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Region 2 RAC2
Remedial Action Contract

Draft Focused Feasibility Study Report

Old Roosevelt Field Contaminated Groundwater Site, Operable Unit 2 – Eastern Plume

Remedial Investigation/ Focused Feasibility Study

Garden City, New York

June 7, 2017

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PROJECT: EPA Region 2 RAC2 Contract No.: EP-W-09-002
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SUBJECT: Draft Focused Feasibility Study Report
Old Roosevelt Field Contaminated Groundwater Site
OU2-Eastern Plume
Remedial Investigation/Focused Feasibility Study
Garden City, New York

Dear Ms. Henry:

CDM Federal Programs Corporation (CDM Smith) is pleased to submit the Draft Focused Feasibility Study Report for the Old Roosevelt Field Contaminated Groundwater Site, OU2-Eastern Plume in Garden City, New York.

If you have any questions regarding this submittal, please contact me at 732-590-4638.

Very truly yours,

CDM FEDERAL PROGRAMS CORPORATION

Thomas Mathew

Thomas Mathew, P.E.
Site Manager

PSO: _KS_

Enclosure
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Table of Contents

List of Tables

List of Figures

Appendices

Acronyms

amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CDM Smith	CDM Federal Programs Corporation
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CFR	Code of Federal Regulations
COPC	chemical of potential concern
CSM	conceptual site model
CTE	central tendency exposure
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
FFS	focused feasibility study
GCW	groundwater circulation well
GRA	general response action
HHRA	human health risk assessment
HI	hazard index
MCL	maximum contaminant level
MNA	monitored natural attenuation
NCP	National Contingency Plan
OU	operable unit
O&M	operation and maintenance
PCE	tetrachloroethene
PRG	preliminary remediation goal
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RI	remedial investigation
RME	reasonable maximum exposure
the Site	Old Roosevelt Field Contaminated Groundwater Site
T/M/V	toxicity, mobility, or volume
TBC	to be considered
TCE	trichloroethene
VOC	volatile organic compound
VPGAC	vapor phase granular activated carbon
WA	work assignment
1,1-DCE	1,1-dichloroethene
cis-1,2-DCE	cis-1,2-dichloroethene
µg/L	micrograms per liter

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Section 1

Introduction

CDM Federal Programs Corporation (CDM Smith) received Work Assignment (WA) 047-RICO-02PE for the Old Roosevelt Field Contaminated Groundwater Site (the Site), Operable Unit (OU) 2-Eastern Plume, under the Remedial Action Contract, Contract No. EP-W-09-002 for the United States Environmental Protection Agency (EPA), Region 2. The objective of this WA is to perform a Remedial Investigation (RI)/Focused Feasibility Study (FFS) and a human health risk assessment (HHRA) for the Site.

1.1 Purpose and Organization of Report

The overall purpose of the FFS is to develop and evaluate groundwater remedial alternatives for the eastern plume area and provide the regulatory agencies with sufficient information to select a feasible and cost-effective remedial alternative that protects public health and the environment from potential risks at the Site. This report is comprised of five sections as described below.

- **Section 1 – Introduction** provides a summary of the OU2 RI, including site description, history, and physical characteristics; OU2 RI sampling results; nature and extent of contamination; conceptual site model (CSM); and human health risks.

- **Section 2 – Development of Remedial Action Objectives and Technology Screening** presents a list of remedial action objectives (RAOs) developed by considering the characterization of contaminants, the risk assessments, and compliance with site-specific applicable or relevant and appropriate requirements (ARARs); documents the quantities of contaminated media; identifies general response actions (GRAs); and identifies and screens remedial technologies and process options.

- **Section 3 – Development of Remedial Action Alternatives** presents the remedial alternatives developed by combining the feasible technologies and process options and provides the conceptual design assumptions and descriptions of each alternative.

- **Section 4 – Detailed Analysis of Remedial Action Alternatives** provides a detailed analysis of each alternative with respect to the following seven criteria: overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume (T/M/V) through treatment; short-term effectiveness; implementability; and costs. Two additional criteria — state acceptance and community acceptance — are not evaluated in this report. This section also provides an overall comparative analysis of the remedial alternatives.

- **Section 5 – References** provides a list of references in the study.

1.2 Site Location and Description

The Old Roosevelt Field Contaminated Groundwater Site is an area of groundwater contamination within the Village of Garden City, in central Nassau County, Long Island, New York (**Figure 1-1**).

The OU1 portion of the Site is located just east of Clinton Road, south of the intersection with Old Country Road; it extends approximately 800 feet east of Clinton Road, running parallel to Clinton Road, south past Commercial Avenue. It includes the western portion of the former Roosevelt Field airfield (**Figure 1-1**). The OU2 portion of the Site is east of OU1, and extends south, parallel to OU1. The study area of OU2 is governed by the plume that was identified at monitoring well cluster MW-3 and the wells downgradient of MW-3 where the plume was detected. It also extends south past Commercial Avenue. The OU2 portion of the Site includes the eastern portion of the former Roosevelt Field airfield (**Figure 1-1**). The former Roosevelt Field airfield area is currently developed as a large retail shopping mall with a number of restaurants and a movie theater. Several office buildings (including Garden City Plaza) are on the western perimeter of the mall and share parking space with the mall.

1.3 Site History

The history of the Site is summarized in the following sections.

1.3.1 Early Site History

The Site was used for aviation activities from 1911 to 1951. The United States military began using the field prior to World War I. After World War I, the U. S. Air Service authorized aviation-related companies to operate from Roosevelt Field.

Roosevelt Field was used by the Army and Navy during World War II. As of March 1942, there were 6 steel/concrete hangars, 14 wooden hangars, and several other buildings at Roosevelt Field. In addition to the training activities, the Roosevelt Field facilities were used to receive, refuel, crate, and ship Army aircraft. Operation included aircraft repair and maintenance, equipment installation, preparation and flight delivery of "lend-lease" aircraft, and metal work. The facility also performed salvage work. The Navy vacated the field after the end of the war. Restoration of buildings and grounds was completed in 1946, and Roosevelt Field operated as a commercial airport until it closed in May 1951.

It is likely that chlorinated solvents were used at Roosevelt Field during and after World War II. Chlorinated solvents such as tetrachloroethene (PCE) and trichloroethene (TCE) have been widely used for aircraft manufacturing, maintenance, and repair operations since approximately the 1940s. The Village of Garden City installed Supply Wells GWP-10 (N-03934) and GWP-11 (N-03935) in 1952 and placed them into service in 1953. Both wells have shown the presence of PCE and TCE since they were first sampled in the late 1970s and early 1980s.

The Site was listed on the National Priorities List on May 11, 2000. EPA completed an RI/feasibility study in 2007. This RI is referred as OU1 RI.

1.3.2 OU1 Remedial Investigation and Record of Decision

The site-related volatile organic compound (VOC) contaminants were selected based on historical data. They are TCE, PCE, 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-1,2-DCE), and carbon tetrachloride. PCE and TCE are the two contaminants most frequently detected at elevated concentrations (in hundreds of micrograms per liter [µg/L]). The other contaminants were only detected occasionally.

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Eight multi-port monitoring wells were installed during the OU1 RI. Two rounds of VOC samples were collected from the 8 multi-port monitoring wells and the 10 existing wells. The highest levels of PCE and TCE (350 and 280 µg/L, respectively) were detected at SVP-4 (**Figure 1-2**), at approximately 250 to 310 feet deep.

The Garden City supply wells GWP-10 (N-03934) and GWP-11 (N-03935) each have a capacity to pump approximately 1 million gallons per day of groundwater from the Magothy aquifer. To reduce the contaminant concentrations reaching these supply wells without impacting the water quality and pumping operation at these two supply wells, the OU1 Record of Decision selected groundwater extraction, ex situ treatment, and discharge of treated water to a local Nassau County recharge basin as the key components of the remedy.

1.3.3 OU1 Remedial Design and Remedial Action

During the OU1 remedial design, a total of six multi-port wells (SVP-9 to SVP-14) and seven single-screen wells were installed to better define the extent of the contaminant plume and to support the evaluation of the capture zone of the OU1 groundwater extraction wells. Three groundwater extraction wells, EW-1S, EW-1I, and EW-1D, were installed in August 2010. The groundwater treatment plant was built in 2011, and startup testing was conducted in December 2011. Operation of the OU1 pump and treat system started at the beginning of 2012. Due to the detection of elevated contaminant concentrations (hundreds of µg/L) in multiport well SVP-11 (**Figure 1-2**), three additional groundwater extraction wells, SEW-1S, SEW-1I, and SEW-1D, were installed. The extracted groundwater was piped to the same groundwater treatment plant, and the treatment plant was upgraded to treat the combined flow. These extraction wells are referred to as southern groundwater extraction wells.

As part of the operation and maintenance (O&M) of the OU1 pump and treat system, groundwater samples were collected from 25 monitoring wells and 2 supply wells (N-03934 and N-03935) to monitor the migration of contaminants and provide data for evaluating the effectiveness of the pump and treat system. The 25 monitoring wells include 14 multi-port wells (SVP-1 through SVP-14 with a total of 117 ports) and 11 single-screen wells (MW-1S, MW-1I, MW-2S, MW-2I, MW-3S, MW-3I, MW-8D, MW-12S, N-10019, N-10020, and N-8068). MW-3 well cluster was installed to collect data for the capture zone analysis of OU1 groundwater extraction wells. However, elevated PCE and TCE concentrations were observed in the MW-3 monitoring well cluster. This contamination is not within the groundwater plume that originates in the OU1 western mall/office complex area. This was the impetus to create an additional operable unit east of OU1 to address the newly identified plume. On August 22, 2012, the Site was divided into OU1 and OU2, and the OU2 Eastern Plume RI was initiated.

The Town of Hempstead water supply well field, approximately one block south (downgradient) of multi-port monitoring wells SVP-6 and SVP-8, has been contaminated with VOCs since the 1980s. The source of this contamination is currently unknown because several potential sources are located in the vicinity of the Hempstead Well Field.

1.4 Summary of OU2 Remedial Investigations

The OU2 RI was conducted over 2 years, with the initial investigation conducted in 2014 and the supplemental investigation in 2016. Activities of these investigations are as follows:

- Existing well investigation, which evaluated existing Nassau County wells to be used in the OU2 RI
- Groundwater screening and natural gamma geophysical logging in six boreholes (SVP-15, 16, 17, 18, 19, and MW-3D) to determine the monitoring well screen intervals and collect site-specific geology data
- Installation of 12 monitoring wells in four well clusters (MW-15, 16, 17, and 18) and MW-3D
- Two rounds of monitoring well sampling and synoptic water level measurements (2014 and 2016)

1.5 Physical Characteristics of the Study Area

1.5.1 Topography, Geomorphology, Surface Water, and Drainage

The topography is locally characterized by a gently southward-sloping glacial outwash plain. The Roosevelt Field shopping center is located on a flat area originally called Hempstead Plains, which is at an elevation of approximately 90 feet above mean sea level (amsl). Almost the entire site area is paved or occupied by buildings and designated as Urban Land by the United States Department of Agriculture; therefore, the majority of surface water runoff is routed into storm water collection systems and commonly discharged directly to either dry wells or local recharge/detention basins.

1.5.2 Regional Geology and Hydrogeology

Long Island geology is characterized by a southeastward-thickening wedge of unconsolidated sediments that unconformably overlie a gently dipping basement bedrock surface. See **Figure 1-3** for a general geologic section of Long Island. This sedimentary wedge ranges in thickness from 0 feet beneath Long Island Sound to the north, on the submerged western margin of the Coastal Plain, to more than 2,000 feet under the southern shores of Long Island. In the vicinity of the Site, the sedimentary units are about 800 feet thick and thicken to approximately 1,500 feet beneath the barrier islands south of the Site (Krulikas 1987; Buxton et al. 1989).

The regional geologic deposits shown on **Figure 1-3** are listed from youngest to oldest and consist of the following units:

- Pleistocene Deposits – Include the fluvial Jameco Gravel, the marine Gardiners Clay, and the Upper Glacial deposits. The Upper Glacial (water table) aquifer consists of glacial outwash that is predominantly stratified sand and gravel.
- Magothy Formation – The Magothy Formation consists of fine to medium quartz sand, interbedded clayey sand with silt, clay, and gravel interbeds or lenses. The deposits are fluvio-deltaic in origin and have considerable vertical and lateral heterogeneity. Discontinuous layers of grey lignitic clay are common in the upper zones of the Magothy Formation, creating predominantly confined conditions in the deeper zones (Eckhardt and Pearsall 1989). The top of the Magothy Formation, also known as the Cretaceous-Tertiary unconformity, is marked by a highly irregular erosion surface upon which the Pleistocene

deposits rest. It is incised by a predominantly north-northeast and south-southwest trending paleovalley beneath the barrier islands south of the Site. This paleovalley may be evidence of deep erosional incision by a post-Cretaceous drainage channel (Krulikas 1987).

- Raritan Formation – Cretaceous Lloyd Sand Member (sand and gravel) and the overlying Raritan Clay Member (clay and silt)
- Basement Bedrock – Precambrian to Early Paleozoic igneous or metamorphic bedrock

The Pleistocene deposits and the Magothy Formation are the geologic units of interest for the Site. These two units are unconfined and form a single aquifer unit although with different hydrogeological properties. They are the most productive and heavily utilized groundwater resource on Long Island. Horizontal velocity in the Upper Glacial aquifer generally ranges from 1 to 2 feet per day (CDM Smith 2007).

1.5.3 Site-Specific Geology and Hydrogeology

Site-specific geology and hydrogeology are derived from lithologic and hydraulic data obtained during OU1 investigations and from gamma logs run in OU2 borings.

The upper glacial deposits are approximately 80 to 100 feet thick and fairly uniform in grain size distribution and lithology at the Site. OU1 RA geological data indicate the presence of a local aquitard that, where present, separates the overlying upper glacial deposits from the underlying Magothy Formation. Lithologic data show the aquitard thickness ranges from 10 to 33 feet but was typically 10 to 20 feet thick. This aquitard is potentially present in northern OU2 borings, SVP-15 and MW-3D, based on an elevated gamma response located at the approximate top of the Magothy Formation. However, a corresponding gamma signature was not observed in downgradient borings SVP-16, 17, and 18.

Locally, the top of the Magothy Formation was observed in the average depth range of 80 to 100 feet below ground surface (bgs) in the majority of the site area. In the upgradient portion of the Site, the Magothy is approximately 525 feet thick. Soil boring and gamma logs indicate it is characterized by vertically alternating layers of sand, clayey sand, sandy clay, lignite, and some gravel in the basal section. Gravel-rich zones were encountered at the boreholes located south of the mall (MW-16 and MW-17) in the first 100 feet and caused borehole collapse. An outer casing was installed to mitigate this issue. Below the first 100 feet, thin layers of gravel were also encountered, which caused sudden loss of drilling mud circulation. Site geology and hydrogeology are presented in **Figure 1-4**. The vertical groundwater contours presented on **Figure 1-4** are drawn from the water levels collected during the 2016 event.

<u>OU2 Gamma Logs</u>

Local lithology in the OU2 area is derived primarily from natural gamma logs run through the outer casing in the upper glacial deposits (the top 80 to 100 feet) and in the open boreholes below the casing to the terminal depth. The gamma log in borings SVP-15, 16, 17, 18, and 19 indicated glacial materials, including gravel, silt, and sand, extend from the surface to the top of the Magothy Formation at 80 feet bgs (SVP-17) to 104 feet bgs (SVP-19). The Magothy Formation at each location was primarily sand with clay rich zones. The most clay was observed at SVP-16, with zones from 10 to over 50 feet thick. SVP-15 had the least amount of clay, with zones no more than 5 feet thick. MW-3D had glacial gravel to 50 feet, clay zones began at 96 feet bgs and were 3 to 26 feet thick to 476 feet bgs.

Synoptic Water Level Measurements and Groundwater Flow

The water table ranges from approximately 17 feet bgs (SVP-6-5) to 35 feet bgs (MW-2S) in the area as measured during the December 2016 synoptic water level measurements. Previous synoptic water level measurements indicate that groundwater flow is generally to the south (CDM Smith 2007). Synoptic water level measurements were collected during each groundwater sampling event. The water level elevations from each event were used to create water level potentiometric surface maps for shallow, intermediate, and deep aquifer zones. (**Figures 1-5a** and **1-5b**).

As shown in these figures, groundwater flow is generally to the south/southwest in all three depth zones. The horizontal hydraulic gradients for the shallow, intermediate, and deep zones are 0.0016, 0.0019, and 0.0021 feet/foot, respectively, based on the 2016 synoptic water level round data. It should be noted that these potentiometric surface maps did not include the water levels in the public supply wells and the existing remediation pumping wells since these data are not readily available and their operations are dynamic. Groundwater extraction from the Garden City supply wells (N-03934 and N-03935), the Uniondale supply wells (N-08474 and N-08475), and the Hempstead supply wells (as indicated on the figure) could have great impacts on the direction of groundwater flow. The remediation pumping wells, including but not limited to the northern extraction wells (EW-1S, EW-1I, and EW-1D), the southern extraction wells (SEW-1S, SEW-1I, and SEW-1D), and the Purex extraction wells, could impact localized groundwater flow when they are in operation. For example, groundwater at well cluster MW-3 would be captured by Garden City wells or the OU1 southern extraction wells instead of migrating downgradient as shown in the model simulation (**Appendix A**). It should be noted that the groundwater model simulation was conducted under steady state conditions and the capture zones shown demonstrate the capture zones after 20 years of operation. This is considered a reasonable assumption for the municipal wells and the OU1 southern groundwater extraction wells.

1.6 Nature and Extent of Contamination

PCE and TCE are the primary site-related contaminants and the focus of discussions regarding the nature and extent of groundwater contamination.

1.6.1 Groundwater Screening Results

During the 2014 investigation, the highest concentrations of PCE and TCE were found in SVP-16, the farthest downgradient (southern-most) boring at the time (190 and 53 µg/L, respectively, at 340 feet bgs). In the most upgradient (northern) boring, SVP-15, PCE exceeded its screening criterion at 130, 160, and 310 feet bgs with concentrations less than 20 µg/L. During the 2016 investigation, the highest concentrations of PCE and TCE were found in SVP-18, the most downgradient boring (730 and 150 µg/L, respectively, at 400 feet bgs).

1.6.2 Monitoring Well Analytical Results

The core of the OU2 PCE and TCE plumes is located within the intermediate zone in the area between MW-16 well cluster and to the south/southwest of MW-18 well cluster. Concentrations in 2016 were slightly higher than in 2014. The highest PCE concentrations were 600 and 500 µg/L, respectively, in MW-16I1 and MW-18I, and the highest TCE concentration was 110 µg/L in both wells in 2016.

The data collected in 2014 and 2016 indicated that the OU2 PCE/TCE plumes (exceeding the MCLs of 5 µg/L), were over 6,500 feet long, beginning upgradient of the MW-15 cluster, continuing south/southwest through the MW-3 and MW-16 clusters, and extending beyond MW-18 cluster to just north of SVP-6 (**Figures 1-6a** through **c** and **1-7a** through **c)**. The contaminant plume migrated downward as they moved south as shown in **Figures 1-8a** and **1-8b**.

Results of the RI indicate a vertical thinning of the plume from the intermediate zone to the deep zone (**Figures 1-8a** and **1-8b**) and a widening of the OU2 plume as it is pulled to the southwest by the Hempstead supply wells and to the east by the Uniondale supply wells. The OU1 and OU2 plumes appear to be commingling as they converge toward the Hempstead Well Field.

1.7 Conceptual Site Model

The physical setting with respect to the CSM is summarized below.

- Underlying 80 to 100 feet of glacial deposits is the Magothy Formation, which is a sandy unit over 500 feet thick with discontinuous layers of gravel, lignite, and clay.
- Groundwater generally flows toward the south/southwest with a horizontal gradient of approximately 0.0019 feet/foot and a downward gradient throughout.
- Groundwater flow is strongly influenced by pumping at the Garden City wells and the OU1 southern extraction wells located to the west of the northern portion of the OU2 plume; and by Town of Hempstead and Uniondale public supply wells located east and west of the southern portion of the OU2 plume. Historically, groundwater flow might also be influenced by pumping of remediation wells at the Purex site.

Contaminant sources are summarized below.

- Sources of contamination in the OU2 plume include the former hangars and airfield where solvents, such as TCE and PCE, were used for cleaning, degreasing, and de-icing. Even though ground disposal of solvents most likely occurred close to hangars where aircraft maintenance was performed, numerous discharges of solvents in the airfield most likely occurred while the airfield was active.
- Based on source area investigation conducted during the OU1 RI and the contaminant distribution found during OU2 RI, these areas where the solvents were originally discharged to the ground are no longer containing source materials. Chlorinated solvent contaminants have migrated down and were mainly detected in the Magothy aquifer in a dissolved form at relatively low concentrations (in hundreds of µg/L).

The fate and transport of PCE and TCE at the Site are summarized below.

- The contaminant plume identified under OU2 evolved over a long period of time (might be 90 to 100 years). Its development was impacted by many human activities in this area, such as the construction of pavement and buildings that decreased infiltration; the installation and operation of cooling water wells historically that might have enhanced vertical migration of contaminants; the installation and operation of supply wells and the increased pumping at the supply wells due to increases of population and drinking water demand, which could have changed groundwater flow direction. Even though the contaminant plume outlined in **Figures 1-7** to **1-9** indicated where contaminants were detected in 2014 and 2016, it should not be assumed that contaminants in the northern portion of the plume would migrate to the south as a standard contaminant plume would under natural conditions. In fact, the direction of contaminant migration as of now and in the future would depend on the pumping operation at the supply wells and the OU1 southern extraction wells (**Appendix A**).

- Groundwater at the northern portion of the OU2 plume could be pulled toward the Garden City supply wells and the OU1 southern extraction wells. Groundwater flow at the southern portion of the OU2 plume (in the vicinity of MW-16 well cluster and downgradient) is being pulled southwest toward the Hempstead Well Field, where there is potential commingling with the OU1 plume, and east toward the Uniondale supply wells.
- Dissolved contaminants migrate primarily via advection, with minimal retardation through the Magothy Formation.
- The detection of cis-1,2-DCE and vinyl chloride indicate the presence of anaerobic biodegradation of PCE and TCE in groundwater. However, the extent and level of biodegradation appeared to be limited since concentrations of cis-1,2-DCE and vinyl chloride were low and the level of organic carbon in soil was low and could not sustain the reductive dechlorination degradation pathway.
- The leading edge of the plume has been delineated just upgradient (north) of SVP-6 based on sample results collected in December 2016.
- Based on the estimated contaminant transport velocities and the distance of approximately 1,400 feet between the 100 µg/L OU2 plume and the Hempstead Well Field, the OU2 plume will take approximately 4.7 to 24.6 years to reach the Hempstead Well Field (CDM Smith 2017).

1.8 Human Health Risk Assessment

The HHRA is developed to characterize potential human health risks associated with the Site in the absence of any remedial action. The HHRA is conducted in accordance with current EPA guidance outlined in Risk Assessment Guidance for Superfund, Parts A, D, and E and other EPA guidance pertinent to human health risk assessments.

1.8.1 Exposure Assessment

Chemicals of potential concern (COPCs) are identified based on criteria outlined in EPA risk assessment guidance, primarily through comparison of maximum detected concentrations to risk-based screening levels. Eleven VOCs and five inorganics are identified as COPCs in groundwater. Exposure point concentrations (EPCs) for the COPCs are used in the exposure assessment calculations to estimate potential chemical intake. The EPC is the lower of the upper confidence limit on the mean or the maximum detected concentration.

Potential exposure pathways at the Site are defined based on potential source areas, release mechanisms, and current and potential future uses of the Site. Since pumped water from the Village of Garden City wells is treated before reaching potential receptors, only potential future residents and site workers are evaluated in the risk assessment. Exposure pathways evaluated for groundwater include ingestion of, and dermal contact with, groundwater and inhalation of vapor released during showering and bathing and inhalation of vapor through vapor intrusion.

Quantification of exposure includes evaluation of exposure parameters that describe the exposed population (e.g., contact rate, exposure frequency and duration, and body weight). Each exposure parameter in the equation has a range of values. Daily intakes are calculated based on the reasonable maximum exposure (RME) scenario (an upper bound exposure reasonably expected to occur). The intent is to estimate a conservative exposure case that is still within the range of possible exposures. Central tendency exposure (CTE) assumptions are also developed when the estimated risks under the RME scenario exceed EPA's threshold risk range. CTE scenarios reflect more typical exposures.

1.8.2 Toxicity Assessment

COPCs are quantitatively evaluated on the basis of their noncancer and/or cancer potential. The reference dose and reference concentration are the toxicity values used to evaluate noncancer health hazards in humans. Inhalation unit risk and slope factor are the toxicity values used to evaluate cancer health effects in humans. These toxicity values are obtained from various sources following the hierarchy order specified by EPA.

1.8.3 Risk Characterization

Risk characterization integrates the exposure and toxicity assessments into quantitative expressions of risks and health effects. To characterize potential noncancer health effects, comparisons are made between estimated intakes of substances and toxicity thresholds. Potential cancer effects are evaluated by calculating probabilities that an individual will develop cancer over a lifetime exposure based on projected intakes and chemical-specific dose-response information. In general, EPA recommends an acceptable cancer risk range of 1×10^{-6} (1 in 1 million) to 1×10^{-4} (1 in 10,000) and noncancer health hazard index (HI) of unity (1) as threshold values for potential human health impacts. These values aid in determining whether additional remedial action is necessary at the Site.

Potential risks and hazards were identified for future residents and site workers in the unlikely event that a private well is installed on the Site. Cancer risks for future residents exceed EPA's acceptable cancer risk range mainly due to vinyl chloride and TCE in groundwater (**Table 1-1**). The estimated cancer risks may be overestimated because vinyl chloride was only detected in 1 out of 13 data points. The estimated cancer risk for site workers under the RME scenario is above EPA's acceptable cancer risk range but within EPA's acceptable cancer risk range under the CTE scenario. For noncancer hazards, the total HIs for future residents are above EPA's threshold of unity at the Site under both the RME and CTE scenarios and driven primarily by potential exposure to TCE and PCE in groundwater (**Table 1-1**).

Lead was evaluated separately and does not appear to be a concern for all receptors because the maximum detected concentration was below the screening level. Results of the vapor intrusion evaluation indicated that future site workers and residents potentially might be exposed to elevated concentrations of several volatile COPCs, including TCE and PCE, via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion.

It should be noted that vapor intrusion was a human health concern and was investigated during OU1 RI. No occurrence of vapor intrusion was found. Evaluating vapor intrusion for the OU2 plume is conservative because it assumes that the contaminant plume is right below the buildings, while in fact, based on the OU2 RI data, there is a zone of uncontaminated groundwater above the OU2 plume.

Section 2

Development of Remedial Action Objectives and Technology Screening

RAOs are media-specific goals for protecting human health and the environment. Remedial alternatives are developed to meet the RAOs. The process of identifying the RAOs follows the identification of affected media and contaminant characteristics; evaluation of exposure pathways, contaminant migration pathways, and exposure limits; and the evaluation of contaminant concentrations that will result in unacceptable exposure. The RAOs are based on regulatory requirements, which may apply to the various remedial activities being considered for the Site. This section of the RI/FFS reviews the affected media and contaminant exposure pathways and identifies federal, state, and local regulations that may affect remedial actions.

Preliminary remediation goals (PRGs) were selected based on federal or state promulgated ARARs and risk-based levels, with consideration also given to other guidelines. These PRGs were then used as a benchmark in the technology screening, alternative development and screening, and detailed evaluation of alternatives presented in the subsequent sections of the FFS report.

2.1 Identification of Remedial Action Objectives

The process of identifying site-specific RAOs follows the identification of site-related contaminants, identification of potentially applicable or relevant and appropriate federal and state regulations and other guidance, and finally, selection of the PRGs based on the ARARs and guidance values. Generally, where a chemical-specific ARAR exists, it provides the basis for the corresponding PRG. If more than one chemical-specific ARAR exists, the most stringent applicable requirements are generally applied first. The selected PRGs provide the basis for the evaluation of remedial technologies. A detailed discussion of the PRG development is included in Section 2.3.

2.1.1 Contaminants and Media of Concern

In this FFS, contaminated groundwater is the contaminated medium to be addressed. Five site-related groundwater contaminants were identified in the OU1 RI. They are PCE, TCE, 1,1-DCE, carbon tetrachloride, and cis-1,2-DCE. Carbon tetrachloride was only detected at trace concentrations lower than the New York State Department of Environmental Conservation groundwater quality standards and maximum contaminant level (MCL). 1,1-DCE was detected at low concentrations. The human health risk assessment indicated that PCE, TCE, and vinyl chloride are the risk drivers if there is an exposure pathway. Therefore, in the FFS, the contaminants of interest are PCE, TCE, and their degradation products: cis-1,2-DCE and vinyl chloride.

It should be noted that the OU2 groundwater contamination is at depth. There is a clean zone of groundwater above the contaminant plume. Therefore, vapor intrusion is unlikely to occur and is not a concern for OU2, the eastern plume.

2.1.2 Principal Threat Waste

The concept of principal threat waste and low level threat waste, as developed by EPA in the National Contingency Plan (NCP), is to be applied on a site-specific basis when characterizing source material. The NCP establishes an expectation that EPA will use treatment to address the principal threat wastes posed by a site wherever practicable (NCP 300.430(a)(1)(iii)(A)). Principal threat waste is source material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air or acts as a source for direct exposure. The principal threat waste would present a significant risk to human health and the environment should exposure occur.

For this site, the contamination consists of a dissolved groundwater plume, which is considered non-source material. Therefore, principal threat waste consideration is not applicable.

2.1.3 Remedial Action Objectives

Based on the site-specific HHRA results, risks associated with direct contact with site-related contaminants are above EPA's acceptable levels. RAOs for groundwater are identified as follows:

- Prevent or minimize potential, current, and future human exposures, including inhalation, ingestion, and dermal contact with VOC-contaminated groundwater that exceeds the MCLs
- Minimize the potential for offsite migration of groundwater with VOC contaminant concentrations greater than MCLs
- Restore groundwater to beneficial use levels within a reasonable time frame, as specified in the NCP

2.2 Potential ARARs, Guidelines, and Other Criteria

As required under Section 121 of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), remedial actions carried out under Section 104 or secured under Section 106 must be protective of human health and the environment and attain the levels or standards of control for hazardous substances, pollutants, or contaminants specified by the ARARs of federal environmental laws and state environmental and facility siting laws unless waivers are obtained. According to EPA guidance, remedial actions also must take into account non-promulgated "to be considered" criteria or guidelines if the ARARs do not address a particular situation.

The degree to which these environmental and facility siting requirements must be met varies, depending on the applicability of the requirements. Applicable requirements must be met to the full extent required by law. CERCLA provides that permits are not required when a response action is taken on site. The NCP defines the term onsite as the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for the implementation of the response action (40 Code of Federal Regulations [CFR] 300.5). Although permits are not required, the substantive requirements of the applicable permits must be met. On the other hand, only the relevant and appropriate portions of non-applicable requirements must be achieved and only to the degree that they are substantive rather than administrative in nature.

2.2.1 Definition of ARARs

A requirement under CERCLA, as amended, may be either "applicable" or "relevant and appropriate" to a site-specific remedial action, but not both. The distinction is critical to understanding the constraints imposed on remedial alternatives by environmental regulations other than CERCLA.

Applicable Requirements
Applicable requirements pertain to those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable. Applicable requirements are defined in the NCP at 40 CFR 300.5 Definitions.

Relevant and Appropriate Requirements
Relevant and appropriate requirements pertain to those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site per se, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate. Relevant and appropriate requirements are defined in the NCP at 40 CFR 300.5 Definitions.

Other Requirements To Be Considered
These requirements pertain to federal and state criteria, advisories, guidelines, or proposed standards that are not generally enforceable but are advisory and that do not have the status of potential ARARs. Guidance documents or advisories "to be considered" (TBC) in determining the necessary level of remediation for protection of human health or the environment may be used where no specific ARARs exist for a chemical or situation or where such ARARs are not sufficient to be protective.

Waivers
CERCLA specifies situations under which ARARs may be waived (40 CFR 300.430: Remedial Investigation/Feasibility Study Selection of Remedy). The situations eligible for waivers include:

- The alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement
- Compliance with the requirement will result in greater risk to human health and the environment than other alternatives
- Compliance with the requirement is technically impracticable from an engineering perspective

- The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach
- With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state.
- For Fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund monies to respond to other sites that may present a threat to human health and the environment. Where remedial actions are selected that do not attain ARARs, the lead agency must publish an explanation in terms of these waivers. It should be noted that the "fund balancing waiver" only applies to Superfund-financed remedial actions.

ARARs apply to actions or conditions located on site and off site. Onsite actions implemented under CERCLA are exempt from administrative requirements of federal and state regulations (such as permits) as long as the substantive requirements of the ARARs are met. Offsite actions are subject to the full requirements of the applicable standards or regulations (including all administrative and procedural requirements).

Based on the CERCLA statutory requirements, the remedial actions developed in this FFS will be analyzed for compliance with federal and state environmental regulations. This process involves the initial identification of potential requirements, the evaluation of the potential requirements for applicability or relevance and appropriateness, and, finally, a determination of the ability of the remedial alternatives to achieve the ARARs.

2.2.2 Identification of ARARs

Three classifications of requirements are defined by EPA in the ARAR determination process: chemical-, location-, and action-specific ARARs. Additionally, TBC criteria are also evaluated.

Each of these groups of ARARs and TBCs are summarized in **Tables 2-1**, **2-2**, and **2-3**.

2.3 Preliminary Remediation Goals

Both federal and state chemical-specific ARARs were identified for groundwater. New York State groundwater quality standards are considered applicable for the remediation of groundwater contamination at the Site. Federal and state primary drinking water regulations are considered relevant and appropriate for consideration in the remediation of the groundwater since all groundwater in New York State is classified as class GA, groundwater suitable as a source of drinking water, and the site groundwater is currently used as a source of potable water.

The groundwater PRGs for the site contaminants of concern, PCE, TCE, cis-1,2 DCE, vinyl chloride, and 1,1-DCE, are provided in **Table 2-4**.

2.3.1 Groundwater Contaminant Plume to be Remediated

The OU2 contaminant plume evolved over time due to many factors as discussed in Section 1. Due to the complexity of the groundwater flow system at the OU2 study area and to minimize impact to the operation of supply wells, groundwater remediation would target the 100 μg/L PCE or TCE plume. Groundwater model simulation (**Appendix A**) demonstrated that contaminants in the northern portion of the OU2 plume (in the areas of MW-15 well cluster and MW-3 well cluster) would migrate toward the OU1 southern extraction wells and/or the Garden City supply wells over time. Groundwater contamination in the vicinity of MW-17, MW-16, and MW-18 well clusters would migrate toward Hempstead Well Field. Accordingly, groundwater remediation under OU2 would target the area between MW-17 well cluster and SVP-6.

2.4 General Response Actions

General response actions are broad categories of actions that might satisfy the RAOs and that characterize the range of remedial responses appropriate to the media of concern at the Site. Following the development of GRAs, one or more remedial technologies and process options were identified for each general response action category. Although an individual response action might satisfy the RAOs alone, combinations of response actions are usually required to address site contamination adequately. GRAs applicable to groundwater remediation at this site are described below.

2.4.1 No Action

NCP and CERCLA require the evaluation of a No Action alternative as a basis for comparison with other remedial alternatives. Under the No Action alternative, no remedial actions are implemented, the site conditions remain unchanged, and no action would be taken to reduce the potential for exposure to contamination.

2.4.2 Institutional/Engineering Controls

Institutional/Engineering controls typically are restrictions placed to minimize access (i.e., fencing) or future use of the site (i.e., deed restriction, groundwater use restriction). These measures are implemented to provide some protection of human health and the environment from exposure to site contaminants. Long-term monitoring, which includes sampling and sample analysis, is usually used with institutional/engineering controls. Long-term monitoring provides information on contaminant migration and concentration changes. Institutional/Engineering controls are generally used in conjunction with other remedial technologies. Alone, they are not effective in preventing contaminant migration or reducing contamination.

2.4.3 Monitored Natural Attenuation

Monitored natural attenuation (MNA) refers to the remedial action that relies on naturally occurring attenuation processes to achieve site-specific remediation goals within a reasonable time frame. Natural attenuation processes that reduce contaminant concentrations in groundwater include destructive (biodegradation and chemical reactions with other subsurface constituents) and nondestructive mechanisms (dilution, dispersion, volatilization, and adsorption). Biodegradation is generally the most significant destructive attenuation mechanism. Extensive modeling and monitoring are typically performed as part of the MNA response action to demonstrate that contaminants are within the controlled boundary and that degradation is occurring. Review of site data suggests that anaerobic biodegradation, generally the most significant degradation mechanism for PCE and TCE, is not occurring to a significant extent to be effective at this Site.

2.4.4 Containment

Containment actions use physical or low permeability barriers to minimize or eliminate contaminant migration. Containment technologies do not involve treatment to reduce the toxicity or volume of contaminants. The response actions require long-term monitoring to determine whether containment actions are performing successfully. The NCP does not prefer containment response actions since they do not provide permanent remedies. The contamination at the Site extends to more than 450 feet bgs. Containment technologies would not be implementable at this site due to the significant depth of contamination.

