Final
Hydrogeologic Investigation Report - Operable Unit 1

Stanton Cleaners Area
Groundwater Contamination Site
Great Neck, Nassau County, New York

Prepared for:

U.S. Environmental Protection Agency Region II
Emergency and Remedial Response Division
Removal Action Branch
Edison, New Jersey

Prepared by:

EARTH TECH
Greenville, South Carolina

Volume I
(Text, Tables, Figures, Appendix A and B)

April 2004

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GROUNDWATER CONTAMINATION SITE
GREAT NECK, NASSAU COUNTY, NEW YORK

Prepared for

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ACRONYMS

a.k.a.	also know as
ARARs	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
atm-m^3/mole	atmosphere – cubic meters per mole
bgs	below ground surface
BOD	biochemical oxygen demand
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CDC	Citizen's Development Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFM	cubic feet per minute
CLP	Contract Laboratory Program
COD	chemical oxygen demand
DESA	Division of Environmental Science and Assessment
dB	decibels
DNAPL	Dense Non-Aqueous Phase Liquids
DO	Dissolved Oxygen
DQOs	Data Quality Objectives
ERRS	Emergency and Rapid Response Services
ERT	Environmental Response Team
ft	feet
ft/day	feet per day
ft^2/day	feet squared per day
ft/ft	feet per foot
ft/yr	feet per year
GAC	Granular Activated Carbon
gpm	gallons per minute
HASP	Health & Safety Plan
HI	Hydrogeologic Investigation
IDW	Investigation-Derived Waste
K_d	Distribution Coefficient
LIRR	Long Island Railroad
LTRA	Long-Term Response Action
MCLs	Maximum Contaminant Levels
MCLGs	Maximum Contaminant Level Goals
MODFLOW	Modular Three-Dimensional Finite-Difference Ground-Water Flow Model
msl	mean sea level
MTBE	Methyl Tertiary Butyl Ether
NCDOH	Nassau County Department of Health
NPL	Federal National Priorities List
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	Operation and Maintenance
OU-1	Operable Unit 1
OU-2	Operable Unit 2
ORD	Office of Research and Development
ORP	Oxidation-Reduction Potential
OSC	On-Site Coordinator

ACRONYMS (Continued)

OSWER	Office of Solid Waste and Emergency Response
P&T	Pump and Treatment
PCE	Tetrachloroethylene
PLC	Programmable Logic Controller
ppb	parts per billion
ppm	parts per million
PRPs	Principal Responsible Parties
psi	per square inch
PSD	Passive Sampling Devices
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plans
QC	Quality Control
RAB	Removal Action Branch
REAC	Response Engineering Analytical Contract
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPM	Remedial Project Manager
RSCC	Regional Sampling Control Center
RST	Removal Support Team
SAMP	Sampling and Analysis Management Plan
SCA	Stanton Cleaners Area
SCADA	Supervisory Control and Data Acquisition
SCP	Stanton Cleaners Property
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SOW	Scope of Work
START	Superfund Technical Assessment and Response Team
SVE	Soil Vapor Extraction
SVOCs	Semi-Volatile Organic Compounds
TAGM	Technical and Administrative Guidance Memorandum
TAL	Target Analyte List
TBC	to-be-considered
TCE	Trichloroethene
TCL	Target Compound List
TDS	total dissolved solids
TOC	Total Organic Carbon
TSS	total suspended solids
ug/m^3	micrograms per cubic meter
USACE	United States Army Corp of Engineers
U.S. EPA	United States Environmental Protection Agency
USCS	Unified Soils Classification System
USGS	United States Geological Survey
UST	underground storage tank
VOC	Volatile Organic Compound
WAGNN	Water Authority of Great Neck North

EXECUTIVE SUMMARY

Earth Tech, Inc. conducted a Hydrogeologic Investigation (HI) for the United States Environmental Protection Agency (U.S. EPA) Region II, Emergency & Remedial Response Division, Removal Action Branch (RAB) to characterize the hydrogeology of the Stanton Cleaners Area (SCA). This partially fulfilled the March 1999, EPA issued Record of Decision (ROD) and identified remedial activities associated with the Design of a Groundwater Extraction and Treatment System (P&T) for the SCA Groundwater Contamination Site (hereinafter, the Site). The SCA Groundwater Contamination Site is located near the Village of Great Neck in Nassau County, Long Island, New York (Figure 1).

The HI included the installation of:

- 4 Soil Vapor Extraction (SVE)/Sparge wells (EPA-SVE-01 through –04);
- 2 SVE wells (EPA-SVE-05 and EPA-SVE-6 and manifold system);
- 3 extraction wells (EPA-EXT-01 through –03);
- 1 combination monitoring well/C-Sparge^{TM} re-circulation well (EPA-MW-24); and
- 20 monitoring wells (CL-1S, -1D, -2, -3, -4S, -4D, EPA-MW-9A, -11D, -21 through –23, and –25 through –33).

The wells were developed and sampled. Borehole permeability tests (slug tests) and groundwater sampling were also performed on all existing wells in the monitoring well network. Three aquifer tests were performed on wells screened in the shallow Upper Glacial Aquifer. Extensive water level monitoring was undertaken to evaluate the effects of the Water Authority of Great Neck North (WAGNN) public supply wells PW-9 and PW-2A on water levels and to estimate the radius of influence. WAGNN personnel, at the request of the EPA On-Site Coordinator (OSC), performed scheduled pumping of the public supply wells. Continuous groundwater level monitoring was performed for approximately three months during the field investigation to: 1) estimate the radius of influence of the public supply wells; 2) conduct the shallow Upper Glacial Aquifer tests; and, 3) collect background water levels before, during, and after investigation activities.

Boring logs from this HI in conjunction with boring logs from previous investigations were utilized in developing geologic cross-sections. The cross-sections illustrate the numerous fine grain units that underlie the Site. The fine grain units are typical of glacial deposits with the potential for relict erosional features and discontinuity. Reports produced by the United States Geological Survey (USGS) document the erosional features that exist in the area of the Site and the existence of a semi-confining unit (North

Shore Confining Unit) which divides the Upper Glacial sediments beneath the Site. These geologic conditions may allow interaction between the shallow, intermediate, and deep Upper Glacial Aquifers. The shallow Upper Glacial Aquifer is defined as the first groundwater encountered in the Upper Glacial Aquifer. The intermediate Upper Glacial Aquifer is the zone directly above the North Shore confining unit. The deep Upper Glacial Aquifer zone is beneath the North Shore confining unit.

Initial groundwater sampling (September 1999) during this investigation confirmed tetrachloroethylene (PCE) concentrations in groundwater at similar levels as detected during previous investigations. PCE concentrations are present in groundwater from the immediate vicinity of Stanton Cleaners to the WAGNN well field, approximately 1,000 feet (ft) to the southwest of the Site. High concentrations of PCE have persistently been detected on-site and just south (down-gradient) of the Site. Elevated concentrations have also been detected in the deep Upper Glacial at monitoring well CL-1D, down-gradient of the Site (in the vicinity of the WAGNN well field).

PCE concentrations have declined in Site monitoring wells since the upgraded Site extraction and treatment (P&T) system was put on-line. The highest PCE concentrations in groundwater from the September 2002 sampling event were detected in Site monitoring well EPA-MW-21 at 6,600 parts per billion (ppb) and down-gradient monitoring well ST-MW-19 at 6,400 ppb (both screened in the shallow Upper Glacial Aquifer). These concentrations show a 75% decrease in the highest detected PCE concentration since September 1999, when PCE was detected at 26,000 ppb in ST-MW-19.

Graphs of influent PCE concentration data from the WAGNN wells (Water Mill Lane well field) also exhibit a declining trend since the P&T was put on-line in September 2001. Some of the decline can conceivably be attributed to contaminant mass removal by the both the P&T system and the SVE system, which had removed more than 15,000 pounds of PCE by May 29, 2002. However, a substantial portion is probably due to decreased transport of PCE contamination as a result of decreased pumping rates of the Water Mill Lane well field southwest of the Site.

Aquifer tests and slug tests indicate that the aquifers are very permeable with high hydraulic conductivity values. Aquifer tests in the shallow Upper Glacial Aquifer also indicate that the wells have low efficiencies and water levels are affected by pumping from the public supply wells, barometric pressure, and possibly tidal influences. Long-term monitoring of water levels across the Site show more pronounced response to public supply well pumping in the intermediate and deep Upper Glacial wells than in the shallow Upper Glacial wells.

1.0 INTRODUCTION

This document presents the findings of the Hydrogeologic Investigation (HI) Report, Operable Unit-1 (OU-1), as prepared by Earth Tech, Inc. for the U. S. EPA Region II - Removal Action Branch (RAB), under its Emergency and Rapid Response Services (ERRS) Contract No. 68-S2-99-08, Delivery Orders No.002, 017, and 036. This partially fulfills the EPA issued Record of Decision (ROD) (March 1999) by identifying remedial activities associated with the design of a groundwater extraction and treatment system for the Stanton Cleaners Area (SCA) Groundwater Contamination Site, Town of North Hempstead, Great Neck, Nassau County, New York.

This OU-1 represents the first of two planned operable units for the Site. OU-1 addresses the principal threats at the Site and the fate and transport of the source contamination in the groundwater emanating from the Site.

The major components of the selected remedy for OU-1 include:

- Enhancement of the on-site groundwater extraction and treatment system, including increased pumping from the extraction well and an upgrade of the treatment system;
- Pumping of contaminated groundwater from extraction wells, installed both near and down-gradient of the Site, and treating the groundwater through the use of air stripping of volatile organic compounds (VOCs) with granular activated carbon (GAC) treatment of off-gasses (if necessary), and chemical precipitation and filtering for metals, if necessary;
- Continued operation of the on-site SVE system for VOC-contaminated soils, including on-site treatment of contaminated vapors using a vapor phase GAC treatment system;
- Indoor air monitoring;
- Long-term groundwater monitoring; and
- Groundwater use restrictions.

A second Operable Unit-2 (OU-2) for the Site addresses additional potential sources of groundwater contamination. The boundary defined for OU-2 is from Northern Boulevard to the south, WAGNN wells to the north, Great Neck Road to the east, and Little Neck Bay to the west.

Within this OU-2 study area, the following properties were evaluated based upon documented petroleum and/or hazardous material spills as reported by the New York State Department of Environmental Conservation (NYSDEC) Spill Group.

- Fenley Amoco Gas Station;
- Mayflower Cleaners;
- Citizen's Development Corporation (CDC), (a.k.a. Flower Fashion Cleaners); and
- Active Amoco Gas Station/Jonathan's Auto Repair Shop.

Due to the large study area and extensive volume of material reviewed, the OU-2 Summary Report (Earth Tech, February 2003, Draft) will be provided under a separate cover. The anticipated completion date of this report is July 2003.

1.1 REPORT ORGANIZATION

This HI OU-1 Report is organized such that the step-by-step approach to meeting the project goals may be reviewed in an orderly manner, as follows:

- Section 1.0 (Introduction) presents the relevant background information concerning past and present status of the SCA Site as well as the focus of the HI OU-1.
- Section 2.0 presents a summary of Previous and Current Investigation Activities, including a comprehensive chronology of EPA and EPA Superfund Technical Assessment and Response Team (START)/Removal Support Team (RST) contractor activities. This section also provides a detailed summary of major EPA actions, including a section on the operating Pump and Treatment (P&T) System.
- The investigation activities performed to meet the project objectives are documented in Sections 3.0 and 4.0.
- Section 5.0 presents the findings of the HI as they relate to physical and chemical characteristics of the site.
- A summary of findings and conclusions derived from all aspects of the HI and EPA's overall accomplishments is presented in Section 6.0.

1.2 PROJECT OBJECTIVE

As described in the Work Plan and support documents, the general objectives of this investigation were to:

- Further assess and delineate the extent of VOC contamination, [i.e., tetrachloroethylene (PCE)];
- Evaluate additional remedial alternatives capable of expediting site cleanup; and
- Develop a remedial design program to verify the components of the conceptual design and provide the details necessary for the construction, operation and maintenance (O&M), and monitoring of the remedial program.

Historical data were utilized along with data acquired during this investigation to further characterize the Site and resolve any uncertainties identified during the NYSDEC Remedial Investigation and Feasibility Report (RI/FS) (Dvirka and Bartilucci, 1998). Additional hydrogeologic data were collected through an exploratory program of soil borings and monitoring wells advanced in the shallow, intermediate, and deep Upper Glacial Aquifers both up-gradient and down-gradient of the Site. Furthermore, existing and newly installed monitoring and extraction wells were sampled to provide additional groundwater flow and quality data, and in-situ hydraulic conductivity tests and aquifer tests were conducted to evaluate hydraulic characteristics of the aquifers underlying the Site.

The hydrogeologic data collected during the HI OU-1 were used to develop a groundwater flow and transport model for the SCA. The objectives of the flow and transport model were to: 1) develop a calibrated flow model that could be used to evaluate potential remedial options including groundwater extraction rates and injection; 2) to develop a transport model that could be used to evaluate cleanup times and compare remedial strategies; and 3) to simulate the groundwater extraction necessary to remediate contamination at the SCA. A report detailing the specifics of the groundwater model construction, calibration, and results was previously provided under separate cover (Earth Tech, May 2001).

1.3 TECHNICAL APPROACH

The HI OU-1 was conducted in accordance with the scope of work (SOW) presented in the work plan and delivery order(s) to Earth Tech, Inc. The data generated for this HI OU-1 Report was from field investigation activities conducted between September 1999 and October 2002. These activities included installing and sampling of soil borings, monitoring and extraction wells; collecting groundwater elevation and flow data; conducting groundwater pump tests; indoor and outdoor air sampling; groundwater modeling; and design of the staging area for the groundwater extraction and treatment unit. Investigation areas and field activities were approved and observed by the U.S. EPA On-Site Coordinator (OSC) and Remedial Project Manager (RPM).

Quality Assurance/Quality Control (QA/QC) measures were performed in accordance with the approved *Sampling Quality Assurance Project Plan* (QAPP) (Earth Tech, January 2001) including the Work Plan (and Addendums) and Sampling and Analysis Management Plan (SAMP). Health and safety procedures were conducted in accordance with the approved *Site Specific Health & Safety Plan* (HASP) (Earth Tech, July 23, 2001).

The wells installed as part of this SOW include six shallow Upper Glacial Aquifer monitoring wells, three intermediate Upper Glacial Aquifer monitoring wells, two deep Upper Glacial Aquifer monitoring wells, one innovative in-situ technology shallow Upper Glacial monitoring well (designed for recirculation/sparging or groundwater extraction), three shallow Upper Glacial Aquifer extraction wells, four shallow Upper Glacial Aquifer SVE/air sparge/monitoring wells, and two shallow Upper Glacial Aquifer SVE wells. In addition, two shallow, two intermediate, and one deep Upper Glacial Aquifer monitoring wells were installed as part of the OU-2 area investigation. Details regarding these wells are presented in Section 3.3.1 and in Table 1.

One 96-hour aquifer test was performed by the U.S. EPA Environmental Response Team (ERT)/Response Engineering Analytical Contract (REAC) on the Principal Responsible Parties (PRPs) extraction system well ST-IW-01. This test was performed early in the investigation to collect the data necessary to estimate hydrogeologic characteristics of the Upper Glacial aquifer in the vicinity of the source area.

Two 72-hour aquifer tests were performed separately using the existing extraction well ST-IW-01 (located adjacent ST-MW-14 and EPA-MW-27), and the innovative in-situ recirculation/extraction well EPA-MW-24 (located adjacent ST-MW-19 and EPA-EXT-01). The purpose of the 72-hour aquifer tests was to estimate the radius of influence and maximum pumping rates for the remedial design. In conjunction with the two 72-hour aquifer tests, an extensive water level monitoring program was initiated to evaluate the effects of pumping by public supply wells PW-9 and PW-2A on water levels during and after the aquifer tests. The major objective of the water level monitoring was to provide the data necessary to estimate the radius of influence for each public supply well.

After the installation and development of EPA-EXT-02, a 9-hour pumping test was performed. The pumping test was designed to collect information to aid in the design of the P&T system and ensure that the pumping rates stipulated in the ROD (U.S. EPA Region II, March 31, 1999) could be met. Details regarding the pumping test, as well the aquifer tests, is presented in Section 3.3.7 and Appendix F.

Monitoring wells in the immediate vicinity of and northeast of the public supply wells were sampled along with Site monitoring wells to: 1) provide a comprehensive water quality data set for incorporation into the groundwater flow and transport model; 2) assess the current extent of groundwater contamination; and 3) provide information for the evaluation of groundwater injection of shallow/intermediate Upper Glacial Aquifer water into the underlying deep Upper Glacial Aquifer.

2.0 SITE DESCRIPTION AND BACKGROUND

The Site includes an active dry-cleaning business, located at 110 Cutter Mill Road in the Town of North Hempstead, Nassau County (Figure 1 through 3 and 4A). The Stanton Cleaners Property (SCP) is approximately 1/4-acre in size and includes a one-story building in which the dry-cleaning business operates and an adjacent one-story boiler/storage building (Figure 4B). Adjacent areas that have been affected by the contamination include but are not limited to, the neighboring Plaza Tennis Center (hereinafter, the Tennis Club), the Century Condominium Complex (hereinafter, the Century Complex), the North Shore Sephardic Synagogue (hereinafter, the Synagogue), and the Long Island Hebrew Academy (hereinafter, the Synagogue Pre-school). The surrounding community is zoned commercial/ residential and is serviced by public water, which is supplied by WAGNN.

2.1 SUMMARY OF PREVIOUS REPORTS

EPA RAB and Earth Tech, Inc. have reviewed the following technical reports regarding the Site:

- *Remedial Investigation and Feasibility Study, Stanton Cleaners Site, Great Neck, NY,* dated 1998, prepared by Dvirka and Bartilucci for the NYSDEC;
- *Proposed Remedial Action Plan for the Stanton Cleaners Area Groundwater Contamination Site, Operable Unit 1,* dated 1999, prepared by Dvirka and Bartilucci for the NYSDEC;
- *Focused Feasibility Study and Interim Remedial Measure/Presumptive Remedy Selection, Stanton Cleaners Area Groundwater Contamination Site, Operable Unit 1,* January 1999, prepared by Dvirka and Bartilucci for the NYSDEC;
- United States Environmental Protection Agency (U.S. EPA) Region II, *ROD for the Stanton Cleaners Area Groundwater Contamination Site,* March 31, 1999;
- U.S. EPA Region II, *Action Memorandum: Authorization to Initiate Remedial Design Activities Related to the Groundwater Extraction and Treatment System at the Stanton Cleaners Area Groundwater Contamination Site, Town of North Hempstead, Nassau County, New York,* August 20, 1999;
- U.S. EPA Region II, *Action Memorandum: Authorization to a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Removal at the Stanton Cleaners Site, Great Neck, Nassau County, New York,* September 14, 1998;

- U.S. EPA Region II, *Action Memorandum: Authorization to request and document approval of a Change in Scope of Response, Ceiling Increase and 12-Month Exemption for the Removal Action at the Stanton Cleaners Area Groundwater Contamination (a.k.a. Stanton French Cleaners) Site, Great Neck, Nassau County, New York*, August 5, 1999; and
- *Technical Guidance: Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites*, Office of Solid Waste and Emergency Response (OSWER) 9283.1-12, October 1996.

2.2 SITE HISTORY

The RI/FS (1998) prepared by Dvirka and Bartilucci for the NYSDEC documents a detailed history of the SCA Groundwater Contamination Site, Great Neck, NY. A brief summary of site history is presented below.

Since 1958, a dry cleaning operation has existed on the SCP. The SCP changed ownership several times during its history; the current owner acquired the property in November 1967. During the late 1970s and early 1980s, Nassau County Department of Health (NCDOH) identified low levels of the VOC PCE, a solvent commonly used by dry cleaners, in the public water supply wells located about 1,000 ft down-gradient of the SCP. In 1983, the WAGNN solicited help from NCDOH to assist them in identifying potential sources of the PCE contamination. As a result, in 1983, the SCP was inspected by the NCDOH. At that time, it was noted that a discharge pipe led from the dry cleaning fluid separator to the grassy, sloped area at the rear of the building. Shortly thereafter, the discharge was stopped.

In 1996, the NYSDEC initiated a RI/FS to determine the nature and extent of contamination and to develop a long-term and permanent remedy to mitigate threats to human health and the environment. During the RI/FS, NYSDEC in conjunction with the New York State Department of Health (NYSDOH) performed indoor air sampling in some of the buildings adjacent to the SCP in order to determine the contaminant levels in the indoor air. Sampling was performed in the Tennis Club, the Synagogue, and the Century Complex, which are all adjacent to the SCP.

Samples collected in spring of 1998 showed the presence of high levels of PCE in the air within the segment of the Tennis Club nearest to the SCP. Within the basement of the Synagogue, PCE concentrations also exceeded NYSDOH indoor air quality guidelines. In addition, low levels of PCE were found in the garage level of the Century Complex to the north of the SCP.

In September 1998, the EPA performed air sampling to confirm indoor PCE levels and to target where PCE vapors entered the structures adjacent to the SCP. The sampling confirmed the elevated concentrations of PCE in the Tennis Club; revealed elevated concentrations of PCE in the parking garage of the Century Complex; and revealed no further PCE contamination within the Synagogue or its adjacent pre-school building.

Based upon the air, soil, and groundwater data collected from the Site to date, it was evident that PCE was migrating from the subsurface soils into the indoor environments of the above-referenced affected buildings adjacent to the SCP and into the groundwater beneath the Site.

Some interim remedial measures have been conducted at the Site. In 1983, following the discovery of elevated levels of PCE contamination in soils [up to 8000 parts per million (ppm)] by NCDOH at the rear of the SCP, approximately 20 cubic yards of soil were removed by the PRP to an off-site disposal facility.

In May 1998, NYSDEC requested that the PRPs repair the groundwater extraction and treatment system on the SCP, which had worked only intermittently since it began operations in 1989. In July 1998, the system was repaired and put back on-line; however, follow-up sampling showed that effluent water samples exceeded discharge standards. In 1998, the PRP repaired and added two 55-gallon drums of aqueous phase GAC to the PRP system, so that it was temporarily operational and complied with the surface water discharge requirements.

Additionally, three WAGNN public water supply wells are located approximately 1000 ft south of the SCP. Two of these wells are approximately 145 ft deep and the third well is 434 ft deep. In 1998, due to increasing levels of PCE contamination, the NYSDEC funded the construction of a new air stripper treatment system for two of the affected WAGNN water supply wells (PW-2A and PW-9). This new treatment system on the WAGNN supply wells is currently in operation and VOC contamination has been reduced to below federal and state drinking water standards.

2.3 PREVIOUS INVESTIGATIONS/ACTIVITIES

Initial response activities to the release of PCE contamination at the SCP were performed by the NCDOH, NYSDEC, and NYSDOH (see Section 2.2). As stated in Section 2.2, the NYSDEC initiated a RI/FS in 1996. The RI was conducted between September 1997 and October 1998. The FS was issued in January 1999.

The field work for the RI included an inspection of Site facilities; private water well survey; public water supply well survey; soil gas survey of the SCP; soil probe borings and soil sampling; groundwater monitoring system installation and sampling; groundwater elevation and flow data collection; indoor and outdoor air sampling; drainage system sediment sampling; steam/vacuum system sampling; subsurface soil sampling; and an aquifer test. Detailed findings of the RI/FS can be found in the 1998 report by Dvirka and Bartilucci.

2.4 WATER AUTHORITY OF GREAT NECK NORTH

As mentioned previously, a public water supply well field located at Water Mill Lane (Figure 4A) and operated by WAGNN exists approximately 1000 ft south of the SCP. Two of the WAGNN wells, PW-2A (N-12796) and PW-9 (N-4388), are screened in the deep portions of the Upper Glacial Aquifer with a total depth of approximately 145 ft below ground surface (bgs) (WAGNN well construction information, influent concentrations, and pumping rates are presented in Appendix H). The presence of discontinuous clays (discussed in Section 4.2.3) allows for hydrogeologic inter-connection between the deep and shallow/intermediate portions of the Upper Glacial Aquifer. Thus making the deep Upper Glacial Aquifer susceptible to surface contamination migrating from the impacted shallow/intermediate Upper Glacial Aquifer.

Water level measurements were collected during this investigation and used to approximate the radius of influence of WAGNN wells PW-2A and PW-9. As discussed in Section 4.2.5, the radius of influence extends several thousand ft, placing the SCP within the capture zone of these wells.

Concentrations of PCE have been detected in groundwater samples collected from public water supply wells PW-9 and PW-2A. Due to the location of the SCP (up-gradient and within the capture zone of the WAGNN well field), historic and present elevated concentrations of PCE contamination found at the Site, and PCE plume delineation defined by this report, the SCP was found to be a likely source for a major portion of the PCE contamination.

As discussed in Section 2.2, the NYSDEC funded the construction of a new air stripper treatment system for PW-2A and PW-9 due to increasing levels of PCE. The new system, which is currently operational, has reduced VOC contamination to below federal and state drinking water standards.

To reduce the susceptibility of the public water supply to contaminants and to mitigate groundwater contamination caused by past activities on the SCP, the ROD, issued for the Stanton Cleaners Site March 31, 1999, called for an upgrade of the existing extraction system. The resulting EPA P&T system was put on-line in September 2001 and is currently operational.

Trend plots (discussed in Section 6 of this document) show that PCE concentrations in WAGNN wells PW-2A and PW-9 have declined since the extraction system was put on-line in September 2001. Some of the decline can conceivably be attributed to capture of contaminant mass by the Site extraction systems (SVE and P&T systems). However, we can probably contribute a major portion of this contaminant reduction to the foresight and cooperation of WAGNN, which opened the Community Drive well field in the summer of 2000, there-by reducing their dependence on the Water Mill Lane well field in recent years. The subsequent decrease in pumping rates at the Water Mill Lane well field probably resulted in decreased transport of PCE contamination.

With the limited pumping of the Water Mill Lane well field, the EPA P&T system, which averages an extraction rate of 65 gallons per minute (gpm), was allowed to capture a substantial portion of the contaminant plume (at concentrations of 1 ppm PCE and above).

2.5 EPA CHRONOLOGY OF EVENTS

Presented below is a brief chronology of EPA responses and actions at the SCA Groundwater Contamination Site for both the Removal and Remedial Programs.

2.5.1 Removal Activities

On April 6, 1998, the NYSDEC requested that the EPA conduct a *Time-Critical Removal Action* to address VOC contamination in soils, which were impacting nearby public water supply wells (WAGNN) and the indoor air of buildings adjacent to the SCP.

On September 14, 1998, the EPA authorized a *Time-Critical Removal Action* to reduce threats to public health and the environment by reducing indoor air contamination in affected structures (including but not limited to the neighboring Tennis Club, the Century Complex, the Synagogue, and the Synagogue Pre-School). This action included the implementation of a SVE system and temporary measures (i.e, sealing, sub-slab systems, etc.) to reduce VOCs within the soils at the Site.

In late September 1998, EPA installed a sub-slab ventilation system as a temporary measure to minimize vapors from entering the Tennis Club. On November 18, 1998, indoor air sampling showed a PCE concentration of 325 micrograms per cubic meter (ug/m^3), a reduction of greater than 78% from previous measurements.

On December 10, 1998, dry sump vapor check valves were installed by the EPA into two sumps on the lower-level parking garage at the Century Complex. Subsequent air sampling showed PCE levels had dropped to 21 ug/m^3, a reduction of greater than 98% from previous measurements.

On September 17, 1998, the EPA ERT performed indoor air sampling which showed low level PCE contamination within the Synagogue and warehouse (proposed pre-school).

EPA completed installation of four SVE/Air Sparge extraction wells on December 4, 1998. The EPA began installation of an interim, manually-operated SVE [200 cubic feet per minute (CFM)] system on January 25, 1999. The interim SVE system was activated on February 15, 1999.

On May 19, 1999, the full-scale trailer mounted SVE 800 CFM system was placed on-line for operation. The full-scale trailer mounted SVE 800 CFM system was in continuous operation until late August 2000 when construction of the Groundwater P&T system building began. Approximately 14,300 pounds of PCE had been removed by the SVE 800 CFM system by that date.

On August 5, 1999, EPA authorized a Change in Scope of Response, Ceiling Increase and 12-Month Exemption for the Time-Critical Removal Action at the SCA Groundwater Contamination, Great Neck, Nassau County, New York. The proposed action described in this memorandum was to complete the installation, automation/ security control, and continued O&M of the SVE system; to provide transportation and disposal of PCE contaminated material generated from the installation of SVE extraction wells and operation of the SVE system (i.e., soil, water, vapor phase carbon, etc,); and to perform an operation test of in-well air sparging to determine its effectiveness to expedite PCE removal from high source areas.

On February 5, 2001, a final 250 CFM SVE system was installed and began operating, and is still in operation to this date. Approximately 15,400 pounds of PCE had been removed by the SVE System by May 29, 2002 (this value includes PCE removed by the interim 200 CFM system, the full scale 800 CFM system, and the final 250 CFM system).

