgradient of the LIFS. These wells did not extend beyond the top few feet of the MA. YU's 2009 Immediate Investigation report concluded that:

- Based on potentiometric surface elevations, groundwater flow is primarily toward the south with a clear downward vertical hydraulic gradient existing in the UGA near the FPC site;

- Primary VOCs detected during this investigation were PCE and its degradation products, TCE and cis-1,2-DCE. TCE concentrations were an order of magnitude lower than PCE concentrations;

- VOC contamination detected within the investigation area originates from multiple potential sources including the FPC site, LIFS, and possibly unknown source(s) upgradient of the FPC site; and

- PCE contamination migrates from the FPC site and across the LIFS in a southerly direction with a slightly westward component. Downgradient of the FPC site, higher levels of contamination at depth suggest a general dipping of the contaminant plumes as they move southward along the direction of groundwater flow. The downward dipping trend observed in the plumes is potentially the result of the downward hydraulic gradient and density effects of the contamination, with the downward hydraulic gradient being the primary influence.

1.2.3 Liberty Industrial Finishing Site Investigations (Plume A)

The initial LIFS facilities were built in 1934 by Kirkham Engineering and Manufacturing Company, for the manufacture of aircraft-related equipment. In the 1940s, the Defense Plant Corporation established operations at the Site for the manufacture of aircraft parts by the lessee, Liberty Aircraft Products Corporation. Liberty Aircraft Products Corporation and its various successors operated the facility as a metal plating operation until 1978. The Liberty site RI report (Roy F. Weston, Inc. 1994) documented the history of the Liberty site in detail, based on files compiled by the EPA and NYSDEC. The final CRI report (URS 2000) presents additional detail about the Liberty site history.

Based on investigations conducted at and around the LIFS, two groundwater contamination plumes have been identified in the Farmingdale area. "Plume A" consists of cadmium, chromium, TCE, and its daughter products. Plume A is extends from the LIFS southward towards the Southern State Parkway. "Plume B" (identified as originating from the FPC site and unknown source(s) north of the FPC site) is the subject of this study and generally consists of PCE and its daughter products, which include TCE, and is found within both the UGA and MA. South of approximately Fallwood Parkway, Plumes A and B have comingled making delineation difficult.

In August 1998, the EPA issued a unilateral administrative order to the LIFS PRPs to initiate an interim groundwater action. This action ultimately resulted in construction and operation of an on-site groundwater pump and treat system operated as a non-time critical removal action. Other remedial activities have occurred at the LIFS since the original groundwater recovery system was installed, including removal of over 80,000 tons of on-site soil (2009–2010), design and completion of off-site sediment remediation at Pond A in Massapequa Preserve (2008-2009), and design and construction of an off-site groundwater recovery and treatment system (2009–2010). The off-site groundwater recovery system has numerous components. Groundwater is extracted from the UGA near 1st Avenue and Tomes Avenue by three recovery wells and from the MA by three additional wells that have an estimated capture width of approximately 940 feet near Spielman Avenue. In addition, at the distal end of the cadmium and chromium plume near 9th Avenue, a single UGA extraction well operates with a design capture width of approximately 500 feet (EEEPC 2008).

1.3 Farmingdale Plaza Cleaners Off-Site Remedial Investigation (OU-2)

EEEPC completed an RI at the FPC Site in 2011 – 2012 on behalf of NYSDEC in order to define the nature and extent of the off-site groundwater contamination and assess the potential threats posed by these contaminants to human health and the environment. A summary of the RI findings is presented in Sections 1.3.1 through 1.3.4 of this report.

1.3.1 Site Geology and Hydrogeology

Four geologic units lie beneath the site, including glacial deposits composed of the Ronkonkoma and/or Harbor Hill glacial outwash (Upper Glacial Aquifer), the Magothy Formation and Matawan Group (Magothy Aquifer), a clay member of the Raritan Formation (Raritan Clay), and the Lloyd Sand Member of the Raritan Formation (Lloyd Sand). Only two of these units (the Upper Glacial and Magothy aquifers) were encountered during the RI (EEEPC 2013).

The nature of the overburden at the site was characterized during the RI (EEEPC 2013) through research of existing documentation from previous investigations of the FPC site and LIFS, gamma logging during groundwater profile boring installation, and limited soil corings. The overburden encountered at the site is consistent with the regional model of unconsolidated glaciofluvial outwash deposits. The uppermost units comprise the UGA and were deposited during various stages of the Wisconsin-age glaciation. Previous investigations in the site vicinity reported the UGA as 60 to 90 feet thick (YU 2009; URS 2000). During the RI for FPC OU-2, the UGA was observed to be approximately 85 to 100 feet thick based on gamma logs, including the transitional unit at the base of the UGA (EEEPC 2013). The soils within the upper portion of the UGA generally consisted of brown, tan, or orange brown, gravelly sand, sometimes with a trace of silt. The grain size of the sand was generally unsorted and ranged from fine to coarse. The lower portion of the UGA (zone immediately above the MA) is generally characterized by fine-grained sand, silt, and clay, but sometimes also contained a trace of gravel. The color of this transitional unit was generally dark brown to gray. These finer grained soils of varying thickness were generally recognizable in gamma logs from the profile borings but exhibited a gradational transition and appear to correlate with a unit identified as the “20-foot-clay” described in regional geologic literature (URS 2000; Perlmutter and Geraghty 1962).

The soils of the MA (or Magothy Formation) consist of Cretaceous-age non-marine, interlayered sand, silt, and clay deposits ranging from approximately 30 to 1,000 feet thick in southern Nassau County. The sandy portions of the MA are reported to consist of gray or tan, fine- to medium-grained sand in contrast to the generally brown coarser deposits of the UGA. Sands of the MA often contain some lignite (coal). Beds of clay, silt, and gravel also occur (Perlmutter and Geraghty 1962). The MA soils described in soil cores during the RI generally consisted of interbedded tan/gray/brown/dark brown, medium- to coarse-grained sands, dark gray silty sand, dark brown/ gray clayey silt, and dark brown silty clay (EEEPC 2013). Gamma logs showed layers containing a relatively high clay content compared to other zones. These clay layers were of variable depth and thickness, were sometimes sharply defined, and other times there was a gradational change from sand to silt to clay.

Based on static water level measurements obtained during the RI, the general groundwater flow pattern within the area was to the south in both aquifers, consistent with the previous investigations (EEEPC 2013; YU 2009). Localized variation between the groundwater flow patterns in the two aquifers was observed, possibly due to localized variation in hydraulic conductivity and gradient between the specific monitoring zones of the wells.. In both the UGA and MA, the overall horizontal gradient was measured to be approximately 0.2% to the south.

In terms of the vertical gradient, the 2009 Immediate Investigation report (YU 2009) stated that a downward hydraulic gradient exists in the UGA near the FPC site (OU-1). The report concluded that chlorinated contamination could travel vertically through the vadose zone, encounter groundwater within the UGA, and continue to migrate downward through the UGA as it traveled southward (along the groundwater flow direction) before migrating into the MA. However, migration of contaminants from the UGA into the MA is not only affected by the gradient, but also by the presence of physical barriers, such as the fine-grained transitional unit between the aquifers. The LIFS CRI report (URS 2000) indicated that the fine-grained transitional unit is well developed at least in the vicinity of the LIFS site as well as south of Plitt Avenue. The CRI report further indicated a potential "gap" in the transitional unit where it was not as prominently developed. Gamma logs obtained along Fallwood Parkway during the OU-2 RI investigation supported this idea (EEEPC 2013). The gamma response in profile borings PW-12, PW-13, and PW-14 was not as prominent at the base of the UGA as it was elsewhere. However, there was a positive gamma response within the transitional unit and additional positive responses indicative of clay layers within the upper MA. This indicates that the transitional unit at the base of the UGA is not completely absent but likely contains less silt and clay than it does in other areas. The PCE contaminant plume is present in the MA both upgradient and downgradient of Fallwood Parkway and, therefore, has either migrated downward around the FPC site (OU-1 area) or there are additional sources present with the MA upgradient of the FPC site.

To further evaluate the potential for vertical contaminant migration, vertical hydraulic gradients were calculated based on data collected during the RI (EEEPC

2013). The vertical gradient was determined at well pairs by dividing the difference in head (groundwater elevation) by the vertical distance between the midpoints of the screens. Vertical gradients were estimated for well pairs screened only in the UGA; for well pairs screened only in the MA; and for well pairs across the UGA – MA boundary. The vertical gradient in the UGA appears to be generally flat throughout OU-2 and to the south (0.03% at the MW-9 and MW-11 well clusters) and have a slight upward gradient at OU-1 (0.72% at the EPA-MW-5 well cluster). The vertical gradient in the MA appears to vary. It is generally flat to a slight upward gradient in the main portion of the plume (0.1 to 0.39% at the MW-11, MW-28, and MW-31 well clusters). A stronger upward gradient (1.7%) was calculated at the MW-9 well cluster south of the plume. Between the UGA and MA, the gradient varies. There is a slight downward gradient in some areas (0.2 to 1.1% at well clusters MW-9, MW-11, and MW-29), but there is also a slight upward gradient in other areas (0.36% at well cluster MW-31).

1.3.2 Nature and Extent of Contamination

The RI sample results confirmed the presence of chlorinated VOCs (primarily PCE, TCE, and cis-1,2-DCE) in the off-site groundwater plume. Chlorinated compounds, especially PCE, are commonly used in the dry cleaning industry for their ability to dissolve and remove stains without damaging natural or man-made fibers. Chlorinated VOCs have relatively light to moderate molecular weight and are more soluble in water (solubilities generally range from 150,000 to 3,500,000 µg/L), than heavier molecular weight chlorinated semivolatile organic compounds. VOCs also have high volatilization rates and do not sorb to soil or other organic material at as high of a rate as other organic compounds. A summary of the RI findings are presented below:

- A total of 11 groundwater profile borings (see Figure 1-2 for locations) were installed as part of the RI (EEEPC 2013). The purpose of the groundwater profile borings was to aid in the delineation of the horizontal and vertical extent of groundwater contamination. A total of 68 groundwater grab samples were collected and analyzed. In-field screening using the Color-Tec method was employed to determine whether the horizontal and vertical extent of chlorinated VOC contamination had been reached. The same samples were also sent to the lab for quantification of VOC concentrations. Chlorinated VOCs were detected in 19 of the 68 groundwater grab samples, with the majority of the detections from the MA. A total of 23 different VOCs were detected in the groundwater grab samples, 13 of which were found at levels exceeded NYSDEC Class GA groundwater standards or guidance values (PCE, TCE, cis-1,2 DCE, 1,2-dichlorobenzene [DCB], 1,1-dichloroethane, tetrahydrofuran, Freon-12, benzene, methyl tertiary butyl ether [MTBE], toluene, xylenes, acetone, and methyl ethyl ketone [MEK]). PCE/TCE were found frequently and at concentrations exceeding the Class GA standards in 8 of the 11 profile borings and the majority of the detections were in the MA. The highest total chlorinated VOC concentration was from a sample collected in the MA from profile boring PW-17 (126 µg/L). The majority of the non-chlorinated aliphatic detections were at relatively low concentration with the exception of MEK at 260 µg/L and tetrahydrofuran at 18,000 µg/L(considered a single, anomalous detection) in the MA at PW-15; MTBE at 110 µg/L in the MA at PW-16; and benzene at 74 µg/L in the UGA at PW-19.

- A total of 39 groundwater samples were collected from permanent monitoring locations and were analyzed for VOCs (see Figure 1-2). There were 10 VOCs detected in at least one of the groundwater samples, seven of which were detected at concentrations that exceeded Class GA standards in at least one sample (PCE, TCE, cis-1,2 DCE, Freon-12, 1,2-DCB, MTBE, and chlorobenzene). Total chlorinated VOCs ranged from non-detect to 231 µg/L in the MA.

- Ten of the groundwater samples were also submitted for analysis of natural attenuation parameters including methane, ethane, ethene (MEE), nitrate/nitrite, sulfate, phosphate, ferrous ion, total iron, total organic carbon (TOC), and quantitative polymerase chain reaction (qPCR) analysis for *Dehalococcoides* bacteria. Evaluation of these parameters generally indicated that there is some evidence but limited potential for reductive dechlorination of PCE and TCE by anaerobic biodegradation.

Using the groundwater data collected from monitoring wells and profile borings during the RI (EEEPC 2013) and previous FPC and LIFS investigations, the RI characterized the lateral and vertical extent of the PCE and TCE contamination within the UGA and the MA. Figures 1-3 and 1-4 display the lateral extent of the PCE and TCE contamination in the UGA and the MA. Different datasets were combined with data collected during this RI investigation to prepare these figures. Wells and profile boring labels colored purple on the figures represent data obtained as part of the FPC OU-2 RI between August 2011 and March 2012. Well labels colored orange represent data from other studies that were incorporated in order to assist with the evaluation. The previous datasets that were incorporated include the 2007 RI for OU-1 (O'Brien & Gere 2007), the 2008 NYSDEC Immediate Investigation (YU 2009), and LIFS groundwater monitoring program semiannual reports from 2010 through 2012 (EEEPC 2010; 2011a; and 2012).

Except for one sample interval at profile well PW-1 (near Fulton Street), groundwater contamination in the upper UGA (within approximately 35 feet of ground surface) is below NYSDEC Class GA standards. As shown on Figure 1-3, PCE is present upgradient of the FPC site based on its presence in monitoring well DEC-MW-3 during this investigation. PCE was also detected upgradient of the FPC site in UGA wells during previous investigations (O'Brien & Gere 2007). The PCE plume shape downgradient of the site was interpreted to be discontinuous based on the locations of the detections exceeding 5 µg/L and the lack of PCE above Class GA in wells north of Motor Avenue exceeding NYSDEC Class GA standards. However, based on the shallow depth of monitoring well MW-34B and the PCE detection in PW-9, the PCE plume is interpreted to extend a few hundred feet north of Motor Avenue along the base of the UGA. The PCE plume within the UGA appears to end south of Fallwood Parkway. No additional PCE was detected exceeding the NYSDEC Class GA standard south of Yoakum Avenue within the UGA except for well MW- 36B near the Southern State Parkway, which contained 8.1 µg/L of PCE in June 2011. In regard to TCE, this contamination also appears to be discontinuous, with localized, disconnected portions of the plume extending from Motor Avenue (MW-38B) south to MW-36B near the Southern State Parkway (see Figure 1-3). The portion of the TCE plume with highest concentrations within the UGA appears to be centered on PW-15 between Fallwood Parkway and Radcliff Avenue.

Figure 1-4 depicts the extent of PCE and TCE contamination within the MA. There is only one MA well in the vicinity of the FPC site (EPA-MW-1B), which is not directly downgradient of the dry cleaner site, but nearby to the southeast. PCE was detected at low concentrations below the NYSDEC Class GA standard in 2006 and 2007; however, no TCE was detected (O'Brien & Gere 2007). No MA monitoring wells are known to exist upgradient and in the vicinity of the FPC site. The closest downgradient groundwater sample location to the FPC site that contains PCE at a concentration exceeding the NYSDEC Class GA standard is in the lowest channel (Channel 0) of profile well PW-4, which is interpreted to be within the uppermost portion of the MA. The concentration of PCE at this location was 39 µg/L in 2008 (YU 2009). The PCE plume widens as it extends southward until the plume ends abruptly at Tomes Avenue (based on the lack of PCE in wells MW-31C, -31D, and -47C). TCE was not detected above the NYSDEC Class GA standard in the MA north of Fallwood Parkway. The TCE plume in the MA also widens as it extends southward and ends abruptly near Tomes Avenue (see Figure 1-4).

Three cross sections (see Figures 1-5 through 1-7) were prepared to depict the vertical extent of PCE and TCE contamination. The locations of the cross sections are shown on Figure 1-2. Figure 1-5 represents an east-west section A-A′ along Fallwood Parkway. This figure shows that PCE contamination is restricted to the lower part of the UGA and upper part of the MA only. The concentrations are relatively low and do not exceed 12 µg/L (at a depth of 135 feet in PW-13). There is even less TCE present – only one detection is above the groundwater standard (a detection of 10 µg/L in MW-29C).

Figure 1-6 represents a generally east-west section B-B′ along Spielman Avenue. This figure shows that PCE and TCE contamination are restricted to the MA only with the possible exception of some TCE on the west end of the diagram. The presence of TCE in the basal portion of the UGA in that area is interpreted based on its historical presence in LIFS profile boring VP-01 in 2005 (EEEPC 2005). The extent of PCE appears to have been defined both to the east and west and may be affected by the presence of clay layers in the MA as seen in PW-18. To the west the extent of PCE appears to end west of Woodward Parkway. The maximum concentration of PCE observed in this area was 110 µg/L (MW-46C). The maximum TCE concentration was 460 µg/L in June 2012 (MW-11C);

however, the concentration in this well has fluctuated significantly with no apparent trend and the reported value is considered an estimate for the purpose of defining the plume (EEEPC 2011a). The base of both the PCE and TCE contamination is interpreted to end at an approximate depth of 200 feet at a clay layer detected in numerous groundwater profile borings.

Figure 1-7 represents a generally north-south section C-C′. This figure shows the extent of PCE in the UGA and MA from north to south; however, the line of section is mostly to the east of the TCE plume and no TCE is present above the groundwater standard of 5 μg/L, except at profile well PW-9 near Motor Avenue. PCE is shown to be present in the UGA at the FPC site location and in profile well PW-9 near Motor Avenue. The remainder of the PCE plume is confined to the MA. Only one monitoring well(EPA-MW-1B) is installed in the MA near the site and sample results from 2007 show the PCE levels to be below Class GA standards in this area; therefore, the northern extent of the PCE contamination in the MA remains unclear.

Based on the review of these figures, it is apparent that the extent of PCE and TCE contamination in the UGA and MA has decreased compared to data from 2006 through 2008 (O’Brien & Gere 2007; YU 2009), and remains similar to data from LIFS monitoring program in 2011 (EEEPC 2011a). Slight increases in the extent of TCE contamination in the MA shown in the FPC OU-2 RI report (EEEPC 2013) are due to the availability of additional data collected during that investigation. Reduction in the extent of TCE contamination in the UGA is attributed to the construction and operation of the LIFS groundwater treatment system and the FPC OU-1 vapor extraction system, in addition to natural degradation processes including, but not limited to, dispersion, dilution, and reductive dechlorination. The overall reduction and limitation to the horizontal extent of PCE contamination may be attributed to elimination of the source at the FPC site and natural degradation processes.

1.3.3 Contamination Fate and Transport

As the RI was focused on the off-site groundwater contaminant plume, the only transport mechanism that was considered was the groundwater flow (EEEPC 2013). Based on the depth of contamination in the off-site area, mechanisms such as surface water flow, infiltration, subsurface utilities, and volatilization, were not believed to be viable migration pathways.

Groundwater flow can allow both vertical and lateral migration of water soluble contaminants located within the saturated zone of both the UGA and MA. The horizontal flow gradient within both the UGA and MA was calculated to be approximately 0.2%. The vertical flow gradient has been shown to vary seasonally and with location throughout the area. The LIFS CRI report indicated that while groundwater movement is predominantly horizontal, upward or downward gradients exist within the MA and also between the two aquifers on a seasonal basis (URS 2000).

Vertical gradients calculated during the RI for OU-2 identified a flat to slightly upward gradient within both the UGA and MA, but there was generally a downward gradient between the two aquifers (EEEPC 2013). Although downward vertical gradients do exist, migration of groundwater between the aquifers is affected by the low vertical hydraulic gradient within the aquifers as well as the presence a fine-grained transitional unit at the base of the UGA with a relatively low hydraulic conductivity compared to the over- and underlying sand and gravel units. As indicated in the LIFS CRI report, the horizontal flow velocity exceeds the vertical flow velocity by approximately two orders of magnitude due in part to the presence of the transitional unit (URS 2000).

The transport of aqueous phase organic contaminants in groundwater is also limited by chemical properties of the contaminants. Site-specific hydraulic data was not collected during the RI (EEEPC 2013). In the LIFS CRI report (URS 2000), the effective porosity for the UGA was estimated to be 30% and slug test results indicated an average hydraulic conductivity of approximately 180 feet per day. Based on these two studies, the horizontal groundwater seepage velocity in the UGA was estimated to be 1.2 feet per day and that of the MA was estimated to be 0.4 feet per day. Contaminant migration velocities were calculated based on retardation factors for PCE and TCE. The average PCE contaminant velocity in the UGA was determined to be approximately 0.05 feet per day and the average TCE contaminant velocity was approximately 0.10 feet per day. Similarly, the average PCE contaminant velocity in the MA was determined to be approximately 0.02 feet per day and the average TCE contaminant velocity was about 0.03 feet per day.

The groundwater data collected during the RI supplemented with data from previous investigations indicates that dissolved-phase contaminants migrate in groundwater from the FPC site and possibly other upgradient sources to the south in the direction of regional groundwater flow. PCE contamination in the UGA starts upgradient of OU-1 and appears to extent approximately 2,800 south of the plaza site. The extent of UGA contamination appears to have diminished with time, although there is also a small area of PCE contamination in the UGA approximately 8,000 feet south of the site near the Southern State Parkway. TCE contamination within the UGA is discontinuous, which is likely due to natural degradation process as well as LIFS remediation.

