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Office of Solid Waste and Emergency Response
Office of Superfund Remediation and
Technology Innovation

Optimization Review
Groveland Wells Numbers 1 and 2 Superfund Site
Town of Groveland, Essex County, Massachusetts

OPTIMIZATION REVIEW

**GROVELAND WELLS NUMBERS 1 AND 2 SUPERFUND SITE
TOWN OF GROVELAND, ESSEX COUNTY, MASSACHUSETTS**

Report of the Optimization Review
Site Visit Conducted at the Groveland Wells Numbers 1 and 2 Superfund Site on
February 29, 2012

FINAL REPORT
January 7, 2013

EXECUTIVE SUMMARY

Optimization Background

U.S. Environmental Protection Agency's definition of optimization is as follows

*“Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness.”*¹

An optimization review considers the goals of the remedy, available site data, conceptual site model (CSM), remedy performance, protectiveness, cost-effectiveness and closure strategy. A strong interest in sustainability has also developed in the private sector and within Federal, State and Municipal governments. Consistent with this interest, optimization now routinely considers green remediation and environmental footprint reduction during optimization reviews. An optimization review includes reviewing site documents, interviewing site stakeholders, potentially visiting the site for one day and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent review, and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans and quality assurance project plans (QAPP).

Site-Specific Background

The Groveland Wells Nos. 1 and 2 Superfund Site is located within the Town of Groveland, Essex County, Massachusetts within the watershed of the Merrimack River. The site consists of two operable units (OU):

¹ U.S. Environmental Protection Agency (EPA). 2012 Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28, 2012.

- Source Control operable unit (OU 2), which is limited to the original release area and the immediately surrounding property; and
- Management of Migration operable unit (OU 1), which encompasses an approximately 850-acre study area including the aquifer that recharges the Groveland Municipal Well Stations Nos. 1 and 2, which were impacted by site contaminants.

OU2 is located at 64 Washington Street and is commonly referred to as the “Valley property” or “Valley/GRC property” because the contaminants of concern were released from the former Valley Manufactured Products Company (Valley), located on property owned and formerly operated by the Groveland Resources Corporation (GRC). Valley and GRC both formerly operated metals and plastic parts manufacturing businesses in a building on the property. The building was abandoned when the owner and operator went bankrupt. Both GRC and Valley are Responsible Parties (RPs). Chlorinated solvents and cutting oils were released at the property on numerous occasions in prior years, including surface releases, leakage from underground storage tanks (UST) and discharges to subsurface disposal systems located at the Valley facility. Previous subsurface studies determined that the releases from Valley caused the contamination of groundwater extracted by the Town of Groveland’s public water supply wells Nos. 1 and 2.

Summary of Conceptual Site Model

The Valley property overlies the shoulder of a local bedrock high that is overlain by approximately 30 feet (ft) of unsaturated overburden and 10 ft of saturated overburden. Releases of trichloroethene (TCE) at the Valley property caused soil and groundwater concentrations indicative of the presence of non-aqueous phase liquid (NAPL) in unsaturated zone and the thin saturated overburden in the southeastern portion of the Valley property. Due to the relatively thin saturated zone of contamination in the source area and mixing with regional groundwater flow, concentrations of TCE approximately 500 ft downgradient of the source area were approximately a half order of magnitude lower (6,600 micrograms per liter ($\mu\text{g/L}$) at extraction well EW-S5 compared to 40,000 $\mu\text{g/L}$ at extraction well EW-S2) prior to operation of the current pump and treat (P&T) operation.

During approximately 10 years of P&T operation the TCE concentrations in groundwater in the source area P&T wells (EW-S1, EW-S2, and EW-S3) remained orders of magnitude above the maximum contaminant levels (MCL), suggesting a continuing source of groundwater contamination. By contrast, TCE concentrations in groundwater at the next set of downgradient P&T wells (EW-S4 and EW-S5) decreased by a factor of approximately 30 within 2 years and were near or below MCLs within 8 years. Due to a relatively steep hydraulic gradient (approximately 0.06 ft per ft) between the source area and P&T wells EW-S4/EW-S5, and a high hydraulic conductivity, the groundwater flow velocity is relatively fast, and TCE concentrations in this area change over the course of a few months as a result of remedial activities.

The recently implemented *in situ* thermal treatment (ISTT) remedy in the source area removed the majority of mass and has reduced TCE concentrations in soil and groundwater near the source area accordingly. However, TCE concentrations in confirmation soil samples are nearly 2 orders of magnitude higher than the site-specific soil cleanup standard for TCE, and suggest that contamination is still present in vadose zone soil that has the potential to result in TCE groundwater contamination at concentrations orders of magnitude above MCLs. The August 2011 TCE concentration of 78 $\mu\text{g/L}$ in monitoring well RW-05 (based on the most recent round of sampling at that location available to the optimization review team), further suggests the potential that a source of groundwater contamination remains in this area. It is unclear, however, whether these observed soil and groundwater concentrations are isolated and of

insufficient mass to serve as the source for an extensive TCE plume above MCLs, or whether they merit further attention.

Summary of Findings or Conceptual Model Highlights

The following findings are some of the key findings discussed in Sections 4.0 and 5.0 of the report:

- Due to 10 years of P&T operation, the plume extent has been significantly reduced to the source area and the 500 ft of aquifer immediately downgradient of the source area.
- Due to ISTT operation, the majority of source area contamination has been removed and the TCE concentrations in groundwater have been substantially reduced.
- Although the TCE concentrations in confirmation soil samples CSB-10 and CSB-12 were above the soil clean up level established for the site, these results may be isolated and of insufficient mass to serve as the source for an extensive TCE plume above MCLs (see Sections 4.1 and 4.2.1 for detailed discussion).
- Based on data from newly installed bedrock monitoring wells and monitoring of existing bedrock monitoring and extraction wells, NAPL did not appear to enter bedrock. Furthermore, remediation of the overburden with ISTT has significantly reduced dissolved TCE concentrations in bedrock groundwater.

Summary of Recommendations

Recommendations are provided to improve remedy effectiveness and assist with accelerating site closure. Recommendations to reduce costs and for technical improvement were not provided given the focus on site closure. The recommendations in these areas are as follows:

Improving effectiveness – The optimization review team recommends continued operation of specific extraction wells (EW-S1 through EW-S4) and treatment with the existing system for up to 1 year. Currently EW-S4 is operating and wells EW-S1 through EW-S3 will be re-started in the near future now that temperatures have mostly recovered from the effects of ISTT remediation. Operation of other extraction wells is not recommended. The optimization review team recommends more frequent (i.e., monthly) sampling and analysis of groundwater from select wells in and downgradient of the source area, for up to 1 year, to improve the understanding of site conditions following the ISTT remedy. As P&T operation is currently planned, the recommended P&T for up to 1 year does not impact estimated costs for the next year. The more frequent monitoring will add approximately \$20,000 in cost. However, these recommendations are intended to provide data that will shorten the time frame for active remediation and ultimately result in net cost savings, as described in the following paragraph. An alternative approach that does not include operation of extraction wells EW-S1 through EW-S3, and a discussion of the advantages and disadvantages of that alternative approach, is presented in Section 6.1.2.

Reducing cost – The optimization review team has not provided specific recommendations for reducing costs for operating the P&T system in its current form (for example, treatment plant upgrades) because continued P&T operation for more than one year (at most) is considered unlikely. However, the recommendations described above (i.e., extraction for up to 1 year with monthly monitoring) are anticipated to result in one of several potential outcomes that will lower long-term costs relative to the current P&T system. Possible outcomes and associated estimates for potential costs savings include:

- A likely potential outcome is that P&T operation at this site will be terminated within 1 year (and perhaps much less than 1 year). If that occurs, the current cost of \$345,600 per year would likely be reduced to approximately \$65,000 per year (for project management and groundwater monitoring). Thus, cost would be reduced by approximately \$280,000 per year for this scenario versus the current P&T system.
- Another potential outcome is that P&T extraction can be limited to source area wells EW-S1 through EW-S3 within 1 year, and the lower overall system flow rate would allow for a simpler treatment approach. The current cost of \$345,600 per year would likely be reduced to approximately \$115,000 per year (for project management, extraction/treatment, and groundwater monitoring). Thus, cost would be reduced by approximately \$230,000 per year for this scenario versus the current P&T system. It is expected that treatment plant modifications for this scenario would require up-front costs of approximately \$50,000, with payback achieved in much less than 1 year.
- Another potential outcome is that additional source area remediation (likely to consist of excavation and disposal) may be required in a targeted area to allow for the complete shutdown of P&T operations. Based on the size of the targeted area, the up-front costs might range from less than \$100,000 to \$500,000 or more. These up-front costs would be offset by annual savings of approximately \$280,000 per year that would result from complete termination of P&T operations (as discussed above). Thus, the payback period might range from less than 1 year to as much as several years for this scenario.

For these potential outcomes, the current treatment system would not be operated in its current form for more than 1 year (and perhaps much less than 1 year). Therefore, the optimization review team recommends that any currently planned upgrades to the P&T system be delayed if at all possible. Any such upgrades that can ultimately be avoided, by delaying the upgrades until the treatment plant is eliminated, would result in additional costs savings (not quantified by the optimization review team).

Technical improvement – None provided.

Site closure – The optimization review team recommends that the site team develop P&T shutdown criteria for the remaining extraction wells and consider remedial options for the source area if P&T shutdown criteria will not be met in the near future. A decision framework in the form of a flowchart has been provided (see Figure 6-1) to illustrate how decisions on terminating the P&T activities and or conducting additional investigation and remediation of the source area can be made based on data collected over the next year (in conjunction with the P&T shutdown criteria).

Green remediation – Given the focus on site closure (i.e., the expectation that the current P&T system will only operate for a short period of time), no opportunities for footprint reduction regarding the current P&T system (for example, treatment plant upgrades) were contemplated. However, to the extent P&T operations are terminated or significantly scaled back within 1 year or less, remedy footprints will be reduced accordingly. The actual footprint reductions will depend on which of the potential outcomes on the decision flowchart actually occurs (i.e., similar to the potential cost savings).