On August 24, 2001, EPA authorized additional funding, a Change in Scope of Response, Ceiling Increase and 12-Month Exemption for the Time-Critical Removal Action at the SCA Groundwater Contamination, Great Neck, Nassau County, New York. The purpose of this funding was to delineate, excavate and remove buried tanks and contents on the SCP, and, if necessary, to treat contaminated soils with the existing SVE system and contaminated groundwater with the P&T system. As a result of EPA's involvement at the World Trade Center site, this action was delayed until January 2002.

In January 2002, field operations for the underground storage tank (UST) action were completed with the removal of two, 250-gallon PCE USTs and one, 500-gallon oil UST. Two SVE wells (one vertical and one horizontal) were placed in the area of the former USTs to treat contaminated soils. These wells were connected to the existing on-site SVE system to target areas with elevated PCE vapors.

2.5.2 Remedial Activities

The Site was proposed for Federal National Priorities List (NPL) listing under the Hazard Ranking System (HRS) in January 1999 and listed final on May 17, 1999.

In March 1999, EPA issued a ROD identifying the selected remedy for the Site, which included: 1) upgrade of the existing air stripper on the SCP, 2) installation of a groundwater P&T system for the Site, 3) continued operation of the SVE system, 4) indoor air monitoring of the affected adjacent buildings, 5) long term groundwater monitoring, and 6) groundwater use restrictions.

In September 1999, EPA tasked Earth Tech, Inc. and other EPA START contractors to initiate remedial design activities for the groundwater P&T system. These activities included the following: extraction well and treatment unit installation, treatability studies, pretreatment studies, installation/sampling of monitoring wells, pump tests, evaluation of the on-site air stripper, performance of a re-injection study, groundwater modeling, and design of the staging area and on-site treatment building.

From September 1999 thru February 2000, Earth Tech, at the request of the EPA, completed the Drilling Work Plan, QAPP, and HASP as part of the supplemental HI Study OU-1 and the Flow and Transport Model. EPA performed a background review of state and county files of other sites potentially impacting the WAGNN public supply wells, (i.e., Fenley Amoco, Mayflower Cleaners, Citizen Development Corp., etc.).

From February to March 2000, Earth Tech, Inc., along with other START contractors, initiated field activities at the request of the EPA. These activities included the installation/development of eight new monitoring/extraction wells near the SCP, including soil, geological, and contaminant characterization and profiling. EPA evaluated alternate remediation technologies and performed pump tests on system pumping rates.

In March 2000, Earth Tech, at the request of the EPA, completed an aquifer test at the PRP extraction well, ST-IW-01, and the newly installed combination C-Sparge™/monitoring well, EPA-MW-24. Newly installed monitoring wells were also sampled during this time.

In April through July 2000, Earth Tech, at the request of EPA, initiated the HI OU-1 and the Flow and Transport Model studies for the Site. The United State Geological Survey (USGS) was issued first draft reports for review.

August 2000, Earth Tech, at the request of EPA, completed draft specifications for the P&T system and treatment building design.

September 2000, Earth Tech, at the request of EPA, initiated remedial action activities for the construction of an enhanced groundwater P&T system and evaluated potential upgrades of the existing on-site PRP groundwater air stripper system. EPA continues operation of the PRP extraction well (ST-IW-01) with treatment through the EPA Mobile Groundwater Treatment System.

October 2000, Earth Tech, at the request of EPA, started construction of the Treatment Building to house the EPA P&T system.

November 2000, Earth Tech, at the request of EPA, completed the design specifications for the P&T system and treatment building.

From November to December 2000, Earth Tech, at the request of EPA, completed field activities with the installation of five additional OU-2 area monitoring wells (off-site near the CDC and Mayflower sites). High efficiency extraction wells EPA-EXT-02 and 03 were installed on the SCP to optimize the potential pumping rates for the P&T System.

January 2001, Earth Tech, at the request of EPA, completed exterior shell of the treatment building. The third round of groundwater sampling of all monitoring wells on-site and off-site was completed by the U.S. EPA Division of Environmental Science and Assessment (DESA) at this time.

From February to March 2001, USGS comments were received on the HI OU-1 (Preliminary Draft) and the Groundwater Flow and Transport Modeling Report (Preliminary Draft) - SCA Groundwater Contamination Site.

From April to May 2001, Earth Tech, at the request of EPA, completed construction of the treatment building, with the installation of insulation, interior walls, electrical, and control offices. EPA contractor, ETI procured the services of a Programmable Logic Controller (PLC) programmer to expedite the eventual automation of the P&T System.

From June to September 2001, Earth Tech, at the request of EPA, completed installation of the P&T system components (i.e., air stripper, aqueous and vapor phase GAC systems, etc.), and began manual operation of the P&T system for testing with a shake-down period of three months in order to finalize system pumping rates. The treatment system design was based upon the *Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites*, October 1996. EPA discontinued temporary operation of the PRP extraction well (ST-IW-01) with treatment through the EPA Mobile Groundwater Treatment System. The total treated water was approximately 2 million gallons.

From October through December 2001, as a result of EPA's involvement at the World Trade Center, the P&T system automation was delayed. The P&T system three-month shake-down period was extended to continue manual operation of the system.

From October 2001 through March 2003, preliminary results from the EPA system discharge equivalency monitoring sampling indicate a steady decline in influent PCE concentrations (i.e. 26,000 ppb in October 2001 to <500 ppb in March 2003).

From January 2002 to May 2003, EPA completed the installation and testing of the PLC for automation of the P&T System. As of April 2003, EPA has pumped and treated approximately 32 million gallons of VOC contaminated groundwater.

From January 2002 through April 2003, EPA continued testing and monitoring to finalize NYSDEC permit requirements for discharge monitoring. After approximately 16 months of effluent discharge sampling events, data continues to indicate non-detect for all VOCs (including PCE).

In July 2002, the EPA released the following reports for public comment: *Underground Storage Tank Closure Report – Final* (Earth Tech, July 10, 2002) and the *Indoor Air Quality Summary Report - Final Draft* (Earth Tech, July 23, 2002).

In August 2002, the EPA released the *Draft Final Groundwater Flow and Transport Modeling Report* (Earth Tech, May 2001) for public comment.

From September 2002 to May 2003, EPA finalized the funding for the Long-Term Response Action (LTRA) at the Site and development of the O&M Manual for continued operation of the P&T System.

At the request of the EPA, *A Draft Capture Zone Analysis Plan* (Earth Tech) was completed in September 2002. Subsequently in April 2003, Earth Tech completed a *Draft Capture Zone Analysis Report* to evaluate and optimize the pumping rate for PCE plume capture at the Site.

2.5.3 Current EPA Actions/Investigations

2.5.3.1 Soil Vapor Extraction Removal Action

In April 1998, EPA received a written request from the NYSDEC to conduct an emergency response action to address contaminated soil at the Site. Soil contamination, in addition to impacting the groundwater and nearby public supply wells, was impacting the indoor air of adjacent buildings.

As discussed in Section 2.5.1, the EPA authorized a *Time-Critical Removal Action* in September 1998 to reduce indoor air contamination in affected structures (including but not limited to the neighboring Tennis Club, the Century Complex, the Synagogue and the Synagogue Pre-school). This action included the implementation of a SVE system and temporary measures (i.e, sealing, sub-slab systems, etc.) to reduce the VOCs within the soils at the Site.

To provide interim mitigation for the affected structures prior to the startup and implementation of the SVE system, in late September 1998, soil gas entry points in the adjacent structures (i.e., Tennis Center, etc.) were sealed to reduce convective and diffusive vapor movement between the soil and building. A sub-slab ventilation system was installed to establish a low-pressure area under the foundation to prevent vapors from entering the building.

By December 1998, four vapor extraction/monitoring wells (EPA-SVE-01 through EPA-SVE-04), were installed and connected to an interim SVE (200 CFM) system.

By February 1999, EPA began operation testing of the interim SVE (200 CFM) system and with the arrival of two, 2,000 pound vapor phase GAC vessels to capture off-gas, the interim system was activated. After approximately four months of running the interim SVE system, with initial air concentration readings ranging as high as 2,500 ppm, concentrations stabilized to levels approaching 400 ppm.

Between February 24, 1999 and March 3, 1999, the NYSDOH performed another round of air sampling within the Tennis Center. These results indicated a gradual but steady decline of PCE levels, suggesting the SVE technology had been effective in reducing the infiltration and capturing residual PCE vapors from high source areas.

In April 1999, the full-scale trailer mounted 800 CFM SVE system was delivered. Replacement of the interim SVE (200 CFM) system was completed by May 1999. The U.S. EPA trailer mounted and enclosed SVE (800 CFM) system is pre-wired with all integral piping and controls included. The SVE system consists of a explosive proof, positive displacement blower rated at 800 CFM air flow at 8 to 10 inches of Hg. The blower is fitted with a discharge silencer. The system is fitted with a knockout tank designed for air/water separation and comes with a progressive cavity discharge pump. Discharge from the knockout tank goes to an aqueous phase GAC filter for treatment prior to discharge. A particulate filter, vacuum relief valve, and vacuum gauge is present on the blower influent.

Field operation of the trailer mounted SVE system requires only the connection of influent and effluent piping, electrical service connections, calibration of monitoring instruments, and testing of the PLC. The control system is fully automated and fail-safe, requiring only periodic operator attention for major fault conditions and scheduled preventive maintenance.

A Supervisory Control and Data Acquisition-type (SCADA) software system is provided for remote control and monitoring capabilities. Data logging capabilities is provided for all monitoring and control devices, along with motor run times and alarm conditions. The trailer enclosure is equipped with sound-dampening materials such that external noise levels are below 60 decibels (dB). The control room portion of the enclosure is equipped with heating and cooling systems and can be occupied for field testing, monitoring, and service.

By August 2000, it was estimated that the combined effort of the interim SVE system and the trailer mounted SVE system had captured approximately 14,300 pounds of VOCs. The trailer mounted SVE system was then replaced by a smaller unit (rated at 250 CFM), which was more cost effective and, at the same time, provided optimum contaminant removal for the remaining residual PCE entrapped in soil. On February 5, 2001, the final 250 CFM SVE system replaced the trailer mounted 800 CFM SVE system, and began operations.

The 250 CFM SVE system continues to operate as an integral part of the groundwater management system.

A complete report on SVE operations and recovery rates (i.e., PCE) is presently being compiled in the *SVE Pre-Closure Report* (Earth Tech, August 2002, Draft). The anticipation completion date of this report is July 2003.

The EPA and the NYSDOH continue to perform air monitoring of adjacent structures impacted by the PCE contamination and to assess remediation efforts of the SVE system.

2.5.3.2 Indoor Air Monitoring Program

The impact to indoor air quality was the initial catalyst to start EPA response actions at the Site. Indoor air quality is now a major issue at many Superfund sites. The initial response actions to the contamination of indoor air (i.e., sub-slab depressurization system) dramatically lowered the indoor air contaminant concentrations that were eventually lowered even further by the installation of the SVE system (see Section 2.5.3.1).

During the period from December 1997 through January 2003, the NYSDEC, the NYSDOH, and the EPA have performed multiple rounds of indoor air sampling from various locations within and around the four affected buildings (i.e., Tennis Club, Century Complex, Synagogue, and Synagogue Pre-School). Sample data from these sampling events were collected in support of Site investigation activities and to evaluate the effectiveness of the remedial actions being implemented. Samples were collected using Passive Sampling Devices (PSDs), SUMMA™ canisters, and charcoal sorbent tubes and were analyzed for VOCs at EPA and NY State approved laboratories. The locations and designations of the sampling locations have varied from each sampling event depending on the requirements of the field activities being conducted and the agency involved in completing the sampling.

The objectives of this indoor air monitoring program was to provide a comprehensive testing plan to measure the effectiveness of EPA response actions in reducing and maintaining the indoor airborne PCE concentrations to acceptable levels. Since the U.S. EPA initiated remedial measures at the Site, indoor ambient air concentrations of PCE have been reduced at the Tennis Club from a high of 2,500 ug/m^3 to between 3 ug/m^3 and 40 ug/m^3. Ambient PCE levels at the Synagogue have been reduced from highs ranging between 189 ug/m^3 and 200 ug/m^3 to non-detectable concentrations (< 0.3 ug/m^3). PCE concentrations in the Synagogue Pre-School have dropped from a high of 81 ug/m^3 to a low range of 3.4 ug/m^3 to 5.2 ug/m^3. Finally, ambient air concentrations of PCE have been reduced in the parking garage basement of the Century Complex from a high of 1,092 ug/m^3 to a low ranging from 3.1 ug/m^3 to 15 ug/m^3. Overall, EPA remedial actions have reduced ambient air concentrations of PCE in all affected building structures, with an average reduction in PCE levels of 98 percent for all affected structures.

A comprehensive summary of this indoor air monitoring program is provided in the *Indoor Air Quality Summary Report - Final Draft* (Earth Tech, July 23, 2002), released for public comment in July 2002.

The U.S. EPA remediation effort at the SCA Site is ongoing. The operation of the SVE system will continue until source removal of PCE contamination meets NYSDEC guidelines for soil cleanup. EPA anticipates continued periodic indoor air quality sampling in surrounding structures. Results of sampling activities conducted after October 2002 will be included as addenda to this report.

2.5.3.3 PRP Extraction & Treatment System

In January 2000, EPA performed an evaluation of the potential upgrade of the existing SCP extraction and treatment system, which consisted of one extraction well (ST-IW-01). The well was pumped at 8 gpm, followed by air stripping and discharge to a storm sewer. An evaluation of the upgrade for the existing SCP system was part of the selected remedy of the March 1999 ROD. The EPA recommended re-development of the extraction well (ST-IW-01), the replacement of the existing pump with a pump rated for higher flow, and a pump test to evaluate the potential pumping rate and radius of influence (EPA ERT/REAC, May 1999). Portions of the influent and effluent lines would be replaced with larger diameter piping and further insulated for cold weather operations. The extraction well flow rate was increased to 15 gpm.

As a result, EPA's technical evaluation of the potential upgrade of the existing SCP treatment system recommended that substantial modifications and equipment upgrades would be necessary: 1) full system winterization; 2) air stripper upgrade to treat influent concentration levels to meet NYSDEC discharge requirements; and 3) implementation of off-gas treatment from the air stripper to meet air discharge requirements. These modifications would result in significant monetary expenditures in order to perform a complete upgrade of the existing SCP system so that discharge requirements could be met. These recommendations were found to be neither cost effective nor technically feasible, nor would this upgrade benefit the comprehensive groundwater cleanup at the Site. Incorporating the existing SCP system's re-developed extraction well (ST-IW-01), upgrading existing influent and discharge lines, and then installing a new pump has proven to be the most cost effective method of upgrading the existing SCP system. Thus, the ROD's selected remedy (U.S. EPA, March 1999) of enhanced groundwater plume capture and treatment has been configured to incorporate portions of the existing SCP system into the primary P&T system in order to achieve the most technically feasible and cost effective way to address the Site groundwater contamination.

2.5.3.4 Underground Storage Tank Removal Action

As mentioned in Section 2.5.1, the EPA authorized additional funding, a Change in Scope of Response, Ceiling Increase and 12-Month Exemption for the Time-Critical Removal Action at the Stanton Cleaners Area Groundwater Contamination, Great Neck, Nassau County, New York in August 2001. The action was necessary to delineate, excavate and remove buried tanks and their contents on the SCP, and, if necessary, to treat contaminated soils with the existing SVE system and contaminated groundwater with the P&T system. This action was delayed until January 2002 as a result of EPA's involvement at the World Trade Center site.

In January 2001, during negotiations with one of the PRPs to clarify the site access agreement for construction of the on-site P&T system, the boiler/garage structure (which had previously been subleased to an off-site tenant as storage space) was emptied and available for inspection. Close inspection within the garage portion of the structure indicated numerous valves and piping indicative of a tank system commonly used by dry cleaning facilities. With the exception of a underground oil storage tank, no indications of any above and/or below ground structures were indicated in the PRPs response to the EPA information request.

In April 2001, with the completion and receipt of the clarified access agreements, EPA ERT was requested to perform a geophysical survey of the area to look for USTs. ERT completed the geophysical survey in May 2001, utilizing ground penetrating radar, and determined two potential areas where tanks may have been buried (U.S. EPA REAC, June 28, 2001).

In January 2002, field operations for the buried UST removal action were completed with the removal of two PCE USTs and one fuel oil UST. Two SVE wells (EPA-SVE-05 and EPA-SVE-06) were placed in the area of the former USTs to treat contaminated soils. These wells were connected to the existing on-site SVE system to target areas with elevated PCE vapors.

A comprehensive summary report of this UST Removal Action is provided in the *Underground Storage Tank Closure Report - Final Draft* (Earth Tech, July 10, 2002), released for public comment in July 2002.

2.5.3.5 Flow & Transport Model

The Modular Three-Dimensional Finite-Difference Ground-Water Flow Model (MODFLOW) (McDonald and Harbaugh, 1988) was used to model the sedimentary aquifers underlying the SCA Site. This model is well documented, and can simulate highly variable aquifer thickness, hydraulic conductivity, and unconfined conditions. MODFLOW also incorporates all necessary boundary conditions required, and simulates both steady-state and transient conditions. In addition, solute transport models are available that use the output from MODFLOW as input.

The transport modeling for the Site was done using the three-dimensional contaminant transport code MODFLOWT developed by Glenn Duffield (Duffield, 1996) and Jeff Benegar. MODFLOWT is an enhanced version of MODFLOW, and simulates three-dimensional advective-dispersive transport of a single miscible species subject to adsorption and decay. The program uses an implicit finite-difference discritization scheme for the numerical solution of the partial differential equations for solute transport.

The objectives of this groundwater modeling project were to:

- construct a numerical model of the site groundwater flow system;
- estimate flow rates for effective hydraulic control of the VOC plume;
- simulate contaminant fate and transport, and remedial alternatives;
- evaluate whether proposed plume control measures will reduce VOC concentrations in the water supply wells.

The flow and transport model was used to simulate potential remedial alternatives including various groundwater extraction scenarios. Remedial pumping scenarios were first presented in the ERT/REAC Draft Final Report, *Initial Groundwater Flow and Contaminant Transport Modeling and Groundwater Treatment System Design, Stanton Cleaners Site, Great Neck, New York* (December 1998). The primary goal of this study was to determine which scenario would best intercept the 1 ppm PCE contour to minimize further migration in the southwesterly direction of the public supply wells. The following proposed remedial scenarios were considered to be consistent with the ERT/REAC Report and the ROD at the SCA Groundwater Contamination Site:

Scenario #1: Hypothetical, No Action scenario, which portrays the contaminant plume if no control measures were implemented. The scenario took into consideration a constant source and did not include degradation effects. This scenario was simulated for 100 years.

Scenario #2: Simulation of a groundwater pump and treat system located on-site with groundwater extraction in the vicinity of IW-01 and down-gradient in the vicinity of MW-19. This scenario incorporated a constant source and the two recovery wells pumping at a rate of 50 gpm each. The groundwater extraction was simulated without return to the aquifer system. This scenario was simulated without degradation for 100 years.

Scenario #3: Simulation of a groundwater pump and treat system located on-site with groundwater extraction in the vicinity of IW-01 and down-gradient in the vicinity of MW-19. This scenario incorporated a constant source and the two recovery wells pumping at a rate of 100 gpm each. The groundwater extraction was simulated without return to the aquifer system. This scenario was simulated without degradation for 100 years.

Scenario #4: Simulation of a groundwater pump and treat system located on-site with an extraction well, IW-01, pumping at a rate of 15 gpm. The groundwater extraction was simulated without return to the aquifer system. This scenario included the effects of degradation and was simulated with a constant source for 100 years.

A comprehensive summary report of this flow and transport model is presented in the *Draft Final Groundwater Flow and Transport Modeling Report* (Earth Tech, May 2001), released for public comment in August 2002. This report describes the model construction and calibration, and presents the results of simulating various remedial alternatives.

Based upon the operation of the P&T System since September 2001, Earth Tech has prepared a *Capture Zone Analysis Report* (April 2003) as directed by the EPA to estimate the capture zone created by the Site extraction system and to analyze the stability/transport of the plume outside the capture zone. This report is anticipated to be available for public review in July 2003. The findings of this report will be used to finalize the *Draft Capture Zone Analysis Plan* (Earth Tech, September 2002) for use in future P&T system evaluation.

2.5.3.6 Pump and Treat System

Due to the early operation and completion of the remedial design (November 2000) and remedial action (September 2001) for the SCA P&T System, EPA has provided in this section a summary of the remedial action components completed as required by the proposed plan and ROD for the Site.

The final P&T system design will be integrated into the O&M Manual after final review by the U.S. Army Corp of Engineers, under the LTRA. This included but is not limited to, as-builts, electrical schematics, flow and control diagrams, QAPP (i.e., sampling and analysis), health & safety plan, etc.

The SCA P&T system has been operational since September 2001. It has run at an average flow rate of 50 gpm, with recent upgrades to 65 gpm, and has treated approximately 36 million gallons of contaminated groundwater to date.

After approximately 21 months of groundwater remediation, PCE source concentrations have decreased significantly. These reductions are consistent with the projected Fate & Transport model results (Earth Tech, May 2001), and continue the already successful remediation of PCE source areas (i.e., SVE operation).

2.5.3.6.1 Basis of Design Parameters

In March 1999, EPA issued a ROD identifying the selected remedy which included: 1) an upgrade of the existing groundwater air stripper on the SCP, 2) a groundwater extraction and treatment system for the Site, 3) continued operation of the SVE system, 4) indoor air monitoring of the affected buildings adjacent to the SCP, 4) long term groundwater monitoring, and 6) groundwater use restrictions. Details of the P&T system components, as required by the ROD, were as follows:

- The P&T system for the Site should include an enhanced system to capture the contaminated groundwater plume. Contaminated groundwater from high source areas should be pumped from one or two down-gradient extraction wells. The extracted groundwater should be pumped to an off-site treatment system.
- The extraction wells should be installed at the 1 ppm PCE contaminant contour, approximately 400 ft south of the SCP. These wells should be pumped at a rate of approximately 50 to 100 gpm. As a result of the strong influence of the WAGNN well pumping rates on the aquifer, which is in close proximity to these wells, it is not feasible to capture the leading edge of the groundwater VOC plume. However, the leading edge

of the plume is being captured by the WAGNN wells where it is treated to meet federal and state drinking water standards.

- Contaminated groundwater should be pumped from the aquifer and directed through an air stripping treatment system to remove VOCs. Off-gasses should be treated, if required, using a vapor phase GAC filter to federal and state ambient air quality standards. Pretreatment may be necessary to prevent fouling of the air stripper by metals, which naturally exist in the groundwater. The pretreatment process for metals removal should utilize chemical precipitation and pH adjustment combined with filtering and/or equivalent. Pre-treatment metals residuals should be disposed of off-site according to federal and state RCRA disposal standards, and the treated groundwater should be discharged to either a storm sewer/sanitary sewer and/or for re-injection, according to federal and state effluent discharge standards. The vapor phase GAC filters should be designed for regeneration and/or off-site disposal.
- The operation time for extraction and treatment is expected to be 20 years. The long-term groundwater monitoring program is assumed to remain in effect for up to 30 years.

The ex-situ treatment component of the groundwater remedy utilized presumptive technologies identified in Directive 9283.1-12 from EPA's OSWER. Since contaminants of concern include volatile and Semi-Volatile Organic Compounds (SVOCs), one or more of the presumptive technologies - air stripping, GAC, chemical/UV oxidation and anaerobic reactors - were evaluated for treating aqueous contaminants in the extracted groundwater. Other technologies were also considered in the treatment system for removal of suspended solids and treatment of vapor phase contaminants. The actual technologies and sequence of technologies used for the treatment components were determined during remedial design. Final selection of these technologies was based on Site information collected during the preparation of this report (OU-1) and the remedial design process.

The parameters required to design this groundwater extraction, treatment, and discharge system (basis of design parameters) were developed and finalized in the November 2000, *Design Specifications for the P&T System and Treatment Building, Stanton Cleaners Area Groundwater Contamination Site.*

A comprehensive summary report of the flow and transport model for the Site is presented in the *Draft Final Groundwater Flow and Transport Modeling Report* (Earth Tech, May 2001*)* (as discussed in Section 2.5.3.5). The primary goal of this study was to determine which scenario would best intercept the 1 ppm PCE contour to minimize further migration in the southwesterly direction of the public supply wells. This report describes the construction, and calibration of the model, and presents the results of simulating various remedial alternatives.

The treatment system, as presented in the ROD, included chemical precipitation of metals (or equivalent) and air stripping and carbon adsorption for VOCs with treated groundwater being discharged to either a storm sewer or sanitary sewer. The re-injection option was to be evaluated based upon strong public opinion during the public comment period. Due to extensive confining layers present on the SCP, re-injection was found to be unfeasible and dropped from future consideration.

2.5.3.6.2 Groundwater Treatability Study

No treatability tests were conducted on the groundwater during the NYSDEC RI/FS. Groundwater treatability tests of chemical precipitation for metals removal (i.e., iron and manganese), or equivalent, were recommended. Air stripping and carbon adsorption tests were not deemed necessary based upon the presumptive remedy criteria.

During this investigation, groundwater samples from the multiple pump tests and operation of the PRP ST-IW-01 extraction system were analyzed for conventional water quality parameters. Pump test water was treated through the U.S. EPA Mobile Water Treatment Trailer (approximately 2 million gallons).

These samples were collected and analyzed to support the design criteria for the permanent on-site P&T system. These samples were analyzed for: chloride, total suspended solids (TSS), total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), langlier index, carbon dioxide, Target Compound List (TCL) volatiles, Target Analyte List (TAL) metals, hardness, sulfide, sulfate, carbonate alkalinity, bicarbonate alkalinity, alkalinity, total organic carbon (TOC), nitrate, nitrite, dissolved manganese, total iron, and dissolved iron. The results have indicated elevated iron and manganese concentrations above the MCL (both at 300 ppb), but based upon long-term operation of the U.S. EPA Mobile Water Treatment Trailer, these concentrations would have limited impact to the operation of the final P&T system. Refer to Section 5.2.4.3, Water Quality Parameters, for a detailed summary of results.

After operation of the P&T System for approximately 21 months and 36 million gallons of groundwater remediation, no significant effect has been seen in treatment operations from these iron and manganese concentrations.

2.5.3.6.3 Treatment System Design

EPA reviewed the existing data, including the proposed remedial system as presented in the NYSDEC RI/FS, Proposed Plan, and ROD. Based upon this information, the conceptual design (January 2000), and the ex-situ treatment component of the groundwater remedy, which utilizes presumptive technologies identified in Directive 9283.1-12 from EPA's OSWER, EPA developed the remedial system discussed below.

In November 2000, EPA completed the design specifications for the P&T system and treatment building. The design specifications and O&M manual describe the methodologies, protocols and systems that were developed to address the handling of contaminated groundwater from the P&T system for the SCA Site.

This system consists of a VOC removal system (low-profile air stripper), probes, sensors, aqueous- and vapor-phase carbon, and a PLC for complete integration and automation of system components. The system is capable of both manual and automatic operation. Although the system has been designed to run in a continuous mode, it also has the capability of batch treatment. System monitoring and automated control is available from both local and remote locations.

It is anticipated that this system will be unmanned and monitored from a remote location for a majority of its operational life. Additionally, treated water is discharged directly into a local storm sewer in accordance with the requirements of NYSDEC discharge equivalency permit. Preference was given to systems/technologies that minimized the following:

- The need for chemical additives;
- The danger of accidental breakthrough of contaminated water/chemical feeds (if necessary) in the effluent water;
- Frequent maintenance requirements; and
- The handling and associated disposal costs of additional waste streams.

The design of the complete groundwater recovery and treatment system includes the following items:

- Three (3) extraction/interceptor wells;
- Three (3) submersible well pumps;
- Chemical addition system (included in the original design but not required);
- 400 gpm - Low profile air stripper;
- Two (2), 400 pound aqueous-phase GAC vessels;
- One (1) 3,000 pound vapor-phase GAC recovery system for off-gas treatment from the air stripper and SVE system;

- All pumps as required to transfer water within the treatment component and ultimately deliver treated water to the discharge point;
- Master Control Center PLC;
- Electronically actuated flow control valves;
- Probes and sensors, level indicators, differential pressure gauges and other probes and sensors as required for complete automation of the system;
- Piping between system components and to final discharge point;
- Wiring from the PLC to the components, probes and sensors; and
- A building to house the treatment system components.

Integrated into the P&T System is the active 250 CFM SVE System, which includes the following:

- PLC based control panel (also controls P&T System);
- Six (6) SVE extraction wells (i.e., includes UST removal manifold system);
- A skid mounted, 250 CFM SVE unit with knockout tank and pump;
- 120 gallon holding tank and pump; and
- One (1) 3,000 pound vapor-phase GAC recovery system for off-gas treatment from the air stripper and SVE system.

2.5.3.6.4 Sequence of Operations

The water treatment system sequence of operations is as follows. Water is designed to pump from up to three extraction wells to the treatment building. The water then flows through a flow meter/totalizer. The flow from each well can be controlled through individual electronic flow control valves regulated by the PLC. The water then meets at the piping manifold and flows to the air stripper.

Monitoring of the influent line includes a flow meter/totalizer, pH sensor, conductivity sensor, and a temperature transmitter. The combined influent then flows into the air stripper, which contains high-high, high, and low level sensors in the sump to control the flow. The off-gas vent from the VOC removal system (i.e., air stripper) is monitored with an air flow meter.