The southern extent of both PCE and TCE contamination in the MA is Tomes Avenue, approximately 4,800 feet south of the site. The MA contaminant plume appears to be more continuous than the UGA plume and is wider than the UGA plume (approximately 2,000 feet at its widest) (see Figure 1-4). The maximum depth of groundwater contamination appears to be 200 feet below grade (approximately 153 feet below sea level).

1.3.4 Qualitative Human Health Risk Evaluation

Chlorinated VOCs have been identified as the compounds of potential concern and were evaluated along current and potential future exposure pathways to assess the potential for human exposure risks. For contamination to pose a human health risk, there must be a complete pathway of exposure to the contamination and the magnitude of the exposure to contamination must be sufficient to cause an adverse health effect.

The conceptual site model considered in the RI for contaminant migration resulted in assessment of two exposure pathways (EEEPC 2013):

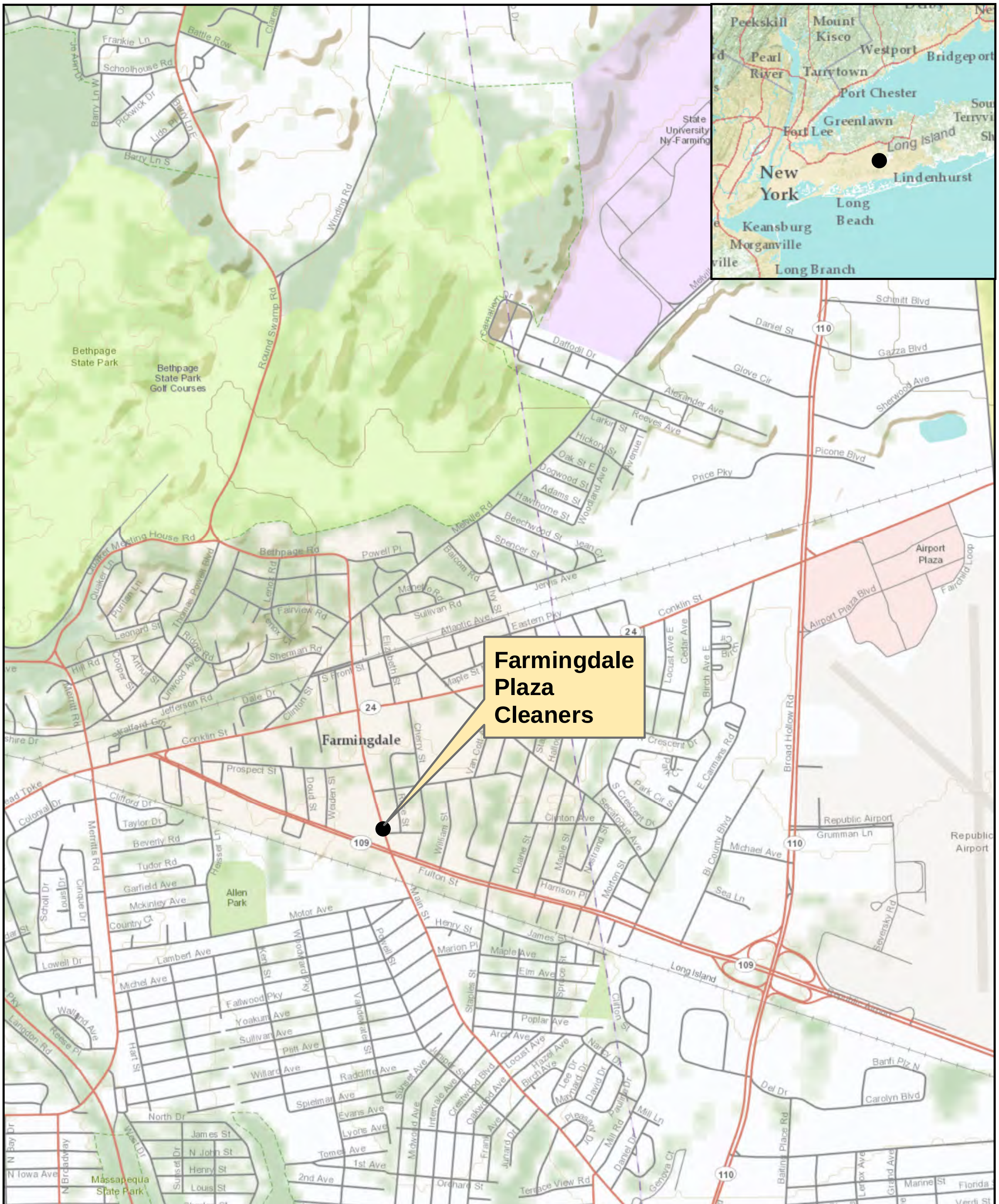
- Exposure to contaminants via ingestion of groundwater; and
- Exposure to contaminants via inhalation of vapors migrating from groundwater to indoor air.

Based on the location and depth of groundwater contamination, the provision of municipally supplied water throughout the area, the locations and depths of municipal supply wells with respect to that of the contamination, the safeguards associated with the municipal supplies, and New York State Environmental Conservation Law ECL 15-1525 requirements for installing new wells within Nassau County, it was determined that exposure to contaminants via ingestion of groundwater is not a current or viable potential future exposure pathway. Groundwater is used as a municipal water supply; however, the locations and depths of municipal supply wells are such that they are not impacted by this contaminant plume. Safeguards are in place to prevent additional well drilling within the plume and municipal supply well water is tested and treated prior to distribution in accordance with state law. Even if exposed to untreated groundwater, the anticipated risks associated with the concentrations of PCE and TCE detected within the plume are expected to be minimal. Only the maximum concentration of TCE detected in the MA (86 µg/L) could pose a potentially unacceptable risk of 2.0×10^{-4} (EEEPC 2013).

Volatilization can cause contaminants in groundwater to migrate upward through the unsaturated zone of the soil, collect under structures, and potentially migrate to indoor air through cracks and other entryways in buildings. This migration pathway is not considered to be complete and, therefore, not of a concern based on the depth to groundwater contamination (90 feet or more throughout most of the plume) as well as NYSDOH's review of available information from NYSDEC and EPA concluding that vapor intrusion was not a concern.

Thus, the possibility of adverse health effects associated with the OU-2 contaminant plume is not reasonably anticipated. However, if a residential user were to obtain access to untreated groundwater in the absence of institutional controls, the prolonged ingestion of groundwater at current contaminant concentrations could potentially cause an unacceptable risk. Furthermore, the Upper Glacial and Magothy aquifers are part of the EPA-designated sole source Nassau-Suffolk Aquifer System.

L:\Buffalo\Farmingdale\Maps\MXD\location.mxd



N

0 1,000 2,000 3,000 4,000 5,000 Feet

Figure 1-1

Site Location Map
Farmingdale Plaza Cleaners
Farmingdale, New York

Source: Esri, DeLorme, NAVTEQ

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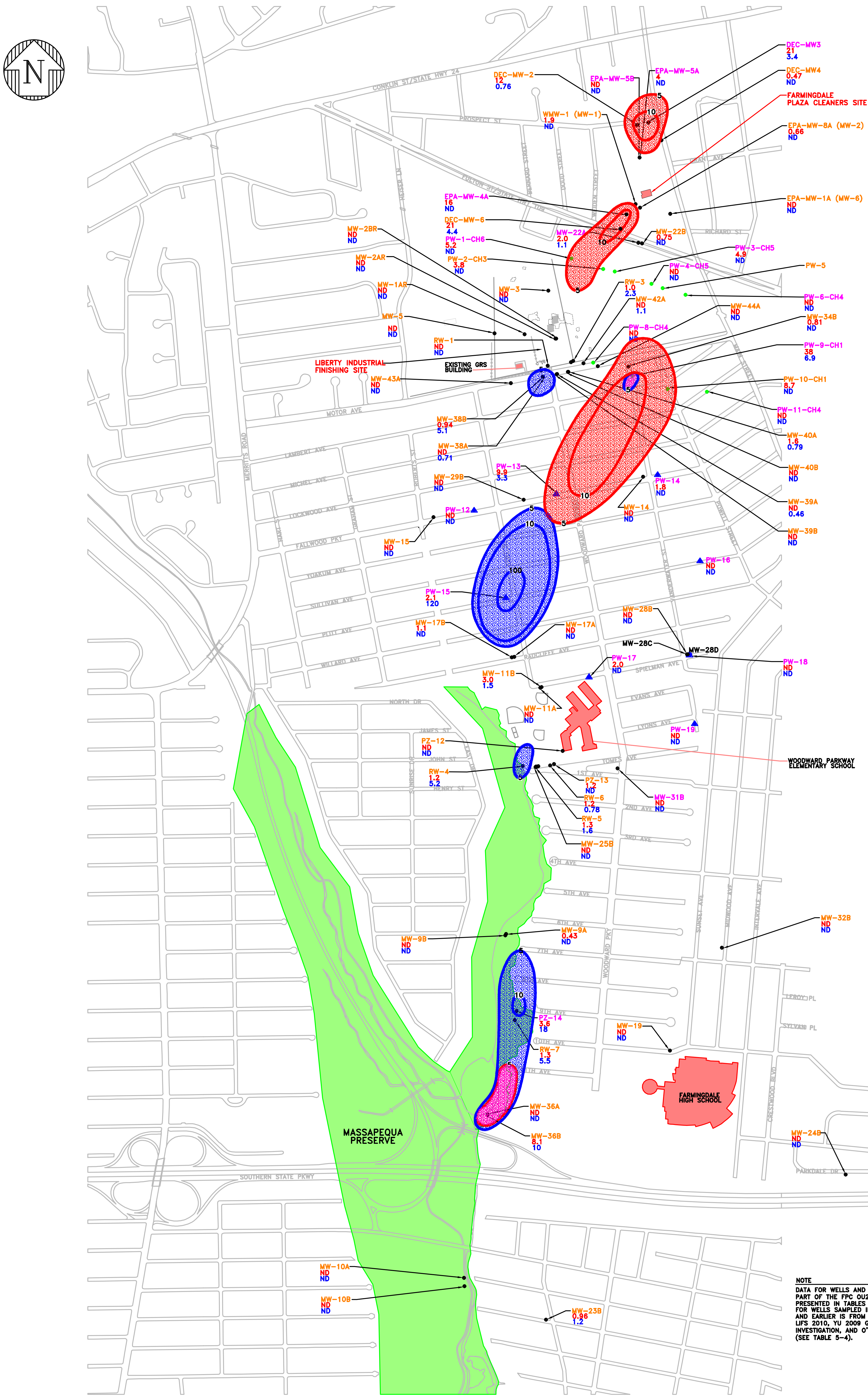
FIGURE 1-2 WELL LOCATION MAP WITH CROSS-SECTION LOCATIONS FARMINGDALE PLAZA CLEANERS SITE FARMINGDALE, NEW YORK

F:\Farmingdale Cleaners\FS 1-14-13\Figure 1-3.dwg



NOTE
DATA FOR WELLS AND BORINGS SAMPLED AS PART OF THE FPC OU2 INVESTIGATION IS PRESENTED IN TABLES 5-1 AND 5-3. DATA FOR WELLS SAMPLED IN OTHER STUDIES 2012 AND EARLIER IS FROM LIFS 2012, LIFS 2011, LIFS 2010, YU 2009 GROUNDWATER INVESTIGATION, AND O'BRIEN & GERE 2007 RI (SEE TABLE 5-4).

LEGEND

•	EXISTING MONITORING WELL, RECOVERY WELL, OR PIEZOMETER		APPROXIMATE EXTENT OF PCE	ND	PCE RESULT IN µg/L
•	2008 FPC GROUNDWATER PROFILE WELL		APPROXIMATE EXTENT OF TCE	ND	TCE RESULT IN µg/L
▲	2011 FPC GROUNDWATER PROFILE BORING		APPROXIMATE AREA WHERE PCE AND TCE INTERSECT	LIFS	LIBERTY INDUSTRIAL FINISHING SITE
•	2011 FPC MONITORING WELL				
MW-22A	WELL/BORING SAMPLED FOR THE FPC OU2 INVESTIGATION				
PW-5	WELL SAMPLED FROM OTHER STUDIES 2012 OR EARLIER				

SCALE IN FEET

0 800 1600 2400

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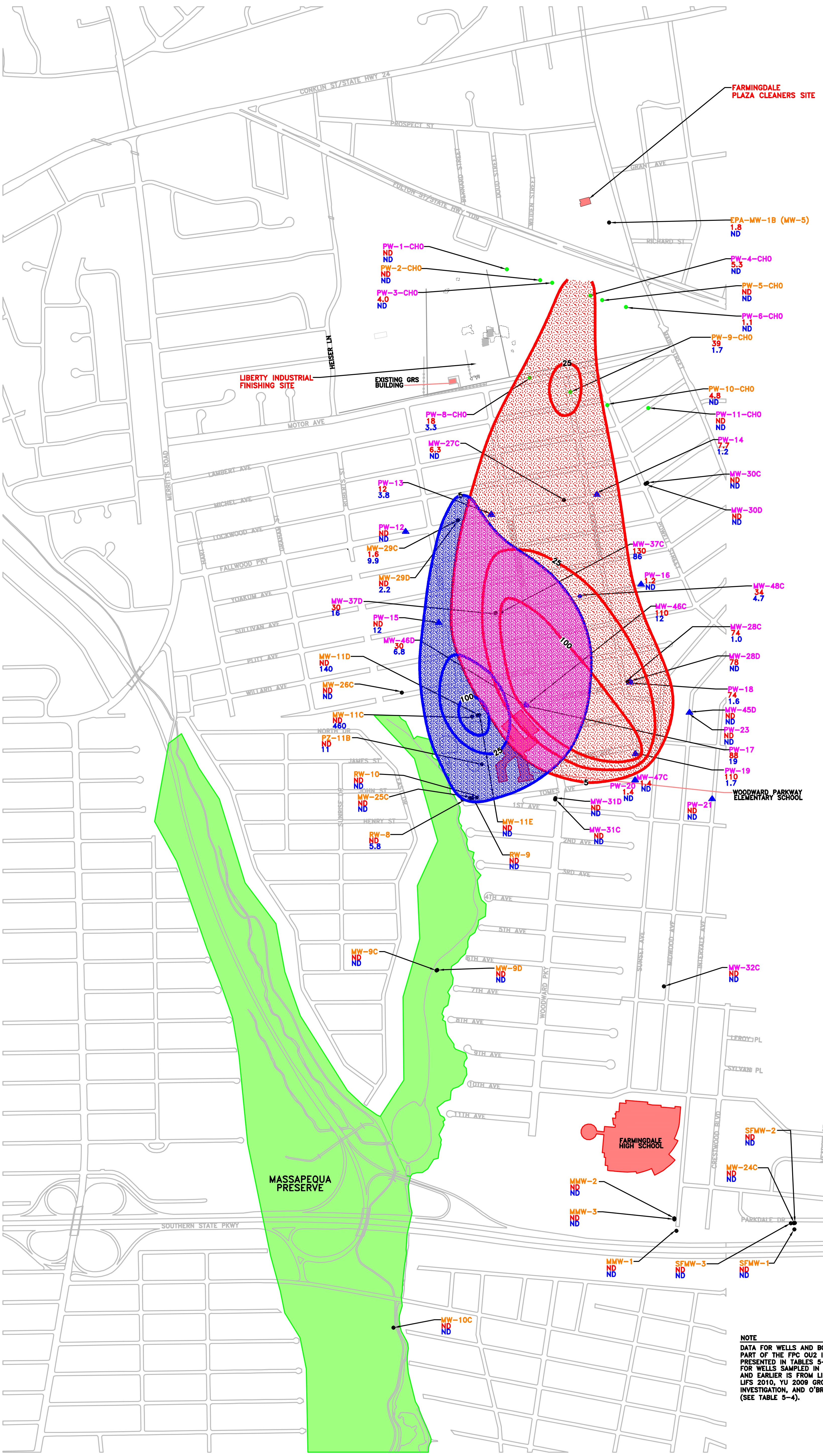
FIGURE 1-3 GROUNDWATER CONTAMINANT PLUME, UPPER GLACIAL AQUIFER
FARMINGDALE PLAZA CLEANERS SITE
FARMINGDALE, NEW YORK

F:\Farmingdale Cleaners\FS 1-14-13\Figure 1-4.dwg



NOTE
DATA FOR WELLS AND BORINGS SAMPLED AS PART OF THE FPC OU2 INVESTIGATION IS PRESENTED IN TABLES 5-1 AND 5-3. DATA FOR WELLS SAMPLED IN OTHER STUDIES 2012 AND EARLIER IS FROM LIFS 2012, LIFS 2011, LIFS 2010, YU 2009 GROUNDWATER INVESTIGATION, AND O'BRIEN & GERE 2007 RI (SEE TABLE 5-4).

LEGEND

- EXISTING MONITORING WELL, RECOVERY WELL, OR PIEZOMETER
- 2008 FPC GROUNDWATER PROFILE WELL
- 2011 FPC GROUNDWATER PROFILE BORING
- 2011 FPC MONITORING WELL
- MW-22A WELL/BORING SAMPLED FOR THE FPC OU2 INVESTIGATION
- PW-5 WELL SAMPLED FROM OTHER STUDIES 2012 OR EARLIER
- APPROXIMATE EXTENT OF PCE
- APPROXIMATE EXTENT OF TCE
- APPROXIMATE AREA WHERE PCE AND TCE INTERSECT
- ND PCE RESULT IN µg/L
- ND TCE RESULT IN µg/L
- LIFS LIBERTY INDUSTRIAL FINISHING SITE

SCALE IN FEET

0 800 1600 2400

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FIGURE 1-4 GROUNDWATER CONTAMINANT PLUME, MAGOTHY AQUIFER
FARMINGDALE PLAZA CLEANERS SITE
FARMINGDALE, NEW YORK

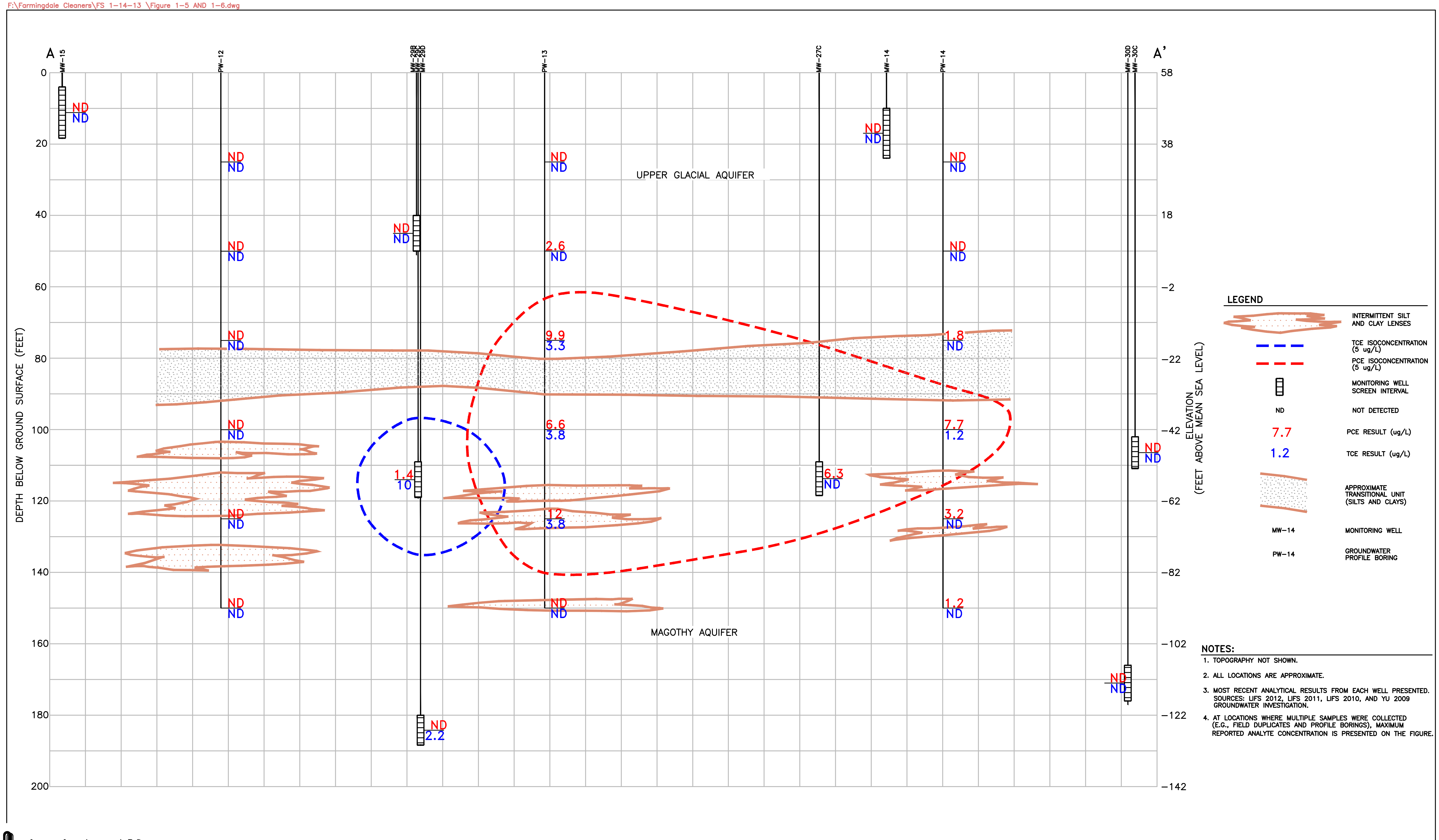

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FIGURE 1-5
CROSS-SECTION A-A' (FALLWOOD PKWY) WITH ANALYTICAL RESULTS
FARMINGDALE PLAZA CLEANERS SITE
FARMINGDALE, NEW YORK