2.4.5 Groundwater Extraction

Groundwater extraction can provide hydraulic control to prevent migration of dissolved contaminants. Groundwater extraction is usually used in conjunction with other technologies, such as treatment or discharge options, to achieve the RAOs for the removed media. The extraction response action does not reduce the concentrations of contaminants in groundwater. It merely transfers the contaminants to be managed under another response action.

2.4.6 Treatment

Treatment involves the destruction of contaminants in the affected media, transfer of contaminants from one media to another, or alteration of the contaminants, thereby making them innocuous. The result is a reduction in T/M/V of the contaminants in the treated media. Treatment technologies vary among environmental media and can consist of chemical, physical, thermal, and biological processes. Treatment can occur in place or above ground. This GRA is usually preferred unless Site- or contaminant-specific characteristics make it infeasible from an engineering or implementation perspective or too costly.

2.4.7 Discharge

Discharge response actions for groundwater involve the discharge of extracted and treated groundwater via onsite injection, onsite surface recharge, or surface water discharge. Discharged water must meet regulatory discharge requirements.

2.5 Identification and Screening of Remedial Technologies and Process Options

For each GRA there are various remediation methods, or technologies, used to carry out the response action. The term technology refers to general categories of technology types. Each technology may have several process options, which refer to the specific material, equipment, or method used to implement a technology. For example, the technology category of physical treatment for groundwater may include process options such as air stripping and carbon adsorption. These technologies describe broad categories used in remedial action alternatives but do not address details, such as performance data, associated with specific process options.

The technology screening approach is based upon the procedures outlined in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988). This evaluation process uses three criteria: effectiveness, implementability, and relative cost. Among these three, the effectiveness criterion outweighs the implementability and relative cost criteria. These criteria are described below:

- Effectiveness – This evaluation criterion focuses on: (1) the effectiveness in extracting, treating, and/or handling by other means (e.g., in situ treatment or natural attenuation) the estimated volume of contaminated groundwater and the ability to meet the remediation goals; (2) the potential impacts to human health and the environment during the construction and implementation phases; and (3) how proven and reliable the process options are expected to be with respect to the contaminants and conditions at the site.

- Implementability – This evaluation criterion includes: (1) the technical and administrative feasibility of implementing the remedial system components and (2) the amount of space needed for treatment and disposal facilities, piping and discharge runs, the availability of space, accessibility, and available vendors.

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

All remedial technologies (both screened out and retained) are described in **Table 2-5**. Remedial technologies and process options that were retained will be used for the development of alternatives. Only remedial technologies or process options that could achieve the RAOs, either alone or in combination with other technologies and process options, were retained.

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Section 3

Development and Screening of Remedial Action Alternatives

The objective of this section is to describe remedial action alternatives for the eastern contaminant plume. To address the site-specific RAOs, alternatives were created by combining the technologies and process options retained in Section 2.

3.1 Development of Remedial Alternatives

Several technologies and process options were retained for contaminated materials based on the screening in Section 2. The retained technologies and process options were combined to develop remedial action alternatives.

The retained technologies and process options are summarized below.

- No action
- Institutional controls (such as well drilling restriction and long-term monitoring)
- Groundwater extraction
- Ex situ treatment
- Groundwater circulation well (GCW)/in-well stripping
- In situ adsorption
- Onsite surface recharge
- Onsite injection

To develop remedial alternatives for the Site, representative process options were selected from the same groups of remedial technologies, as appropriate. However, other process options may still be applicable and should be considered during the remedial design stage of the project. The retained technologies were combined into four alternatives as listed below.

- Alternative 1 – No Action
- Alternative 2 – Groundwater Extraction and Ex Situ Treatment (Pump and Treat)
- Alternative 3 – In-well Stripping
- Alternative 4 – In Situ Adsorption

3.1.1 Common Elements

The common elements included as part of Alternatives 2 through 4 are described here. Note that the description for each remedial alternative is a conceptual approach. Many assumptions are made so that an order of magnitude cost estimate could be provided. The final approach for the selected remedial action would be determined during the remedial design as additional data and more site-specific information becomes available.

Remedial Design

The remedial design would be developed incorporating data collected during the RI, a pre-design investigation (if conducted), a pilot study (if conducted), site access, and inputs from other stakeholders (including local authorities). The remedial design would provide the rationale and detailed approaches for the remedy described in a design analysis report, bidding documents (specifications and contract plans), and cost estimates for the remedial action.

Institutional Controls

Drilling of private wells for potable use will be restricted by the New York Department of Conservation and the local municipality to eliminate the human exposure pathways to the contaminated groundwater.

Long-term Groundwater Monitoring

Long-term groundwater monitoring would be implemented to monitor and track any changes in groundwater contamination and to evaluate the progress of the remediation. The long-term monitoring would involve periodic updates of the site-specific groundwater model to support the evaluation of the effectiveness of the remediation.

Five-Year Site Reviews

Five-year reviews would be conducted for the selected remedy as required by CERCLA. The reviews would assess any ongoing risks to human health and the environment and the effectiveness of remediation and institutional controls. The data collected during the long-term monitoring program would be used in the reviews. Based on each review, a decision would be made for future management of the Site. For a feasibility study, site review would be included in each remedial alternative for a common element.

3.1.2 Alternative 1 – No Action

No remedial action would be implemented under this alternative. The No Action alternative was retained in accordance with the NCP to serve as a baseline for comparison with the other alternatives.

3.1.3 Alternative 2 – Pump and Treat

A pre-design investigation would be conducted to better define the boundary of 100 µg/L PCE/TCE plume. The pre-design investigation would consist of the installation of two monitoring well clusters shown in **Figure 3-1** and one round of groundwater sampling to update the OU2 contaminant distribution. At each proposed location, groundwater screening would be conducted first to facilitate the selection of monitoring well screens. The updated results would be used to update the groundwater model and support the final location of a groundwater extraction well during the remedial design.

Under this alternative, a groundwater extraction well would be installed in the median of Garden Street to intercept the contaminant plume. A test boring would be installed prior to the installation of the well to collect lithology and adjustment to the well construction might be made accordingly. Based on the groundwater modeling results (**Appendix A**), a groundwater extraction rate of 300 gallons per minute would be necessary to capture the 100 μg/L PCE/ TCE plume between MW-16 well cluster and MW-18 well cluster without significantly impacting the operation of the Hempstead municipal wells. The capture zone of the proposed OU2 extraction well and those of existing pumping wells in the area are shown in **Appendix A**. Groundwater simulations have also shown that the portion of the 100 μg/L PCE/TCE plume north of MW-16 well cluster would be captured by the OU1 southern remediation wells or the Garden City municipal wells. Even though the model simulations in **Appendix A** were conducted under steady state, it demonstrated that the migration of the northern portion of the OU2 plume depends on the pumping conditions of OU1 southern remediation wells and the Garden City supply wells. Contaminants in the northern portion of the OU2 plume would likely not migrate toward south/southwest within the contaminant contours shown in **Figures 1-6** and **1-8** due to influence from the surrounding pumping wells. Contamination outside the capture zone of the proposed OU2 extraction well would be allowed to naturally attenuate through dilution and dispersion and be captured by existing pumping wells at low concentrations.

For this FFS, the extracted groundwater is assumed to be piped to a treatment plant at the Garden City recreation area near Grove Street as shown in **Figure 3-1**. Currently, there are utilities (electrical, water, and gas) within the median of Garden Street. The groundwater extraction line could be routed in the median or on the street, if necessary.

A treatment plant would be built in or near the recreation area on Grove Street. The treatment system would include an equalization tank, transfer pumps, bag filters, a low-profile air stripper, and two vapor phase granular activated carbon (VPGAC) units. The treated groundwater would be discharged to the nearby Nassau County recharge basin as shown in **Figure 3-1**.

It should be noted that access to Garden Street for the construction of the groundwater extraction well and pipeline is critical for the implementation of this remedy. The location for the treatment plant would be subject to change if access to the recreation area at Grove Street for the treatment plant and/or the use of Nassau County recharge basin are not granted. One alternative location for a groundwater treatment plant would be the open area south of Commercial Avenue. If the treatment plant is constructed at this location, the treated water likely would be re-injected into the subsurface through injection wells.

Under this alternative, a long-term monitoring program would be implemented to monitor the progress of this remedy and the migration and changes of the OU2 plume. The monitoring wells sampled during the 2016 OU2 RI sampling event and the two new monitoring wells would be used for the long-term monitoring program. The groundwater model would be updated periodically and used to analyze the effectiveness of plume capture and to predict the time frame required for the operation of the OU2 extraction well to remediate the 100 μg/L PCE/TCE plume.

3.1.4 Alternative 3 – In-Well Stripping

Under this alternative, a line of groundwater circulation well/in-well stripping system would be installed in the median of Garden Street to intercept the 100 µg/L PCE/TCE plume. The GCW technology is usually designed to create a 3-dimensional vertical circulation pattern in an aquifer by drawing contaminated groundwater from the aquifer through one screened section (usually the bottom screen) of a two-screened well, treating the water within the well, and then discharging it into the aquifer through another screened section (usually the top screen) without bringing the contaminated groundwater above ground. When the vertical circulation pattern is generated, the treated groundwater may be circulated several times in the aquifer before it flows downgradient, which would greatly enhance contaminant removal from low permeability zones compared to a pump and treat technology. However, for this Site, groundwater model simulation indicated that the 3-dimensional vertical circulation pattern would be limited (approximately 10 percent of injected water would return to the extraction screen) due to the large hydraulic influence from the Hempstead supply wells and the relative low vertical permeability. Therefore, for this Site, the GCWs would need to capture the 100 µg/L PCE/TCE plume and effectively remove PCE/TCE from groundwater via in well stripping prior to discharging the treated water back to the aquifer.

A pilot study would be conducted to: (1) evaluate the radius of influence or the extent of groundwater capture zone of a GCW; (2) determine the effectiveness of in-well stripping; and (3) obtain site-specific design parameters. Due to the significant depth of this application (450 feet bgs), implementing GCW/in-well stripping technology would be challenging. Conducting a pilot study is critical to obtain site-specific data for the full-scale design. Design parameters to be collected include but are not limited to the required air injection pressure and flow rate, the amount of water level increase required for recharge of treated water back to the aquifer, any mechanical issues due to the significant depth and the long length of well screen and casing, and the level of noises that need to be addressed during operation. For this FFS, it is assumed that the pilot study GCW/in-well stripping system would be installed at a target distance (150 feet) to the west of MW-18 well cluster in the median of Garden Street. MW-18 would be used to monitor and estimate the radius of influence by the GCW.

The configuration of a pilot GCW/In-well stripping system is illustrated in **Figure 3-2.** The well construction would consist of an 8-inch outer casing with a 60-foot screen section at the bottom (based on the estimated thickness of the plume) for water intake and a discharge screen (80 feet long) approximately 40 feet above the plume. The airlift/air stripping mechanism would consist of a 6-inch inner casing and a 1-inch pneumatic air pipe centered within the inner casing. The airlift mechanism would be positioned to a depth matching the lower screened interval. The 6-inch inner casing would have the same bottom screen interval as the outer casing and a shallow screen at a depth across the water table to allow the separation of vapor and treated water and the return of treated water to the aquifer via the annular space between the inner casing and the outer casing. Packer bladders would be installed between the outer and inner casings at a depth below the upper screen of the outer casing to separate the intake and discharge screens. The wellhead would be air tight with connections for compressed air injection and vapor extraction. During the pilot study, compressed air at different flow rate would be injected, and the radius of influence would be monitored at MW-18 well cluster by checking and recording the water levels. Water levels in the outer casing above the packer would be monitored and recorded; samples could be taken from the treated groundwater and extracted vapor for VOC analysis. After the pilot study and with successful results, this well could be used for the full-scale implementation.

For cost estimating purpose, a conceptual approach for the full-scale implementation is described herein. The actual approach would be developed during the remedial design based on a successful pilot study. As shown in **Figure 3-3**, three GCW/in-well stripping systems (including the one in the middle for pilot study) would be installed in the median of Garden Street between Tremont Street and Grove Street, with a well spacing of approximately 400 feet. The GCW/in-well stripping system would be constructed similar to the configuration shown in **Figure 3-2**, with any adjustment recommended by the pilot study results. The wellhead of each of GCW/in-well stripping system would be air tight, connected to an air injection line, a vapor extraction line, and isolation valves. Pressure in the packers would be maintained constantly with air lines connected to the air compressor. Pressure and vacuum gauges, sample ports, and flow meters would be installed for system performance monitoring. The compressed air and vapor extraction vacuum will be supplied remotely from an equipment building situated on Grove Street, southeast of Garden Street, in a grassed area adjacent to a Nassau County recharge basin. This building would house the compress air system consisting of rotary screw compressors that could supply compressed air at approximately 200 pounds per square inch gauge. The vapor extraction vacuum blower, condensate collection tank, and VPGAC units would be placed in the equipment building. The piping for compressed air and vapor extraction would be installed underground. The piping might be routed within the grass center median or the pavement of Garden Street since the median contains multiple mature trees, bushes, and existing utilities, including electrical, water, and gas piping.

It should be noted that access to Garden Street for the construction of GCW/in-well stripping systems, the installation of piping, and the construction of an equipment building at the grassy area (a Garden City recreation area) on Grove street need to be secured by EPA for the implementation of this remedy.

Under this alternative, a long-term monitoring program would be implemented to monitor the progress of this remedy and the migration and changes of the OU2 plume. Two new monitoring wells would be installed as shown in **Figure 3-3**. The monitoring wells sampled during the 2016 RI sampling event and these two new monitoring wells would be used for the long-term monitoring program. The groundwater model would be updated periodically and used to predict the time frame required for the operation of the OU2 extraction well to remediate the 100 µg/L PCE/TCE plume.

3.1.5 Alternative 4 – In Situ Adsorption

A pre-design investigation would be conducted to better define the boundary of 100 µg/L PCE/TCE plume. The pre-design investigation would consist of the installation of three monitoring well clusters shown in **Figure 3-4** and one round of groundwater sampling to update the OU2 contaminant distribution. At each proposed monitoring well cluster location, groundwater screening would be conducted first to facilitate the selection of monitoring well screen intervals. The updated results would be used to update the groundwater model and support the final configurations of the in situ adsorption remedy. A pilot study would be performed to collect site-specific implementation parameters.

Under this alternative, micron-size activated carbon would be injected through a series of injection wells along two stretches of streets to treat the contaminant plume, one within the open space south of Commercial Avenue and the other within the median or pavement of Garden Street as shown in **Figure 3-4**. The injected activated carbon would form two permeable treatment barriers. As PCE- and TCE-contaminated groundwater flow through the treatment barrier, they would be adsorbed onto the activated carbon, which would minimize the migration of the contaminant plume. Other reagents, such as iron-based chemical reductant or slow release organic carbon, could be injected with the micron-size activated carbon. This would promote in-situ chemical or biological reaction within the treatment zone to regenerate the activated carbon. Metallic iron may also be incorporated into the activated carbon to promote contaminant degradation via abiotic pathway and regenerate the adsorption capacity of activated carbon. Since the adsorption is the main mechanism for contaminant removal from groundwater, the in-situ chemical reduction or biological reactions could be limited and would not negatively impact the groundwater quality downgradient. Existing monitoring wells and the injection wells would be sampled periodically to assess the treatment progress and determine if the treatment barriers remain effective.

Commercially available products for in situ adsorption are limited. For cost estimating purposes, it is assumed that the activated carbon would be distributed through closely spaced injection wells (spaced 35 feet apart) to target the 100 µg/L PCE/TCE plume. The injected quantity of activated carbon would provide sufficient capacity to retain (i.e., adsorb) PCE and TCE for 10 to 15 years, assuming no regeneration of the carbon capacity due to chemical or biological reactions. The adsorption capacity could be higher when chemical or biological reactions are included in the capacity calculation. Based on the groundwater modeling results, it would take 10 to 15 years for contaminated groundwater to migrate from the treatment barrier near Commercial Avenue to the barrier along Garden Street. During this period, contaminants upgradient of Commercial Avenue would either be treated by this barrier or captured by nearby pumping wells such as GWP-10 (N-03934) and GWP-11 (N-03935) (**Appendix A**). After 10 to 15 years of treatment, contaminant concentrations migrating to these two barriers might be lower than 100 µg/L. However, to ensure the barriers would be actively treating the contaminants until their concentrations are reduced to below 100 µg/L, a second round of injection is assumed to occur 12 years after the first injection for cost estimating purpose. The second injection could be a combination of micron-size activated carbon and carbon-rejuvenating agents.

The use of micron-size or colloidal activated carbon is an innovative technology that has only been tested in the field for a few years. The distribution of activated carbon in the subsurface and the long-term adsorption capacity of the activated carbon need to be verified in the field through groundwater sampling and monitoring.

It should be noted that access to the green space south of Commercial Avenue and to Garden Street for the injection well construction and activated carbon injection would need to be secured by EPA.

Under this alternative, a long-term monitoring program would be implemented to monitor the progress of this remedy and the migration and changes of the OU2 plume. The monitoring wells sampled during the 2016 RI sampling event, three new monitoring wells and selected injection wells would be used for the long-term monitoring program. The groundwater model would be updated periodically and used to predict the time frame required for remediating the 100 μg/L PCE/TCE plume.

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Section 4

Detailed Analysis of Remedial Action Alternatives

The remedial alternatives described in Section 3 are evaluated in this section against the criteria described below.

4.1 Evaluation Criteria

EPA's nine evaluation criteria address statutory requirements and considerations for remedial actions in accordance with the NCP and additional technical and policy considerations proven to be important for selecting among remedial alternatives (EPA 1988). The following subsections describe the nine evaluation criteria used in the detailed analysis of remedial alternatives.

4.1.1 Overall Protection of Human Health and the Environment

Each alternative is assessed to determine whether it can provide adequate protection of human health and the environment from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site. Evaluation of this criterion focuses on how site risks are eliminated, reduced, or controlled through treatment, engineered controls, or institutional controls and whether an alternative poses any unacceptable cross-media impacts.

4.1.2 Compliance with ARARs

Section 121(d) of CERCLA, 42 United States Code § 9621(d), the NCP, 40 CFR Part 300 (1990), and guidance and policy issued by EPA require that remedial actions under CERCLA comply with substantive provisions of ARARs from the federal and state environmental laws and non-promulgated advisories and guidance during and at the completion of the remedial action or provide grounds for invoking the waivers.

4.1.3 Long-Term Effectiveness and Permanence

Long-term effectiveness evaluates the likelihood that the remedy would be successful and the permanence it affords. Factors to be considered, as appropriate, are discussed below.

- Magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. The characteristics of the residuals are considered to the degree that they remain hazardous, taking into account their T/M/V and propensity to bioaccumulate.

- Adequacy and reliability of controls used to manage treatment residuals and untreated waste remaining at the site. This factor includes an assessment of containment systems and institutional controls to determine if they are sufficient to ensure any exposure to human and ecological receptors is within protective levels. This factor also addresses the long-term reliability of management controls for providing continued protection from residuals, the assessment of the potential need to replace technical components of the alternative, and the potential exposure pathways and risks posed should the remedial action need replacement.

4.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Each alternative is assessed for the degree to which it employs a technology to permanently and significantly reduce T/M/V, including how treatment is used to address the principal threats posed by the site. Factors to be considered, as appropriate, include the items below.

- The treatment processes the alternatives employ and materials they would treat
- The amount of hazardous substances, pollutants, or contaminants that would be destroyed or treated, including how the principal threat(s) would be addressed
- The degree of expected reduction in T/M/V of the waste due to treatment
- The degree to which the treatment is irreversible
- The type and quantity of residuals that would remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate such hazardous substances and their constituents
- Whether the alternative would satisfy the statutory preference for treatment as a principal element of the remedial action

4.1.5 Short-Term Effectiveness

This criterion reviews the effects of each alternative during the construction and implementation phase of the remedial action until remedial response objectives are met. The short-term impacts of each alternative are assessed, considering the following factors, as appropriate.

- Short-term risks that might be posed to the community during implementation of an alternative
- Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures
- Potential adverse environmental impacts resulting from construction and implementation of an alternative and the reliability of the available mitigation measures during implementation in preventing or reducing the potential impacts
- Time until protection is achieved for either the entire site or individual elements associated with specific site areas or threats

4.1.6 Implementability

The technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation is evaluated under this criterion. The ease or difficulty of implementing each alternative is assessed by considering the following factors:

Technical Feasibility

- Technical difficulties and unknowns associated with the construction and operation of a technology

- Reliability of the technology, focusing on technical problems that will lead to schedule delays
- Ease of undertaking additional remedial actions, including what, if any, future remedial actions would be needed and the difficulty to implement additional remedial actions

Administrative Feasibility

- Activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for offsite actions)

Availability of Services and Materials

- Availability of adequate offsite treatment, storage capacity, and disposal capacity and services
- Availability of necessary equipment and specialists and provisions to ensure any necessary additional resources

4.1.7 Cost

Detailed cost estimates for each alternative were developed in accordance with *A Guide to Developing and Documenting Cost Estimates during the Feasibility Study* (EPA 2000). Detailed cost estimates for the alternatives are included in **Appendix B** and include the following:

- Capital costs
- Annual O&M costs
- Periodic costs
- Present value of capital and annual O&M costs

It should be noted that for the purpose of comparing the remedial action costs, pre-design investigation, pilot study, and remedial design costs are not included in this FFS.

4.1.8 State (Support Agency) Acceptance

State (support agency) acceptance is a modifying criterion under the NCP. Assessment of state acceptance will not be completed until comments on the final FFS report are submitted to EPA. Thus, state acceptance is not considered in the detailed analysis of alternatives presented in the FFS.

4.1.9 Community Acceptance

Community acceptance is also a modifying criterion under the NCP. Assessment of community acceptance will include responses to questions that any interested person in the community may have regarding any component of the remedial alternatives presented in the final FS report. This assessment will be completed after EPA receives public comments on the proposed plan during the public comment period. Thus, community acceptance is not considered in the detailed analysis of alternatives presented in the FFS.

4.2 Detailed Analysis of Remedial Alternatives

Table 4-1 provides detailed analysis of the remedial alternatives developed in Section 3 for the Site against the seven criteria discussed in Section 4.1. **Table 4-2** provides a comparison of the estimated costs. **Appendix B** provides the detailed cost estimates.

4.3 Comparative Analysis of Remedial Alternatives

In this section, a comparative analysis of the four alternatives against the seven criteria is performed as below.

Overall Protection of Human Health and the Environment

Alternative 1 would not provide overall protection of human health and the environment and would not meet the RAOs since no action would be taken.

Alternatives 2 would provide overall protection of human health and the environment and would meet the RAOs. Alternative 3 would provide overall protection of human health and the environment and would meet the RAOs if it is demonstrated to be effective during the pilot study as there are uncertainty in its implementation. Alternative 4 uses an innovative technology. It would be protective of human health and the environmental and would meet the RAOs if it is demonstrated to be effective in the pilot study and its long-term effectiveness is verified over time in the full-scale application. Exposure pathways to contaminated groundwater would be eliminated through institutional controls, such as restriction of drilling private wells. The contaminant concentrations in groundwater would be reduced through extraction and treatment or through in situ adsorption within the 100 µg/L PCE/TCE plume. Contaminants at lower concentrations could be addressed through natural processes such as dilution and dispersion.

Note that OU2 contaminants at lower concentrations would also be captured by the Garden City supply wells, the Hempstead supply wells, and the OU1 southern extraction wells and be effectively treated with their existing air strippers.

Compliance with ARARs

Alternative 1 would not meet the chemical-specific ARARs since no action would be taken. Location- and action-specific ARARs are not applicable for Alternative 1.

Alternative 2 would achieve chemical-specific ARARs through extraction and ex situ treatment of contaminated groundwater. Alternative 3 would achieve chemical-specific ARARs through groundwater extraction and in-well stripping of contaminants if demonstrated to be successful in a pilot study. Alternative 4 would achieve chemical-specific ARARs through in situ adsorption and potentially in situ degradation processes, however, its long-term effectiveness need to be verified in the field since it utilize an innovative technology. For Alternatives 2 to 4, location- and action-specific ARARs would be met through compliance with local construction codes, health and safety requirements, off-gas treatment requirements, if applicable, and water discharge criteria when applicable.

Long-term Effectiveness and Permanence

Alternative 1 would not provide long-term effectiveness and permanence since groundwater contamination would not be addressed. Alternatives 2 would provide long-term effectiveness and permanence. Alternative 3 would provide long-term effectiveness and permanence if it is demonstrated to be effective in a pilot study. Alternative 4 is an innovative technology, it would require time to demonstrate that it can provide long-term effectiveness and permanence as designed.

<u>Magnitude of residual risks:</u> Alternative 1 would have the highest level of residual risks since no action would be taken to reduce the contaminant mass nor to protect human health. Alternative2 would reduce contaminant concentrations in the aquifer within the capture zone with certainty. Alternative 3 would reduce contaminant concentrations in the aquifer within the capture zone; its effectiveness would need to be demonstrated and verified in a pilot study. Alternative 4 is an innovative technology that has potential to significantly reduce contaminant concentration in the in situ treatment zones. Its permanence would need to be monitored and verified over time. Remaining contaminant concentrations would decrease over time through natural attenuation processes such as dilution and dispersion.

<u>Adequacy and reliability of controls:</u> Alternative 1 would not provide any controls of contamination. Alternative 2, pump and treat, would provide the most adequate and reliable controls since it is a proven technology and is implemented for OU1. The GCW/in-well stripping technology has been implemented at some sites in the United States but not at the significant depth as this Site. Alternative 3 could provide adequate controls of the contaminated groundwater within the target treatment zone after it is successfully demonstrated through a pilot study that the GCW could capture the contaminant plume and the in-well air stripping could be operated reliably and effectively in reducing contaminant concentrations to below the PRGs. Alternative 4 is an innovative technology, which has yet to demonstrated that it can provide adequate and reliable control of groundwater contamination over time at this site.

Institutional controls under Alternatives 2, 3, and 4 would be effective in eliminating the human exposure pathways to contaminated groundwater.

<u>Reduction of T/M/V through Treatment</u>

Alternative 1 would not provide any reduction of T/M/V. Alternative 2 would reduce T/M/V of the 100 µg/L plume through the pump and treat system. Alternative 3 would reduce T/M/V of the 100 µg/L plume through the GCW/in-well stripping system. Alternative 4 would provide reduction of contaminant T/M/V of the 100 µg/L plume through in situ carbon adsorption. Alternatives 2, 3, and 4 would also reduce the toxicity of the overall contaminant plume.

Note that OU2 contaminants at lower concentrations could also be captured by the Garden City supply wells, the Hempstead supply wells, and the OU1 southern extraction wells and be treated with their existing air strippers, thus, reducing their T/V.

<u>Short-term Effectiveness</u>

Alternative 1 would not pose any short-term impacts to workers and the community since no action would be implemented at the Site.

Among Alternatives 2, 3, and 4, Alternative 2 would have the lowest short-term impact to the community. The installation of extraction well and monitoring well clusters, construction of yard piping and the treatment plant, and operation and maintenance of the extraction well would cause some disturbance to the local community since this is a densely-populated area, but the construction duration would be much shorter compared to Alternatives 3 and 4. Alternative 3 would have more short-term impacts to the community than Alternative 2 since more wells would be installed and the in-well striping system would require more space for the installation of a well vault to hold necessary equipment, valves, and fittings. Operation of the in-well stripping system might generate noise. Maintenance of the in-well stripping system and the compressed air line or vapor vacuum line might also have limited impacts to the local community. The well maintenance under Alternative 3 might also be more frequent compared to Alternative 2 since discharge of treated water back into the aquifer might cause iron fouling at the well screen. Alternative 4 would have the greatest short-term impacts to the local community during construction due to the significant number of injection wells to be installed and the large quantity of amendments to be injected. It would require traffic control over a much longer period of time compared to Alternatives 2 and 3. However, after the initial construction phase, there would be minimum operation and maintenance activities.

For Alternatives 2, 3, and 4, implementation of a health and safety plan, traffic controls, noise control and managing the hours of construction operation could minimize the impacts to local communities. Health and safety measures would also be implemented during operation and maintenance of the pump and treat system and the GCW/in-well stripping system and during sampling and analysis to protect the site workers.

Implementability

Alternative 1 could be implemented immediately since no services or actions would be required.

Among Alternatives 2, 3, and 4, Alternative 2 would be the easiest to implement since this technology has been implemented under OU1. Equipment and experienced vendors are readily available.

Successful implementation of Alternative 3 would require a pilot test to demonstrate the technology could be operated reliably and the PRGs could be achieved through in-well stripping. Construction of GCW/in-well stripping system at this depth (450 feet bgs) has not been documented before. There could be design, construction, and operation challenges, and any potential issues would need to be resolved during the pilot study prior to the full scale implementation of this alternative. Additionally, the pilot study is also necessary to provide site-specific design parameters such as radius of influence and cost for the design of a full-scale remedy.

Implementing Alternative 4 would be the most difficult among the three alternatives due to the significant number of injection wells it requires. This is an innovative technology, and there could be unforeseeable challenges. Commercially available vendors that can implement this technology are limited.

For Alternatives 2 to 4, EPA would need to obtain access agreement from the Village of Garden City for the construction of wells and yard piping on the street and land for the construction of the treatment plant or equipment building. EPA would also need to obtain permission to discharge treated water to the local Nassau County recharge basin under Alternative 2.

Cost

The capital cost, O&M costs, and present worth of each alternative are presented in **Table 4-2**. Alternative 4 has the highest present worth, the highest capital costs and the lowest O&M costs. The present worth, capital costs, and annual O&M costs for Alternatives 2 and 3 are comparable.

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Section 5

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Tables

TABLE 1-1
RISK SUMMARY
Old Roosevelt Field Contaminated Groundwater Site, OU2 - Eastern Plume
Garden City, New York

Time Frame	Exposure Medium	Receptor	Cancer Risk [1]				Noncancer Hazard Index [2]			
			RME	Risk Driver	CTE	Risk Driver	RME	Organ/Effect (Risk Driver)	CTE	Organ/Effect (Risk Driver)
Future	Groundwater	Resident [3]	**$2{\times}10^{-3}$**	TCE ($3{\times}10^{-4}$) VC ($2{\times}10^{-3}$)	**$4{\times}10^{-4}$**	TCE ($3{\times}10^{-4}$) VC ($2{\times}10^{-3}$)	**67**	HI CNS: 11 (PCE) HI Development: 54 (TCE) HI Heart: 53 (TCE) HI Immune System: 53 (TCE) HI Kidney: 65 (TCE, PCE) HI Liver: 65 (TCE, PCE) HI Lung: 2 (cobalt) HI Nervous System: 12 (PCE)	**16**	HI CNS: 4 (PCE) HI Developmental: 11 (TCE) HI Heart: 11 (TCE) HI Immune System: 11 (TCE) HI Kidney: 14 (TCE, PCE) HI Liver: 14 (TCE, PCE) HI Nervous System: 4 (PCE)
		Site Worker	**$2{\times}10^{-4}$**	TCE ($1{\times}10^{-4}$)	$4{\times}10^{-5}$	--	**8**	HI Development: 6 (TCE) HI Heart: 5 (TCE) HI Immune System: 5 (TCE) HI Kidney: 7 (TCE, PCE) HI Liver: 7 (TCE, PCE) HI Nervous System: 2 (PCE)	**3**	HI Developmental: 2 (TCE) HI Heart: 2 (TCE) HI Immune System: 2 (TCE) HI Kidney: 2 (TCE) HI Liver: 2 (TCE)

RME = reasonable maximum exposure
CTE = central tendency exposure
TCE = trichloroethene
PCE = tetrachloroethene
VC = vinyl chloride

[1] bolded values exceed EPA's target range of $1x10^{-6}$ to $1x10^{-4}$
[2] bolded values exceed EPA's threshold of unity (1)
[3] cancer risk is based on age-adjusted scenario and noncancer hazard index is based on child exposure scenario

CDM Smith

Table 2-1
Chemical-specific ARARs, Criteria, and Guidance
Old Roosevelt Field Contaminated Groundwater Superfund Site – Operable Unit 2
Garden City, New York

Regulatory Level	ARAR Identification	Status	Requirement Synopsis	Feasibility Study Consideration
Federal	National Primary Drinking Water Standards (40 CFR 141)	Relevant and Appropriate	Establishes health-based standards for public drinking water systems. Also establishes drinking water quality goals set at levels at which no adverse health effects are anticipated, with an adequate margin of safety.	The MCLs and MCLGs will be considered in the development of the PRGs if there are no applicable standards.
State	New York Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations (NYCRR Part 703)	Applicable	Establish numerical standards for groundwater and surface water cleanups.	The standards will be used to develop the PRGs.
State	New York State Department of Health Drinking Water Standards (10NYCRR Part 5)	Applicable	Sets maximum contaminant levels (MCLs) for public drinking water supplies.	The standards will be considered in the development of the PRGs if there are no applicable standards and if action involves future use of groundwater as a public supply source.

Table 2-2
Location-specific ARARs, Criteria, and Guidance
Old Roosevelt Field Contaminated Groundwater Superfund Site – Operable Unit 2
Garden City, New York

Regulatory Level	ARARs	Status	Requirement Synopsis	Action to be Taken to Attain ARARs
General	National Historic Preservation Act (40 CFR 6.301)	To Be Considered	This requirement establishes procedures to provide for preservation of historical and archeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program.	The effects on historical and archeological data will be evaluated during the identification, screening, and evaluation of alternatives.

Table 2-3
Action-specific ARARs for Site Remediation
Old Roosevelt Field Contaminated Groundwater Superfund Site – Operable Unit 2
Garden City, New York

ARARs	Status	Requirement Synopsis	Action to be Taken to Attain ARARs
General Requirement for Site Remediation			
OSHA—Record keeping, Reporting, and Related Regulations (29 CFR 1904)	Applicable	This regulation outlines the record keeping and reporting requirements for an employer under OSHA.	These regulations apply to the companies contracted to implement the remedy. All applicable requirements will be met.
OSHA—General Industry Standards (29 CFR 1910)	Applicable	These regulations specify an 8-hour time-weighted average concentration for worker exposure to various organic compounds. Training requirements for workers at hazardous waste operations are specified in 29 CFR 1910.120.	Proper respiratory equipment will be worn if it is not possible to maintain the work atmosphere below the 8-hour time-weighted average at these specified concentrations.
OSHA—Construction Industry Standards (29 CFR 1926)	Applicable	This regulation specifies the type of safety equipment and procedures to be followed during site remediation.	All appropriate safety equipment will be on site, and appropriate procedures will be followed during remediation activities.
RCRA Identification and Listing of Hazardous Wastes (40 CFR 261)	Applicable	Describes methods for identifying hazardous wastes and lists known hazardous wastes.	Applicable to the identification of hazardous wastes that are generated, treated, stored, or disposed during remedial activities.
RCRA Standards Applicable to Generators of Hazardous Wastes (40 CFR 262)	Applicable	Describes standards applicable to generators of hazardous wastes.	Standards will be followed if any hazardous wastes are generated onsite.
RCRA—Standards for Owners/Operators of Treatment, Storage, and Disposal Facilities (40 CFR 264)	Relevant and Appropriate	This regulation lists general facility requirements including general waste analysis, security measures, inspections, and training requirements.	Facility will be designed, constructed, and operated in accordance with this requirement. All workers will be properly trained.
New York Hazardous Waste Management System – General (6 NYCRR Part 370)	Applicable	This regulation provides definition of terms and general standards applicable to hazardous wastes management system.	The regulations will be applied to any hazardous waste operation during remediation of the site.

Table 2-3
Action-specific ARARs for Site Remediation
Old Roosevelt Field Contaminated Groundwater Superfund Site – Operable Unit 2
Garden City, New York

ARARs	Status	Requirement Synopsis	Action to be Taken to Attain ARARs
New York Solid Waste Management Regulations (Part 360)	Applicable	This regulation provides requirements for solid waste management facilities	Any disposal facility contracted to accept solid waste from the site will be required to comply with this regulation.
New York Identification and Listing of Hazardous Waste (6 NYCRR Part 371	Applicable	Describes methods for identifying hazardous wastes and lists known hazardous wastes.	Applicable to the identification of hazardous wastes that are generated, treated, stored, or disposed during remedial activities.
Waste Transportation			
Hazardous Materials Transportation Regulations (49 CFR Parts 107, 171, 172, 177 to 179)	Applicable	This regulation outlines procedures for the packaging, labeling, manifesting, and transporting hazardous materials.	Any company contracted to transport hazardous material from the site will be required to comply with this regulation.
RCRA Standards Applicable to Transporters of Hazardous Waste (40 CFR 263)	Applicable	Establishes standards for hazardous waste transporters.	Any company contracted to transport hazardous material from the site will be required to comply with this regulation.
New York Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities (6 NYCRR Part 372)	Applicable	Establishes record keeping requirements and standards related to the manifest system for hazardous wastes.	Any company contracted to transport hazardous material from the site will be required to comply with this regulation.
New York Waste Transporter Permit Program (6 NYCRR Part 364)	Applicable	Establishes permit requirements for transportations of regulated waste.	Must use permitted waste transporters when shipping wastes.
Waste Disposal			
RCRA Land Disposal Restrictions (40 CFR 268)	Relevant and Appropriate	This regulation identifies hazardous wastes restricted for land disposal and provides treatment standards for land disposal.	Hazardous wastes will be treated to meet disposal requirements.
New York Standards for Universal Waste (6 NYCRR Part 374-3) and Land Disposal Restrictions (6 NYCRR Part 376)	Applicable	These regulations establish standards for treatment and disposal of hazardous wastes.	Hazardous wastes must comply with the treatment and disposal standards.