The treated effluent water is monitored for conductivity, pH, and temperature. It then flows to a three-way valve where it can either be re-circulated into the system or discharged through a flow totalizer to the storm sewer. All system components are integrated through the PLC for system automation, data recording/retrieval, control, security, and off-site monitoring.

2.5.3.6.5 Groundwater Extraction System

The groundwater extraction system selected in the final design is based upon groundwater extraction in the vicinity of ST-IW-01, and down-gradient in the vicinity of MW-19, with the two recovery wells pumping at a rate of between 50 and 100 gpm each.

At this time, the SCA extraction system consists of two extraction wells (EPA-EXT –02 and EPA-MW-24) placed at the base of the Upper Glacial Aquifer pumping at a combined rate of 50 to 100 gpm, and one extraction well at ST-IW-01, pumping at a rate up to 15 gpm on the SCP. The extraction wells (EPA-EXT-02 and EPA-MW-24) are installed to capture the 1 ppm PCE contaminant contour, approximately 400 ft south of the SCP (U.S. EPA Region II, ROD, March 1999). As previously stated, due to the strong pumping influence of the WAGNN pumping wells on that portion of the aquifer which is in close proximity to these wells, it is not feasible to capture the leading edge of the groundwater VOC plume.

A total of three recovery pumps will be utilized to handle liquids generated from the extraction wells. A submersible pump, sized to provide the anticipated design recovery yield, 50 to 75 gpm (per well), plus a reserve capacity will also be used. Recovery well flow rates can be adjusted by a flow control valve and discharged into a common, single-walled discharge pipe, with check valves located at each extraction point to prevent backflow. Recovery well pumps are connected to the discharge pipe using a pitless adapter to facilitate pump removal and maintenance. Discharge piping between extraction points and the water treatment system are buried in a trench(es), if feasible, and/or positioned to prevent interference with site operations and to meet safety concerns. Electrical power supply is installed by direct burial and buried in protective polyvinyl chloride (PVC) casings.

The design parameters for the recovery well collection system is to maintain velocities and system losses within reasonable limits so that all pumps selected will be commercially available and similar in horsepower.

2.5.3.6.6 Treatment Components

Chemical Feed System

Preliminary information in the NYSDEC RI/FS indicated pretreatment might be necessary to prevent fouling of the air stripper by metals that naturally exist in the groundwater. RI/FS results indicated iron levels as high as 472,000 ppb (dissolved), and manganese levels as high as 9,450 ppb (dissolved). The NYSDEC Class GA groundwater standard for both iron and manganese is 300 ppb.

Based upon samples analyzed from multiple pump tests and operation of the PRP ST-IW-01 extraction system, which treated this water through the U.S. EPA Mobile Water Treatment Trailer, these metals had minimal influence and pre-treatment was not required. Please refer to Sections 2.5.3.6.3 and 5.2.4.3, for further information.

Air Stripping Unit

The purpose of air stripping is to treat any volatiles or semi-volatiles that remain in the wastewater after the aeration process. Air stripping is a process in which volatile contaminants transfer from the groundwater into the air stream. The air stream laden with stripped VOCs is subsequently carried to an off-gas treatment system.

In general, contaminants with low water solubility and high vapor pressures are amenable to air stripping. For low concentrations of contaminants in water, Henry's Law coefficients serve as a measure of determining whether a contaminant is capable of being stripped. Compounds with Henry's Law constants greater than 3 X 10-3 atmosphere-cubic meters per mole (atm-m^3/mole) can be readily removed by air stripping, with removal efficiencies generally as high as 99 percent.

The VOCs of concern at SCA site groundwater are amenable to air stripping. Based upon influent contaminant concentrations and required effluent treatment goals, removal of methyl tertiary butyl ether (MTBE) was the design-controlling factor for the air stripper system.

Preliminary vendor screening was performed to evaluate packed column versus low-profile tray type strippers. Based upon the scope and space limitations, a low-profile air stripper was utilized. A general description of the unit installed is presented in the paragraph that follows.

The active components of a low profile air stripper are sieve aeration trays. Air is forced upwards through hundreds of 3/16" diameter holes in the aeration tray. The air forms a froth of bubbles approximately six inches deep on the aeration tray, generating a large mass transfer surface area where the contaminants are volatilized. The necessary contact or residence time to reach required volatilization is achieved through model size, addition of trays, and flow rate selection.

The air stripper installed at Stanton is rated for 400 gpm, capable of treating MTBE at concentrations up to 200 ppb.

Liquid- and Vapor-Phase GAC

The purpose of the liquid-phase GAC adsorption is to remove residual VOCs left in the effluent after the air stripper system.

This process consists of percolating the water discharged from the air stripper system through a bed of liquid-phase GAC, which allows for adsorption of organic compounds on the active sites of the carbon particles. Periodically, as the majority of the active sites are occupied, the activated carbon becomes exhausted and must be exchanged for fresh carbon while the exhausted carbon is sent for off-site regeneration. The liquid-phase carbon adsorbers are piped and valved in a lead/lag arrangement.

In general, highly substituted organic compounds with low solubility are best adsorbed by activated carbon. Adsorption of DCE is the limiting factor on which this design was based, since this compound has the poorest adsorption rate.

Two (2), 400 pound aqueous-phase GAC vessels are included as part of this system. Based upon approximately 21 months of the P&T system operation, at a pumping rate averaging approximately 50 gpm, aqueous phase carbon change-outs are running at approximately 6 month interval periods.

As a pollution control measure, a single, 3,000 pound, vapor phase GAC vessel has been included for treatment of off-gasses from the air stripper and SVE system.

Discharge Options and Limits

Treated water has been discharged directly into the local storm sewer in accordance with the requirements of NYSDEC discharge equivalency permit. A 100 gpm, effluent pump is used to withdraw water from the carbon adsorbers to the outfall point. The previously installed PRP effluent line, after upgrades, was utilized to minimize disruption to local properties where access was granted.

2.5.3.7 Long Term Response Action

To insure continued long-term operation of the P&T System, EPA has implemented the LTRA. The LTRA is to set forth the funding, framework, and requirements for implementing the groundwater remedy (OU-1) at the SCA Site, in accordance with the ROD, the objectives of the remedial design, and the O&M manual that was prepared during the construction of the groundwater extraction and treatment facilities. The LTRA contract will be performed through an existing interagency agreement with the United States Army Corp of Engineers (USACE).

Under the present SOW, the following have been tasked:

- Operation of the P&T system and SVE system (treatment plant) constructed on the SCP. An O&M manual has been prepared for the treatment plant, and is completed. Sampling will be required in order to ensure compliance with standards set in NYSDEC's discharge equivalency permit. Groundwater level measurements will be performed once a month in approximately 15 monitoring wells to evaluate drawdown.
- Work Plan preparation to address the operation of the treatment plant components; system operation and discharge sampling (P&T, SVE, etc.); groundwater monitoring well sampling; and in-door air quality sampling at the EPA specified locations.
- Provision of administrative and project management services and support.
- USACE will provide oversight and monitoring of O&M activities in coordination with the EPA RPM to ensure compliance with all contract requirements. USACE will also provide written monthly updates and off-site hour reports, and discuss operations, problems, corrective actions, or any other pertinent issues with the EPA RPM.

3.0 INVESTIGATION ACTIVITIES

This section summarizes Site activities performed during this investigation.

3.1 DESCRIPTION OF FIELD ACTIVITIES

Prior to initiating site activities, the site was cleared of extraneous debris the following steps were taken:

- Acquire consent for access from property owners to perform field activities (i.e., groundwater sampling, well installation, etc.) and perform required utility searches (i.e. telephone, gas, cable, water, etc.).
- Mobilize contractor and establish support zone, contamination reduction zone, and exclusion zone (if required). Locate all underground utilities. Survey all sampling points, existing and newly installed monitoring, observation and extraction wells, and physical features of the site.
- Draft and finalize Work Plan, HASP, and QAPP, as well as contingency plans for the proposed work.
- Collect an appropriate number of soil and groundwater samples from the suspected contaminant source areas and monitoring wells, and undertake treatability tests to support treatment design.
- Solicit, select and secure (as per contract requirements) subcontractors to provide heavy equipment, support zone accoutrements, and laboratory services.
- Draft and finalize plans for air monitoring, and soil and groundwater sampling implemented during intrusive drilling and soil boring operations to control off-site migration of airborne contaminants.
- Solicit, select, and secure (as per contract requirements) subcontractors to provide the following: 1) Drilling units with operators, including all associated equipment (e.g. soil borings, discrete water sampling, and SVE, air sparging, extraction and monitoring well installation, etc.); 2) Chemical analysis of drilling fluids, purge water, drilling spoils, etc., for treatment and/or off-site disposal; 3) Procurement of U.S. EPA Region II, DESA-Edison Laboratory; and/or U.S. EPA Contract Laboratory Program (CLP) and/or private laboratory services for performance of groundwater characterization for water quality parameters; soil characterization and geotechnical parameters; disposal characterization; and treatability studies for P&T system design; 4) Geophysical survey

to identify utilities and possible buried structures (i.e., tanks) in area of soil borings, extraction and monitoring well installation, and to support subsurface geological information /interpretation (if applicable); and 5) Computer modeling for development of a groundwater flow and transport model for the Site.

This investigation procured and utilized the services of the U.S. EPA Region II RAB; U.S. EPA Region II New York Remediation Branch; U.S. EPA ERT, U.S. EPA ERT/REAC; U.S. EPA Region II DESA; ERRS contractor Earth Tech, Inc.; U.S. EPA Region II START/RST contractor, Weston Solutions (formerly Roy F. Weston); U.S. EPA CLP; U.S. EPA Region II, DESA-Edison Laboratory; and private laboratories.

All field work was performed in accordance with provisions of the EPA approved, Earth Tech Drilling Work Plan (January 10, 2001), QAPP (January 2001), and Site-specific HASP (January 23, 2001); as well as Site-specific plans developed by U.S. EPA-ERT/REAC; U.S. EPA Region II DESA; and U.S. EPA Region II START and RST.

The following areas of OU-1 were targeted and addressed: the SCP, areas adjacent to the SCP that have been affected by the contamination (including but not limited to, the neighboring Tennis Club, the Century Complex, the Synagogue, the Synagogue Pre-School), and WAGNN public water supply wells located about 1000 ft down-gradient of the SCP.

As previously mentioned in Section 1.0, other areas were targeted as part of the OU-2 investigation. Due to the large study area and extensive volume of material reviewed, the OU-2 Summary Report (Earth Tech, February 2003, Draft) will be provided under a separate cover. The anticipated completion date is July 2003.

3.2 GEOLOGIC CHARACTERIZATION

The majority of monitoring and extraction wells were drilled utilizing Rotosonic™ drilling techniques. Rotosonic™ drilling subcontractors, Boart Longyear and Miller Drilling, utilized a truck-mounted Gus Pech GP2400 RS Rotosonic™ drilling rig and Versa-Sonic (by Acker Drill Co.), respectively. Rotosonic™ drilling utilizes ultrasonic vibrations to advance a core pipe to the target depth. Some of the distinct advantages and capabilities of this drilling technique were: sampling and well installation is faster as compared to drilling with mud rotary or auger techniques; sample recovery and integrity is continuous with larger volumes as compared to split spoon sampling and sample collection for a larger number of analytes; the stratigraphy and lithology is depicted accurately and completely; no water, air or additives are necessary to core sample overburden formations; and investigation derived waste is minimized (70% to 80% reduction).

In general, the Rotosonic™ drilling rig first advances a four-inch-diameter core barrel for soil sampling. Upon reaching the desired depth or the end of the stroke, an outer six-inch-diameter casing is advanced to the same depth. Then the core barrel and rods are removed. The four-inch core is displaced from the core barrel by using a low vibration and is contained in a clear plastic tube. The core tube is then placed in a trough for examination, logging, and sampling. Once the core is removed, the core barrel and rods are lowered back to the bottom of the hole. Another rod is added and the system is ready to advance again. The outer casing prevents cross contamination and formation mixing and allows for controlled placement of well installation materials.

All soil samples were classified in the field by the project hydrogeologist in accordance with the Unified Soils Classification System (USCS) and applicable American Society for Testing and Materials (ASTM) D 2488 procedures. Lithologic data were recorded on Test Boring Reports which are provided in Appendix A.

Soil descriptions included, in order of description: moisture content; color; grain size (most abundant to least abundant); angularity; and other pertinent textural or mineralogical properties. Soil descriptions were used to assess Site-specific geologic and hydrogeologic properties. A USCS field classification name was applied to all soil samples collected [e.g., Poorly-Graded Sand (SP)].

3.3 HYDROGEOLOGIC CHARACTERIZATION

3.3.1 Monitoring Well Installation

Wells installed as part of this investigation included the following:

Well ID	Aquifer	Installation Date	Installed By	Comments
EPA-SVE/Sparge-01	SUG	11/21/98	U.S. EPA ERTC	Combination SVE/Sparge well with SVE wells screened at 35 and 65 ft bgs and sparge wells from 80 to 90 ft bgs.
EPA-SVE/Sparge-02	SUG	11/21/98	U.S. EPA ERTC	
EPA-SVE/Sparge-03	SUG	12/4/98	U.S. EPA ERTC	
EPA-SVE/Sparge-04	SUG	12/4/98	U.S. EPA ERTC	
EPA-SVE-05	SUG	1/30/02	U.S. EPA ERTC	Installed during UST Removal Action; horizontal well ~3.5 ft bgs and covering an area of ~15 ft X ~75 ft.
EPA-SVE-06	SUG	1/30/02	U.S. EPA ERTC	Installed during UST Removal Action; shallow (15-20 ft bgs) with horizontal manifold system.
CL - 1S	IUG	5/3/99	U.S. EPA ERTC	

Well ID	Aquifer	Installation Date	Installed By	Comments
CL - 1D	DUG	5/3/99	U.S. EPA ERTC	
CL - 2	IUG	5/11/99	U.S. EPA ERTC	
CL - 3	IUG	5/11/99	U.S. EPA ERTC	
CL - 4S	IUG	5/11/99	U.S. EPA ERTC	
CL - 4D	DUG	5/11/99	U.S. EPA ERTC	
EPA-EXT-01	SUG	3/25/99	U.S. EPA ERTC /Aquifer Drilling and Testing	Well was abandoned as an extraction well due to poor yield and is currently being
EPA-EXT-02	SUG	11/11/00	Earth Tech/Miller Drilling	
EPA-EXT-03	SUG	11/9/00	Earth Tech/Miller Drilling	
EPA-MW - 9A	SUG	3/16/99	U.S. EPA ERTC /Aquifer Drilling and	
EPA-MW - 11D	IUG	5/20/99	U.S. EPA ERTC	
EPA-MW - 21	SUG	2/14/00	Earth Tech/Boart Longyear	Installed as monitoring wells with the option of being converted to either air-sparge or extraction wells
EPA-MW - 22	SUG	2/15/00	Earth Tech/Boart Longyear	
EPA-MW - 23	SUG	2/16/00	Earth Tech/Boart Longyear	
EPA-MW - 24	SUG	2/17/00	Earth Tech/Boart Longyear	Installed as a combination monitoring well/C-Sparge™
EPA-MW - 25	IUG	2/18/00	Earth Tech/Boart Longyear	
EPA-MW - 26	SUG	2/19/00	Earth Tech/Boart Longyear	
EPA-MW - 27	IUG	2/20/00	Roy F. Weston/Boart Longyear	
EPA-MW - 28	SUG	2/21/00	Roy F. Weston /Boart Longyear	
EPA-MW - 29	DUG	11/29/00	Earth Tech/Miller Drilling	These wells were installed as part of the OU-2 area investigation.
EPA-MW - 30	IUG	12/1/00	Earth Tech/Miller Drilling	
EPA-MW - 31	SUG	11/14/00	Earth Tech/Miller Drilling	
EPA-MW - 32	IUG	11/28/00	Earth Tech/Miller Drilling	
EPA-MW - 33	SUG	12/4/00	Earth Tech/Miller Drilling	

NOTES: SUG – Shallow Upper Glacial; IUG – Intermediate Upper Glacial; DUP – Deep Upper Glacial; Please see Table 1 for a complete summary of monitoring wells installed at the site during this investigation, as well as during previous investigations.

Additional monitoring wells were installed in the SCA to define the extent of impacted groundwater and soils. Figure 4A and 4B show the location of the existing monitoring wells and the locations of the new wells. Three monitoring wells up-gradient of the SCP (EPA-MW-22, -26, and –28), two monitoring wells on the SCP (EPA-MW-21 –23) and four monitoring wells down-gradient of the SCP (EPA-MW-9A, -24, -31, and –33) were installed to provide lithological data and to further define the extent of contamination in the shallow Upper Glacial Aquifer. To provide additional lithologic, water quality, and water level data from the intermediate Upper Glacial Aquifer, on up-gradient monitoring well (EPA-MW-25) and eight down-gradient monitoring wells (CL-1S, -2, -3, and –4S and EPA-MW-11D, -27, -20, and –32) were installed. Finally, three down-gradient monitoring wells (CL-1D and –4D and EPA-MW-29) were installed to provide lithology and analytical data for the deep Upper Glacial Aquifer. The lithologic/analytical information from previous investigations along with the recent work was utilized in this report to generate cross-sections (discussed in Section 4.0) and provided the necessary data for the groundwater flow and transport model.

Each 2-inch diameter monitoring well was constructed inside a nominal six-inch-diameter outer drill rod with the exception of EPA-MW-24, which was constructed as a four-inch well in a nominal 10-inch-diameter outer drill rod. Monitoring well construction information is listed in Table 1.

The monitoring wells consisted of two-inch PVC materials. The screen length was 10 ft and consisted of two-inch diameter schedule 40 PVC wire wrapped screen with 0.010-inch slot size. The riser sections were two-inch diameter schedule 40 flush threaded PVC. Following drilling, the well casing/screen assembly was inserted into the Rotosonic^{TM} outer casing to the appropriate depth. PVC centralizers were placed one foot above the screen and at 20-foot intervals where possible along the riser casing.

A filter pack (#1 FilterSil) was placed around the screen by free pouring through the open casing. The filter pack consisted of clean, inert, sorted silica sand that is appropriate for the formation and slot size of the screen. The filter pack extended two to three ft above the top of the well screen. The filter pack level was verified by tag-line measurement during emplacement. The volume of filter pack versus the theoretical annular volume was compared to verify proper placement of the filter pack.

A two to four ft thick bentonite pellet seal was placed immediately above the sand filter pack by free pour through the open casing. The level of the top of the bentonite seal was verified by tag-line measurement. Hydration of the bentonite pellets was allowed for one hour before installation of grout in the remaining annulus.

The grout was emplaced from the bottom of the borehole upward by pumping through a tremie pipe until the undiluted grout mixture returned at the ground surface. The grout mixture typically consisted of a 13.5- to 14-pound-per-gallon cement slurry with two-percent sodium-bentonite powder. The grout was allowed to cure for at least 24 hours prior to development. The wellheads were completed as flush mounts with locking protective covers.

3.3.2 Sparge Point/Monitoring Well Installation

Three monitoring wells (designated EPA-MW-21, EPA-MW-22, EPA-MW-23) were installed as two-inch diameter wells in the shallow Upper Glacial Aquifer in the immediate vicinity of the SCP for the purpose of monitoring groundwater beneath the Site and providing a better understanding of subsurface conditions. The three monitoring wells have the option of being utilized as sparge points in conjunction with the SVE system previously installed at the Site or as groundwater monitoring points.

The air sparge/monitoring wells were constructed in the same manner as the monitoring wells except the air sparge/monitoring wells include the option of being converted to either sparge points or extraction wells. The well heads were completed as flush mount completions with a locking compression cap.

Using the EPA mobile SVE/air sparging system, an air sparging pilot test was performed on July 19, 1999 at the SCP on the EPA SVE/sparge wells, installed as part of the EPA Removal Action (August 5, 1999) (Figure 4A). Air injection tests were performed on four separate sparge wells (EPA-SVE-01 through -04), with air injected at pressures up to 10 pounds per square inch (psi). Repeated field tests led to bypass of air through the pressure relief value.

With the SVE system operating since early 1999, it was speculated that the wells may have collapsed or clogged. Measures were taken to re-develop and re-open the sparge well screens. After completion of the development program the air injection tests were re-run, but resulted in the same operating conditions (i.e, system bypass).

It was determined the technology was unfeasible due to the confining nature of the stratigraphy on the SCP. These wells were then designated and utilized as monitoring wells for all future activities

3.3.3 Extraction and/or Recirculation-Sparge Point Well Installation

One additional well (designated EPA-MW-24) was initially installed for the purpose of performing a pilot study to determine the effectiveness of an innovative remedial system. However, it also can be utilized in conjunction with an in-situ treatment technology or as the long-term extraction well for the pump and treat technology included in the ROD. Several scenarios from the ROD were modeled and are discussed under separate cover in the *Groundwater Flow and Transport Modeling Report* (Earth Tech, May 2001).

EPA-MW-24 was constructed as a four-inch PVC monitoring well screened at two depths (75-85 and 90-95 ft bgs) within the shallow Upper Glacial Aquifer. The complete details of the construction of EPA-MW-24 can be found in Appendix B of this report. Also installed in the same boring was a three-foot long PVC sparge point, manufactured by C-Sparge^{TM} Systems. It was installed in #00 FilterSil sugar sand below EPA-MW-24 from 109.49 to 105.5 ft bgs for the purpose of sparging ozone. The ozone sparge point was to be part of a recirculation/sparge innovative in-situ remediation technology. The sparge point is connected by ¾-inch PVC threaded casing extending to the ground surface in the same boring as EPA-MW-24. It is not known at this time if the sparge point will be utilized as part of a recirculation/sparge technology as part of the continuing effort to evaluate innovative remediation technologies to expedite the cleanup of contamination at the SCA Site. EPA Region II applied through the U.S. EPA Office of Research and Development (ORD) as a potential candidate for field testing and evaluation of the C-Sparge^{TM} in-situ treatment technology.

The C-Sparge^{TM} process combines in-situ air stripping with ozone injection. Dissolved-phase chlorinated hydrocarbons (such as PCE, Trichloroethene (TCE), DCE, or vinyl chloride) are first extracted from aqueous solution and through gas-to-gas reaction with ozone and are converted to dilute hydrochloric acid, carbon dioxide, and water. An ozone/air mixture is injected sequentially into the formation through lower and upper sparge points. Intermittent operation of a submersible pump installed in the well creates vertical circulation of groundwater. The proposed technology was attractive due to the unique set of challenges at the SCA that make the application of conventional groundwater treatment approaches difficult and costly. These challenges included:

- High density commercial and residential development that severely limits the ability to construct wells and site and build treatment facilities;
- A deep zone of contamination that is 100 ft bgs;
- A wide spread zone of contamination extending more than 1500 ft; and
- A large municipal well field 1500 ft from the site that is pumping up to 2000 gpm and drawing the contamination into the wells.

As a result of the above site characteristics, the remedial action options available were limited and costly. The approach using ozone was suggested as an economical alternative for source area remediation instead of more conventional approaches (i.e. those that involve the design and construction of above groundwater treatment systems).

Additional suggested benefits from the ozone system include the following:

- The ozone is added to the groundwater in the well and the water is circulated in the well (not pumped to the surface for treatment). This eliminates the need for costly above ground structures and treatment equipment at sites where space is limited (e.g. SCA);
- The equipment has low power costs and requires minimal O&M; and
- The approach is new and innovative and, if it is as effective on this site as it has been suggested to be on other similar sites, it would provide the government a very economical treatment technology for use at other sites.

After a thorough review of protocols and regulations on the use of in-situ treatment technologies, it was determined that due to the potential impact to public water authority wells (i.e., the SCA is within the radius of influence of the WAGNN wells), the remediation technology was shelved for further testing and evaluation. ORD is presently performing a study of the C-Sparge^{TM} technology at another U.S. EPA Region IV project site. At this time, the technology is still under evaluation.

Two additional extraction wells, EPA-EXT-02 and EPA-EXT-03, were installed in November 2000 as part of the ROD to enhance the pump and treat system. These high efficiency extraction wells were installed using Rotosonic^{TM} technology to increase the pumping capacity (i.e., yield) of the extraction wells to estimated pumping rates modeled in the *Groundwater Flow and Transport Modeling Report* (Earth Tech, May 2001) and to capture the 1 ppm contour interval. Both extraction wells were constructed as 6-inch monitoring wells in a nominal 10-inch diameter outer drill rod with schedule 80 PVC casing. Each extraction well was completed in the shallow Upper Glacial Aquifer with 20 ft wire wrapped screen constructed of stainless steel and with a slot size of 0.040-inch

EPA-EXT-01 was abandoned as an extraction well due to poor yield (< 10 gpm) and poor performance of the drilling method. This was one of the reasons Rotosonic^{TM} drilling was utilized for future drilling operations (i.e., to produce a higher yield well). EPA-EXT-01 is presently utilized as an observation/monitoring well.

3.3.4 Well Development

Upon completion of all monitoring well, air sparge well, and recovery well installations, the wells were developed to ensure that they produced relatively clear, sediment-free, representative groundwater samples. A minimum 24-hour period was observed between well completion (grouting) and development to ensure the stability of the well.

Each well was developed by surging and pumping. Development continued until groundwater was reasonably sand free, turbidity was reduced, and pH and specific conductance were stabilized to within 0.2 standard units and 10%, respectively. Well development logs are included in Appendix B.

3.3.5 Well Sampling

Collection of groundwater samples from monitoring wells was necessary to characterize the nature and extent of contamination. Low-Stress (Low-Flow) purging and sampling was performed for all groundwater sampling events, as per the U.S. EPA Region II March 1998 Low-Stress (Low-Flow) approved groundwater Standard Operating Procedure (SOP). The purpose of this SOP is to define the requirements for the collection of groundwater samples using the low-flow purge and sample method. Because of concerns about turbidity in the wells, and the effects of turbidity on metals sampling results, the low-flow purge and sample method was used. The low-flow purge and sample method creates less disturbance and agitation in the well, and therefore excess turbidity is not generated during the purging and sampling process. The result is a more rapid stabilization of turbidity and other parameters (pH, temperature, specific conductivity, dissolved oxygen (DO), and Eh), and a sample more representative of conditions in the formation from which the sample is collected.

The low-flow purge and sample method consists of using a submersible pump to purge the well at a very low flow rate (0.2 to 0.5 liters per minute). The pump intake is set approximately in the middle of the well screen, with a stagnant water column over the top of the pump. The well is purged at the low flow rate until the field parameters (temperature, pH, specific conductivity, turbidity, DO, and Eh) have stabilized. The sample is then collected directly from the pump discharge at a low flow rate.

Low-flow sampling of groundwater was conducted in accordance with the SOP as follows:

1. The well was checked for any damage or evidence of tampering and the condition was recorded.
2. The well cap was removed.
3. Well headspace was measured with a PID or FID and recorded the reading in the field logbook.
4. The depth to water was measured with an electronic water level device and recorded in the field logbook. Depth to bottom information was obtained from installation information in the field logbook or drilling logs. Volume of the water column was calculated as: depth of water column x cross-sectional area of the well.

5. Polyethylene sheeting was spread on the ground and the monitoring, purging, and sampling equipment was placed on the sheeting. To avoid cross-contamination none of the down-hole equipment was permitted to touch the ground.

6. The depth to water was re-checked and recorded after approximately 5 minutes. If the measurement had changed more than 1/100th of a foot, the measurement was checked and recorded again; then well purging was begun.

7. Teflon-lined polyethylene tubing was attached and secured to the low-flow submersible pump. The safety drop cable, tubing, and electrical lines were secured to each other using nylon stay-ties placed approximately 5 ft apart as the pump was slowly lowered into the well.

8. The pump was set at approximately the middle of the screen and care was taken not to place the pump intake less than 2 ft above the bottom of the well as this may cause mobilization of any sediment present in the bottom of the well. Well pumping was initiated at 0.2 to 0.5 liters per minute.

9. The water level in the well was monitored during pumping, and care was taken to attain a pump rate equal to the well recharge rate with little or no water level drawdown in the well (stabilize the water level for the pumping rate) and to keep at least 1 foot of water over the pump intake so there was no risk of the pump suction being broken, or entrainment of air in the sample; pumping rate adjustments and depth(s) to water were recorded in the logbook. Pumping rates were reduced to the minimum capabilities of the pump (0.1 - 0.2 liters per minute) when necessary to avoid purging the well dry. If the recharge rate of the well was very low and the well was purged dry, samplers waited until the well had recharged to a sufficient level and collected the appropriate volume of sample with the submersible pump.

10. The well was purged at a low-flow rate (from 0.2 to 0.5 liters per minute) and field parameters (temperature, pH, turbidity, specific conductance, DO, and Eh) were monitored approximately every 3 to 5 minutes until the parameters had stabilized to within 10 percent over a minimum of last parameters to stabilize. Readings were taken in a clean container (preferably a glass beaker) and the monitoring instrument allowed to stabilize before collection of the next sample. Measurements were taken as often as practicable.

11. Once the field parameters had stabilized, samples were collected directly from the end of the tubing. Volatiles and analytes that degrade by aeration were collected first. The bottles were preserved and filled according to the procedures specified in the QAPP. All

sample bottles were filled by allowing the pump discharge to flow gently down the inside of the bottle with minimal turbulence and each bottle was capped as it was filled.