NOTICE

Work described herein including preparation of this report was performed by Tetra Tech for the U.S. Environmental Protection Agency under Work Assignment 2-58 of EPA contract EP-W-07-078 with Tetra Tech EM, Inc., Chicago, Illinois. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

This report was prepared as part of a national strategy to expand Superfund optimization from remedial investigation to site completion implemented by the United States Environmental Protection Agency (EPA) Office of Superfund Remediation and Technology Innovation (OSRTI) ². The project contacts are as follows:

Organization	Key Contact	Contact Information
EPA Office of Superfund Remediation and Technology Innovation (OSRTI)	Kathy Yager	EPA Technology Innovation and Field Services Division (TIFSD) 11 Technology Drive (ECA/OEME) North Chelmsford, MA 01863 yager.kathleen@epa.gov phone: 617-918-8362
Tetra Tech EM, Inc. (Contractor to EPA)	Jody Edwards, P.G.	Tetra Tech EM Inc. 1881 Campus Commons Drive, Suite 200 Reston, VA 20191 jody.edwards@tetrattech.com phone: 802-288-9485
Tetra Tech GEO (Subcontractor to Tetra Tech EM, Inc.)	Doug Sutton, PhD, P.E.	Tetra Tech GEO 2 Paragon Way Freehold, NJ 07728 doug.sutton@tetrattech.com phone: 732-409-0344

² U.S. Environmental Protection Agency (EPA). 2012. Memorandum: Transmittal of the *National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion*. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28, 2012.

LIST OF ACRONYMS

$\mu\text{g}/\text{kg}$	micrograms per kilogram
$\mu\text{g}/\text{L}$	micrograms per liter
$\mu\text{g}/\text{m}^3$	micrograms per cubic meter
ARARs	applicable or relevant and appropriate requirements
AWQC	Ambient Water Quality Criteria
bgs	below ground surface
BMP	best management practice
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-dichloroethene
COC	chemical of concern
COPC	chemical of potential concern
CSM	conceptual site model
DPT	direct-push technology
EPA	United States Environmental Protection Agency
ERH	electrical resistance heating
ESD	Explanation of Significant Difference
FEMA	Federal Emergency Management Agency
f_{oc}	fraction of organic carbon
FS	feasibility study
ft	feet
ft^2	feet squared
ft^3	cubic feet
GAC	granular activated carbon
GETS	groundwater extraction and treatment system
gpm	gallons per minute
GRC	Groveland Resources Corporation
GWTF	groundwater treatment facility
HP	Horsepower
HRSC	high-resolution site characterization
Hz	Hertz
ISCO	<i>In situ</i> chemical oxidation
ISTT	<i>In situ</i> thermal treatment
K	hydraulic conductivity
K_d	partitioning coefficient
K_{oc}	organic carbon partitioning coefficient
kW	kilowatt
kWh	kilowatt hours
L/kg	liters per kilogram
L/mg	liters per milligram

LTM	long term monitoring
MassDEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MOM	Management of Migration
MW	monitoring well
NAPL	non-aqueous phase liquid
NPL	National Priorities List
OSRTI	Office of Superfund Remediation and Technology Innovation
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
P&T	pump and treat
PDB	passive diffusion bag
PCE	tetrachloroethylene (perchloroethylene)
PID	photoionization detector
PRP	Potentially Responsible Party
PVC	polyvinyl chloride
QA	quality assurance
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RA	Remedial Action
RAO	remedial action objective
RI	remedial investigation
ROD	Record of Decision
RSE	remedial system evaluation
SC	source control
SVE	soil vapor extraction
TCE	Trichloroethylene
UST	underground storage tank
UVOx	ultraviolet oxidation
VFD	variable frequency drive
VI	vapor intrusion
VOC	volatile organic compound

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1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001 independent site optimization reviews called Remediation System Evaluations (RSEs) were conducted at 20 operating Fund-lead pump and treat (P&T) sites (i.e., those sites with P&T systems funded and managed by Superfund and the States). Due to the opportunities for system optimization that arose from those RSEs, the U.S. Environmental Protection Agency Office of Superfund Remediation and Technology Innovation (OSRTI) has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies as documented in *OSWER Directive No. 9283.1-25, Action Plan for Ground Water Remedy Optimization*. Concurrently, the EPA developed and applied the Triad Approach to optimize site characterization and development of a conceptual site model (CSM). The EPA has since expanded the definition of optimization to encompass investigation stage optimization using Triad Approach best management practices (BMP), optimization during design, and RSEs. The EPA's working definition of optimization is as follows:

Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness.¹

As stated in the definition, optimization refers to a "systematic site review," indicating that the site as a whole is often considered in the review. Optimization can be applied to a specific aspect of the remedy (for example, focus on long-term monitoring [LTM] optimization or focus on one particular operable unit [OU]), but other site or remedy components are still considered to the degree that they affect the focus of the optimization. An optimization review considers the goals of the remedy, available site data, CSM, remedy performance, protectiveness, cost-effectiveness and closure strategy. A strong interest in sustainability has also developed in the private sector and within Federal, State and Municipal governments. Consistent with this interest, OSRTI has developed a Green Remediation Primer (<http://clu.in.org/greenremediation/>), and now routinely considers green remediation and environmental footprint reduction during optimization reviews.

The optimization review includes reviewing site documents, potentially visiting the site for one day and compiling this report, which includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental footprint reduction

¹ U.S. Environmental Protection Agency (EPA). 2012. Memorandum: Transmittal of the *National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion*. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28, 2012.

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation, and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance project plans (QAPP).

The national optimization strategy includes a system for tracking consideration and implementation of the optimization review recommendations and includes a provision for follow-up technical assistance from the optimization review team as mutually agreed upon by the site management team and EPA OSRTI.

The Groveland Wells Nos. 1 and 2 Superfund Site consists of two operable units:

- Source Control (SC) operable unit (OU2), which is limited to the original release area and the immediately surrounding property; and
- Management of Migration (MOM) operable unit (OU 1), which encompasses an approximate 850-acre area constituting the aquifer that recharges the Groveland Municipal Well Stations Nos. 1 and 2, which were impacted by site contaminants.

OU 2 is commonly referred to as the “Valley Property” or the “Valley/GRC site” because the contaminants of concern were released from the former Valley Manufactured Products Company, located at 64 Washington Street on property owned by Groveland Resources Corporation (GRC). The site remedial activities are currently managed and funded by the Massachusetts Department of Environmental Protection (MassDEP). EPA Region 1 nominated the site for an optimization review on behalf of the MassDEP to optimize the remedy after EPA’s completion of *in situ* thermal treatment (ISTT) in the source area using electrical resistance heating (ERH). This optimization review focuses primarily on site conditions following ISTT implementation.

1.2 TEAM COMPOSITION

The optimization review team consisted of the following individuals:

Name	Affiliation	Phone	Email
Rob Greenwald	Tetra Tech GEO	732-409-0344	Rob.Greenwald@tetrattech.com
Peter Rich	Tetra Tech GEO	410-990-4607	Peter.Rich@tetrattech.com
Doug Sutton	Tetra Tech GEO	732-409-0344	Doug.Sutton@tetrattech.com

Kathy Yager, Ed Gilbert, and Gary Newhart from EPA OSRTI also attended the site visit.

1.3 DOCUMENTS REVIEWED

The following documents were reviewed in support of the optimization review.

- *Field Sampling Plan – QAPP* (Nobis – February 2012)
- *Monthly Site Visit Report for May 2011* (Nobis – June 13, 2011)
- *Remedial Action Report for the Operable Unit 2 Remedial Action* (Nobis – September 20, 2011)
- *April 2011 through December 2001 Monthly Operations Reports* (Nobis – June 2011 through January 2012)
- *Draft 2010 Data Evaluation Report* (Nobis – May 18, 2011)
- Laboratory data reports and data management spreadsheets for 2011 groundwater monitoring data
- *Second Five-Year Review Report* (EPA Region 1 – June 2010)
- April 24, 2008 Letter from MassDEP to Thomas Cusick, Jr., Groveland Water Department regarding Groveland Well No. 1.
- November 26, 2007 Memorandum from Metcalf & Eddy | AECOM to Derrick Golden, EPA Region 1 Regarding the Proposed Pumping Rate Increase at Station No. 1
- *Explanation of Significant Differences, OU2* (EPA Region 1 – September 2007)
- *Data Evaluation Report for Remedial Action, Spring 2003 Monitoring Round* (Metcalf & Eddy, 2003)
- *Supplemental Management of Migration Remedial Investigation Report* (NUS Corporation – February 1991)
- *Explanation of Significant Differences, OUI* (EPA Region 1 – November 15, 1996)
- *Explanation of Significant Differences, OU2* (EPA Region 1 – November 15, 1996)
- *Record of Decision, OUI* (USEPA Region 1 – September 30, 1991)
- *Supplemental Remedial Investigation (NUS Corporation – 1991)*
- *Record of Decision, OU2* (USEPA Region 1 – September 30, 1988)
- *Remedial Investigation* (Environmental Research & Technology, Inc. – June 1985)

1.4 QUALITY ASSURANCE

This optimization review utilizes existing environmental data to interpret the CSM, evaluate remedy performance and make recommendations to improve the remedy. The quality of the existing data is evaluated by the optimization review team prior to using the data for these purposes. The evaluation for data quality includes a brief review of how the data were collected and managed (where practical, the site QAPP is considered), the consistency of the data with other site data and the use of the data in the optimization review. Data that are of suspect quality are either not used as part of the optimization review or are used with the quality concerns noted. Where appropriate, this report provides recommendations to improve data quality.

A site visit was conducted on February 29, 2012. In addition to the optimization review team and EPA OSRTI personnel, the following persons were present for the site visit:

Name	Affiliation	Email Address
Janet Waldron	MassDEP	janet.waldron@state.ma.us
Derrick Golden	EPA Region 1	golden.derrick@epa.gov
Paul Craffey	MassDEP	
Kimberly White	EPA Region 1	
Steve Mahoney	MassDEP	
Diane Baxter	Nobis	
Frank Ricciardi	Weston & Sampson Services	
Brian Farmer	Weston & Sampson Services	
Jim Vurgaropoulos	Weston & Sampson Services	

2.0 SITE BACKGROUND

2.1 LOCATION

The Groveland Wells Nos. 1 and 2 Superfund Site is located in the Town of Groveland (Town), Essex County, Massachusetts. The site contains nearly 850 acres, mostly located in the southwestern part of the Town of Groveland. The Site Source Area (the Valley property) is located in the southwest portion of the site. The site is bounded to the west by Washington Street and the former Haverhill Municipal Landfill, to the south by Salem Street, to the east by School Street and to the north by the Merrimack River. The Haverhill Municipal Landfill originally was part of the Groveland Wells Site but it has since been separately listed on the National Priorities List (NPL) and is no longer part of the site. Figure 1 from the Second Five-Year Review (EPA Region 1 – June 2010) illustrates the site boundaries and key features (see Attachment A for this figure).

2.2 SITE HISTORY

2.2.1 HISTORIC LAND USE AND OPERATIONS

According to the Second Five-Year Review (EPA Region 1 – June 2010), the Valley property (located on Washington Street in the southwestern portion of the site) was used for metal and plastic parts manufacturing from 1963 until 2001. The original building, in which the Valley Manufactured Products Company was housed, was constructed on the property around 1900. Prior to 1963 the building housed agricultural and textile operations. In 1963, GRC leased the property and began on-site manufacturing of screw machine products. GRC reportedly purchased the property in 1966. Valley Manufactured Products Company acquired GRC's on-site operations in August 1979; however, GRC retained property ownership.