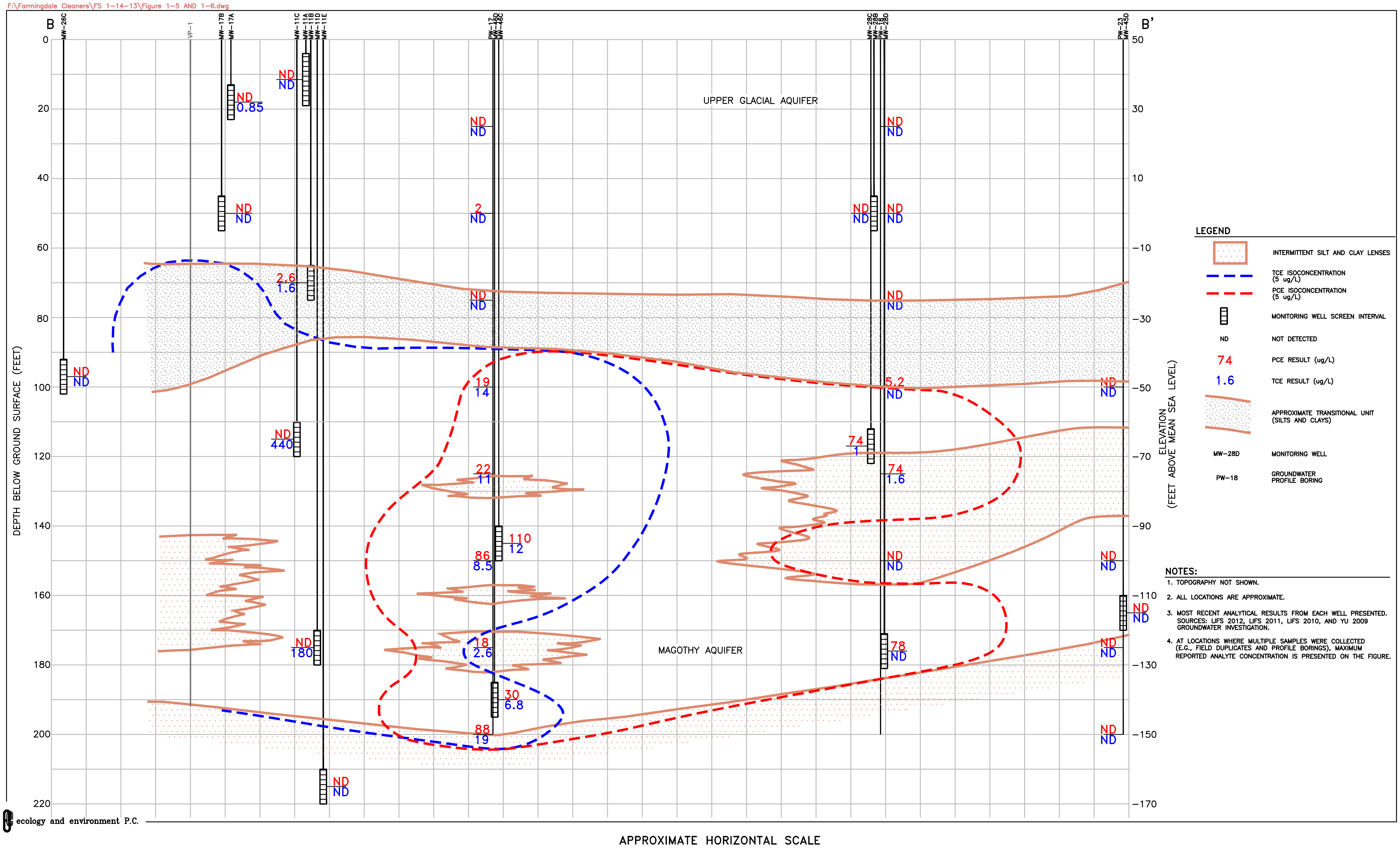
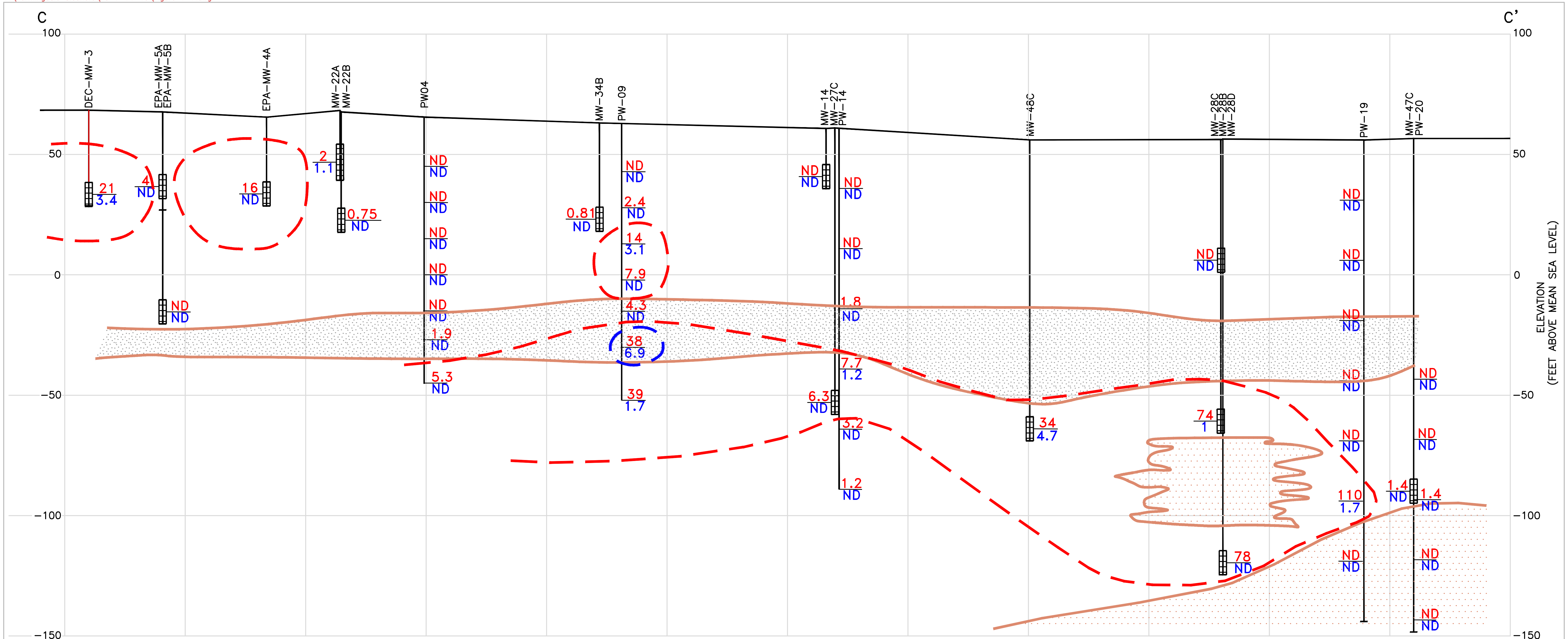


FIGURE 1-6
CROSS-SECTION B-B' (SPEILMAN AVE) WITH ANALYTICAL RESULTS
FARMINGDALE PLAZA CLEANERS SITE
FARMINGDALE, NEW YORK



NOTES:

1. ALL LOCATIONS ARE APPROXIMATE.
2. MOST RECENT ANALYTICAL RESULTS FROM EACH WELL PRESENTED. SOURCES: LIFS 2012, LIFS 2011, LIFS 2010, AND YU 2009 GROUNDWATER INVESTIGATION.
3. AT LOCATIONS WHERE MULTIPLE SAMPLES WERE COLLECTED (E.G., FIELD DUPLICATES AND PROFILE BORINGS), MAXIMUM REPORTED ANALYTE CONCENTRATION IS PRESENTED ON THE FIGURE.

LEGEND

INTERMITTENT SILT AND CLAY LENSES

TCE ISOCONCENTRATION (5 ug/L)

PCE ISOCONCENTRATION (5 ug/L)

APPROXIMATE TRANSITIONAL UNIT (SILTS AND CLAYS)

74 PCE RESULT (ug/L)

1.6 TCE RESULT (ug/L)

MONITORING WELL SCREEN INTERVAL

ND NOT DETECTED

MW-28D MONITORING WELL

PW-18 GROUNDWATER PROFILE BORING

APPROXIMATE HORIZONTAL SCALE

0 400 800 1200

APPROXIMATE VERTICAL SCALE

0 40 80 120

FIGURE 1-7
CROSS-SECTION C-C'
FARMINGDALE PLAZA CLEANERS SITE
FARMINGDALE, NEW YORK

2 Identification of Standards, Criteria, Guidelines, and Remedial Action Objectives

This section identifies the site contaminants of concern (COCs) and media of interest, and establishes proposed cleanup goals and specific RAOs for the contaminated groundwater plume. Also presented are estimates of the areal extents of the groundwater contaminant plume (OU-2).

2.1 Introduction

The RI for OU-2 identified VOC contamination in off-site groundwater associated with the FPC Site (EEEPC 2013). Based on screening of the analytical results, the RI report further identified potential risks posed by site contamination by evaluating contaminant concentrations and identifying potential exposure routes for human receptors. As described in Section 1.3.4, no complete exposure pathway exists and the possibility of adverse health effects associated with -site groundwater contamination are not reasonably anticipated. However, groundwater quality within this sole-source aquifer has been impacted. NYSDEC classifies all groundwater in New York State as protected as a source of drinking water and the groundwater standards for some of the constituents have been exceeded.

Hence, RAOs were developed (see Section 2.3) to reduce or eliminate the contaminant concentrations in impacted media to meet applicable chemical-specific standards at the site. Chemical-specific cleanup goals were developed only for groundwater to evaluate the areal extent or volume of this media that must be addressed to meet the RAOs.

SCGs include state requirements used to establish cleanup goals and identify the locations where remedial actions are warranted. The following sections present potentially applicable SCGs and other standards and establish proposed cleanup goals and specific RAOs for contaminated groundwater.

2.2 Potentially Applicable Standards, Criteria, and Guidelines (SCGs) and Other Criteria

SCGs include applicable or relevant and appropriate requirements as well as other criteria.

- **Applicable Requirements** are legally enforceable standards or regulations, such as groundwater standards for drinking water that have been promulgated under state law.

- **Applicable or Relevant and Appropriate Requirements (ARARs)** include those requirements that have been promulgated under state law that may not be "applicable" to the specific contaminant released or the remedial actions contemplated but are sufficiently similar to site conditions to be considered relevant and appropriate. If a relevant or appropriate requirement is well suited to a site, it carries the same weight as an applicable requirement during the evaluation of remedial alternatives.

- **To Be Considered Criteria (TBC)** are non-promulgated advisories or guidance issued by state agencies that may be used to evaluate whether a remedial alternative is protective of human health and the environment in cases where there are no standards or regulations for a particular contaminant or site condition. These criteria may be considered along with SCGs when establishing cleanup goals for protection of human health and the environment.

The following sections present the three categories of SCGs: chemical-specific, location-specific, and action-specific.

2.2.1 Chemical-Specific SCGs

Chemical-specific SCGs are typically technology or health-risk-based numerical limitations on the contaminant concentrations in the environment. They are used to assess the extent of remedial action required and to establish cleanup goals for a site. Chemical-specific SCGs may be used as actual cleanup goals or as a basis for establishing appropriate cleanup goals for the contaminants of concern at a site. Chemical-specific SCGs for OU-2 are presented in Table 2-1.

2.2.2 Location-Specific SCGs

Location-specific SCGs are site- or activity-specific. Examples of location-specific SCGs include building code requirements and zoning requirements. Location-specific SCGs are commonly associated with features, such as wetlands, floodplains, sensitive ecosystems, or historic buildings, located on or close to the site. Location-specific SCGs for OU-2 are presented in Table 2-2.

2.2.3 Action-Specific SCGs

Action-specific SCGs are usually administrative or activity-based limitations that guide how components of remedial actions are conducted. These may include record-keeping and reporting requirements; permitting requirements; design and performance standards for remedial actions; and treatment, storage, and disposal requirements. Action-specific SCGs for OU-2 are presented in Table 2-3.

2.3 Remedial Action Objectives

The RAOs for the groundwater contaminant plume (OU-2) were developed based on information presented in the RI and other investigation reports, including the contaminants identified and existing or potential exposure pathways in which the contaminants may affect human health (EEEPC 2013). The following RAOs for groundwater contaminant plume were considered:

- Reduce the contaminant concentrations in impacted media to meet applicable chemical-specific standards at the site;
- Prevent ingestion of groundwater with contaminant levels exceeding drinking water standards; and
- Prevent contact with or inhalation of volatiles from contaminated groundwater.

2.4 Cleanup Objectives and Volume of Impacted Media

The following sections describe the process used to select numeric cleanup objectives and estimate the volume of impacted material.

2.4.1 Groundwater

2.4.1.1 Selection of Groundwater Cleanup Goals

Standards

Numeric cleanup goals identified for groundwater quality for the contaminant plume are contained in the Division of Water, Technical and Operational Guidance Series (1.1.1) (TOGS 1.1.1) *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations*. The primary purpose of TOGS 1.1.1 is to provide a compilation of ambient water quality standards and guidance values, including the standards promulgated in 6 NYCRR 703.5 and guidance values for chemicals with no promulgated standard.

Selection Process

The selected cleanup goals for groundwater are presented in Table 2-4. The preliminary cleanup values were selected as follows:

- TOGS 1.1.1 *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations* were selected as the cleanup objective;
- The maximum observed concentration for each compound was then compared to the selected cleanup goal in order to determine which compounds may require cleanup; and
- The contaminants identified for cleanup were reviewed to determine whether they are site-related and whether cleanup is warranted.

2.4.1.2 Selection of Contaminants of Concern

Based on historic site operations and the concentrations detected in environmental media, PCE and its daughter products (TCE and cis-1,2-DCE) are the primary contaminants of concern within OU-2.

2.4.1.3 Determination of the Extent of the Contaminated Groundwater Plume

The results of groundwater sampling performed during the RI (EEEPC 2013) were used to determine the approximate lateral and vertical extent of the chlorinated VOC groundwater plume in the UGA and Magothy aquifers. Figures 1-3 and 1-4 display the lateral extent of the PCE and TCE contamination in the UGA and the MA. The boundary lines of the plumes depicted represent an interpreted concentration of 5 μg/L, which is the NYSDEC Class GA standard for both PCE and TCE. Three cross sections (see Figures 1-5 through 1-7) were prepared to depict the vertical extent of PCE and TCE contamination. The locations of these cross sections are shown on Figure 1-2. Figure 1-5 represents an east-west section A-A′ along Fallwood Parkway. Figure 1-6 represents a generally east-west section B-B′ along Spielman Avenue. Figure 1-7 represents a generally north-south section C-C′.

As indicated in Section 1.3.3, the groundwater seepage velocities in the UGA were estimated to be 1.2 feet per day and that in the MA to be 0.4 feet per day. Additionally, the average PCE contaminant velocity in the UGA was determined to be approximately 0.05 feet per day and the average TCE contaminant velocity was approximately 0.10 feet per day. Similarly, the average PCE contaminant velocity in the MA was determined to be approximately 0.02 feet per day and the average TCE contaminant velocity was about 0.03 feet per day.

As indicated in Section 1.3.3, PCE contamination in the UGA starts upgradient of OU-1 and appears to extent approximately 2,800 feet south of the plaza site. The extent of UGA contamination appears to have diminished with time, although there is also a small area of PCE contamination in the UGA approximately 8,000 feet south of the site near the Southern State Parkway. TCE contamination within the UGA is discontinuous, which is likely due to natural degradation process as well as construction and operation of the LIFS groundwater treatment system and the FPC OU-1 vapor extraction system.

Based on 2011 and 2012 data, the northern (upgradient) extent of PCE contamination appears to be south of the plaza site near Fulton Street. The TCE contaminant plume in the MA begins further to the south in the vicinity of Fallwood Parkway. The southern extent of both PCE and TCE contamination is Tomes Avenue, approximately 4,800 feet south of the plaza site. The MA contaminant plume appears to be more continuous than the UGA plume and is wider than the UGA plume (approximately 2,000 feet at its widest) (see Figure 1-4). The maximum depth of groundwater contamination appears to be 200 feet below grade (153 feet below sea level).

Table 2-1 Chemical-Specific ARARs, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
State Chemical-Specific ARARs					
Groundwater					
NYSDEC	NYSDEC's Derivation and Use of Standards and Guidance Values	6 NYCRR Part 702; also, TOGS 1.1.3, 1.1.4, and 1.1.5	Provides basis for derivation and use of water quality standards. The TOGS series also provide methodologies for deriving site-specific standards and guidance values.	Applicable	Applicable to groundwater cleanup levels.
	New York State Water Classifica-tions and Quality Standards	6 NYCRR Parts 609; 700-704	Applicable	Applicable	Applicable to groundwater treatment. May be applicable if remedial activities include discharge to groundwater or surface water.
	NYSDEC Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations	NYSDEC TOGS 1.1.1, June 1998 (with updates)	Provides a compilation of ambient water quality guidance values and groundwater effluent limitations for use where there are no standards (in 6 NYCRR 703.5) or regulatory limitations (in 6 NYCRR 703.6). For convenience, standards in 6NYCRR 703.5 and groundwater effluent limitations in 6NYCRR 703.6 are also included in TOGS 1.1.1.	Applicable	Applicable to groundwater cleanup levels and groundwater treatment.
	NYSDEC Standards for Raw Water Quality	10 NYCRR 170.4	Provides water quality standards.	Potentially applicable	May be applicable to groundwater cleanup levels.
Federal Chemical-Specific ARARs					
Groundwater					
EPA	Safe Drinking Water Act (SDWA).	Pub. L. 95-523, as amended by Pub. L. 96-502, 42 USC 300(f) et. seq.	Main federal law that ensures the quality of the nation's drinking water; sets limits to the maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs).	Applicable	
	SDWA MCL Goals.	40 CFR 141	MCLG is the level of a contaminant in drinking water below which there is no known or expected risk to health.	Applicable	MCLGs allow for a margin of safety and are public health goals that are not legally enforceable.

Table 2-1 Chemical-Specific ARARs, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
	National Primary Drinking Water Standards.	40 CFR Part 141	Applicable to the use of public water systems; protects public health by limiting the levels of contaminants in drinking water; establishes maximum allowable contaminant levels in drinking water delivered to customer; establishes monitoring requirements and treatment techniques.	Applicable	Primary MCLs are legally enforceable. The MCLs are set, based on a risk assessment process, as close to MCLG's as possible using best available treatment technology and taking cost into consideration.
	National Secondary Drinking Water Standards.	40 CFR Part 143	Applicable to the use of public water systems; controls contaminants in drinking water that primarily affect the cosmetic or aesthetic qualities relating to public acceptance of drinking water; these contaminants are not considered to present a risk to human health at the secondary MCL levels; however, at considerably higher concentrations than secondary MCLs, health implications may also exist.	Applicable	Secondary MCLs pertain to cosmetic effects (e.g., skin or tooth discoloration) or aesthetic characteristics (taste, odor, or color in drinking water), and are not legally enforceable.

Key:

ARAR = Applicable Relevant and Appropriate Regulation.
CFR = Code of Federal Regulations.
EPA = (United States) Environmental Protection Agency.
MCLs = Maximum Contaminant Levels.
MCLGs = Maximum Contaminant Level Goals.
NYCRR = New York Codes, Rules, and Regulations.
NYSDEC = New York State Department of Environmental Conservation.
RCRA = Resource Conservation and Recovery Act.
USC = United States Code.

Table 2-2 Location-Specific ARARs, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Local Location-Specific ARARs					
Town Code (Town of Oyster Bay)	Noise	Chapter 156	Restricts unnecessary noise and construction equipment noise within the town during certain time frames.	Applicable	Applicable as it requires limiting noise resulting from remedial activities conducted at and in the vicinity of the site.
	Building Construction	Chapter 93	Requires procurement of a building permit prior to construction, alteration, removal, improvement, or demolition of any building or structure.	Potentially applicable	Required if remedial actions results in construction or alteration of buildings.
	Solid Waste	Chapter 201	Provides guidance on collection, transport, and disposal of solid waste to the Town's solid waste disposal facilities.	Applicable	Applicable as it relates to placement of municipal waste generated during remedial activities in collection containers.

Key:
ARAR = Applicable Relevant and Appropriate Regulation.