12. Samples were preserved, labeled, placed immediately into a cooler and maintained at 4°C, recorded on the chain-of-custody, and shipped according to the procedures specified in the QAPP.
13. The pump assembly was carefully removed from the well and the teflon-lined polyethylene tubing was disposed of after use.
14. The total depth of the well was measured and recorded after sampling was completed.
15. The well was closed and locked.
16. Between sampling locations, all non-dedicated sampling equipment was disposed of or decontaminated according to the procedure described in Field Operations Plan.

Equipment calibration, logbook documentation, sample bottle filling and preservation, and shipping were conducted in accordance with the procedures specified in the QAPP (Earth Tech, January 2001). Personal protective equipment was donned in accordance with the requirements of the Site-specific HASP (Earth Tech, July 23, 2001). Wells were sampled in the order of least contaminated to most contaminated when at all possible. Groundwater sampling details are presented on the Well Sampling Logs and Data Sheets in Appendix C.

3.3.6 In-Situ Hydraulic Conductivity Tests

Slug tests were conducted in 20 monitoring wells located within the Site monitoring network in order to provide a range of hydraulic conductivities for the groundwater fate and transport model and to collect data regarding the variability of the Upper Glacial Aquifer (Table 2). Water levels were monitored during the slug test using a Troll™ SP 4000 data logger. Prior to introducing any equipment into each well, the static water level was measured to the nearest 0.01 foot and recorded in the field logbook.

Rising head slug tests were performed by lowering a decontaminated PVC cylinder attached to a clean, new rope and lowered into the well. When static conditions were attained, a Troll™ SP 4000 data logger was calibrated and activated, and immediately thereafter the cylinder was quickly removed from the well. The recovery of the water in the well (rising head) was monitored with the Troll™ SP 4000 data logger until the water level recovered to static conditions.

Falling head slug tests were performed by lowering a decontaminated PVC cylinder attached to a clean, new rope and lowered into the well directly above the static water level. The Troll™ SP 4000 data logger was activated and immediately thereafter the cylinder was quickly dropped into the water column. The recovery of the water in the well (falling head) was monitored with the Troll™ SP 4000 data logger until the water level recovered to static conditions

Slug test data were then downloaded from the Troll™ SP 4000 data logger to a computer. Plots of the change in water level versus time were generated, analyzed, and the hydraulic conductivities were calculated using the techniques of Bouwer and Rice (1976) and Bouwer (1989). Slug test data are provided in Appendix E and the results summarized in Table 2.

3.3.7 Aquifer Testing

Three constant-rate aquifer tests and one pumping test were conducted to observe the effects of pumping and to estimate aquifer hydraulic parameters of the shallow Upper Glacial Aquifer. The shallow Upper Glacial Aquifer consists of a mix of fine to coarse grain sands, silts, and minor amounts of clay. The shallow and intermediate portions of the Upper Glacial Aquifer comprise approximately 90 to 100 ft of sediments below the test site and have a moderately continuous, silty, semi-confining layer occurring at approximately 70 ft bgs (light green unit illustrated on Figures 8 through 15). Water level data collected at the Site indicate that the potentiometric surface occurs within or just above this silty, semi-confining layer. There are indications that portions of the Upper Glacial Aquifer behave in a confined manner and other portions in an unconfined manner.

Event Date	Performed By	Pumping Well	Aquifer	Purpose
May 12-16 1999	U.S. EPA/REAC	ST-IW-01	Shallow Upper Glacial	To collect data necessary to estimate hydrogeologic characteristics of the Upper Glacial aquifer in the vicinity of the source area.
March 15-18, 2000	Earth Tech, Inc.	ST-IW-01	Shallow Upper Glacial	To estimate hydraulic properties of the Upper Glacial Aquifer in support of the fate and transport model; to provide data in support of pump and treat system design.
March 20-23, 2000	Earth Tech, Inc.	EPA-MW-24	Shallow Upper Glacial	To estimate hydraulic properties of the Upper Glacial Aquifer in support of the fate and transport model; to provide data in support of pump and treat system design
March 17, 2001	Earth Tech, Inc.	EPA-EXT-02	Shallow Upper Glacial	To provide data necessary for design of the permanent Site treatment system; to assess the extraction wells' ability to meet the requirements of the ROD (U. S. EPA Region II, March 31, 1999)

All tests were conducted in the shallow Upper Glacial Aquifer. The general procedures for the tests are outlined below. A detailed description of test design, operation, and analysis is presented in Appendix F for each test.

In general, the test procedures included:

- A step drawdown pre-test to establish pumping rate and refine pump setting (May 1999 and March 2000 tests only);
- A period of pre-test water level monitoring to document pre-pumping test water level trends;
- A constant rate aquifer test for a specified duration (96 hours in May 1999, 72-hours for both tests in March 2000, and 9 hours in March 2001); and
- Water level recovery monitoring following the pumping test.

All tests involved partial penetration since the pumping wells (ST-IW-01, EPA-MW-24, and EPA-EXT-02) are screened across only a portion of the full aquifer thickness. As a result, aquifer test analytical methods that account for partial penetration impacts were used whenever possible. Other hydraulic impacts that occurred during some or all of the pump tests were: 1) on-going pumping in nearby public water supply wells; 2) precipitation events; 3) barometric pressure fluctuation throughout the testing period; and 4) background water level trends. A summary of the test results is presented in Table 3 and aquifer test data are provided in Appendix F.

3.3.8 Water Level Study

A Site-specific water level study was undertaken to provide background data for the aquifer tests and to provide the data to estimate the radii of influence of the public supply wells. The data was also subsequently used to support the development of the *Capture Zone Analysis Report* (Earth Tech, April 2003, Draft). The study was conducted by installing water level sensors and automatic data loggers (Troll™) in selected wells. The wells were selected to provide a distribution of water level measurements across all three aquifer zones. The wells selected were: MW-9a, -11D, -14, -15, -17, -20, -25, -27, CW-01, and CL-4S. Water levels were recorded periodically from March 3, 2000 to June 16, 2000 to provide coverage of the variety of pumping conditions that occur and because well PW-9 was out of service for part of the monitoring period for pump replacement. Additionally, water level measurements were collected in January 2003 from CL-1D, CL-4D, CL-4S, EPA-EXT-03, EPA-MW-9a, -11D, -21 through –29, ST-GP-02 and –03, ST-IW-01, ST-MW-02, and ST-MW-02 through –20, to provide data after the pump and treat system had been operating for some time. Information gathered from WAGNN is located in Appendix H.

3.4 SOIL CHARACTERIZATION

During this investigation, 69 subsurface soil samples (not including QA/QC samples) were collected from borings installed as part of the monitoring/extraction well installation program. The purpose of these installations was to further define potential sources areas of PCE (on-site and down-gradient), to characterize the subsurface lithology, to further delineate the PCE groundwater contaminant plume, and to provide information necessary to evaluate the effectiveness of source removal as part of the EPA SVE removal operations.

Soil samples were collected from all wells installed as part of this investigation, with the exception of EPA-EXT-02 and EPA-EXT-03. Subsurface soil samples were collected through the core barrel of the Rotosonic™ drilling rig. The four-inch core was displaced from the core barrel by using low vibration and the core was then contained in a clear plastic tube. The core tube was subsequently placed in a trough for examination, logging, and sampling.

Subsurface soil boring location and depth were designated by the following nomenclature: designated agency (e.g., EPA); type of well installed (e.g., -MW for a monitoring well or -EXT for an extraction well); location number (e.g. -23 or -02) and sample depth (e.g., -20 for 20 ft).

Subsurface soil boring samples were collected by the U.S. EPA Region II START and RST contractor, Weston Solutions (formerly Roy F. Weston), for each of the soil borings drilled during this Site investigation. Sample locations were selected based upon headspace readings and observed changes in lithology, (i.e., fine grain units). The subsurface soil samples were collected utilizing the EnCore® sampling method to minimize the loss of volatiles in accordance with the *Sampling QAPP* (Earth Tech, January 2001). Each EnCore® sampler cartridge was manually driven into the soil at the sampling depth. The EnCore® samplers were labeled, sealed in a zip-lock bag, and stored on ice in a cooler. Analysis of the Encore® samplers was through the U.S. EPA CLP.

One soil sample was collected at each of the wells EPA-MW-26 and EPA-MW-28 for laboratory analysis of TOC. These samples were collected from the core sample within the screened interval. The data from this analysis was used to estimate the distribution coefficient (K_d) used in the groundwater flow and transport model (Earth Tech, May 2001).

Additional soil analyses were taken during UST Removal Operations (January 2002). These samples were analyzed for TCL VOCS (SW846 Method 8260) and SVOCs (SW846 Method 8267) due to a leakage of fuel oil from the UST. Information regarding the sample results can be found in the *UST Closure Report* (Earth Tech, July 10, 2002).

3.5 GROUNDWATER CHARACTERIZATION

Water quality sampling was performed in accordance with provisions of the EPA approved, Earth Tech Drilling Work Plan (January 10, 2001), QAPP (January 2001), and Site-specific HASP (July 23, 2001), as well as Site-specific plans developed by U.S. EPA ERT/REAC; U.S. EPA Region II DESA; and U.S. EPA Region II START and RST. All rounds of groundwater samples were analyzed for TCL VOCs, with selected wells during the April 2000 and January 2001 events analyzed for full analysis (as described in Section 3.8.2)

Established EPA sampling protocols, analytical methods, and QA/QC procedures were followed. Field measurements of DO and oxidation-reduction potential (ORP) were collected at each well during sampling (Appendix C). This information was used to determine where degradation should be included in the groundwater flow and transport model. The QAPPs for all sampling under this study were prepared by the START and/or RST contractor under separate cover. Daily activities logs are located in Appendix I of this report.

3.6 INVESTIGATION-DERIVED WASTE MANAGEMENT

All Investigation-Derived Waste (IDW) was managed in accordance with applicable state and federal regulations. During all field operations, solid IDW (i.e., drilling spoils) was contained in a lined 20-yard roll-off container. Aqueous IDW was initially contained in two, portable, 500 gallon polytanks and subsequently transferred to the EPA Mobile Groundwater Treatment Trailer, where it was treated through mechanical filtration, air stripping (with vapor phase GAC for off-gas treatment), and final polishing through aqueous phase GAC prior to discharge through the storm sewer system. Analytical testing was performed on representative discharge samples as part of the monitoring for the U.S. EPA P&T System, NYSDEC discharge equivalency permit.

3.7 SITE SURVEYING

Upon completion of the monitoring well construction work, all new and existing wells were surveyed for horizontal location, land surface elevation, and top of casing elevation. Horizontal control was performed to within 1 ft and vertical within 0.01 ft. The work was completed in state plane coordinates with the elevations in mean sea level (msl). Bench Mark 02E16N was utilized as the control point. A more detailed location map is included in Appendix G along with the survey data.

3.8 ANALYTICAL TESTING

This investigation utilized the analytical services of the U.S. EPA ERT/REAC laboratory; U.S. EPA Region II DESA-Edison Laboratory; U.S. EPA CLP; and/or private laboratories procured through ERRS and U.S. EPA Region II START and RST contractors.

The following table summarizes the laboratories used during this investigation. Analytical Laboratory Certificates of Analysis are provided in Appendices C and D for groundwater samples and soil samples, respectively.

Laboratory	Sampling Events
Chemtech Consulting Group	May 1999 Groundwater Sampling
STL – Buffalo	September 1999 Groundwater Sampling
GPL Laboratories, LLLP	February 2000, March 2000, and April 2000 Groundwater Sampling
Mitkem Corp.	January 2001 Groundwater Sampling (VOCs, SVOCs, and Pesticides Only)
Compuchem (Liberty)	January 2001 Groundwater Sampling (Metals Only)
Gulf Coast Analytical Labs	March 2001 Groundwater Sampling (VOCs, Metals, and Select Water Quality Parameters)
Severn Trent Services	March 2001 Groundwater Sampling (Select Water Quality Parameters Only)
Shealy Environmental	October 2001 Groundwater Sampling
U.S. EPA Region II DESA Lab	September 2002 Groundwater Sampling
Datachem Labs	February 2000 Soil Sampling
Compuchem (Liberty)	November 2000 Soil Sampling
American Analytical & Technical Services (SWL – Tulsa)	December 2000 Soil Sampling

QA/QC samples were prepared for all sampling events and included deionized water blanks, daily field blanks, and trip blanks. Field and deionized water blanks were submitted for full TCL analyses. Trip blanks were submitted for volatile organic analyses only.

3.8.1 Soil

Soil samples were analyzed for TCL VOCs (EnCore® SW846 Method 8260 and 5035) for both the February 2000 and November/December 2000 monitoring/extraction well installation and soil boring programs. Soil samples were also collected from the two up-gradient wells (EPA-MW-26 and -28) for TOC Analysis (SW846 Method 9060)

Additional shallow subsurface samples were collected as part of the UST Removal Action (January 2002), and analyzed for TCL VOCs (SW846 Method 8260) and SVOCs (SW846 Method 8267).

3.8.2 Groundwater

All rounds of groundwater samples were analyzed for TCL VOCs (EPA Method 524.2, or OLM0 4.2), with selected wells during the April 2000 and January 2001 groundwater events analyzed for full analysis in accordance with the *U.S. EPA CLP SOW for Organic Analysis, Multi-media, Multi-concentration OLM0 4.2* and *U.S. EPA CLP SOW for Inorganic Analysis, Multi-media, Multi-concentration ILM0 4.0*

Groundwater samples were analyzed for conventional water quality parameters from the multiple pump/aquifer tests and operation of the PRP ST-IW-01 extraction system, which was treated through the U.S. EPA Mobile Water Treatment Trailer. These samples were collected and analyzed to support the design criteria for the permanent on-site P&T system. These samples were analyzed for some or all of the following parameters: bicarbonate alkalinity, BOD, carbon dioxide, carbonate alkalinity, chemical oxygen demand, chloride, corrosivity (Langlier Saturation Index), dissolved iron, dissolved manganese, hardness as CACO3, mercury, nitrate, nitrite, sulfate, sulfide, temperature, total alkalinity, total dissolved solids, total organic carbon, and total suspended solids.

The following table summarizes information regarding all the groundwater sampling events conducted during this investigation.

Sampling Event	Contractor	Parameters Sampled	Wells Sampled	Comments
May 1999	REAC/START	VOCs Total Metals Dissolved Metals Water Quality Parameters	ST-IW-01	Aquifer test sampling of site extraction well
September 1999	START /Weston	VOCs	EPA-EXT-01 EPA-MW-9A EPA-MW -11D, EPA -SPARGE-02 ST-MW-09 ST-MW –11 ST_MW –19 CL-1D CL -1S, CL-2 CL-3 CL-4D CL-4S	

Sampling Event	Contractor	Parameters Sampled	Wells Sampled	Comments
February 2000	Earth Tech	VOCs	ST-AM-03, ST-MW-01 ST-MW –02 ST-MW-06 ST-MW-09 ST-MW–12 ST-MW-13 ST-MW-14 ST-MW-15 ST-MW-16 ST-MW-17 ST-MW-18 ST-MW-19 ST-MW-20, ST-IW-01	
March 2000	Earth Tech	VOCs	ST-IW-01 EPA-MW-24	Sampling of wells during aquifer test
April 2000	Earth Tech	VOCs SVOCs TAL Metals Pesticides	CL-1S CL-1D CL-3 CL-4S CL-4D EPA-MW-21 EPA-MW-22 EPA-MW-23 EPA-MW-24 EPA-MW-25 EPA-MW-26 EPA-MW-27 EPA-MW-28	

Sampling Event	Contractor	Parameters Sampled	Wells Sampled	Comments
Jan 2001	U.S. EPA/ DESA	VOCs SVOCs TAL Metals Pesticides	EPA-MW-9A EPA-MW-22 EPA-MW-23 EPA-MW-24 EPA-MW-25 EPA-MW-26 EPA-MW-27 EPA-MW-29 EPA-MW-30 EPA-MW-31 EPA-MW-32 EPA-MW-33 ST-AM-3 ST-AM-4 ST-MW-02 ST-MW-11 ST-MW-12 ST-MW-14 ST-MW-15 ST-MW-16 ST-MW-18 ST-MW-19 ST-MW-19	
March 2001	Earth Tech	VOCs Total Metals Dissolved Metals Water Quality Parameters	EPA-EXT-02 EPA-EXT-03	Sampling during extraction well development/pump test
October 2001	U.S. EPA/ DESA	VOCs	CL-1S CL-1D CL-3 CL-4S CL-4D CW-1 CW-2 FN-3 EPA-EXT-03 EPA-MW-29 EPA-MW-31 EPA-MW-33 ST-AM-3 ST-AM-4 ST-MW-19	

Sampling Event	Contractor	Parameters Sampled	Wells Sampled	Comments
September 2002	U.S. EPA/ DESA	VOCs	EPA-MW-21 EPA-MW-22 EPA-MW-23 EPA-MW-25 EPA-MW-26 EPA-MW-27 EPA-MW-28 EPA-MW-29 EPA-MW-30 EPA-MW-31 EPA-MW-32 EPA-MW-33 ST-MW-19	

3.9 DATA VALIDATION

Earth Tech performed independent QC checks of both field and laboratory procedures that were used for the water sample collection and analysis for the February 2000, March 2000, April 2000, and March 2001 groundwater sampling events. The START contractor performed the independent QC checks for the soil samples collected in 2000 and groundwater collected in the May 1999 and September 1999 sampling events. Analytical data collected during the January 2001, October 2001, and September 2002 groundwater sampling events was validated by the U.S. EPA DESA/Regional Sampling Control Center (RSCC). The QC checks verify that the data collected are of appropriate quality for the intended data use and that the Data Quality Objectives (DQOs) were met. The analytical procedures, where appropriate, were validated with respect to the EPA CLP *Laboratory Data Validation Functional Guidelines for Evaluating Organics Analysis* (EPA-540/R94-082) and *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analysis* (EPA-540/R94-083). Quality Control Reports are located in Appendix J of this report.

Data validation and data assessment corrective action was performed in accordance with the *U.S. EPA Region II SOP No. HW-6: CLP Organics Data Review and Preliminary Review* and *HW-2 R11* for Inorganics (CLP/SOW OLM0 4.2 and CLP/SOW ILM0 4.0); and the *U.S. EPA Region II CERCLA Quality Assurance Manual.*

3.10 DATA MANAGEMENT

Data generated under this document was evaluated according to the appropriate criteria contained in the Removal Program Data Validation Procedures which accompany OSWER Directive #9360.4-1 and in accordance with U.S. EPA Region II guidelines.

4.0 REGIONAL AND LOCAL CHARACTERISTICS

4.1 REGIONAL CHARACTERISTICS

This section summarizes regional characteristics in the vicinity of SCA.

4.1.1 Regional Geology

Long Island's geology is composed of a sequence of unconsolidated glacial, lacustrine, deltaic, and marine deposits of clay, silt, and gravel that range in age from Upper Cretaceous to Pleistocene (Figures 5, 6A, and 6B). These deposits overlay a Precambrian to Paleozoic crystalline bedrock. In the region of Nassau County where the SCA is located, the thickness of the unconsolidated deposits is approximately 500 ft.

The Raritan Formation overlies the crystalline bedrock surface and includes the Lloyd Sand Member and the Unnamed Clay Member. The Lloyd Sand Member has a maximum thickness of 500 ft and consists of fine to coarse sand and gravel, commonly with a clayey matrix. Some lenses and layers of solid and silty clay are included. The Lloyd locally has a gradational contact with the overlying Unnamed clay unit (Raritan clay). The Unnamed Clay Member known as the Raritan Confining Unit has a maximum thickness of 200 ft and consists of clay, solid and silty, with few lenses or layers of sand and gravel. An unconformity separates the Unnamed Clay Unit from the Magothy Formation above.

The Magothy Formation has a maximum thickness of 1100 ft and consists of fine to medium sand, clayey in parts inter-bedded with lenses and layers of coarse sand and sandy clay. Gravel is common in the basal zone. An unconformity separates the Magothy from the Pleistocene glacial deposits (Upper Glacial Formation).

The Upper Glacial Formation has a maximum thickness of 340 ft and consists of glacial till, unsorted clay, sand, gravel and boulders. Outwash deposits of stratified brown sand and gravel are also present in the Upper Glacial Formation.

4.1.2 Regional Hydrogeology

The aquifers underlying the SCA are comprised of coastal-plain deposits of continental and marine origin of Late Cretaceous age overlain by unconsolidated glacial deposits of Pleistocene age (Figure 6B). These deposits are underlain by bedrock of Lower Paleozoic and/or Precambrian age. The elevation of the top of bedrock is at –419 ft msl, which is approximately 500 ft beneath the Site, is virtually impermeable, and forms the base of the aquifer.

The Lloyd Aquifer overlays the crystalline bedrock and is poorly to moderately permeable. The Lloyd is located at about –273 ft msl (approximately 350 ft below the Site) and is the major regional drinking water aquifer with well yields of 1,600 gpm and specific capacities of 10 to 20 gpm per foot of drawdown. The Lloyd has been intruded by salty groundwater from over pumping, locally in necks near the north shore, where the aquifer is shallow and overlying clays are discontinuous.

The Raritan Clay located at –223 ft msl (approximately 300 ft beneath the Site) constitutes a confining unit for the Lloyd Aquifer preventing the impact by contaminants from the overlying Upper Glacial formation. The average vertical hydraulic conductivity of the Raritan is approximately 0.0001 feet per day (ft/day).

As shown in Figures 6A and 6B, the Magothy Formation has been eroded and is absent beneath the Site. The Upper Glacial Aquifer is found immediately above the Raritan Clay in the vicinity of the SCP (Stumm, 2000).

The deep Upper Glacial Aquifer constitutes the principal aquifer for public-supply in eastern Queens, most of Nassau, and western/central Suffolk counties. Wells screened in the basal zone of the aquifer yield as much as 1,400 gpm. Specific capacities commonly range from 15 to 30 gpm per foot of drawdown. The deep Upper Glacial Aquifer has also been invaded by salt water from over pumping locally in southwestern Nassau and southern Queens County and in small areas along the north shore. Hydraulic continuity may exist between the deep Upper Glacial Aquifer and the shallow/intermediate Upper Glacial Aquifer across the North Shore Confining Unit. The North Shore Confining Unit is approximately 20 to 30 ft thick below the Site and is encountered at 120 to 145 ft below the Site (-65 ft msl).

The Upper Glacial Aquifer constitutes the surface aquifer and is composed of glacial till and outwash deposits. The till is relatively impermeable and may cause local perched aquifers and impede downward movement of precipitation. However, the outwash deposits of sand and gravel are highly permeable and wells screened in these deposits can yield as much as 1400 gpm. The Upper Glacial Aquifer has been impacted by industrial and municipal activities and is vulnerable to impacts by contaminants.

4.2 SITE-SPECIFIC CHARACTERISTICS

4.2.1 Climate

The local climate of Long Island is considered temperate. The yearly precipitation totals for the past 20 years averaged 48.7 inches and over 50 years the average is 44.3 inches.

4.2.2 Topography and Surface Drainage

The surface topography as illustrated on Figure 3 is slightly sloping to the south and east. The topography in the area is variable with areas of local relief greater than 79 ft. Stanton Cleaners Site is located at an elevation of approximately 82 ft above msl. An elevated area to the north of the Site controls the surface water flow toward the Long Island Railroad (LIRR). The LIRR divides the Site from southwest to northeast along what resembles a relic surface drainage. The surface drainage empties into the lowland area that is part of Little Neck Bay. A small stream flows into the area of the drainage used by the LIRR from the northeast portion, emptying eventually into Little Neck Bay through the lowland area. In the areas covered by pavement the surface runoff is directed to the stormwater system, which drains into dry wells located at low points within the Site (three to four such dry wells exist behind the Synagogue). Considering the residential nature of parts of the surrounding area, some of the precipitation infiltrates into the ground and becomes recharge for the Upper Glacial Aquifer.

4.2.3 Geology

Subsurface lithologic cross-sections, a fence diagram, and a fine grain units map have been prepared to illustrate subsurface conditions in the Upper Glacial Formation across the Site. Boring logs from this investigation and previous investigations were utilized to develop the subsurface figures. The locations of the lithologic cross-sections are illustrated on Figure 7. Subsurface geology is illustrated on cross-sections A-A' through E-E' which are presented on Figures 8 through 13, respectively. A three dimensional representation of the lithologic data is presented on the Fence Diagram (Figure 14) and the fine grain units are illustrated on Figure 15.

The Upper Glacial Formation has been subdivided into shallow, intermediate and deep zones for groundwater monitoring purposes. The shallow Upper Glacial Formation consists primarily of orange brown, poorly-graded to well-graded sands. A fine grain unit is present in the shallow Upper Glacial Formation, generally coinciding with the water table, consisting of light gray to white micaceous silty sand and or clay. The intermediate portion of the Upper Glacial Formation contains increasing fine grain units as it transitions into the North Shore Confining Unit. This confining unit consists of light brown clay, light gray clayey silts and silty clays and separates the deep Upper Glacial from the shallow and intermediate Upper Glacial Formations. The North Shore Confining Unit appears in the cross-sections C-C', D-D', and E-E'. Other fine grain units exist in the Upper Glacial Formation but are less continuous and less significant.

At monitoring well ST-MW-11D (Figure 13), the fine grain unit (generally encountered above the water table at other locations across the Site) is not present. Instead, a thick sequence of silty, fine grain sand cuts through the upper portion of the formation. The silty fine sand unit may have been an eroded channel feature based on reports that the area experienced reworking of the Upper Glacial Formation (Stumm, 2000). The boring did not extend deep enough to determine the base of the Upper Glacial Formation or to determine if the North Shore unit was present at this location (Figure 13).

Previous investigations drilled through the confining/semi-confining North Shore unit, which separates the shallow and intermediate Upper Glacial Formation from the deep Upper Glacial Formation. The unit appears to be similar to the light gray, fine grain unit near the water table in the shallow Upper Glacial with the exception of more light brown, lean clay, and tan to pale white, dense, clayey silt lenses present. The North Shore unit ranges from 10 ft thick at MW-19 to approximately 40 ft thick at MW-14. At well, MW-19, the North Shore unit consists primarily of clayey silt. At well CL-1D and CL-1S, and CL-4D and CL-4S, the North Shore unit is absent.

Site-specific information on the deep Upper Glacial Formation is limited. Only monitoring wells ST-MW-14, -18, -20, ST-AM-03, CL-1D, and -4D extend into the deep Upper Glacial Formation. The boring for ST-MW-19 was drilled into the deep Upper Glacial Formation but was screened in the shallow Upper Glacial Formation. The deep Upper Glacial Formation consists of orange to tan, fine to medium saturated sands, little silt, and trace fine gravel. The deep Upper Formation is reported to be 100 to 150 ft thick beneath the Site.

Figure 14 illustrates a fence diagram of the cross-sections presented in Figures 8 through Figure 13. The North Shore unit can be seen in the southern and central portions of the investigated area; however borings were not drilled deep enough in the north portion of the investigated area to determine if the North Shore unit is present. Figure 15 illustrates the fine grain units. The holes in the north, central, south portions of the model are due to lack of data at these specific locations. From the fine grain model, an upper and lower fine grain unit can be seen to exist across the area of investigation. The upper fine grain unit corresponds to the silty clays that generally appear above the shallow Upper Glacial Aquifer and the lower fine grain unit corresponds to the North Shore Confining Unit, which separates the shallow/intermediate Upper Glacial Aquifer from the deep Upper Glacial Aquifer.

4.2.4 Hydrogeology

The shallow, intermediate, and deep portions of the Upper Glacial Aquifer were evaluated during this investigation. These zones correspond to the saturated portions of the shallow, intermediate and deep Upper Glacial Formation. The shallow Upper Glacial Aquifer is defined as the first groundwater encountered within the Upper Glacial Aquifer and generally occurs between 15 and -20 ft msl. The intermediate Upper Glacial Aquifer is the zone directly above the North Shore Confining Unit and generally occurs between -20 and -70 ft msl. The North Shore Confining unit may be discontinuous across the Site and separates the shallow/intermediate Upper Glacial Aquifer from the deep Upper Glacial

Aquifer. The North Shore Confining unit generally occurs between -70 and -100 ft msl. The deep Upper Glacial Aquifer is the zone below the North Shore Confining Unit and generally occurs below -100 ft msl.

WAGNN operates three pumping wells in the vicinity of the Site. Two of these public supply wells, PW-2A and PW-9, are screened in the deep Upper Glacial Aquifer and are within the domain of this investigation. The third public supply well, PW-11, is screened in the Lloyd Aquifer. At this time, there is no indication that PW-11 has been impacted by site activities, and therefore, it will not be discussed in this report.

Public supply wells PW-2A and PW-9 were in operation when water levels used in this evaluation were collected. The operation of public supply wells PW-2A and PW-9 affects the groundwater flow directions and gradients in the aquifers evaluated. A description of the hydrogeologic characteristics at the Site is provided below.

4.2.4.1 Shallow Upper Glacial Aquifer

This section describes the groundwater flow directions, gradients, hydraulic conductivity, and seepage velocities of the shallow Upper Glacial Aquifer.