Table 2-3
Action-specific ARARs for Site Remediation
Old Roosevelt Field Contaminated Groundwater Superfund Site – Operable Unit 2
Garden City, New York

ARARs	Status	Requirement Synopsis	Action to be Taken to Attain ARARs
Groundwater Discharge			
Clean Water Act (CWA) – National Pollutant Discharge Elimination System (40 CFR 100 et seq)	Relevant and Appropriate	National Pollutant Discharge Elimination System (NPDES) permit requirements for point source discharges must be met, including the NPDES Best Management Practice Program. These regulations include, but are not limited to, requirements for compliance with water quality standards, a discharge monitoring system, and records maintenance.	Project will meet NYPDES permit requirements for point source discharges.
Clean Water Act Effluent Guidelines and Standards for the Point Source Category (40 CFR 414)	To Be Considered	Establishes criteria for discharge quality of wastewater that contains organic chemicals, plastics and/or synthetic fibers	The criteria will be evaluated for surface water discharge of treated groundwater
Clean Water Act (Federal Ambient Water Quality Criteria [FAWQC] and Guidance Values [40 CFR 131.36])	To Be Considered	Establishes criteria for surface water quality based on toxicity to aquatic organisms and human health.	The criteria will be evaluated for surface water discharge of treated groundwater
Safe Drinking Water Act – Underground Injection Control Program (40 CFR 144, 146)	To Be Considered	Establish performance standards, well requirements, and permitting requirements for groundwater re-injection wells	Project will evaluate the requirement for treated groundwater reinjection and injection of reagent for in situ treatment
New York Regulations on State Pollution Discharge Elimination System (SPDES) (6 NYCRR parts 750-757)	Applicable	This permit governs the discharge of any wastes into or adjacent to State waters that may alter the physical, chemical, or biological properties of State waters, except as authorized pursuant to a NPDES or State permit.	Project will meet NPDES permit requirements for surface discharges of any wastes. Monitoring of discharges will be conducted as required.
New York Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations (6NYCRR Part 703)	Applicable	Establish numerical criteria for groundwater treatment before discharge.	Project will meet groundwater effluent limitations before discharge.

Table 2-3
Action-specific ARARs for Site Remediation
Old Roosevelt Field Contaminated Groundwater Superfund Site – Operable Unit 2
Garden City, New York

ARARs	Status	Requirement Synopsis	Action to be Taken to Attain ARARs
New York State Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (TOGS 1.1.1)	To Be Considered	Provides groundwater effluent limitations for use where there are no standards.	The guidance values will be considered for the treated groundwater to be discharge into surface water body.
Off-Gas Management			
Clean Air Act (CAA)—National Ambient Air Quality Standards (NAAQs) (40 CFR 50)	Applicable	These provide air quality standards for particulate matter, lead, NO_2, SO_2, CO, and volatile organic matter.	During excavation, treatment, and/or stabilization, air emissions will be properly controlled and monitored to comply with these standards.
Federal Directive – Control of Air Emissions from Superfund Air Strippers (OSWER Directive 9355.0-28)	To Be Considered	These provide guidance on the use of controls for superfund site air strippers as well as other vapor extraction techniques in attainment and non-attainment areas for ozone.	Project will consider the requirements in remediation alternatives that involve air stripping and vapor extraction process.
New York General Prohibitions (6 NYCRR Part 211)	Applicable	Prohibition applies to any particulate, fume, gas, mist, odor, smoke, vapor, pollen, toxic or deleterious emissions.	Proper dust suppression methods and monitoring will be required when implementing excavation, decontamination, and/or stabilization actions to prevent particulate matter from becoming airborne.
New York Air Quality Standards (6 NYCRR Part 257)	Applicable	This regulation requires that maximum 24-hour concentrations for particulate matter not be exceeded more than once per year. Fugitive dust emissions from site excavation activities must be maintained below 250 micrograms per cubic meter ($\mu g/m^3$).	Proper dust suppression methods, such as water spray, will be specified when implementing excavation and/or solidification/stabilization actions.
New York State Department of Environmental Conservation (DAR-1) Air Guide 1, Guidelines for the Control of Toxic Ambient Contaminants	To be considered	These guidelines outline procedures for evaluating emissions of criteria and non-criteria air contaminants.	Project will consider the requirements in remediation alternatives that involved air stripping and vapor extraction processes.

Table 2-4
Preliminary Remediation Goals for Groundwater
Old Roosevelt Field Contaminated Groundwater Superfund Site - Operable Unit 2
Garden City, New York

Contaminants of Concern	National Primary Drinking Water Standards[1] (µg/L)	NYS Groundwater Quality Standards[2] (µg/L)	NYSDOH Drinking Water Quality Standards[3] (µg/L)	PRGs[4] (µg/L)	Maximum Detected Concentrations (µg/L)
Volatile Organic Compounds					
Trichloroethene (TCE)	5	5	5	5	**150**
Tetrachloroethene (PCE)	5	5	5	5	**730**
cis-1,2-dichloroethene (cis-1,2-DCE)	70	5	5	5	**24 J+**
1,1-dichloroethene	7	5	5	5	**57 J+**
Vinyl Chloride	7	2	5	2	**49 J**

Notes:

1. EPA National Primary Drinking Water Standards (web page), EPA 816-F-09-004, May 2009, check May 2017
2. New York Surface Water and Ground Water Quality Standards (6NYCRR Part 703.5), Current through April 15, 2017
3. New York State Department of Health Drinking Water Standards (10NYCRR Part 5)
4. The PRGs are selected based on NYS Groundwater Quality Standards and drinking water standards

Bold figures indicate detected concentrations exceed PRGs.

NYSDOH = New York State Department of Health.

PRG = Preliminary Remedial Goal.

µg/L = micrograms per liter.

Table 2-5
Technology Screening for Groundwater
Old Roosevelt Field Contaminated Groundwater Superfund Site - Operable Unit 2
Garden City, New York

General Response Action	Remedial Technology	Process Options	Description	Implementability	Effectiveness	Cost	Retained
No Action	None	Not Applicable	The No Action alternative is retained as a baseline for comparison with other alternatives as required by the National Contingency Plan (NCP). No remedial actions will be implemented. The groundwater contamination would continue to migrate downgradient.	Implementable. No significant administrative difficulties are anticipated since no action would be taken.	The response would not mitigate human health risks due to contaminated groundwater, and it would not meet the RAOs.	No capital, operation, or maintenance costs.	Yes
Institutional Controls	Well Drilling Restrictions	Not Applicable	Well drilling restriction within the contaminant plume would eliminate the exposure pathways to contaminated groundwater through restricted uses of groundwater and the property within contamination affected areas.	Well drilling restrictions would be implemented through the current administrative system. Well drilling restrictions could be used in addition to other active remediation activities as a protective measure to prevent exposure to contaminants during remediation.	Well drilling restrictions can effectively eliminate the potential human exposure pathways to contaminated groundwater through restricted use of groundwater within the contaminated area. However, this will not reduce contaminant migration and the associated environmental impact.	Low costs for administration.	Yes
	Long-term Monitoring	Not Applicable	Long-term monitoring includes periodic sampling and analysis of groundwater samples, which provides data to evaluate the movement of the contaminants and the progress of remedial activities.	Implementable through sampling of the existing monitoring well network. It is a proven and reliable process and could be easily implemented. All monitoring wells are easily accessible for sample collection.	Long-term monitoring would not alter the human health risks posed by groundwater contamination. Monitoring is a reliable method for tracking the migration of contaminants and contaminant concentration changes.	Low capital costs to establish the sampling work plan and procedures. Medium operation and maintenance costs.	Yes
Monitored Natural Attenuation (MNA)	MNA	Not Applicable	MNA uses natural subsurface processes (e.g., dilution, volatilization, biodegradation, adsorption, and reaction with subsurface materials) to reduce contaminant concentrations to acceptable levels within a reasonable time frame. At sites with contaminant concentrations significantly higher than cleanup criteria, it usually requires evidence of effective biological degradation to ensure that MNA alone is adequate in controlling the contaminant plume. Concentrations of contaminants (PCE, TCE), degradation byproducts (cis-DCE, VC) and indicator parameters (e.g., oxidation/reduction potential) are monitored to verify the effectiveness of natural attenuation.	Implementable. Requires periodic groundwater sampling and analysis to monitor the contaminant distribution, contaminant trends, and movements and monitor the extent of contaminant degradation. Groundwater modeling is also commonly used for MNA evaluation.	At this site, measurements of DO and ORP within the contaminant plume indicated anoxic conditions; ferrous iron concentrations were at trace levels; the concentrations of cis-1,2-DCE were very low; and VC has not been detected. There might be very limited level of naturally occurring biodegradation of PCE and TCE through reductive dechlorination; however, the extent and rate of biodegradation would not be sufficient to reduce site contaminants to meet the groundwater quality standards prior to their migration to the water supply wells. Therefore, MNA is not effective at this site.	Low capital costs. Medium operation and maintenance costs. Would also include long-term monitoring.	No
Containment	Vertical Barrier	Slurry Walls	A slurry wall is a subsurface barrier consisting of a vertically excavated trench filled with a slurry. The slurry (typically either a soil/bentonite mixture or a cement/bentonite mixture) prevents the trench from collapsing and provides a physical barrier to groundwater flow.	Not implementable. Typical slurry wall applications reach installation depths of about 30 to 40 feet bgs, based upon practical limitations associated with excavator trenching. Slurry walls can be installed to depths exceeding 100 feet bgs using one-pass trenching. At the Site, the contamination extends to more than 400 feet bgs, exceeding the practical limits of the slurry wall.	Not effective for this site because the contaminant plume is deep, more than 400 feet bgs, and this technology is not implementable.	High capital costs.	No
		Sheet Pile Barriers	Sheet pile barriers (e.g., walls) are constructed by driving or vibrating sections of steel sheet piling into the ground. Each sheet pile section is interlocked at its edges, and the seams are often grouted to prevent leakage.	Not implementable. Typical sheet pile wall applications reach installation depths of about 80 feet bgs, based upon practical limitations associated with installation. Sheet pile walls can be installed to depths exceeding 100 feet bgs at a higher unit cost. At the Site, the contamination extends to more than 400 feet bgs, exceeding the practical limits of sheet piling.	Not effective for this site since it is not implementable.	High capital costs.	No
Extraction	Groundwater Extraction	Extraction Wells	Groundwater extraction wells can be installed to extract the contaminated groundwater and prevent or minimize the downgradient migration of a contaminant plume.	Implementable. Groundwater modeling is used to support the design of groundwater extraction wells for effective capture of the contaminant plume.	Effective in providing hydraulic control at sites where the hydrogeology is well understood and the pumping rate necessary to maintain hydraulic control is sustainable. Continuous pumping would be sustainable at this site.	Medium capital costs, medium to high operation and maintenance costs.	Yes
		Extraction Trenches	Extraction trenches are constructed perpendicular to the direction of groundwater flow to intercept and prevent downgradient migration of a shallow contaminant plume. The trench is typically backfilled with material of higher permeability than the native aquifer (e.g., gravel) to create a zone of preferential flow, and perforated piping or extraction wells are typically installed in the trench to collect the intercepted groundwater.	Not implementable due to the depth of contaminated groundwater.	Effective in capturing shallow groundwater to provide hydraulic control. Extraction trenches are not typically installed at depths greater than 30 feet bgs due to equipment limitations and, therefore, would not be effective for this site.	Medium capital costs.	No
Treatment	Ex Situ Treatment	Precipitation and Filtration	Physically removes dissolved and suspended solids from groundwater in order to reduce fouling within the subsequent treatment processes.	Easily implementable. Equipment and chemicals for precipitation and filtration are readily available.	Proven technology, effective in removing solid materials, needs to be combined with other treatments to remove VOC contaminants.	Medium capital. Medium operation and maintenance costs.	Yes

Table 2-5
Technology Screening for Groundwater
Old Roosevelt Field Contaminated Groundwater Superfund Site - Operable Unit 2
Garden City, New York

General Response Action	Remedial Technology	Process Options	Description	Implementability	Effectiveness	Cost	Retained
Treatment	Ex Situ Treatment	Air Stripping	Air stripping involves the mass transfer of volatile contaminants from water to air by increasing the surface area of the groundwater exposed to air. The commonly used systems are countercurrent packed column, multiple chamber fine bubble aeration system, and low profile sieve tray air strippers.	Implementable. Air stripper equipment is readily available. Generally will require off-gas treatment (i.e., vapor phase carbon) and permit for discharge to the atmosphere.	Air stripping is effective in removing VOCs from groundwater. Off gas may require treatment prior to discharge.	Medium capital cost. Medium operation and maintenance costs.	Yes
		Liquid-Phase Activated Carbon Adsorption	Contaminants in groundwater are adsorbed by passing the extracted groundwater through a series of reactor vessels containing granular activated carbon. Spent carbon must be reactivated or replaced periodically.	Implementable. Technology can treat VOC-contaminated groundwater. No administrative difficulties anticipated for implementation of a liquid-carbon adsorption system.	Carbon adsorption is not effective in removing VC, a degradation byproduct of PCE and TCE. However, no VC has been detected at this site.	Medium capital costs. Medium operation and maintenance costs.	Yes
		Vapor-Phase Activated Carbon Adsorption	Carbon adsorption can be used to treat the off-gas generated during air stripping. Activated carbon is not effective in the removal of VC; an additional treatment method would be required for sites with significant concentrations of VC. However, VC has not been detected at this site.	This technology is implementable and proven.	Effective in removing contaminants with moderate or highly organic carbon partition coefficients (K_{oc}) from off-gas. Not effective for VC; however, VC has not been detected at this site.	Medium capital cost. Medium operation and maintenance costs.	Yes
		Ultraviolet (UV) Oxidation	Contaminated groundwater is transferred to a reactor where it is mixed with ozone and/or hydrogen peroxide under UV light. Organic contaminants are destroyed by oxidation reactions. Systems may require off-gas treatment to destroy unreacted ozone and volatilized contaminants.	Implementable. Equipment is available. May require permit for discharge of unreacted ozone and volatilized VOCs. Alternatively, treatment of off-gas may be required.	UV oxidation is effective in the destruction of a wide variety of organic contaminants, including chlorinated hydrocarbons (e.g., TCE, PCE, and VC). Aqueous stream must have good transmissivity; high turbidity causes interference.	High capital costs. High operation and maintenance costs.	Yes
		Biological Treatment	Ex situ biological treatment techniques stimulate microorganisms to grow and use contaminants as a food and energy source by creating a favorable environment for the microorganisms. Oxygen content, redox potential, nutrient balance, temperature, and pH are factors that need to be controlled in order to ensure effective treatment.	Implementable. However, biodegradation is not an instantaneous process. It would require space and time for the reactions to fully occur. This site is in a densely populated residential and commercial area; available space for treatment system is limited.	Enhanced anaerobic biodegradation has been demonstrated to be effective in treating chlorinated solvents. The groundwater will need to be changed from aerobic or anoxic conditions to anaerobic conditions for the reductive dechlorination to occur and would require a longer residence time than a physical treatment technology (such as air stripping) to reach the same treatment goals.	Medium capital cost. Medium maintenance costs.	No
	In Situ Treatment	Permeable Reactive Barriers (PRBs)	PRBs are constructed perpendicular to the flow path of a contaminant plume. Contaminants are removed through reaction with the permeable reactive medium. Barriers may be permanent or replaceable units and typically constructed using conventional trenching techniques for shallow groundwater contamination. PRBs can be placed at greater depth using hydraulic fracturing and injection methods.	Conventional trenching method is not applicable at this site due to the significant depth of contaminated groundwater. Trenchless method using hydraulic fracturing and injection had successfully placed PRBs to 115 feet bgs. Implementing a PRB at more than 400 feet bgs is not a proven technology.	Effectiveness for this site is uncertain due to the depth of contamination. PRBs constructed of zero-valent iron filings are effective in the treatment of TCE/PCE to below detection limits. PRBs would be effective for heterogeneous soil conditions. PRBs may lose efficiency over some years due to precipitation caused by unfavorable groundwater geochemistry. Reactivation of PRBs or reinstallation of PRBs may be necessary after 15 years.	High capital costs compared to other in situ treatment technologies. Low operation and maintenance costs for groundwater monitoring; these costs may be significant if replacement of reactive medium is necessary.	No
		In Situ Chemical Oxidation (ISCO)	ISCO involves the injection of chemical oxidants into the subsurface to destroy organic contaminants in groundwater. Complete oxidation of contaminants results in their breakdown into non-toxic compounds such as carbon dioxide, water, and minerals. In order to treat a contaminant plume, the entire area needs to be treated, or repeated application of oxidant in a treatment barrier configuration needs to be applied.	Implementing ISCO at this site would be extremely challenging due to the size of the contaminant plume and the more than 400-foot depth of contamination. It is impossible to apply the oxidant over the entire plume. ISCO implementation through a treatment barrier type of configuration using ozone or permanganate might be possible. However, the depth needed for ozone injection would require a specially designed system that is not readily available on the market. Continuous injection of permanganate at the treatment barrier may result in precipitation around the injection wells over time and reduce the treatment effectiveness. There is also the concern of permanganate migrating to the supply wells. Furthermore, establishing a treatment barrier using ISCO technology would require closely spaced injection wells and frequent operation and maintenance, which would be impossible in a residential neighborhood.	ISCO is an effective treatment for mass reduction of chlorinated solvent contamination at a source area. The effectiveness of ISCO depends on adequate direct contact between oxidants and contaminants. Subsurface heterogeneities can adversely affect adequate distribution of the oxidants. The effectiveness of ISCO in treating a chlorinated solvent contaminated groundwater plume could be problematic because a large portion of the injected oxidants could be wasted in overcoming the soil oxidant demand than destroying the contaminants. Maintaining adequate direct contact between oxidants and contaminants migrating with groundwater flow could be difficult and extremely costly.	High capital cost. High operation and maintenance costs.	No
		Air Sparging (AS) with Soil Vapor Extraction (SVE)	Clean air is injected into groundwater to strip the chlorinated contaminants via volatilization. The contaminant-containing air is then removed from the vadose zone using an SVE system.	Not implementable at this site because there is a layer of clean groundwater on top of the contaminant plume. Air sparging would cause spreading of contaminants into the shallow uncontaminated groundwater.	AS with SVE would not be effective at this site due to the more than 400-foot depth of contamination and the fact that shallow groundwater above the contaminant plume is not contaminated. Spreading of contaminants into the shallow groundwater above the contaminant plume would not be acceptable.	Medium to high capital cost. Medium operation and maintenance costs.	No

Table 2-5
Technology Screening for Groundwater
Old Roosevelt Field Contaminated Groundwater Superfund Site - Operable Unit 2
Garden City, New York

General Response Action	Remedial Technology	Process Options	Description	Implementability	Effectiveness	Cost	Retained
Treatment (continued)	In Situ Treatment (continued)	Groundwater Circulation Well (GCW) and In-Well Stripping	The GCW technology is designed to create a 3-dimensional vertical circulation pattern in an aquifer by drawing contaminated groundwater from the aquifer through one screened section (usually the bottom screen) of a two-screened well, treating the water within the well and then discharging it into the aquifer through another screened section (usually the top screen) without bringing the contaminated groundwater above ground. When the vertical circulation pattern is generated, the treated groundwater may be circulated several times in the aquifer before it flows downgradient, which would greatly enhance contaminant removal from low permeability zones compared to a pump and treat technology. The withdrawal of contaminated groundwater is usually achieved using the air-lifting mechanism. Contaminants transfer into the vapor phase in the well are collected above the ground and treated by granular activated carbon (GAC) prior to discharge to the atmosphere. The difference in the horizontal and vertical transmissivity influences the radius of influence of the system. Proper design and testing need to be done to prevent the spreading of contamination.	Implementable with site-specific challenges due to the significant depth (more than 400 feet) of contamination, potentially stratigraphic lithology, a residential neighborhood, and hydrogeological impact of the treated area by pumping of Hempstead supply wells. The low DO and ORP values at well MW-18I may cause iron fouling concerns if ambient air is used for air stripping. However, the iron fouling issue may be mitigated by using nitrogen.	GCW systems could effectively treat PCE and TCE if the air stripping inside the well is effective. Hydrogeologically, the withdrawal of contaminated groundwater and the establishment of vertical circulation pattern in the formation could intercept the contaminant plume. Issues that may result in failure of a GCW include (1) short circuiting around the well, resulting in limited radius of influence, and (2) high ratio between vertical hydraulic conductivity and horizontal hydraulic conductivity, preventing the establishment of a circulation loop in the designed treatment zone. At this site, the Magothy aquifer consists of alternating sequences and gradations of sand, clayey sand, sandy clay, clay, lignite, and some gravel, which may make the development of vertical circulation cells around the well difficult. The estimated vertical hydraulic conductivity is 30 to 60 times higher than the estimated horizontal hydraulic conductivity, which is within the range for a GCW system. The effectiveness of GCW needs to be pilot tested.	Medium to high capital cost. Medium operation and maintenance costs.	Yes
		Enhanced Anaerobic Bioremediation (EAB)	EAB involves the injection of organics (serving as electron donors), nutrients, and potentially dechlorinating microorganisms into the subsurface to stimulate the anaerobic biodegradation of chlorinated solvent contaminants. For PCE and TCE, the degradation intermediates include cis-1,2-DCE, trans-1,2-DCE, and VC. The ultimate degradation product is ethene.	EAB could be implemented using bio-barrier technology where organics are injected through a line of injection wells perpendicular to the groundwater flow to form a treatment zone that intercepts and treats the contaminant plume. The current available slow release amendment, such as emulsified vegetable oil, could last 2 to 5 years. Repeated amendment injection will be required. However, implementing EAB would cause the concerns that degradation intermediates (such as vinyl chloride) or byproducts (such as methane) may impact the water quality of supply wells. As a result, EAB is considered not implementable for this site.	EAB has been demonstrated to effectively reduce PCE and TCE contamination at many sites. The addition of organics (serving as electron donors) would change the groundwater from aerobic or anoxic conditions to anaerobic conditions, resulting in the increases of ferrous iron, cis-1,2-DCE, VC, ethene, and methane. Based on accumulated knowledge of EAB treatment, ferrous iron would not migrate far from the active treatment zone. Concentrations of cis-1,2-DCE, VC, ethene, and methane could be oxidized when groundwater transitions from anaerobic to aerobic conditions downgradient of the active treatment zone. However, due to the close distance of the leading edge of the contaminant plume to the supply wells, if active EAB is implemented, the degradation intermediates and products may impact the water quality of the supply wells.	High capital cost bio-barrier technology due to closely spaced injection wells. High operation and maintenance costs due to repeated amendment injection.	No
		In Situ Adsorption	The technology involves the injection or emplacement of activated carbon within the contaminant plume to adsorb contaminants and minimize migration of dissolved contaminants.	This technology is implementable. Activated carbon could be injected through a serious of injection wells installed perpendicular to groundwater flow. The radius of influence from each injection well might be limited, and a large number of wells may be required. Because the activated carbon has finite adsorption capacity, multiple lines of injection at different distances within the plume would be necessary.	This is an innovative technology. Currently, two products, BOS 100® and PlumeStop®, are available on the market. Both contain activated carbon and both could be emplaced in the subsurface through injection. Limited case studies have demonstrated that the activated carbon could adsorb contaminants and prevent or minimize contaminant migration toward the receptors. Both products claimed to promote contaminant degradation in addition to adsorption, which could regenerate the activated carbon in situ. The long-term effectiveness of these products is not known.	High capital costs. Potential low to medium operation and maintenance costs.	Yes
Discharge	Onsite Discharge	Onsite Injection	Treated groundwater is discharged on site to the subsurface through a series of injection wells.	Implementable. Minor administrative difficulties are anticipated for groundwater reinjection; discharge permit may be required for injection to the subsurface. The lower portion of the Magothy formation might contain dissolved iron, which might cause fouling of the injection wells. Periodic maintenance of the injection wells may be necessary.	Groundwater must be treated to meet discharge requirements. At the Site, the formation is generally sandy and should be able to accept the treated groundwater. There is concern of iron fouling in the deep portion of the Magothy formation. Injection wells could be designed with high capacity and revitalized periodically as necessary.	Medium capital costs. High operation and maintenance costs.	Yes
		Onsite Surface Recharge	Treated groundwater can be disposed on site using a surface recharge system such as a drain field or a recharge basin. Recharge basins are shallow ponds that allow water to infiltrate into the ground gradually and, depending on the permeability of the soil, generally require large surface areas.	Implementable, as standard construction methods and materials would be utilized. An existing recharge basin is located to the east of Garden Street, which might be available for use.	Effectiveness of this option would rely on the proper construction of the recharge system, including adequate sizing, and use of suitable sand and gravel. Currently, there is a recharge basin to the east of Garden Street that may be available for use.	Low capital costs. Low operation and maintenance costs.	Yes
	Offsite Discharge	Surface Water Discharge	Treated groundwater is discharged to an offsite surface water body such as a nearby stream.	Not implementable. There is no surface water body near the Site.	Not effective for this site since it is not implementable.	Low capital costs. Low operation and maintenance costs.	No

NOTES:

[shaded box]: Technology eliminated from further evaluation.
bgs: below ground surface
DO: dissolved oxygen
ORP: oxidation-reduction potential
RAO: remedial action objective
CVOC: chlorinated volatile organic compound
TCE: trichloroethene
DCE: dichloroethene
PCE: tetrachloroethene
VC: vinyl chloride
VOC: volatile organic compound

Table 4-1
Summary of Detailed Analysis of Remedial Action Alternatives
Old Roosevelt Field Contaminated Groundwater Site – Operable Unit 2
Garden City, New York

EVALUATION CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 PUMP AND TREAT	ALTERNATIVE 3 IN-WELL STRIPPING	ALTERNATIVE 4 IN SITU ADSORPTION
Summary of Components	None	▪ Pre-design investigation ▪ Groundwater modeling and remedial design ▪ Groundwater extraction well ▪ Ex situ treatment system ▪ Onsite surface discharge ▪ Institutional controls ▪ Long-term monitoring ▪ 5-year Site reviews	▪ Pre-design investigation and pilot study ▪ Groundwater modeling and remedial design ▪ Groundwater Circulation Well (GCW)/In-well stripping system ▪ Above-ground utilities and facility ▪ Institutional controls ▪ Long-term monitoring ▪ 5-year Site reviews	▪ Pre-design investigation and pilot study ▪ Remedial design ▪ Installation of injection wells ▪ Injection of activated carbon ▪ System rejuvenation ▪ Institutional controls ▪ Long-term monitoring ▪ 5-year Site reviews
Overall Protection of Human Health and the Environment	This alternative would not provide protection of human health and the environment, since no action would be taken to reduce contaminant mass and to restore the contaminated area.	This alternative would provide overall protection of human health and the environment and would meet the RAOs. Exposure pathways to contaminated groundwater would be eliminated through institutional controls, such as private well drilling restriction. The pump and treat system would extract the contaminated groundwater with tetrachloroethene (PCE) and/or trichloroethene (TCE) concentration greater than 100 μg/L and treat the contaminants in the above ground ex situ treatment system. Contaminants at lower concentrations could be addressed through natural processes, such as dilution and dispersion. Note that OU2 contaminants at lower concentrations could also be captured by the Garden City supply wells, the Hempstead supply wells, and the OU1 southern extraction wells and be effectively treated with their existing air strippers.	This alternative would provide overall protection of human health and the environment and would meet the RAOs if demonstrated to be effective and reliable through a pilot study, as there are uncertainty of implementation for this technology at such depth. Exposure pathways would be eliminated through institutional controls. The groundwater circulation wells and in-well stripping system withdraw the contaminated groundwater with tetrachloroethene (PCE) and/or trichloroethene (TCE) with concentration greater than 100 μg/L and strips the contaminants into vapor phase inside the well and return the treated water at a shallower depth. Contaminants at lower concentrations could be addressed through natural processes, such as dilution and dispersion. Note that OU2 contaminants at lower concentrations could also be captured by the Garden City supply wells, the Hempstead supply wells, and the OU1 southern extraction wells and be effectively treated with their existing ex situ treatment system.	This alternative would provide overall protection of human health and the environment if demonstrated to be effective and reliable through a pilot study, as this alternative involves using an innovative technology. Its long-term effectiveness also needs to be verified in the field over time. Exposure pathways would be eliminated through institutional controls. The injected activated carbon would adsorb contaminants, minimize their migration toward the supply wells. Contaminants at lower concentrations could be addressed through natural processes, such as dilution and dispersion. Note that OU2 contaminants at lower concentrations could also be captured by the Garden City supply wells, the Hempstead supply wells, and the OU1 southern extraction wells and be effectively treated with their existing ex situ treatment system.
Compliance with ARARs	Since no action would be taken, this alternative would not meet chemical-specific ARARs. Location- and action-specific ARARs do not apply.	The alternative would meet the PRGs and would achieve chemical-specific ARARs through extraction and ex situ treatment of contaminated groundwater. Location and action-specific ARARs would be met through compliance with health and safety and off-gas treatment requirements and water discharge criteria.	The alternative would meet the PRGs and would achieve chemical-specific ARARs through extraction and in-place treatment of contaminated groundwater. Location and action-specific ARARs would be met through compliance with health and safety and off-gas treatment requirements and water discharge criteria.	The alternative would meet the PRGs and would achieve chemical-specific ARARs through in situ adsorption of contaminants and potentially in situ degradation processes. Its long-term effectiveness in meeting the chemical-specific ARARs need to be verified in the field since this is an innovative technology. Location and action-specific ARARs would be met through compliance with health and safety and off-gas treatment requirements and water discharge criteria.

Table 4-1
Summary of Detailed Analysis of Remedial Action Alternatives
Old Roosevelt Field Contaminated Groundwater Site – Operable Unit 2
Garden City, New York

EVALUATION CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 PUMP AND TREAT	ALTERNATIVE 3 IN-WELL STRIPPING	ALTERNATIVE 4 IN SITU ADSORPTION
Long-term Effectiveness and Permanence	This alternative does not provide long-term effectiveness and permanence, since the contaminated media would not be addressed.	This alternative would provide long-term effectiveness and permanence. Magnitude of residual risk: This alternative would reduce contaminant concentrations in the aquifer with certainty. Remaining contaminant concentrations would decrease over time through natural attenuation processes, such as dilution and dispersion. Adequacy and reliability of controls: pump and treat is a proven technology and is considered adequate and reliable in reducing and control contaminant migration. Institutional controls would be effective in eliminating the human exposure pathways to contaminated groundwater.	This alternative would provide long-term effectiveness and permanence if the pilot study demonstrates the effectiveness of capturing the contaminant plume and the in-well stripping treatment. Magnitude of residual risk: This alternative would reduce contaminant concentrations in the aquifer within the capture zone of the GCW/in-well stripping systems. Remaining contaminant concentrations would decrease over time through natural attenuation processes, such as dilution and dispersion. Adequacy and reliability of controls: GCW/in-well stripping has been implemented at some sites in the United States and is considered adequate and reliable in reducing contaminant mass and minimize plume migration. Due to the significant depth of contamination at this site, its adequacy and reliability need to be demonstrated in a pilot study. Institutional controls would be effective in eliminating the human exposure pathways to contaminated groundwater.	This alternative would provide long-term effectiveness and permanence if the pilot study demonstrates the effectiveness and longevity of treatment. Magnitude of residual risk: This alternative would reduce contaminant concentrations in the aquifer by adsorbing contaminants onto activated carbon in situ. Remaining contaminants that are not in direct contact with the activated carbon would be at low concentrations and would decrease over time through natural attenuation processes, such as dilution and dispersion. Adequacy and reliability of controls: this is an innovative technology and weather it can adequately and reliably reduce site contaminant concentration over 15 to 30 years yet to be verified in the field. Institutional controls would be effective in eliminating the human exposure pathways to contaminated groundwater.
Reduction of Toxicity/ Mobility/Volume (T/M/V) Through Treatment	The alternative would not reduce contaminant T/M/V.	This alternative would reduce T/M/V of contaminants within the capture zone of the pump and treat system. Note that OU2 contaminants at lower concentrations could also be captured by the Garden City supply wells, the Hempstead supply wells, and the OU1 southern extraction wells and be treated with their existing air strippers, thus reducing their T/V.	This alternative would reduce T/M/V of contaminants in the 100 μg/L plume through groundwater extraction, in-well stripping and carbon adsorption. Note that OU2 contaminants at lower concentrations could also be captured by the Garden City supply wells, the Hempstead supply wells, and the OU1 southern extraction wells and be treated with their existing air strippers, thus reducing their T/V.	This alternative would reduce T/V/M of contaminants through in situ treatment by carbon adsorption within the target treatment zone. Note that OU2 contaminants at lower concentrations could also be captured by the Garden City supply wells, the Hempstead supply wells, and the OU1 southern extraction wells and be treated with their existing air strippers, thus reducing their T/V.

Table 4-1
Summary of Detailed Analysis of Remedial Action Alternatives
Old Roosevelt Field Contaminated Groundwater Site – Operable Unit 2
Garden City, New York

EVALUATION CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 PUMP AND TREAT	ALTERNATIVE 3 IN-WELL STRIPPING	ALTERNATIVE 4 IN SITU ADSORPTION
Short-term Effectiveness	Since no action would be implemented at the site, this alternative would not pose short-term impact to workers and the community.	The installation of monitoring well and extraction well, construction of yard piping and the treatment plant, and operation and maintenance of the extraction well would cause some disturbance to local community, since this is a densely-populated area. Implementation of health and safety plan, traffic controls, noise control, and managing hours of construction operation could minimize the impacts to local communities. Health and safety measures would also be implemented during operation and maintenance of the pump and treat system and during sampling and analysis to protect the site workers.	The installation of monitoring well and GCW/in-well stripping systems, construction of yard piping, and the equipment building would require traffic controls and cause disturbance to local community, since this is a densely-populated area. Operation of the in-well stripping system below the ground may generate noise. Maintenance of GCW/in-well stripping system due to iron fouling or equipment failure could also temporarily disturb the routine life of residents. Implementation of health and safety plan, traffic controls, noise control, and managing hours of construction operation could minimize the impacts to local communities. Health and safety measures would also be implemented during operation and maintenance of the pump and treat system and during sampling and analysis to protect the site workers.	The installation of a significant number of wells, transport of well construction materials and extracted water during well development, and injection of activated carbon would require a long time and significantly impact the local community. Implementation of health and safety plan, traffic controls, noise control, and managing hours of construction operation could minimize the impacts to local communities. Health and safety measures would also be implemented during operation and maintenance of the pump and treat system and during sampling and analysis to protect the site workers.
Implementability	This alternative could be implemented immediately since no services or actions would be required.	This alternative is implementable and is the same as the OU1 remedy. Equipment and experienced vendors are readily available. EPA would need to obtain access agreement from the Village of Garden City for the construction of yard piping and the treatment plant. EPA would also need to obtain permission to discharge treated water to the local Nassau County recharge basin.	This alternative is implementable and would require a pilot test to demonstrate its effectiveness and it reliability in the long-term. Additionally, the pilot study would obtain design parameters, such as radius of influence. Construction of GCW at the deep depth (450 feet bgs) as required by this site has not been documented before. There could be design, construction, and operation challenges that need to be resolved to demonstrate its effectiveness and implementability. EPA would need to obtain access agreement from the Village of Garden City for the construction of yard piping and the equipment building.	This alternative would be very difficult to implement due to the significant number of injection wells it requires. This is an innovative technology and there could be unforeseeable challenges. Commercially available vendor that can implement this technology is limited. EPA would need to obtain access agreement from the Village of Garden City for the installation of injection wells.
Present Worth	There are no capital or O&M costs associated with this alternative.	The present worth of this alternative is $13 million for 30 years.	The present worth of this alternative is $ 13.7 million for 30 years.	The present worth of this alternative is $14.6 million for 30 years.