Table 2-3 Action-Specific ARARs, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
State Action-Specific ARARs					
New York Waste Transport Permit Regulations	Permitting Regulations, Requirements, and Standards for Transport	6 NYCRR 364	The collection, transport, and delivery of regulated waste, originating or terminating at a location within New York, will be governed in accordance with Part 364.	Potentially applicable	Applicable if site's wastes fall into regulated categories.
Environmental Conservation Law, Articles 3, 19, 23, 27, and 70	Hazardous Waste Management System - General	6 NYCRR 370	Provides definition of terms and general standards applicable to 6 NYCRR 370 - 374, 376.	Potentially applicable	
	Identification and Listing of Hazardous Waste	6 NYCRR 371	Identifies characteristic hazardous waste and lists specific wastes.	Potentially applicable	Applies to transportation and all other hazardous waste management practices in New York State. Applicable if hazardous waste is generated during remediation
	Hazardous Waste Manifest System and Related Standards	6 NYCRR 372	Establishes manifest system and record-keeping standards for generators and transporters of hazardous waste and for treatment, storage, and disposal facilities.	Potentially applicable	Applicable to transportation of hazardous material by bulk rail and water shipments for off-site treatment.
	Hazardous Waste Treatment, Storage, and Disposal Facility Permitting Requirements	6 NYCRR 373	Regulates treatment, storage, and disposal of hazardous waste.	Potentially applicable	Applicable to off-site treatment/disposal of hazardous waste.

Table 2-3 Action-Specific ARARs, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
	Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities.	6 NYCRR 374	Subpart 374-1 establishes standards for the management of specific hazardous wastes (Subpart 374-2 establishes standards for the management of used oil).	Potentially applicable	Applicable to the management of specific hazardous wastes that may be generated during remedial activities.
Environmental Conservation Law, Articles 1, 3, 27, and 52; Administrative Procedures Act Articles 301 and 305.	Inactive Hazardous Waste Disposal Sites	6 NYCRR 375	Identifies process for investigation and remedial action at state funded Registry site; provides exception from NYSDEC permits. Part 375-6.8 provides the soil cleanup objectives used for this report.	Applicable	
Environmental Conservation Law, Articles 3 and 27.	Land Disposal Restrictions	6 NYCRR 376	Identifies hazardous wastes that are restricted from land disposal. Defines treatment standards for hazardous waste.	Potentially applicable	
Federal Action-Specific ARARs					
Comprehensive Environmental Response, Compensation, and Liability Act of 1980, and the Superfund Amendments and Reauthorization Act of 1986	National Contingency Plan	40 CFR 300, Subpart E	Outlines procedures for remedial actions and for planning and implementing off-site removal actions.	Applicable	

Table 2-3 Action-Specific ARARs, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Occupational Safety and Health Act	Worker Protection	29 CFR 1910 and 1926	Provides enforceable occupational safety and health standards (permissible exposure limits, or PELs) for workers engaged in on-site field activities.	Applicable	These standards regulate employee exposure to air contaminants and provide guidelines for equipment handling and personal protection.
RCRA	Criteria for Municipal Solid Waste Landfills	40 CFR 258	Establishes minimum national criteria for management of non-hazardous waste.	Potentially applicable	Applicable to remedial alternatives that involve the generation of non-hazardous waste. Non-hazardous waste must be hauled and disposed of in accordance with RCRA.
	Hazardous Waste Management System - General	40 CFR 260	Provides definition of terms and general standards applicable to 40 CFR 260 - 265, 268	Potentially applicable	Applicable to remedial alternatives that involve generation of a hazardous waste (e.g., contaminated soil). Hazardous waste must be handled and disposed of in accordance with RCRA.
	Identification and Listing of Hazardous Waste	40 CFR 261	Identifies solid wastes that are subject to regulation as hazardous wastes.	Potentially applicable	
	Standards Applicable to Generators of Hazardous Waste	40 CFR 262	Establishes requirements (e.g., EPA ID numbers and manifests) for generators of hazardous waste.	Potentially applicable	
	Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Establishes standards that apply to persons transporting manifested hazardous waste within the United States.	Potentially applicable	

Table 2-3 Action-Specific ARARs, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
	Standards Applicable to Owners and Operators of Treatment, Storage, and Disposal Facilities	40 CFR 264	Establishes the minimum national standards that define acceptable management of hazardous waste.	Potentially applicable	
	Standards for owners of hazardous waste facilities	40 CFR 265	Establishes interim status standards for owners and operators of hazardous waste treatment, storage, and disposal facilities.	Potentially applicable	
	Land Disposal Restrictions	40 CFR 268	Identifies hazardous wastes that are restricted from land disposal.	Potentially applicable	
	Hazardous Waste Permit Program	40 CFR 270, 124	EPA administers the hazardous waste permit program for CERCLA/ Superfund Sites; covers basic permitting, application, monitoring, and reporting requirements for off-site hazardous waste management facilities.	Potentially applicable	

Key:
ARAR = Applicable Relevant and Appropriate Regulation.
CFR = Code of Federal Regulations.
EPA = (United States) Environmental Protection Agency.
NYCRR = New York Codes, Rules, and Regulations.
NYSDEC = New York State Department of Environmental Conservation.
OSHA = Occupational Safety and Health Administration.
RCRA = Resource Conservation and Recovery Act.
SPDES = State Pollutant Discharge Elimination System.

Table 2-4 Groundwater Cleanup Objectives, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Analyte	NYS Ambient (Class GA) Water Quality Standard (µg/L) [a]	Maximum Concentration (µg/L) [b]	Selected Cleanup Goal (µg/L)
1,1-Dichloroethane	5	2.5	-
1,2-Dichlorobenzene	3	16	3
1,4-Dichlorobenzene	3	1.9	-
Chlorobenzene	5	6.3	5
cis-1,2-Dichloroethene (cis-1,2-DCE)	5	16	5
Dichlorodifluoromethane	5	25	5
Methyl tertiary butyl ether (MTBE)	10	15	10
Tetrachloroethene (PCE)	5	130	5
Trichloroethene (TCE)	5	86	5

Notes:

[a] New York State Department of Environmental Conservation, Technical and Operational Guidance No.1.1.1: Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, 1998 Table 1, Class GA Groundwater and Guidance Values.

[b] Concentration listed is the maximum detected value from groundwater samples collected from permanent monitoring wells within the PCE plume boundary in March 2012 during the Farmingdale Plaza Cleaners OU-2 RI (EEEPC 2013).

Key:

µg/L = micrograms per liter
NYS = New York State

3 Identification and Screening of Remedial Technologies

3.1 Introduction

This section presents the results of the preliminary screening of remedial actions that may be used to achieve the RAOs for the groundwater plume. Potential remedial actions, including general response actions and remedial technologies, are evaluated during the preliminary screening. Past performance (e.g., demonstrated technology) and operating reliability were also considered in identifying and screening applicable technologies. Technologies which were not initially considered effective and/or technically or administratively feasible were eliminated from further consideration.

The purpose of the preliminary screening is to eliminate remedial actions that may not be effective based on anticipated on-site conditions, or cannot be implemented at the site. The general response actions considered herein are intended to include those actions that are most appropriate for the site and, therefore, are not exhaustive and may not be applicable to all areas overlying the contaminant plume.

3.2 General Response Actions

Based on the information presented in the RI (EEEPC 2013) and the RAOs established in Section 2, this section identifies general response actions, or classes of responses for contaminated groundwater. General response actions describe classes of technologies that can be used to meet the remediation objectives for contaminated groundwater. As previously discussed, PCE and TCE contamination in groundwater will be the focus of remedial actions addressed by this FS.

General response actions identified for the groundwater are as follows:

- No action;
- Institutional controls;
- Long-term monitoring;
- In-situ treatment; and
- Ex-situ treatment.

3.3 Identification of Remedial Technologies

This section identifies the potential remedial action technologies that may be applicable for remediation of groundwater contamination. Table 3-1 provides a summary of results from the screening of remedial technologies.

3.3.1 No Action

The no-action alternative involves taking no further action to remedy the condition of contaminated groundwater. NYSDEC and EPA guidance set forth in the CERCLA National Contingency Plan (NCP), requires that the no-action alternative automatically pass through the preliminary screening and be compared to other alternatives in the detailed analysis of alternatives.

3.3.2 Institutional Controls

Institutional controls (ICs) are meant to be non-physical means of enforcing a restriction on the use of real property that limits human and environmental exposure, restricts the use of groundwater, provides notice to potential owners, operators, or members of the public, or prevents actions that would interfere with the effectiveness of the remedial program or with the effectiveness and/or integrity of operation, maintenance and/or monitoring activities at or pertaining to a remedial site. They typically include easements, deed restrictions, covenants, well drilling prohibitions, zoning restrictions, and building or excavation permits.

ICs are meant to supplement engineering controls (ECs) during all phases of cleanup and may be a necessary component of the completed remedy. Engineering Controls (ECs) are defined as any physical barriers or methods employed to actively or passively contain, stabilize, or monitor contamination, restrict the movement of contamination to ensure the long-term effectiveness of a remedial program, or eliminate potential exposure pathways to contamination. Engineering controls include, but are not limited to: pavement, caps, covers, subsurface barriers, vapor barriers, slurry walls, building ventilation systems, fences, groundwater monitoring wells, provision of alternative water supplies via connection to an existing public water supply, adding treatment technologies to such water supplies, and installing filtration devices on private water supplies.

ICs are not generally expected to be the sole remedial action unless active response measures are determined to be impracticable. For this site, institutional and engineering controls such as deed restrictions, covenants, installation of fencing and signs, etc. are not applicable to off-site areas of the plume within privately-owned residential neighborhoods. Some laws already exist that could limit exposure to contaminated groundwater within the off-site portion of the plume. These include:

- New York State Environmental Conservation Law (ECL) 15-1525 that states that prior to drilling a water well within New York, registered well contractors are required to notify NYSDEC as well as file a preliminary report for the proposed well;

- Monitoring of chemical constituents of existing potable water supplies is required by ECL 33-0714 and New York State Public Health Law, Section 225, Subpart 5-1 (Public Water Systems); and

- Article IV of the Nassau County Public Health Ordinance prohibits potable water supply well installation within areas serviced by existing public water supplies, which includes the Farmingdale area.

ICs and ECs will be considered in conjunction with other engineered alternatives, where appropriate, to achieve RAOs, but will not be considered an independent alternative.

3.3.3 Long-Term Monitoring (LTM)

Long-term monitoring (LTM) is not an IC, but a part of site operations, monitoring, and maintenance (OM&M). LTM can be performed in multiple environmental media, but is most applicable to groundwater at this site. LTM in groundwater generally uses an array of monitoring wells that are regularly sampled and tested by an analytical laboratory for contaminants of concern. These wells are placed such that they would detect migration toward potential receptors. LTM will not actively reduce contamination levels but it can be useful in demonstrating the changes in contaminant concentrations over time. For this site, LTM of groundwater will be further considered in conjunction with ICs/ECs and other engineered alternatives.

3.3.4 In-Situ Treatment

In situ treatment technologies for groundwater remediation typically fall in the following categories:

- Physical/chemical treatment; and

- Biological treatment.

The following sections present a discussion of applicable groundwater remediation technologies under each general response category described above.

3.3.4.1 Physical/Chemical Treatment

Air Sparging/Soil Vapor Extraction

Air sparging (AS) is remedial technology that reduces concentrations of VOCs that are adsorbed to soils and dissolved in groundwater. This technology, which is also known as "in situ air stripping" and "in situ volatilization," involves the injection of contaminant-free air into the subsurface saturated zone under pressure, enabling a phase transfer of VOCs from a dissolved state to a vapor phase. The air and vapor phase VOCs are then vented through the unsaturated zone.

Air sparging is most often used together with soil vapor extraction (SVE), but it can also be used with other remedial technologies. When air sparging is combined with SVE, the SVE system creates a negative pressure in the unsaturated zone through a series of extraction wells to control the vapor plume migration. This combined system is called AS/SVE. Implementing a site-specific AS/SVE system would require the completion of a pilot study to evaluate the site conditions as well as to collect the required data and design parameters that would be required for full-scale implementation.

This technology is viable at this site due of the presence of the volatile organic compounds within the groundwater. However, the implementation of this technology would require injection of air that would flush out the contamination through the unsaturated zones and would require the installation of vapor extraction systems to remove the generated vapor phase contamination. As the plume area is densely populated, the implementation of this technology would be difficult at the site. Additionally, the potential for uncontrolled movement of vapor phase contamination into structures within this project area also exists and hence in situ AS/SVE will not be retained for further consideration.

In-situ Chemical Treatment

In-situ chemical treatment involves the introduction of chemical compounds into the contaminated media to treat and convert the contaminants into non-hazardous or non-toxic compounds. In-situ chemical treatment could include oxidation or reduction depending on the site conditions. In-situ chemical products have been shown to most effectively treat chlorinated organic compounds typically include oxidants such as hydrogen peroxide (H_2O_2) with iron (Fe), potassium permanganate ($KMnO_4$), persulfate ($S_2O_8^{2-}$) and ozone (O_3). Typically these oxidizing agents are injected into the ground through a series of injection wells that cover the plume area.

The type and physical form of the oxidant indicates the general materials handling and injection requirements. The persistence of the oxidant in the subsurface is important since this affects the contact time for advective and diffusive transport and ultimately the delivery of oxidant to targeted zones in the subsurface. For example, permanganate persists for long periods of time, and diffusion into low-permeability materials and greater transport distances through porous media are possible. Hydrogen peroxide has been reported to persist in soil and aquifer material for minutes to hours, and the diffusive and advective transport distances will be relatively limited (USEPA 2006).

The use of hydrogen peroxide with soluble (ferrous) iron (Fe^{2+}) to oxidize organic compounds is based on Fenton's chemistry, where hydrogen peroxide is decomposed by iron to form hydroxyl radicals. The hydroxyl radicals act as strong oxidants capable of attacking the carbon-hydrogen bond and converting complex organic compounds into carbon dioxide and water. Generally, a low pH environment (2 to 4 pH) is needed to promote the generation of hydroxyl radicals, although some vendors have reportedly developed ways to apply this technology at pHs closer to neutral. Using hydrogen peroxide has two main advantages: no organic by-products are formed during the oxidation process and the abundance and low cost of iron and hydrogen peroxide. A major concern with using hydrogen peroxide is handling large quantities of chemicals and introducing acidic solutions into the environment. In addition, special measures may be required during injection of hydrogen peroxide into the ground because it can readily break down into water vapor and oxygen.

Potassium permanganate is also an effective oxidizing agent for some, but not all, organic contaminants. Permanganate-based chemical treatment is more fully developed than other forms of oxidants and has been used for a variety of contaminants and geologic environments (USEPA 2006). The reaction of potassium permanganate with organic compounds produces manganese dioxide (MnO_2) and carbon dioxide (CO_2) or an intermediate organic compound. Since manganese dioxide is naturally present in soils, the introduction of permanganate into the environment is generally not a concern. However, the production of manganese dioxide particles may result in reduction of permeability.

Ozone, like potassium permanganate and hydrogen peroxide, is also an effective oxidant for organic contaminants. One advantage of using ozone is the ability to generate it on-site, which eases transportation and storage problems.

In-situ oxidation technologies have gained attention as feasible alternatives to remediate sites contaminated with chlorinated and non-chlorinated organic compounds. One of the primary concerns and key to successful implementation of in-situ oxidation technologies is delivery of the aqueous chemical oxidants to the contaminated region. This is especially important with hydrogen peroxide because it is relatively unstable in the environment. Field demonstrations of in-situ oxidation technologies have shown treatment efficiencies for VOCs ranging between 70% and 99% (EPA 2006).

Some of the potential advantages of in-situ oxidation technologies are: applicable to a wide variety of contaminants; in-situ treatment; cost competitive; and relatively fast treatment. Some of the disadvantages are: safety and oxidant delivery problems due to reactive material; potential contaminant mobilization; potential permeability reduction; high reactivity with competing compounds; and temporary reduction of natural degradation rates after active treatment.

In general, implementation of in-situ oxidation proceeds in three phases: laboratory bench-scale study, on-site pilot program, and full-scale treatment. The bench-scale study determines the effectiveness of oxidation on the site's contaminants and the optimum treatment quantity. Upon successful completion of the lab study, an on-site pilot-scale study is conducted for which a series of well points are installed in a representative area of the plume (typically the highest area of contamination) to further evaluate the treatment potential of the sites contaminants. Specific system monitoring and sampling procedures are performed during the 2- to 3-month-long pilot program to evaluate reaction efficiency and environmental response. If the pilot program is successful, full-scale treatment is performed using procedures similar to the pilot program, and a chemical delivery system is designed to cover the plume area.

In-situ chemical treatment technologies have been successfully implemented at multiple sites, including sites on Long Island; therefore, this technology will be retained for further consideration.

Permeable Reactive Barriers

A permeable reactive barrier (PRB) is a passive-type technology used to degrade chlorinated organic compounds in groundwater and is considered a manipulation of reduction-oxidation (redox) reactions in the groundwater. PRBs are often intended for source management or as an on-site containment remedy. The treatment can be achieved by using reactive materials such as zero-valent iron (ZVI). The oxidation of the ZVI by water provides a source of electrons for reductive dehalogenation of the chlorinated organic compounds. The simultaneous oxidation of iron and degradation of the chlorinated organic compounds proceeds spontaneously without the addition of catalysts or a source of energy. The products of this reaction are chloride and non-toxic hydrocarbons. The two most common configurations of PRBs are the funnel and gate system and the continuous permeable wall systems.

The funnel and gate system uses impermeable funnel sections that are installed to direct groundwater to the reactive permeable gate sections containing the ZVI. The continuous permeable wall system uses a reactive wall section that is placed to intersect the entire plume. These continuous walls can be anchored to an impermeable layer or hung from the surface. The appropriate configuration is usually based on site characteristics, prevention of groundwater from escaping below or around the reactive wall, and providing the optimal residence time (contact time) for reducing the contaminant concentrations to cleanup levels.

PRBs are not typically implemented as a stand-alone technology but depend on other processes (such as monitored natural attenuation) to achieve RAOs. However, PRBs can be an effective technology in many environmental settings with varying hydrogeological and geochemical conditions. Careful assessment of the site is essential as varying conditions may limit the effectiveness of the technology.

Several studies have evaluated the potential use of zero-valent metals to degrade halogenated organic compounds dissolved in water. Since this technology was commercialized, more than 200 PRB systems have been installed (ITRC 2011). The process of implementing a site-specific reactive wall technology proceeds in a phased approach. Bench-scale testing is conducted first to determine the rate of degradation and residence time required to achieve the required cleanup levels. An on-site, pilot scale study is then conducted to collect the required data and design parameters that would be required for full-scale implementation. Finally, a full-scale system is designed using the data collected during the pilot study.

PRBs are suitable in areas with limited to no infrastructure or utilities that would interfere with trenching or excavation. PRBs are ideal for areas with contamination distribution less than 45 feet to the base of the contaminant plume (ITRC 2011). For deeper contamination, biowalls are PRBs that promote biological treatment of contaminants within the wall as well as in areas downgradient of the constructed treatment zones due to migration of organic materials. Biowalls use organic materials such as mulch, compost, emulsified vegetable oils, sodium lactate, molasses or solid or viscous fluid hydrogen-release compounds. However, the longevity of the biowalls is anticipated to be short and might require replenishment of amendments.

At OU-2, the groundwater contaminant plume is located underneath densely populated residential areas, which would present accessibility issues for implementing this technology at the site. Additionally, the groundwater plume extends between depths of approximately 80 and 200 feet below grade and traditional PRBs cannot be used and would require injection of reactive media across the width of contaminant plume. Even though this technology is potentially feasible at this site, its implementability and other limitation compared to other treatment technologies limits its usefulness and will not be retained for further consideration.

3.3.4.2 Biological In-situ Treatment

Bioremediation

The biological treatment processes described herein is a form of in-situ reduction of chlorinated organic compounds. In cases where this process does not occur naturally, it can be promoted by artificially providing the required conditions. Biological treatment, or biodegradation, can be enhanced aerobically using oxygen-releasing compounds (ORCs) or anaerobically using hydrogen-releasing compounds (HRCs).

Biodegradation of chlorinated organic compounds (including PCE and TCE) will occur if the proper anaerobic conditions are established. At this site, there is limited evidence but some potential for biodegradation through reductive dechlorination to occur based on the presence of daughter products and some existing geochemical conditions (EEEPC 2013). Therefore, enhancement of the natural process would be required to promote the destruction of PCE and TCE. This enhancement process involves the injection of products into the subsurface to establish conditions favorable for existing microorganisms. If favorable anaerobic conditions are established, degradation of PCE and TCE would occur over time. The degradation process would result in the attenuation of the parent compounds and the formation of other compounds (daughter compounds) including cis-1,2-DCE and vinyl chloride (VC). VC is of concern as it is more toxic than PCE or TCE and is not degraded as efficiently under anaerobic conditions; however, it can be reductively dechlorinated under the correct conditions or aerobically degraded outside of the primary anaerobic treatment zone.

Based on preliminary evaluation presented in the RI report (EEEPC 2013), it appears that reductive dechlorination of PCE to TCE and TCE to cis-1,2-DCE may be occurring but to a limited extent. However, based on the geochemical and microbiological results, it appears that this process is slow, incomplete and not likely an effective means of reducing contaminant concentrations to regulatory levels within an acceptable time period without augmentation. As this technology would augment and assist in the reductive dechlorination process, this technology will be further considered for evaluation.

3.3.5 Ex-situ Treatment

Groundwater Pumping and Treatment

Groundwater pumping and treatment (pump and treat) is a common method for cleaning up contaminated groundwater. Pumps are used to extract contaminated groundwater for treatment as needed prior to disposal. Ex-situ treatment allows for greater flexibility in controlling the physical, chemical, or biological conditions, or any combination of these conditions, that are required to remove or destroy the contaminants.