4.2.4.1.1 Groundwater Flow Direction and Horizontal Gradients

The shallow groundwater flow directions are semi-radial from ST-MW-06 toward ST-MW-19 and toward the public supply wells during the June 2000 water level event. Figure 16 illustrates the shallow Upper Glacial Aquifer potentiometric surface and the groundwater flow directions using measurements collected June 21, 2000. Both public supply wells were pumping simultaneously, 24-hours a day during the June 2000 sampling event. PW-2A was pumping an average of 921.875 gpm and PW-9 was pumping an average of 1012.15 gpm. The following figures and calculations are based on water levels collected during the June 2000 water level event. Groundwater elevations are summarized in Table 4.

Groundwater gradients were calculated from the shallow Upper Glacial Aquifer potentiometric surface map for June 2000. The gradient is based on an average of the gradient in the center of the Site and the somewhat faster gradient in the northeast portion of the Site.

The hydraulic gradient parallel to groundwater flow was calculated using the formula below.

$$\textit{Horizontal Hydraulic Gradient} = h_L / L \ (ft/ft)$$

where:

h_L = head difference between the contour lines selected (ft)
L = distance measured normal to contour lines between the lines selected (ft).

The hydraulic gradients in the shallow Upper Glacial Aquifer were measured to be 0.0042 feet per foot (ft/ft) in the center portion of the investigated area and 0.0182 ft/ft in the northeast corner of the investigated area for an average gradient of 0.0112 ft/ft. Hydraulic gradients are summarized in Table 5.

4.2.4.1.2 *Vertical Groundwater Gradients*

This section describes the vertical gradients between the shallow Upper Glacial Aquifer and the intermediate Upper Glacial Aquifer and the gradients between the shallow Upper Glacial Aquifer and the deep Upper Glacial Aquifer. Vertical gradients were measured in well clusters installed during this investigation and historic wells in close proximity to each other located at the Site. The following equation was used to calculate groundwater gradients:

$$\textit{Vertical Hydraulic Gradient} = h_y / D_y \ (ft/ft)$$

where:

h_y = head difference between the well pair (ft)
D_y = distance between the middle of the well screens (ft)

Vertical gradients were calculated using the head difference (h_y) from June 20, 2000 water level readings and the distance between the mid-point of the screened interval (D_y) in the following well clusters:

Shallow and Intermediate Upper Glacial Aquifer:

Shallow Well	Intermediate Well	hy	Dy	Vertical Gradient
ST-MW-12	ST-MW-17	0.18	52.12	3.5E-03 ft/ft (downward)
ST-IW-01	EPA-MW-27	-0.13	53.18	2.4E-03 ft/ft (upward)

Vertical gradients between the shallow and intermediate Upper Glacial Aquifer were slightly downward in the ST-MW-12/ST-MW-17 well pair down-gradient of the Site and slightly upward in the ST-IW-01/EPA-MW-27 well pair in the vicinity of the Site. Additional water level measurements will determine if this difference in gradient direction is persistent between the two well pairs.

Shallow and Deep Upper Glacial Aquifer:

Shallow Well	Deep Well	hy	Dy	Vertical Gradient
ST-MW-12	ST-MW-20	9.77	131.67	7.4E-2 ft/ft (downward)
ST-IW-01	ST-MW-14	9.6	124.85	7.7E-2 ft/ft (downward)

Vertical gradients between the shallow and deep Upper Glacial Aquifer were downward at both well pairs.

4.2.4.1.3 Hydraulic Conductivity from Aquifer Tests in the Upper Glacial Aquifer

A detailed description of the aquifer test procedures and analytical results is included in Appendix F. Various analytical methodologies were used to analyze the data collected during the test. Reasonable estimates for aquifer hydraulic properties were obtained using each analytical method, as shown in Table 3. These values were averaged to obtain the best estimates for aquifer hydraulic properties. Using this approach, along with the March 2000 aquifer test data, the aquifer transmissivity was estimated to be 12,336 feet squared per day (ft^2/day). Utilizing an aquifer thickness of 100 ft, the estimated horizontal hydraulic conductivity was 1,234 ft/day and the estimated specific yield was 0.20. The average value elastic storage coefficient was 3.58 E-4.

Based upon the data obtained from EPA-MW-14 (a well screened in the underlying deep Upper Glacial Aquifer that was monitored during the March 2000 test), it appears that pumping the shallow Upper Glacial Aquifer apparently did not affect water levels in the semi-confined deep Upper Glacial Aquifer. The pumping of nearby public supply wells, screened in the deep Upper Glacial Aquifer (with flow rates approximately 40 times that of the pump test wells), overwhelmed the impacts from the aquifer test. Thus, the hydraulic interconnectivity of the two units could not be sufficiently addressed.

4.2.4.1.4 Hydraulic Conductivity from Slug Tests

The hydraulic conductivity values for the shallow Upper Glacial Aquifer were estimated from rising- and/or falling-head slug test data. Questionable slug test data (noted in Table 2) were not used to calculate the average conductivity. Based on slug test analysis results, hydraulic conductivity values range from 0.304 ft/day to 77.8 ft/day, with an average 13.5 ft/day. Hydraulic conductivity test results are summarized in Table 2.

4.2.4.1.5 Groundwater Seepage Velocity

The following modified Darcy equation provides an estimate of the local groundwater seepage velocity, by combining the average hydraulic gradient information from above, with the average hydraulic conductivity of the shallow Upper Glacial Aquifer as determined by slug test analysis, and using an effective porosity value of 0.20:

$$v = KI / n_e$$

where:

v = groundwater seepage velocity ft/day
K = hydraulic conductivity (ft/day)
I = hydraulic gradient (ft/ft)
n_e = effective porosity

The seepage velocity in the shallow Upper Glacial Aquifer was calculated to be 276 feet per year (ft/yr). Table 5 summarizes groundwater seepage velocities.

4.2.4.2 Intermediate Upper Glacial Aquifer

This section describes the groundwater flow direction, gradients, hydraulic conductivity, and seepage velocities of the intermediate Upper Glacial Aquifer.

4.2.4.2.1 Groundwater Flow Direction and Horizontal Gradients

The flow direction in the intermediate Upper Glacial Aquifer during the June 2000 water level event is in a southern direction toward the public supply wells, with a low at CL-1S near PW-9. Figure 17 illustrates the groundwater flow direction in the intermediate Upper Glacial Aquifer for the June 2000 water level event.

Groundwater gradients were calculated using the method described in Section 4.2.4.1.1. The hydraulic gradients in the intermediate Upper Glacial Aquifer were calculated to be 0.0095 ft/ft in the northern portion of the Site and 0.0121 ft/ft in the central portion of the Site for an average of 0.0108 ft/ft. Hydraulic gradients are summarized in Table 5.

4.2.4.2.2 Vertical Groundwater Gradients

This section describes the vertical gradients between the intermediate Upper Glacial Aquifer and the deep Upper Glacial Aquifer. Water levels were measured in well clusters installed during this investigation and historic wells in close proximity to each other located at the Site. Vertical groundwater gradients were calculated using the method described in Section 4.2.4.1.2.

Intermediate Well	Deep Well	hy	Dy	Vertical Gradient
ST-MW-17	ST-MW-20	9.59	79.55	1.2E-01 ft/ft (downward)
ST-MW-27	ST-MW-14	9.73	71.67	1.4E-01 ft/ft (downward)
CL-1S	CL-1D	22.34	59.98	3.7E-01 ft/ft (downward)
CL-4S	CL-4D	4.82	59.47	8.1E-02 ft/ft (downward)

Vertical gradients between the intermediate and deep Upper Glacial Aquifer were downward at all well pairs. The converging flow at the area near well PW-9 (i.e. at well pairs CL-1S/-1D and CL-4S/-4D) occurs where the North Shore Confining Unit is absent. The vertical gradients are greater in this area than elsewhere, and indicate that downward groundwater flow is occurring.

4.2.4.2.3 Hydraulic Conductivity

The hydraulic conductivity values of the intermediate Upper Glacial Aquifer were estimated from rising- and/or falling-head slug test data. Based on slug test analysis results, hydraulic conductivity values range from 1.86 ft/day to 6.77 ft/day, with an average 4.61 ft/day. Hydraulic conductivity test results are summarized in Table 2.

4.2.4.2.4 Groundwater Seepage Velocity

The groundwater seepage velocity was calculated using the equation provided in Section 4.2.4.1.5 by combining the hydraulic gradient information with the hydraulic conductivity of the intermediate Upper Glacial Aquifer as determined by slug test analysis, and using an effective porosity value of 0.20. The seepage velocity in the intermediate Upper Glacial Aquifer was calculated to be 18 ft/yr. Table 5 summarizes groundwater seepage velocities.

4.2.4.3 Deep Upper Glacial Aquifer

This section describes the groundwater flow direction, gradients, hydraulic conductivity, and seepage velocities of the deep Upper Glacial Aquifer.

4.2.4.3.1 Groundwater Flow Direction and Horizontal Gradients

The flow direction in the deep Upper Glacial Aquifer during the June 2000 water level event is toward the south and converges toward public supply well PW-9 with a low at CL-1D near PW-9. Figure 18 illustrates the groundwater flow direction in the deep Upper Glacial Aquifer.

Groundwater gradients were calculated using the method described in Section 4.2.4.1.1. The hydraulic gradients in the deep Upper Glacial Aquifer were calculated to be 0.0340 ft/ft in the northern portion of the Site and 0.0182 in the western portion of the Site for an average of 0.0261 ft/ft. Hydraulic gradients are summarized in Table 5.

4.2.4.3.2 Hydraulic Conductivity

The hydraulic conductivity values of the deep Upper Glacial Aquifer were estimated from rising-head slug test data. Based on slug test analysis results, hydraulic conductivity values range from 22 ft/day to 42.8 ft/day, with an average 32.4 ft/day. Hydraulic conductivity test results are summarized in Table 2.

4.2.4.3.3 Groundwater Seepage Velocity

The groundwater seepage velocity was calculated using the equation provided in Section 4.2.4.1.5 by combining the hydraulic gradient information with the hydraulic conductivity of the deep Upper Glacial Aquifer as determined by slug test analysis, and using an effective porosity value of 0.20. The seepage velocity in the deep Upper Glacial Aquifer was calculated to be 1,543 ft/yr. Table 5 summarizes groundwater seepage velocities.

4.2.5 Distance Drawdown Analysis During Public Supply Well Operation

This section describes the drawdown observed in selected observation wells while public supply wells PW-2A and/or PW-9 were in operation. The effects of pumping PW-2A and/or PW-9 were measured in monitoring wells completed in the shallow, intermediate, and deep Upper Glacial Aquifer. Table 6 presents a summary of the distance-drawdown data. Measured drawdowns in the observation wells were graphed and the zero-drawdown distance was projected for each aquifer. This projection was done because drawdown occurred at all of the wells. The drawdowns used in the distance drawdown plots were estimated from hydrographs (Appendix F) of wells located in the study area. Figure 19 illustrates how each hydrograph was evaluated to develop drawdowns for each well. Because of the data set available, these drawdown calculations are approximate. Figure 19 illustrates drawdown at observation well ST-MW-20 from well PW-2A, from well PW-9, and from wells PW-2A and PW-9 combined. The drawdown at observation wells resulting from the operation of well PW-9 is illustrated on Figure 20. The drawdown at observation wells resulting from the operation of well PW-2A is illustrated on Figure 21. The drawdown resulting from the combined operation of wells PW-2A and PW-9 is illustrated on Figure 22. The results of the distance-drawdown analyses are presented below.

Shallow Upper Glacial Aquifer:

Active Pumping Well	Distance From Pumping Well To Zero Drawdown (ft)
PW-9	1,900
PW-2A	1,900
PW9 and PW-2A	2,000

Intermediate Upper Glacial Aquifer:

Active Pumping Well	Distance From Pumping Well To Zero Drawdown (ft)
PW-9	1,900
PW-2A	3,500
PW9 and PW-2A	3,000

Deep Upper Glacial Aquifer:

Active Pumping Well	Distance From Pumping Well To Zero Drawdown (ft)
PW-9	15,500
PW-2A	9,500
PW9 and PW-2A	20,000

These values represent the projected distances from each public supply well to the point where the drawdown should be zero. For the combined drawdown plots, the pumping well location was assumed to be at the midpoint between PW-2A and PW-9. Distance drawdown plots assume that the aquifer is uniform and infinite in aerial extent. Boundary conditions will influence the distance to zero drawdown. The calculated point at which the drawdown from the combined pumping wells is zero is approximately 20,000 ft from the pumping wells. A cone of depression this large is not likely since it would intersect hydraulic boundaries such as Little Neck Bay, resulting in a radius of influence that will truncate at a distance less than the calculated distances.

5.0 NATURE AND EXTENT OF CONTAMINATION

This section provides an overview of analytical test results and a summary of the nature and extent of contaminants. Historical data collected during previous investigations are not included in this section and were not used to characterize the nature and extent of contaminants but can be located in a previous investigation report by Dvirka and Bartilucci (1998).

Analytical data results presented in this Section were compared to Applicable or Relevant and Appropriate Requirements (ARARs) where available. The ARARs were used in the evaluation and derivation of the chemicals of concern at the SCA site. *Applicable* requirements are defined as those promulgated federal or state requirements (e.g., cleanup standards, standards of control) that specifically address a hazardous substance, pollutant, or contaminant found at a CERCLA site. *Relevant and appropriate* requirements are those promulgated federal or state requirements that, while not applicable, address problems sufficiently similar to those encountered at CERCLA sites where their use is appropriate. Chemical-specific ARARs provide guidance on acceptable or permissible concentrations of contaminants in soil, air, and water. The ARARs for this investigation are:

- *New York State Groundwater Standards* (NYSDEC 1998) have been promulgated by NYSDEC for the protection of human health and/or aquatic life and are legally enforceable; and
- *The Safe Drinking Water Act* (SDWA) promulgated National Primary Drinking Water Standards (40 CFR Part 141) for the regulation of contaminants in all surface water or groundwater utilized as potable water supplies. The primary standards include both maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs). MCLs are enforceable standards for specific contaminants based on human health factors as well as the technical and economic feasibility of removing the contaminant from the water supply. MCLGs are unenforceable standards that do not consider the feasibility of contaminant removal. The SDWA also includes secondary MCLs (40 CFR Part 143) that are unenforceable guidelines for those contaminants that may adversely affect the aesthetic quality of drinking water, such as taste, odor, color, and appearance.

In addition to ARARs, other federal, state, and local criteria, advisories, or guidances may apply to the conditions found at the site. These are referred to as to-be-considered (TBC) items. TBCs are not legally binding but may be useful within the context of assessing site risks and determining site cleanup goals. Chemical-specific ARARs provide guidance on acceptable or permissible concentrations of contaminants in soil, air, and water. The TBCs applicable to this investigation are:

New York State Recommended Soil Cleanup Objectives have been established by NYSDEC in a Technical and Administrative Guidance Memorandum (TAGM) (NYSDEC 1994). This TBC guidance outlines the basis and procedure for determining soil cleanup levels at a state Superfund site. The document includes recommended soil cleanup objectives as well as eastern United States native soil concentration ranges for metals.

In this section, detected concentrations are summarized and compared to ARARs and TBCs where they are available. Complete analytical data from soil and groundwater samples collected during this investigation are presented in Tables 7 through 12. Analytical laboratory certificates of analysis are provided in Appendices C and D and analytical data qualifiers are presented in Table 13.

5.1 SOIL SAMPLING

Soil samples were collected during this investigation to evaluate possible residual soil contamination that may present a continued source to of groundwater. A total of 69 sub-surface soil samples (not including QA/QC samples) were collected during this investigation. Thirty four were collected during the installation of wells EPA-MW-21 through –28 on February 14 – 21, 2000 and additional 35 were collected during the installation of EPA-MW-29 through –33 and EPA-EXT-01 on November 8 – December 4, 2000.

As described in Section 3.4, the EnCore® sampling method was used to collect soil samples for analysis of VOCs. A summary of detected VOCs in soil is presented in this section and the results are compared to NYSDEC TAGM values when available. Complete analytical results for VOCs in soil can be found in Table 7.

Volatile Organic Compounds in Soil	NYSDEC TAGM (ug/kg)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
1,1,2-Trichloro-1,2,2-trifluoromethane	6,000	1.0 – 2.0	5	0
1,2-Dibromoethane	NA	1.0	1	0
2-Butanone	300	6.0 – 11	5	0
Acetone	200	4.0 – 48	17	0
Benzene	60	1.0 – 170	5	2
Carbon Disulfide	2700	0.6 – 3.0	3	0
Cis-1,2-Dichloroethene	NA	0.5 – 46	18	0
Cyclohexane	NA	2.0 – 6.0	2	0
Ethylbenzene	5,500	3.0 – 41,000	8	1
Isopropylbenzene	2,300	0.3 – 11	8	0
MTBE	120	0.7 – 20	9	0

Volatile Organic Compounds in Soil	NYSDEC TAGM (ug/kg)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Methylcyclohexane	NA	2.0 – 14,000	5	0
Methylene Chloride	100	26	1	0
Tetrachloroethene	1,400	1.0 – 1,200	28	0
Toluene	1,500	0.2 – 86,000	25	1
Trichloroethene	700	0.3 – 32	18	0
Trichlorofluoromethane	NA	0.6 – 2.0	3	0
Xylenes (Total)	1,200	0.3 – 170,000	9	1

PCE was the most prevalent VOC detected in sub-surface soil samples with 28 detections. The highest detected concentrations of PCE were 1,200 ug/L in EPA-EXT-01 at 81 ft bgs, 970 ug/L in EPA-MW-27 at 65 ft bgs, and 720 ug/L in EPA-MW-24 at 75 ft bgs. PCE degradation products TCE and cis-1,2-DCE were also widespread with 18 detections each. The highest concentration of each was detected at EPA-EXT-01 at 81 ft bgs, with a TCE concentration of 32 ug/L and a cis-1,2-DCE concentration of 46 ug/L. No detected concentrations for the constituent of concerns (i.e., PCE, TCE, and cis-1,2-DCE) exceeded the NYSDEC TAGM values.

The only exceedances of NYSDEC TAGM values were for benzene, toluene, ethylbenzene, and xylenes (BTEX compounds). Two benzene detections (170 ug/L at 55 ft bgs in EPA-MW-31 and 160 ug/L at 52 ft bgs in EPA-MW-33) exceeded the standards, while toluene, ethylbenzene and xylenes had one exceedance each with concentrations of 86,000 ug/L, 41,000 ug/L, and 170,000 ug/L, respectively, at EPA-MW-33 (51 ft bgs). These high concentrations of BTEX are grouped south of the Site in the OU-2 portion of the investigation area. Given the past history of the Site, BTEX are not a constituent of concern for the SCA.

The remaining eleven VOCs were detected infrequently and/or at low concentrations that did not exceed ARARs for soils.

5.2 GROUNDWATER SAMPLING

This section summarizes the groundwater quality in the shallow, intermediate, and deep Upper Glacial Aquifer (Sections 5.2.1, 5.2.2, and 5.2.3, respectively). Results from six rounds of groundwater sampling (September 1999, February 2000, April 2000, January 2001, October 2001, and September 2002) conducted as part of the SCA investigation (OU-1 and OU- 2) are presented. Samples from all rounds were analyzed for TCL VOCs. Samples from April 2000 and January 2001 were also analyzed for full TCL SVOCS, TCL pesticides, and TAL inorganics. Additional sampling was conducted for conventional water quality parameters as part of the P&T System design and aquifer tests. These data are presented in Section 5.2.4.

Concentrations ranges for detected compounds are summarized below and, where appropriate, are compared to the lower of NYSDEC groundwater (GA) standards or federal MCLs. Analytical results for VOCs, SVOCs, inorganics, pesticides, and groundwater quality parameters are presented in Tables 8 through 12, respectively.

5.2.1 Shallow Upper Glacial Aquifer

This section discusses the groundwater quality in the shallow Upper Glacial Aquifer. Results for each class of compounds are summarized for sampling events conducted between September 1999 and September 2002.

5.2.1.1 Volatile Organic Compounds

Detected VOCs are summarized below for each of the six groundwater sampling events between September 1999 and September 2002. A complete list of VOC analytical results is presented in Table 8.

September 1999

Volatile Organic Compounds in Groundwater (September 1999)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Methylene Chloride	5	0.6 – 1,800	5	3
Tetrachloroethene	5	26 – 26,000	6	6
Trichloroethene	5	0.46 – 0.89	2	0

In the six shallow wells sampled in September 1999, three VOCs were detected. PCE was detected in six samples with six exceedances of the NYSDEC GA standard. The highest concentrations of PCE were detected at ST-MW-19 (26,000 ug/L) and EPA-MW-EXT-01 (14,000 ug/L) immediately down-gradient of the SCA. Methylene Chloride was detected in five of the six samples, with three exceedances. EPA-EXT-01 and ST-MW-19 had the highest detections for methylene chloride, with concentrations of 1,800 ug/L and 560 ug/L, respectively. TCE was also detected in two samples (EPA-MW-9A and ST-MW-11) at concentrations below the NYSDEC GA standard.

February 2000

Volatile Organic Compounds in Groundwater (February 2000)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
1,1,1-Trichloroethane	5	1.0	1	0
1,1,2-Trichloroethane	1	3.0	1	1
Cis-1,2-Dichloroethene	5	2.0 – 480	4	2
Cyclohexane	NA	1.0 – 41	6	0
MTBE	10	2.0 – 58	3	1
Tetrachloroethene	5	12 – 23,000	10	10
Trans-1,2-Dichloroethene	5	1.0	1	0
Trichloroethene	5	1.0 – 150	6	3

Eight VOCs were detected in the ten samples collected during the February 2000 groundwater sampling event. Of these, PCE was the most widespread VOC in groundwater with ten detections, all of which exceeded the NYSDEC GA standard. PCE degradation products TCE (six detections and three exceedances) and cis-1,2-dichloroethene (cis-1,2-DCE) (four detections and two exceedances) were also prevalent. As in the previous event, the highest concentration of PCE (23,000 ug/L) was detected in well ST-MW-19 immediately down-gradient of the Site. The highest concentration of TCE (150 ug/L) was also detected in ST-MW-19, while on-site extraction well ST-IW-01 had the highest detected concentration of cis-1,2-DCE (480 ug/L).

Other detected VOCs included 1,1,1-trichloroethane, 1,1,2-trichloroethane, cyclohexane, MTBE, and trans-1,2-dichloroethene. Of these detections, 1,1,2-trichloroethane and MTBE each had one exceedance.

April 2000

Volatile Organic Compounds in Groundwater (April 2000)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
1,1,1-Trichloroethane	5	1.0 – 2.0	3	0
1,2-Dichlorobenzene	3	10	1	1
1,4-Dichlorobenzene	3	1.0	1	0
2-Hexanone	50	2.0	1	0
4-Methyl-2-Pentanone	NA	2.0	1	0
Chlorobenzene	5	1.0	1	0
Cyclohexane	NA	2.0	1	0
MTBE	10	28 - 55	2	2
Tetrachloroethene	5	120 – 24,000	5	5

Volatile Organic Compounds in Groundwater (April 2000)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Toluene	5	6.0	1	1
Trichloroethene	5	3.0 – 300	5	4

Six shallow wells were sampled during the April 2000 event, resulting in detections of eleven VOCs. PCE and TCE were the most prevalent VOCs in groundwater with five detections each. All five the PCE detections exceeded state standards, while four of the five TCE detections exceeded. The highest concentrations of each compound were detected in EPA-MW-24 (24,000 ug/L PCE and 110 ug/L TCE) directly down-gradient of the SCA, and Site monitoring well EPA-MW-21(20,000 ug/L PCE and 300 ug/L TCE).

Other detected VOCs included 1,1,1-trichloroethane, 1,2-dichlorobenzene, 1-4, dichlorobenzene, 2-hexanone, 4-methyl-2-pentanone, chlorobenzene, cyclohexane, MTBE, and toluene. Of these, MTBE had two exceedances and toluene had one exceedance.

January 2001

Volatile Organic Compounds in Groundwater (January 2001)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
1,2-Dibromo-3-chloropropane	0.04	1.0 – 400	3	3
2-Butanone	NA	5.0	3	0
2-Hexanone	50	5.0	3	0
Acetone	50	5.0 – 170	6	3
Benzene	1	490	1	1
Bromodichloromethane	50	0.8	1	0
Chloroform	7	0.7	1	0
Cis-1,2-Dichloroethene	5	220	1	1
Dibromochloromethane	50	1.0	1	0
Ethyl Benzene	5	61	1	1
Tetrachloroethene	5	3.0 – 19,000	11	10
Trichloroethene	5	0.6 – 120	2	1
Xylenes (Total)	5	260	1	1

Thirteen VOCs were detected in the fourteen shallow wells sampled during the January 2001 groundwater sampling event. PCE was the most widespread VOC with eleven detections and ten exceedances. Wells EPA-MW-24 and ST-MW-19 immediately down-gradient of the SCA exhibited the highest PCE values, with concentrations of 19,000 ug/L and 4,800 ug/L, respectively. PCE degradation products TCE (two detections) and cis-1,2-DCE (one detection) each had one exceedance at monitoring well ST-MW-19 (120 ug/L TCE and 220 ug/L cis-1,2-DCE).

Other detected VOCs included 1,2-dibromo-3-chloropropane, 2-butanone, 2-hexanone, acetone, benzene, bromodichloromethane, chloroform, dibromochloromethane, ethyl benzene, and total xylenes. Of these, 1,2-dibromo-3-chloropropane and acetone each had three exceedances. Benzene, ethyl benzene and total xylenes had one exceedance each at OU-2 monitoring well EPA-MW-31 (490 ug/L benzene, 61 ug/L ethyl benzene, and 260 ug/L total xylenes) down-gradient of the Site.

October 2001

Volatile Organic Compounds in Groundwater (October 2001)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
1,1-Dichloroethane	5	0.31	1	0
1,1-Dichloroethene	5	0.68 – 0.95	2	0
2-Butanone	NA	1.9	1	0
Benzene	1	3.9 – 1100	4	4
Carbon Disulfide	60	0.22 – 2.6	2	0
Carbon Tetrachloride	5	0.077	1	0
Chlorobenzene	5	0.74	1	0
Chloroform	7	0.68	1	0
Cis-1,2-Dichloroethene	5	3.3 – 190	4	3
Cyclohexane	NA	12 – 190	2	0
Ethyl Benzene	5	11 – 880	4	4
Isopropylbenzene	5	0.5 – 50	4	2
Methylcyclohexane	NA	4.5 – 100	3	0
MTBE	10	5.7 – 18	4	2
Styrene	5	110	1	1
Tetrachloroethene	5	0.17 – 2,700	6	2
Toluene	5	44 – 8,400	4	4
Trans-1,2-Dichloroethene	5	0.24 – 1.5	2	0
Trichloroethene	5	7.2 – 180	3	3
Xylenes (Total)	5	70 – 4,900	4	4

Twenty VOCs were detected in the eight shallow Upper Glacial Aquifer wells sampled in October 2001. PCE, TCE, and cis-1,2-DCE were again among the most detected compounds. PCE was detected in six samples, two of which exceeded NYSDEC GA standards. TCE was detected in three samples, all of which exceeded the standards. Cis-1,2-DCE had four detections and three exceedances. The highest concentrations of PCE and its degradation products TCE and cis-1,2-DCE were found in down-gradient monitoring well ST-MW-19 (2,700 ug/L PCE, 180 ug/L TCE and 89 L cis-1,2-DCE) and in on-site extraction well EPA-EXT-03 (270 ug/L PCE, 26 ug/L TCE, and 190 ug/L cis-1,2-DCE).

Seventeen other VOCs were detected in the October 2001 shallow Upper Glacial Aquifer samples. BTEX compounds (benzene, ethylbenzene, toluene, and xylenes (total)) were each detected in four samples with all detected concentrations exceeding groundwater standards. The highest concentrations of BTEX were detected in down-gradient monitoring wells CW-2 (1100 ug/L benzene, 8,400 ug/L toluene, 880 ug/L ethyl benzene, and 4,900 total xylenes), EPA-MW-31 (430 ug/L benzene, 44 ug/L toluene, 63 ug/L ethyl benzene, and 200 total xylenes), and FN-3 (440 ug/L benzene, 91 ug/L toluene, 330 ug/L ethyl benzene, and 1500 total xylenes). Isopropylbenzene and MTBE each had four detection, two of which exceeded groundwater standards and styrene had one detection at a concentration exceeding the standard. The remaining VOCs were detected infrequently at concentrations below the federal and state guidance values.

September 2002

Volatile Organic Compounds in Groundwater (September 2002)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
1,1,1-Trichloroethane	5	1.1	1	0
1,1-Dichloroethene	5	0.4	1	0
1,2,4-Trimethylbenzene	5	27	1	1
1,3,5-Trimethylbenzene	5	5	1	0
Acetone	50	0.9 – 13	5	0
Benzene	1	360	1	1
Chloroform	7	1.0	1	0
Cis-1,2-Dichloroethene	5	0.3 – 44	4	3
Ethyl Benzene	5	66	1	1
Isopropylbenzene	5	2.0	1	0
M + p -xylene	5	140	1	1
Naphthalene	10	8	1	0
n-Propylbenzene	5	4	1	0
o-xylene	5	46	1	1
Tetrachloroethene	5	7.8 – 6,600	6	6
Toluene	5	32	1	1
Trichloroethene	5	0.3 – 120	6	3
Trichlorofluoromethane	5	0.7	1	0

In the eight shallow wells sampled during September 2002, seventeen VOCs were detected. PCE and its degradation products, TCE and cis-1,2-DCE, were again the most prevalent compounds. PCE and TCE were each detected in six wells, with six and three exceedances of the NYSDEC GA standards, respectively. Cis-1,2-DCE was detected in four wells, three of which exceeded the state guidance values. The greatest concentration of these contaminants was found in on-site monitoring well EPA-MW-21 (6,600 ug/L PCE, 120 ug/L TCE, and 44 ug/l cis-1,2-DCE) and at well ST-MW-19 (6,400 ug/L PCE, 63 ug/L TCE, and 36 ug/L cis-1,2-DCE) located immediately down-gradient of the Site.