A former 400 square-foot wooden shed, reportedly connected to the south end of the Valley Manufactured Product Company building, was used to store virgin trichloroethene (TCE), “Solvosol” (an unspecified solvent), and cutting oils. Waste cutting oils and solvents were also stored in the wooden shed. The exact location of the shed has not been verified.

In 1972 and 1973, GRC reportedly installed six underground storage tanks (USTs) ranging in size from 700 to 3,000 gallons for storage of cutting oils, solvents and mineral spirits in the southern portion of the Valley property. Cutting oils were pumped from the USTs into distribution piping running throughout the machining areas of the facility. Recovered oils were recirculated through the system. Waste oils were reportedly disposed of off-site. During October 1983, pressure testing of the USTs was conducted. The USTs exhibited some initial pressure loss that was attributed to leakage occurring at the couplings on the tank vent lines.

On-site processes included machining, degreasing and finishing of metal parts. The machining process used cutting oils and lubricants. After machining, metal parts were cleaned (degreased) in a hydrocarbon solvent vapor degreaser and then spun dry. TCE was used in the vapor degreasing operation from 1963 to 1979. Methylene chloride was used from 1979 to 1983. Solvosol and other solvents were also used. In 1984, Valley discontinued the use of solvents and replaced them with detergent degreasers.

If parts required additional cleaning, they were then immersed in either an alkaline cleaning solution (containing caustic soda) or an acid solution (“Brite Dip” process, containing nitric acid). Once cleaned, the parts were rinsed and excess rinse water was discharged to a Brite Dip subsurface disposal system. Several subsurface disposal systems were used on the property. Approximate locations of these storage tanks and subsurface disposal systems are shown on Figure 4 of the Second Five-Year Review (EPA Region 1 – June 2010), which is provided in Attachment A.

2.2.2 CHRONOLOGY OF ENFORCEMENT AND REMEDIAL ACTIVITIES

According to the Second Five-Year Review (EPA Region 1 – June 2010), in June and October 1979, groundwater in two Town drinking water supply wells, Groveland Wells Nos. 1 and 2, was determined to be impacted with TCE. The wells were taken off-line and the Town imposed water rationing. Later in 1979 the Town developed another drinking water well, Station No. 3, in a different aquifer. In 1982, the EPA determined that the groundwater contamination at the site constituted a threat to public health and the environment and placed the site on the NPL in December of that year. Groveland Well No. 1 was eventually returned to service in 1987 with treatment via granular activated carbon (GAC). The requirement for GAC treatment at the well was removed in 1994 based on non-detectable concentrations of TCE since 1989. The following table provides a brief timeline of operational, enforcement and remedial activities from 1982 through 2011 (derived from Table 1 of Second Five-Year Review (EPA Region 1 – June 2010)).

Date	Event
May 1963	GRC leases property at 64 Washington Street in Groveland to house a metal products manufacturing plant
May 1963	GRC begins operation of metal products manufacturing
1965	Groveland municipal well Station No. 1 is put into operation
November 1966	GRC purchases property at 64 Washington Street in Groveland
1973	Groveland municipal well Station No. 2 is put into operation
May 1979	TCE detected in Station No. 1; well is shut down
August 1979	Valley Manufactured Products Company acquires GRC's manufacturing operations
September 1979	TCE detected in Station No. 2 Groveland municipal well Station No. 3 is put into operation
October 1979	Station No. 2 permanently shut down
December 1982	Groveland Wells Site placed on the National Priorities List
1985	Management of Migration (MOM) Remedial Investigation (RI) for the Groveland Wells Site completed
August 1986	MOM Feasibility Study (FS) for the Groveland Wells Site completed
1986	MassDEP amendment to 1984 consent order requiring Valley/GRC to construct a groundwater interceptor treatment unit north of Mill Pond
1987	Installation of GAC treatment system and reactivation of Station No. 1
September 1987	EPA issues consent order to Valley and GRC to conduct a Supplemental RI
Late 1987 – Early 1988	Pilot study of soil vapor vacuum extraction system (SVE) at Valley site
April 1988	Installation of Mill Pond Groundwater Extraction/Treatment System by Valley/GRC
July 1988	Final Phase 1 Supplemental RI Report completed by Valley/GRC subcontractor
August 1988	Supplemental FS for the Valley Site completed by EPA subcontractors
September 1988	Source Control (OU2) Record of Decision (ROD) for the Valley site signed
February 1991	Supplemental MOM RI Report completed by EPA subcontractor
July 1991	Supplemental MOM Feasibility Study completed by EPA subcontractor

Date	Event
September 1991	MOM (OU1) ROD is signed
March 1992	EPA issues Administrative Order to Valley/GRC to remediate soil and groundwater at the Valley Site (i.e., the Source Control OU, OU2)
May 1992	EPA issues Administrative Order to Valley/GRC to remediate groundwater contamination that had migrated beyond the Valley Site (i.e., the part of the plume defined as the MOM OU, OU1)
June 1992	Valley/GRC informs EPA that they cannot comply with the Administrative Order to remediate the MOM OU
August 1992	EPA issues a Notice of Failure to Comply to Valley/GRC, for failure to initiate work to remediate the MOM Operable Unit
August 1992	EPA approves the SVE and groundwater treatment system design for the Valley Site
October 1992	Valley/GRC informs EPA that they cannot continue to comply with the Administrative Order for remediation of the Source Control OU
November 1992	EPA issues a Notice of Failure to Comply to Valley/GRC for failure to continue remedial work at the Source Control OU
December 1992	EPA visits Valley Site and learns that the SVE system had in fact been constructed and was in operation
January 1993	EPA issues a Second Notice of Failure to Comply to Valley/GRC for failure to submit monthly progress reports on the SVE system
May 1994	GAC treatment system at Station No. 1 is taken off line by the town, with approval from MassDEP, because TCE contamination had not been detected in the influent water since 1989
June 1994	Valley/GRC begins routine submission of monthly progress reports to EPA
Spring 1994	EPA subcontractor installs an extraction well and conducts hydrogeological tests at the Valley Site for EPA
January 1995	EPA approves the 100% design for the MOM OU groundwater extraction and treatment system (GETS or P&T system)
Spring 1995	Budget constraints cause EPA to put construction of the MOM facility on hold
March 1996	EPA conducts sampling of 22 monitoring wells and determines that the plume has decreased in extent
August 1996	EPA issues Explanations of Significant Differences (ESD) for both the Source Control and MOM OUs, modifying the remedies to treat groundwater from both OUs in a combined facility
September 1996	EPA subcontractor submits a 100% design for the combined facility
April 1997	EPA approves final design
December 1997	EPA receives funding for remedial action
May 1998	EPA sends bid documents to qualified bidders
October 1998	Remedial action subcontract awarded
April 1999	Mobilization and site clearing begin
April 2000	GETS (P&T system) is determined to be substantially complete. New system starts up and Mill Pond system is shut down.
May 2000	Routine operation and maintenance of the GETS (P&T system) begins
July/August 2000	All construction punch list items are completed and final inspection is conducted
September 2000	Operational and Functional Completion Report and certification are submitted to EPA by the remedial action subcontractor
March 2001	Operational and Functional Completion Report and certification are submitted to EPA, revised to address MassDEP comments
April 2002	SVE system is shut down and abandoned by potentially responsible parties (PRPs)

Date	Event
September 2002	An RSE report is completed for the site
April 2004	EPA initiates source area re-evaluation
June 2005	First Five-Year review is completed
2006	EPA performs chemical oxidation pilot study as part of the Source Area Re-Evaluation
August 2006	EPA removes 6 USTs and the Brite Dip system leaching field from Valley property
September 2006	EPA Source Area Re-Evaluation is completed. The report recommends using thermal treatment technologies to treat residual contamination in the source area.
September 2007	EPA issues an ESD outlining the enhancement of the existing SVE system with a thermal treatment system. The ESD was also written to address the recalculation of the soil clean up levels that were originally specified in the 1988 Source Area ROD.
January 2008	EPA and Valley/GRC enter into a consent decree stating Valley/GRC will pay the government 100% of the net sale or net lease proceeds from the property
April 2009	Construction of the enhanced OU2 Source Control Remedial Action begins with site clearing and surveying
October 2009	The subcontract for the OU2 SC Remedial Action ISTT system is awarded
March 2010	Construction of the ISTT system begins
August 2010 to February 2011	ISTT remediation of Source Area
June 2011	Transfer of OU-1 remedy from EPA to MassDEP approximately 10 years after the remedy was considered Operation and Functional (consistent with State-Superfund Contract between MassDEP and EPA)

Immediately prior to the ISTT test, startup of the vapor and liquid extraction systems occurred on August 9, 2010. The ISTT system began operation on August 17, 2010. The ISTT extraction system was shut down on February 24, 2011 and several events of confirmation monitoring of groundwater were subsequently conducted (March 2011, August 2011, and September 2011).

2.3 POTENTIAL HUMAN AND ECOLOGICAL RECEPTORS

The review of risk assessments and toxicity factors in the Second Five-Year Review (EPA Region 1 – June 2010) indicate that exposure to contaminated groundwater is the primary potential pathway for human exposure to site-related contamination. Human risks associated with other potential exposure pathways (including vapor intrusion (VI)) and ecological risks were determined to be sufficiently low to be protective of human health and the environment either due to low levels of contamination or incomplete exposure pathways.

2.4 EXISTING DATA AND INFORMATION

This section is based on data available from existing site documents. Interpretations included in this section are generally those presented in the documents from which information was obtained. The optimization review team's interpretation of this information is presented in Sections 4.0 and 5.0.

2.4.1 SOURCES OF CONTAMINATION

According to the Second Five-Year Review (EPA Region 1 – June 2010), the primary contaminant released at the Valley property was TCE. In 1973, 500 gallons of TCE were reportedly released to the soil underneath the concrete slab from an UST. A total of 3,000 gallons of TCE is estimated to have been discharged to the environment from several surface and subsurface sources, including the loading dock drainage system, the Brite-Dip disposal system, the USTs and by routine operations practices.

The source area (OU2) addressed by ISTT in 2011, along with baseline TCE soil concentrations sampled in 2009, are depicted on Figures 4-1 through 4-3 of the ERH Remedial Action Report (Nobis – September 20, 2011), which are provided in Attachment A. As depicted in these figures, the maximum TCE concentrations in soil were 20,000 µg/kg, 7,400 µg/kg and 8,700 µg/kg for the 0 to 11 ft, 11 to 26 ft, and 26 to 45 ft intervals below ground surface (bgs). Concentrations of TCE in groundwater in the same area during the 2009 baseline sampling event were as high as 96,000 µg/L, as depicted on Figure 4-4 of the ERH Remedial Action Report (Nobis – September 20, 2011), which is provided in Attachment A. Source area concentrations and mass were historically higher, but the concentrations noted above are representative of the source area at the time of this review.