Pump and treat systems are intended to achieve the following:

(i) Hydraulic containment: To control the movement of contaminated groundwater, preventing the expansion of the contaminated zone; and

(ii) Treatment: To reduce the dissolved concentrations in the groundwater sufficiently that the aquifer complies with the cleanup standards or the treated water withdrawn from the ground can be beneficially reused.

Pump and treat technology may involve the installation of one or more groundwater wells to extract the contaminated groundwater. Groundwater is pumped using these extraction wells to a treatment system or a holding tank prior to treatment. The treatment system may consist of a single cleanup method or include multiple cleanup methods depending on the types of contaminants as well as the concentrations of each of the contaminants. Once the treated water meets the regulatory requirements, it can be discharged to the local sewer, reinjected into the aquifer, or re-used in another way.

Pump and treat implementation may last from a few years to several decades depending on several factors, which vary on a site-specific basis. Some of the factors affecting treatment time include: contaminant concentrations, plume length/width, groundwater flow gradients, and complex geologic settings.

Based on the site conditions observed at the site, such as high groundwater flow velocity and high permeability soils, it appears that pump and treat is a viable alternative for the site. Additionally, a groundwater remediation system is currently operational within the vicinity of this plume, further reinforcing that pump and treat can be implemented at this site. Hence this technology is retained for further evaluation.

Table 3-1 Summary of Remedial Technologies, Farmingdale Plaza Cleaners Site OU-2, Farmingdale, New York

General Response Actions and Remedial Technology	Brief Description	Preliminary Screening Evaluation	Feasible Technology for this Site
No Action			
	No further action to remedy soil conditions at the site.	Ineffective for the protection of human health and the environment.	No
Long-term Monitoring			
	Monitoring of existing groundwater wells to provide documentation that the remedial measure is reducing contaminants at the site.	Provides evidence to verify if a remedial activity is working or not.	Yes
Institutional Controls			
	Includes public notification, deed restrictions, fencing, and signs, where applicable.	Does not reduce contamination concentrations but can reduce potential exposure to the contaminated media.	Yes
In-Situ Treatment			
Physical/Chemical			
Air Sparging	This remedial technology that reduces concentrations of VOCs that are adsorbed to soils and dissolved in groundwater. Air sparging is most often used together with soil vapor extraction (SVE), but it can also be used with other remedial technologies.	This technology is viable at this site due of the presence of the volatile organic compounds within the groundwater. However, this technology is more applicable to vadose zone and water-table contamination. At this site, the contaminant plume is deep and beneath a zone of uncontaminated water. This technology may cause contaminant migration into clean areas. Furthermore, there is the potential for uncontrolled movement of vapor-phase contamination into structures in this densely populated, residential area.	No

Table 3-1 Summary of Remedial Technologies, Farmingdale Plaza Cleaners Site OU-2, Farmingdale, New York

General Response Actions and Remedial Technology	Brief Description	Preliminary Screening Evaluation	Feasible Technology for this Site
In-situ Chemical Treatment	Involves the introduction of chemical compounds into the contaminated media to treat and convert the contaminants into non-hazardous or non-toxic compounds. In-situ chemical treatment could include oxidation or reduction depending on the site conditions. In-situ chemical products have been shown to effectively oxidize/reduce organic compounds and typically include hydrogen peroxide (H_2O_2) with iron (Fe), potassium permanganate ($KMnO_4$), persulfate ($S_2O_8^{2-}$) and ozone (O_3).	High permeability of the soil is conducive for injection at the site; however, there are potential implementation issues, such as space constraints (spacing of injection points), depth of contamination, and safety concerns when applying highly reactive and caustic chemicals, especially in residential areas.	Yes
Permeable Reactive Barrier	A passive technology used to degrade chlorinated organic compounds in groundwater; it is considered a manipulation of reduction-oxidation (redox) reactions in the groundwater. This is often intended for source management or as an on-site containment remedy.	Potential site accessibility issues exist at the site. Additionally, as the plume is deeper, traditional PRBs cannot be used and would require injection of reactive media across the width of contaminant plume. Even though this technology is potentially applicable at this site, injection of iron filings is a relatively new technology with limited data when compared to other treatment technologies. Implementability would be similar to in-situ chemical treatment, which has more established application history and will be maintained for further evaluation.	No

Table 3-1 Summary of Remedial Technologies, Farmingdale Plaza Cleaners Site OU-2, Farmingdale, New York

General Response Actions and Remedial Technology	Brief Description	Preliminary Screening Evaluation	Feasible Technology for this Site
Biological			
Biological Enhancement for Reductive Dechlorination	A mostly passive technology that uses indigenous or selectively cultured microorganisms, primarily anaerobic bacteria, to remove chlorinated organic compounds. Sufficient hydrogen or other electron donors must be present for the bacteria to replace chlorine with hydrogen, converting the chlorinated contaminants into harmless end products such as water, carbon dioxide, ethane, and chloride.	This technology typically involves a relatively longer remediation period compared to other active treatment technologies; however, implementation is typically easier and less intrusive at the surface than other technologies. Conditions must be appropriate (high reduction potential and anaerobic conditions with sufficient quantities of required bacteria and electron donor material). Insufficient bacteria populations or electron donor material can be enhanced through injection of products into the contaminant plume.	Yes
Ex-Situ Treatment			
Pump-and-Treat System	Contaminated groundwater is pumped out of the ground and treated with methods such as granulated activated carbon, chemical reagents, or air stripping. Treated groundwater can be reinjected into the aquifer if appropriate.	Effective in high permeability aquifers that exist within the project area and is currently being implemented for Plume A remediation.	Yes

4 Identification of Alternatives

In collaboration with NYSDEC, five alternatives were identified for addressing the groundwater contaminant plume associated with OU-2 of the FPC site. These alternatives are briefly described below, and detailed descriptions and evaluations of the alternatives are presented in Section 4.

4.1 Alternative No. 1: No Action

The no action alternative was carried through the FS for comparison purposes, as required by the NCP. This alternative would be acceptable only if it is demonstrated that the groundwater contamination is below the RAOs, or that natural processes will reduce the contamination to acceptable levels. This alternative does not include ICs.

4.2 Alternative No. 2: Long-Term Monitoring and Institutional Controls

This alternative consists of long-term monitoring to assess the mobility of the contamination in groundwater. The ICs included in this alternative would consist of access/use and deed restrictions where implementable to limit the potential for human exposure to contaminated groundwater.

4.3 Alternative 3: In-Situ Chemical Treatment with Long-Term Monitoring and Institutional Controls

This alternative consists of long-term monitoring to assess the mobility of the contamination in groundwater and the injection of a chemical to treat the contaminated portion of the groundwater plume. The ICs included in this alternative would consist of access/use and deed restrictions where implementable to limit the potential for human exposure to contaminated groundwater.

4.4 Alternative No. 4: In-Situ Biological Enhancement with Long-Term Monitoring and Institutional Controls

This alternative consists of long-term monitoring to assess the mobility of the contamination in groundwater and the application of a biological amendment to enhance the degradation of contaminants in the groundwater. The ICs included in this alternative would consist of access/use and deed restrictions where implementable to limit the potential for human exposure to contaminated groundwater.

4.5 Alternative No. 5: Pump and Treat, Discharge to Liberty Industrial Finishing Site Groundwater Remediation System, LTM and ICs

This alternative consists of pumping contaminated groundwater and treating the water using the existing LIFS Groundwater Remediation system. To accommodate additional flow, this treatment would require the addition of treatment capacity to the existing LIFS system. In the case where it is not feasible to use the existing LIFS system as a groundwater treatment facility, another location will be chosen to build a new treatment system. ICs included in this alternative would consist of access/use and deed restrictions where implementable to limit the potential for human exposure to contaminated groundwater. Long-term monitoring will be conducted to assess the mobility of groundwater contamination at the site.

5 Detailed Analysis of Alternatives

5.1 Introduction

The purpose of the detailed analysis of remedial action alternatives is to present the relevant information for selecting a remedy for OU-2. In the detailed analysis, the alternatives identified in Section 4 are described in detail and evaluated on the basis of environmental benefits and costs using criteria established by NYSDEC in CP-51, DER-10, and 6 NYCRR Part 375. This approach is intended to provide the information needed to compare the merits of each alternative and select an appropriate remedy that satisfies the RAOs. The evaluation criteria are described below and cost estimates for each alternative are presented in Tables 5-1 through 5-4. Table 5-5 presents a summary of these costs.

5.1.1 Detailed Evaluation of Criteria

This section presents a summary of the evaluation criteria that were used to evaluate the alternatives.

Overall Protectiveness of Public Health and the Environment

This criterion provides an overall assessment of protection of public health and the environment and is based on a composite of factors assessed under the evaluation criteria, especially short-term effectiveness, long-term effectiveness and performance, and compliance with cleanup goals.

Compliance with SCGs

This criterion is used to evaluate the extent to which each alternative may achieve the proposed cleanup goals. The proposed cleanup goals were developed based on the SCGs presented in Section 2.

Short-Term Impacts and Effectiveness

This criterion addresses the impacts of the alternative during the construction and implementation phase until the RAOs are met. Factors to be evaluated include protection of the community during the remedial actions; protection of workers during the remedial action; and the time required to achieve the RAOs. Several alternatives described in the following sections may not be effective in meeting the RAOs in less than 30 years. Therefore, references to short-term impacts and effectiveness may include discussions of impacts/effectiveness over a period of 30 years.

Long-Term Effectiveness and Permanence

This criterion addresses the long-term protection of human health and the environment after completion of the remedial action. It assesses the effectiveness of the remedial action to manage the risk posed by untreated wastes and/or the residual contamination remaining after treatment and the long-term reliability of the remedial action.

Reduction of Toxicity, Mobility, and Volume of Contamination through Treatment

This criterion addresses NYSDEC's preference for selecting "remedial technologies that permanently and significantly reduce the toxicity, mobility, and volume" of the contaminants of concern at the site. It assesses the extent to which the treatment technology destroys toxic contaminants, reduces mobility of the contaminants using irreversible treatment processes, and/or reduces the total volume of contaminated media.

Implementability

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of services and materials required during implementation. Technical feasibility refers to the ability to construct and operate a remedial action for the specific conditions at the site and the availability of the necessary equipment and technical specialists. Technical feasibility also considers construction and OM&M difficulties, reliability, ease of undertaking additional remedial action (if required), and the ability to monitor effectiveness. Administrative feasibility refers to compliance with applicable rules, regulations, and statutes and the ability to obtain permits or approvals from government agencies or offices.

Cost

This criterion evaluates the estimated capital costs, long-term OM&M costs, and environmental monitoring costs. The estimates included herein (unless otherwise noted) assume administrative costs would equal 15% of the capital costs, engineering costs would equal 15% of the capital costs, and contingency costs would equal 30% of the capital costs. A present-worth analysis is completed to compare the remedial alternatives on the basis of a single dollar amount (total cost) for the base year. For the present-worth analysis, assumptions are made regarding the interest rate applicable to borrowed funds and the average inflation rate. A discount rate of 2% before taxes and after inflation was assumed based on economic data available from the Office of Management and Budget Real Discount rates (OMB 2012). In addition, according to the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988a and 1988b), in general, the period of performance for costing purposes should not exceed 30 years for the purpose of the detailed analysis. Therefore, the following detailed analysis of remedial alternatives follows this guidance. The comparative cost estimates are intended to reflect actual costs with an accuracy of +50% to -30%.

Land Use

The land use criterion evaluates the issues and concerns regarding the current, intended, and reasonably anticipated future land uses of the site. Other considerations include the sites' surroundings, compatibility with applicable zoning laws, compatibility with comprehensive community master plans, proximity to incompatible property in proximity to the site, accessibility to existing infrastructure, and a number of other concerns as identified in 6 NYCRR Part 375-1. It is anticipated that the current and reasonably anticipated future use of the on-site portion of the site will remain commercial while the majority of the area above the contaminant plume associated with OU-2 will remain residential. None of the alternatives discussed in this FS are expected to change the land use at the site; therefore, land use is not used as an evaluation criterion for the remedial alternatives presented in this report.

Community Acceptance

This criterion evaluates the issues and concerns the public may have regarding each alternative. This criterion will be addressed in the ROD once comments on the proposed plan have been received. Therefore, community acceptance will not be discussed further in this report.

5.2 Remedial Alternatives

5.2.1 Alternative No. 1: No Action

5.2.1.1 Description

The No Action alternative involves taking no further action to remedy the groundwater contamination. The NCP in 40 CFR §300.430(e) (6) provides that the No Action alternative be considered at every site as a baseline for comparison with other alternatives. This alternative does not include remedial action, institutional or engineering controls, or long-term monitoring.

5.2.1.2 Detailed Evaluation of Criteria

Overall Protectiveness of Public Health and the Environment

This alternative is not protective of human health and the environment, because OU-2 would remain in its present condition. VOC contamination in the groundwater would remain at the site and continue to be a source of contamination to the UGA and MA. Uncontrolled excavations could lead to VOC exposure and, therefore, risk to human health.

Compliance with SCGs

Contaminant concentrations (specifically VOCs) are not expected to decrease appreciably over time. Therefore, this alternative would not comply with the chemical-specific SCGs for OU-2.

Short-Term Impacts and Effectiveness

No short-term impacts (other than those currently existing) are anticipated during the implementation of this alternative since no remedial activities are involved.

This alternative does not include treatment and would not meet the RAOs (as defined in Section 2.3) in a reasonable or predictable time frame.

Long-Term Effectiveness and Permanence

Because this alternative does not involve the removal or treatment of contaminated groundwater, or a decrease in the volume of contamination, the risks associated with the migration of groundwater contamination would remain essentially the same. This alternative is, therefore, not effective in the long-term.

Reduction of Toxicity, Mobility, and Volume of contamination through Treatment

This alternative does not involve removal or treatment of contaminated groundwater, therefore, the toxicity, mobility, and volume of contamination would not be reduced.

Implementability

There are no actions to implement under this alternative.

Cost

There are no costs associated with this alternative.

5.2.2 Alternative No. 2: Long-Term Monitoring and Institutional Controls

5.2.2.1 Description

This alternative involves long-term monitoring and institutional controls. Long-term monitoring of existing groundwater wells would be performed to observe VOC levels in the groundwater and determine whether migration of the contamination occurs.

ICs are meant to be non-physical means of enforcing a restriction on the use of property that limits human and environmental exposure, restricts the use of groundwater, provides notice to potential owners, operators, or members of the public, or prevents actions that would interfere with the effectiveness of the remedial program or with the effectiveness and/or integrity of OM&M activities at or pertaining to a remedial site. They typically include easements, deed restrictions, covenants, well drilling prohibitions, zoning restrictions, building or excavation permits.

For OU-2, it is important to limit the use of groundwater within the plume area. The State cannot implement ICs on private property and can only implement such controls on site. Therefore, the implementation of ICs is limited and will not be effective at preventing groundwater use in the off-site portion of the plume. However, as discussed in Section 3.2.2, there are existing state and county laws in place that restrict the installation of potable water wells and would help eliminate potential future exposure to contaminated groundwater within the off-site portion of the plume.

Periodic certification of ICs would be required to document the continued effectiveness of any ICs implemented on site. It is assumed for costing purposes that annual certification of ICs would be performed.

New and existing wells within and outside of the plume would be used for long-term monitoring. A total of 33 wells would be sampled. Within the UGA plume, 16 wells (fourteen existing, two new) would be sampled during the long-term monitoring event. It was assumed that two new monitoring wells would be installed within the UGA aquifer. Fifteen existing wells and two new wells within the MA would be sampled during the long-term monitoring event. This includes two new MA wells at the FPC site, just upgradient and downgradient of the FPC building. These wells would help monitor any MA-related contamination from potential upgradient sources. Figure 5-1 identifies the locations of the UGA and MA monitoring wells included in the long-term monitoring program.

For costing purposes, it is assumed that these wells would be sampled annually for the first five years and every five years for a total duration of 30 years. The collected samples would be analyzed for VOCs by EPA Method SW8260 at an off-site laboratory.

In accordance with 6 NYCRR Part 375 regulations, sites at which institutional or engineering controls are employed as part of a remedy, a written certification should be submitted annually to the NYSDEC. Since the implementation of this alternative would result in using institutional/engineering controls, annual certification would be required at the site.

5.2.2.2 Detailed Evaluation of Criteria

Overall Protectiveness of Public Health and the Environment
The implementation of institutional controls, such as deed restrictions to control future use of groundwater within the groundwater contaminant plume, would provide some long-term protection of human health.

Compliance with SCGs
Based on the results of the evaluation performed during the RI (EEEPC 2013) for the presence of daughter products (cis-1,2-DCE and VC), oxygen, nitrate, ferrous/total iron, sulfate, sulfide, chloride, pH, and oxidation-reduction potential (ORP) in the source area, it was determined that there is some evidence but limited potential for anaerobic biodegradation within the plume under existing conditions. Reductive dechlorination of PCE and TCE may be occurring; however, the process is slow, incomplete, and likely not an effective means of reducing contaminant concentrations to regulatory levels within an acceptable time period. Therefore, this alternative is not anticipated to comply with the chemical-specific SCGs for OU-2.

Short-Term Impacts and Effectiveness

Controlling future use of groundwater through the use of institutional controls would ensure that public's health is protected with respect to the on-site portion of the plume. However, ICs cannot be implemented off-site on private property and therefore would not be effective at limiting exposure to off-site contamination. Additionally, implementation of ICs would not restore the designated sole-source aquifer to pre-release conditions. Short-term impacts would be minimal and likely only involve minor inconvenience to the public during the performance of monitoring events performed in public rights of way or private properties.

Long-Term Effectiveness and Permanence

This alternative would not be effective in the long term (in terms of protecting human health and the environment) because this alternative does not involve removal or treatment of contamination from the groundwater. Deed or other restrictions are not applicable for privately owned properties within the off-site contaminant plume.

Reduction in Toxicity, Mobility, or Volume of Contamination through Treatment

This alternative does not involve the removal or treatment of contaminated groundwater. Therefore, the toxicity, mobility, and volume of contamination would be expected to decrease very slowly through natural degradation processes such as dispersion.

Implementability

This alternative can be readily implemented on a technical and administrative basis using typical institutional control practices and procedures.

Cost

The 2012 total present-worth cost of this alternative based on a 30-year period is $649,800. Table 5-1 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. Cost estimating information was obtained from RS Means Cost Data series and engineering judgment. Groundwater sampling and renewal of institutional controls are assumed with this alternative.

5.2.3 Alternative No. 3: In-Situ Chemical Treatment with Long-Term Monitoring and Institutional Controls

5.2.3.1 Description

This alternative involves in-situ chemical oxidation with long-term monitoring and ICs. Long-term monitoring of existing groundwater wells would be performed to observe VOC levels in the groundwater and determine whether migration of the contamination occurs. ICs as described in Alternative 2 would be included within this alternative.

Although the RI report indicated that dissolved oxygen levels were generally low in most wells tested (see Table 2-5 in EEEPC 2013), existing conditions of the aquifers are neither strongly reducing nor oxidizing and in-situ chemical treatment is viable for this contaminant plume.

The maximum PCE concentration detected in the UGA during the RI was 38 μg/L at the base of this unit near Motor Avenue (EEEPC 2013). The maximum TCE concentration detected during the RI was also near the bottom of the UGA (120 μg/L); however, the TCE is present upgradient and within the capture zone of the existing LIFS mid-field groundwater extraction wells (see Figures 1-3, 1-5, 1-6, and 1-7). The extent of PCE and TCE contamination in the UGA has been decreasing over time, due in part to natural degradation processes as well as construction and operation of the LIFS groundwater treatment system and FPC OU-1 SVE system. Therefore, PCE and TCE concentrations associated with Plume B that are outside the capture zone of the LIFS treatment system within the UGA are likely to continue to diminish with time and are not expected to impact human health. Hence, treatment of this portion of the contaminant plume is not considered to be warranted and this alternative focuses on in-situ chemical treatment of the MA within the area of maximum contaminant concentration.

Based on the contaminant types and concentrations, oxidant efficiency and cost, and oxidant half-life in the environment, this alternative has been developed to include injection of potassium permanganate solution into the area of the plume with the highest PCE contaminant concentrations. Potassium permanganate works under most environmental conditions (pH range of 3.5 to 12) and will oxidize a wide range of contaminants. Contaminant oxidation occurs by electron transfer rather than through a rapid reaction, thereby providing the opportunity for potassium permanganate to be injected through medium and high permeability materials as well as for it to persist for a long duration (USEPA 2006).

This alternative includes the construction of an in-situ treatment zone across the width and depth of contamination within the MA (see Figure 5-2). The treatment zone would be approximately 800 linear feet and will be installed by injecting a 2% potassium permanganate solution using 16 injection points along the portion of Radcliffe Avenue between Kent and Vanderwater streets. This area coincides with the estimated 100 μg/L contour line and only slightly overlaps with the modeled capture zone of the LIFS midfield extraction wells.