Of the remaining fourteen VOCs, BTEX compounds and 1,2,4-trimethylbenzene were each detected in OU-2 monitoring well EPA-MW-31 at concentrations that exceeded standards (360 ug/L benzene, 32 ug/L toluene, 66 ug/L ethyl benzene, 140 ug/L m+p-xylenes, 46 ug/L o-xylenes and 27 ug/L 1,2,4-trimethylbenzene). 1,3,5-Trimethylbenzene was detected in one well (EPA-MW-31) at a concentration equal to the NYSDEC GA standard (5 ug/L). The remaining compounds were detected infrequently and/or did not exceed federal or state guidance values.

5.2.1.2 Semi-Volatile Organic Compounds

Select samples from April 2000 and January 2001 were analyzed for full TCL SVOCs. Detected SVOCs are summarized below for both groundwater sampling events. A complete list of SVOC analytical results is presented in Table 9.

April 2000

In the three shallow Upper Glacial Aquifer wells (EPA-MW-23, EPA-MW-24, and EPA-MW-26) sampled for SVOCs in April 2000, there were no SVOCs detected.

January 2001

Semi-Volatile Organic Compounds in Groundwater (January 2001)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
2,4-Dimethylphenol	50	1.0	1	0
Di-N-Butylphthalate	NA	1.0	1	0
Di-N-Octylphthalate	50	1.0	1	0
Naphthalene	10	6.0	1	0

Four SVOCs were detected in the two shallow Upper Glacial Wells (EPA-MW-31 and –33) sampled in January 2001. All of the detects were infrequent and at low concentrations. None of the detected concentrations exceeded federal MCLs or NYSDEC GA standards.

5.2.1.3 Inorganic Compounds

Select samples from April 2000 and January 2001 were analyzed for TAL inorganics. Detected inorganic compounds are summarized below for both groundwater sampling events. A complete list of inorganic analytical results is presented in Table 10.

April 2000

Inorganic Compounds in Groundwater (April 2000)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Aluminum	NA	95.1	1	0
Barium	1000	31.7 – 63.1	3	0
Calcium	NA	20,200 – 96,300	3	0
Chromium	50	3.4 – 7.4	3	0
Cobalt	NA	1.5 – 5	2	0
Copper	200	1.6 – 4.2	3	0
Iron	300	109 – 345	3	1
Magnesium	35,000	1,850 – 12,900	3	0
Manganese	300	23.9 – 116	3	0
Nickel	100	3.8 – 8.5	3	0
Potassium	NA	1,620 – 5,980	3	0
Selenium	10	3.4 – 5.7	3	0
Sodium	20,000	21,500 – 65,100	3	3
Zinc	2,000	3.8 – 11.3	3	0

Fourteen inorganic compounds were detected in the three shallow Upper Glacial monitoring wells (EPA-MW-23, -24, and –26) sampled during April 2000. Of these, sodium was detected in all three wells with three exceedances of the NYSDEC GA standard. Iron was also detected in all three wells, with one exceedance at well EPA-MW-24 (345 ug/L). Neither of these inorganic compounds is believed to be related to past Site activities. The remaining twelve compounds (aluminum, barium, calcium, chromium, cobalt, copper, magnesium, manganese, nickel, potassium, selenium, and zinc) were detected at concentrations below federal and state ARARs.

January 2001

Inorganic Compounds in Groundwater (January 2001)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Aluminum	NA	59.6	1	0
Arsenic	10	12.2	1	1
Barium	1000	61.6 – 493	2	0
Calcium	NA	39,200 – 42,700	2	0
Chromium	50	9.0 – 12.9	2	0
Cobalt	NA	1.7	1	0
Copper	200	0.86 – 1.5	2	0
Iron	300	446 – 28,700	2	2
Magnesium	35,000	16,900 – 17,800	2	0
Manganese	300	67.3 – 5,530	2	1
Mercury	0.7	0.12	1	0
Nickel	100	8.6 – 10.8	2	0
Potassium	NA	2,270 – 2,350	2	0
Sodium	20,000	31,500 – 51,200	2	2
Vanadium	NA	1.1	1	0
Zinc	2,000	1.9	1	0

In the two monitoring wells sampled for analysis of inorganic contaminants (OU-2 area wells EPA-MW-31 and –33), sixteen compounds were detected. Iron and sodium were detected in both wells at concentrations greater than the NYSDEC GA standards. Concentrations of manganese were detected in both wells, and the concentration in EPA-MW-31(5,530 ug/L) exceeded the NYSDEC GA standard. Arsenic was also detected in monitoring well EPA-MW-31 at a concentration (12.2 ug/L) that exceeded the federal MCL. None of these inorganic compounds are believed to be Site related. The remaining twelve inorganic compounds (aluminum, barium, calcium, chromium, cobalt, copper, magnesium, mercury, nickel, potassium, vanadium, and zinc) were detected at low concentrations and did not exceed the ARARs.

5.2.1.4 Pesticides

Select samples from April 2000 and January 2001 were also analyzed for full TCL pesticides. No pesticides were detected in the three shallow Upper Glacial Aquifer groundwater samples (EPA-MW-23, -24 and –26) collected in April 2000 or the two shallow Upper Glacial Aquifer groundwater samples

(EPA-MW-31 and –33) collected in January 2001. A summary of pesticide analytical results is presented in Table 11.

5.2.2 Intermediate Upper Glacial Aquifer

This section discusses the groundwater quality in the intermediate Upper Glacial Aquifer. Results for each class of compounds are summarized for sampling events conducted between September 1999 and September 2002.

5.2.2.1 Volatile Organic Compounds

September 1999

Volatile Organic Compounds in Groundwater (September 1999)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Tetrachloroethene	5	0.5 – 2.2	3	0

Five intermediate Upper Glacial monitoring wells (CL-1S, -2S, -3, -4S, and EPA-MW-11D) were sampled for VOC analysis in September 1999. PCE was the only detected VOC and was detected in three down-gradient wells (CL-1S, CL-4S, and EPA-MW-11D). All detected concentrations were below the ARARs.

February 2000

Volatile Organic Compounds in Groundwater (February 2000)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Cis-1,2-Dichloroethene	5	1.0	1	0
Tetrachloroethene	5	170	1	1
Trichloroethene	5	2.0	1	0

In February 2000, one intermediate Upper Glacial monitoring well, ST-MW-17, was sampled for VOCs. PCE and its degradation products, TCE and cis-1,2-DCE, were detected in this well, which is located down-gradient of the SCA. PCE was detected at a concentration of 170 ug/L, which exceeds federal and state standards. Cis-1,2-DCE and TCE were detected at low concentrations that did not exceed ARARs.

April 2000

Volatile Organic Compounds in Groundwater (April 2000)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
2-Hexanone	50	1.0	1	0
4-Methyl-2-Pentanone	NA	1.0	1	0
Methyl Acetate	NA	10	2	0
Methylcyclohexane	NA	10	2	0
Tetrachloroethene	5	4.0 – 93	3	2
Trichloroethene	5	2.0	1	0

Six VOCs were detected in the five intermediate Upper Glacial Aquifer wells sampled in April 2000. PCE had detectable concentrations in three wells, two of which exceeded ARARs. These exceedances were at CL-3 (93 ug/L) and CL-4S (54 ug/L); both wells are located down-gradient of the SCA in the vicinity of the WAGNN well field. The remaining five VOCs (2-hexanone, 4-methyl-2-pentanone, methyl acetate, methylcyclohexane, and TCE) were infrequently detected at concentrations less than state and federal guidance values.

January 2001

Volatile Organic Compounds in Groundwater (January 2001)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Acetone	50	89	1	1
Benzene	1	2.0	1	1
Tetrachloroethene	5	4.0 - 380	2	1

Three VOCs were detected in the five intermediate Upper Glacial Aquifer samples collected in January 2001. PCE was detected in two of the five samples, at concentrations of 380 ug/L (ST-MW-17) and 4.0 ug/L (EPA-MW-30). Concentrations at down-gradient well ST-MW-17 exceeded state and federal ARARs. Acetone (89 ug/L) and Benzene (2.0 ug/L) each had one detection that exceeded ARARs at Site monitoring well EPA-MW-27. Neither compound is believed to be related to past activities at the SCA.

October 2001

Volatile Organic Compounds in Groundwater (October 2001)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
1,1,1-Trichloroethane	5	0.51	1	0
MTBE	10	1.5	1	0
Tetrachloroethene	5	1.9 – 5.0	4	0

During the October 2001 groundwater sampling event, four intermediate Upper Glacial wells were sampled. Three VOCs were detected in these samples. PCE was detected in all four samples, at concentrations ranging from 1.9 ug/L (EPA-MW-30) to 5.0 ug/L (CL-3). None of the PCE detections exceeded federal or state guidance values. Two other VOCs, 1,1,1-trichloroethane and MTBE, were each detected in one well (CL-1S) at concentrations below ARARs.

September 2002

Volatile Organic Compounds in Groundwater (September 2002)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Acetone	50	1.1 - 110	4	1
Tetrachloroethene	5	0.9 – 2.6	2	0

Four Upper Glacial monitoring wells were sampled in September 2002, resulting in detected concentrations of two VOCs. Acetone was the most frequently detected VOC, with detected concentrations in each of the four wells sampled. The concentration of acetone (110 ug/L) in EPA-MW-25 east of the SCA exceeded the NYSDEC GA standards. However, this compound is not believed to be related to past activities at the Site. PCE was also detected in two wells; EPA-MW-25 east of the Site and EPA-MW-30 down-gradient of the Site. Neither detection of PCE exceeded federal or state guidance values.

5.2.2.2 Semi-Volatile Organic Compounds

Select samples from April 2000 and January 2001 were analyzed for full TCL SVOCs. Detected SVOCs are summarized below for both groundwater sampling events. A complete list of SVOC analytical results is presented in Table 9.

April 2000

In the two intermediate Upper Glacial Aquifer wells (EPA-MW-25 and EPA-MW-27) sampled for SVOCs in April 2000, there were no SVOCs detected.

January 2001

Semi-Volatile Organic Compounds in Groundwater (April 2000)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Di-N-Butylphthalate	NA	1.0	1	0

Di-N-butylphthalate was the only SVOC detected in the two intermediate Upper Glacial Wells (EPA-MW-30 and –32) sampled in January 2001. The contaminant was detected at a low concentration (1.0 ug/L) and did not exceed ARARs.

5.2.2.3 Inorganic Compounds

Select samples from April 2000 and January 2001 were analyzed for TAL inorganics. Detected inorganic compounds are summarized below for both groundwater sampling events. A complete list of inorganic analytical results is presented in Table 10.

April 2000

Inorganic Compounds in Groundwater (April 2000)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Barium	1000	51.7 – 68.6	2	0
Calcium	NA	32,200 – 40,200	2	0
Chromium	50	3.9 – 5.4	2	0
Cobalt	NA	1.5	1	0
Copper	200	2.7 – 2.8	2	0
Iron	300	70.2 – 2,400	2	1
Lead	15	1.4	1	0
Magnesium	35,000	15,200 – 18,200	2	0
Manganese	300	34.8 – 330	2	0
Nickel	100	4.4 – 7.0	2	0

Inorganic Compounds in Groundwater (April 2000)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Potassium	NA	2,420 – 2,510	2	0
Selenium	10	2.7	1	0
Sodium	20,000	45,400 – 53,100	2	2
Zinc	2,000	4.0 – 4.5	2	0

Two intermediate Upper Glacial Aquifer samples (EPA-MW-25 and –27) collected in April 2000 resulted in the detection of fourteen inorganic compounds. Iron and sodium were the only inorganic compounds detected at concentrations above NYSDEC GA standards. Iron exceeded the ARARs at EPA-MW-27 with a concentration of 2,400 ug/L. Sodium exceeded the ARARs in both EPA-MW-25 and –27 with concentrations of 53,100 ug/L and 45,400 ug/L, respectively. Neither compound is believed to be related to past activities conducted in the SCA. The remaining twelve inorganic compounds were detected at low concentrations that did not exceed ARARs.

January 2001

Inorganic Compounds in Groundwater (January 2001)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Aluminum	NA	240 - 944	2	0
Barium	1000	17.3 – 35.9	2	0
Beryllium	3	0.12 – 0.13	2	0
Calcium	NA	27,500 – 30,500	2	0
Chromium	50	14.3 – 25.6	2	0
Cobalt	NA	0.92 – 2.4	2	0
Copper	200	2.4 – 27.4	2	0
Iron	300	619 - 853	2	2
Magnesium	35,000	10,400 – 10,900	2	0
Manganese	300	33.2 - 179	2	0
Mercury	0.7	0.10 – 0.12	2	0
Nickel	100	10.5 – 19.3	2	0
Potassium	NA	1,550 – 3,080	2	0
Sodium	20,000	8,300 – 19,800	2	0
Vanadium	NA	0.76 – 2.4	2	0
Zinc	2,000	2.5 – 41.8	2	0

Sixteen inorganic compounds were detected in both intermediate Upper Glacial Aquifer samples (EPA-MW-30 and –32) collected in January 2001. Iron was the only compound exceeding the NYSDEC GA standard with detected at concentrations of 619 ug/L (EPA-MW-30) and 853 ug/L (EPA-MW-32). Iron is not believed to be related to past activities conducted in the SCA. The remaining fifteen inorganic compounds were detected at low concentrations that did not exceed ARARs.

5.2.2.4 Pesticides

Select samples from April 2000 and January 2001 were also analyzed for full TCL pesticides. No pesticides were detected in the two intermediate Upper Glacial Aquifer groundwater samples (EPA-MW-25 and –27) collected in April 2000 or the two intermediate Upper Glacial Aquifer groundwater samples (EPA-MW-30 and –32) collected in January 2001. A summary of pesticide analytical results is presented in Table 11.

5.2.3 Deep Upper Glacial Aquifer

This section discusses the groundwater quality in the deep Upper Glacial Aquifer. Results for each class of compounds are summarized for sampling events conducted between September 1999 and September 2002.

5.2.3.1 Volatile Organic Compounds

September 1999

Volatile Organic Compounds in Groundwater (September 1999)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
1,1-Dichloroethane	5	0.24	1	0
Methylene Chloride	5	25	1	1
Naphthalene	10	2.1	1	0
Tetrachloroethene	5	3.4 – 1,300	2	1

Two deep Upper Glacial monitoring wells (CL-1D and –4D) were sampled for VOC analysis in September 1999. PCE was detected in both wells, and exceeded the ARARs in monitoring well CL-1D with a concentration of 1,300 ug/L. Methylene chloride was also detected in CL-1D at a concentration of 25 ug/L, which exceeded NYSDEC GA standards. The remaining VOCs (1,1-dichloroethane and naphthalene) were detected at concentrations less than the ARARs.

February 2000

Volatile Organic Compounds in Groundwater (February 2000)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
1,1,1-Trichloroethane	5	1.0 – 2.0	2	0
1,1-Dichloroethene	5	2.0 – 3.0	2	0
1,2-Dichloroethane	0.6	1.0	1	1
Cis-1,2-Dichloroethene	5	1.0	1	0
Cyclohexane	NA	4.0	1	0
Tetrachloroethene	5	1.0 – 5.0	4	0
Trichloroethene	5	2.0	1	0

Seven VOCs were detected in the four deep Upper Glacial Aquifer samples collected in February 2000. Of these, one sample (ST-MW-20) exceeded the NYSDEC GA standard for 1,2-dichloroethane. PCE was detected in all four wells, at concentrations ranging from 5.0 ug/L in ST-MW-20 south-southwest of the Site to 1.0 ug/L at ST-AM-03 south of the Site. TCE and cis-1,2-DCE were each detected in one well at concentrations less than the ARARs. TCE was detected in ST-MW-20 at 2.0 ug/L and cis-1,2-DCE was detected in (ST-MW-14 at 1.0 ug/L. The remaining VOCs (1,1,1-dichloroethane, 1,1-dichloroethene, and cyclohexane) were detected infrequently at concentrations less than the ARARs.

April 2000

Volatile Organic Compounds in Groundwater (April 2000)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Benzene	1	10	1	1
Tetrachloroethene	5	840	1	1
Trichloroethene	5	5.0	1	0

Two deep Upper Glacial Aquifer samples (CL-1D and –4D) were collected in April 2000 resulting in the detection of three VOCs. PCE and TCE were each detected in CL-1D south of the SCA. PCE exceeded ARARs with a detected concentration of 840 ug/L and TCE was detected at a concentration equal to the MCL and NYSDEC GA value of 5.0 ug/L. Benzene was detected in monitoring well CL-4D south of the Site at a concentration of 10 ug/L. Although this detection exceeded federal and state guidance values, benzene is not believed to be related to past activities at the SCA.

January 2001

Volatile Organic Compounds in Groundwater (January 2001)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
1,1,1-Trichloroethane	5	1.0	1	0
1,1-Dichloroethene	5	2.0	1	0
1,2-Dichloroethane	0.6	0.6	1	0
Acetone	50	64 – 160	3	3
Cis-1,2-Dichloroethene	5	0.8	1	0
Tetrachloroethene	5	0.9 – 2.0	2	0
Trichloroethene	5	0.8	1	0

Seven VOCs were detected in the four deep Upper Glacial Aquifer samples collected in January 2001 from monitoring wells ST-AM-03, EPA- MW-29, ST-MW-14, and ST-MW-18. Acetone was detected above the NYSDEC GA standard in three wells (EPA-MW-29, ST-MW-14, and –18) at concentrations ranging from 64 ug/L to 160 ug/L. These acetone detects are not believed to be related to past activities at the Site. PCE was detected in two wells, while TCE and cis-1,2-DCE were each detected in one well, all at concentrations below federal and state guidance values. The remaining VOCs (1,1,1-trichloroethane, 1,1-dichloroethene, and 1,2-dichloroethane) were detected infrequently at concentrations less than the ARARs.

October 2001

Volatile Organic Compounds in Groundwater (October 2001)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Acetone	50	100	1	1
Carbon Tetrachloride	5	0.054 – 0.056	2	0
Cyclohexane	NA	0.056	1	0
Tetrachloroethene	5	0.26 - 23	4	1
Trichloroethene	5	0.24 – 0.59	2	0

Four deep Upper Glacial monitoring wells, CL-1D, -4D, EPA-MW-29, and ST-AM-03, were sampled for VOCs in October 2001. PCE was the most frequently detected VOC with four detections and one exceedance of ARARs at CL-1D (23 ug/L) south of the Site. TCE was detected in wells CL-1D and ST-AM-03 south of the Site at concentrations of 0.59 ug/L and 0.24 ug/L, respectively. Acetone, which is not believed to be Site related, was detected at 100 ug/L in ST-AM-03, a concentration which exceeded the NYSDEC GA standard for this compound. The remaining VOCs (carbon tetrachloride and cyclohexane) were found at concentrations below ARARs.

September 2002

Volatile Organic Compounds in Groundwater (October 2001)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Acetone	50	3.7	1	0

EPA-MW-29, located south of the Site, was the only deep Upper Glacial well sampled in September 2002. One VOC, acetone, was detected at 3.7 ug/L, less than the ARARs for this compound. No other VOCs were detected during this sampling round.

5.2.3.2 Semi-Volatile Organic Compounds

In April 2000 and January 2001, select samples were analyzed for full TCL SVOCs. No SVOCs were detected in deep Upper Glacial Aquifer wells during the April 2000 (CL-1D) or January 2001 (EPA-MW-29) event. A complete list of SVOC analytical results is presented in Table 9.

5.2.3.3 Inorganic Compounds

Select samples from April 2000 and January 2001 were analyzed for TAL inorganics. Detected inorganic compounds are summarized below for both groundwater sampling events. A complete list of inorganic analytical results is presented in Table 10.

April 2000

Inorganic Compounds in Groundwater (April 200)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Barium	1000	51.4	1	0
Calcium	NA	40,600	1	0
Chromium	50	4.4	1	0
Copper	200	2.8	1	0
Iron	300	55	1	0
Magnesium	35,000	15,600	1	0
Manganese	300	2.6	1	0
Nickel	100	4.7	1	0
Potassium	NA	2,810	1	0

Inorganic Compounds in Groundwater (April 200)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Selenium	10	3.1	1	0
Sodium	20,000	30,900	1	1
Zinc	2,000	4.3	1	0

One deep Upper Glacial monitoring well, CL-1D was sampled for inorganic compounds in April 2000. Sodium was detected at a concentration of 30,900 ug/L, which exceeded the NYSDEC GA standard of 20,000 ug/L, but is not believed to be related to past Site activities. The remaining eleven inorganic compounds were detected at concentrations below the federal and state guidance values.

January 2001

Inorganic Compounds in Groundwater (January 2001)	MCL or NYSDEC GA (ug/L)	Detected Concentration Range (ug/L)	Number of Detections	Number of Exceedances
Aluminum	NA	23.3	1	0
Barium	1000	31.4	1	0
Calcium	NA	27,800	1	0
Chromium	50	1.3	1	0
Cobalt	NA	0.89	1	0
Copper	200	0.91	1	0
Iron	300	18	1	0
Magnesium	35,000	13,400	1	0
Manganese	300	0.94	1	0
Nickel	100	1.6	1	0
Potassium	NA	1,920	1	0
Sodium	20,000	24,400	1	1

One well screened in the deep Upper Glacial Aquifer, EPA-MW-29, was sampled for inorganic compounds in January 2001. The detected concentration of sodium (24,400 ug/L) exceeded the NYSDEC GA standard (20,000 ug/L), but this compound is not believed to be related to past Site activities. Concentrations were below ARARs for the remaining eleven detected inorganic compounds.

5.2.3.4 Pesticides

Select samples from April 2000 and January 2001 were also analyzed for full TCL pesticides. No pesticides were detected in deep Upper Glacial Aquifer monitoring well CL-1D in April 2000 or in deep

Upper Glacial Aquifer monitoring well EPA-MW-29 in January 2001. A summary of pesticide analytical results is presented in Table 11.

5.2.4 Aquifer Test/Extraction Well Sampling

Groundwater samples from operation of the PRP ST-IW-01 extraction system (May 1999) and from aquifer and pump tests (EPA-MW-24 in March 2000 and EPA-EXT-02 in March 2001) were collected and analyzed to support the design criteria for the permanent on-site P&T system. Samples from all events were analyzed for TCL VOCs (Table 8). Samples from May 1999 and March 2001 were also analyzed for TAL inorganics (Table 10) and water quality parameters (Table 12). Results for each class of compounds below for these events.

5.2.4.1 Volatile Organic Compounds

VOCs in Groundwater	MCL or NYSDEC GA (ug/L)	May 1999		March 2000		March 2001	
		Detected Conc. Range (ug/L)	Detections / Exceedances	Detected Conc. Range (ug/L)	Detections / Exceedances	Detected Conc. Range (ug/L)	Detections / Exceedances
1,1,2-Trichloroethane	1	14 – 15	2 / 2	ND	ND	ND	ND
Acetone	50	NA	NA	ND	ND	50	1 / 0
Bromoform	50	ND	ND	ND	ND	20	1 / 0
Cis-1,2-Dichloroethene	5	13 – 13.7	2 / 2	ND	ND	28	1 / 1
Cis-1,3-Dichloropropene	0.4	ND	ND	ND	ND	20	1 / 1
MTBE	10	ND	ND	11 - 13	3 / 3	ND	ND
Tetrachloroethene	5	3,600 – 3,800	2 / 2	16,000 – 17,000	3 / 3	2,340 – 9,680	2 / 2
Total 1,2-Dichloroethene	5	NA	NA	ND	ND	28	1 / 1
Trans-1,3-Dichloropropene	0.4	ND	ND	ND	ND	20	1 / 1
Trichloroethene	5	14	2 / 2	85 - 94	3 / 3	36.2 – 63.5	2 / 2

NOTES: NA – Not Analyzed; ND – Non-detect

All samples from May 1999 (2 samples from ST-IW-01), March 2000 (3 samples from EPA-MW-24) and March 2001 (1 sample each from EPA-EXT-02 and –03) exceeded ARARs for PCE and TCE. Furthermore, both samples from May 1999 and one sample from March 2001 exceeded the NYSDEC GA standard for cis-1,2-DCE. In March 2000, all three samples exceeded NYSDEC GA standards for MTBE. Both samples from May 1999 exceeded the NYSDEC GA standard for 1,1,2-trichloroethane; and cis-1,3-dichloropropene, total-1,2-dichloroethene, and trans-1,3-dichloropropene each had one detection in March 2001 that exceeded ARARs. Acetone and bromoform we each detected in one sample from March 2001 at a concentration less than ARARs.

5.2.4.2 Inorganic Compounds

Inorganics in Groundwater	MCL or NYSDEC GA (ug/L)	May 1999		March 2001	
		Detected Conc. Range (ug/L)	Detections / Exceedances	Detected Conc. Range (ug/L)	Detections / Exceedances
Aluminum	NA	69.7	1 / 0	ND	ND
Barium	1000	33.2 – 35.8	2 / 0	56 - 81	2 / 0
Beryllium	3	2.0 – 2.3	2 / 0	ND	ND
Calcium	NA	72,500 – 78,400	2 / 0	73,300 – 84,800	2 / 0
Chromium	50	13.2 – 15	2 / 0	ND	ND
Copper	200	4.3 – 8.7	2 / 0	ND	ND
Iron	300	ND	ND	336 – 529	2 / 2
Magnesium	35,000	14,600 – 15,700	2 / 0	9,550 – 14,800	2 / 0
Manganese	300	4.5 – 5.0	2 / 0	233 – 313	2 / 1
Nickel	100	1.4	2 / 0	ND	ND
Potassium	NA	4,880 – 5,350	2 / 0	5,830 – 6,070	2 / 0
Sodium	20,000	19,300 – 20,500	2 / 1	21,800 – 23,000	2 / 2
Zinc	2,000	12.0 – 12.2	2 / 0	ND	ND

One sample from May 1999 and two samples from March 2001 exceeded ARARs for sodium. Furthermore, in March 2001, two samples exceeded ARARs for iron and one for manganese. The remaining compounds were either not detected or were detected at concentrations below ARARs.

5.2.4.3 Water Quality Parameters

Water Quality Parameters	MCL or NYSDEC GA	Concentration Range (May 1999)	Concentration Range (March 2001)
Bicarbonate Alkalinity (mg/L)	NA	NA	156
Biochemical Oxygen Demand (mg/L)	NA	4.77 – 6.21	ND
Carbon Dioxide (ug/L)	NA	452 – 485	74,600 – 90,500
Carbonate Alkalinity (mg/L)	NA	NA	ND
Chemical Oxygen Demand (mg/L)	NA	ND	9.2 – 13.8
Chloride (IC) (mg/L)	250	58.5 – 63.8	43.4 – 63.8
Corrosivity - Langlier Saturation Index (Std. Unit)	NA	-1.13 - -1.07	-1.08 - -0.77
Dissolved Iron (mg/L)	0.3	ND – 29.2	0.227 – 0.482
Dissolved Manganese (mg/L)	0.3	4.6 – 4.8	0.214 – 0.297
Hardness as $CACO_3$ (mg/L)	NA	241 – 260	244 – 251
Mercury (mg/L Hg)	0.007	NA	ND
Nitrate (mg/L)	10	1.80 – 1.85	2.6 – 2.84
Nitrite (mg/L)	1	ND	ND – 0.1

Water Quality Parameters	MCL or NYSDEC GA	Concentration Range (May 1999)	Concentration Range (March 2001)
Sulfate (mg/L)	250	12.4 – 13.9	57.6 – 62.9
Sulfide (mg/L)	NA	ND	ND – 0.02
Temperature (Field) (Deg. C)	NA	14.9	12.77 – 13.3
Total Alkalinity (mg/L)	NA	162 – 174	156
Total Dissolved Solids (mg/L)	NA	220 – 240	ND – 378
Total Organic Carbon (mg/L)	NA	ND	ND
Total Suspended Solids (mg/L)	NA	3.0 – 6.0	5.0 – 6.0

NOTES: NA – Not Analyzed; ND – Non-detect.

Water quality parameters were analyzed to support the design criteria for the permanent on-site P&T system. Concentration ranges for the parameters are presented in the table above. In May 1999, one detected concentration of dissolved iron and two detected concentrations of dissolved manganese in ST-IW-01 exceeded NYSDEC GA standards. Neither of these compounds is believed to be related to past activities at the Site.