Table 4-2
Estimated Remedial Action Costs
Old Roosevelt Field Contaminated Groundwater Site – Operable Unit 2
Garden City, Long Island, New York

Remedial Alternatives	Alternative 1 – No Action	Alternative 2 – Pump and Treat	Alternative 3 – In-Well Stripping	Alternative 4 – In Situ Adsorption
Capital Costs	$0	$5.08 million	$5.26 million	$10.70 million
Annual Operation and Maintenance Costs	$0	$650,000	$678,000	$232,800
Present Worth	$0	$13.14 million	$13.67 million	$14.56 million

Figures

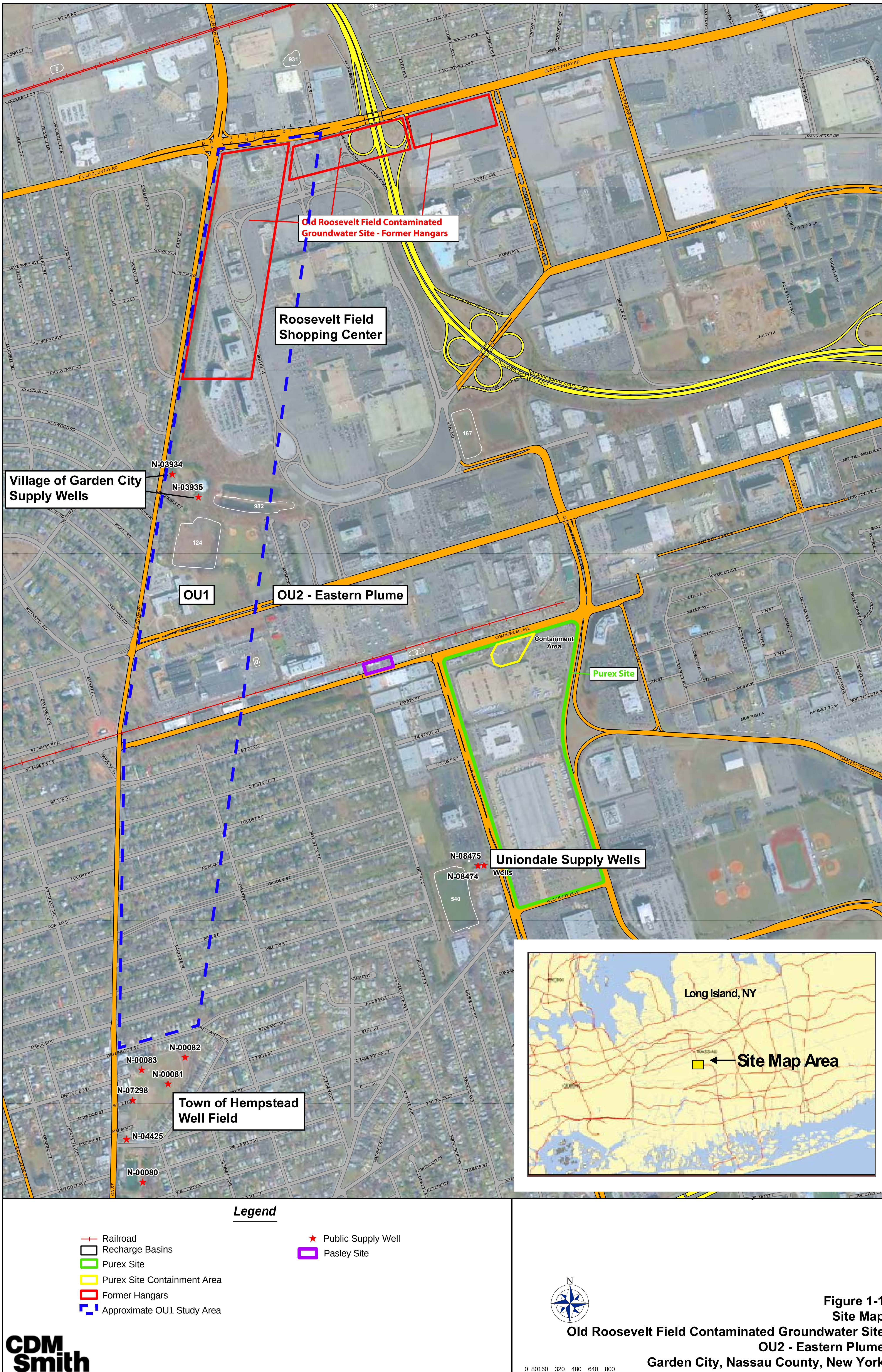
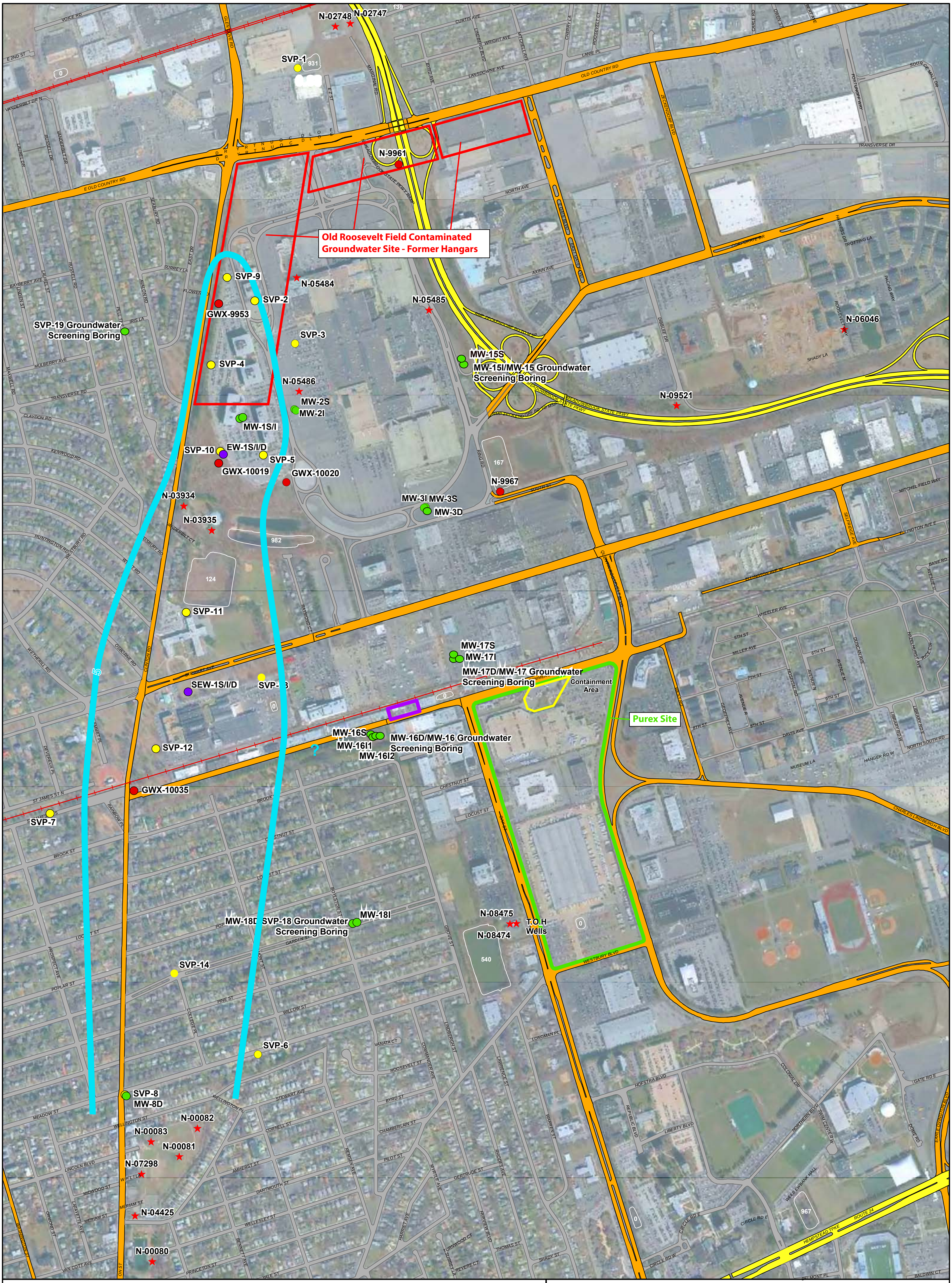


Figure 1-1
Site Map
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York



Legend

- Railroad
- Recharge Basins
- Purex Site
- Purex Site Containment Area
- OU1 PCE/TCE Plume - 5 µg/L*
- Monitoring Wells
- Existing Multi-port Well
- Existing Nassau County Well
- Public Supply Well
- Public Supply Well
- Pasley Site

*OU1 PCE/TCE Plume is adapted from the OU1 Annual Progress Report - Year 4 (2015) and draft Year 5 data

CDM Smith

Source: Nassau County Geographic Information System

N

0 80160 320 480 640 800 Feet

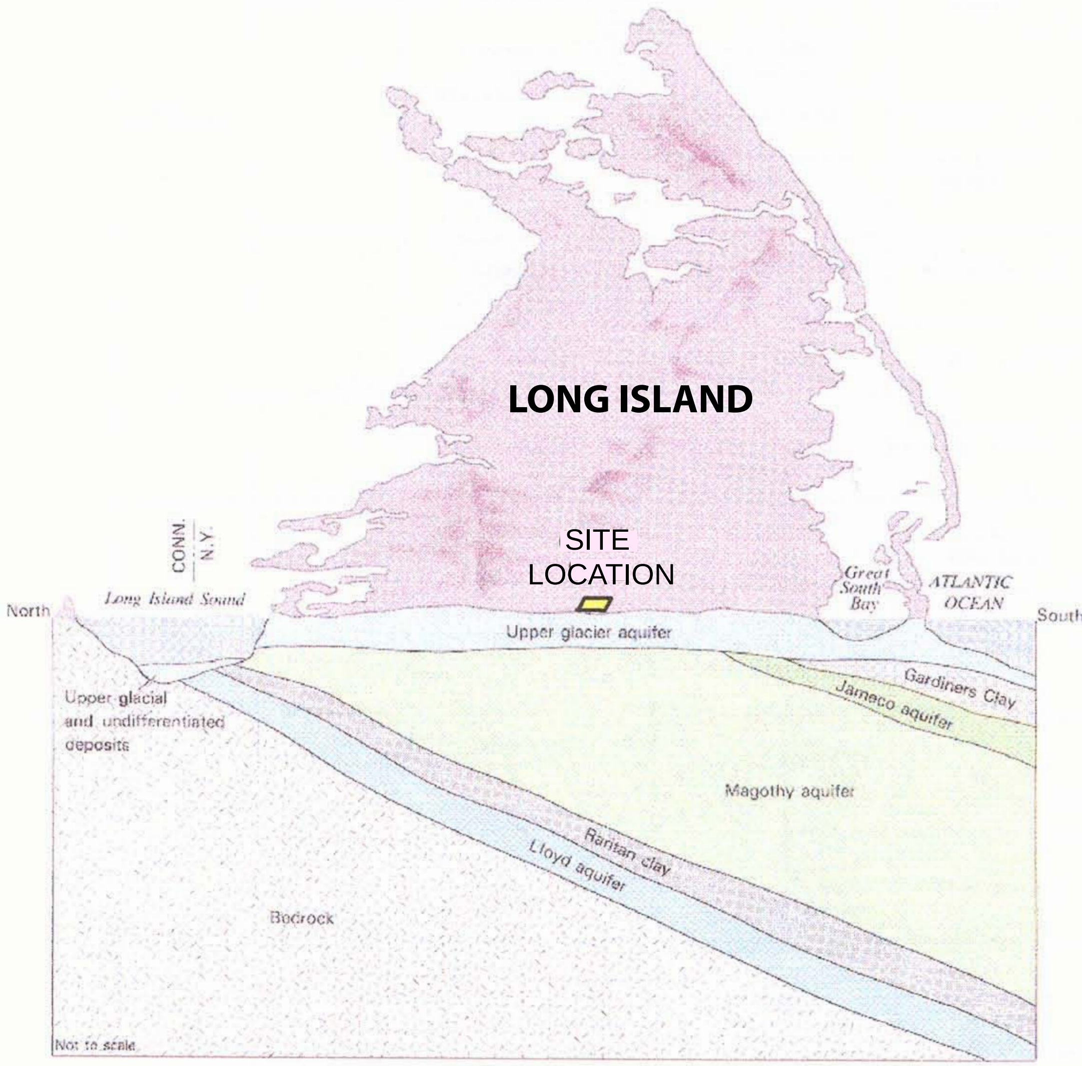
Figure 1-2

Multi-port Well, Existing Monitoring Well, and Supply Well Locations and Current OU1 Groundwater Plume Map

Old Roosevelt Field Contaminated Groundwater Site

OU2 - Eastern Plume

Garden City, Nassau County, New York



Modified from Franke and McClymonds (1972)

Figure 1-3
General Geologic Section of Long Island Aquifer System in Nassau County
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York

CDM Smith

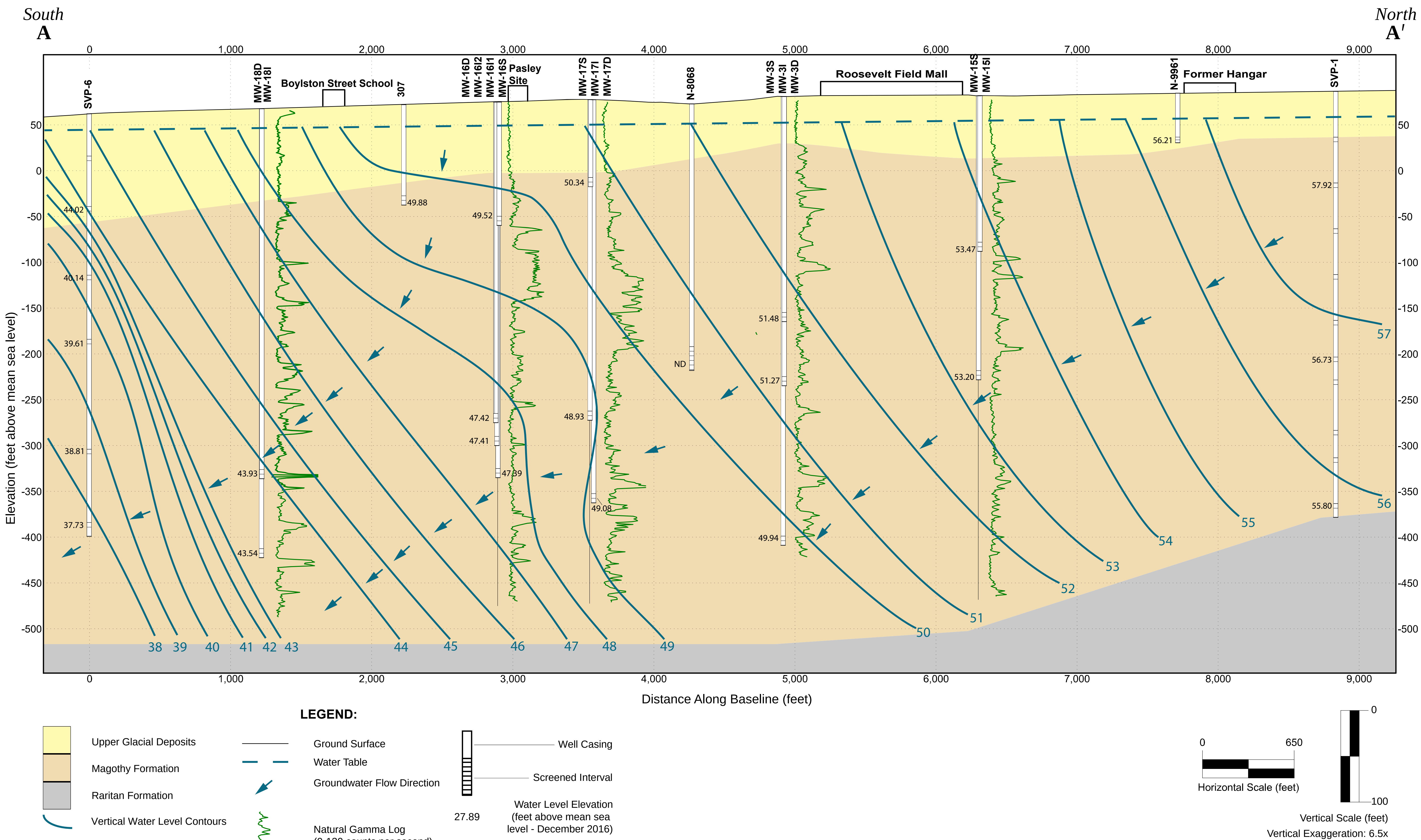


Figure 1-4
Geologic Cross Section
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York

CDM Smith

STANDARD CROSS SECTION: ORF OU2 ORF OU2.GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 2/6/15 REV.

- Conventional Well
- Multiport Well
- Extraction/Supply Wells
- Potentiometric Surface (ft msl)

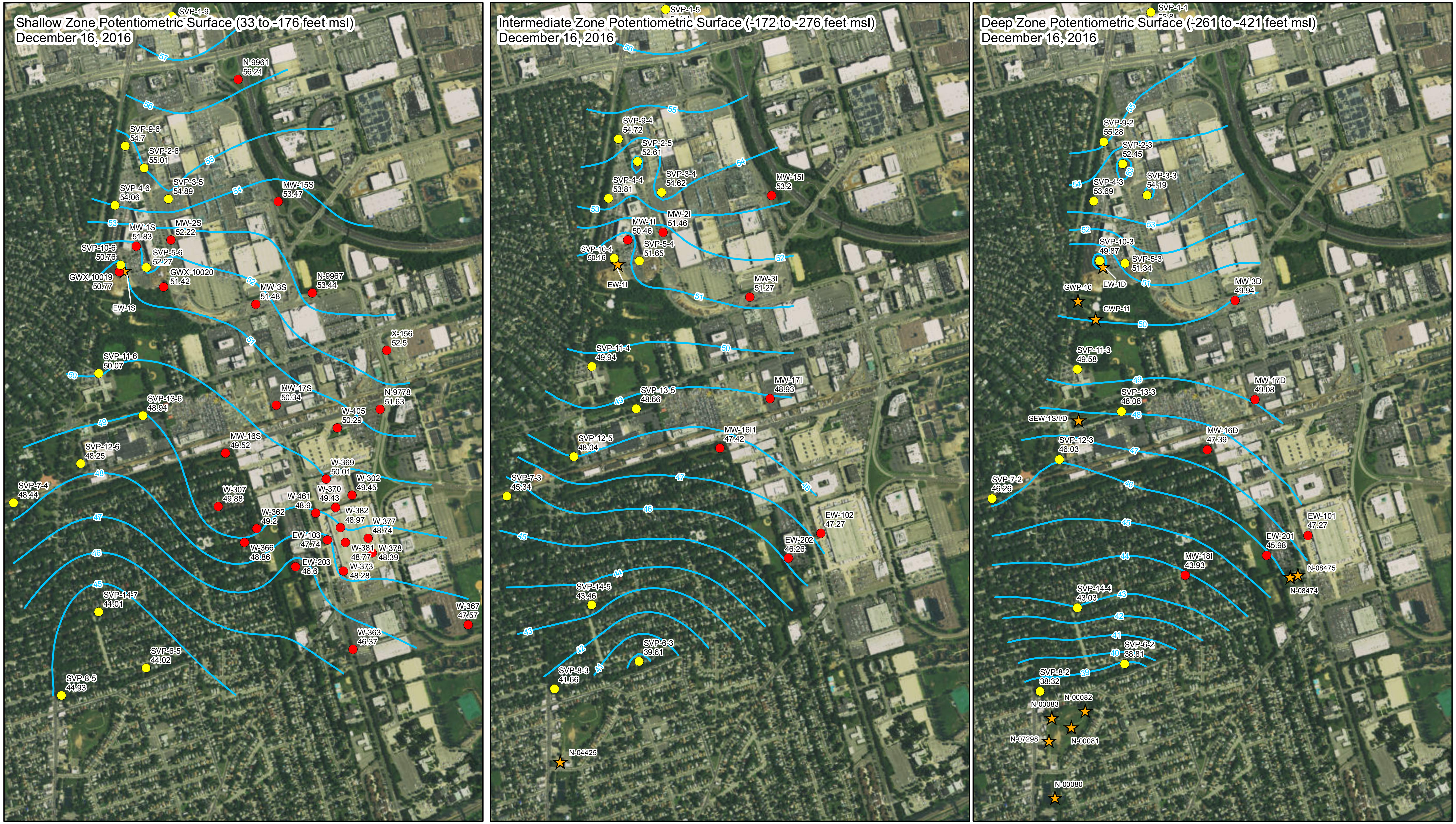
Notes:
1. Only wells used to create each potentiometric surface are displayed. The water level data used to create the potentiometric surface are posted next to each well.
2. Water levels at N-9778 and wells with "W" and "EW" prefixes were measured by Nassau County on November 18, 2014 during a concurrent synoptic measurement event.
3. Water level data could not be collected from SVP-1 due to localized flooding.
4. Potentiometric surface contours in feet above mean sea level (msl), NAVD88 datum.

N

1,000 500 0 1,000 Feet

Figure 1-5a
Shallow, Intermediate, and Deep Zone Potentiometric Surface Maps, November 2014
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York

CDM Smith



- Conventional Well
- Multiport Well
- Extraction/Supply Wells
- Potentiometric Surface (ft msl)

Notes:
1. Only wells used to create each potentiometric surface are displayed. The water level data used to create the potentiometric surface are posted next to each well.
2. Water levels at N-9778 and wells with "W" and "EW" prefixes were measured by Nassau County on December 16, 2016 during a concurrent synoptic measurement event.
3. Potentiometric surface contours in feet above mean sea level (msl), NAVD88 datum.

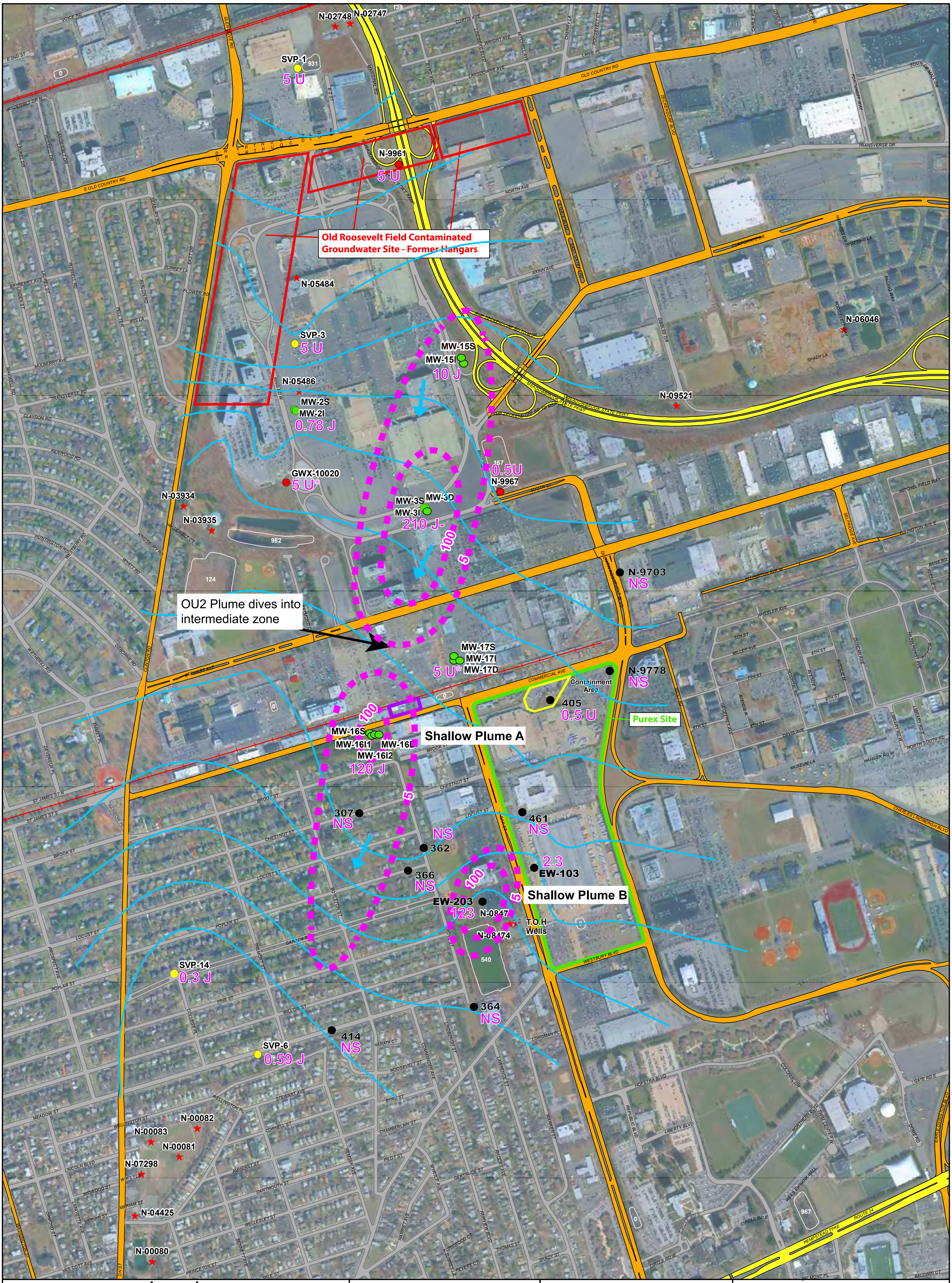
N

1,000 500 0 1,000 Feet

Figure 1-5b
Shallow, Intermediate, and Deep Zone Potentiometric Surface Maps, December 2016
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York

CDM Smith

TOMASELLIT
\\nysvr1\R2R2 Community Folder\WA 047 - RIFS Old Roosevelt Eastern Plume\RI Report\Reports-Presentations\Figures\GIS Source Files\IMS\GIS\Roosevelt\MXD\RI Report\Figure_3-6b_Potentiometric_Surface_Maps_2016.mxd 4/6/2017



Legend

- Monitoring Wells (12/2016)
- Existing Multi-port Well (12/2016)
- Existing Nassau County Well (12/2016)
- Existing Nassau County Well (11/2016)
- Public Supply Well
- Pasley Site
- Groundwater elevation contour
- PCE Plume Isocontour
- 0.5U Sample Result
- * detection limit is 0.5 µg/L
- NS not sampled
- Railroad
- Recharge Basins
- Purex Site
- Purex Site Containment Area

N

0 80 160 320 480 640 800 Feet

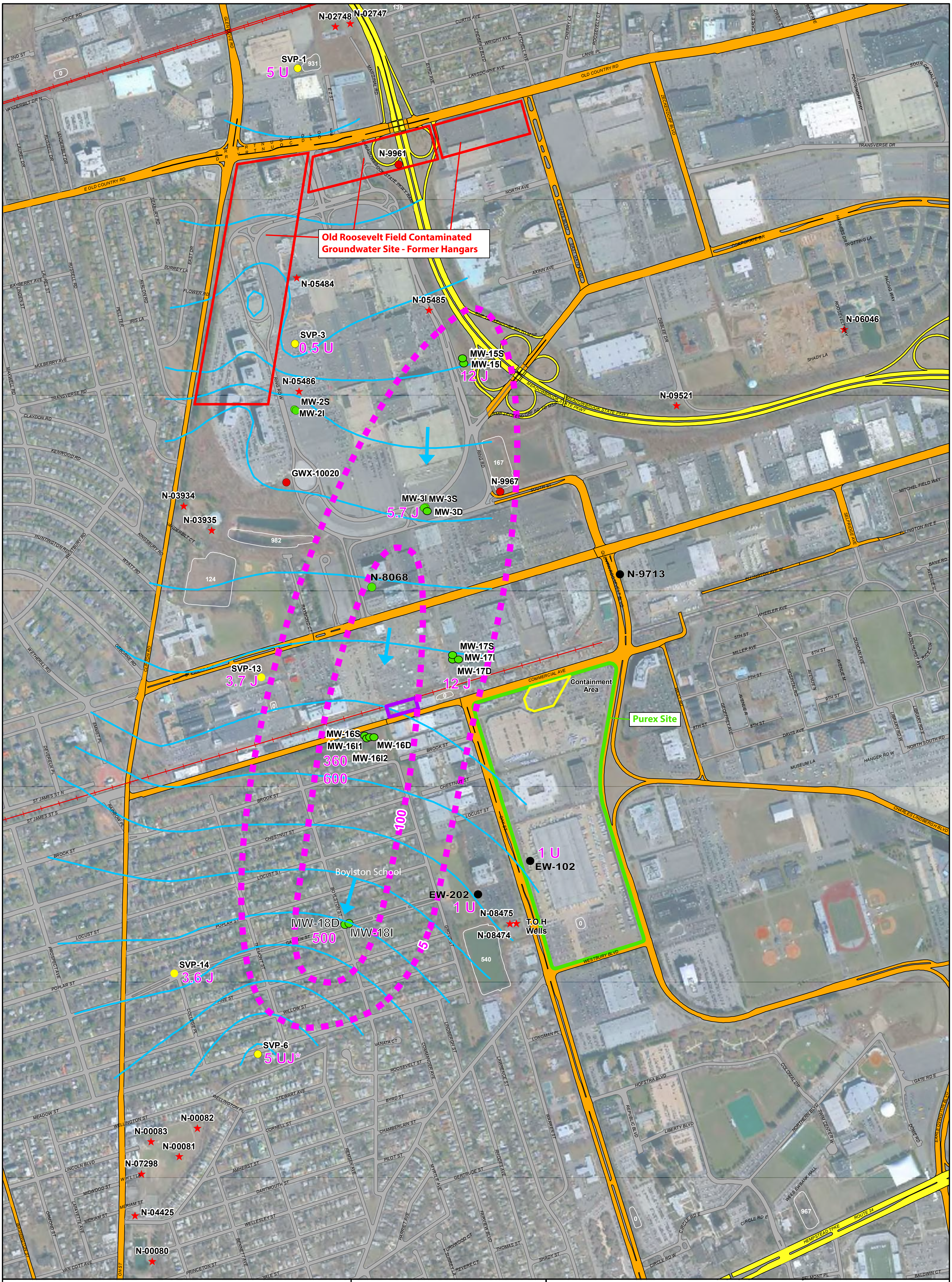
CDM Smith

Source: Nassau County Geographic Information System

Well ID	Screen or Port Depth (ft bgs)
SVP-1	103/port 9
SVP-3	103/port 6
SVP-6	105/port 5
SVP-14	100/port 9
MW-2S	236-246
MW-3S	234-244
MW-15S	160-170
MW-16S	125-135
MW-17S	85-95
GWX-10020	185-190
N-9961	48-54
N-9967	48-54
9703	96-106
9778	72-82
307	100-110
362	104-114
364	102-112
366	105-115

Well ID	Screen or Port Depth (ft bgs)
405	204-214
414	124-134
461	161-171
EW-103	229-239
EW-203	219-229

Figure 1-6a
Shallow Zone (<250 feet bgs)
PCE Isocontour Map 2016
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York



Legend

- PCE Plume Isocontour
- 0.5U Sample Result
- Railroad
- Recharge Basins
- Purex Site
- Purex Site Containment Area
- Monitoring Wells (12/2016)
- Existing Multi-port Well (12/2016)
- Existing Nassau County Well (12/2016)
- Existing Nassau County Well (11/2016)
- Public Supply Well
- * detection limit is 0.5 µg/L
- Groundwater elevation contour
- Pasley Site

Well ID	Screen or Port Depth (ft bgs)
SVP-1	293/port 5
SVP-3	293/port 4
SVP-6	250/port 3
SVP-13	295/port 5
SVP-14	300/port 5
MW-3I	304-314
MW-15I	340-350
MW-16I1	340-350
MW-16I2	365-375
MW-17I	340-350
MW-18I	394-404
9713	208-218
8068	265-291
EW-202	337-347
EW-102	288-298

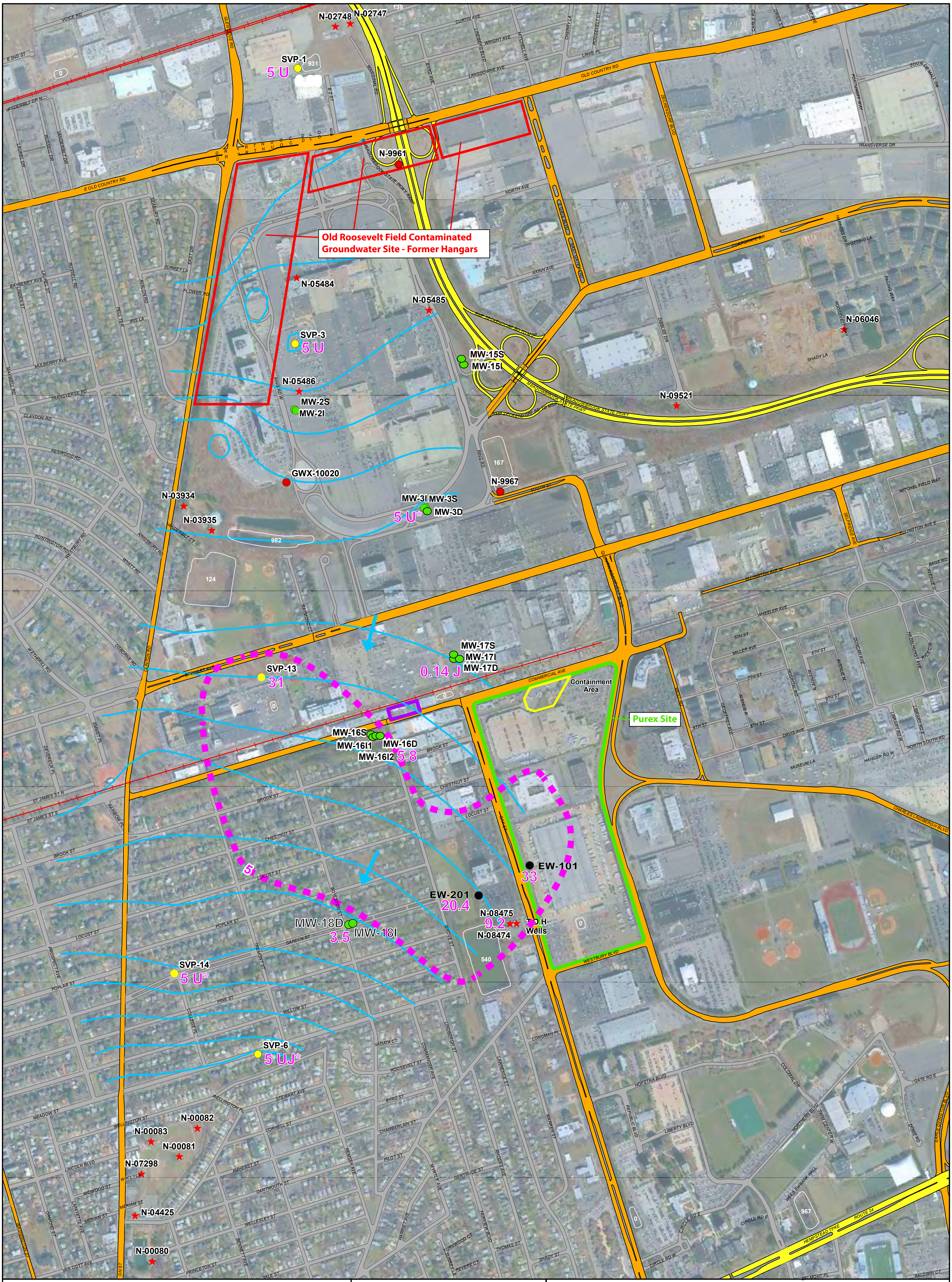
N

0 80160 320 480 640 800 Feet

Figure 1-6b
Intermediate Zone (250 - 400 feet bgs)
PCE Isocontour Map 2016
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York

CDM Smith

Source: Nassau County Geographic Information System



Legend

- PCE Plume Isocontour
- 0.5U Sample Result
- Railroad
- Recharge Basins
- Purex Site
- Purex Site Containment Area
- Monitoring Wells (12/2016)
- Existing Multi-port Well (12/2016)
- Existing Nassau County Well (12/2016)
- Existing Nassau County Well (11/2016)
- Public Supply Well
- * detection limit is 0.5 µg/L
- Groundwater elevation contour
- Pasley Site

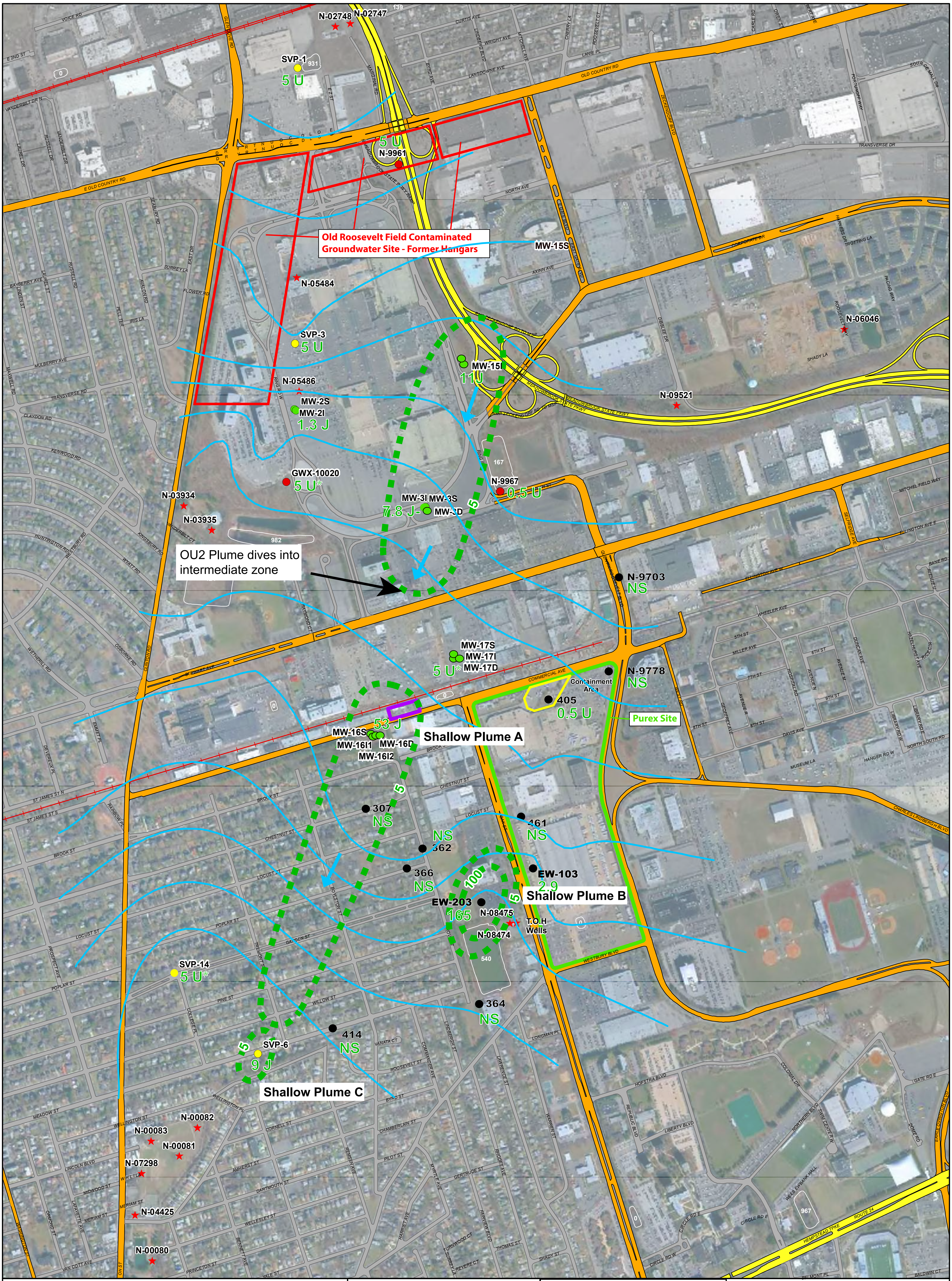
Well ID	Screen or Port Depth (ft bgs)
SVP-1	450/port 1
SVP-3	450/port 1
SVP-6	447/port 1
SVP-13	405/port 3
SVP-14	410/port 3
MW-3D	490-500
MW-16D	400-410
MW-17D	430-440
MW-18D	480-490
N-08475	409-481
EW-101	374-384
EW-201	416-426