2.4.2 GEOLOGY SETTING AND HYDROGEOLOGY

According to the Supplemental RI (NUS Corporation – 1991), the site lies within a shallow, north-trending bedrock valley that has been partially filled with the glacial sediments. This small valley intersects with the Merrimack River valley along the northern edge of the site. According to the Second Five-Year Review (EPA Region 1 – June 2010), the site is located within the Johnson Creek drainage basin. Johnson Creek originates south of the site and flows in a northerly direction through Mill Pond, located approximately 450 ft east of the Valley property. Argilla Brook, located to the east of Mill Pond, flows northwest through the site and discharges to Johnson Creek. Brindle Brook is a small tributary to Johnson Creek that flows northwestward through the southeast corner of the site area, eventually joining with Johnson Creek near Center Street. There are limited wetland areas at the site, located mostly next to Mill Pond, Argilla Brook, Johnson Creek, Brindle Brook and isolated areas east of Johnson Creek. A portion of the site lies within the 100-year floodplain delineated by the Federal Emergency Management Agency (FEMA).

Topographic relief within the valley is generally low, with most of the prominent relief due to past surface mining of sand and gravel deposits within the valley. The overall topography in the area is controlled by bedrock surface elevations with higher ground surface elevations south, west and east of the site being a function of higher bedrock surface elevations in these areas.

Based on Figure 6-2 of the Draft 2010 Data Evaluation Report (Nobis Engineering – 2010), which provides a cross-section of the geology from north to south, site geology consists of unconsolidated overburden sediments consisting predominantly of glacial drift deposits overlying bedrock. These deposits include both stratified and non-stratified (till) drift deposits. Along Johnson Creek and Argilla Brook, minor amounts of alluvium are present. There is a general increase in glacial drift thickness and a decrease in bedrock surface elevation from the valley margins to the center of the valley and from south to north through the site. Near Groveland Municipal Well Station No. 1 there is approximately 98 ft of glacial drift. The bedrock beneath the overburden is a phyllite (a fine-grained foliated metamorphic rock). The Supplemental RI (NUS Corporation – 1991) states that, according to Environmental Research & Technology, Inc. (ERT 1985), the strike of this bedrock unit is to the northeast, with an average dip of 56 degrees to the northwest. The foliation of the phyllite also reportedly dips to the north-northwest at an angle of approximately 40 degrees.

Groundwater is encountered in both the glacial drift deposits and bedrock at the Groveland Wells Site. The stratified glacial drift deposits form an important aquifer in the areas where a substantial thickness of these deposits exists. Groveland Municipal wells at Stations No. 1 and 2 are located in the glacial drift aquifer. Bedrock is moderately permeable at shallow depths, due to its highly fractured nature. At greater depths, the frequency of fracturing and resulting permeability of the bedrock is unknown.

2.4.3 GROUNDWATER CONTAMINATION

Volatile organic compounds (VOCs) (primarily TCE) were detected in groundwater on the Valley property. Prior to remediation, concentrations as high as 150,000 µg/L of TCE and 7,900 µg/L of 1,2-DCE were reported in groundwater samples collected from wells bordering the Valley property. Similarly high concentrations of TCE and other chlorinated VOCs were detected in groundwater under the portion of the Valley property known as the Material Storage Area, which was constructed in 1980. Both spent and unused cutting oils and solvents had been stored in drums and USTs in this area. Inorganic analytes were also detected in groundwater under the Material Storage Area slab, including: arsenic at 230 µg/L, chromium at 70 µg/L, copper at 1,100 µg/L and lead at 130 µg/L. A free oil phase was also observed in some groundwater samples.

The RIs revealed that a large groundwater contaminant plume of primarily TCE and 1,2-DCE extended from the Valley property approximately 3,900 ft northward, along the path of Johnson Creek, downgradient past Station No. 2. The plume width in 1991 was approximately 350 ft in the Valley/Mill Pond area and roughly 1,000 ft wide where it encompassed Station No. 2. The contamination resulted in the need to provide GAC treatment for water from Groveland Well Station No. 1, while Station No. 2 was completely shut down. Concentrations as high as 50,000 µg/L TCE were reported near the Valley property, while concentrations near the Town wells were generally less than 100 µg/L, but above the MCL of 5 µg/L. Several inorganics were also detected in site groundwater at concentrations exceeding MCLs, but it was also noted that concentrations of some inorganics in samples from wells upgradient of the site also exceeded MCLs.

Remedial activities have greatly reduced the concentrations and extent of contaminants in groundwater. The recent Field Sampling Plan - QAPP (Nobis, 2012) states that “based on the long term groundwater monitoring and recent ISTT confirmation sampling conducted at the site, the contaminants of concern are generally limited to TCE and cis-1,2-DCE in site soil and groundwater located within the source area (Valley Manufacturing property) and in groundwater within the downgradient plume.” Recent TCE concentrations in the overburden (Fall 2010) are illustrated on Figure 4 from the Field Sampling Plan – QAPP (Nobis, 2012). The greatly diminished extent of the overall VOC plume is depicted on Figure 2-1 of the ERH Remedial Action Report (Nobis – September 20, 2011), which is provided in Attachment A. Figure 7 from the Second Five-Year Review (EPA Region 1 – 2010), which is provided in Attachment A, depicts the concentrations of TCE in bedrock wells in 2009, prior to the ISTT remedy.

A detailed discussion regarding the substantial concentration reductions provided by the recent ISTT remediation in the source area is presented in Section 4.1.

2.4.4 SOIL CONTAMINATION

Contaminated soil requiring remediation was limited to the soils addressed by the Source Control OU. Surface soil at the Valley property was not found to be contaminated, but subsurface soil was found to be contaminated with VOCs, primarily TCE and methylene chloride, with lower concentrations of other chlorinated VOCs such as 1,1,1-trichloroethane, tetrachloroethene (PCE), and 1,2-trans-dichloroethene. TCE is the primary contaminant of concern (COC) in soil at the Valley property.

The highest levels of subsurface soil contamination were found in the southernmost portion of the Valley property within 10 ft of the solvent storage tank. Analysis of subsurface soil gas samples collected from an area under the Valley building prior to remediation detected total VOC concentrations as high as 1,300 parts per million (ppm), indicating that additional subsurface soil contamination was likely to be present under the portion of the building that was constructed in 1974.

As stated earlier, the baseline TCE soil concentrations sampled in 2009, prior to the ISTT remediation, are depicted on Figures 4-1 through 4-3 of the ERH Remedial Action Report (Nobis – September 20, 2011), which is provided in Attachment A. As depicted on these figures, the maximum TCE concentrations in soil were 20,000 µg/kg, 7,400 µg/kg and 8,700 µg/kg for the 0 to 11 ft, 11 to 26 ft, and 26 to 45 ft intervals below ground surface (bgs).

The recent ISTT remediation has eliminated the majority of soil contamination. A detailed discussion regarding the substantial concentration reductions provided by the recent ISTT remediation in the source area is presented in Section 4.1.

2.4.5 SEDIMENT AND SURFACE WATER CONTAMINATION

The Second Five-Year Review (EPA Region 1 – June 2010) states that the RIs determined that sediment and surface water contamination were low level and sporadic. Detections of VOCs in surface water were below Ambient Water Quality Criteria (AWQC) and the EPA determined that the low level of sporadic contamination in sediment presented minimal risk to human health and the environment.

3.0 DESCRIPTION OF PLANNED OR EXISTING REMEDIES

This section is based on information available from existing site documents. Interpretations included in this section are generally those presented in the documents from which the information was obtained. The optimization review team's interpretation of this information and evaluation of remedy components are presented in Sections 4.0 and 5.0.

3.1 REMEDY AND REMEDY COMPONENTS

This section describes the following remedy components:

- Former SVE system
- P&T system
- ISTT remediation in the source area

3.1.1 FORMER SVE SYSTEM

An SVE system in the source area was constructed and began operations in 1992. The SVE system was operated and maintained by Valley's contractor from approximately December 1992 through April 2002. Historical data for the SVE system indicated that only a nominal amount of TCE was removed and the system was minimally effective in reaching soil clean up goals throughout the site. Additionally, there was a pilot test of *in situ* chemical oxidation (ISCO) using potassium permanganate as part of a 2006 Source Area Re-evaluation, but ISCO was minimally effective due to the heterogeneity of the subsurface soils and the potential presence of NAPL. The previous SVE system and ISCO pilot tests are not a focus of this optimization evaluation, and are not discussed further.

3.1.2 P&T SYSTEM

The P&T system has consisted of a network of up to 10 extraction wells located as shown on Figure 2 of the Field Sampling Plan - QAPP (Nobis – February 2012), which is provided in Attachment A. Only 4 of the 10 extraction wells were operating at the time of the site visit:

- The three source area extraction wells (EW-S1 through EW-S3) were shut down for the ISTT remediation in the source area, and are planned to be re-started when groundwater temperature declines below 100 degrees F.
- Three of the extractions wells (EW-M2, G-1, and G-2) have been shut down due to low VOC concentrations.

The table below summarizes the design rate and typical extraction rates for each well.

Well	Design Extraction Rate (gallons per minute)	Typical Observed Extraction Rates (gallons per minute)
Source Area Wells		
EW-S1	2	3*
EW-S2	2	0.4*
EW-S3	2	0.5*
South of Mill Pond		
EW-S4	5	40
EW-S5	2	1
North of Mill Pond		
EW-M1	35	30
EW-M2	35	Off since August 2008
EW-M3	2	0.6
G-1	20	Off since 2002
G-2	20	Off since 2002

**Not operating at the time of the site visit. These wells had been turned off during the ISTT remediation of the source area and are scheduled to be re-activated once temperatures in groundwater decline to less than 100 degrees F.*

Double-walled underground pipelines with leak detection transport the extracted groundwater from the extraction wells to the Groundwater Treatment Facility (GWTF) for treatment. The GWTF is located behind the Valley building on property owned by the Archdiocese of Boston. All unit operations are contained in the same building, including:

- Pretreatment consisting of equalization, clarification and filtration to remove suspended solids (grit and precipitated metals, primarily iron). Hydrogen peroxide (2 ppm) is added into the 8,000 gallon equalization tank. There are two 3 horsepower (HP) pumps to move water from the equalization tank (one used at a time) to the incline plate clarifier. These pumps have variable frequency drives (VFDs) set to approximately 35% (33 Hz). Sludge is generated via an incline plane clarifier (no polymer addition needed), and moved to a thickener approximately once per week using one of two parallel double diaphragm sludge pumps. Sludge is disposed of off-site approximately once per 5 years as non-hazardous solid waste. Two 15 HP pumps (one used at a time) then move water through the sand filters, which consist of three US Filter multimedia filters arranged in parallel (each filter has a capacity of 75 gpm). These pumps have VFDs and operate at approximately 34 Hz. The sand filters are backwashed approximately once every 2 weeks with a cycle lasting approximately 20 minutes, so the backwash pump (one of two 20 HP pumps operating at approximately 43 Hz) is used very infrequently.
- After sand filtration, the water is treated to destroy VOCs via ultraviolet oxidation (UVOx) with hydrogen peroxide (6 ppm) as oxidant. The water passes from the sand filter to the UVOx system with no additional pump required. Only one of the four UVOx lamps (30 kW) operates at a time (lasts approximately 3,000 hours).
- Catalytic activated carbon adsorption is used for destruction of residual hydrogen peroxide, to prevent effluent toxicity. The catalytic carbon unit contains 3,000 pounds of carbon and is rated for approximately 150 gpm.