5.2.5 Discussion

Based upon the sampling results presented in Section 5 and Figure 23, the highest concentrations of PCE have been detected in the shallow Upper Glacial Aquifer near wells ST-MW-19 (26,000 ug/L in September 1999 and 23,000 ug/L in February 2000) and EPA-MW-24 (24,000 ug/L in April 2000). These wells are both located just south (down-gradient) of the SCP across Cutter Mill Road (Figure 4B). High concentrations of PCE have also been detected at monitoring wells EPA-MW-21 (20,000 ug/L in April 2000) and EPA-MW-23 (5,400 ug/L in April 2000) located on the SCP (Figure 23).

Elevated PCE concentrations have also been detected in the intermediate and deep Upper Glacial Aquifers creating a relatively narrow plume (Figures 24 and 25). The highest detection of PCE in the intermediate Upper Glacial Aquifer was in monitoring well ST-MW-17 (170 ug/L in February 2000 and 380 ug/L in January 2001) down-gradient of the SCP. In the deep Upper Glacial Aquifer, the highest detected PCE concentration was 840 ug/L (April 2000) at well CL-1D, located south of the Site near the WAGGN well field.

The contamination plume, consisting of PCE and sometimes its degradation products (TCE and cis-1,2-DCE), exists at relatively shallow depths and appears to migrate into deeper layers as it travels towards the WAGNN well field, located south and down-gradient of the Site. PCE concentrations were also detected in wells installed as part of the OU-2 investigation, both in the vicinity of the WAGNN well field, and south of the WAGNN well field (Figures 24 and 25).

The upgraded P&T system was operational beginning in September 2001, and PCE concentrations around the facility have since decreased significantly. For example, concentrations in ST-MW-19 have decreased from 26,000 ug/L in September 1999 to 6,400 ug/L in September 2002 – this is a 75.4% decrease in the PCE concentration in the well. Although this decrease was noted in the most recent sampling event (September 2002), the plume could not be thoroughly delineated from this data as wells south of ST-MW-19 and EPA-MW-24 could not be sampled. Therefore, the complete effectiveness of the P&T system (i.e., its ability to capture the 1 ppm contour as directed in the ROD) could not be evaluated (see *Draft Capture Zone Analysis Report*, Earth Tech, April 2003). The capture zone analysis and evaluation will be undertaken periodically in the future as part of the LTRA.

During the October 2001 and September 2002 sampling events, concentrations of PCE in the intermediate and deep portions of the Upper Glacial aquifer also decreased substantially when compared to earlier sampling events. However, not enough monitoring wells were sampled to determine if the concentrations of PCE are below the MCL in intermediate and deep portions of the Upper Glacial aquifer. Specifically, the intermediate Upper Glacial aquifer monitoring well CL-3, which is near PW-09 and was not sampled in September 2002, had a concentration equal to the MCL for PCE (5.0 ppb) when it was last sampled in October 2001.

The effluent PCE concentrations from EPA-EXT-02 were measured on March 18, 2002, March 28, 2002, April 3, 2002, and on April 9, 2002 at a concentrations of 1,900 ug/L, 2,000 ug/L, 1,900 ug/L, and 1,600 ug/L, respectively. Based on the extraction data, the system is capturing part of the 1,000 ug/L PCE plume, but because the down-gradient wells were not sampled during the September 2002 sampling event, it is uncertain if the pump and treat system is effectively capturing the 1,000 ug/L plume (*Draft Capture Zone Analysis*, Earth Tech, April 2003).

The concentrations in the intermediate and deep portions of the Upper Glacial aquifer are much lower than those in the shallow portion of the Upper Glacial Aquifer. The concentrations present in these deeper zones are likely the result of the downward gradients created by pumping the public supply wells. Given historical concentrations of PCE, dense non-aqueous phase liquids (DNAPL) may also be present as a result of gravity flow; however, no DNAPL was identified during drilling of the wells. The solubility of PCE is 150 ppm and the highest concentration of PCE in groundwater is 24 ppm at well EPA-MW-24 during the February/April 2000 sampling event. This concentration is 16 percent of the solubility of PCE indicating the potential for DNAPL to be present. The highest concentration of PCE in groundwater during the most recent sampling event, September 2002, was 6.6 ppm at EPA-MW-21. This concentration is 4 percent of the solubility of PCE. The last round of groundwater sampling shows only two wells with concentrations high enough for the percent solubility of PCE to be greater than one, ST-MW-19 with a concentration of 6.4 ppm and EPA-MW-21 with a concentration of 6.6 ppm (both 4 percent of the solubility of PCE). The high concentrations at these locations may also be due to the fact that these wells (ST-MW-19 and EPA-MW-24) are partially screened in silty material and EPA-MW-21 is screened immediately beneath silty material. The silty material present at these locations may tend to retard the flow of PCE creating high concentrations locally. If this mechanism is present, PCE will defuse from the silt and rapidly disperse in the more permeable sandy aquifer.

In addition to frequent detections of constituents of concern (PCE, TCE, and cis-1,2-DCE), other compounds including MTBE and BTEX were also prevalent throughout this investigation. These detections were most frequent in the OU-2 portion of the study area. Due to the location of the detections, as well as Site historical data, these compounds (i.e., MTBE and BTEX compounds) are not believed to be related to past Site activities.

6.0 SUMMARY OF FINDINGS AND CONCLUSIONS

The following text discusses the summary and conclusions developed by this investigation.

6.1 GEOLOGY

The geology beneath the SCA consists of inter-bedded glacial deposits on top of the Raritan formation. These deposits are fine grain units inter-bedded with well-graded and poorly-graded sands. The inter-bedded fine grain silty clay and silty sand lenses are not continuous across the Site, with the exception of two significant fine grain units. The first is encountered at the top of the shallow Upper Glacial Aquifer and the second is at the base of the intermediate Upper Glacial sediments, separating these sediments from the deeper Upper Glacial sediments. Subsurface erosional features may be present in the shallow and intermediate Upper Glacial sediments in the vicinity of well MW-11D and in the area between monitoring wells Cl-1D and Cl-4D. These erosional features may influence the interaction of the groundwater flow between the shallow/intermediate Upper Glacial and the deep Upper Glacial in the vicinity of these wells.

6.1.1 Hydrogeology

The hydro-stratigraphic units of the SCA have been divided into three distinct units based on the generated cross-sections. The units will be discussed in the following sections.

6.1.1.1 Shallow Upper Glacial Aquifer

The shallow Upper Glacial Aquifer consists primarily of a fine grain, silty, micaceous sand at the water table (approximately 10 to 15 ft thick), grading into an orange brown, fine to coarse sand approximately 20 to 50 ft thick, and is defined as the first water table encountered. Groundwater flow directions in the shallow Upper Glacial are semi-radial from ST-MW-06 toward ST-MW-19 and toward the public supply wells, and are influenced by the pumping in the WAGNN well field. Vertical gradients for the shallow and intermediate Upper Glacial Aquifer range from 3.5E-03 ft/ft downward between wells ST-MW-17 and ST-MW12 to 2.4E-03 ft/ft upward between wells ST-IW-01 and EPA-MW-27. Vertical gradients between the shallow Upper Glacial and the deep Upper Glacial were downward, and ranged from 7.4E-2 ft/ft to 7.7E-2 ft/ft.

Three constant rate aquifer tests and one pumping test were performed in the shallow Upper Glacial and describe the aquifer as being under semi-confined to confined conditions. The estimated average transmissivity for the shallow Upper Glacial Aquifer had a calculated range of 1,510 ft^2/day to 22,900 ft^2/day. Utilizing the aquifer thickness of 100 ft, the horizontal hydraulic conductivity was estimated to be 151 ft/day to 2,290 ft/day and the calculated range for elastic storage coefficient was 6.41 E-07 to 6.21 E-01 (Note: low range values for storage coefficient are probably invalid for the shallow Upper Glacial Aquifer as they indicate highly confined conditions). An estimate for specific yield of 0.10 to 0.49 was obtained using the Neuman method (Neuman, 1975).

6.1.1.2 Intermediate Upper Glacial Aquifer

Less clay lenses are present within the intermediate Upper Glacial Aquifer than are present in the shallow Upper Glacial Aquifer. The intermediate transitions into a semi-confining to confining unit (North Shore Confining Unit) above the deep Upper Glacial and is defined as the zone directly above the North Shore Confining Unit. Well CL-1D, located adjacent to well CL-1S, is screened in the deep Upper Glacial, but did not encounter a significant confining unit between the intermediate Upper Glacial and the deep Upper Glacial. This is consistent with USGS reports (USGS, 1979; Stumm, 2000), which state that the deep Upper Glacial Aquifer and the shallow/intermediate Upper Glacial Aquifer may be hydraulically connected in some areas. Groundwater flow directions in the intermediate Upper Glacial are southern, toward the public supply wells with a low at CL-1S near PW-9.

6.1.1.3 Deep Upper Glacial Aquifer

The deep Upper Glacial Aquifer, as described from drilling logs of a previous investigation (Dvirka and Bartilucci, 1998), consists of a tan, fine to medium sand with occasional gravel. The formation is reported to be 100 to 150 ft thick beneath the Site. The deep Upper Glacial Aquifer is defined as the zone beneath the North Shore Confining Unit. Groundwater flow directions in the deep Upper Glacial are south towards the public supply wells. The vertical gradients calculated between the shallow Upper Glacial and the deep Upper Glacial were downward between wells ST-MW-12 and ST-MW-20, and between wells ST-IW-01 and ST-MW-14 and ranged from 7.4E-02 to 7.7E-02 ft/ft.

Utilizing the in-situ water level monitoring data and with the cooperation of the WAGNN personnel, distance drawdown analysis was performed to estimate the magnitude of the influence of the public supply wells. Distance drawdown plots were developed for each public supply well separately and then combined. The combined pumping of supply wells produced a radius of influence of approximately 2,000 ft in the shallow Upper Glacial Aquifer and of approximately 3,000 ft in the intermediate Upper Glacial Aquifer. The radius of influence in the deep Upper Glacial was calculated to be approximately 20,000 ft, however, this is not likely since it would intersect hydraulic boundaries such as Little Neck Bay. Additional evidence and/or analysis would be required to verify this information.

6.2 SOIL QUALITY

Soils sampled within the vadose zone or below the water table during the investigation revealed elevated PCE concentrations in the wells of the immediate vicinity of Stanton Cleaners (EPA-MW-21, -22, -23) and in the area of EPA-MW-24. Elevated soil concentrations (EPA-MW-27, EPA-MW-24, and EPA-MW-23) are most likely the result of partitioning from the water phase. None of the soil concentrations for the contaminants of concerns (i.e., PCE, TCE, or cis-1,2-DCE) were detected above the NYSDEC TAGM levels.

6.3 GROUNDWATER QUALITY

PCE concentrations (Figures 23 through 25) are moving down through the shallow Upper Glacial Aquifer in the vicinity of the Site, are moving into the intermediate Upper Glacial to the southwest of the Site, and are eventually migrating into the deep Upper Glacial in the vicinity of monitoring well CL-1D. However, a detection of 2.3 ppb was also observed in the deep Upper Glacial well CL-4D down-gradient of PW-9 and 2A approximately 400 ft from CL-1D. These detects in the OU-2 area may represent another source of contamination to the WAGNN wells.

As directed by the ROD, the P&T system was designed to capture the 1000 ppb PCE contour. This design criteria recognizes that any reasonable extraction system in place at the Site could not compete with the 2000 gpm WAGNN well system for capture of the plume. A *Draft Capture Zone Analysis* (April 2003) was under taken to evaluate the effectiveness of the P&T system to reach the goals set forth by the ROD. The *Draft Capture Zone Analysis Plan* (Earth Tech, September 2002) will be finalized and integrated into the O&M manual as part of the LTRA.

The PCE concentrations have decreased substantially since the start up of the P&T system in September 2001, as shown in the trend plots for select monitoring wells (Figure 26). However, PCE concentrations are still above the MCL in the vicinity of the Site and down-gradient near ST-MW-19 and EPA-MW-24 in the shallow Upper Glacial Aquifer.

Trend plots of influent PCE concentration data from the WAGNN wells (Figures 27 and 28) show a similar decline since the P&T was put on-line in September 2001. Although some of the decline can conceivably be attributed to contaminant mass removal by the Site extraction systems (SVE and P&T systems), a substantial portion is probably due to decreased transport of PCE contamination as a result of decreased pumping rates at the Water Mill Lane well field (PW-2A and PW-9) as discussed in Section 2.4.

With the limited pumping of the Water Mill Lane well field, the EPA P&T system appears to be capturing at least a major portion of the plume, as evident by the 75.4% reduction in the maximum detected PCE concentration. However, the effectiveness of the P&T system could not be fully evaluated because the extent of the contamination in the intermediate and deep Upper Glacial aquifer, up-gradient and in the vicinity of the public supply wells, was not thoroughly delineated by recent groundwater sampling (i.e., some wells could not be sampled due to snow accumulation). Furthermore, the P&T capture zone could not be determined due to observation well drawdown caused by the operation of the P&T system, as the WAGNN well pumping rates and their effect on water levels was unknown during recent water level measurement events. Future groundwater sampling events will be reviewed and modified to include all wells necessary to delineate/define the PCE plume and water level measurement events will be conducted when public water supply wells are pumping at a known and constant rate. This information will be integrated into the *Final Capture Zone Analysis Plan* for plume monitoring and P&T system optimization.

Low concentrations of TCE and cis-1,2-DCE were also detected, indicating that some degradation is occurring. In order to fully evaluate the potential for natural attenuation of the uncaptured portion of the plume, future groundwater sampling events should include analysis for natural attenuation parameters in some wells in the source area, as well as in background areas. Analysis of monitored natural attenuation parameters in accordance with EPA/600/R-98/128, OSWER Directive 9200.4-17 (Wiedemeier, et.al., 1998) will provide invaluable data for future P&T system evaluation, as well as possible future capture zone analyses and groundwater modeling efforts.

6.4 COMPLETION OF REMEDIAL ACTION OBJECTIVES

In March 1999, EPA issued a ROD for the Site which was based on the findings of earlier investigations. The ROD considered three separate groundwater alternatives including the alternative: "Upgrade of the existing Groundwater Extraction and Treatment System (SCP), Groundwater Plume Enhanced Capture and Treatment (off SCP), and Continued Operation of the Source Control SVE System". Based upon EPA's criteria to evaluate potential alternatives, the remedy of active P&T was selected to address groundwater, and Soil Vapor Extraction (SVE) was selected to address soil source control and in-door air issues.

By June 2003, the SVE soil remedy, which was initiated through the removal program in early 1999, and which continued to be operated through the remedial program, is nearing completion. Operation of the system has resulted in the recovery of approximately 16,000 pounds of PCE. This information is in the process of being summarized in the *SVE Pre-Closure Report* (Earth Tech, Inc., August 2002, Draft).

To further the objective of source control and removal, in January 2002, field operations for the buried tank removal action were completed with the removal of two 250-gallon PCE UST and one 500-gallon underground oil storage tank. A SVE manifold extraction system was connected to the existing on-site SVE system to target areas with elevated PCE vapors. A comprehensive summary report of this UST Removal Action is provided in the *Underground Storage Tank Closure Report - Final Draft* (Earth Tech, July 10, 2002), released for public comment in July 2002.

Since the U.S. EPA initiated remedial measures at the SCA Site in 1998, overall indoor ambient air concentrations of PCE have been reduced in all affected building structures with an average percent reduction in PCE levels of 98 percent for all affected structures. A comprehensive summary of this indoor air monitoring program is provided in the *Indoor Air Quality Summary Report - Final Draft* (Earth Tech, July 23, 2002), released for public comment in July 2002.

As further protection against the future potential impact of PCE vapors in the Long Island Hebrew Academy (i.e., Pre-School), a sub-slab depressurization system was installed in January 2003, after an extensive engineering evaluation of the structure.

EPA has completed additional groundwater studies to satisfy the requirements of the ROD by completing the Remedial Design (November 2000), Flow & Transport Model (August 2002), and Remedial Action (September 2001) for the P&T System at an accelerated rate, even with EPA's response and continuing involvement at the World Trade Center disaster, which stressed the resources and availability of EPA and contractor personnel. Remedial design requirements were expedited by utilizing the *Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites* (U.S. EPA, October 1996).

The SCA P&T system has been operational since September 2001, running at an average flow rate of 50 gpm, with recent upgrades to 65 gpm, and has treated approximately 36 million gallons of PCE contaminated groundwater. After approximately 21 months of groundwater remediation, PCE source concentrations have dropped significantly and are consistent with the projected Fate & Transport model results (Earth Tech, May 2001). These reductions continue the already successful remediation of PCE source areas (i.e., SVE operation).

As part of the on-going management program for the P&T System, EPA is in the process of finalizing a *Capture Zone Analysis Plan* (Earth Tech, September 2002, Draft) in order to 1.) Estimate the capture zone created by the Site extraction system, 2.) Analyze the stability/transport of the plume outside the capture zone, and 3.) Put in place measures to optimize future operation of this system. This plan is anticipated to be completed by July 2003 and will be integrated into the O&M Manual.

To insure continued long-term operation of the P&T and SVE System, EPA has funded and implemented the LTRA, which will continue its successful operation, and address continued indoor air quality and groundwater monitoring at the SCA site.

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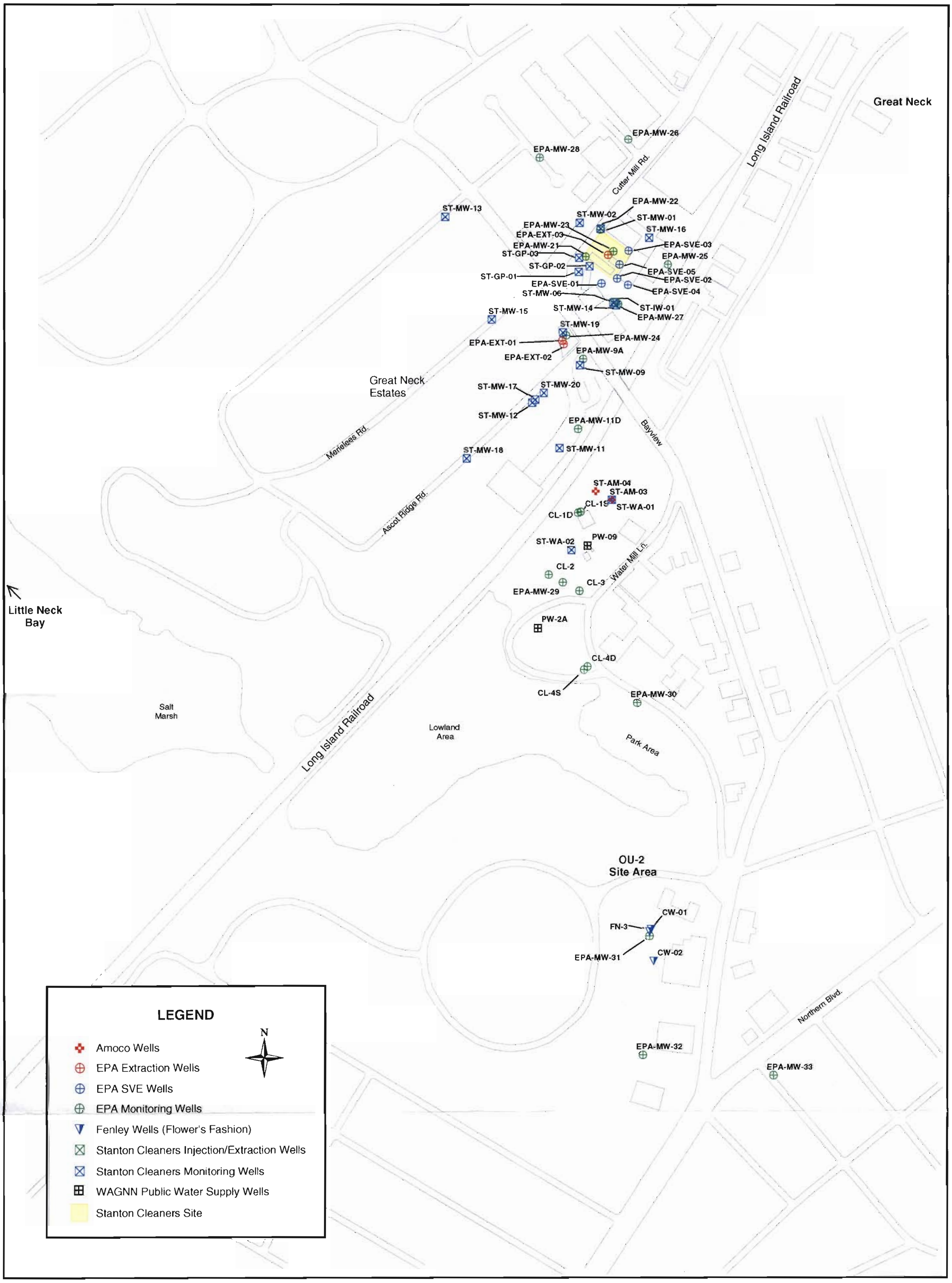

SCALE BAR

0 350 700

1 INCH = 350 FEET

E A R T H T E C H

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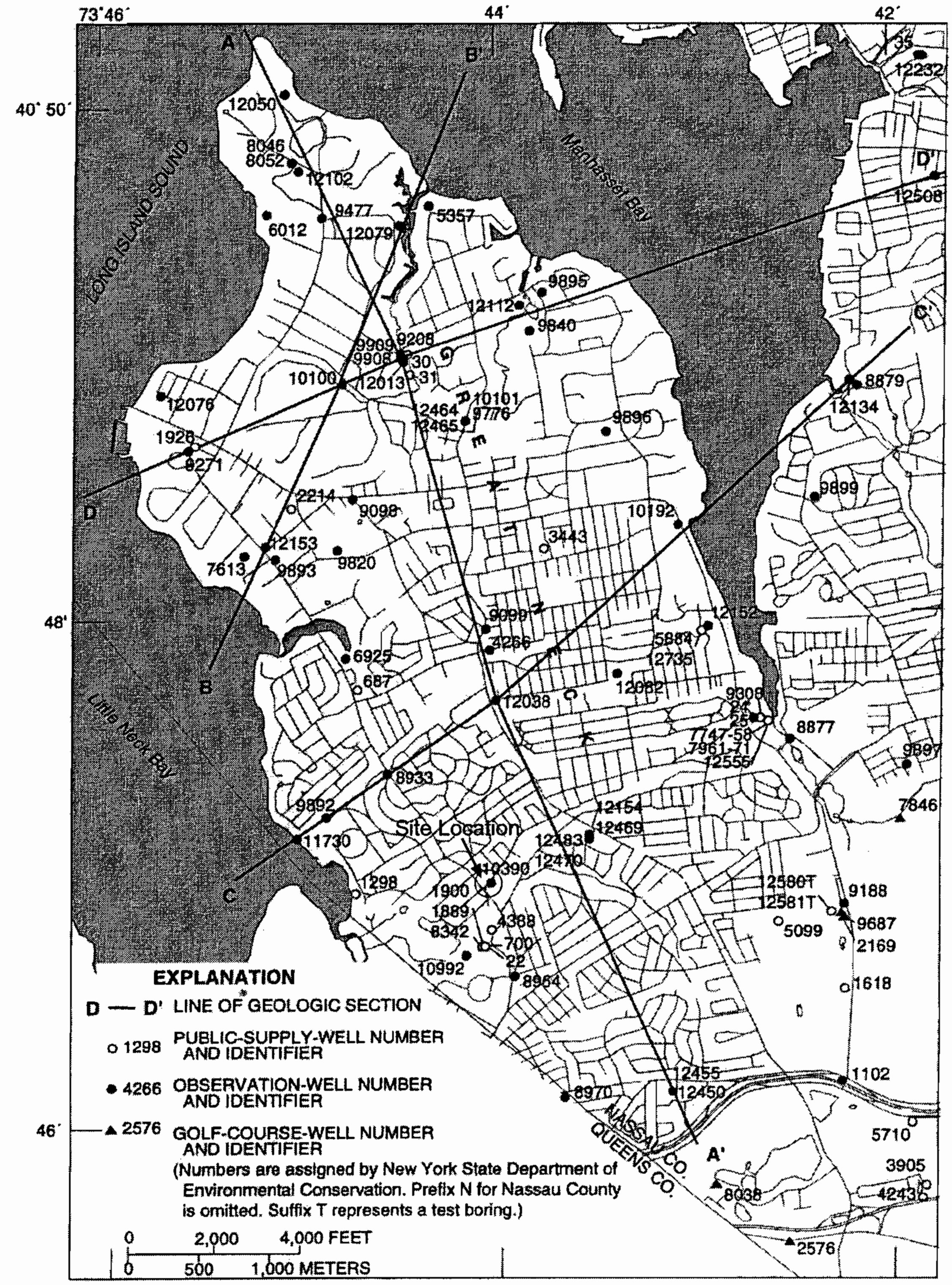
FIGURE 4A
Well Location Map

Stanton Cleaners Area
Groundwater Contamination Site
Great Neck, Nassau County, New York



Base from New York State Department of Transportation, 1:24,000, 1981

Locations of public-supply wells, observation wells, and golf-course wells within the Great Neck pennisula, Nassau County, N.Y.