CDM Smith

Source: Nassau County Geographic Information System

0 80 160 320 480 640 800 Feet

Figure 1-6c
Deep Zone (>400 feet bgs)
PCE Isocontour Map 2016
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York



Well ID	Screen or Port Depth (ft bgs)
SVP-1	103/port 9
SVP-3	103/port 6
SVP-6	105/port 5
SVP-14	100/port 9
MW-2S	236-246
MW-3S	234-244
MW-15S	160-170
MW-16S	125-135
MW-17S	85-95
GWX-10020	185-190
N-9961	48-54
N-9967	48-54
9703	96-106
9778	72-82
307	100-110
362	104-114
364	102-112
366	105-115

Well ID	Screen or Port Depth (ft bgs)
405	204-214
414	124-134
461	161-171
EW-103	229-239
EW-203	219-229

Figure 1-7a
Shallow Zone (<250 feet bgs)
TCE Isocontour Map 2016
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York

CDM Smith
Source: Nassau County Geographic Information System

Legend

- Plume Isocontour
- 0.5U Sample Result
- Railroad
- Recharge Basins
- Purex Site
- Purex Site Containment Area
- Monitoring Wells (12/2016)
- Existing Multi-port Well (12/2016)
- Existing Nassau County Well (12/2016)
- Existing Nassau County Well (11/2016)
- Public Supply Well
- * detection limit is 0.5 µg/L
- Groundwater elevation contour
- Pasley Site

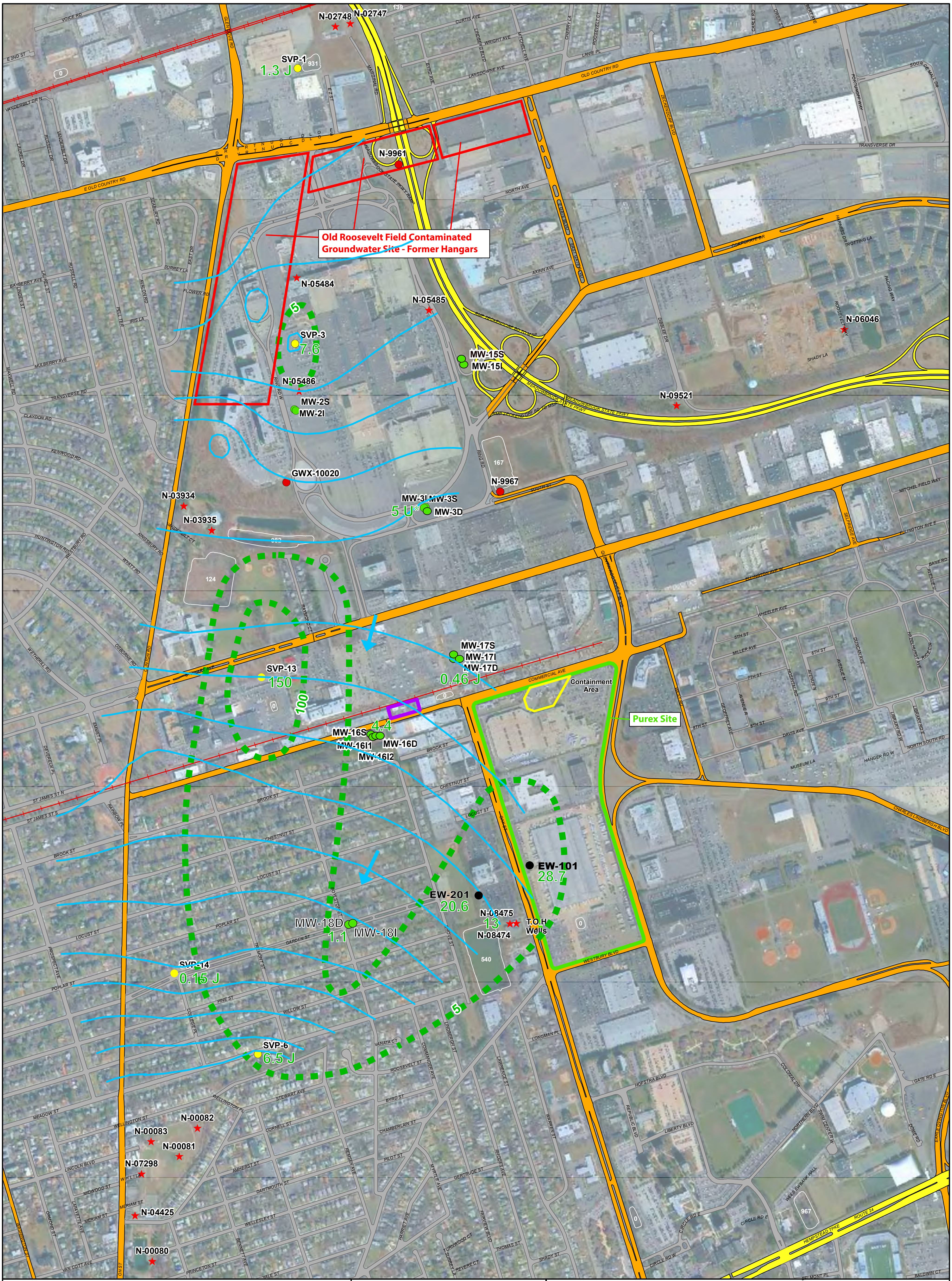
Well ID	Screen or Port Depth (ft bgs)
SVP-1	293/port 5
SVP-3	293/port 4
SVP-6	250/port 3
SVP-13	295/port 5
SVP-14	300/port 5
MW-3I	304-314
MW-15I	340-350
MW-16I1	340-350
MW-16I2	365-375
MW-17I	340-350
9713	208-218
8068	265-291
EW-202	337-347
EW-102	288-298

0 80 160 320 480 640 800 Feet

Figure 1-7b
Intermediate Zone (250 - 400 feet bgs)
TCE Isocontour Map 2016
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York

CDM Smith

Source: Nassau County Geographic Information System



Legend

- TCE Plume Isocontour
- 0.5U Sample Result
- Railroad
- Recharge Basins
- Purex Site
- Purex Site Containment Area
- Monitoring Wells (12/2016)
- Existing Multi-port Well (12/2016)
- Existing Nassau County Well (12/2016)
- Existing Nassau County Well (11/2016)
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Well ID	Screen or Port Depth (ft bgs)
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SVP-14	410/port 3
MW-3D	490-500
MW-16D	400-410
MW-17D	430-440
N-08475	409-481
EW-101	374-384
EW-201	416-426

0 80 160 320 480 640 800 Feet

Figure 1-7c
Deep Zone (>400 feet bgs)
TCE Isocontour Map 2016
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York

CDM Smith

Source: Nassau County Geographic Information System

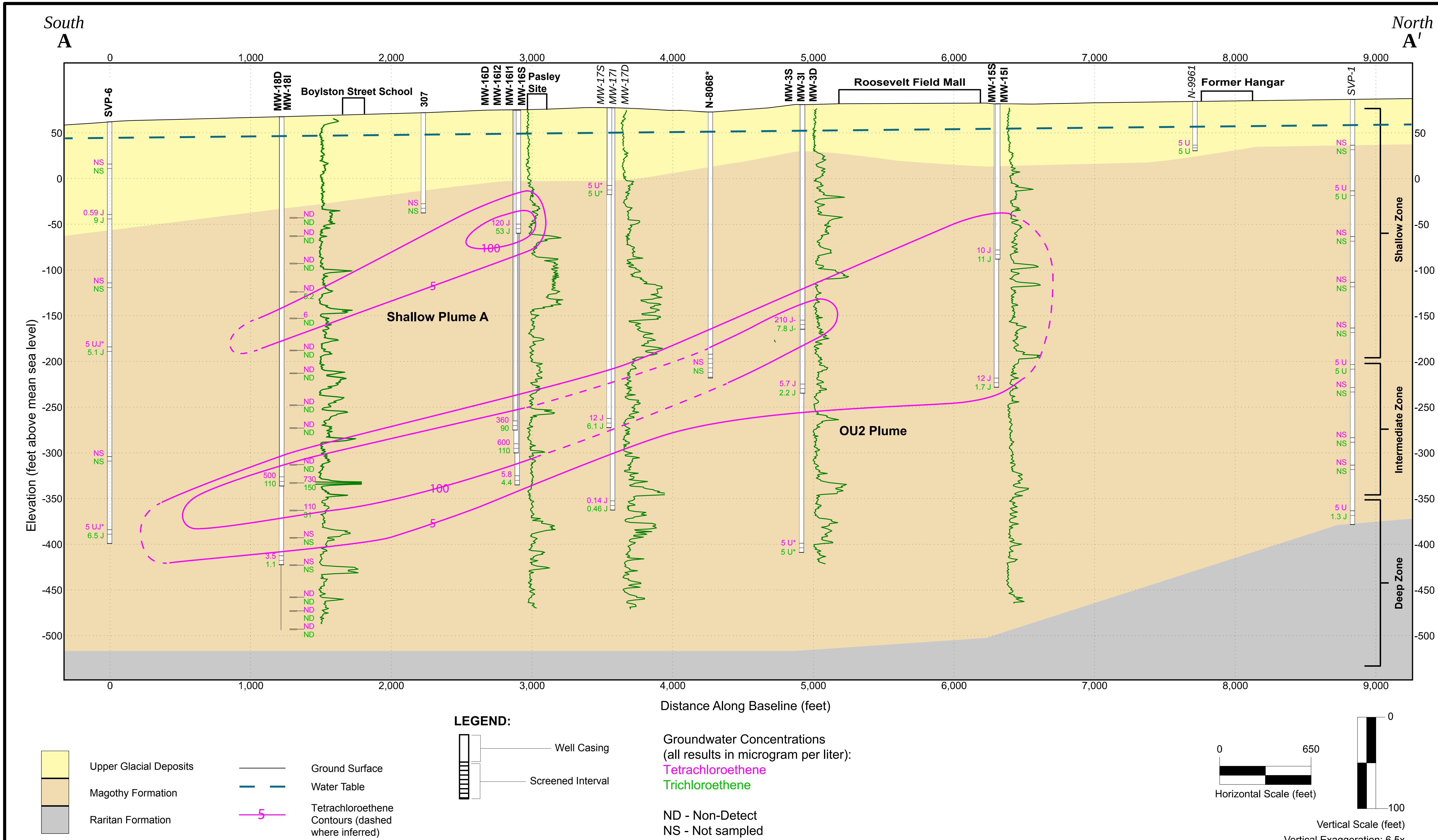
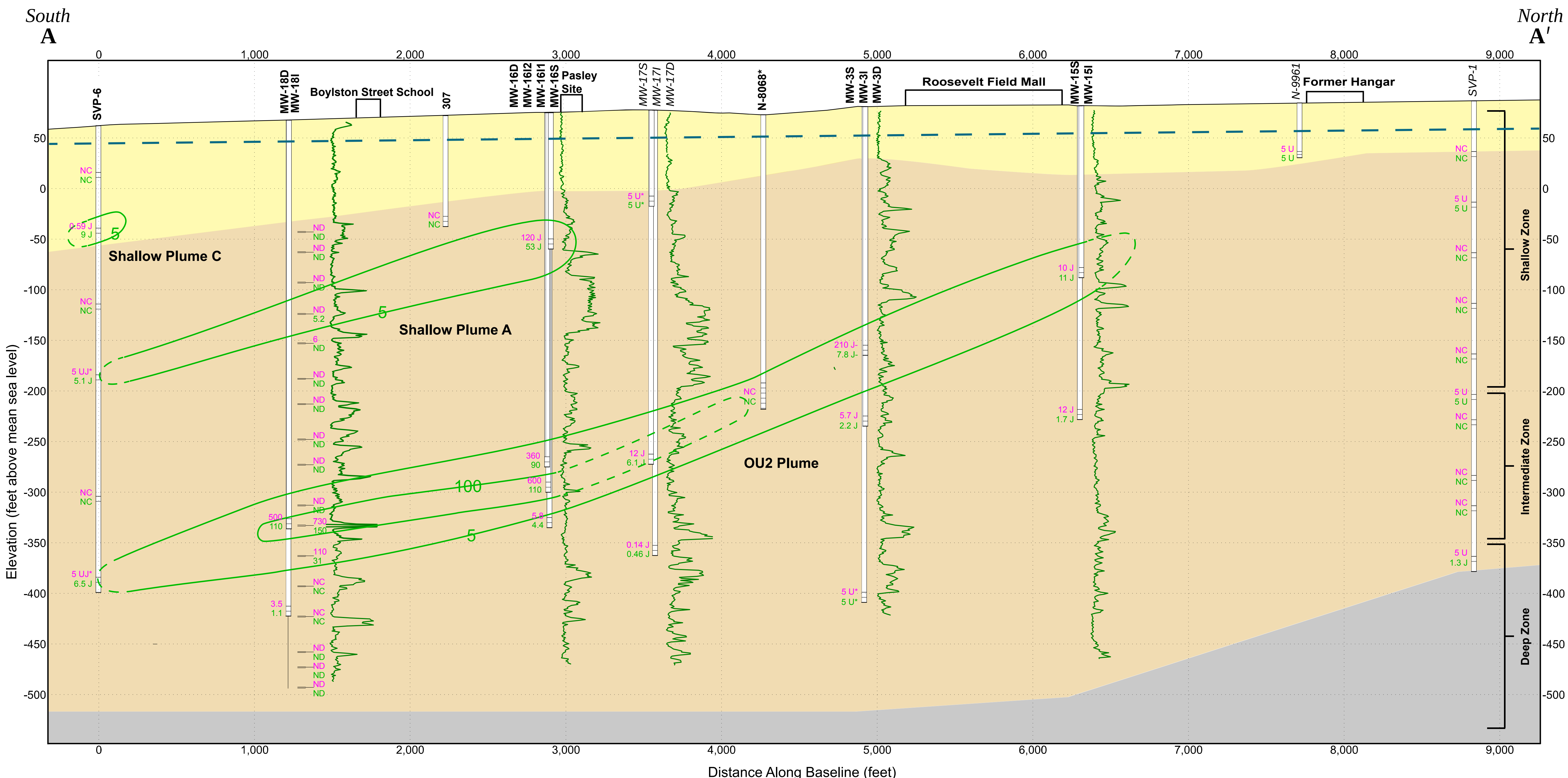


Figure 1-8a
PCE Cross Section 2016
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York



LEGEND:

Upper Glacial Deposits

Magothy Formation

Raritan Formation

Ground Surface

Water Table

Trichloroethene Contours (dashed where inferred)

Natural Gamma Log (0-130 counts per second)

Well Casing

Screened Interval

N-8068* Well abandoned November 2014

Groundwater Concentrations
(all results in microgram per liter):
Trichloroethene
Tetrachloroethene

ND - Non-Detect
NC - Not collected
U - Not Detected, detection limit is value to left
J - Estimated Concentration
* - detection limit is 0.5 µg/L
MW-17S - italicized well are projected onto cross section

Horizontal Scale (feet) 0 650

Vertical Scale (feet) 0 100

Vertical Exaggeration: 6.5x

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Figure 1-8b
TCE Cross Section 2016
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York

STANDARD CROSS SECTION: ORF OU2 ORF OU2.GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 2/6/15 REV.

angellja R:\101995_RooseveltField\02_MXD\OU2\RemedialAlternative_1.mxd 4/21/2017

Legend

- Monitoring Well
- Extraction Well
- Nassau County Monitoring Well
- Multi-port Well
- Municipal Supply Well
- PCE OU2 Isocontour Inferred
- Purex Site
- Purex Site Containment Area

N

Feet
0 200 400 800

Figure 3-1
Proposed Layout for Alternative 2
Pump and Treat
Old Roosevelt Field Contaminated
Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York

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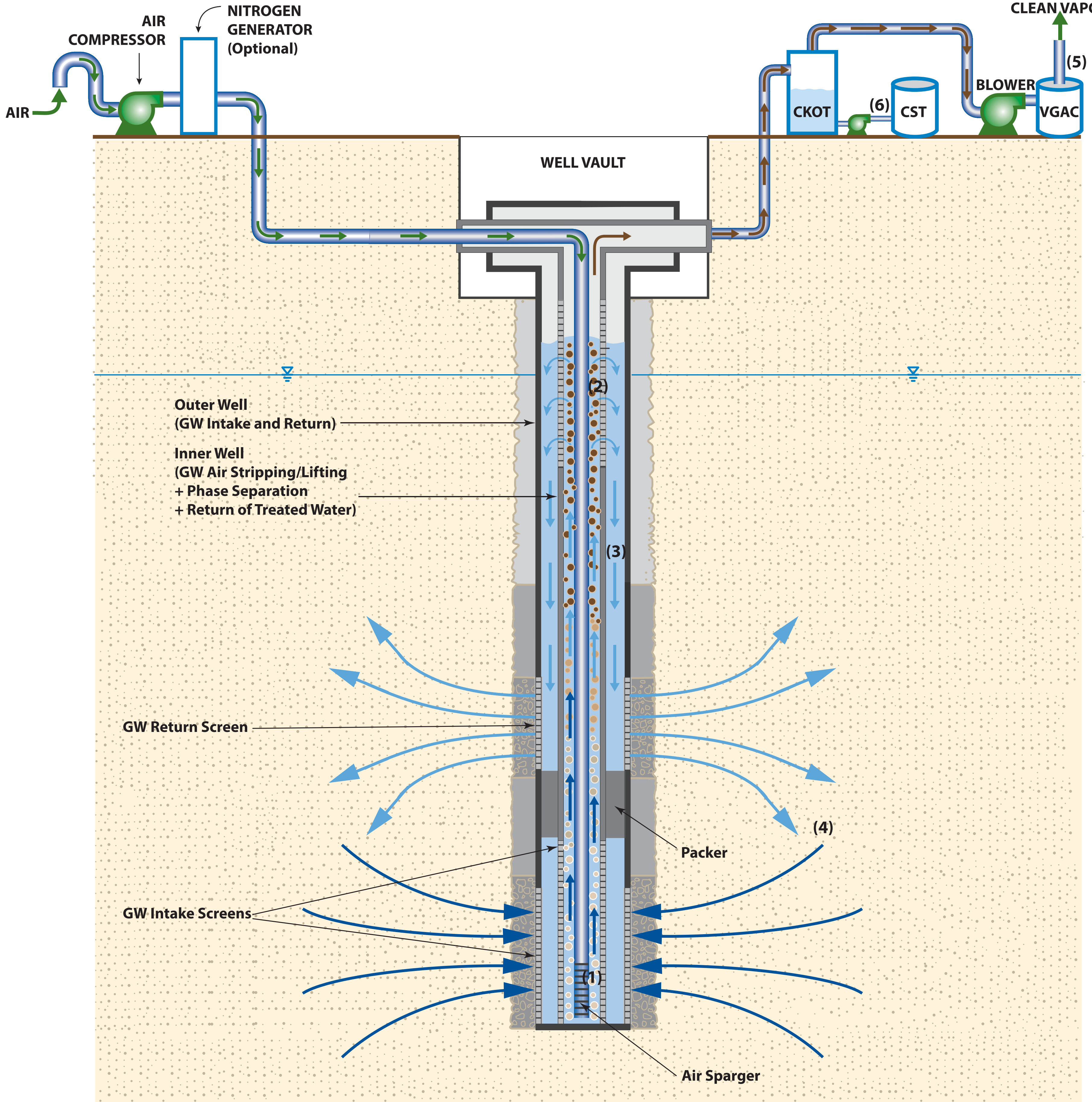

NOT TO SCALE

Key System Components:

Outer Well - consists of two screened sections. The two screens are separated by a solid riser pipe and seal and grout outside the riser. The lower screen is located across the target groundwater contamination zone. The upper screen is located near or above the top of the contamination zone.

Inner Well - consists of two screened sections. The lower screen stretches from the bottom of the outer well to above the top of the lower screen of the outer well. The upper screen stretches from several feet below the native water table to a few feet below the ground surface as necessary.

Packer - separates the incoming contaminated groundwater and the treated water inside the outer well.

Air Sparger - consists of an air diffuser tube located at the bottom of the inner well and is connected to a compressed air (or nitrogen) line from above ground. The air injected through this tube provide the lifting mechanism for drawing groundwater into the wells, it also provide stripping effect for transferring the contaminants from groundwater to vapor phases. Additional air sparger could be installed as necessary to ensure the effectiveness of in well stripping.

Above-ground Equipment - consists of an air compressor (high pressure), a nitrogen source as necessary, a vacuum blower, vapor phase granular activated carbon (VGAC), a condensate knock-out tank (CKOT) and a condensate storage tank (CST). The above-ground equipment will be housed in a building away from the wells.

Process Description:

(1) Compressed air or nitrogen is injected and sparged inside the inner well near the bottom. This creates an upward movement of the water within the inner well due to the air lift mechanism, while concurrently resulting in the air stripping of VOCs from the impacted groundwater. As the water moves upwards through the inner well, makeup volume of water is drawn into the bottom screen of the outer well and through the bottom screen of the inner well.

(2) As the air water mixture climbing up the inner well reaches the upper screen of the inner well, air water phase separation starts. The water phase starts moving radially outwards into the annular space between the outer and the inner wells. This also creates a net rise in the water level or head within the annual space compared to the static water table in the formation. The vapor phase continues to move upwards under the draw of the applied vacuum at the top of the well by the blower.

(3) Treated water that found its way into the annular space of the outer casing continues to move downwards and discharge to the aquifer due to rise in water level or head in the annual space and potentially due to the draw down cased by the inward flow from the bottom screen.

(4) The packer situated at the top of the lower screen of the inner well (also the bottom of the upper screen of the outer well), plays the key role in facilitating and continually directing the flow of water in and through the in-well vapor stripper and back out into the formation and creating a groundwater circulation pattern, without impacting the regional groundwater flow regime.

(5) At the top of the inner well, as the treated water moves radially outwards into the annular space, the air stripped vapors continue to move upwards under the draw of the applied vacuum, first through the CKOT, then past the blower and finally through the VGAC which takes out the organic contaminants before the clean air is released to the atmosphere.

(6) Condensate removed by the CKOT from the vapor stream will be contained in the CST and properly disposed.

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Figure 3-2
Conceptual Configuration of Groundwater Circulation
Well/In-Well Stripping System
Old Roosevelt Field Contaminated Groundwater Site
Operable Unit 2 - Eastern Plume
Garden City, Nassau County, New York

Legend

- Monitoring Well
- Extraction Well
- Nassau County Monitoring Well
- Multi-port Well
- Municipal Supply Well
- Groundwater Circulation Well (GCW)/In-Well Stripping System
- PCE OU2 Isocontour Inferred
- Purex Site
- Purex Site Containment Area

N

Feet
0 200 400 800

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Figure 3-3
Proposed Layout for Alternative 3
In-Well Stripping
Old Roosevelt Field Contaminated
Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York

Legend

- Monitoring Well
- Extraction Well
- Nassau County Monitoring Well
- Multi-port Well
- Municipal Supply Well
- PCE OU2 Isocontour Inferred
- Purex Site
- Purex Site Containment Area

N

Feet
0 200 400 800

Figure 3-4
Proposed Layout for Alternative 4
In-Situ Adsorption
Old Roosevelt Field Contaminated Groundwater Site
OU2 - Eastern Plume
Garden City, Nassau County, New York

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Appendix A

Appendix A

Groundwater Model Memorandum

Contents

Figures

Tables

Introduction

This memo describes the analysis and simulation of proposed extraction wells to address groundwater contamination found in Operable Unit 2 (OU2) of the Old Roosevelt Field (ORF) Contaminated Groundwater Site. The determination of the location, vertical screen length and pumping rate required to capture the areas of high detections identified at groundwater wells is detailed below.

Tetrachloroethene (PCE) and trichloroethene (TCE) have been detected at levels near or above 100 parts per billion (ppb) in groundwater wells MW-16I2, MW-16I1, and MW-18I at the ORF OU2, shown on Figure 1. The PCE and TCE detections are within the zone of capture for the Hempstead Village public supply wells. The proposed remedy will capture the area of highest detections and reduce migration of contamination to the public water supply wells.

Groundwater Modeling

A groundwater flow and transport model was adapted from the existing groundwater model developed for the western portion of the ORF plume (OU1).

The Old Roosevelt Field groundwater model was previously calibrated to measured groundwater head data collected on-site in April and July 2006 and was initially used to evaluate various alternatives for the OU1 FS. The development of the groundwater model was documented in a technical memorandum dated August 13, 2007, included as Appendix A of the OU1 FS (CDM Smith 2007c).

An aquifer test conducted in 2010 was used to verify the groundwater model and adjustments in model properties were made (CDM Smith 2011). Model calibration was not verified with additional synoptic groundwater head data since post-2009 water supply pumping was not yet available at the time and pumping from nearby supply wells could influence head at the Site. Rather, the model was verified during the aquifer test simulation by comparing head changes at various wells/ports in response to pumping the extraction well system.

During the spring of 2012, the ORF groundwater model was used for preliminary evaluation of the location and extraction rates of a set of extraction wells to capture contamination that has migrated south of the Garden City supply wells GWP-10 and GWP-11. As part of that effort, model discretization was enhanced through the incorporation of 5 additional levels and more than 3,700 nodes (CDM Smith 2012).

The model was updated to evaluate capture zones for the 2012 through 2016 OU1 Annual Reports by incorporating additional water supply pumping data and recharge. The groundwater model was run in a transient fashion for these annual reports, simulating the anticipated capture zones since the extraction systems were put into operation. Groundwater head data were collected at several multiport and conventional monitoring wells and used for model verification.

For the OU2 FS, a few additional nodes were added near the proposed extraction well location. In order to simulate the long-term impact of the OU2 extraction wells on the groundwater flow paths in the area, steady-state pumping conditions were simulated. This approach is similar to the one used for the design of the OU1 extraction system so that long-term capture is understood to properly design the screen intervals and pumping rates of the system. The finite element grid used for the simulations is shown in Figure 2. Model stratigraphy and associated hydraulic properties are summarized in Table 1.

Table 1 - Model Layer Hydraulic Properties, Descriptions, Elevations, and Thickness near MW-18

Model Layer	K_h (ft/day)	K_v (ft/day)	Unit Name	Model Elevation (ft)	Model Thickness (ft)
17, 18	200	20	Upper Glacial	64 to 1	63
16	60	0.6	Upper Magothy	1 to -100	101
7 to 15	40	0.7	Middle Magothy	-100 to -385	285
3 to 6	80	1.2	Basal Magothy	-385 to -523	138
2	0.3	0.0001	Raritan Clay	-523 to -691	168
1	40	4	Lloyd	-691 to -943	252

Baseline Groundwater Conditions

The groundwater model simulations were conducted under steady-state conditions, using average industrial pumping, public water supply pumping and recharge from precipitation for the 10 year period from 2007 through 2016. The average pumping rate for 2016 was used to simulate the operation of the OU1 extraction wells, EW-1 and SEW-1.

Precipitation data from the National Oceanic and Atmospheric Administration (NOAA) for the Floral Park station was used to calculate recharge for the groundwater model. Annual precipitation at the Floral Park station for 2016 is 42.24 inches per year which is slightly lower compared to the long-term average annual precipitation of 44.5 inches per year at the Mineola station (1949-2010; no longer in service).

Groundwater flow patterns in the ORF OU2 area are largely controlled by withdrawals from the major water suppliers, Hempstead Village and Garden City.

Figure 3 shows the simulated steady-state groundwater contours for the water table on the left and at model level 8, an elevation of approximately -350 ft, located just below the MW-18I screen, shown on the right. The aquifer head is shown as groundwater contour lines (blue for the water table and light blue for level 8). The lines are shown in 2 foot increments. Groundwater flow is perpendicular to the groundwater contour lines. At the water table, groundwater generally flows south-south west as shown as a black arrow on the figure. There is a mound of water from the discharge of OU1 to the recharge basin between SEW-1 and EW-1. At level 8, the influence of the Garden City and the Hempstead Village water supply wells (bottom edge of figure) is shown as closely spaced lines which represent the cones of depression associated with each of the pumping locations. Groundwater flow near MW-18 is slightly more southwest at this depth and flows towards the Hempstead Village wells.

Figure 4 shows the simulated contributing areas under steady-state average pumpage for the public water supply wells at elevations of -250 ft and -400 ft msl. The contributing areas were run for a period of 20 years (under assumed steady-state conditions). These depths were chosen based on the high detections of PCE and TCE in MW-16I1, MW-16I2 and MW-18I. The colored shades show the area at each depth that would be captured with the associated wells if pumping remains consistent to the steady-state conditions in the future. Groundwater at MW-18, MW-16 and MW-17 would be captured by the Hempstead Village wells (purple shading). PCE and TCE at MW-3 is/would be captured by the Garden City wells (blue shading) or the OU2 SEW-1 well (red shading) depending on the depth of the contaminant.

The steady-state simulated groundwater flow field should not be used to predict location of the source of the detections of PCE and TCE in the groundwater. The flow field does not reflect historical changes in the local groundwater conditions including the increases in water withdrawals associated with regional population growth, the operation of the OU1 extraction system, the operation of the Garden City and Hempstead systems, industrial pumping and historical pumping at the Purex site located to the east of MW-16 and MW-18.

As shown on Figure 4, the MW-03 cluster is on the fringe of the capture area to the Garden City supply wells (light blue). As evident in the aquifer test and continuous water level data that were collected in 2010, it is evident that MW-3I is influenced by the Garden City supply wells and perhaps Roosevelt Field well 7 (N-09521) to some degree (Figure 5). Therefore, contamination in MW-03 is likely at least partially captured by the Garden City supply wells.

Particle tracks for wells with high PCE/TCE detections are shown in Figure 6. Mass at MW-15S, MW-15I, MW-3S and MW3I are within the capture zone for the Garden City and OU1 SEW well. Mass at MW-18, MW-16 and MW-17 are within the capture zone for the Hempstead wells.

Proposed Extraction Well

An extraction well was simulated near MW-18 to capture contamination before further migration to the Hempstead Village supply wells. This well is located in the median of Garden Street, west of MW-18 between Tremont Street and Boylston Street, shown on Figure 7. The simulated well was screened from -300 ft to -350 ft msl in the middle portion of the Magothy aquifer. Treated water is simulated to be discharged at the stormwater recharge basin located at east of Grove Street between Pine Street and Meadow Street. The impact of various pumping rates, screen lengths and locations for this proposed OU2 extraction well were simulated along with steady-state groundwater withdrawal and recharge rates. The analysis focused on addressing groundwater contamination detected at MW-18I at an elevation of approximately -325 ft msl and shallower detections upgradient of MW-18 in MW-16I2 and MW-16I1 at elevations of between -250 and -300 ft msl. Contributing areas for each simulation were plotted at elevations of -250 ft and -400 ft msl to show capture at these locations and depths. Contributing areas were run for 50 years, however the most of the water in the area of MW-16 and MW-18 reaches the proposed extraction well in less than 15 years.

Figure 8 shows contributing areas for pumping of the proposed OU2 extraction well at 300 gpm. Groundwater capture at -250 ft msl includes MW-18 south to Willow Street and north to MW-16 and MW-17. The deeper contributing area at -400 ft msl includes the deeper detections at MW-18 at extends north near to MW-16.

Contributing areas shown on Figures 4 and 8 do not reflect the time it takes for water or groundwater contamination to travel through the aquifer to the extraction well. The movement of mass through the aquifer is controlled by the groundwater flow (advection) but also dispersion, diffusion and chemical interactions. Figure 9 shows contributing areas with time of travel in 5 year increments based on an effective porosity of 0.15. This figure should not be used to determine clean-up times since it assumes that the contamination travels with groundwater flow (i.e. no retardation), there is no mass degradation, and contamination sources have been remediated. Figure 9 shows that most of the groundwater near MW-18 and MW-16 will be captured in the initial 5 to 15 years of groundwater extraction.

Groundwater north of MW-16 is not captured by the simulated OU2 extraction well. Groundwater between MW-16 and the southern OU1 extraction well capture area can reach the Hempstead Village supply wells (see purple area on Figure 8). Figure 10 shows the impacts of much larger pumping (900 gpm) that would be required to address area between MW-16, MW-17 and the southern extent of the OU1 capture zone. Although it is not certain that the recharge basin would be able to handle that flow.

Figure 11 shows the simulated results with a longer 150 ft well screen spanning both the middle and basal Magothy aquifer, from -150 to -400 ft msl. The pumping rate of 300 gpm was simulated. The simulated capture zones are narrower and longer than the simulated capture zones for the shorter screen.

Figure 12 shows the simulated results from moving the extraction location closer to MW-18 and a 300 gpm pumping rate. This scenario would reduce the piping needed to transport water to the recharge basin. This simulation shows that the capture zone and subsequent contributing area will shift to the east as compared to the previous location.

Proposed Extraction and Reinjection Wells

Simulations were conducted to evaluate the impact of withdrawal and then reinjection of treated water in the same borehole. For these simulations, water was extracted at a well screened from -315 to -375 ft msl and reinjected at the same location at elevations -225 ft to -285 ft msl. Withdrawal rates of 100 gpm and 200 gpm at the proposed OU2 extraction well were simulated. Figure 13 shows the capture zone at an elevation of -250 ft and -400 ft msl for the 100 gpm steady-state simulation for 20 years. Figure 14 shows the capture zone at an elevation of -250 ft and -400 ft msl for the 200 gpm simulation. Groundwater at MW-18 is not captured at -400 ft in either simulation. Groundwater at MW-16 at -250 ft is captured.

To improve capture width, three extraction and injection wells were simulated along Garden Street. The wells were located 400 ft west of MW-18, adjacent to MW18 and 400 ft east of MW-18. Each well was screened from -315 to -375 ft msl with water reinjected at the same location at elevations of -225 ft to -285 ft mls. Withdrawal rates of 100 gpm were simulated at each well, for a total of 300 gpm. Figure 15 shows the capture zone at elevations of -250 ft and -400 ft msl which is similar to the capture zone for the single well at 300 gpm.

Estimates of pressure increase in the aquifer due to the reinjection were estimated. These estimates are based on estimated aquifer conditions in the model and may reflect the site-specific conditions in the aquifer at the proposed location. The change in aquifer head due to the extraction and reinjection is shown in Figure 16. The increase in the aquifer pressure due to the reinjection at each well is between 2.8 to 3.4 ft. The increases in pressure do not include pressure changes due to screen design, construction or fouling. Geochemistry has a significant influence on the success of the injection well. In many cases, injection wells can foul up by introducing oxygenated water to the well as dissolved iron within the formation precipitates out. In addition, the change in head is within the aquifer. The head in the well will be higher.

Conclusions

Under existing groundwater flow conditions, detections PCE and TCE in groundwater from MW-18I, MW-16I1 and MW-16I2 will be captured by the Hempstead Village public supply wells. An extraction well placed south of MW-18 in the median of Garden Street would be able to capture groundwater and mass in the aquifer at the locations of the detections above. If a system of extraction and injection is used, three wells would be needed spread along Garden Street in order to capture mass at MW-16 and MW-18. These simulations assume that operation of the OU1 extraction system and that the Garden City and Hempstead Village withdrawals are similar to average long-term pumping rates, recharge remains constant and no additional changes in industrial or other pumping occur. Simulations conducted are intended to support the FS. Well locations and extraction rates presented herein should not be used for design. Additional simulations should be conducted to support model design including refinement of well placement (vertically and horizontally) and adjustments of pumping volumes. Design simulations should include fluctuations in the flow field due to changes in pumping and recharge.

References

CDM Smith 2007. Old Roosevelt Field Groundwater Model and Transport Simulations. Technical Memorandum, August 13, 2007.

CDM Smith. 2011. Old Roosevelt Field: Simulation of Aquifer Test and Model Refinement. Technical Memorandum, April 13, 2011.

CDM Smith. 2012. Old Roosevelt Field: Simulation of Extraction Well for Southern Portion of Groundwater Plume. Technical Memorandum, August 24, 2012.