- Process water from the catalytic carbon unit flows to a 5,600 gallon effluent tank, followed by discharged via gravity through an underground pipeline that emerges at an outfall constructed on the western shore of Mill Pond.
- Vapor phase carbon adsorption is used for treating off-gases from various tanks. Two 1,000 pound vapor phase GAC units are aligned in series to treat VOC-laden air from the head space of the influent, filter feed and decant tanks as well as the clarifier.

Total hydrogen peroxide use (for influent and UVOx) is approximately 2 gallons per day of a 20 percent solution.

3.1.3 ISTT REMEDIATION IN THE SOURCE AREA

The goal of the ISTT was to reduce the contaminant concentrations in source area soils and overburden groundwater to below their respective cleanup goals. An alternative performance endpoint was to terminate before attainment of the cleanup goals if the contaminant removal rate diminished to the point where continued operation of the ISTT system was not cost effective, i.e., the point of diminishing returns. Performance objectives were to achieve (1) a minimum temperature in the vadose zone (0-25 ft) of 90 degrees C and (2) a minimum temperature in the saturated zone (25-45 ft) of approximately 100 degrees C. Performance metrics included (1) 85percent of the temperature sensors in the vadose zone reach 90 degrees C, (2) 85 percent of the temperature sensors in the saturated zone reach about 100 degrees C, and (3) 100 percent of all temperature sensors reach 60 degrees C.

Nobis contracted TerraTherm, Inc. to design, construct, and operate the ISTT system, which consisted of four areas with treatment depths ranging from 10 to 45 ft. The total treatment zone was approximately 14,830 square ft with a volume of 17,450 cubic yards (see Figure 3-1 of the ERH Remedial Action Report, which is provided in Attachment A. The ISTT system included 40 standard electrode wells, 24 mini-electrode wells, 29 shallow SVE wells, 15 multi-phase extraction wells, 16 temperature sensor wells and 12 temperature, pressure and vacuum sensor wells. In total, 143 electrodes were installed.

Construction of the ISTT Source Control remedy began in April 2009, with site clearing and a geophysical survey of the treatment area. In July and August of 2009, site preparation continued with the abandonment of all polyvinyl chloride (PVC) monitoring wells and replacement of a subset of the original wells with stainless steel monitoring wells that would be used for baseline and confirmation monitoring of groundwater. Baseline sampling of Source Area soil and groundwater was also performed in summer 2009 to assist in ISTT design and establish baseline conditions. In March 2010, construction of the ISTT system was initiated. Startup of the vapor and liquid extraction systems was on August 9, 2010 and the ISTT system was commissioned on August 17, 2010. The ISTT extraction system was shut down on February 24, 2011. From August 9, 2010 to February 24, 2011 (192 days of operation), the total volume of liquid removed by ISTT was 2,244,363 gallons. The total amount of energy used during ISTT operations was approximately 3,639,520 kilowatt hours (kWh).

3.2 RAOs AND STANDARDS

This section provides a summary of remedial action objectives (RAOs) for groundwater, cleanup standards for groundwater and soil and treatment standards for the GWTF.

3.2.1 REMEDIAL ACTION OBJECTIVES FOR GROUNDWATER

The Second Five-Year Review (EPA Region 1 – 2010) summarizes the RAOs for Source Control OU2 as follows:

- Prevent ingestion of groundwater contaminated in excess of relevant and appropriate drinking water standards or, in their absence, an excess cancer risk level of 10^{-6} , for each carcinogenic compound. Also, to prevent ingestion of groundwater contaminated in excess of a total excess cancer risk level for all carcinogenic compounds of 10^{-4} to 10^{-7} ;
- Prevent ingestion of groundwater contaminated in excess of relevant and appropriate drinking water standards for each non-carcinogenic compound and a total hazard index greater than unity for all non-carcinogenic compounds;
- Prevent migration of contaminants in soils and groundwater that would result in groundwater contamination in excess of relevant and appropriate drinking water standards and surface water contamination in excess of relevant and appropriate AWQC for the protection of aquatic life; and
- Remediate inorganic contamination to the extent that such remediation is incidental to organics remediation and to evaluate attainment of the applicable or relevant and appropriate requirements (ARARs) of federal and state environmental regulations.

The Second Five-Year Review (EPA Region 1 – 2010) summarizes the RAOs for MOM OU1 as follows:

- To prevent ingestion of groundwater contamination in excess of relevant and appropriate drinking water standards or, in their absence, an excess cancer risk level of 10^{-6} for each carcinogenic compound. Also, to prevent ingestion of groundwater contaminated in excess of a total excess cancer risk level for all carcinogenic compounds of 10^{-4} to 10^{-6} .
- To prevent ingestion of groundwater contaminated in excess of relevant and appropriate drinking water standards for each non-carcinogenic compound and a total hazard index greater than unity for non-carcinogenic compounds having the same target endpoint of toxicity.
- To restore the groundwater aquifer to relevant and appropriate drinking water standards or, in their absence, the more stringent of an excess cancer risk of 10^{-6} for each carcinogenic compound or a hazard quotient of unity for each non-carcinogenic compound. Also, restore the aquifer to the more stringent of (1) a total cumulative excess cancer risk of 10^{-4} to 10^{-6} and/or (2) a total cumulative hazard index not to exceed an acceptable range for noncarcinogenic compounds having the same target endpoint of toxicity.

3.2.2 CLEANUP STANDARDS FOR GROUNDWATER AND SOIL

The current standards for groundwater contaminants of potential concern that were listed in the MOM OU ROD are listed in the table below, which is based on Attachment 3 –Table 1 of the Second Five-Year Review (EPA Region 1 – 2010).

Contaminants of Potential Concern Listed in the MOM OU ROD	Federal Safe Drinking Water Act (SDWA) Standards		Massachusetts Drinking Water Standards (mg/L)	Massachusetts Drinking Water Guidelines (mg/L)	RCRA MCL (mg/L)
	MCL (mg/L)	MCLG (mg/L)			
Organic Compounds					
Acetone	--	--	--	6.3	--
Benzene	0.005	0	0.005	--	--
Chlorobenzene	0.1	0.1	0.1	--	--
1,1-Dichloroethane	--	--	--	0.07	
1,2-Dichloroethane	0.005	0	0.005	--	--
1,1-Dichloroethene	0.007	0.007	0.007	--	--
cis-1,2-Dichloroethene	0.07	0.07	0.07	--	
trans-1,2-Dichloroethene	0.1	0.1	0.1	--	
Methylene chloride	0.005	0	0.005	--	--
Tetrachloroethene	0.005	0	0.005	--	--
Toluene	1	1	1	--	--
1,1,1-Trichloroethane	0.2	0.2	0.2	--	
Trichloroethene	0.005	0	0.005	--	--
Vinyl chloride	0.002	0	0.002	--	--
Inorganic Compounds					
Arsenic	0.01	0	0.01	--	0.05
Barium	2	2	2	--	
Beryllium	0.004	0.004	0.004	--	
Cadmium	0.005	0.005	0.005	--	0.01
Chromium (total)	0.1	0.1	0.1	--	0.05
Mercury (inorganic)	0.002	0.002	0.002	--	0.002
Selenium	0.05	0.05	0.05	--	
Silver	0.1	0.1	0.1	--	
Vanadium	--	--	--	--	
Other Analytes Detected in Groundwater					
Antimony	0.006	0.006	0.006	--	--
Lead	TT*	0	TT*	--	0.05
Nickel	--	--	--	0.1	--

* TT: Treatment technique. Lead and copper are regulated by a treatment technique that requires systems to control the corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps. The action level for copper is 1.3 milligrams per liter (mg/L) and for lead is 0.015 mg/L.

MCLG = maximum contaminant level goal

RCRA = Resource Conservation and Recovery Act

A summary of groundwater cleanup levels for VOCs is provided in Table 2 of the recent Field Sampling Plan – QAPP (Nobis – 2012) as follows:

Compound	Groundwater Cleanup Level (µg/L)
Trichloroethene	5
1,1-Dichloroethene	7
Trans-1,2-Dichloroethene	100
Cis-1,2-Dichloroethene	70
Methylene Chloride	5
Tetrachloroethene	5
1,1,1-Trichloroethane	200
Toluene	1,000
Vinyl Chloride	2

As summarized in Table 2 of the recent Field Sampling Plan – QAPP (Nobis, 2012); µg/L – micrograms/liter.

The Second Five-Year Review (EPA Region 1 – 2010) provides the following discussion regarding cleanup standards for subsurface soil in the source area:

“Soil cleanup levels were developed in the Source Control ROD to be protective of the potential leaching of organic compounds to groundwater based on 1988 default soil/water equilibrium partitioning assumptions. The 2005 Five-Year Review determined that the ROD soil cleanup levels were overly protective of both direct contact and leaching to groundwater using a comparison to Region 9 residential PRGs (EPA, 2004b) and to generic Soil Screening Levels (EPA, 2002b) protective of contaminant migration to groundwater (using the EPA recommended dilution attenuation factor of 20). Therefore, a re-evaluation of the soil cleanup levels was recommended. The 2007 ESD established new soil clean-up goals based on recalculation using site-specific soil characteristics. The new levels were also developed based on the following guidance: Soil Screening Guidance: User's Guide, April 1996, OSWER Directive 9355.4-23 and the Supplemental Guidance for Developing Soil Screening Levels for Superfund sites, August 2001, OSWER Directive 9355.4-24. These recalculated site-specific soil clean up levels are protective of groundwater (MCLs), direct contact exposures (i.e., the incidental ingestion, dermal contact and inhalation of dust released from the soil), and for the subsurface vapor intrusion pathway (i.e., the inhalation of contaminated air).”

The table below summarizes the cleanup standards for soil as per the 2007 ESD.