Ref.: Hydrogeology and Extent of Saltwater Intrusion of the Great Neck
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Figure 6A
Cross-Section Orientations
from Stumm, 2000

Stanton Cleaners Area
Ground Water Contamination Site
Great Neck, Nassau County, New York

work/42792/WP/hydro rpt/figures/F_6ACrSect.fh9

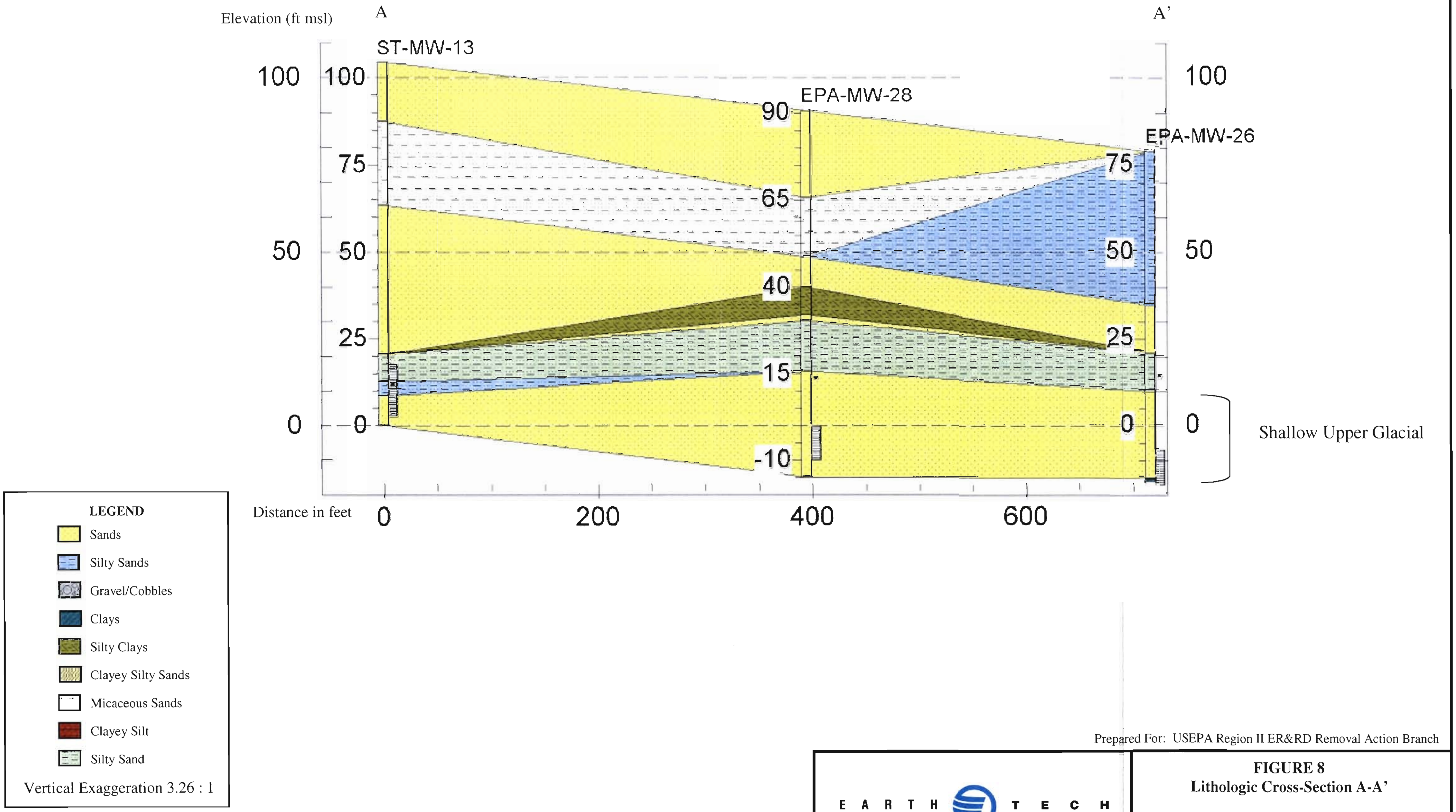

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FIGURE 8
Lithologic Cross-Section A-A'

Stanton Cleaners Area
Groundwater Contamination Site
Great Neck, Nassau County, New York

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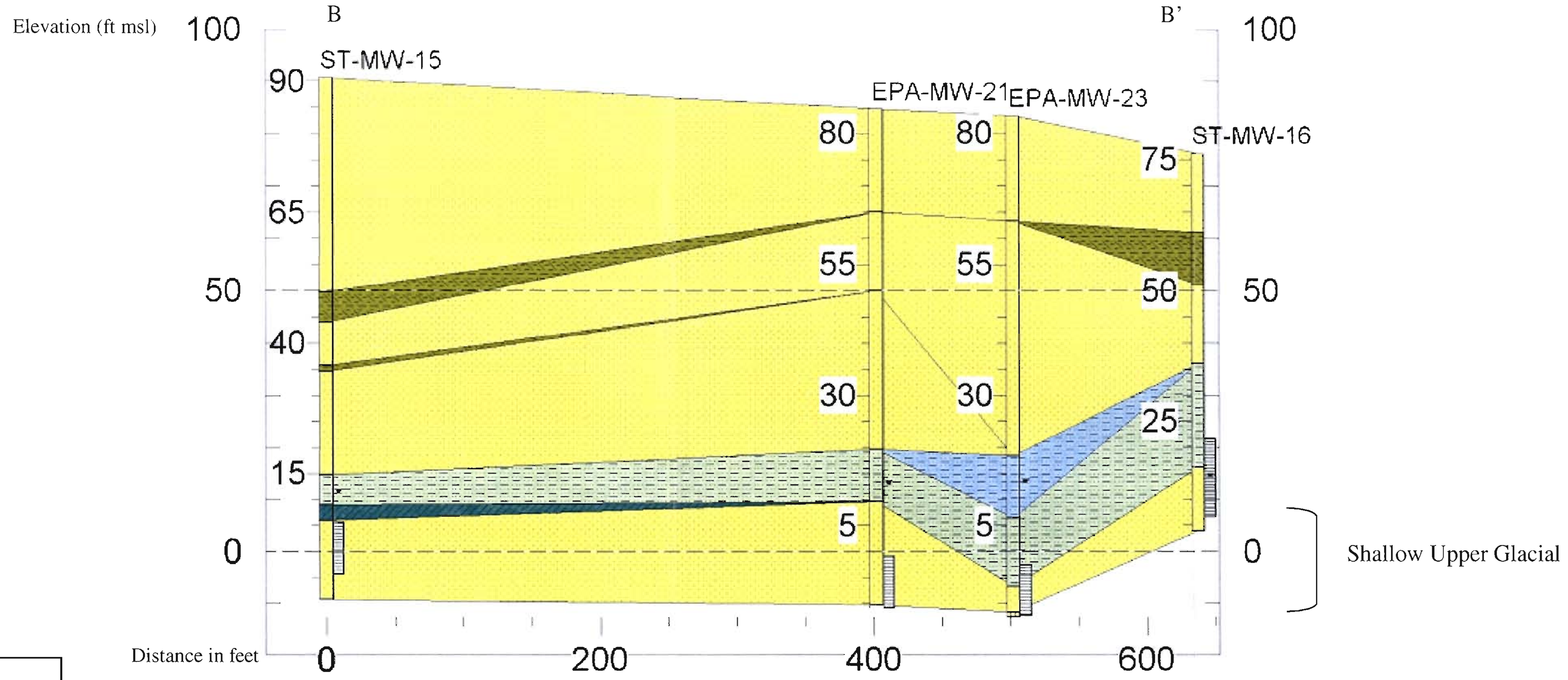

LEGEND

- 🟨 Sands
- 🟦 Silty Sands
- ▨ Gravel/Cobbles
- ▨ Clays
- 🟩 Silty Clays
- ▨ Clayey Silty Sands
- ☐ Micaceous Sands
- 🟥 Clayey Silt
- ▨ Silty Sand

Vertical Exaggeration 3.87 : 1

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FIGURE 9
Lithologic Cross-Section B-B’

Stanton Cleaners Area
Groundwater Contamination Site
Great Neck, Nassau County, New York

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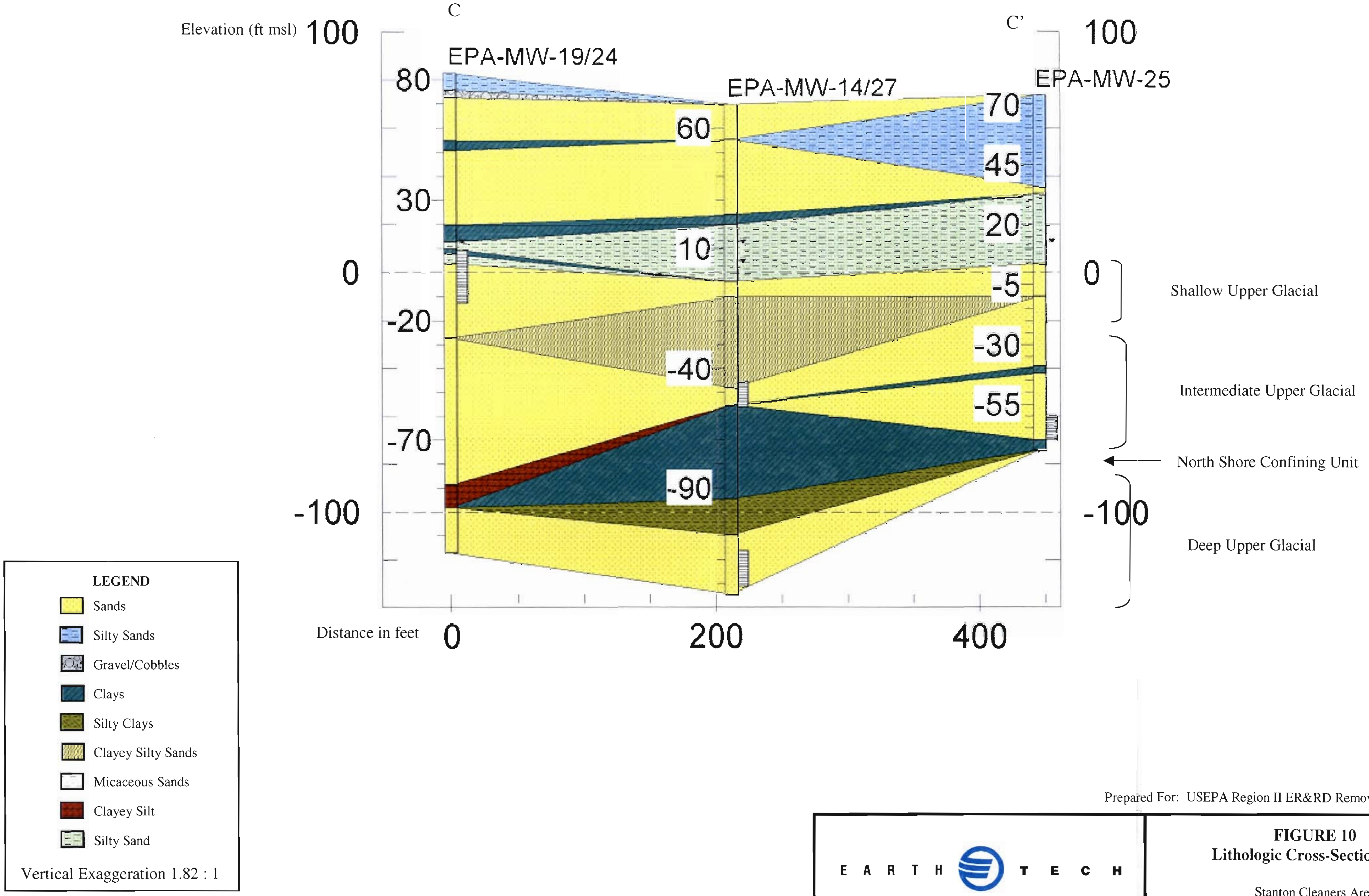

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FIGURE 10
Lithologic Cross-Section C-C'

Stanton Cleaners Area
Groundwater Contamination Site
Great Neck, Nassau County, New York

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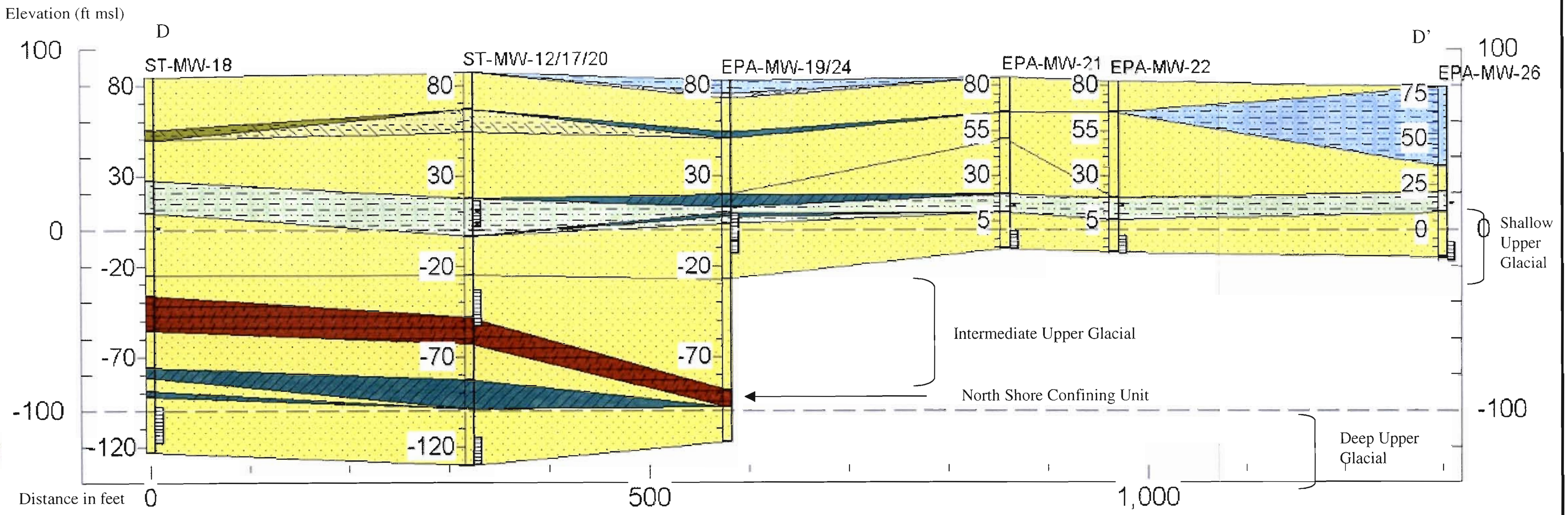

LEGEND

- 🟨 Sands
- ▤ Silty Sands
- ▨ Gravel/Cobbles
- ▨ Clays
- ▨ Silty Clays
- ▨ Clayey Silty Sands
- ☐ Micaceous Sands
- 🟥 Clayey Silt
- ▤ Silty Sand

Vertical Exaggeration 1.81 : 1

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FIGURE 11
Lithologic Cross-Section D-D'

Stanton Cleaners Area
Groundwater Contamination Site
Great Neck, Nassau County, New York

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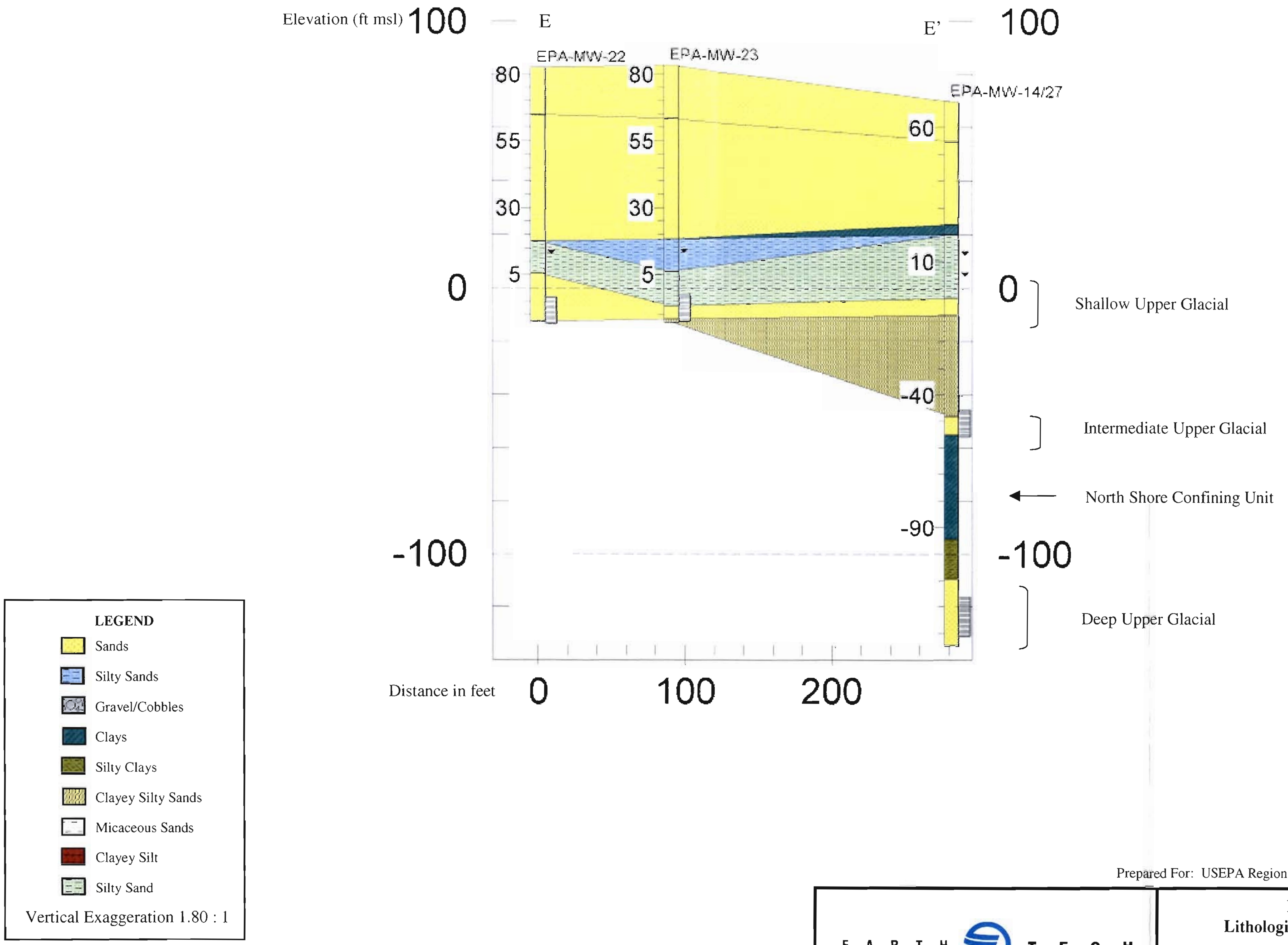

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FIGURE 12
Lithologic Cross-Section E-E'

Stanton Cleaners Area
Groundwater Contamination Site
Great Neck, Nassau County, New York

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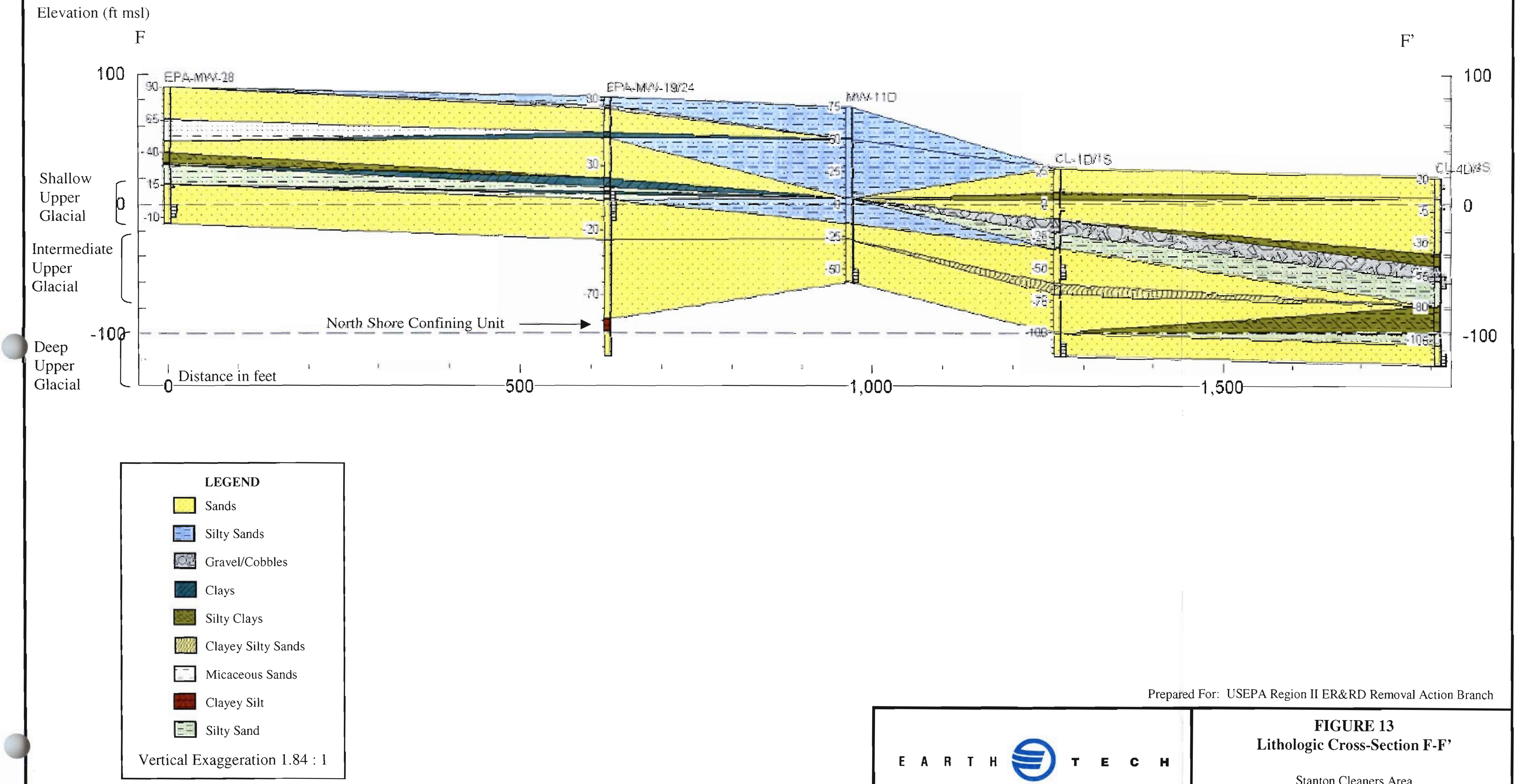

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FIGURE 13
Lithologic Cross-Section F-F'

Stanton Cleaners Area
Groundwater Contamination Site
Great Neck, Nassau County, New York

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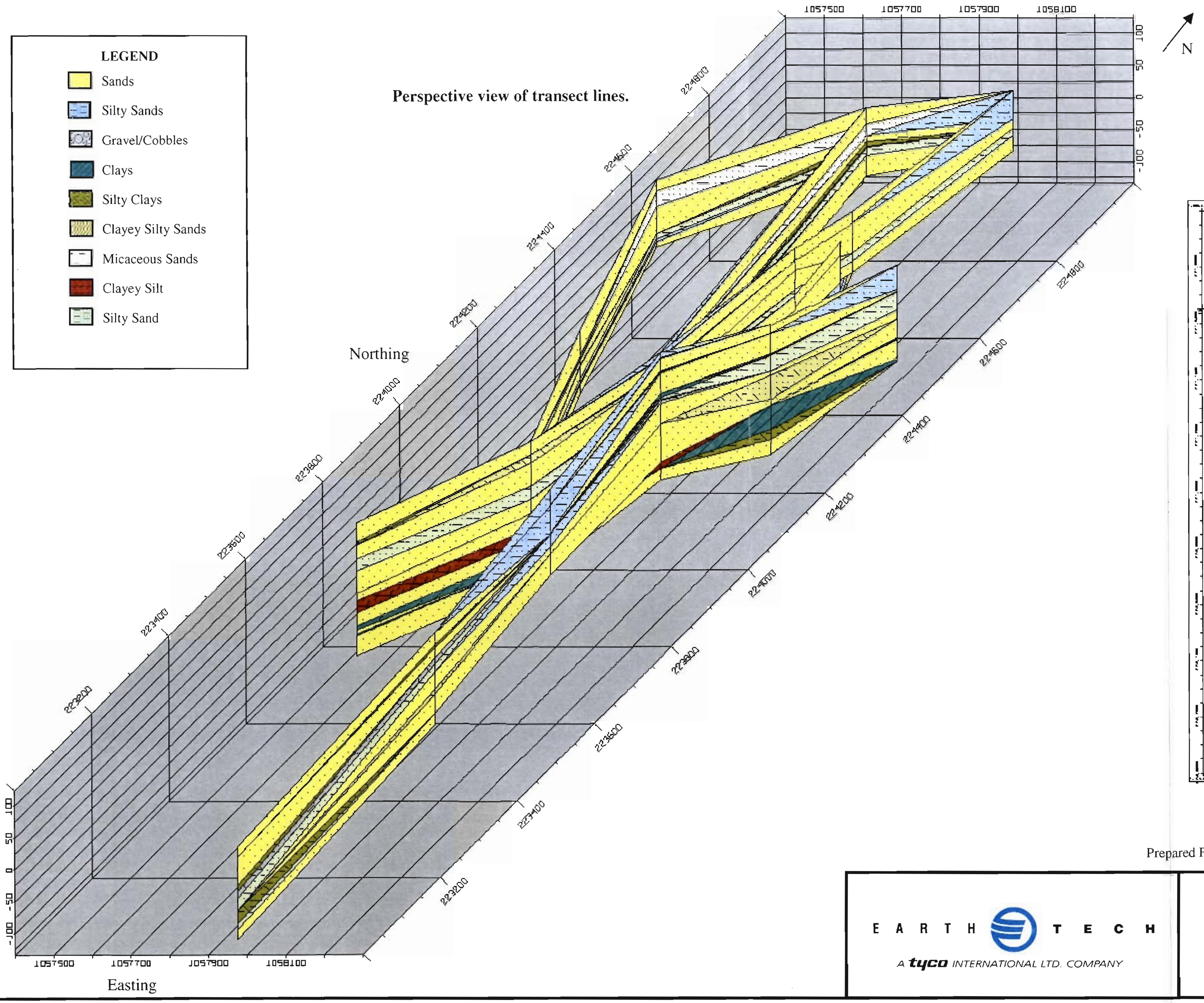

Plan view of wells

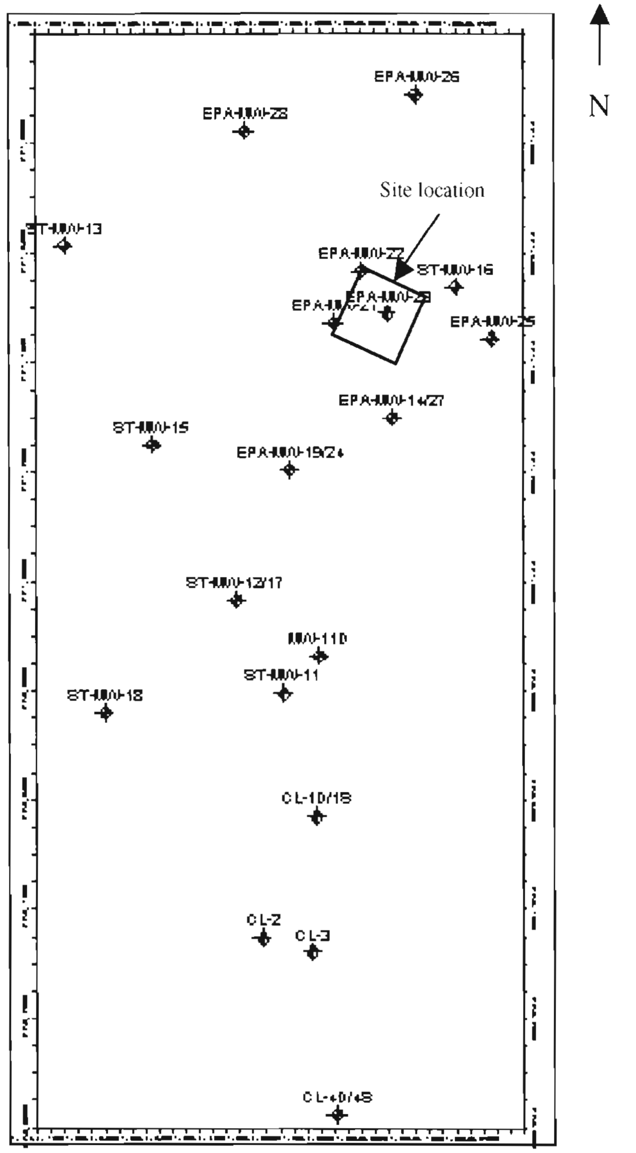

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FIGURE 14
Fence Diagram

Stanton Cleaners Area
Groundwater Contamination Site
Great Neck, Nassau County, New York

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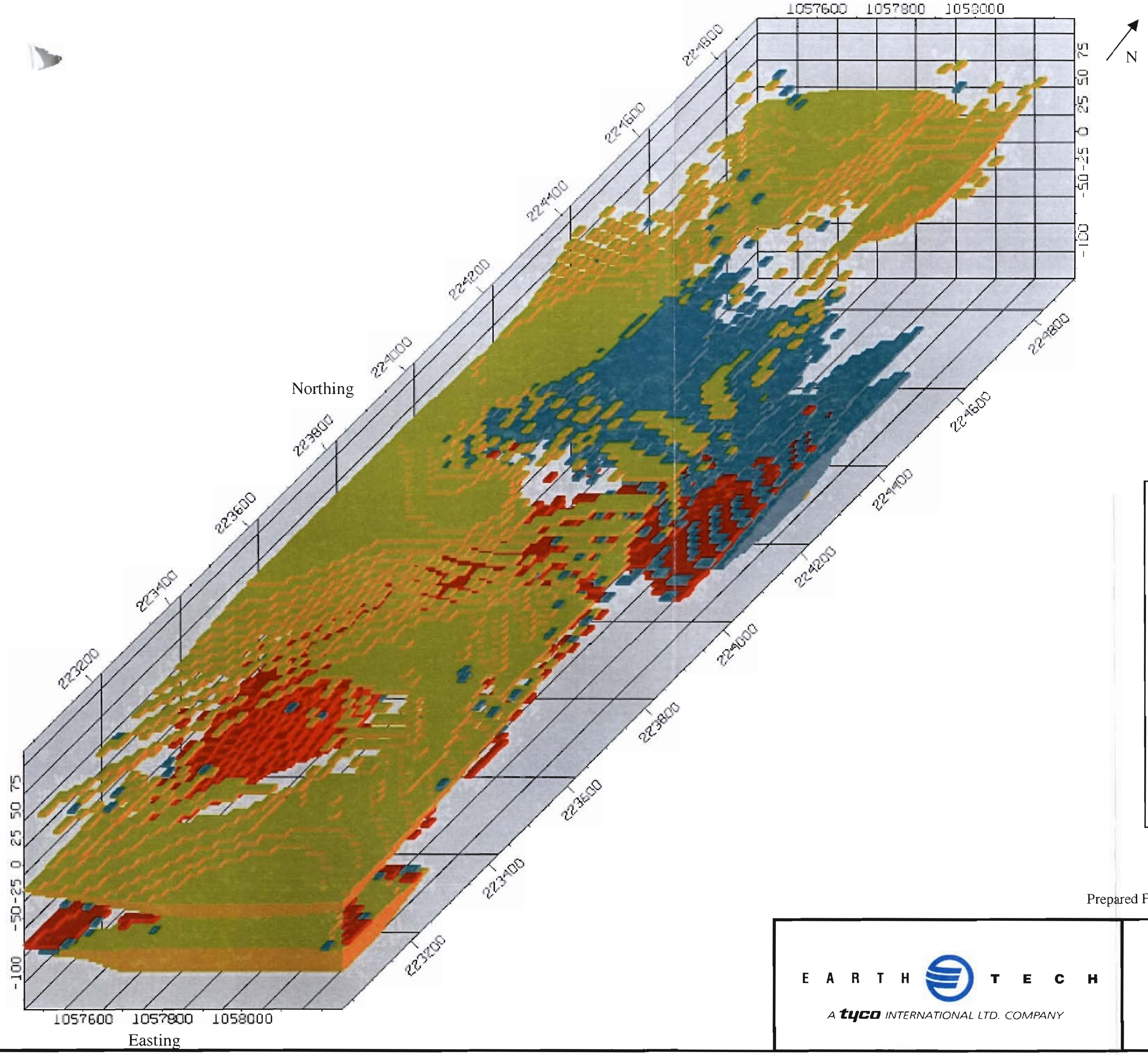

LEGEND

- 🟨 Sands
- ▤ Silty Sands
- ▨ Gravel/Cobbles
- 🟦 Clays
- 🟩 Silty Clays
- ▨ Clayey Silty Sands
- ☐ Micaceous Sands
- 🟥 Clayey Silt
- ▤ Silty Sand

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FIGURE 15
Fine Grain Units Model

Stanton Cleaners Area
Groundwater Contamination Site
Great Neck, Nassau County, New York

F_15fingrainunits_rev.ppt