The injection is intended to achieve a continuous in-situ reactive “wall” of potassium permanganate. The potassium permanganate solution would be injected into 16 injection points that would be constructed of 4-inch diameter schedule 80 PVC riser and 4-inch diameter continuous wire-wrapped stainless steel well screen and drilled on 50-foot intervals. Each injection well would be constructed with 50 feet of well screen centered within the area of highest contamination across the width of the PCE plume as described above. Specific depth intervals within these zones could be targeted as needed utilizing inflatable packers to achieve full vertical coverage of potassium permanganate within the aquifer. The injection plan should be designed to mitigate the potential for groundwater displacement during injection activities and minimize the short-term impacts to the surrounding community associated with the injection. A bench-scale test is also recommended to further refine the chemistry and oxidant concentration.

As potassium permanganate is highly reactive and requires carefully handling during implementation. It could potentially impact existing infrastructure; however, at the proposed depths and locations of injection, no impacts at this site are anticipated. Limitations of potassium permanganate injection include reduced levels of natural attenuation through reductive dechlorination for some time after active treatment. However, it is expected that these natural processes would re-establish themselves over time to the extent naturally achievable within this aquifer after active treatment has occurred.

As the barrier treats the most contaminated section of the plume, this alternative would be able to significantly reduce the contaminant concentration within the plume and reduce the number of years required for meeting the RAOs for OU-2. The need for a second injection would be evaluated based on the results of performance monitoring following the first injection. However, for costing purposes, it was assumed that a second injection would be needed.

Performance monitoring of the treatment area will be performed to evaluate if the implemented in-situ chemical treatment is operating properly and successfully and as expected to protect human health and the environment. Long-term monitoring would follow the performance monitoring until the RAOs are achieved. In order to properly monitor the plume, groundwater sampling will be performed to determine and monitor the contaminant concentration fluctuations.

Performance monitoring and long-term monitoring will be conducted on the new and existing wells located within and outside of the plume area. Performance monitoring is estimated for 15 existing wells and two new wells within the MA. Selection of well locations for monitoring and new well installation (including two MA monitoring wells upgradient and downgradient of the FPC building) should be considered during the design phase. It was assumed that the performance monitoring would be completed semiannually for three years, following which the long-term monitoring would be completed annually for the remaining two years and every five years thereafter for duration of 30 years. Even though the plume is expected to achieve the groundwater cleanup goals earlier than 30 years, for equality of costing purposes, a 30-year timeframe was assumed.

Long-term monitoring of the UGA wells will also be completed to monitor the progress of the contaminant plume within this aquifer. Within the UGA plume, 16 wells (fourteen existing and two new) would be sampled during the long-term monitoring event. It was assumed that two new monitoring wells would be installed within the UGA aquifer. It is assumed that these wells would be sampled annually for the first five years and every five years thereafter for a total duration of 30 years. All samples would be analyzed for VOCs by EPA Method SW8260 at an off-site laboratory. Figure 5-2 identifies the locations of the UGA and MA monitoring wells included in the long-term monitoring program.

In accordance with 6 NYCRR Part 375 standards, sites at which institutional or engineering controls are employed as part of a remedy, a written certification should be submitted annually to the NYSDEC. Since the implementation of this alternative would result in using institutional/engineering controls, annual certification would be required at the site.

5.2.3.2 Detailed Evaluation of Criteria

Overall Protectiveness of Public Health and the Environment
Chemical treatment would provide long-term protection of human health by reducing the mass of contaminants within the plume.

Compliance with SCGs
Chemical treatment of the most contaminated section of the plume would reduce contaminant concentrations within the aquifer. Lower concentrations remaining would be expected to naturally degrade at a faster rate than before treatment through dispersion and reductive dechlorination, thereby increasing the potential for faster remediation of the plume associated with OU-2. Therefore, this alternative would comply with the chemical-specific SCGs for OU-2.

Short-Term Impacts and Effectiveness
Contaminant mass reduction would be achieved in the long-term. Short-term control of groundwater use through the implementation of ICs would ensure that the public's health is protected but only with respect to the on-site portion of the plume. ICs cannot be implemented off-site on private property and therefore would not be effective at limiting exposure to off-site contamination. Short-term impacts would include those associated with the machinery required for installation of injection points and actual injection of oxidant, such as traffic and noise. In addition, there is a potential for spills of highly reactive chemicals.

Long-Term Effectiveness and Permanence
This alternative would be marginally effective in the long term (in terms of protecting human health and the environment) because it only treats a small portion of the contaminated plume. The need for additional chemical injections would be evaluated during the performance monitoring phase and may further improve the effectiveness of this technology in the long term. Remediation of untreated portions of the plume would rely on natural degradation processes to further mitigate impacts associated with the contamination. During the time period prior to complete destruction of the plume, deed or other restrictions are not applicable for privately owned properties within the off-site contaminant plume and would not be effective at controlling exposure.

Reduction in Toxicity, Mobility, or Volume of Contamination through Treatment
This alternative involves the treatment of contaminated groundwater by injecting chemicals into the ground. The toxicity of the groundwater is expected to

temporarily increase but will reduce over time. The implementation of this alternative is expected to reduce the mobility and volume of the contamination within the groundwater that passes through the barrier.

Implementability

The groundwater plume is located underneath densely populated residential areas, which might present accessibility issues at the site. Additionally, as these chemicals are highly reactive, the potential for spills or impacts to surface features or utilities exists and needs to be considered during design. However, at the proposed depths and locations of injection, no impacts at this site and on the current LIFS system are anticipated. However, this alternative can be readily implemented on a technical and administrative basis using typical chemicals (potassium permanganate) and institutional control practices and procedures.

Cost

The 2012 total present-worth cost of this alternative based on a 30-year period is $4,080,116. Table 5-2 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. Cost estimating information was obtained from quotes obtained from Groundwater and Remediation Services (GES) and other vendors, RS Means Cost Data series and engineering judgment. Groundwater sampling and annual certification of ICs are included in the costs for this alternative.

5.2.4 Alternative No. 4: In-Situ Biological Enhancement with Long-Term Monitoring and Institutional Controls

5.2.4.1 Description

This alternative involves enhancement of the natural biological degradation process with long-term monitoring and ICs. Long-term monitoring of existing groundwater wells would be performed to observe VOC levels in the groundwater and determine whether migration of the contamination occurs. ICs as described in Alternative 2 would be included within this alternative.

As indicated in the RI report (EEEPC 2013), field and laboratory data were collected to evaluate if reductive dechlorination is occurring within the UGA and MA plumes. Based on this evaluation, it was determined that there is some evidence of the occurrence of anaerobic degradation within OU-2 but limited potential for unaugmented natural attenuation to attain RAOs within a reasonable timeframe. The presence of daughter products (TCE and cis-1,2-DCE), including in wells upgradient of the LIFS, suggests that reductive dechlorination may be occurring to a limited extent. However, prior use of TCE and possibly cis-1,2-DCE at the LIFS and the general lack of vinyl chloride and ethene throughout the plume suggests that the process is incomplete. Dissolved oxygen levels were generally low in most wells (see Table 2-5 in EEEPC 2013) and would not suppress anaerobic processes; the presence of ferrous iron further suggests that reductive dechlorination is possible within OU-2. *Dehalococcoides* counts within the plume were low, but this microbial reductive dechlorinator was present. Evaluation of the chemical, geochemical, and microbiological parameters in the

RI report according to EPA's *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water* (EPA 1998) indicates a low to moderate potential for natural biodegradation.

Based on this information a biological amendment would need to be added to the plume area to expedite the rate of natural degradation. Enhanced anaerobic dechlorination is the practice of adding hydrogen, a source of hydrogen, or a hydrogen-releasing compound as an electron donor. Anaerobic microorganisms substitute hydrogen for chlorine in the chlorinated aliphatic hydrocarbon molecules. The addition of hydrogen as an electron donor material can increase the rates of reductive dechlorination up to several orders of magnitude, rapidly taking the contaminant through the step-wise enhanced dechlorination process that ultimately results in the production of non-toxic compounds such as carbon dioxide, ethane, and chloride ions.

The maximum PCE concentration detected in the UGA during the RI was 38 µg/L at the base of this unit near Motor Avenue (EEEPC 2013). The maximum TCE concentration in the UGA was also found near the bottom of the UGA (120 µg/L); however, the TCE is present upgradient and within the capture zone of the existing LIFS mid-field groundwater extraction wells (see Figures 1-3, 1-5, 1-6, and 1-7). The extent of PCE and TCE contamination in the UGA has been decreasing over time, due in part to natural degradation processes as well as construction and operation of the LIFS groundwater treatment system and FPC OU-1 SVE system. Therefore, PCE and TCE concentrations associated with Plume B that are outside the capture zone of the LIFS treatment system within the UGA are likely to continue to diminish with time and are not expected to impact human health. Hence, treatment of this portion of the contaminant plume is not considered to be warranted and this alternative focuses on enhanced biodegradation of contamination within the MA in the area of maximum contaminant concentration.

This alternative includes the construction of a treatment zone across the width and depth of contamination within the MA outside of the capture zone of the LIFS midfield groundwater extraction wells (see Figure 5-3). The treatment zone would be created by injecting a biological enhancement in a single row of injection points along Radcliffe Avenue from approximately Kent Street east to the end of Radcliffe Avenue. This would enhance the reductive dechlorination process and reduce the contamination concentrations within the plume from the estimated 100 µg/L contour line on the west to the estimated 5 µg/L contour line on the east. It is expected that this process would reduce the number of years required for meeting the RAOs for OU-2.

For the purposes of this evaluation, it was assumed that biological enhancement would be achieved by adding a commercially available product to the plume area to increase reduction of PCE contamination at the site. Consideration should be given to a variety of suitable products during design; however, for development of cost estimates for this alternative analysis, the use of 3-D Microemulsion® by

Regenesis was assumed. The product is an engineered electron donor material that offers a three-stage electron donor release profile, pH neutral chemistry and is delivered on-site as a factory–emulsified product. Three stages of release include: immediate, mid-range, and long-term controlled-release of lactic, organic, and fatty acids for the production of hydrogen to support enhanced anaerobic biodegradation. This process is expected to ultimately result in the production of non-toxic compounds such as ethene and chloride. Under the influence of this or an equivalent product, the reductive dechlorination process is expected to be sustained for periods of up to two to four years, depending upon subsurface conditions (Regenesis 2012).

A 1,300-foot injected barrier of a reductive dechlorination enhancement product would be installed across the width of the plume. The location of the injection barrier was selected by considering various site factors, such as plume location, limited site accessibility, and capture zone of the existing LIFS remedial system. The barrier is expected to extend vertically throughout the majority of the PCE contaminant plume within the MA and would be approximately 80 feet thick. The barrier would be installed using direct-push methods with injection points located at 15-foot intervals, for a total of 87 injection points. A total of 181,000 pounds of the product would be required to completely install the barrier (assuming 3-D Microemulsion product for cost estimation). It is assumed that the biological enhancement barrier would be effective for up to three years.

Based on an average groundwater seepage velocity in the MA of approximately 0.4 feet/day, it is expected that approximately 440 feet of the groundwater plume would pass through the barrier in three years. However, as the barrier treats the widest and most contaminated section of the plume, this alternative would be able to significantly reduce the contaminant concentration within the plume. It is assumed that the need for a second injection would be evaluated based on the results of performance monitoring. However, for costing purposes, it was assumed that a second injection would be needed.

Performance monitoring of the treatment area will be performed to evaluate if the implemented biological treatment is operating properly and successfully and as expected to protect human health and the environment. Long-term monitoring would follow the performance monitoring until the RAOs are achieved. In order to properly monitor the plume, groundwater sampling will be performed to determine and monitor the contaminant concentration fluctuations.

Performance monitoring and long-term monitoring will be conducted on the new and existing wells located within and outside of the plume area. Performance monitoring is estimated for 15 existing wells and two new wells within the MA. Selection of well locations for monitoring and new well installation (including two MA monitoring wells upgradient and downgradient of the FPC building) should be considered during the design phase. It was assumed that the performance monitoring would be completed semiannually for three years (expected period of product survivability), following which the long-term monitoring would be completed annually for the remaining two years and every five years thereafter for duration of 30 years. Even though the plume is expected to achieve the groundwater cleanup goals earlier than 30 years, for equality of costing purposes, a 30-year timeframe was assumed.

Long-term monitoring of the UGA wells will also be completed to monitor the progress of the contaminant plume within this aquifer. Within the UGA plume, 16 wells (fourteen existing, two new) would be sampled during the long-term monitoring events. It was assumed that two new monitoring wells would be installed within the UGA aquifer. It is assumed that these wells would be sampled annually for the first five years and every five years thereafter for a total duration of 30 years.

The samples would be analyzed for VOCs by EPA Method SW8260 at an off-site laboratory. Figure 5-3 identifies the locations of the UGA and MA monitoring wells included in the long-term monitoring program.

In accordance with 6 NYCRR Part 375 standards, sites at which institutional or engineering controls are employed as part of a remedy, a written certification should be submitted annually to the NYSDEC. Since the implementation of this alternative would result in using institutional/engineering controls, annual certification would be required at the site.

5.2.4.2 Detailed Evaluation of Criteria

Overall Protectiveness of Public Health and the Environment

The application of the biological amendment would provide further protection of human health.

The implementation of institutional controls, such as well drilling restrictions to control future use of groundwater within the contaminated groundwater plume, would provide some long-term protection of human health.

Compliance with SCGs

Based on the results of the evaluation performed during the RI (EEEPC 2013), it was determined that there is some evidence of anaerobic biodegradation within the aquifers. However, the process appears to be slow, incomplete, and likely not an effective means of reducing contaminant concentrations to regulatory levels within an acceptable time period. Addition of a biological enhancement would increase the degradation rate of contamination within OU-2. Therefore, this alternative would comply with the chemical-specific SCGs for OU-2.

Short-Term Impacts and Effectiveness

Contaminant mass reduction may be achieved in the long-term. Short-term control of groundwater use through the implementation of ICs would ensure that the public's health is protected but only with respect to the on-site portion of the plume. ICs cannot be implemented off-site on private property and therefore would not be effective at limiting exposure to off-site contamination. Short-term impacts would include those associated with the machinery required for installation of injection points and actual injection of product, such as traffic and noise.

Long-Term Effectiveness and Permanence

This alternative will be marginally effective in the long term (in terms of protecting human health and the environment) because it only treats a small portion of the contaminated plume. The need for additional biological amendment injections would be evaluated during the performance monitoring phase and may further improve the effectiveness of this technology in the long term. Remediation of untreated portions of the plume would rely on natural degradation processes to further mitigate impacts associated with the contamination. In the interim period prior to complete destruction of the plume, deed or other restrictions are not applicable for privately owned properties within the off-site contaminant plume and would not be effective at controlling exposure.

Reduction in Toxicity, Mobility, or Volume of contamination through Treatment

This alternative involves the treatment of contaminated groundwater by enhancing the biodegradation process by several orders of magnitude. This is expected to reduce the mobility and volume of the contamination within the groundwater that passes through the barrier.

Implementability

The groundwater plume is located underneath densely populated residential areas, which might present accessibility issues at the site. Apart from that, this alternative can be readily implemented on a technical and administrative basis using typical biological enhancements, and institutional control practices and procedures. Since the majority of the proposed treatment area is east and outside of the capture zone of the LIFS mid-field extraction wells, no impact to the existing LIFS system is expected.

Cost

The 2012 total present-worth cost of this alternative based on a 30-year period is $3,649,716. Table 5-3 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. Cost estimating information was obtained from vendor information, RS Means Cost Data series, and engineering judgment. Groundwater sampling and annual certification of ICs are included in the costs for this alternative.

5.2.5 Alternative No. 5: Pump and Treat System, Discharge to Liberty Industrial Finishing Site Groundwater Remediation System, LTM, and ICs

5.2.5.1 Detailed Description

This alternative involves the design and construction of a pump and treat remedial system for the extraction and subsequent treatment of contaminated groundwater from OU-2. The system would include recovery wells, discharge pipes, and treatment systems capable of removing the PCE and TCE contamination associated with Plume B. For cost estimation purposes, it is assumed that the extracted groundwater would be transported to the existing LIFS groundwater remedial system for treatment prior to discharge. To accommodate the additional flow, the LIFS system would need to be upgraded. The upgraded system would be capable of removing the additional Plume B contamination not already captured by the existing LIFS groundwater remedial treatment system. In the event that the existing LIFS treatment facility is not usable for this purpose, an alternate lowest-cost location would need to be identified during design to construct an appropriate treatment facility for the influent contaminated groundwater. Additional piping would be required to transport the contaminated groundwater to the new treatment system.

The pump and treat system flows were estimated using the procedures described in Alternative 5. This pump and treat system would require the installation of the same four new recovery wells, well chambers, and fittings described in Alternative 5. The existing piping configuration from the LIFS midfield recovery wells would be reconfigured to handle the additional flow from the four new Plume B recovery wells. Currently the LIFS groundwater system includes a 6-inch diameter header that transports 260 gpm from the midfield UGA wells, a 4-inch diameter header that transports 85 gpm from the midfield MA wells, and a 4-inch diameter header that transports 65 gpm from the farfield UGA well. As part of this alternative, the flows from the midfield UGA wells would be re-routed from the existing 6-inch header through the 4-inch header that was previously used for midfield MA wells while the flow from the midfield MA wells would be re-routed from the existing 4-inch header through the 6-inch header so that the flow from the four new recovery wells could be added to the flow through this 6-inch header. Flows from the far-field UGA well will remain in the existing 4-inch header. The 6-inch header is estimated to be sufficient to transport the additional water from the recovery wells to the treatment system building located at the LIFS. A new common header (estimated at 1,400 feet) would be installed to transport the water from the four new wells to the existing 6-inch header at the west end of 1st Avenue. It was assumed that necessary permits required for the construction of the treatment building would be obtained during the design phase. It was assumed that the piping system would be installed using standard open-cut methods and horizontal directional drilling (see Figure 5-4).

Three additional pairs of granular activated carbon vessels would also need to be installed at the LIFS treatment building to handle the additional MA flow from the four new FPC recovery wells. Three new in-line pumps would also need to be installed in the existing treatment building in order to increase the water pressure to allow the combined flow to be transmitted through the treatment system. The need for pre-treatment filtration would also need to be determined during the design phase. All controls for the new equipment will be added to the system. Following treatment, the treated water would be primarily discharged into the county sewer. A portion of the water may be able to be discharged to an infiltration basin at the LIFS. It is assumed that the necessary discharge permits would be obtained during the design phase.

Regular OM&M of the treatment system would be required to ensure its successful operation. OM&M will include regular maintenance site visits, replacement parts, and building and grounds maintenance. For costing purposes, it is assumed that the LIFS system would be operational for 30 years to achieve the groundwater cleanup standards and OM&M would be required during that time period.

To evaluate the success of the alternative, regular monitoring activities would be completed at the site. A total of 33 wells would be sampled to evaluate the changes/reduction in contaminant concentrations at the site. Sixteen wells in the UGA (14 existing and two new wells) and 17 wells in the MA (15 existing and two new wells) would be sampled annually for the first five years and then every five years thereafter for a total duration of 30 years. ICs would be included as described in Alternative 2.

In accordance with 6 NYCRR Part 375 standards, sites at which institutional or engineering controls are employed as part of a remedy, a written certification should be submitted annually to the NYSDEC. Since the implementation of this alternative would result in using institutional/engineering controls, annual certification would be required at the site.

5.2.5.2 Detailed Evaluation of Criteria

Overall Protectiveness of Public Health and the Environment
This alternative is considered protective of human health and the environment, since the contaminated groundwater would be removed and treated.

Compliance with SCGs
This alternative would meet the SCGs since VOC-contaminated groundwater would be removed and treated. During implementation, this alternative would also meet the action- and location-specific SCGs, including noise limitations and OSHA regulations.

Short-Term Impacts and Effectiveness
Contaminant mass reduction would be achieved in the long-term. Short-term control of groundwater use through the implementation of ICs would ensure that the public's health is protected but only with respect to the on-site portion of the plume. ICs cannot be implemented off-site on private property and therefore would not be effective at limiting short-term exposure to off-site contamination. Several short-term impacts on the community and site workers may arise during installation of the treatment system. These potential impacts include traffic, dust, and noise during construction and start-up of the treatment system. In addition, during construction, impacts on workers may result from potential contact with contaminated groundwater. Other short-term impacts (e.g., noise) would be

mitigated by the use of engineering controls (e.g., noise barriers). Health and safety measures, including air monitoring, use of appropriate PPE, and decontamination of equipment leaving the site, would be in place to protect the workers and surrounding community.

Long-Term Effectiveness and Permanence

This alternative is considered to be an effective remedy in the long term, since contaminated groundwater would be removed and treated.

Reduction in Toxicity, Mobility, or Volume of Contamination through Treatment

The volume of contamination would be reduced at the site because this alternative includes the removal and treatment of contaminated groundwater. This would result in the reduction of toxicity, mobility and volume of the contamination that is extracted by the treatment process.

Implementability

This alternative can be readily implemented using standard construction means and methods for installation of treatment system components.

Cost

The 2012 total present-worth cost of this alternative based on a 30-year period is $17,440,100. Table 5-4 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. Cost estimating information was obtained from RS Means Cost Data series and engineering judgment. Groundwater sampling and annual certification of ICs are included in the costs for this alternative.