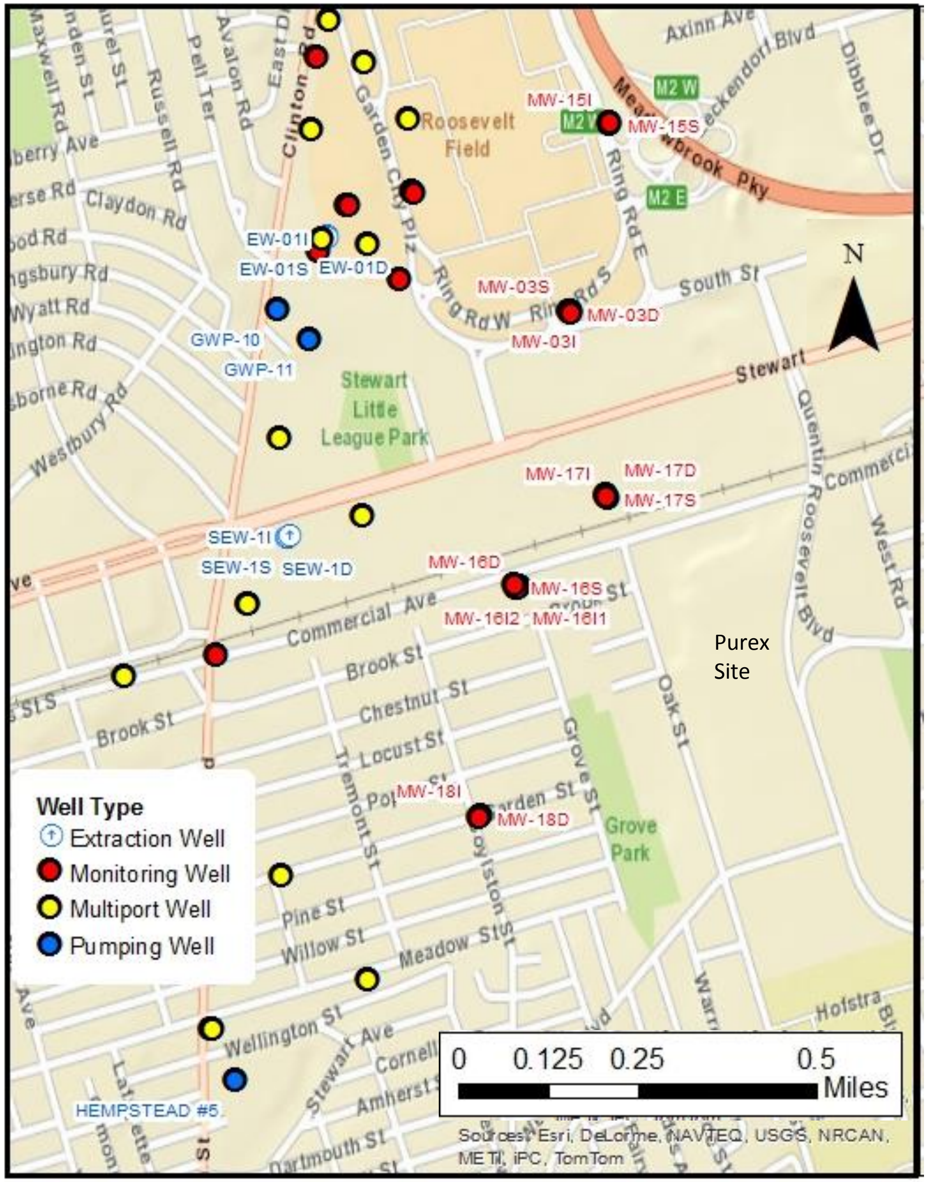


Figure 1
MW-16 and MW-18 Well Locations

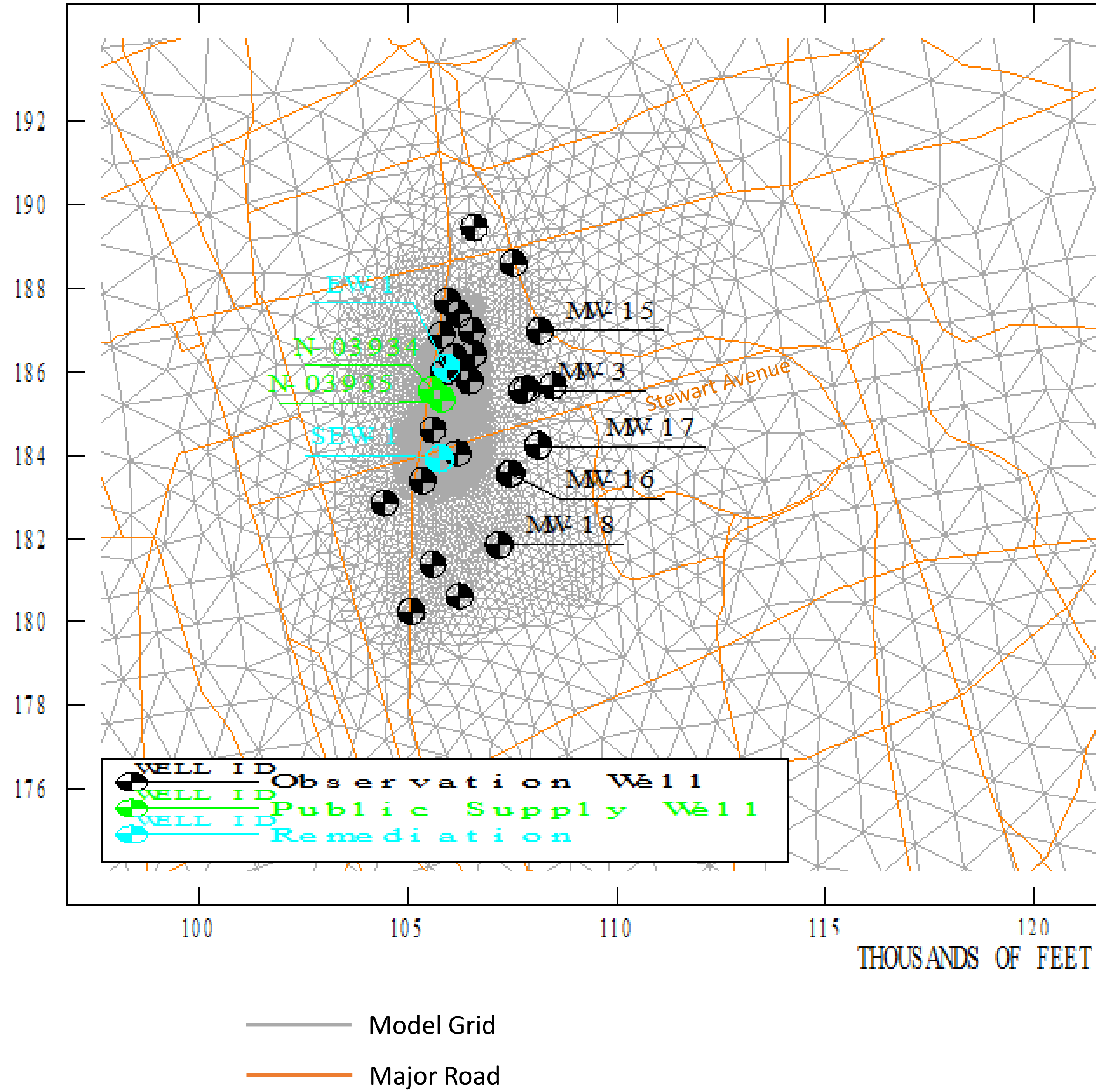
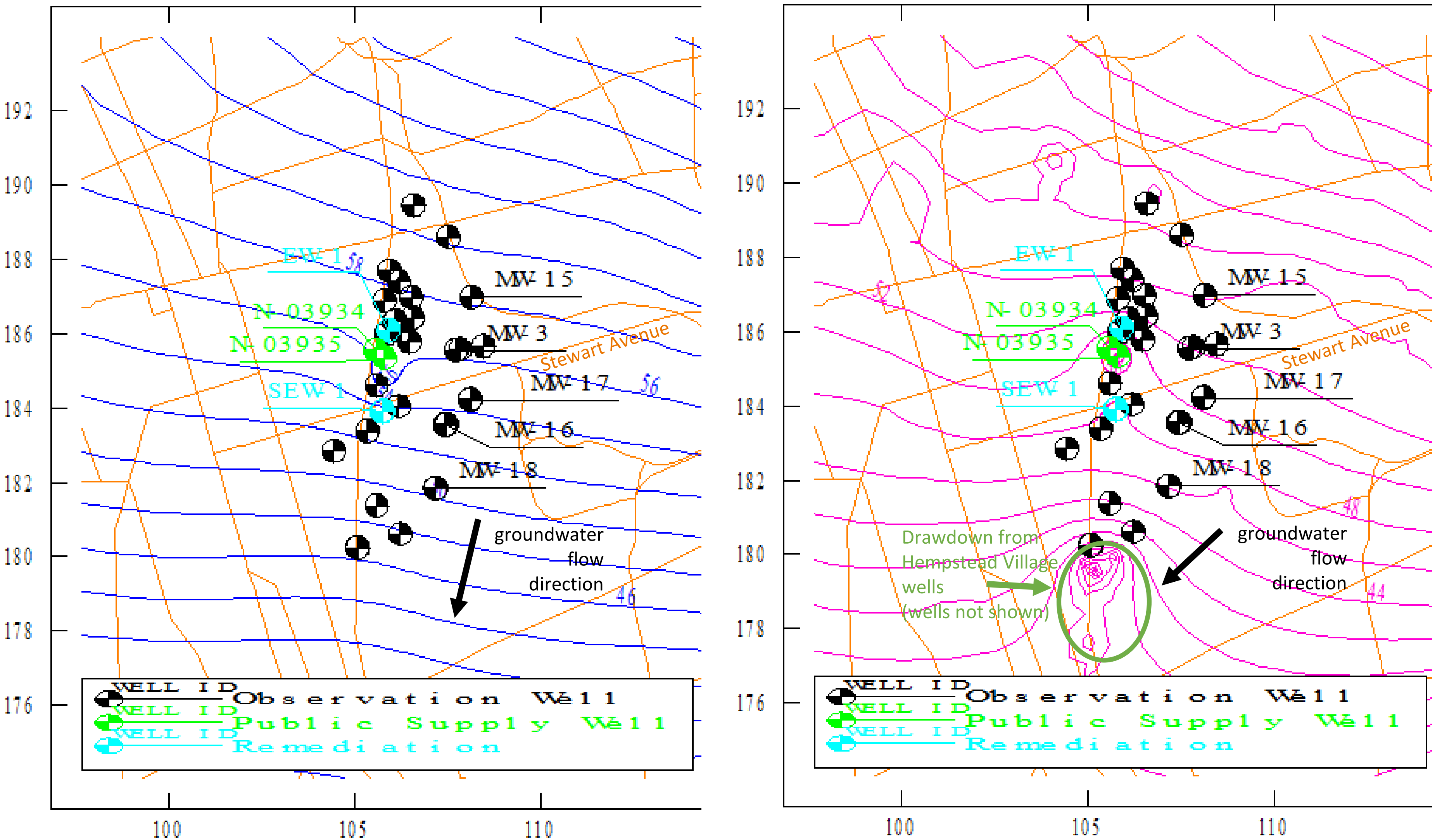


Figure 2
Model Grid near OU2



Major Road
Water Table Contour, 2 ft intervals
Groundwater Contour at approximately -350 msl, 2 ft intervals

Figure 3

Groundwater Contours for Steady-State Pumping Simulation

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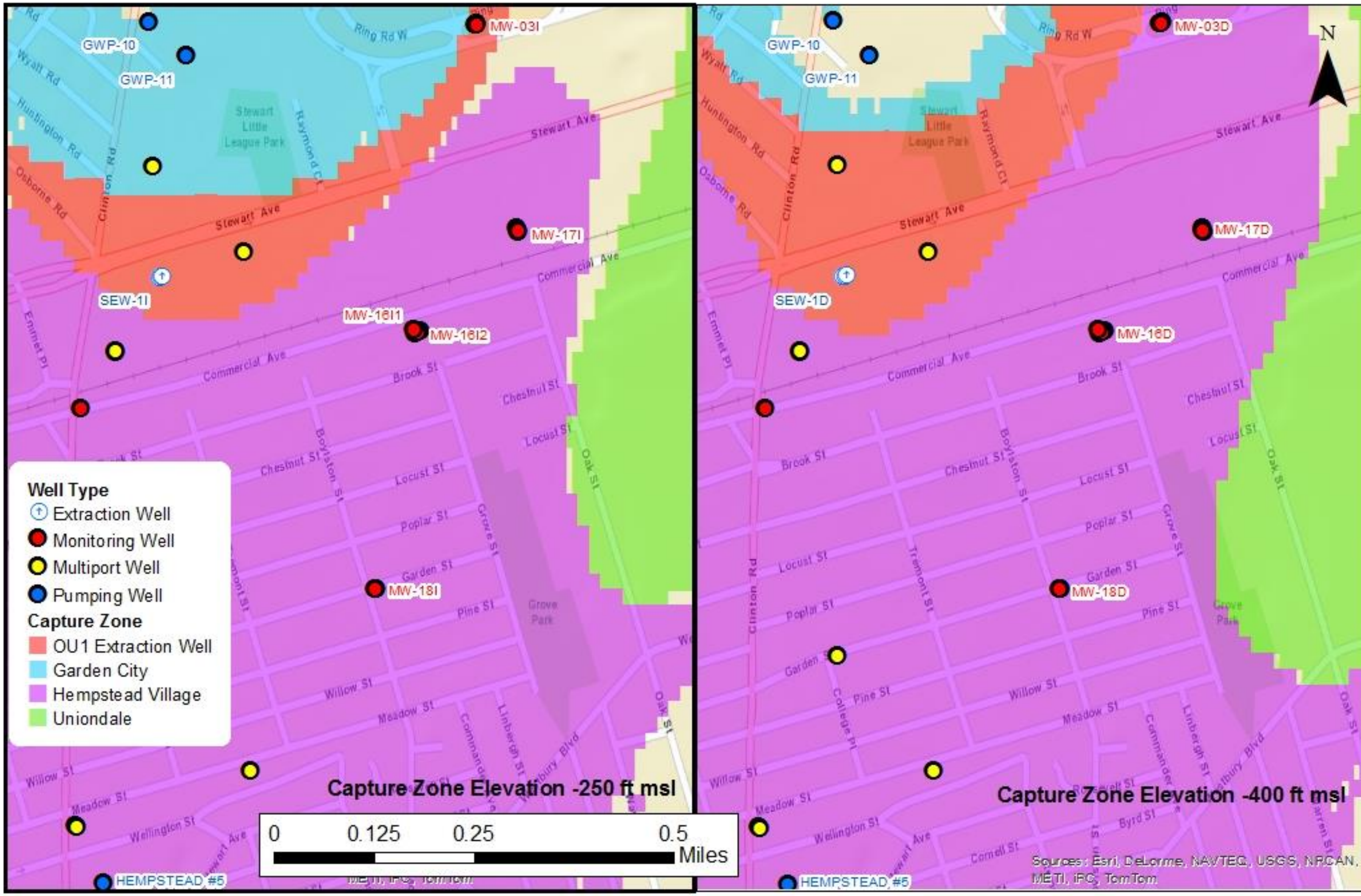

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Figure 4

Capture Zones for Steady-State Pumping Simulation, -250 ft and -400 ft msl

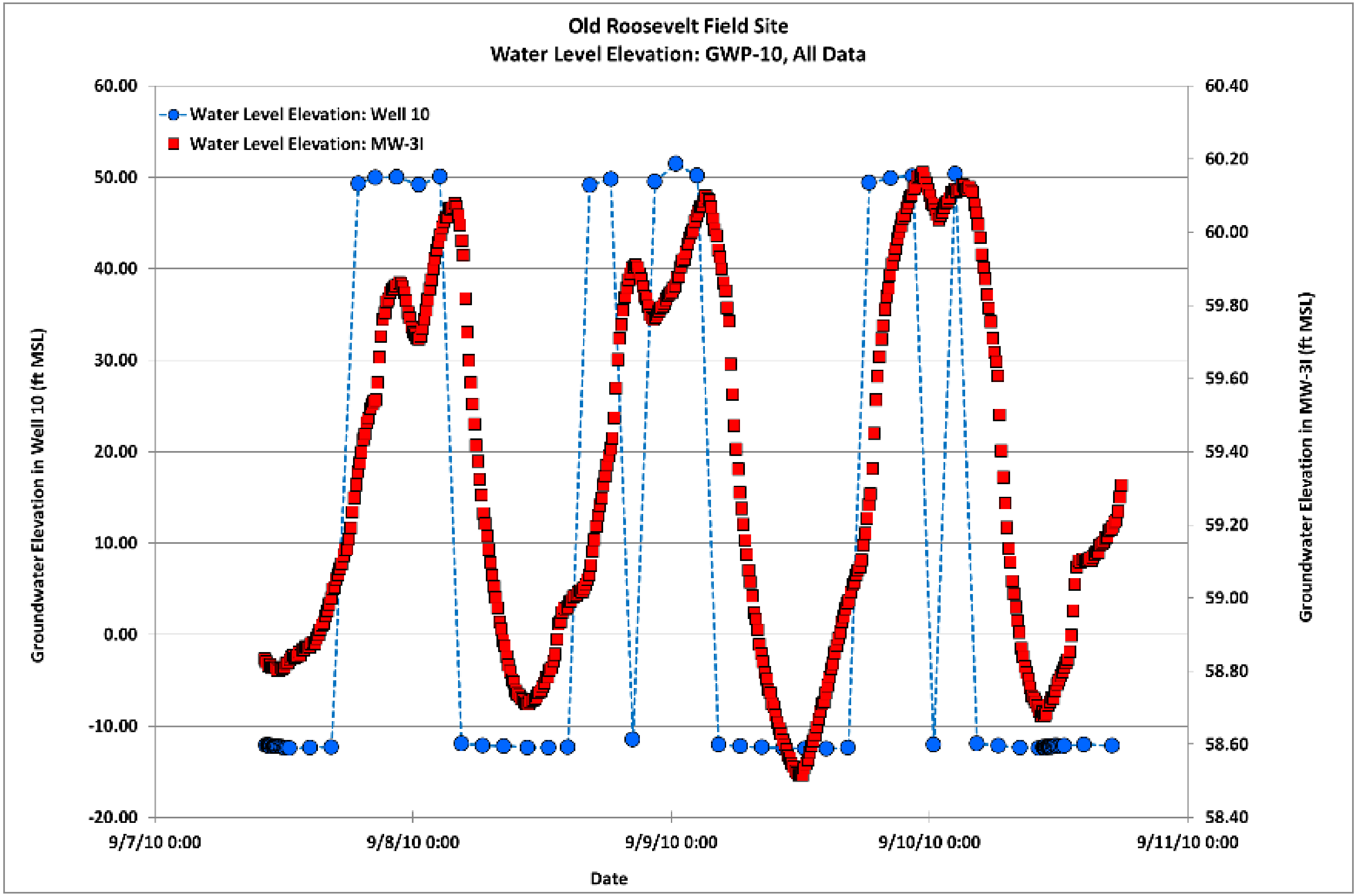

Figure 5

Water Level Elevation for Garden City Well GWP-10 and Observation Well MW-3I

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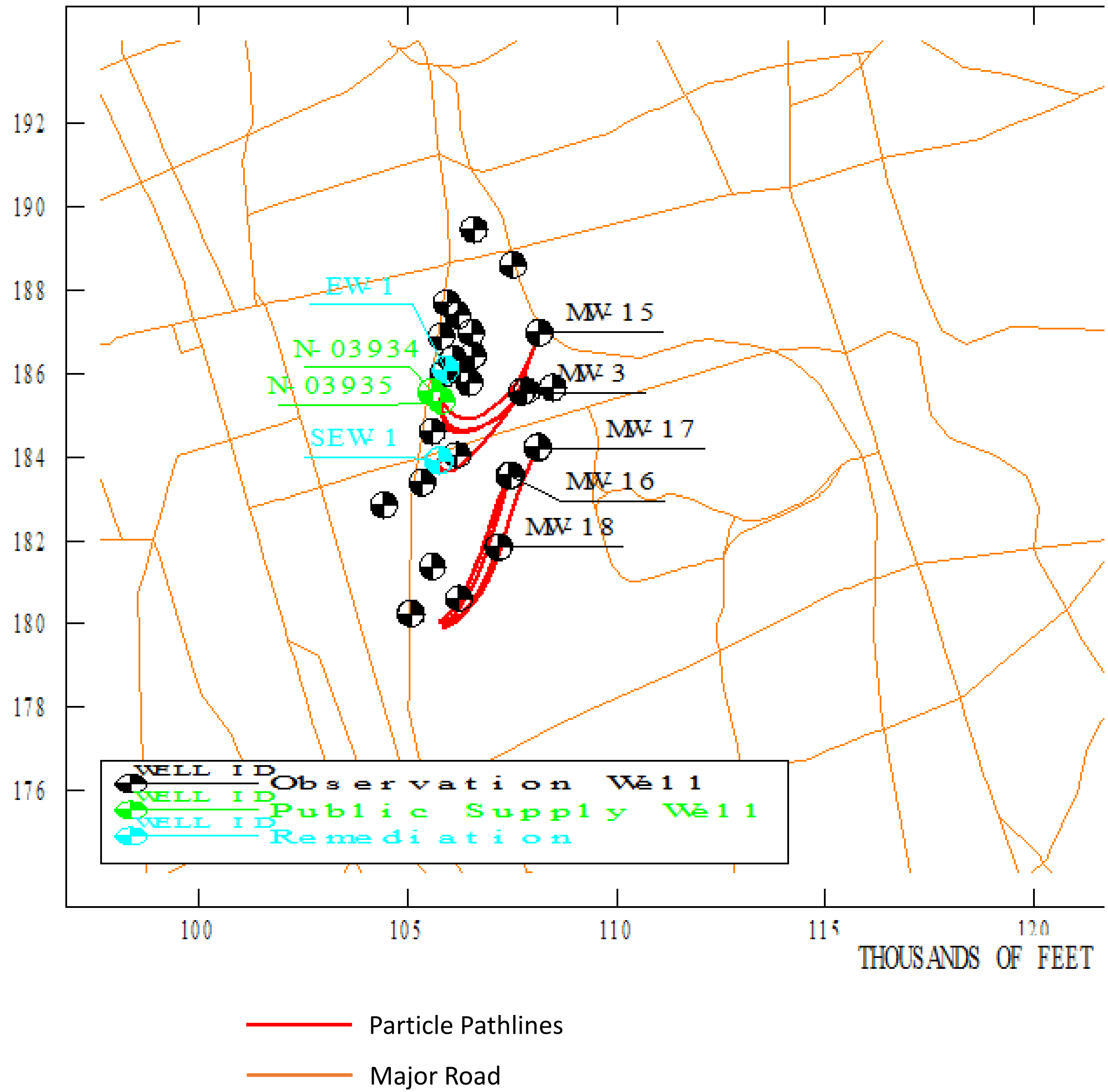

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Figure 6

Particle Tracks from PCE/TCE Detections, Steady-State Pumping Simulation

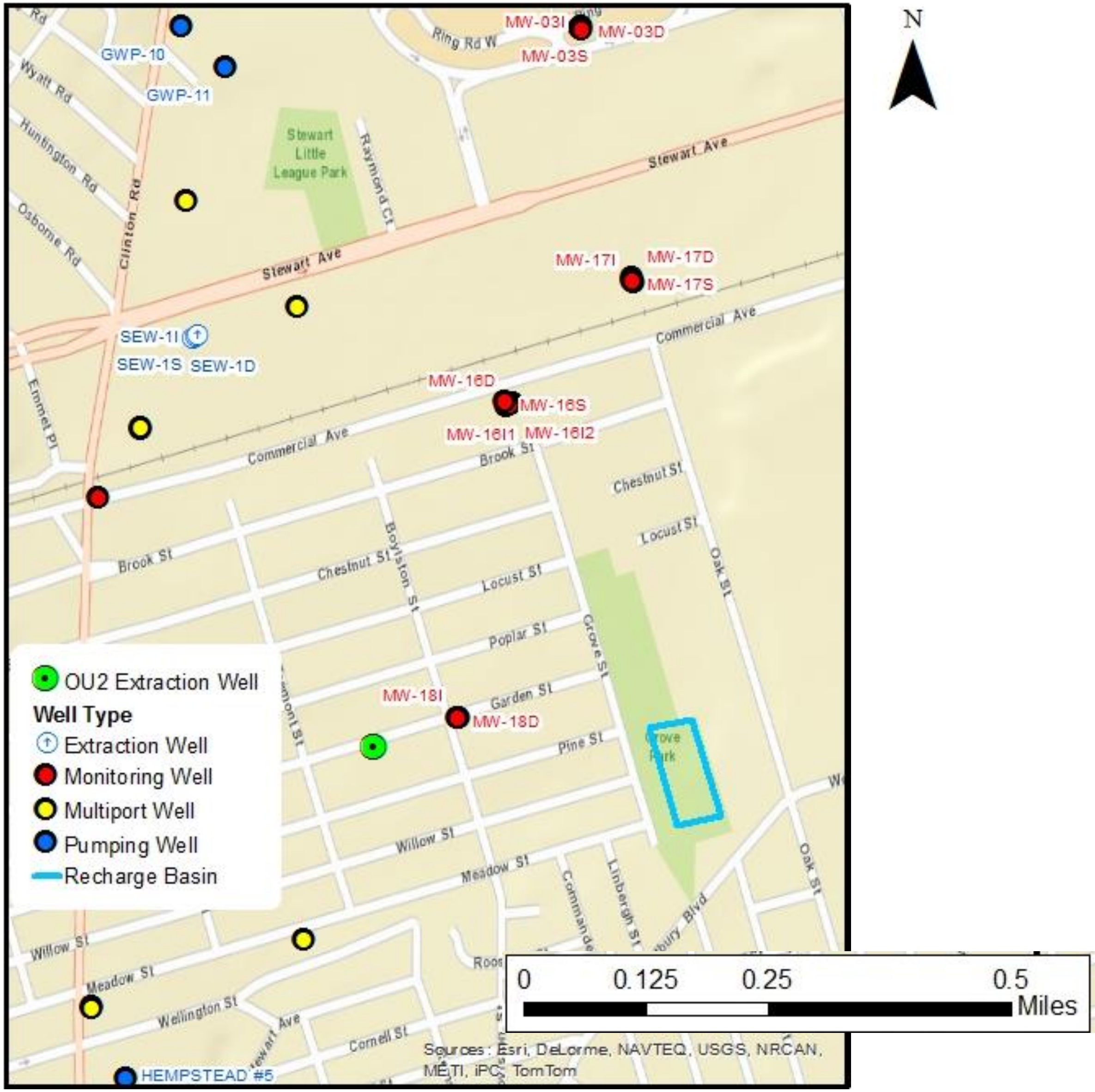

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Figure 7
Proposed OU2 Extraction Well Location

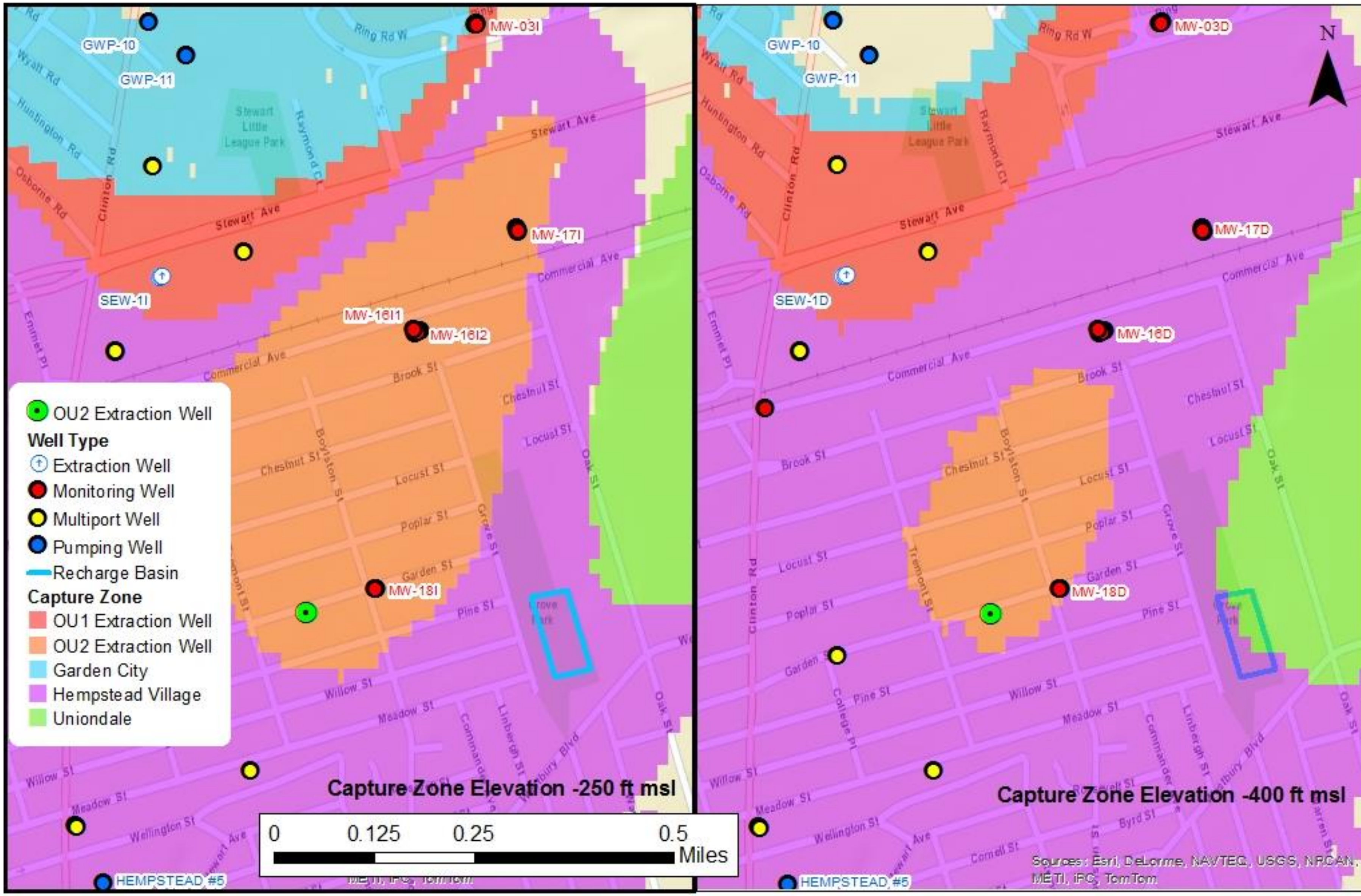

Figure 8

Capture Zone for OU2 Extraction Well (300 gpm) at -250 ft and -400 ft msl

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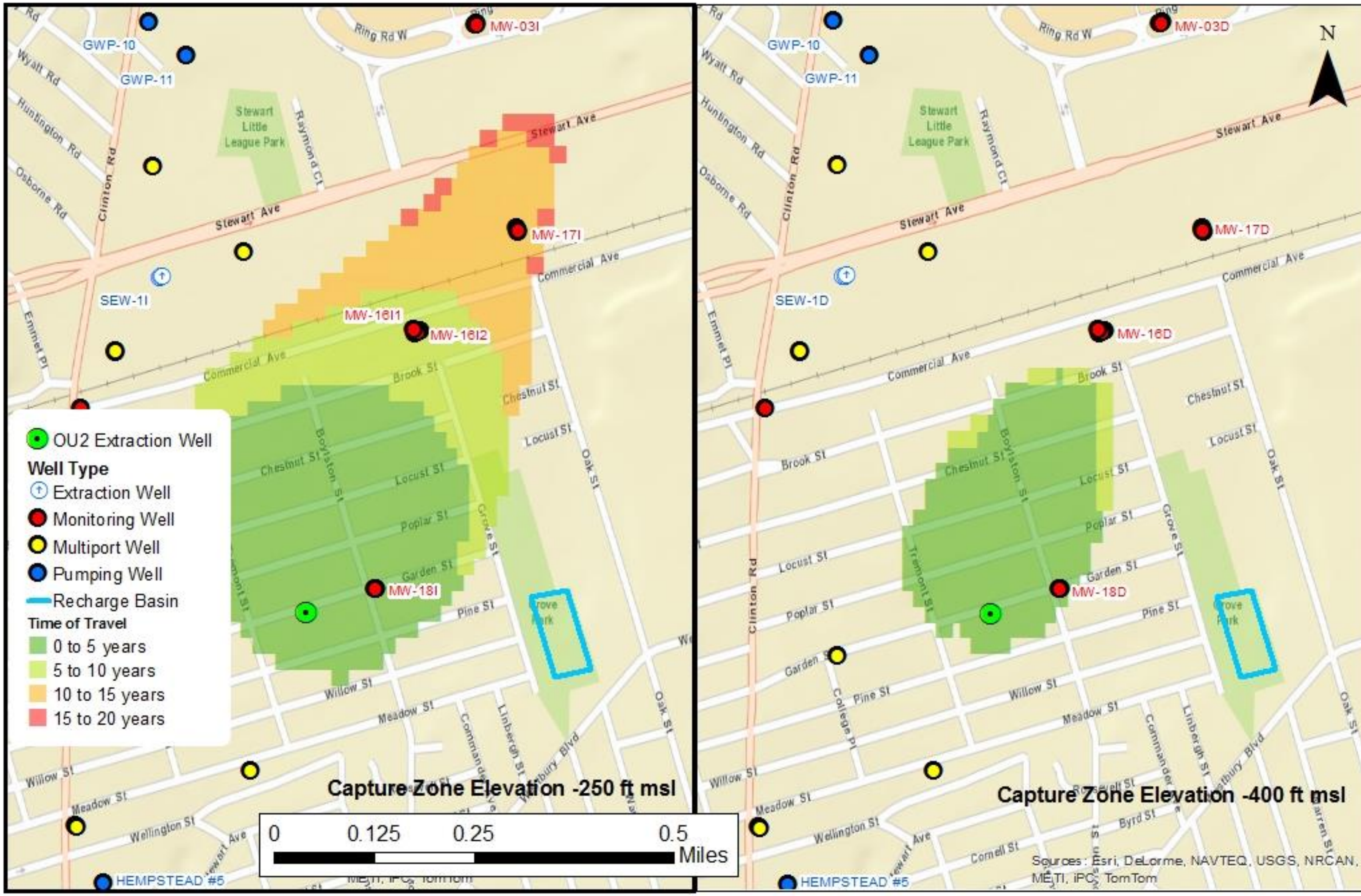

Figure 9

Time of Travel for OU2 Extraction Well (300 gpm) at -250 ft and -400 ft msl

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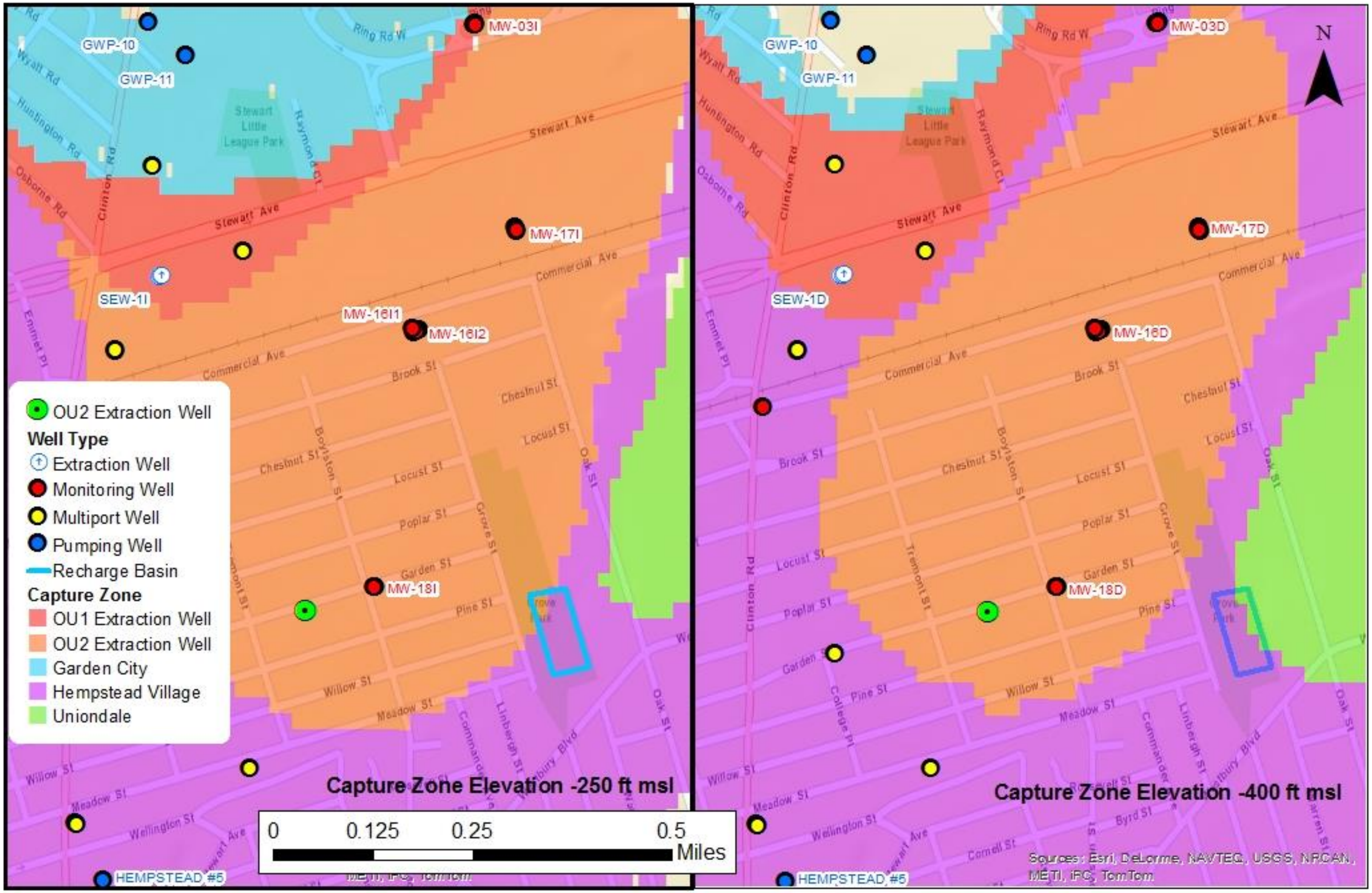