Compound	2007 ESD Cleanup Level for Soil (µg/kg)
Trichloroethene	77
Vinyl Chloride	11
Methylene Chloride	22
Tetrachloroethene	56
1,1-Dichloroethene	45
Trans-1,2-Dichloroethene	626
Toluene	22,753
1,1,1-Trichloroethane	1,388
Cis-1,2-Dichloroethene	418

Summarized from Second Five-Year Review, which references the 2007 Explanation of Significant Differences (ESD); ug/kg = microgram/kilogram.

3.2.3 STANDARDS FOR TREATMENT PLANT

Effluent from the GWTF discharged to Mill Pond is expected to meet “Average Monthly Surface Water/Mill Pond Discharge Limits (µg/L).” The effluent discharge limits in the following table were included in spreadsheets provided to the optimization review team. The specific source of these limits is not identified, but it is the understanding of the optimization review team that these limits were calculated by the EPA based on assumptions of turnover in Mill Pond.

Parameter	Daily Maximum Discharge Limit	Average Monthly Discharge Limit
	(µg/L)	(µg/L)
<u>Volatile Organic Compounds</u>		
Vinyl Chloride	Not Listed	2,816
1,1-Dichloroethene	Not Listed	17.2
Acetone	Not Listed	Not Listed
2-Butanone	Not Listed	Not Listed
Methylene Chloride	Not Listed	8,600
1,2-Dichloroethene (total)	Not Listed	172
1,1-Dichloroethene	Not Listed	Not Listed
1,1,1-Trichloroethane	Not Listed	500
Benzene	Not Listed	381
Trichloroethene	Not Listed	434
Toluene	Not Listed	2,500
Carbon Tetrachloride	Not Listed	Not Listed
1,1,2-Trichloroethane	Not Listed	Not Listed
Tetrachloroethene	Not Listed	47.7
Chlorobenzene	Not Listed	112,600
<u>Metals</u>		
Silver	0.9	Not Listed
Arsenic	Not Listed	0.75
Barium	Not Listed	5,400
Beryllium	Not Listed	10
Cadmium	2.3	2.0
Chromium (total)	41	27
Iron	Not Listed	Not Listed
Mercury	Not Listed	0.273
Manganese	Not Listed	Not Listed
Nickel	355	39
Lead	34	1.3
Antimony	Not Listed	23,000
Selenium	Not Listed	12
Vanadium	Not Listed	Not Listed
Zinc	Not Listed	Not Listed

ug/kg = microgram/kilogram; ug/L = microgram/liter.

Of particular note is the low average monthly discharge limit for arsenic of 0.75 µg/L. Arsenic is not currently considered a COC at the site; rather it is a natural constituent of site soil and ground water. However, because it is present in GWTF influent above the discharge limit of 0.75 µg/L (influent concentration for arsenic is typically on the order of < 5 µg/L to > 20 µg/L depending on which extraction wells are operating) the water must be treated for arsenic prior to discharging it to Mill Pond. It is likely that no treatment for arsenic would be otherwise be required (i.e., if TCE remediation was considered complete or if treated water was recharged to groundwater).

The optimization review team did not notice specific discharge standards for vapors from the vapor GAC units referenced in site documents. The site team indicated after the site visit that the discharge "standard" is the MassDEP Policy "Off-Gas Treatment of Point-Source Remedial Air Emissions", and that the discharge from the vapor GAC units was modeled and met the 95 percent reduction requirement.

3.3 PERFORMANCE MONITORING PROGRAMS

This section discussed routine sampling conducted as part of the remedy. Non-routine sampling, such as the soil sampling associated with the ISTT remedy in the source area, is not discussed in this section.

Groundwater Monitoring Wells

The Field Sampling Plan – QAPP (Nobis – February 2012) indicates that long-term groundwater monitoring events have been routinely conducted in the spring and fall on a semi-annual basis since 1998. Typically, the sampling events have consisted of a smaller spring event (high water table) and a comprehensive fall event (lower water table). The document states that VOC concentrations have historically been higher during the fall, such that comprehensive monitoring events are most appropriately conducted in the fall.

According to Table 3 of the Field Sampling Plan – QAPP (Nobis – February 2012), future groundwater monitoring is anticipated to include the following number of wells:

- Fall events
 - 13 wells in the downgradient plume area (two shallow overburden, six overburden, five bedrock)
 - 16 wells in the source area (11 overburden, five bedrock)
- Spring Events
 - 10 wells in the downgradient plume area (two shallow overburden, four overburden, four bedrock)
 - 12 wells in the source area (eight overburden, four bedrock)

There are also quality assurance/quality control (QA/QC) samples (blanks/duplicates). Water level events are conducted semiannually, and include wells across the site as well as from monitoring points at the north and south ends of Mill Pond.

Many of the source area wells that were historically sampled for groundwater LTM were removed prior to the OU2 ISTT remedial action because they were constructed of PVC and would have been damaged during ISTT operations. Those historical source area wells have been replaced with 13 new stainless steel monitoring wells that will be sampled in the future. This recent sampling plan has eliminated the following monitoring wells in the downgradient plume area from the monitoring program due to a long period of non-detect or very low concentrations of TCE and cis-1,2-DCE during historical sampling events:

- Overburden wells ERT-11, ERT-13, ERT-16 and ME-10D
- Bedrock wells DEQE-13D, 109 and NUS-4A

Wells are generally sampled with passive diffusion bag (PDB) technology. The PDBs are allowed to equilibrate with the aquifer for approximately 21 days prior to retrieval for analysis. Three of the new source area wells will initially be sampled with low-flow techniques until the temperature declines from the ISTT remediation (but are expected to be sampled with PDBs in the future). Analysis is for VOCs using EPA Method 8260B. The first time PDBs are used to sample a monitoring well, several PDBs are deployed spanning the well screen. Four samplers are used in wells with 10 ft screens; eight samplers where screens are 20 ft. Data from the initial event are evaluated to determine the sampling depth for future sampling events.

Groundwater Extraction Wells

Nine of the extraction wells are sampled quarterly, as part of the GWTF operations and maintenance (O&M) activities (well G-1 was eliminated from the sampling program in 2002), with analysis for VOCs and metals.

GWTF

The influent and effluent from the GWTF are monitored on a monthly basis for VOCs and metals to confirm that effluent discharge limits are not exceeded and to observe contaminant removal efficiencies. An in-line VOC analyzer for groundwater effluent was removed in early 2011 (such units are typically difficult to maintain and provide limited benefit).

Since the effluent from the GWTF is discharged to surface water, it is tested for acute and chronic toxicity on a quarterly basis. Toxicity testing includes 48-hour whole effluent screening tests with *Ceriodaphnia dubia* and juvenile fathead minnow (*Pimephales promelas*). The survival of both test species is measured during the test, as well as the growth of the fathead minnow and the reproduction of *Ceriodaphnia*.

VOC concentrations at three points along the vapor GAC units (influent, between the two units, and effluent) are measured quarterly. The optimization review team assumes these measurements are conducted with a photoionization detector (PID).

Surface Water

No surface water sampling is currently conducted. Surface water samples were previously collected from Mill Pond in the spring of 2000, prior to GWTF startup, and again during the spring of 2001, 2002, and 2003. Samples were analyzed for VOCs and metals. The purpose of the sampling was to monitor the impact of the GWTF discharge on Mill Pond. Results showed no significant difference in the level of contaminants or change in water quality in Mill Pond following startup of the GWTF or after 3 years of operation. Surface water sampling was discontinued in 2004 because the treatment plant discharge had no adverse effects during the first 3 years of operation.

4.0 CONCEPTUAL SITE MODEL

This section discusses the optimization review team's interpretation of existing characterization and remedy operation data and site visit observations to explain how historic events and site characteristics have led to current conditions. This CSM may differ from that described in other site documents. CSM elements discussed are based on data obtained from EPA Region 1 and discussed in the preceding sections of this report. This section is intended to include interpretation of the CSM only. It is not intended to provide findings related to remedy performance or recommendations for improvement. Review findings and recommendations are provided in Sections 5.0 and 6.0, respectively.

4.1 CSM OVERVIEW

The Valley property is located on the shoulder of a local topographic and bedrock high that is overlain by approximately 40 ft of unconsolidated overburden sediments, approximately 30 ft of which is unsaturated and 10 ft of which is saturated. TCE releases at the Valley property caused soil and groundwater concentrations indicative of the presence of NAPL in unsaturated zone and the thin saturated overburden on the southeastern portion of the Valley property. Due to the relatively thin saturated zone of contamination in the source area and mixing with regional groundwater flow, concentrations of TCE in groundwater approximately 500 ft downgradient of the source area were approximately a half order of magnitude lower (6,600 µg/L at EW-S5 compared to 40,000 µg/L at EW-S2) prior to any P&T operation.

During approximately 10 years of P&T operation, the TCE concentrations in the source area P&T wells (EW-S1 through EW-S3) remained high, suggesting a continuing source of groundwater contamination. By contrast, TCE concentrations at the next set of downgradient wells (EW-S4 and EW-S5) decreased by a factor of approximately 30 within 2 years, indicating a significant degree of capture provided by the source area P&T wells. Due to a relatively steep hydraulic gradient (approximately 0.06 ft per ft) between the source area and EW-S4/EW-S5, and a high hydraulic conductivity (a value of approximately 50 ft per day is representative based on values provided in RI reports), the groundwater flow velocity is relatively fast, and TCE concentrations in this area change relatively quickly as a result of remedial activities. Despite historic TCE concentrations initially as high as 6,600 µg/L in EW-S5 prior to pumping, TCE concentrations decreased below the MCL permanently after approximately 8 years of operation. TCE concentrations in EW-S4 also decreased substantially, but never declined below the MCL, indicating the source area wells provided a high degree of source control but not full source control. Monitoring data for the wells downgradient of EW-S4 and EW-S5 suggest that EW-S4 and EW-S5 (and the upgradient source area extraction wells) have provided sufficient plume capture to allow downgradient areas to achieve the MCL for TCE. Extraction wells downgradient of EW-S4 and EW-S5 have contributed to capturing the portion of the plume that had migrated past EW-S4 and EW-S5 prior to P&T system operation.

The recent ISTT remedy in the source area removed the majority of mass and has reduced TCE concentrations in soil and groundwater near the source area accordingly. However, the confirmation soil sample analyses from CSB-10 (5,600 µg/kg of TCE between 23 and 25 ft bgs) and CSB-13 (7,000 µg/kg of TCE between 3 to 5 ft bgs) are nearly 2 orders of magnitude higher than the site-specific soil cleanup standard of 77 µg/kg for TCE, and suggest that contamination is still present in vadose zone soil and has the potential to result in TCE groundwater contamination orders of magnitude above MCLs. The August 2011 TCE concentration of 78 µg/L in groundwater from well RW-05 (the latest round of sampling at that location available to the optimization review team), which is located very close to well CSB-10, further suggests the potential that a source of groundwater contamination remains in this area. It is unclear,

however, if these observed soil and groundwater concentrations are isolated and of insufficient mass to serve as the source for an extensive TCE plume above MCLs, or if they merit further attention. Resuming operation of EW-S1, EW-S2, and EW-S3 and sampling them while they operate should provide a representative concentration of TCE in the source area. Based on the TCE concentration at well TW-31 (located just downgradient of the three source area P&T extraction well locations) sampled following the ISTT remedy, it appears that a limited amount of TCE may have escaped the ISTT zone during remediation. A minor temporary increase in the TCE concentration at EW-S4 (further downgradient from TW-31) might be expected over the next several months. Plume maps from the ERH Remedial Action Report (Nobis – September 20, 2011) depicting soil and groundwater TCE contamination from the baseline (2009) event and three events subsequent to the ISTT remedy are provided in Attachment A.