5.3 Comparative Evaluation of Alternatives

Overall Protectiveness of the Human Health and the Environment

Since Alternative 1 employs no action, contaminated groundwater would remain at OU-2, providing no protection of human health and the environment. Alternatives 2, 3, and 4 use long-term monitoring as part of the remedial action. Alternative 3 includes chemical treatment and Alternative 4 includes the application of a biological amendment. Alternative 2 would provide no protection of the environment as the contaminated groundwater plume would continue to exist and would not provide protection of human health in the off-site portion of the plume because the State cannot implement ICs on private property and can only implement such controls on site. However, existing State and county laws should restrict establishment of potable water wells within the off-site portion of the contaminant plume. Alternatives 3 and 4 would provide some protection of human health and the environment as the addition of chemical/biological amendment products would increase the rate of contaminant destruction in the groundwater. Alternative 5 is more protective of human health and the environment as contaminated groundwater would be extracted, treated, and then discharged.

Compliance with SCGs

Alternatives 1 and 2 do not comply with SCGs because the contaminated groundwater would remain and no treatment would occur. Implementation of Alternatives 3, 4, or 5 are estimated to allow the site to comply with SCGs within 30 years since groundwater contamination would be treated to reduce contamination.

Short-Term Impacts and Effectiveness

Short-term impacts are not anticipated under Alternatives 1 and 2, since no remediation activity would occur, with the exception of minor localized inconveniences associated with well sampling during long-term monitoring. Under Alternatives 3 and 4, several short-term impacts may affect the community during remedial activities, such as traffic, dust, and noise during injection. There is also the potential for spills of reactive chemicals during implementation of Alternative 3. Under Alternative 5, significant short-term impacts may affect the community during remedial activities, such as traffic, dust, and noise associated with the installation of recovery wells and pipelines.

Long-Term Effectiveness and Permanence

Since Alternative 1 employs no action, contaminated groundwater would remain in OU-2, providing no protection of human health or the environment. Alternative 2 would only be effective in the long term if existing laws are effective at restricting well installation within the off-site contaminant plume, because ICs that control groundwater use cannot be implemented off-site and therefore would not be effective in the long term. Alternatives 3 and 4 would be effective in the long term provided that sufficient injections are performed to destroy the majority of the contaminant mass and that natural degradation process are capable of destroying the remaining contaminants in low-concentration areas. In the interim period, ICs would not be effective because groundwater use restrictions cannot be implemented off-site on private property. Alternative 5 would be more effective than the other alternatives in the long term because contaminated groundwater would be removed and treated, protecting human health and the environment.

Reduction in Toxicity, Mobility, or Volume of Contamination through Treatment

Alternatives 1 and 2 would not treat contaminated groundwater; therefore, toxicity, mobility, and volume would not be reduced. Alternative 3 and 4 would treat the contaminated groundwater with chemical/biological amendment products, thereby reducing the mobility and volume of contamination within the treatment area. Alternative 5 would reduce the toxicity, mobility, and volume of the contamination as the contaminated groundwater is captured, extracted and treated.

Implementability

There are no actions to implement for Alternative 1. Alternative 2 can be easily implemented, as only a monitoring plan is required. Alternative 3 and 4 can be readily implemented using standard methods for the application of chemical/biological amendment products. Alternative 5 can be readily implemented using standard construction means and methods required for the construction of a pump and treat system.

Cost

Alternative 1 would involve no action and thus would incur no costs. Alternative 2 has a lower total present worth and OM&M cost than Alternative 3 and 4 because chemical/biological amendment products are not included in this alternative. Alternative 5 would require the installation of pump and treat systems to extract and treat the contaminated groundwater. Table 5-5 presents a summary of the costs for all alternatives.

Table 5-1 Cost Estimate for Alternative 2, Long-term Monitoring and Institutional Controls, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Item	Description	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Institutional Controls		1	LS	$20,000	$20,000
Monitoring Well Construction (UGA)	2 new wells in the UGA. 2.5" schedule 80 PVC w/ 20' screen, 75' deep	150	LF	$30	$4,500
Monitoring Well Construction (MA)	2 new wells in the MA. 2.5" schedule 80 PVC w/ 20' screen, 200' deep	400	LF	$30	$12,000
New Monitoring Well Development	Assume 8 hrs/well	32	Hours	$175	$5,600
Subtotal:					$42,100
				Capital Cost Subtotal:	$42,100
				15% Project Administration:	$6,315
				30% Contingency:	$12,630
				15% Legal and Engineering Costs:	$6,315
				Total Capital Cost:	**$67,400**
Annual Groundwater Monitoring (Years 1 through 5)					
Groundwater Sampling	33 wells (16 UGA, 17 MA), 2-persons, 10 hr/day, 6 days	120	HR	$120	$14,400
Analytical Costs (VOCs)	42 VOC samples per round including 33 wells, 1 duplicate sample, 1 MS, 1 MSD and 6 trip blanks	42	Each	$83	$3,486
Data Evaluation and Reporting	Assume 40 hours/report	40	HR	$120	$4,800
Subtotal:					$22,686
				Groundwater Monitoring Subtotal:	$22,686
				15% Project Administration:	$3,403
				30 % Contingency:	$6,806
				15% Legal and Engineering Costs:	$3,403
				Total Annual Groundwater Monitoring Costs:	**$36,298**
				Present Value of Annual Groundwater Monitoring (Years 1 through 5) Costs:	**$171,100**
Annual Certification Costs					
Annual Certification of Institutional Controls	Annual Certification of Institutional Controls and Engineering Controls	1	LS	$5,000	$5,000
Subtotal:					$5,000
				Groundwater Monitoring Subtotal:	$5,000
				15% Project Administration:	$750
				30 % Contingency:	$1,500
				15% Legal and Engineering Costs:	$750
				Total Annual Groundwater Monitoring Costs:	**$8,000**
				Present Value of Annual Groundwater Monitoring Costs:	**$179,200**
5-Year Monitoring					
Groundwater Sampling	33 wells (16 UGA, 17 MA), 2-persons, 10 hr/day, 6 days	120	HR	$120	$14,400
Analytical Costs (VOCs)	42 VOC samples per round including 33 wells, 1 duplicate sample, 1 MS, 1 MSD and 6 trip blanks	42	Each	$83	$3,486
Data Evaluation and Reporting	Assume 40 hours/report	40	HR	$120	$4,800
Institutional Controls	Update/Maintain Institutional Controls	1	LS	$20,000	$20,000
Subtotal					$42,686
				5-Year Monitoring Cost Subtotal:	$42,686
				15% Project Administration:	$6,403
				30% Contingency:	$12,806
				15% Legal and Engineering Costs:	$6,403
				Total 5-Year Costs:	**$68,298**
				30 Year Present Value of 5-Year Costs:	**$232,100**
				2012 Total Present Value Cost:	**$649,800**

Key:

LS: Lump Sum
SF: Square Foot
BCY: Cubic Yard
CF: Cubic Foot
MA: Magothy Aquifer
UGA: Upper Glacial Aquifer

Notes/Assumptions:

1. Contingency = 30%
2. Project Administration = 15%
3. Legal and Engineering Costs = 15%
4. Total long term Monitoring Time 30 years
5. Long-Term Monitoring of the UGA and MA will occur annually for 5 years and every 5 years after that.
   Total # of groundwater monitoring wells to be sampled: 33 wells
6. Present value costs assumes annual interest rate per "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA 540-R-00-002 July 2000) and the Office Management and Budget Real Discount Rates for the year 2012 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html)
   Annual interest rate: 2.0%
7. Institutional Controls include Deed restrictions limiting the use of groundwater.
8. Unit costs listed were obtained from 2012 RS Means Cost Data and engineering judgement.

Table 5-2 Cost Estimate for Alternative 3, In-Situ Chemical Treatment, Long Term Monitoring and Institutional Controls, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Item	Description	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Institutional Controls		1	LS	$20,000	$20,000
Chemical Treatment (Material only) - 1st Injection	Potassium Permanganate product costs, 800 ft wall	1	LS	$600,000	$600,000
Chemical Treatment (Implementation Costs) - 1st Injection	Bench scale testing, drilling costs for 16 injection points, contractor's oversight, traffic control, permitting, sampling or monitoring	1	LS	$380,000	$380,000
Project Oversight - 1st Injection	16 injection points,10 weeks, 5 days/week, 10 hours/day	500	HR	$120	$60,000
Chemical Treatment (Material only) - 2nd Injection	Potassium Permanganate product costs, 800 ft wall	1	LS	$600,000	$600,000
Chemical Treatment (Implementation Costs) - 2nd Injection	Drilling costs for 16 injection points, contractor's oversight, traffic control, permitting, sampling or monitoring	1	LS	$380,000	$380,000
Project Oversight - 2nd Injection	16 injection points,10 weeks, 5 days/week, 10 hours/day	500	HR	$120	$60,000
Monitoring Well Construction (UGA)	2 new wells in UGA. 2.5" schedule 80 PVC w/ 20' screen, 75' deep	150	LF	$30	$4,500
Monitoring Well Construction (MA)	2 new wells in the MA. 2.5" schedule 80 PVC w/ 20' screen, 200' deep	400	LF	$30	$12,000
New Monitoring Well Development	Assume 8 hrs/well	32	Hours	$175	$5,600
Subtotal:					$2,122,100
				Capital Cost Subtotal:	$2,122,100
				15% Project Administration:	$318,315
				30% Contingency:	$636,630
				15% Legal and Engineering Costs:	$318,315
				Total Capital Cost:	**$3,395,400**
Semi-annual Performance Monitoring (Years 1 through 3) for the MA					
Groundwater Sampling	17 wells, assume 6 wells/day, 2-persons, 10 hr/day, 2 rounds/year	120	HR	$120	$14,400
Analytical Costs (VOCs)	23 VOC samples per round including 17 wells, 1 duplicate sample, 1 MS, 1 MSD and 3 trip blanks, 2 rounds/year	46	Each	$83	$3,818
Data Evaluation and Reporting	Assume 40 hours/report	80	HR	$120	$9,600
Subtotal:					$27,818
				Groundwater Monitoring Subtotal:	$27,818
				15% Project Administration:	$4,173
				30 % Contingency:	$8,345
				15% Legal and Engineering Costs:	$4,173
				Total Semi-Annual Performance Monitoring for MA (Year 1 through 3) Costs:	**$44,509**
				Present Value of Semi-Annual Performance Monitoring for MA (Year 1 through 3) Costs:	**$128,400**
Annual Groundwater Monitoring (Years 4 and 5) for MA					
Groundwater Sampling	17 wells, assume 6 wells/day, 2-persons, 10 hr/day	60	HR	$120	$7,200
Analytical Costs (VOCs)	23 VOC samples per round including 17 wells, 1 duplicate sample, 1 MS, 1 MSD and 3 trip blanks	23	Each	$83	$1,909
Data Evaluation and Reporting	Assume 40 hours/report	40	HR	$120	$4,800
Subtotal:					$13,909
				Groundwater Monitoring Subtotal:	$13,909
				15% Project Administration:	$2,086
				30 % Contingency:	$4,173
				15% Legal and Engineering Costs:	$2,086
				Total Annual Groundwater Monitoring for MA (Years 4 and 5) Costs:	**$22,254**
				Present Value of Annual Groundwater Monitoring for MA (Years 4 and 5) Costs:	**$40,716**

Table 5-2 Cost Estimate for Alternative 3, In-Situ Chemical Treatment, Long Term Monitoring and Institutional Controls, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Item	Description	Quantity	Unit	Unit Cost	Total Cost
Annual Groundwater Monitoring (Years 1 through 5) for UGA					
Groundwater Sampling	16 wells, assume 5 wells/day, 2-persons, 10 hr/day	60	HR	$120	$7,200
Analytical Costs (VOCs)	22 VOC samples per round including 16 wells, 1 duplicate sample, 1 MS, 1 MSD and 3 trip blanks	22	Each	$83	$1,826
Data Evaluation and Reporting	Assume 40 hours/report	40	HR	$120	$4,800
Subtotal:					$13,826
				Groundwater Monitoring Subtotal:	$13,826
				15% Project Administration:	$2,074
				30 % Contingency:	$4,148
				15% Legal and Engineering Costs:	$2,074
				Total Annual Groundwater Monitoring for UGA (Year 1 through 5) Costs:	**$22,122**
				Present Value of Annual Groundwater Monitoring for UGA (Year 1 through 5) Costs:	**$104,300**
Annual Certification Costs					
Annual Certification of Institutional Controls	Annual Certification of Institutional Controls and Engineering Controls	1	LS	$5,000	$5,000
Subtotal:					$5,000
				Groundwater Monitoring Subtotal:	$5,000
				15% Project Administration:	$750
				30 % Contingency:	$1,500
				15% Legal and Engineering Costs:	$750
				Total Annual Groundwater Monitoring Costs:	**$8,000**
				Present Value of Annual Groundwater Monitoring Costs:	**$179,200**
Periodic Groundwater Monitoring (Years 6 through 30) for UGA and MA					
Groundwater Sampling	33 wells (16 UGA, 17 MA), 2-persons, 10 hr/day, 6 days	120	HR	$120	$14,400
Analytical Costs (VOCs)	42 VOC samples per round including 33 wells, 1 duplicate sample, 1 MS, 1 MSD and 6 trip blanks	42	Each	$83	$3,486
Data Evaluation and Reporting		40	HR	$120	$4,800
Institutional Controls	Update/Maintain Institutional Controls	1	LS	$20,000	$20,000
Subtotal:					$42,686
				5-Year Monitoring Cost Subtotal:	$42,686
				15% Project Administration:	$6,403
				30% Contingency:	$12,806
				15% Legal and Engineering Costs:	$6,403
				Total 5-Year Costs:	**$68,298**
				30 Year Present Value of 5-Year Costs:	**$232,100**
				2012 Total Present Value Cost:	**$4,080,116**

Key:

LS: Lump Sum
SF: Square Foot
BCY: Cubic Yard
CF: Cubic Foot
MA: Magothy Aquifer
UGA: Upper Glacial Aquifer

Notes/Assumptions:

1. Contingency assumed at: 30%
2. Project Administration assumed at: 15%
3. Legal and Engineering Costs assumed at: 15%

4. Chemical Treatment will be achieved by injecting a Potassium Permanganate product into the Magothy aquifer. The material costs were provided by GES.
5. Total Monitoring Time 30 years
6. Performance Monitoring for the MA (17 wells) will occur semi-annually for the first 3 years and annually for 2 years thereafter.
7. Long-Term annual Monitoring for the UGA (16 wells) will occur annually for 5 years.
8. Periodic Monitoring for the UGA and MA will occur every 5 years for a total duration of 30 years.
9. Present value costs assumes annual interest rate per "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA 540-R-00-002 July 2000) and the Office of Management and Budget Real Discount Rates for the year 2012 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html)
   Annual interest rate: 2.0%
10. Institutional Controls include Deed restrictions limiting the use of groundwater.
11. Unit costs listed were obtained from 2012 RS Means Cost Data and engineering judgement.

Table 5-3 Cost Estimate for Alternative 4, In-Situ Biological Enhancement, Long Term Monitoring and Institutional Controls, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Item	Description	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Institutional Controls		1	LS	$20,000	$20,000
Biological Enhancement (Material only) - 1st Injection	Regenesis Microemulsion product, 1,300 ft wall, Material costs only	181,000	LB	$2.50	$452,500
Biological Enhancement (Labor and Equipment) - 1st Injection	Labor and equipment (Geoprobe) for injection, 200 ft deep, 87 injection points	17,400	LF	$23	$400,200
Biological enchancement oversight - 1st Injection	87 injection points, 4 injections/day, 2-people, 10 hours/day	440	HR	$120	$52,800
Biological Enhancement (Material only) - 2nd Injection	Regenesis Microemulsion product, 1,300 ft wall, Material costs only	181,000	LB	$2.50	$452,500
Biological Enhancement (Labor and Equipment) - 2nd Injection	Labor and equipment (Geoprobe) for injection, 200 ft deep, 87 injection points	17,400	LF	$23	$400,200
Biological enchancement oversight - 2nd Injection	87 injection points, 4 injections/day, 2-people, 10 hours/day	440	HR	$120	$52,800
Monitoring Well Construction (UGA)	2 new wells in UGA. 2.5" schedule 80 PVC w/ 20' screen, 75' deep	150	LF	$30	$4,500
Monitoring Well Construction (MA)	2 new wells in the MA. 2.5" schedule 80 PVC w/ 20' screen, 200' deep	400	LF	$30	$12,000
New Monitoring Well Development	Assume 8 hrs/well	32	Hours	$175	$5,600
Subtotal:					$1,853,100
				Capital Cost Subtotal:	$1,853,100
				15% Project Administration:	$277,965
				30% Contingency:	$555,930
				15% Legal and Engineering Costs:	$277,965
				Total Capital Cost:	**$2,965,000**
Semi-annual Performance Monitoring (Years 1 through 3) for the MA					
Groundwater Sampling	17 wells, assume 6 wells/day, 2-persons, 10 hr/day, 2 rounds/year	120	HR	$120	$14,400
Analytical Costs (VOCs)	23 VOC samples per round including 17 wells, 1 duplicate sample, 1 MS, 1 MSD and 3 trip blanks	46	Each	$83	$3,818
Data Evaluation and Reporting	Assume 40 hours/report	80	HR	$120	$9,600
Subtotal:					$27,818
				Groundwater Monitoring Subtotal:	$27,818
				15% Project Administration:	$4,173
				30 % Contingency:	$8,345
				15% Legal and Engineering Costs:	$4,173
				Total Semi-Annual Performance Monitoring for MA (Year 1 through 3) Costs:	**$44,509**
				Present Value of Semi-Annual Performance Monitoring for MA (Year 1 through 3) Costs:	**$128,400**
Annual Groundwater Monitoring (Years 4 and 5) for MA					
Groundwater Sampling	17 wells, assume 6 wells/day, 2-persons, 10 hr/day	60	HR	$120	$7,200
Analytical Costs (VOCs)	23 VOC samples per round including 17 wells, 1 duplicate sample, 1 MS, 1 MSD and 3 trip blanks	23	Each	$83	$1,909
Data Evaluation and Reporting	Assume 40 hours/report	40	HR	$120	$4,800
Subtotal:					$13,909
				Groundwater Monitoring Subtotal:	$13,909
				15% Project Administration:	$2,086
				30 % Contingency:	$4,173
				15% Legal and Engineering Costs:	$2,086
				Total Annual Groundwater Monitoring for MA (Years 4 and 5) Costs:	**$22,254**
				Present Value of Annual Groundwater Monitoring for MA (Years 4 and 5) Costs:	**$40,716**

Table 5-3 Cost Estimate for Alternative 4, In-Situ Biological Enhancement, Long Term Monitoring and Institutional Controls, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Item	Description	Quantity	Unit	Unit Cost	Total Cost
Annual Groundwater Monitoring (Years 1 through 5) for UGA					
Groundwater Sampling	16 wells, assume 5 wells/day, 2-persons, 10 hr/day	60	HR	$120	$7,200
Analytical Costs (VOCs)	22 VOC samples per round including 16 wells, 1 duplicate sample, 1 MS, 1 MSD and 3 trip blanks	22	Each	$83	$1,826
Data Evaluation and Reporting	Assume 40 hours/report	40	HR	$120	$4,800
Subtotal:					$13,826
				Groundwater Monitoring Subtotal:	$13,826
				15% Project Administration:	$2,074
				30 % Contingency:	$4,148
				15% Legal and Engineering Costs:	$2,074
				Total Annual Groundwater Monitoring for UGA (Year 1 through 5) Costs:	**$22,122**
				Present Value of Annual Groundwater Monitoring for UGA (Year 1 through 5) Costs:	**$104,300**
Annual Certification Costs					
Annual Certification of Institutional Controls	Annual Certification of Institutional Controls and Engineering Controls	1	LS	$5,000	$5,000
Subtotal:					$5,000
				Groundwater Monitoring Subtotal:	$5,000
				15% Project Administration:	$750
				30 % Contingency:	$1,500
				15% Legal and Engineering Costs:	$750
				Total Annual Groundwater Monitoring Costs:	**$8,000**
				Present Value of Annual Groundwater Monitoring Costs:	**$179,200**
Periodic Groundwater Monitoring (Years 6 through 30) for UGA and MA					
Groundwater Sampling	33 wells (16 UGA, 17 MA), 2-persons, 10 hr/day, 6 days	120	HR	$120	$14,400
Analytical Costs (VOCs)	42 VOC samples per round including 33 wells, 1 duplicate sample, 1 MS, 1 MSD and 6 trip blanks	42	Each	$83	$3,486
Data Evaluation and Reporting		40	HR	$120	$4,800
Institutional Controls	Update/Maintain Institutional Controls	1	LS	$20,000	$20,000
Subtotal:					$42,686
				5-Year Monitoring Cost Subtotal:	$42,686
				15% Project Administration:	$6,403
				30% Contingency:	$12,806
				15% Legal and Engineering Costs:	$6,403
				Total 5-Year Costs:	**$68,298**
				30 Year Present Value of 5-Year Costs:	**$232,100**
				2012 Total Present Value Cost:	**$3,649,716**

Key:

LS: Lump Sum
SF: Square Foot
BCY: Cubic Yard
CF: Cubic Foot
MA: Magothy Aquifer
UGA: Upper Glacial Aquifer

Notes/Assumptions:

1. Contingency assumed at: 30%
2. Project Administration assumed at: 15%
3. Legal and Engineering Costs assumed at: 15%
4. Biological Enhancement will be achieved by injecting a Regenesis Microemulsion product into the Magothy aquifer. The material costs were provided by Regenesis.
5. Total Monitoring Time 30 years
6. Performance Monitoring for the MA (17 wells) will occur semi-annually for the first 3 years and annually for 2 years thereafter.
7. Long-Term annual Monitoring for the UGA (16 wells) will occur annually for 5 years.
8. Periodic Monitoring for the UGA and MA will occur every 5 years for a total duration of 30 years.
9. Present value costs assumes annual interest rate per "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA 540-R-00-002 July 2000) and the Office of Management and Budget Real Discount Rates for the year 2012 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html)
   Annual interest rate: 2.0%
10. Institutional Controls include Deed restrictions limiting the use of groundwater.
11. Unit costs listed were obtained from 2012 RS Means Cost Data and engineering judgement.