Figure 10

Capture Zone for OU2 Extraction Well (900 gpm) at -250 ft and -400 ft msl

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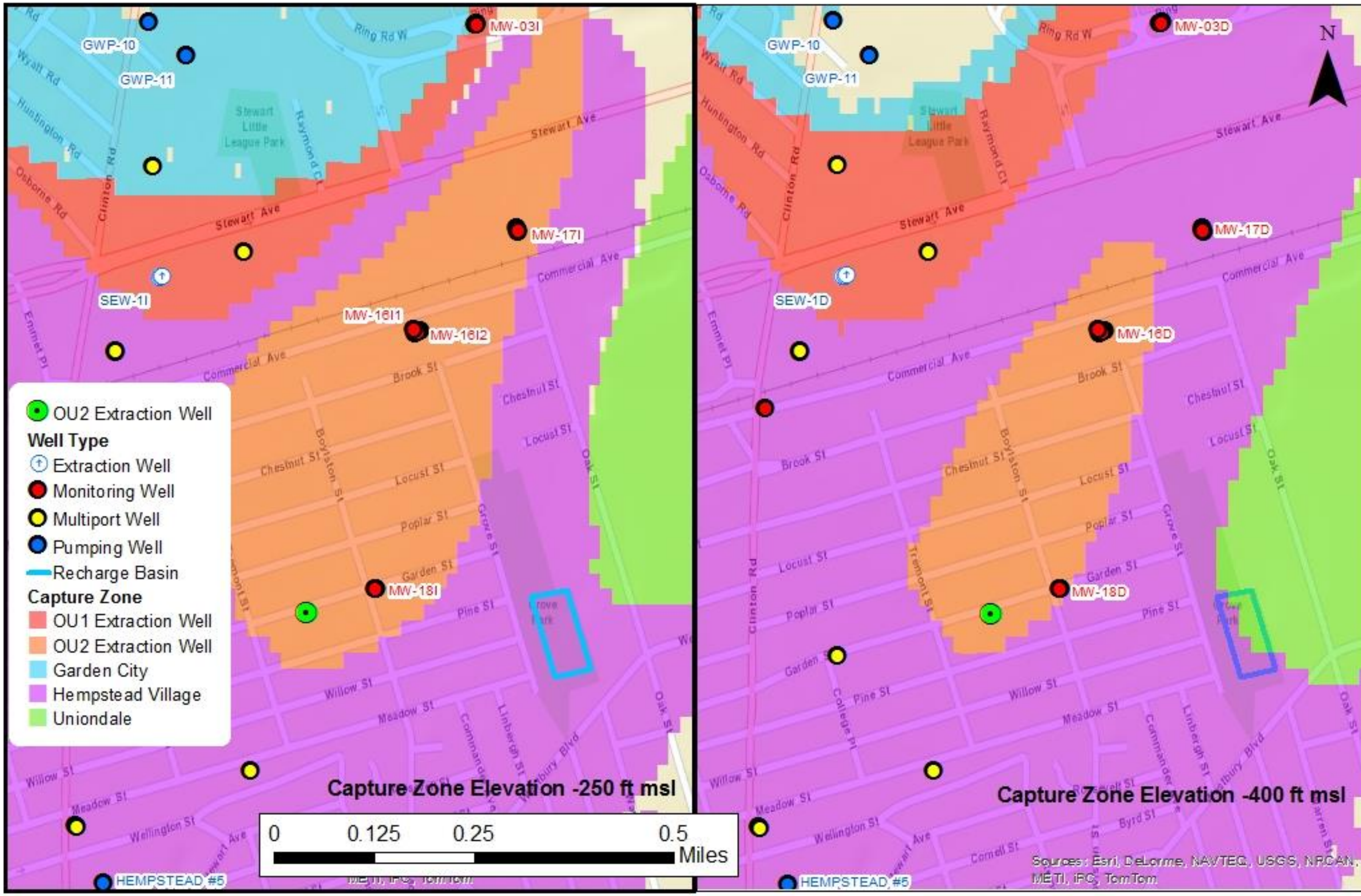

Figure 11

Capture Zone for OU2 Extraction Well (150 ft screen, 300 gpm) at -250 ft and -400 ft msl

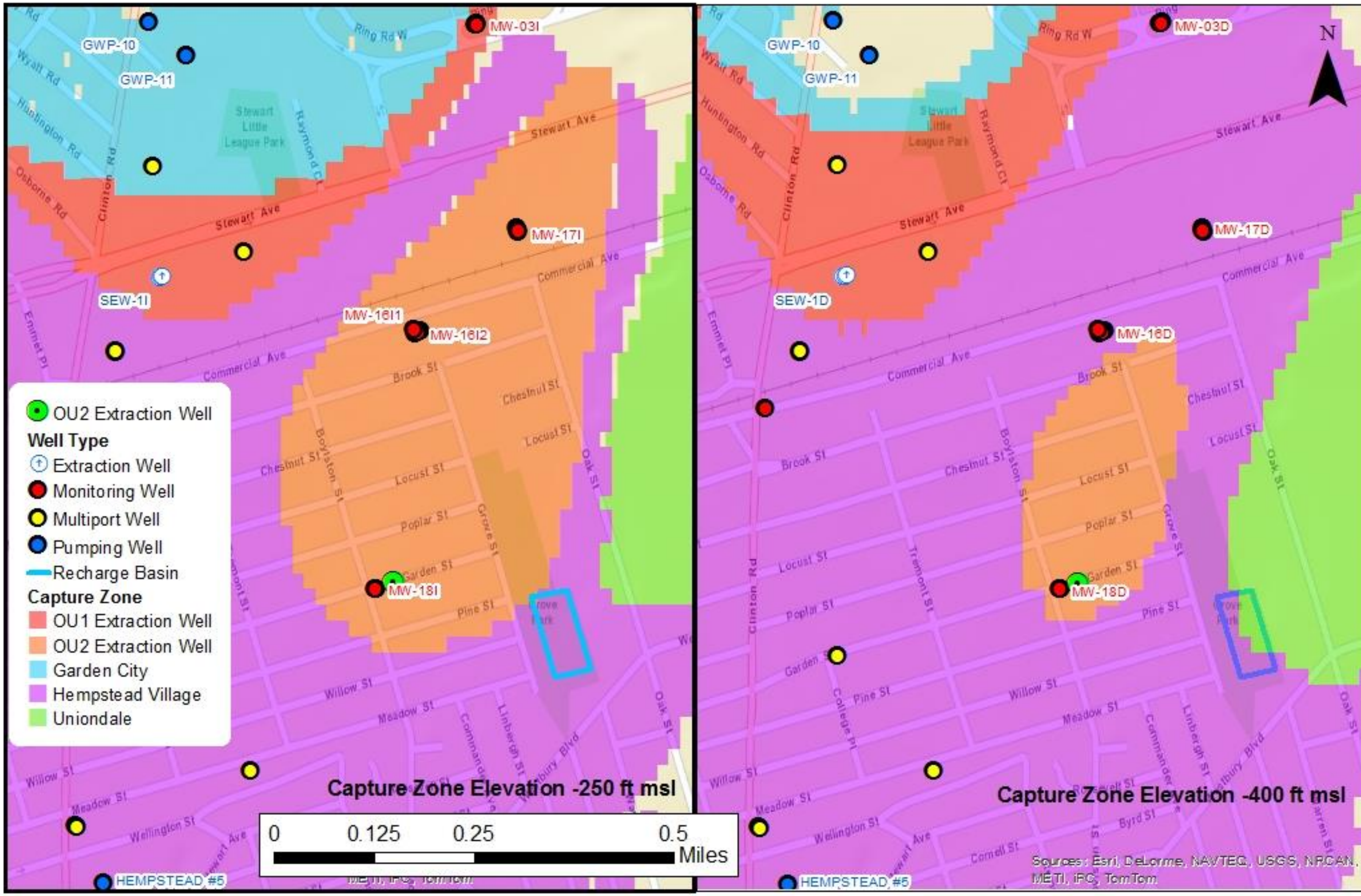

Figure 12

Capture Zone for OU2 Extraction Well (near MW-18, 300 gpm) at -250 ft and -400 ft msl

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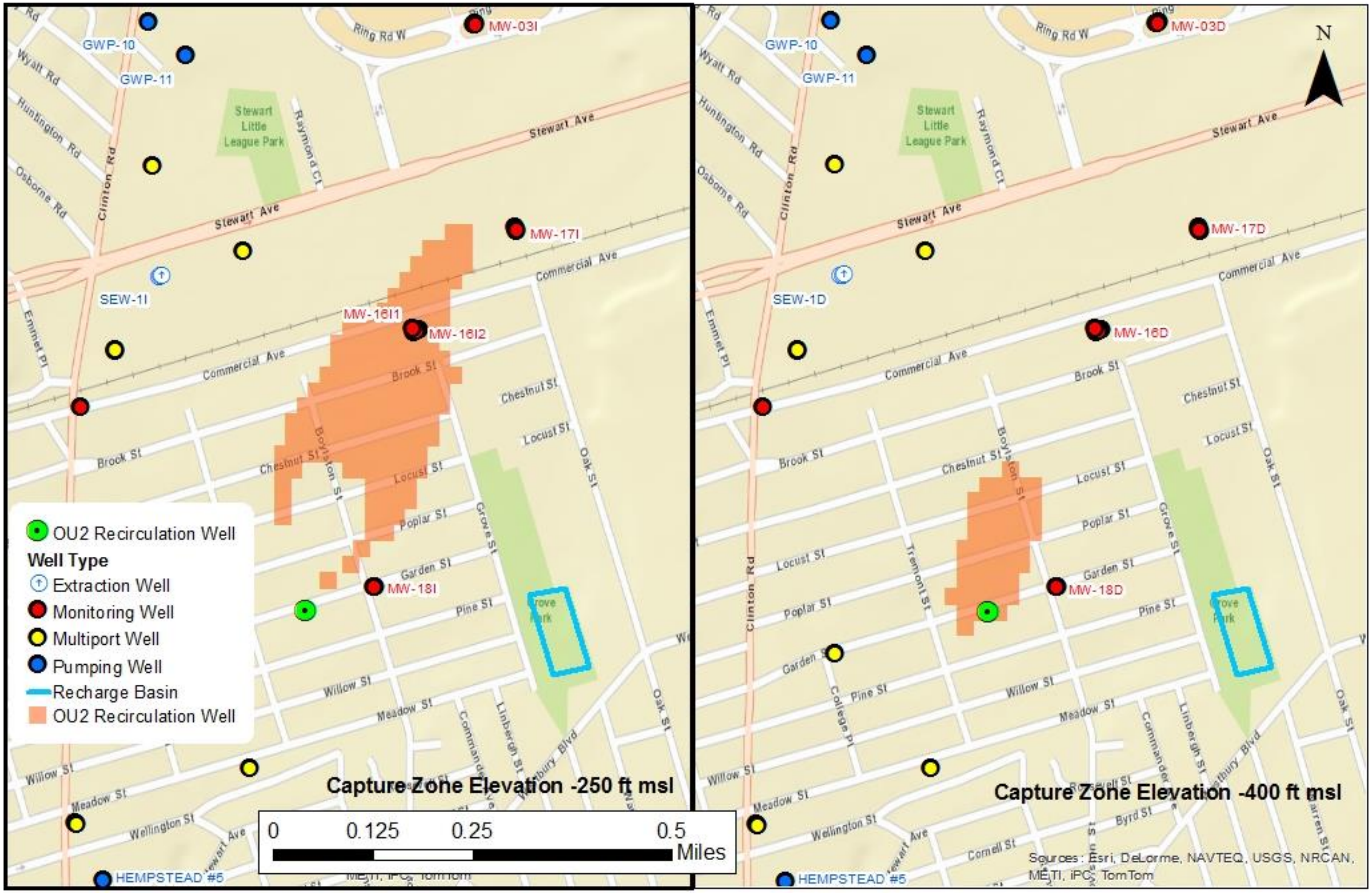

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Figure 13

Capture Zones for OU2 Recirculation Well (100 gpm) at -250 ft and -400 ft msl

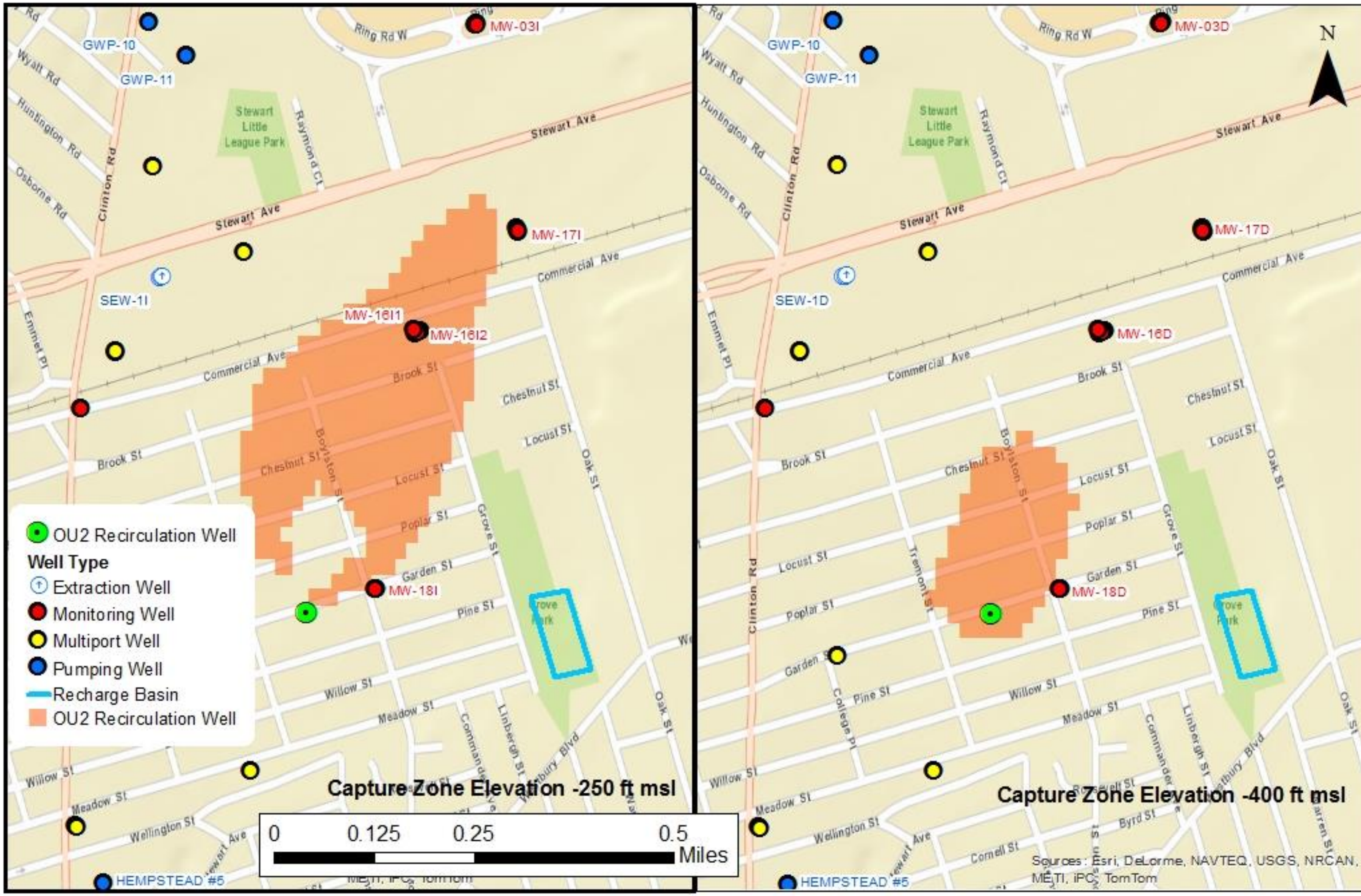

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Figure 14

Capture Zones for OU2 Recirculation Well (200 gpm) at -250 ft and -400 ft msl

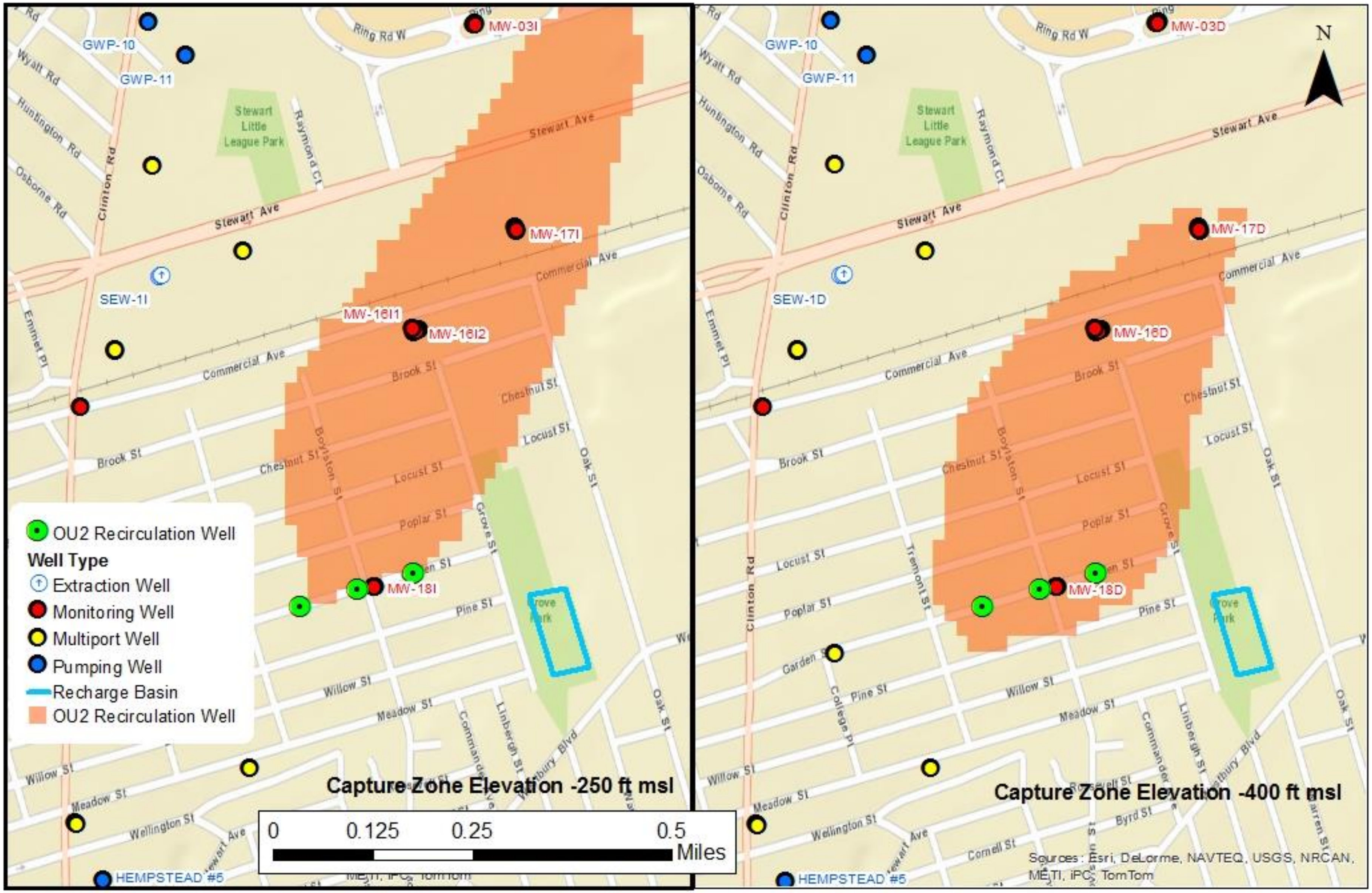

Figure 15

Capture Zones for OU2 Recirculation Wells (300 gpm total) at -250 ft and -400 ft msl

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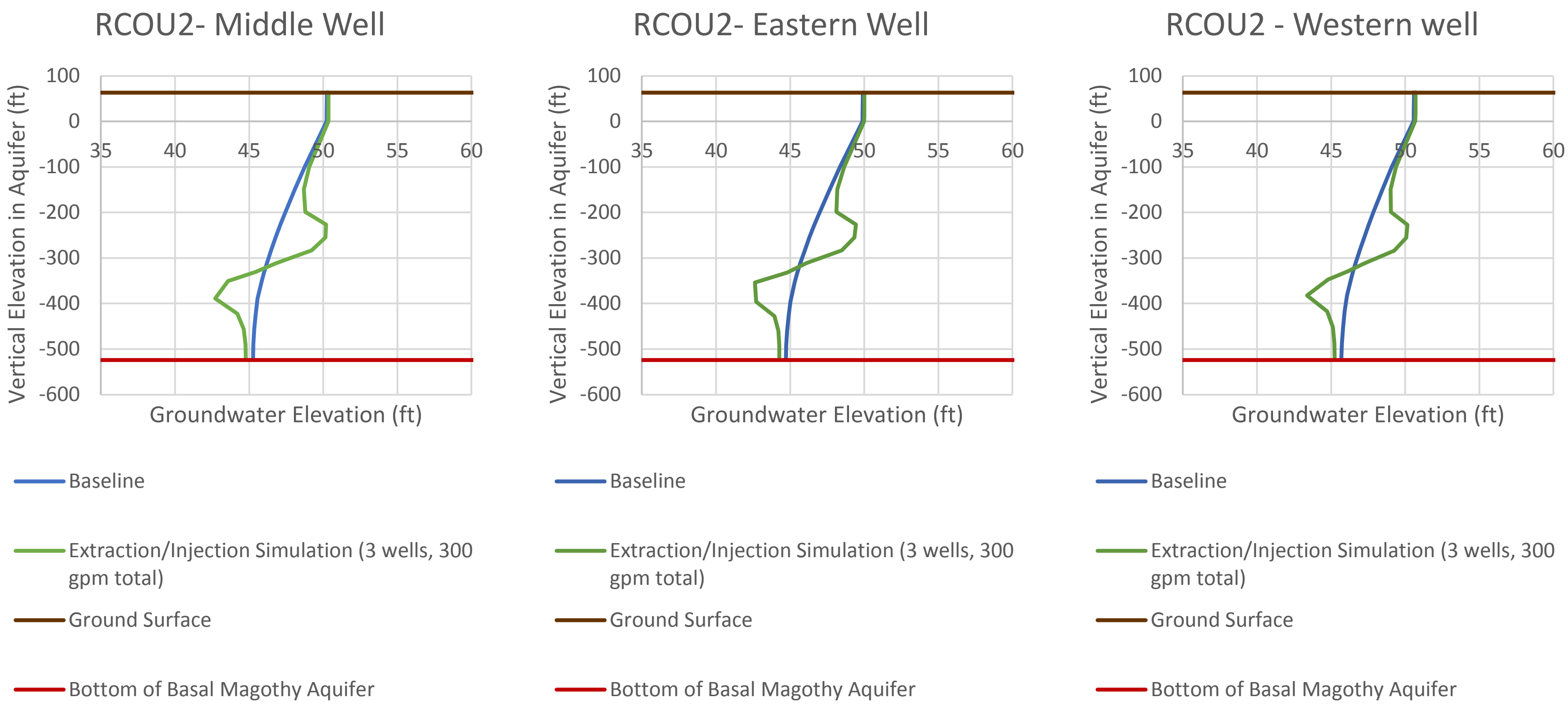

Figure 16
Change in Simulated Aquifer Head

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Appendix B

Appendix B

Cost Estimates

Alternative 2
Groundwater Extraction and Ex Situ Treatment
Old Roosevelt Field Contaminated Groundwater Site - Operable Unit 2
Garden City, Long Island, New York

Item No.	Item Description	Extended Cost
CAPITAL COSTS		
1.	General Conditions (including temporary facilities)	$ 1,784,000
2.	Yard Piping, Survey and Access Road	$ 335,000
3.	Extraction Well System Installation	$ 366,000
4.	Groundwater Treatment Plant Construction	$ 1,177,000
	Subtotal	$ 3,662,000
	General Contractor Markup (profit - 10%)	$ 366,200
	Subtotal	$ 4,028,200
	General Contractor Bond and Insurance (5%)	$ 201,410
	Subtotal	$ 4,229,610
	Contingency (20%)	$ 845,922
	TOTAL CAPITAL COSTS	$ 5,076,000
OPERATION, MAINTENANCE & MONITORING COSTS		
5.	Annual O&M and Sampling	$ 591,000
	Contingency (10%)	$ 59,100
	TOTAL OPERATION, MAINTENANCE & MONITORING COSTS	$ 650,100
PRESENT WORTH		
	Total Capital Costs	$ 5,076,000
	Operations and Maintenance for P&T System (for 30 years)	$ 8,068,000
	TOTAL PRESENT WORTH OF 30 YEAR COSTS	$ 13,144,000

Notes:

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

2.The project costs presented herein are prepared to facilitate alternative comparison. Expected accuracy range of the cost estimate is -30% to +50%.

CDM Smith	PROJECT: ORF Eastern Plume	COMPUTED BY :	AS	CHECKED BY:	KK
	JOB NO.: 101995.3323.047.FS.DFSR	DATE :	5/5/2017	DATE CHECKED:	5/26/2017
	CLIENT: EPA				

Description: Cost Estimate for Alternative 2

General Conditions

General conditions to include the project-dedicated site supervisory staff, development of work plans, site photographs/videos, project signs, mobilization/demobilization, and costs not covered elsewhere. Estimate assumes that following the remedial design, the RA Contractor will mobilize to the site and complete the remedial action.

Project Schedule

Assume the following project schedule:

Pre-Construction Work Plans and Meetings (RA Work), procurement		60	days
Construction			
Mobilization - Permits and Field Trailer Compound Establishment		5	days
Site Preparation (Decon areas, stockpile areas, clearing)		5	days
Access Road Construction		5	days
Well Installation (Well construction including Vaults)		20	days
Influent Force main		5	days
Groundwater Treatment Plant Construction		90	days
Effluent Force main		5	days
Final Site Restoration and Demobilization		10	days
Total Construction Duration		145	days
Project Closeout		90	days
Total Project Duration	=	**295**	**work days**
	=	**59**	**work weeks**
	=	**14**	**months**

General Conditions

A) Project Management and office support

Assume the following Staff for the duration of project:

Project Manager (40 hours per month)	545	hr	$160	=	$87,138
Project Engineer (80 hours per month)	1,089	hr	$110	=	$119,815
Project Engineer - Cost & Scheduling (20 hours per week during construction)	580	hr	$110	=	$63,800
General office support (160 hours per month)	2,178	hr	$75	=	$163,385
Total management and office support				=	**$435,000**

B) Work Plan Preparation

Estimated # of Pre-Construction Work Plans Required:					5 work plans
Estimated # of Hours Required:					
Project Engineer	500	hours at	$110	per hour	$55,000
Project Manager	150	hours at	$160	per hour	$24,000
Total Work Plan Preparation Cost				=	**$395,000**

C) Permits

Permit Specialist	500	hr	$110	=	$55,000
Project Manager	20	hr	$160	=	$3,200
Total Permitting Cost				=	**$58,200**

D) Procurement

Assume procurement of subcontractors for drilling, IDW, laboratory analysis, and construction services

Project Manager	100	hr	$160	=	$16,000
Environmental Engineer	500	hr	$110	=	$55,000
Procurement staff	500	hr	$110	=	$55,000
Total procurement and office support				=	**$110,000**

CDM Smith

PROJECT: ORF Eastern Plume	COMPUTED BY : AS	CHECKED BY: KK	
JOB NO.: 101995.3323.047.FS.DFSR	DATE : 5/5/2017	DATE CHECKED: 5/26/2017	
CLIENT: EPA			

Description: Cost Estimate for Alternative 2
General Conditions

E) Onsite supervisory					
Assume the following full time site supervisory staff for the duration of construction:					
Superintendent (8 hours per day)	1160	hr	$130	=	$150,800
Resident engineer (8 hours per day)	1160	hr	$110	=	$127,600
Total Onsite Supervisory Staff for Construction Duration				**=**	**$278,400**
F) Remedial Construction Report					
Project Manager	40	hr	$160	=	$6,400
Project Engineer	300	hr	$110	=	$33,000
Project Chemist	60	hr	$110	=	$6,600
Reviewers	40	hr	$110	=	$4,400
Total Remedial Construction Report Preparation Cost					**$50,400**
G) Site Photographs/Videos	1	LS	$10,000	=	$10,000
H) Project Signs	1	LS	$3,000	=	$3,000
I) Other Direct Costs	1	LS	$100,000	=	$100,000
SUBTOTAL GENERAL CONDITIONS					**$1,440,000**
Safety and Health Requirements					
SHSO	145	days	$1,000	=	$145,000
Level D PPE for all onsite staff	145	days	$100	=	$14,500
TOTAL H&S COSTS					**$159,500**
Temporary Facilities					
Temporary Facilities to include the field trailers, utilities, cleaning services, and office equipment and supplies.					
Security guard	29	weeks	$3,240	=	$93,960
Assume 12 hours on work day and 24 hours on weekend at $30/hour.					
Mobilization/Demobilization	1	LS	$10,000	=	$10,000
Temporary Facilities and Utilities	1	LS	$79,910	=	$79,910
TOTAL TEMPORARY FACILITY COSTS					**$183,900**
TOTAL COST FOR GENERAL CONDITIONS					**$1,784,000**

CDM Smith	PROJECT: ORF Eastern Plume	COMPUTED BY : AS	CHECKED BY: KK
	JOB NO.: 101995.3323.047.FS.DFSR	DATE : 5/5/2017	DATE CHECKED: 5/26/2017
	CLIENT: EPA		

Description: Individual Cost Item Backup for Alternative 2

Access Road Construction

No. 2 **Yard Piping, Survey, and Access Road**

	Quantity	Unit	Unit Cost		Extended Cost
Survey					
Survey	1	LS	$ 40,000	=	$40,000
Access Road Construction					
Road Construction	80	LF	$ 40	=	$3,200
Yard Piping					
Assume that the soil excavated will be put back after the pipe is installed.					
4" HDPE Pipe	1600	LF	$61		$97,600
4' x 4' trench	947.2	BCY	$13		$12,124
Back fill	947.2	BCY	$9		$8,383
Cut and Restore pavement	6400	SF	$26		$166,400
Landscaping	1	LS	$7,000		$7,000
Sub Total					$291,507
TOTAL					**$335,000**

CDM Smith	PROJECT:	ORF Eastern Plume	COMPUTED BY :	AS	CHECKED BY:	KK
	JOB NO.:	101995.3323.047.FS.DFSR	DATE :	5/5/2017	DATE CHECKED:	5/26/2017
	CLIENT:	EPA				

Descriptio Individual Cost Item Backup for Alternative 2
Extraction Well System Installation

		Quantity	Unit	Unit Cost		Extended Cost
No. 3	**Well Installation and Development**					
	Assume the well installation requires 15 days					
3a	**Extraction Well and Pump Installation**					
	Mobilization and Demobilization	1	LS	$48,000	=	$48,000
	Test Borehole	450	ft	$34	=	$15,300
	Steam Cleaning	8	Hours	$395	=	$3,160
	55-Gallon Drums	2	Drum	$95	=	$190
	Standby Time	1	Hours	$395	=	$395
	Crew Per Diem	20	Crew Day	$425	=	$8,500
	Clearing/Grading	3	Hours	$395	=	$1,185
	Temporary Fencing/Gates at Each Drilling Location	1	LS	$15,000	=	$15,000
	Mud Tub Setup/Breakdown	4	EA	$450	=	$1,800
	Mud Rotary Drilling: 12" borehole, 0-100 ft bgs	100	Feet	$50	=	$5,000
	12-inch Carbon Steel Surface casing, 0-100 feet bgs	100	Feet	$50	=	$5,000
	Mud Rotary drilling, 8-inch borehole, 100-450 ft bgs	350	Feet	$50	=	$17,500
	6-inch Stainless Steel Well Screen	60	Foot	$142	=	$8,520
	6-inch Stainless Steel Well Casing	390	Foot	$110	=	$42,900
	Plumbness and Alignment Testing	1	LS	$1,500	=	$1,500
	Bulk Transport: Cuttings and Drilling Mud	8	Hours	$400	=	$3,200
	Flush Mount Completion	1	each	$750	=	$750
	Well Development	24	Hours	$400	=	$9,600
	Bulk Transport: Development Water	8	Hours	$400	=	$3,200
	Extraction well installation and well head completion	1	per well	$35,000	=	$35,000
	Sub Total					$225,700
3b.	**Aquifer Testing**					
	Assume one step test and a 72-hour yield test and water will be treated and discharged to a recharge basin					
	Step Testing	1	Days	$2,800	=	$2,800
	Yield Testing	3	Days	$5,600	=	$16,800
	Temporary Groundwater Treatment Plant	1	LS	$85,000	=	$85,000
	Sub Total					$104,600
3c.	**IDW**					
	Assume that the water generated could be treated and discharged to a local recharge basin					
	Delivery of 20-cy rolloff	1	EA	$1,000	=	$1,000
	20-cy rolloff rental	2	Mo	$775	=	$1,550
	Waste characterization	1	Mo	$1,600	=	$1,600
	Soil Disposal	11	Tons	$75	=	$825
	Delivery of 21,000 gal frac tank	1	EA	$1,350	=	$1,350
	21,000 gal frac tank rental	1	Month	$1,000	=	$1,000
	21,000 gal frac tank cleanout	1	EA	$1,800	=	$1,800
	Sub Total					$9,125
3d.	**Geologist oversight**					
	Assume days would be 10-hour days. 15 days for well installation and 5 days for testing					
	Geologist	20	days	$1,000	=	$20,000
	Per diem and car rental	20	days	$320	=	$6,400
						$26,400
	TOTAL					**$366,000**

CDM Smith	PROJECT: ORF Eastern Plume	COMPUTED BY : AS	CHECKED BY: FT		
	JOB NO.: 101995.3323.047.FS.DFSR	DATE : 5/5/2017	DATE CHECKED: 5/22/2017		
	CLIENT: EPA				

Description: Individual Cost Item Backup for Alternative 2
Groundwater Treatment Plant Construction

		Quantity	Unit	Unit Cost		Extended Cost
No. 4	**Groundwater Treatment Plant Construction**					
	Groundwater treatment system design					
	Foundation design	200	Hr	$69		$ 13,790
	Building Plans	200	Hr	$69		$ 13,790
	Treatment System Plans	1000	Hr	$69		$ 68,948
	Instrumentation/Electrical Plan	500	Hr	$69		$ 34,474
	QA/QC of Design	100	Hr	$58		$ 5,787
	O&M Manual	300	Hr	$69		$ 20,684
	Sub Total					$ 157,472
	Site Work					
	Site clearing and grading	1	LS	$1,850	=	$ 1,850
	Landscaping and lighting	1	LS	$4,000	=	$ 4,000
	Power drop off	1	LS	$5,000	=	$ 5,000
	Building					
	Treatment Building	1	LS	$514,286	=	$ 515,000
	Fencing					
	6' Chain-link fence	360	LF	$21		$ 7,560
	6' Chain-link Gate	1	EA	$405		$ 405
	Sub Total					$ 7,965
	Treatment Processes					
	Air Stripper, Pump and Panel	1	LS	$159,594	=	$ 159,594
	Air Heater and Panel	1	LS	$24,000	=	$ 24,000
	2 GPC 120 vessels with carbon	1	LS	$104,225	=	$ 104,225
	Bag filters	2	LS	$3,668	=	$ 7,336
	Stage tank (2,000 gallons)	1	LS	$1,000	=	$ 1,000
	Installation (50% of equipment)					$ 148,078
	Sub Total					$ 444,233
	Discharge Piping					
	PVC Pipe	100	LF	$86		$ 8,600
	System Start Up					
	GWTP Commissioning and Startup	1	LS	$36,440		$ 36,440
	TOTAL					**$1,177,000**

CDM Smith	PROJECT: ORF Eastern Plume	COMPUTED BY : AS	CHECKED BY: GC
	JOB NO.: 101995.3323.047.FS.DFSR	DATE : 5/5/2017	DATE CHECKED: 5/25/2017
	CLIENT: EPA		

Description: Individual Cost Item Backup for Alternative 2

Annual O&M for Extraction Wells

The extraction well system and lines will have to be cleaned on an as needed basis depending on operation conditions. The cost estimate assumes annual well and line cleaning. Treatment facility O&M costs include labor, chemical additives, sludge disposal and filter replacement.