Concentrations of cis-1,2-DCE in groundwater are generally more than two orders of magnitude lower than the TCE concentrations, suggesting limited or no TCE degradation. Sampling for 1,4-dioxane was conducted at the site in 2003; 1,4-dioxane was not detected at a detection limit of 1.0 µg/L.

Site hydrogeology and water quality data suggest to the optimization review team that very little of the water extracted by the Town well comes from the site, and that the majority of the water extracted by the well in the stratified drift dilutes the contaminated water such that the blended concentration of TCE is not detectable. For example, TCE concentrations as high as 45,000 ug/L were detected in 1984 at the north end of Mill Pond and concentrations in the Town wells were as high as 118 ug/L, suggesting an approximate dilution factor of almost 400. As concentrations at the north end of Mill Pond decreased due to remedy operation, TCE concentrations at the Town well decreased below detection limits and TCE concentrations in most monitoring wells decreased to below the MCL. In the nine sampling events from September 2007 through Fall 2011, the maximum detected TCE concentration north of Mill Pond has been below 10 ug/L; and below the MCL in four of the nine sampling events. Additionally, TCE concentrations at EW-S4 (south of Mill Pond) are also in the range of 10 ug/L or less except for a potential upcoming pulse of dissolved contamination associated with migration when EW-S1 through EW-S3 were not operating during the ISTT remedy. Using an approximate TCE concentration of 10 ug/L in the vicinity of Mill Pond, the approximate dilution factor of 400 and a reasonable factor of safety, the optimization review team would expect TCE to remain below detection limits in groundwater samples collected from the Town well.

Based on these observations, the optimization review team suggests that the focus of site remediation be on the remaining TCE contamination in the source area and between the source area and EW-S4.

4.2 CSM DETAILS AND EXPLANATION

This section provides and additional details and further explanation of key CSM-related review observations.

4.2.1 POTENTIAL IMPACT OF SOIL CONTAMINATION ON GROUNDWATER

The partitioning coefficient (K_d) governs the equilibrium concentration between soil and groundwater that are in direct contact, as follows:

$$\text{Concentration in Soil (mg/kg)} = K_d (L/kg) \times \text{Concentration in Groundwater (mg/L)}$$

The partitioning coefficient is the product of the organic carbon partitioning coefficient (K_{oc}) and the fraction of organic carbon in the soil (f_{oc}) (i.e., $K_d = K_{oc} \times f_{oc}$). According to the EPA Soil Screening Guidance (www.epa.gov/superfund/health/conmedia/soil/), the K_{oc} for TCE is approximately 100 liters per milligram (L/mg). The f_{oc} is not known, but might be between 0.001 and 0.003. K_d is therefore approximately 1 liter per kilogram (L/kg) to 3 L/kg. Therefore, for remaining TCE soil concentration of 7,000 $\mu\text{g/kg}$ (7 mg/kg) at CSB-13, TCE concentrations for groundwater in direct contact with that soil could be as high as 23 mg/L to 70 mg/L. This is not the concentration that would be expected in groundwater underlying the contaminated unsaturated soil because some degree of attenuation or dilution would be expected. However, it becomes evident that groundwater that comes in contact with this soil or infiltrating water that passes through this soil could result in TCE groundwater concentrations well above the MCL.

4.2.2 DATA GAPS

The primary data gaps are the extent, magnitude and distribution of contamination remaining in the source area and the potential for that TCE to migrate downgradient and ultimately impact groundwater at concentrations above the MCL, including groundwater in bedrock in, and immediately downgradient of, the source area. Wells RW-07B and RW-10B were installed in bedrock in the source area but not in the vicinity of the highest source area concentrations. Remedy extraction wells EW-S1 through EW-S3 extract from both the overburden and bedrock, and EW-S4 extracts groundwater from the bedrock approximately 500 ft downgradient of the source area. Because the ISTT remedy significantly reduced the level of contamination in the overburden (but did not directly address bedrock), continued sampling of the bedrock wells will indicate if high levels of contamination are present in groundwater in the source area bedrock. Sampling to date of the source area monitoring and extraction wells subsequent to the ISTT remedy suggests that TCE is present in bedrock groundwater at concentrations above MCLs between the source area and EW-S4, but not at concentrations that would merit further investigation or targeted remediation of bedrock. Sampling during continued extraction well operation will provide more information about the nature of contamination in this area.

4.3 IMPLICATIONS FOR REMEDIAL STRATEGY

Despite the success of the ISTT remediation with respect to TCE concentration reductions in both soil and groundwater in the source area, soil analytical results from confirmation soil borings (CSB-10 and CSB-13) indicate that some residual contamination remains in the unsaturated overburden. Given this finding, additional source area remediation efforts (if any) would need to target portions of the unsaturated zone and possibly portions of the saturated zone. Continued source area P&T efforts would not speed progress to restoring groundwater in the source area below MCLs. It would, however, help control groundwater impacts that would otherwise migrate from the source area.

Data from continued groundwater monitoring in and downgradient of the source area may or may not suggest that the remaining source area contamination merits additional remediation or continued extraction. Clear criteria should be developed for discontinuing operation of individual extraction wells to prevent operation of a system after it is no longer providing a meaningful benefit for plume control or aquifer restoration.

5.0 FINDINGS

This section presents the observations and interpretations of the optimization review team. These are not intended to imply a deficiency in the work of the system designers, system operators or site managers, but rather are offered as constructive suggestions in the best interest of the EPA and the public. These observations have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of groundwater remediation have changed over time.

5.1 SOURCES

Please refer to Section 4.1 for a discussion regarding the remaining source of contamination and associated data gaps.

5.2 GROUNDWATER

5.2.1 PLUME DELINEATION

The area of the TCE plume with concentrations currently exceeding the MCL is primarily located at and upgradient of EW-S4, including the source area. Other areas historically impacted by the TCE plume now have TCE concentrations below the MCL. Plume maps illustrating recent TCE concentrations in groundwater, in both the overburden and the bedrock, are discussed in Section 2.4.3. Although TCE was present above over 100 µg/L downgradient of Mill Pond as recently as 2001, TCE has not been detected in the Town wells since 1989, indicating that the TCE present in groundwater extracted by the Town wells is significantly diluted by the high rate of groundwater extraction from the stratified drift.

5.2.2 PLUME CAPTURE

Please refer to Section 4.0 for a discussion regarding plume capture.

5.2.3 GROUNDWATER CONTAMINANT CONCENTRATIONS

Please refer to Sections 2.4.3 and 4.1 for a discussion regarding groundwater contamination concentrations.

5.3 SEDIMENT

Sediment is not a primary media of concern at this site.

5.4 TREATMENT SYSTEM COMPONENT PERFORMANCE

5.4.1 P&T SYSTEM

The P&T system has continued to perform as designed for the past 10 years and has been successful at reducing the extent of the TCE plume, such that the area where TCE in groundwater exceeds MCLs is limited to the source area and the area immediately downgradient of the source area. Given the remedial progress made at the site (particularly resulting from the ISTT remediation in the source area), it is

unlikely that the treatment system will continue to operate in its current form for more than 1 or 2 years. If longer term operation of the system is expected, the optimization review team would suggest significant modifications to the P&T system. Therefore, further discussion of individual components of the current system is not included herein. Potential options for a future P&T system, if needed, are discussed in Section 6.4.2.

5.4.2 ISTT

About 80 percent of the vadose zone temperature sensors and about 50 percent of the saturated zone temperature sensors achieved the target performance temperature goals, but 100 percent of the sensor locations exceeded the minimum temperature goal of 60 degrees C. Consequently, performance objectives were partially met. In general, temperatures within two of the ISTT areas (C and D) remained below the target temperature until the system was modified with the introduction of steam-enhanced heating in December 2010.

Confirmation soil sampling was performed in April 2011 and confirmation groundwater sampling was performed in March, May and August 2011. Based on the results of these sampling events, the following conclusions may be made: (1) considerable contaminant mass and concentration reduction was achieved and (2) isolated areas of elevated TCE concentrations remain in the vadose zone. TCE concentrations in groundwater remain above the MCL at 8 of 16 monitored locations measured in the last round of confirmation sampling, with a maximum concentration of 78 µg/L at well RW-5. Additional sampling is likely needed to evaluate the full extent of contaminant rebound given the potentially increasing TCE concentration trend at RW-05.

5.5 REGULATORY COMPLIANCE

No significant regulatory compliance issues were identified during the optimization review. The Second Five-Year Review (EPA Region 1 – 2010) states that a small amount of contaminated groundwater by-passing the source area extraction wells does not affect the protectiveness of the remedy because the groundwater in the area is not being used for household or potable purposes and is not adversely affecting environmental receptors. With respect to effluent from the P&T system, the Second Five-Year Review (EPA Region 1 – 2010) states that there have been minor exceedences of the metals surface water discharge limits in a small fraction of GWTF effluent samples (five arsenic, five lead, and two mercury exceedences in 169 samples), but toxicity testing showed no adverse effects on the ecological receptors.

5.6 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF ANNUAL COSTS

The site team provided approximate O&M costs for a period from late 2011 to early 2012. The table below summarizes these O&M costs pro-rated for an annual period, which sum to approximately \$345,600 per year.

Cost Category	Estimated Annual Cost
Project Management	\$46,500
O&M Labor	\$122,000
Materials	\$1,600
Process Analytical	\$45,000
Groundwater Sampling and Analysis	\$40,000
Other Routine Costs	\$3,800
Non-Routine Costs	\$10,800
Utilities – Electric	\$75,000
Utilities – Gas	\$900
Total Costs	\$345,600

The electric utilities cost is estimated is based on approximate annual electrical usage of 500,000 kWh and an assumed electricity rate of approximately \$0.15 per kWh. The gas utilities cost is estimated based on approximate gas usage of 600 therms (building heat) and an assumed cost of approximately \$1.50 per therm.

These estimated annual O&M costs (less than \$350,000 per year) are substantially lower than costs reported in the Second Five-Year Review (EPA Region 1 – 2010), which pertain to the period when the site was operated by the EPA. In the 5-year period from 2005 to 2009, the annual O&M costs ranged from \$717,000 to \$854,000.