Table 5-4 Cost Estimate for Alternative 5, Pump and Treat System, Discharge to Liberty Industrial Finishing Site Groundwater Remediation System, Long-term Monitoring and Institutional Controls, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Item	Description	Quantity	Unit	Unit Cost	Total Cost
New Treatment Equipment					
Mob/Demob, Site Prep, Site Restoration	Costs obtained from 2008 LIFS treatment system construction, adjusted to 2012	1	LS	$28,269	$28,269
Replace Treatment Bldg Magothy System Pipe	4" header pipe to be replaced with 6" header pipe	250	LS	$97	$25,775
New GAC Vessels	includes pneumatic actuated butterly valves, modulating butterfly valve, manual valves, pressure switch, DP pressure transmitter, and magmeter,adjusted to 2012 costs	1	LS	$286,325	$286,325
Booster pumps	7.5 HP Pumps with a 6" inlet/outlet connections	3	Each	$9,850	$35,815
Building Addition	20' x 25' to ground floor, Costs obtained from 2008 LIFS treatment system construction, adjusted to 2012	500	SF	$31	$19,508
Existing building prep for addition		1	LS	$10,000	$10,000
Control System Upgrades	Assumes 15% increase in equipment, Costs obtained from 2008 LIFS treatment system construction, adjusted to 2012	1	LS	$69,444	$74,193
System Start-up and Testing	Costs obtained from 2008 LIFS treatment system construction, adjusted to 2012	1	LS	$17,051	$17,051
Subtotal:					$496,935
Piping and Well installation					
Mob/Demob, Site Prep, Site Restoration	Costs obtained from 2008 LIFS treatment system construction, adjusted to 2012	1	LS	$130,128	$139,026
Pavement Restoration	Replacement of roads excavated during piping installation	50	SY	$44	$2,824
Piping (furnishing and installation)	HDD from wells to Treatment Building, Costs obtained from 2008 LIFS treatment system construction, adjusted to 2012	1400	LF	$82	$123,046
Recovery Well installation and Equipment	Costs obtained from 2008 LIFS treatment system construction, adjusted to 2012	4	Each	$87,874	$375,530
Recovery Well Chambers	Costs obtained from 2008 LIFS treatment system construction, adjusted to 2012	4	Each	$16,026	$68,486
Recovery Well Pump Start-up and Testing		1	LS	$20,000	$20,000
Discharge Piping	open trenching to install pipe system, 2008 LIFS treatment system costs, adjusted to 2012	500	LF	$100	$63,197
Connection to POTW	Permit to discharge to the POTW	1	LS	$1,000	$1,000
Institutional Controls		1	LS	$20,000	$20,000
Monitoring Well Construction (UGA)	2 new wells in the UGA. 2.5" schedule 80 PVC w/ 20' screen, 75' deep	150	LF	$30	$4,500
Monitoring Well Construction (MA)	2 new wells in the MA. 2.5" schedule 80 PVC w/ 20' screen, 200' deep	400	LF	$30	$12,000
New Monitoring Well Development	Assume 8 hrs/well	32	HR	$175	$5,600
Subtotal:					$835,208
				Capital Cost Subtotal:	$1,332,143
				15% Project Administration:	$199,821
				30% Contingency:	$399,643
				15% Legal and Engineering Costs:	$199,821
				Total Capital Cost:	**$2,131,500**
Annual O&M Costs (30 Years)					
Part-Time Operator	8 hrs/week, 52 weeks/year	416	HR	$100	$41,600
Carbon Replacement and Disposal	2 vessels change out w/ virgin carbon, includes sampling and haz. Disposal	1	LS	$17,200	$17,200
Equipment Replacement	Flow meter, actuators, postitioners, GW pumps, etc.	1	LS	$10,000	$10,000
Effluent Water Quality Samples	Sampled monthly for VOCs and pH, includes 25% markup	12	Each	$110	$1,320
Electric Usage	Assume a continuous use of 20 HP pumps	130000	kwh	$0.15	$19,500
Discharge to POTW	175 gpm x 60 min/hr x 24 hr/day x 365 days	91980	/1000 gal	$3.45	$317,331
Other utilities	Phone, Water, heat	1	Year	$4,000	$4,000
Annual Certification of Institutional Controls	Annual Certification of Institutional Controls and Engineering Controls	1	LS	$5,000	$5,000
Subtotal:					$415,951
				Annual O&M Cost Subtotal:	$415,951
				15% Project Administration:	$62,393
				30% Contingency:	$124,785
				15% Legal and Engineering Costs:	$62,393
				Total O&M Costs:	**$665,522**
				Total O&M Cost for 30 Years:	**$14,905,400**

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Tables 5-1 thru 5-5 Alternative Cost Estimates.xlsx-Table 5-4 Alternative 5-4/24/2013

Table 5-4 Cost Estimate for Alternative 5, Pump and Treat System, Discharge to Liberty Industrial Finishing Site Groundwater Remediation System, Long-term Monitoring and Institutional Controls, Farmingdale Plaza Cleaners Site, Farmingdale, New York

Item	Description	Quantity	Unit	Unit Cost	Total Cost
Annual Groundwater Monitoring (Years 1 through 5)					
Groundwater Sampling	33 wells (16 UGA, 17 MA), 2-persons, 10 hr/day, 6 days	120	HR	$120	$14,400
Analytical Costs (VOCs)	42 VOC samples per round including 33 wells, 1 duplicate sample, 1 MS, 1 MSD and 6 trip blanks	42	Each	$83	$3,486
Data Evaluation and Reporting	Assume 40 hours/report	40	HR	$120	$4,800
Subtotal					$22,686
				Groundwater Monitoring Subtotal:	$22,686
				15% Project Administration:	$3,403
				30 % Contingency:	$6,806
				15% Legal and Engineering Costs:	$3,403
				Total Annual Groundwater Monitoring (Year 1 through 5) Costs:	**$36,298**
				Present Value of Annual Groundwater Monitoring (Year 1 through 5) Costs:	**$171,100**
Periodic Groundwater Monitoring (Years 6 through 30)					
Groundwater Sampling	33 wells (16 UGA, 15 MA), 2-persons, 10 hr/day, 6 days	120	HR	$120	$14,400
Analytical Costs (VOCs)	42 VOC samples per round including 33 wells, 1 duplicate sample, 1 MS, 1 MSD and 6 trip blanks	42	Each	$83	$3,486
Data Evaluation and Reporting	Assume 40 hours/report	40	HR	$120	$4,800
Institutional Controls	Update/Maintain Institutional Controls	1	LS	$20,000	$20,000
Subtotal					$42,686
				5-Year Monitoring Cost Subtotal:	$42,686
				15% Project Administration:	$6,403
				30% Contingency:	$12,806
				15% Legal and Engineering Costs:	$6,403
				Total 5-Year Costs:	**$68,298**
				30 Year Present Value of 5-Year Costs:	**$232,100**
				2012 Total Present Value Cost:	**$17,440,100**

Key:

BCY: Cubic Yard
CF: Cubic Foot
HR: Hour
kwh = Kilowatt Hour
LS: Lump Sum
LF: Linear Foot
SF: Square Foot
SY: Square Yard

Notes/Assumptions:

1. Contingency assumed at: 30%
2. Project Administration assumed at: 15%
3. Legal and Engineering Costs assumed at: 15%
4. Costs for the treatment system construction were obtained from the 2008 LIFS remedial treatment system construction and adjusted to 2012 costs using the 2012 RS Means Historical Cost Indices.
5. Total Monitoring Time 30 years
6. Long-Term Monitoring will occur annually for 5 years and every 5 years after that.
   Total # of groundwater monitoring wells to be sampled: 33 wells
7. Present value costs assumes annual interest rate per "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA 540-R-00-002 July 2000) and the Office of Management and Budget Real Discount Rates for the year 2012 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html)
   Annual interest rate: 2.0%
8. Institutional Controls include Deed restrictions limiting the use of groundwater.
9. Unit costs listed were obtained from 2012 RS Means Cost Data and engineering judgement.
10. Historical cost Index data used for escalating costs were obtained from 2012 RS Means Heavy Construction Cost Book.

Historical Cost Index for year 2012	100
Historical Cost Index for Year 2011	96.3
Historical Cost Index for year 2008	93.6
Historical Cost Index for year 2006	84

Table 5-5 Summary of Total Present Values of Remedial Alternatives at the Farmingdale Plaza Cleaners Site, Farmingdale, New York

Description	Alternative 1 No Action	Alternative 2 Long Term Monitoring and Institutional Controls	Alternative 3 In-Situ Chemical Treatment, Institutional Controls and LTM	Alternative 4 In-Situ Biological Enhancement, Institutional Controls and LTM	Alternative 5 Pump and Treat System, Discharge to LIFS Groundwater Remediation System, LTM, and ICs
Estimated Total Project Duration (Years)	0	30	30	30	30
Capital Cost	$0	$67,400	$3,395,400	$2,965,000	$2,131,500
Annual O&M[1]	$0	$350,300	$452,616	$452,616	$15,076,500
Periodic O&M[2]	$0	$232,100	$232,100	$232,100	$232,100
2012 Total Present Value of Alternative[3]	**$0**	**$649,800**	**$4,080,116**	**$3,649,716**	**$17,440,100**

Notes:

1 - Annual costs would typically include electrical costs, sewer costs, equipment maintenance/replacement, groundwater monitoring and reporting, annual institutional control certifications.

2 - Periodic costs would typically include maintaining/updating institutional controls and groundwater monitoring/reporting.

3 - The Total Present value of Alternative represents the estimated present value of the capital costs and 30-years of annual and periodic costs.

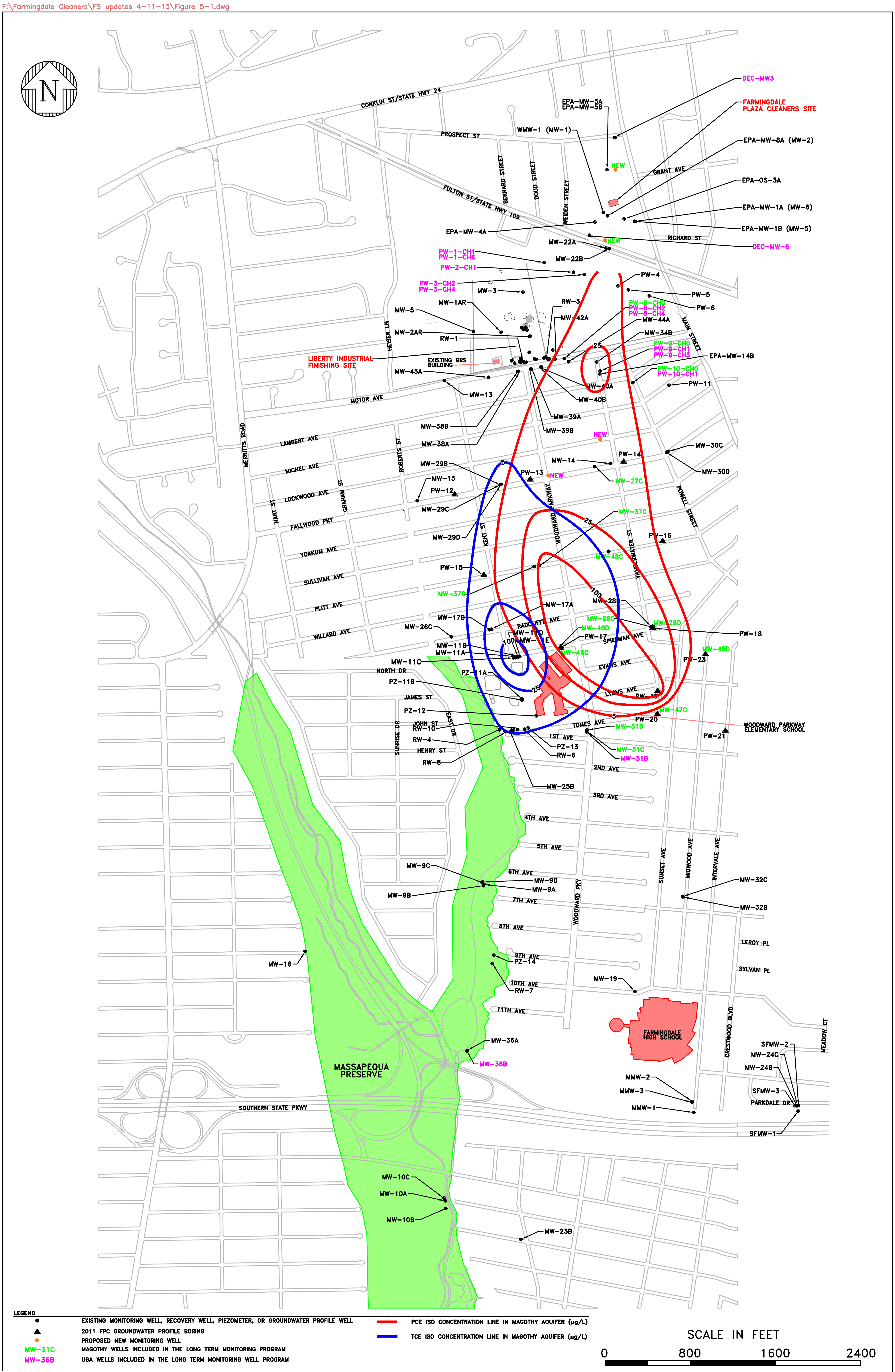

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FIGURE 5-1 ALTERNATIVE 2 – LONG TERM MONITORING AND INSTITUTIONAL CONTROLS
FARMINGDALE PLAZA CLEANERS SITE
FARMINGDALE, NEW YORK

F:\Farmingdale Cleaners\FS updates 4-11-13\Figure 5-2.dwg

NOTE
DATA FOR WELLS AND BORINGS SAMPLED IN AUGUST 2011 THROUGH MARCH 2012 IS PRESENTED IN THIS REPORT. DATA FOR WELLS SAMPLED JUNE 2011 AND EARLIER IS FROM EEEPC 2011, SITE-WIDE GROUNDWATER MONITORING REPORT, LIBERTY INDUSTRIAL FINISHING SITE.

LEGEND
- ● EXISTING MONITORING WELL, RECOVERY WELL, PIEZOMETER, OR GROUNDWATER PROFILE WELL
- ▲ 2011 FPC GROUNDWATER PROFILE BORING
- ● PROPOSED NEW MONITORING WELL
- MW-31C MAGOTHY WELLS INCLUDED IN THE LONG TERM MONITORING PROGRAM
- MW-36B UGA WELLS INCLUDED IN THE LONG TERM MONITORING WELL PROGRAM
- PCE ISO-CONCENTRATION LINE (µg/L)
- TCE ISO-CONCENTRATION LINE (µg/L)
- PERMANGANATE BARRIER

SCALE IN FEET
0 800 1600 2400

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FIGURE 5-2 ALTERNATIVE 3 – IN-SITU CHEMICAL TREATMENT, LONG TERM MONITORING, AND INSTITUTIONAL CONTROLS
FARMINGDALE PLAZA CLEANERS SITE
FARMINGDALE, NEW YORK

NOTE
DATA FOR WELLS AND BORINGS SAMPLED IN AUGUST 2011 THROUGH MARCH 2012 IS PRESENTED IN THIS REPORT. DATA FOR WELLS SAMPLED JUNE 2011 AND EARLIER IS FROM EEEPC 2011, SITE-WIDE GROUNDWATER MONITORING REPORT, LIBERTY INDUSTRIAL FINISHING SITE.

LEGEND

- ● EXISTING MONITORING WELL, RECOVERY WELL, PIEZOMETER, OR GROUNDWATER PROFILE WELL
- ▲ 2011 FPC GROUNDWATER PROFILE BORING
- ● PROPOSED NEW MONITORING WELL
- MW-31C MAGOTHY WELLS INCLUDED IN THE LONG TERM MONITORING PROGRAM
- MW-36B UGA WELLS INCLUDED IN THE LONG TERM MONITORING WELL PROGRAM
- PCE ISO-CONCENTRATION LINE (µg/L)
- TCE ISO-CONCENTRATION LINE (µg/L)
- REGENESIS 3dMe BARRIER

SCALE IN FEET

0 800 1600 2400

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FIGURE 5-3 ALTERNATIVE 4 – IN-SITU BIOLOGICAL ENHANCEMENT, LONG TERM MONITORING, AND INSTITUTIONAL CONTROLS
FARMINGDALE PLAZA CLEANERS SITE
FARMINGDALE, NEW YORK

F:\Farmingdale Cleaners\FS 4-11-13 updates\Fig 5-4.dwg

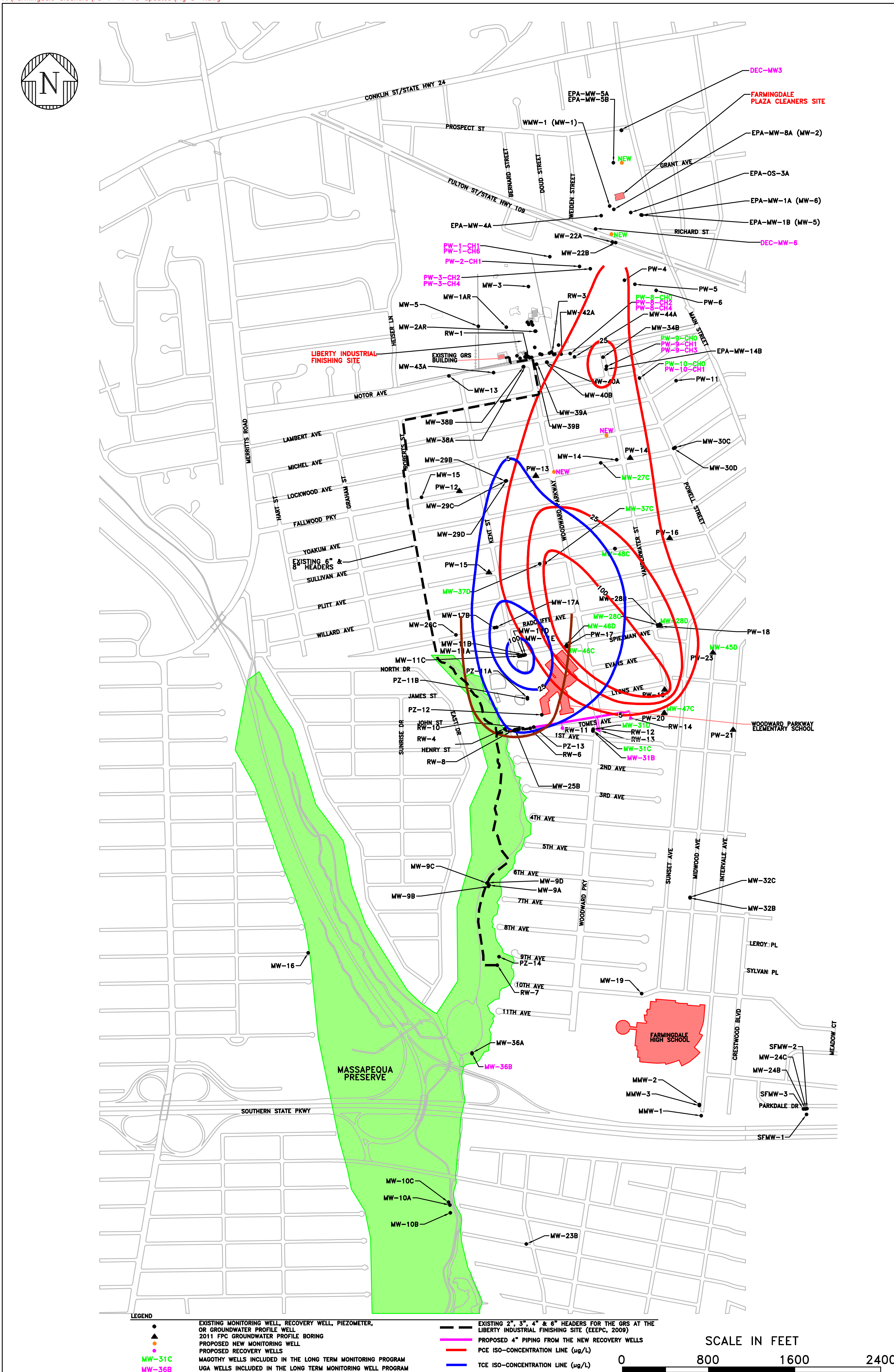

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FIGURE 5-4 ALTERNATIVE 5 – PUMP & TREAT DISCHARGE TO LIFS GRS, ICS & LTM
FARMINGDALE PLAZA CLEANERS SITE
FARMINGDALE, NEW YORK

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