		Quantity	Unit	Unit Cost			Extended Cost
No. 5	**Annual O&M**						
5a.	**Project Management**						
	Project Manager	312	hr	$160	=	$	49,920
	Engineering support	120	hr	$110	=	$	13,200
	Procurement Specialist	96	hr	$100	=	$	9,600
5b	**Annual O&M for Extraction Wells**						
	Engineer & Geologist - Oversight (5 Day)	40	hrs	$110	=	$	4,400
	Materials and subcontractor	1	per year	$12,500	=	$	12,500
5c	**Annual O&M for GWTP Plant**						
	Labor Cost						
	Project Manager (4 hour/month)	12	mo	$640	=	$	7,680
	Engineer - Reporting (24 hours/month)	12	mo	$2,640	=	$	31,680
	Technician (12 hours per week)	52	wk	$1,080	=	$	56,160
	Equipment maintenance	1	LS	$40,000	=	$	40,000
	Annual Report	1	per year	$30,000		$	30,000
	Capital Costs						
	GAC						
	Annual activated carbon replacement (Effluent)	1	LS	$10,000	=	$	10,000
	Other Maintenance Costs						
	Well pump electricity	12	mo	$2,712	=	$	32,544
	Utility (other electricity + Phone and Internet)	12	mo	$1,900	=	$	22,800
	Materials	12	mo	$500	=	$	6,000
	Waste Hauling	1	LS	$825	=	$	825
	Monthly System Samples						
	Number of extraction well	1 well					
	Number of treatment system samples	1 samples					
	Vapor samples	1 samples					
	Sampling						
	Equipment & PPE	1	LS	$150	=	$	150
	Shipping	1	day	$100	=	$	100
	Misc	1	day	$100	=	$	100
	Sampling Analysis (includes QC samples)						
	Vapor VOCs	2	ea	$250	=	$	500
	Aqueous VOCs	4	ea	$150	=	$	600
	Aqueous Metals	1	ea	$106	=	$	106
	Aqueous Other parameters for compliance	1	ea	$120	=	$	120
	Monthly Data Summary						
	Database management	1	month	$440	=	$	440
	Data validation	3.5	hr	$150	=	$	525
	Data visualization	1	LS	$3,000	=	$	3,000
	Prepare the data report	1	LS	$7,000	=	$	7,000
	Subtotal per monthly event					$	12,700
	Subtotal sampling and analysis for 12 months					$	152,400

CDM Smith

PROJECT:	ORF Eastern Plume
JOB NO.:	101995.3323.047.FS.DFSR
CLIENT:	EPA
COMPUTED BY :	AS
DATE :	5/5/2017
CHECKED BY:	GC
DATE CHECKED:	5/25/2017

Description: Individual Cost Item Backup for Alternative 2

5d **Annual Well Sampling for Performance Evaluation and Long-Term Monitoring**

Number of monitoring wells	26	wells/ports
Number of samplers	4	people
Number of 11 hour workdays	5	days

Mob/demob						
Project Manager	4	hr	$160	=	$	640
Engineer	8	hr	$110	=	$	880
Field Scientist	40	hr	$100	=	$	4,000
Sampling						
Field Scientist	55	hour	$100	=	$	5,500
Field Scientist	55	hour	$100	=	$	5,500
Field Scientist	55	hour	$100	=	$	5,500
Field Scientist	55	hour	$100	=	$	5,500
Per diem	20	day	$220	=	$	4,400
Car rental	20	day	$95	=	$	1,900
Equipment & PPE	1	LS	$6,000	=	$	6,000
Shipping	5	day	$300	=	$	1,500
Misc	5	day	$250	=	$	1,250
Sampling Analysis (includes QC samples)						
Aqueous VOCs	38	ea	$150	=	$	5,700
wet chemistry	27	ea	$106	=	$	2,862
Data Summary						
Data validation	20	hr	$150	=	$	3,000
Tabulate the data and prepare figures	1	LS	$6,000	=	$	6,000
Data usability	24	hr	$110	=	$	2,640
Prepare the data report	300	hr	$120	=	$	36,000
Groundwater model update	80	hr	$150	=	$	12,000
Sub Total					$	110,772
Total Annual O&M Costs					**$**	**591,000**

PROJECT:	ORF Eastern Plume	**OMPUTED BY :**	AS	**CHECKED BY:**	GC
JOB NO.:	101995.3323.047.FS.DFSR	**DATE :**	5/5/2017	**ATE CHECKED:**	5/25/2017
CLIENT:	EPA				

scription: Individual Cost Item Backup for Alternative 1

8. Present Worth Calculation

Assume discount rate is 7%:

This is a recurring cost every year for n years.

Find (P given A, i, n) or (P/A,i,n)

P = Present Worth

A= Annual amount

i = interest rate

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

Operations and Maintenance of GWTP and Extraction - Year 1 - 30

n = 30

i = 7%

The multiplier for $(P/A)_{30}$ = **12.409**

Alternative 3
In-Well Stripping
Old Roosevelt Field Contaminated Groundwater Site - Operable Unit 2
Garden City, Long Island, New York

Item No.		Item Description	Extended Cost	
CAPITAL COSTS				
1.		General Conditions (including temporary facilities)	$	1,949,000
2.		Yard Piping, Survey and Access Road	$	341,000
3.		GCW/In-Well Stripping System Installation	$	662,000
4.		Equipment Building Construction	$	840,000
		Subtotal	$	3,792,000
		General Contractor Markup (profit - 10%)	$	379,200
		Subtotal	$	4,171,200
		General Contractor Bond and Insurance (5%)	$	208,560
		Subtotal	$	4,379,760
		Contingency (20%)	$	875,952
		TOTAL CAPITAL COSTS	$	5,256,000
OPERATION, MAINTENANCE & MONITORING COSTS				
5.		O&M and Sampling	$	565,000
		Contingency (20%)	$	113,000
		TOTAL OPERATION, MAINTENANCE & MONITORING COSTS	$	678,000
PRESENT WORTH				
		Total Capital Costs	$	5,256,000
		Operations and Maintenance for GCW/In-Well Stripping System (for 30 years)	$	8,414,000
		TOTAL PRESENT WORTH OF 30 YEAR COSTS	$	13,670,000

Notes:

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

2.The project costs presented herein are prepared to facilitate alternative comparison. Expected accuracy range of the cost estimate is -30% to +50%.

CDM Smith

PROJECT:	ORF Eastern Plume	COMPUTED BY :	AS	CHECKED BY:	KK
JOB NO.:	101995.3323.047.FS.DFSR	DATE :	5/5/2017	DATE CHECKED:	5/26/2017
CLIENT:	EPA				

Description: Cost Estimate for Alternative 3

General Conditions

General conditions to include the project-dedicated site supervisory staff, development of work plans, site photographs/videos, project signs, mobilization/demobilization, and costs not covered elsewhere. Estimate assumes that following the remedial design, the RA Contractor will mobilize to the site and complete the remedial action.

Project Schedule

Assume the following project schedule:

Pre-Construction Work Plans and Meetings (RA Work), procurement		60	days
Construction			
Mobilization - Permits and Field Trailer Compound Establishment		5	days
Site Preparation (Decon areas, temporary facility, clearing)		5	days
Access Road Construction		5	days
Well Installation (Well construction including Vaults)		50	days
Yard Piping		10	days
Equipment Building		90	days
Final Site Restoration and Demobilization		10	days
Total Construction Duration		175	days
Project Closeout		90	days
Total Project Duration	=	**325**	**work days**
	=	**65**	**work weeks**
	=	**15**	**months**

General Conditions

A) Project Management and office support

Assume the following Staff for the duration of project:

Project Manager (40 hours per month)	600	hr	$160	=	$96,000
Project Engineer (80 hours per month)	1,200	hr	$110	=	$132,000
Project Engineer - Cost & Scheduling (20 hours per week during construction)	700	hr	$110	=	$77,000
General office support (160 hours per month)	2,400	hr	$75	=	$180,000
Total management and office support				**=**	**$485,000**

B) Work Plan Preparation

Estimated # of Pre-Construction Work Plans Required:					5 work plans
Estimated # of Hours Required:					
Project Engineer	500	hr	$110	=	$55,000
Project Manager	150	hr	$160	=	$24,000
Total Work Plan Preparation Cost				**=**	**$395,000**

C) Permits

Permit Specialist	500	hr	$110	=	$55,000
Project Manager	20	hr	$160	=	$3,200
Total Permitting Cost				**=**	**$58,200**

D) Procurement

Assume procurement of subcontractors for drilling, IDW, laboratory analysis, and construction services

Project Manager	100	hr	$160	=	$16,000
Environmental Engineer	500	hr	$120	=	$60,000
Procurement staff	500	hr	$110	=	$55,000
Total procurement and office support				**=**	**$115,000**

PROJECT:	ORF Eastern Plume	COMPUTED BY :	AS	CHECKED BY:	KK
JOB NO.:	101995.3323.047.FS.DFSR	DATE :	5/5/2017	DATE CHECKED:	5/26/2017
CLIENT:	EPA				

Description: Cost Estimate for Alternative 3
General Conditions

E) Onsite supervisory					
Assume the following full time site supervisory staff for the duration of construction:					
Superintendent (8 hours per day)	1400	hr	$130	=	$182,000
Resident engineer (8 hours per day)	1400	hr	$110	=	$154,000
Total Onsite Supervisory Staff for Construction Duration				**=**	**$336,000**
F) Remedial Construction Report					
Project Manager	40	hr	$160	=	$6,400
Project Engineer	300	hr	$110	=	$33,000
Project Chemist	60	hr	$110	=	$6,600
Reviewers	40	hr	$110	=	$4,400
Total Remedial Construction Report Preparation Cost					**$50,400**
G) Site Photographs/Videos	1	LS	$10,000	=	$10,000
H) Project Signs	1	LS	$3,000	=	$3,000
I) Other Direct Costs	1	LS	$100,000	=	$100,000
SUBTOTAL GENERAL CONDITIONS					**$1,552,600**
Safety and Health Requirements					
SHSO	175	days	$1,000	=	$175,000
Level D PPE for all onsite staff	175	days	$100	=	$17,500
TOTAL H&S COSTS					**$192,500**
Temporary Facilities					
Temporary Facilities to include the field trailers, utilities, cleaning services, and office equipment and supplies.					
Security guard	35	weeks	$3,240	=	$113,400
Assume 12 hours on work day and 24 hours on weekend at $42/hour.					
Mobilization/Demobilization	1	LS	$10,000	=	$10,000
Temporary Facilities and Utilities	1	LS	$79,910	=	$79,910
TOTAL TEMPORARY FACILITY COSTS					**$203,400**
TOTAL COST FOR GENERAL CONDITIONS					**$1,949,000**

PROJECT:	ORF Eastern Plume	COMPUTED BY :	AS	CHECKED BY:	KK
JOB NO.:	101995.3323.047.FS.DFSR	DATE :	5/5/2017	DATE CHECKED:	5/26/2017
CLIENT:	EPA				

Description: Individual Cost Item Backup for Alternative 3

No. 2 **Yard Piping, Survey, and Access Road**

Survey	Quantity	Unit	Unit Cost		Extended Cost
Survey	1	LS	$ 40,000	=	$40,000
Access Road Construction					
Road Construction	80	LF	$ 40	=	$3,200
Yard Piping					
Pavement Removal	965.55556	SY	$ 12	=	$11,587
Roadway Trench / Backfill	676.01852	CY	$ 12	=	$7,842
Grass Trench / Backfill	135.11111	CY	$ 12	=	$1,567
Backfill and Compaction	811.12963	CY	$ 9	=	$7,300
Underground piping - 1.5-Inch Sch 80 black steel pipe (	90	LF	$ 46	=	$4,095
Underground piping - 2-Inch Sch 80 black steel pipe	400	LF	$ 56	=	$22,400
Underground piping - 3-Inch Sch 80 black steel pipe	1300	LF	$ 83	=	$107,900
Underground piping - 3-Inch PVC Sch 40 pipe (Laterals	150	LF	$ 12	=	$1,770
Underground piping - 4-Inch PVC Sch 40 pipe	240	LF	$ 14	=	$3,384
Underground piping - 6-Inch PVC Sch 40 pipe	240	LF	$ 19	=	$4,500
Underground piping - 8-Inch PVC Sch 40 pipe	1225	LF	$ 26	=	$31,238
Underground conduit - 1-Inch PVC Sch 40 pipe with 6 s	1700	LF	$ 6	=	$9,435
Tracer Wire	1700	LF	$ 0	=	$238
Pavement Restoration (5.5 ft wide)	888	SY	$ 87	=	$76,788
Grass and landscape restoration	1	LS	$ 7,000	=	$7,000
Sub Total					$297,043
TOTAL					**$341,000**

CDM Smith	PROJECT: ORF Eastern Plume	COMPUTED BY : GC	CHECKED BY: KK		
	JOB NO.: 101995.3323.047.FS.DFSR	DATE : 5/18/2017	DATE CHECKED: 5/26/2017		
	CLIENT: EPA				

Descriptio Individual Cost Item Backup for Alternative 3
Extraction Well System Installation

The cost estimate considers the installation of two groundwater circulation wells (GCWs). Each well will be 8-inch stainless steel well that has a vault and will connect to pressure airline and vapor recovery airline to a utility facility. Within each well, there will be an inner 6-inch stainless steel well. Both these well will have two screen sections. Wells must be developed prior to operation. Soil lithology will be logged at each well location. The costs for installing the pilot study GCW is not included here.

Assume it will take 15 days to install and develop each well. 10 days to install inside system

Assume that yield tests will not be conducted

		Quantity	Unit	Unit Cost		Extended Cost
No. 3	**Well Installation and Development**					
3a	**GCW Installation and Development**					
	Mobilization and Demobilization	1	LS	$60,000	=	$60,000
	Test Borehole	900	ft	$34	=	$30,600
	Geotechnical parameter analysis	1	LS	$600	=	$600
	Steam Cleaning	10	Hours	$395	=	$3,950
	55-Gallon Drums	2	Drum	$95	=	$190
	Standby Time	2	Hours	$395	=	$790
	Crew Per Diem	20	Crew Day	$425	=	$8,500
	Clearing/Grading	3	Hours	$395	=	$1,185
	Mud Tub Setup/Breakdown	2	EA	$450	=	$900
	Mud Rotary Drilling: 12" borehole, 0-100 ft bgs	200	Feet	$50	=	$10,000
	12-inch Carbon Steel Surface casing, 0-100 feet bgs	200	Feet	$50	=	$10,000
	Mud Rotary drilling, 8-inch borehole, 100-450 ft bgs	700	Feet	$50	=	$35,000
	8-inch Stainless Steel (SS) Well Screen	280	Foot	$165	=	$46,200
	8-inch SS Well Casing	620	Foot	$120	=	$74,400
	Plumbness and Alignment Testing	2	LS	$1,500	=	$3,000
	Bulk Transport: Cuttings and Drilling Mud	8	Hours	$400	=	$3,200
	Flush Mount Completion	2	each	$750	=	$1,500
	Well Development	20	Hours	$400	=	$8,000
	Bulk Transport: Development Water	8	Hours	$400	=	$3,200
	Inner 6-inch SS screen	280	Foot	$142	=	$39,760
	Inner 6-inch SS casing	620	Foot	$110	=	$68,200
	Inner 1-inch SS sparging pipe	900	foot	$40	=	$36,000
	centralizer	1	LS	$600	=	$600
	Inflatable Packer system	2	LS	$1,500	=	$3,000
	GWC inner system installation	1	LS	$10,000	=	$10,000
	Well vault and well head completion	3	per well	$35,000	=	$105,000
	Sub Total					$563,775
3b	**Monitoring Well Installation (2 cluster, each with 2 wells)**					
	Mud Tub Setup/Breakdown	2	EA	$450	=	$900
	Mud Rotary Drilling: 12" borehole, 0-100 ft bgs	400	Feet	$50	=	$20,000
	12-inch Carbon Steel Surface casing, 0-100 feet bgs	400	Feet	$50	=	$20,000
	Mud Rotary Drilling 4' pilot hole	700	Feet	$26	=	$18,200
	Groundwater screening hydropunch	12	each	$950	=	$11,400
	Mud Rotary drilling, 8-inch borehole, 100-450 ft bgs	1400	Feet	$26	=	$36,400
	4-inch Stainless Steel (SS) Well Screen	40	Foot	$110	=	$4,400
	4-inch SS Well Casing	1760	Foot	$75	=	$132,000
	Bulk Transport: Cuttings and Drilling Mud	8	Hours	$400	=	$3,200
	Flush Mount Completion	4	each	$750	=	$3,000
	Well Development	32	Hours	$400	=	$12,800
	Bulk Transport: Development Water	8	Hours	$400	=	$3,200
	Sub Total					$265,500
3c.	**IDW**					
	Delivery of 30-cy rolloff	2	EA	$1,000	=	$2,000
	30-cy rolloff rental	4	Mo	$775	=	$3,100
	Soil Disposal	45	Tons	$75	=	$3,375
	Soil and water waste characterization	1	LS	$2,500	=	$2,500
	Delivery of 21,000 gal frac tank	1	EA	$1,350	=	$1,350
	21,000 gal frac tank rental	3	Month	$1,000	=	$3,000
	21,000 gal frac tank cleanout	1	EA	$1,800	=	$1,800
	Non-hazardous water disposal	20000	gallons	$0.72	=	$14,400
	Sub Total					$31,525
3d.	**Geologist oversight**					
	Assume days would be 10-hour days.					
	Geologist	50	days	$1,000	=	$50,000
	Per diem and car rental	50	days	$320	=	$16,000
						$66,000
	TOTAL					**$662,000**

PROJECT:	ORF Eastern Plume	COMPUTED BY :	AS	CHECKED BY:	FT
JOB NO.:	101995.3323.047.FS.DFSR	DATE :	5/5/2017	DATE CHECKED:	5/22/2017
CLIENT:	EPA				

Description: Individual Cost Item Backup for Alternative 3

Equipment Building Construction

		Quantity	Unit	Unit Cost			Extended Cost
No. 4	**Groundwater Treatment Plant Construction**						
	Groundwater treatment system design						
	Foundation design	200	Hr	$69		$	13,789.50
	Building Plans	200	Hr	$69		$	13,789.50
	Utility System Plans	1000	Hr	$69		$	68,947.50
	Instrumentation/Electrical Plan	500	Hr	$69		$	34,473.75
	QA/QC of Design	100	Hr	$58		$	5,787.00
	O&M Manual	300	Hr	$69		$	20,684.25
	Sub Total					$	157,471.50
	Site Work						
	Site clearing and grading	1	LS	$1,850	=	$	1,850.00
	Landscaping and lighting	1	LS	$4,000	=	$	4,000.00
	Building						
	Treatment Building	1	LS	$321,429	=	$	322,000.00
	Fencing						
	6' Chain-link fence	360	LF	$21		$	7,560.00
	6' Chain-link Gate	1	EA	$405		$	405.00
	Sub Total					$	7,965.00
	Utility						
	Compressed Air System						
	Oil Free Air Compressors 2-unit package	1	Ea.	$38,416	=	$	38,416.00
	Oil and Particulate filters, valves, etc	1	LS	$400	=	$	400.00
	Condensate drain system	1	LS	$2,000	=	$	2,000.00
	Internal Building Compressed Air Piping	1	LS	$8,000	=	$	8,000.00
	Vapor Recovery System						
	Regenerative vacuum blowers	2	Ea.	$17,055	=	$	34,110.00
	Heat Exchangers - VFD	2	Ea.	$500	=	$	1,000.00
	GAC Vessels - 1,000 SCFM / 2,000 lbs capacity	2	Ea.	$52,000	=	$	104,000.00
	Lead-Lag VP GAC valve tree Assembly (8-inch)	1	Ea.	$1,000	=	$	1,000.00
	Discharge stack	1	Ea.	$2,000	=	$	2,000.00
	Internal Building Vapor Piping	1	LS	$8,000	=	$	8,000.00
	Air Heater and Panel	1	LS	$24,000	=	$	24,000.00
	Installation (50% of equipment)					$	87,055.00
	Sub Total					$	309,981.00
	System Start Up						
	GWC-in-well stripping Commissioning and Startup	1	LS	$40,000		$	40,000
	TOTAL						**$840,000**

PROJECT: ORF Eastern Plume	COMPUTED BY : AS	CHECKED BY: GC
JOB NO.: 101995.3323.047.FS.DFSR	DATE : 5/5/2017	DATE CHECKED: 5/22/2017
CLIENT: EPA		

Description: Individual Cost Item Backup for Alternative 3

Annual O&M for Extraction Wells

The GWC well need maintenance. The cost estimate assumes annual well cleaning, compressor maintenance. Treatment facility O&M costs include labor, chemical additives, filter replacement, equipment maintenance.

		Quantity	Unit	Unit Cost		Extended Cost
No. 5	**Annual O&M**					
5a.	**Project Management**					
	Project Manager	312	hr	$160	=	$ 49,920
	Engineer/Accounting	120	hr	$110	=	$ 13,200
	Procurement Specialist	96	hr	$100	=	$ 9,600
5b	**Annual O&M for Extraction Wells**					
	Engineer - Oversight (10 Day)	80	hrs	$110	=	$ 8,800
	Materials and subcontractor	2	per year	$12,500	=	$ 25,000
5c	**Annual O&M for GWTP Plant**					
	Labor Cost					
	Project Manager (2 hour/month)	12	mo	$320	=	$ 3,840
	Engineer - Reporting (8 hours/month)	12	mo	$880	=	$ 10,560
	Technician (4 hours per week)	52	wk	$720	=	$ 37,440
	Annual Report	1	per year	$25,000		$ 25,000
	Capital Costs					
	GAC					
	Annual activated carbon replacement (Effluent)	1	LS	$10,000	=	$ 10,000
	Other Maintenance Costs					
	Air Compressor and Vacuum Blower electricity	12	mo	$7,000	=	$ 84,000
	Utility (other electricity + Phone and Internet)	12	mo	$1,900	=	$ 22,800
	Materials	12	mo	$200	=	$ 2,400
	Waste disposal (condensate)	1	LS	$825	=	$ 825
	Monthly System Samples					
	assume groundwater sample collected from each GCW well every month to check air stripping efficiency					
	Number of GWC well	3 well				
	Number of water samples	3 samples				
	Vapor samples	1 samples				
	Sampling					
	Equipment & PPE	1	LS	$150	=	$ 150
	Shipping	1	day	$100	=	$ 100
	Misc	1	day	$100	=	$ 100
	Sampling Analysis (includes QC samples)					
	Vapor VOCs	2	ea	$250	=	$ 500
	Aqueous VOCs	5	ea	$150	=	$ 750
	Monthly Data Summary					
	Database management	1	month	$440	=	$ 440
	Data validation	3.5	hr	$150	=	$ 525
	Data visualization	1	LS	$3,000	=	$ 3,000
	Prepare the data report	1	LS	$7,000	=	$ 7,000
	Subtotal per monthly event					$ 12,600
	subtotal sampling and analysis for 12 months					$ 151,200
5d	**Annual Well Sampling for Performance Evaluation and Long-Term Monitoring**					
	Number of monitoring wells	26 wells/ports				
	Number of samplers	4 people				
	Number of 11 hour workdays	5 days				
	Mob/demob					
	Project Manager	4	hr	$160	=	$ 640
	Engineer	8	hr	$110	=	$ 880
	Field Scientist	40	hr	$100	=	$ 4,000

CDM Smith	PROJECT:	ORF Eastern Plume	COMPUTED BY :	AS	CHECKED BY:	GC
	JOB NO.:	101995.3323.047.FS.DFSR	DATE :	5/5/2017	DATE CHECKED:	5/22/2017
	CLIENT:	EPA				

Description: Individual Cost Item Backup for Alternative 3

Sampling						
Field Scientist	55	hour	$100	=	$	5,500
Field Scientist	55	hour	$100	=	$	5,500
Field Scientist	55	hour	$100	=	$	5,500
Field Scientist	55	hour	$100	=	$	5,500
Per diem	20	day	$220	=	$	4,400
Car rental	20	day	$95	=	$	1,900
Equipment & PPE	1	LS	$6,000	=	$	6,000
Shipping	5	day	$300	=	$	1,500
Misc	5	day	$250	=	$	1,250
Sampling Analysis (includes QC samples)						
Aqueous VOCs	37	ea	$150	=	$	5,550
wet chemistry	27	ea	$106	=	$	2,862
Data Summary						
Data validation	20	hr	$150	=	$	3,000
Tabulate the data and prepare figures	1	LS	$6,000	=	$	6,000
Data usability	24	hr	$110	=	$	2,640
Prepare the data report	300	hr	$120	=	$	36,000
Groundwater model update	80	hr	$150	=	$	12,000
Sub Total					$	110,622
Total Annual O&M Costs					**$**	**565,000**

CDM Smith

PROJECT:	ORF Eastern Plume	COMPUTED BY :	AS	CHECKED BY:	KK
JOB NO.:	101995.3323.047.FS.DFSR	DATE :	5/5/2017	DATE CHECKED:	5/26/2017
CLIENT:	EPA				

Description: Individual Cost Item Backup for Alternative 3

Present Worth Calculation

Assume discount rate is 7%:

This is a recurring cost every year for n years.

Find (P given A, i, n) or (P/A,i,n)

P = Present Worth

A= Annual amount

i = interest rate

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

Operations and Maintenance of GCW/In-Well Stripping System - Year 1 - 30

n = 30

i = 7%

The multiplier for $(P/A)_{30}$ = **12.409**

Alternative 4
In Situ Adsorption
Old Roosevelt Field Contaminated Groundwater Site - Eastern Plume
Garden City, Long Island, New York

Item No.	Item Description	Extended Cost
CAPITAL COSTS		
1.	General Conditions (including temporary facilities)	$ 2,361,000
2.	Injection Well Installation	$ 3,155,000
3.	Injection of Activated Carbon *	$ 2,200,000
	Subtotal	$ 7,716,000
	General Contractor Markup (profit - 10%)	$ 771,600
	Subtotal	$ 8,487,600
	General Contractor Bond and Insurance (5%)	$ 424,380
	Subtotal	$ 8,911,980
	Contingency (20%)	$ 1,782,396
	TOTAL CAPITAL COSTS	$ 10,695,000
OPERATION, MAINTENANCE & MONITORING COSTS		
4.	O&M and Sampling	$ 194,000
	Contingency (20%)	$ 38,800
	TOTAL OPERATION, MAINTENANCE & MONITORING COSTS	$ 232,800
5.	One time rejuvenation of the treatment barrier (at 12 years) *	$ 2,200,000
PRESENT WORTH		
	Total Capital Costs	$ 10,695,000
	Operations and Maintenance for P&T System (for 30 years)	$ 2,889,000
	One time rejuvenating the treatment barrier (at 12 years)	$ 977,000
	TOTAL PRESENT WORTH OF 30 YEAR COSTS	$ 14,561,000

Notes:

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

2.The project costs presented herein are prepared to facilitate alternative comparison. Expected accuracy range of the cost estimate is -30% to +50%.

* Vendor quote

CDM Smith	PROJECT: ORF Eastern Plume	COMPUTED BY :	AS	CHECKED BY:	KK
	JOB NO.: 101995.3323.047.FS.DFSR	DATE :	5/5/2017	DATE CHECKED:	5/26/2017
	CLIENT: EPA				

Description: Cost Estimate for Alternative 4
General Conditions

General conditions to include the project-dedicated site supervisory staff, development of work plans, site photographs/videos, project signs, mobilization/demobilization, and costs not covered elsewhere. Estimate assumes that following the remedial design, the RA Contractor will mobilize to the site and complete the remedial action.

Project Schedule

Assume the following project schedule:

Pre-Construction Work Plans and Meetings (RA Work), procurement		60	days
Mobilization - Permits and Field Trailer Compound Establishment		5	days
Site Preparation (Decon areas, temporary facility, clearing)		5	days
Well Installation and injection		480	days
Final Site Restoration and Demobilization		20	days
Total Construction Duration		510	days
Project Closeout		90	days
Total Project Duration	=	**660**	**work days**
	=	**132**	**work weeks**
	=	**30**	**months**

General Conditions

A) Project Management and office support

Assume the following Staff for the duration of project:

Project Manager (26 hours per month)	792	hr	$160	=	$126,720
Project Engineer (40 hours per month)	1,218	hr	$110	=	$134,031
Project Engineer - Cost & Scheduling (10 hours per week during construction)	1,020	hr	$110	=	$112,200
General office support (40 hours per month)	1,218	hr	$75	=	$91,385
Total management and office support				**=**	**$465,000**

B) Work Plan Preparation

Estimated # of Pre-Construction Work Plans Required:					5 work plans
Estimated # of Hours Required:					
Project Engineer	500	hr	$110	=	$55,000
Project Manager	150	hr	$160	=	$24,000
Total Work Plan Preparation Cost				**=**	**$395,000**

C) Permits

Permit Specialist	500	hr	$110	=	$55,000
Project Manager	20	hr	$160	=	$3,200
Total Permitting Cost				**=**	**$58,200**

D) Procurement

Assume procurement of subcontractors for drilling, IDW, laboratory analysis, and construction services

Project Manager	100	hr	$160	=	$16,000
Environmental Engineer	500	hr	$120	=	$60,000
Procurement staff	500	hr	$110	=	$55,000
Total procurement and office support				**=**	**$115,000**

CDM Smith	PROJECT: ORF Eastern Plume	COMPUTED BY : AS	CHECKED BY: KK
	JOB NO.: 101995.3323.047.FS.DFSR	DATE : 5/5/2017	DATE CHECKED: 5/26/2017
	CLIENT: EPA		

Description: Cost Estimate for Alternative 4

General Conditions

E) Onsite supervisory					
Assume the following full time site supervisory staff for the duration of construction:					
Superintendent (8 hours per day)	4080	hr	$130	=	$530,400
Total Onsite Supervisory Staff for Construction Duration				**=**	**$530,400**
F) Remedial Construction Report					
Project Manager	40	hr	$160	=	$6,400
Project Engineer	300	hr	$110	=	$33,000
Project Chemist	60	hr	$110	=	$6,600
Reviewers	40	hr	$110	=	$4,400
Total Remedial Construction Report Preparation Cost					**$50,400**
G) Site Photographs/Videos	1	LS	$10,000	=	$10,000
H) Project Signs	1	LS	$3,000	=	$3,000
I) Other Direct Costs	1	LS	$100,000	=	$100,000
SUBTOTAL GENERAL CONDITIONS					**$1,727,000**
Safety and Health Requirements					
SHSO (once per week)	102	days	$1,000	=	$102,000
Level D PPE for all onsite staff	510	days	$100	=	$51,000
TOTAL H&S COSTS					**$153,000**
Temporary Facilities					
Temporary Facilities to include the field trailers, utilities, cleaning services, and office equipment and supplies.					
Security guard	102	weeks	$3,240	=	$330,480
Assume 12 hours on work day and 24 hours on weekend at $42/hour.					
Mobilization/Demobilization	1	LS	$10,000	=	$10,000
Temporary Facilities and Utilities	1	LS	$139,843	=	$139,843
TOTAL TEMPORARY FACILITY COSTS					**$480,400**
TOTAL COST FOR GENERAL CONDITIONS					**$2,361,000**

CDM Smith

PROJECT:	ORF Eastern Plume	COMPUTED BY :	T.M.	CHECKED BY:	GC
JOB NO.:	101995.3323.047.FS.DFSR	DATE :	5/18/2017	DATE CHECKED:	5/25/2017
CLIENT:	EPA				

Descriptio Individual Cost Item Backup for Alternative 4

Assume a total of 47 injection wells need to be installed for the two treatment barriers

Assume it will take 10 days to install and develop each well.

		Unit	Quantity	Unit Cost		Extended Cost
No. 2	**Well Installation and Development**					
2a	**Injection Well Installation and Development**					
	Mobilization/Demobilization	1	lump sum	$60,000	=	$ 60,000
	Steam Cleaning	94	hour	$395	=	$ 37,130
	55-Gallon Drums (to include pallets)	2	drum	$95	=	$ 190
	Standby Time	6	hour	$395	=	$ 2,370
	Crew Per Diem (2-person crew)	470	crew day	$425	=	$ 199,750
	Clearing/Grading	50	hour	$395	=	$ 19,750
	Temporary Fencing/Gates at Each Drilling Location	2	lump sum	$15,000	=	$ 30,000
	Road Plate	1	lump sum	$4,500	=	$ 4,500
	Lighting	2	month	$1,475	=	$ 2,950
	Mud Tub Setup/Breakdown	47	each	$450	=	$ 21,150
	Mud Rotary Drilling: 12-inch borehole, 0-100 feet bgs	4,700	foot	$50	=	$ 235,000
	8-inch Carbon Steel Surface Casing, 0-100 feet bgs	4,700	foot	$50	=	$ 235,000
	Mud Rotary Drilling: 8-in diameter borehole to 450 feet bg	16,450	foot	$26	=	$ 427,700
	4-inch wire-wrap schedule 80 PVC screen	2,350	foot	$45	=	$ 105,750
	4-inch PVC Well Screen and Casing: Schedule 80	18,800	foot	$30	=	$ 564,000
	Well Development:	376	hour	$395	=	$ 148,520
	Flush Mount Completion	47	each	$475	=	$ 22,325
	Bulk Transport: Cuttings/Drilling Mud and Development W	376	hour	$395	=	$ 148,520
	Drum Transport/Staging:	2	drum	$95	=	$ 190
	Sub Total					$ 2,264,795
2b.	**IDW**					
	Delivery of 30-cy rolloff	14	EA	$1,000	=	$ 14,000
	30-cy rolloff rental	28	Mo	$775	=	$ 21,700
	Soil Disposal	500	Tons	$75	=	$ 37,500
	Delivery of 21,000 gal frac tank	7	EA	$1,350	=	$ 9,450
	21,000 gal frac tank rental	45	Month	$1,000	=	$ 45,000
	21,000 gal frac tank cleanout	7	EA	$1,800	=	$ 12,600
	Non-hazardous water disposal	141000	gallons	$0.72	=	$ 101,520
	Sample Collection Event - Soil/Water	7	event	$400		$ 2,800
	Aqueous Sample Analysis	7	sample	$980		$ 6,860
	Soil Sample Analysis	7	sample	$980		$ 6,860
	4a. Deliver Kiln Dust to Site	4	event	$990		$ 3,960
	4b. Kiln Dust	15	ton	$28		$ 420
	4c. Rental of Kiln Dust Containers	8	month	$390		$ 3,120
	4d. Demobilize Kiln Dust Container	4	lump sum	$990		$ 3,960
	Sub Total					$ 269,750
2e.	**Geologist oversight**					
	Geologist	470	days	$1,000	=	$ 470,000
	Per diem and car rental	470	days	$320	=	$ 150,400
						$ 620,400
	TOTAL					**$ 3,155,000**

PROJECT: ORF Eastern Plume	COMPUTED BY : AS	CHECKED BY: GC
JOB NO.: 101995.3323.047.FS.DFSR	DATE : 5/5/2017	DATE CHECKED: 5/25/2017
CLIENT: EPA		

Description: Individual Cost Item Backup for Alternative 4

		Quantity	Unit	Unit Cost		Extended Cost
No. 4	**Annual O&M**					
4a.	**Project Management**					
	Project Manager	312	hr	$160	=	$ 49,920
	Engineer/Accounting	96	hr	$110	=	$ 10,560
	Procurement Specialist	60	hr	$100	=	$ 6,000
4b	**Annual Well Sampling for Performance Evaluation and Long-Term Monitoring**					
	Number of monitoring wells and injection wells	35	wells/ports			
	Number of samplers	5	people			
	Number of 11 hour workdays	6	days			
	Mob/demob					
	Project Manager	4	hr	$160	=	$ 640
	Engineer	8	hr	$110	=	$ 880
	Field Scientist	40	hr	$100	=	$ 4,000
	Sampling					
	Field Scientist	66	hour	$100	=	$ 6,600
	Field Scientist	66	hour	$100	=	$ 6,600
	Field Scientist	66	hour	$100	=	$ 6,600
	Field Scientist	66	hour	$100	=	$ 6,600
	Field Scientist	66	hour	$100	=	$ 6,600
	Per diem	30	day	$220	=	$ 6,600
	Car rental	30	day	$95	=	$ 2,850
	Equipment & PPE	1	LS	$3,000	=	$ 3,000
	Shipping	6	day	$300	=	$ 1,800
	Misc	6	day	$250	=	$ 1,500
	Sampling Analysis (includes QC samples)					
	Aqueous VOCs	49	ea	$150	=	$ 7,350
	wet chemistry	36	ea	$106	=	$ 3,816
	Data Summary					
	Data validation	20	hr	$150	=	$ 3,000
	Tabulate the data and prepare figures	1	LS	$8,000	=	$ 8,000
	Data usability	24	hr	$110	=	$ 2,640
	Prepare the data report	300	hr	$120	=	$ 36,000
	Groundwater model update	80	hr	$150	=	$ 12,000
	Sub Total					$ 127,076
	Total Annual O&M Costs					**$ 194,000**

PROJECT:	ORF Eastern Plume	**OMPUTED BY :**	AS	**CHECKED BY:**	GC
JOB NO.:	101995.3323.047.FS.DFSR	**DATE :**	5/5/2017	**ATE CHECKED:**	5/25/2017
CLIENT:	EPA				

scription: Individual Cost Item Backup for Alternative 4

Present Worth Calculation

Assume discount rate is 7%:

This is a recurring cost every year for n years.

Find (P given A, i, n) or (P/A,i,n)

P = Present Worth

A= Annual amount

i = interest rate

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

Costs of annual sampling and analysis - Year 1 - 30

n = 30

i = 7%

The multiplier for $(P/A)_{30}$ = **12.409**

present worth of a future expense

Find (P given F, i, n) or (P/F,i,n)

P = Present Worth

F = Future amount

i = interest rate

$$P = F \frac{1}{(1+i)^n}$$

Costs of rejuvenating the treatment barrier at 12 years

n = 12

i = 7%

The multiplier for $(P/F)_{12}$ = **0.444**