5.7 APPROXIMATE ENVIRONMENTAL FOOTPRINT ASSOCIATED WITH REMEDY

The following subsections describe the environmental footprint of the site remedies, considering the five core elements of green remediation defined by the EPA (www.cluin.org/greenremediation).

5.7.1 ENERGY, AIR EMISSIONS AND GREENHOUSE GASES

The energy and air emissions footprints for the P&T remedy are dominated by the electricity usage for the P&T remedy. Approximately 500,000 kWh of electricity is used per year, and more than 50 percent of that use is the one 30kW UV lamp that continues to operate. Another 15 to 20 percent is for pumping water from extraction wells or through the treatment plant. The remainder of the electricity usage is likely associated with building lighting and ventilation and miscellaneous loads. Based on parameters provided in the EPA document *Methodology for Understanding and Reducing a Project's Environmental Footprint* (February 2012), the optimization review team estimates that the hydrogen peroxide, GAC use, waste disposal, personnel transportation and materials transportation each likely contribute less than 1 percent of the energy footprint and, therefore, are also likely small contributors to the air emissions footprints. The natural gas used for heating the building likely contributes slightly more than 1percent to the energy footprint. In the future, efforts to reduce footprints for this core element would focus on reducing electricity use.

For comparison, the ISTT remedy used over 3.6 million kWh of electricity, representing the equivalent of approximately 7 years of P&T operation.

5.7.2 WATER RESOURCES

The primary use of water associated with the remedy is the extraction, treatment and discharge of impacted groundwater to Mill Pond. The extraction and discharge of groundwater does not likely significantly alter the water resources in the area given that the extracted groundwater would likely have discharged to the stream/pond system under natural conditions.

5.7.3 MATERIALS USAGE AND WASTE DISPOSAL

The primary materials usage is hydrogen peroxide and catalytic carbon materials use. Specific quantities were not discussed but are anticipated to represent less than 5,000 pounds of refined materials per year. Note that for this calculation, the water portion of the 20 percent hydrogen peroxide solution is not included.

Waste disposal is primarily limited to iron sludge from the metals removal system. Disposal of approximately 10 cubic yards of solids is required approximately once every 5 years.

5.7.4 LAND AND ECOSYSTEMS

The operating groundwater remedy does not disturb land and ecosystems. The space occupied by the treatment plants may eventually be redeveloped and returned to beneficial use once the remedy is complete.

5.8 SAFETY RECORD

The site team did not report any safety concerns or incidents.

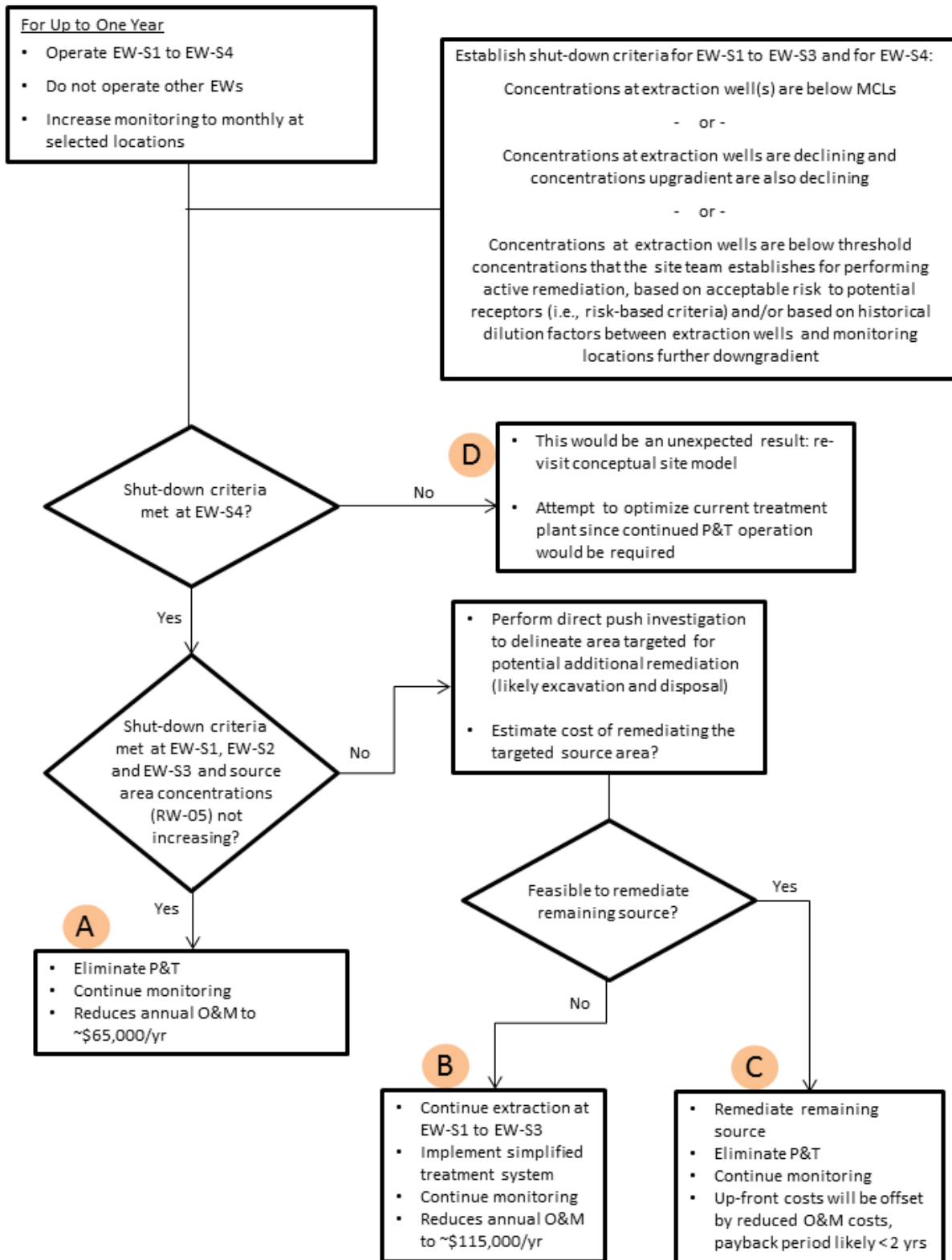
6.0 RECOMMENDATIONS

Several recommendations are provided in this section related to remedy effectiveness, cost control, technical improvement and site closure strategy. Note that while the recommendations provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans and QAPPs.

Cost estimates provided herein have levels of certainty comparable to those typically prepared for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) FS reports (-30% / +50%), and these cost estimates have been prepared in a manner generally consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July, 2000. The costs presented do not include potential costs associated with community or public relations activities that may be conducted prior to field activities. The costs of these recommendations are summarized in Tables 6-1. Table 6-2 summarizes potential effects of the recommendations on the environmental footprint of the remedy.

The recommendations described below are inter-related, and an overall decision framework in the form of a flowchart is illustrated on Figure 6-1 to illustrate those interrelationships. The flowchart begins with a limited period of P&T operation that includes operation of extraction wells EW-S1 through EW-S3 plus EW-4 (see Section 6.1.1), and potential outcomes are identified as “A” through “D” on Figure 6-1. An alternative approach that does not include operation of extraction wells EW-S1 through EW-S3, and a discussion of the advantages and disadvantages of that alternative approach, is presented in Section 6.1.2.

Figure 6-1. Flow Chart Illustrating Suggested Decision Framework



6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

6.1.1 CONTINUE P&T OPERATION (EW-S1 TO EW-S4), WITH MONTHLY MONITORING OF SELECT WELLS, FOR UP TO ONE YEAR

The optimization review team recommends continued operation of specific extraction wells (EW-S1 through EW-S4) and treatment with the existing system for up to 1 year while the system extracts limited contaminant mass that may have migrated from the source area during the ISTT remedy and while the site team establishes shutdown criteria for EW-S1 through EW-S4 (see Section 6.4.1). Currently EW-S4 is operating and EW-S1 through EW-S3 will be re-started in the near future now that groundwater temperatures have mostly recovered from the ISTT remediation. Operation of the other extraction wells is not recommended. Extraction wells EW-M2, G1, and G2 have already been turned off, and TCE concentrations at EW-S5, EW-M1, and EW-M3 are sufficiently low that pumping is providing no meaningful mass removal or plume control.

The optimization review team recommends more frequent (i.e., monthly) sampling of select wells in and downgradient of the source area, for up to 1 year, to improve the understanding of site conditions between the source area and EW-S4 following the ISTT remedy. The relatively fast groundwater flow velocity between the source area and EW-S4 and the relatively short distance between the source area and EW-S4 suggests that meaningful changes in contaminant concentrations can occur on a monthly basis. The optimization review team recommends monthly monitoring of the following wells for VOCs on an interim basis (up to 1 year):

- RW-05
- EW-S1
- EW-S2
- EW-S3
- TW-31
- TW-12
- TW-24
- EW-S4
- EW-S5

P&T operation is currently planned, so the recommended P&T operation for up to 1 year would not impact currently estimated costs for the next year. The more frequent monitoring that is recommended will add cost of approximately \$20,000, including deployment of the PDBs, laboratory analysis of field and QA samples and data management. However, this recommendation is intended to provide data that will shorten the time frame for active remediation and ultimately result in net cost savings, as described below (see Section 6.2). The additional cost for increased monitoring frequency will be smaller if meaningful trends are observed in less than 12 months.

Although sampling the selected wells on a monthly basis for 1 year is more expensive than sampling them quarterly (for extraction wells) or semi-annually (for monitoring wells) for 1 year as currently planned, the optimization review team believes that meaningful trends will become apparent in this area over the course of months under monthly sampling, whereas it might take several years to discern the trends with the current quarterly and semi-annual sampling. Given that these trends will be critical in determining a remedial path forward and may play a significant role in permanently discontinuing P&T operation (a key objective in the site exit strategy), the optimization review team believes that the additional cost is merited.

The interim monthly sampling should continue for 1 year or less if meaningful trends are identified and can be used for decision making. If meaningful trends are not established after 1 year of monthly sampling, then the current monitoring frequency of quarterly for extraction wells and semi-annually for monitoring wells should resume. Section 6.4 discusses how the data from this monitoring can be used to make decisions regarding the remedy that will improve the opportunities for eliminating active remediation in the long-term.

6.1.2 ALTERNATIVE APPROACH – DO NOT OPERATE EW-S1 TO EW-S3 DURING INITIAL MONITORING PERIOD

With respect to the recommendation described in Section 6.1.1, the site team could consider an alternative approach in which extraction wells EW-S1 through EW-S3 are not returned to operating status during the initial monitoring period. EW-S4 would continue to operate, and the GTWF would still be needed. This approach might entirely eliminate the re-start of those three extraction wells if the shutdown criteria for EW-S1 through EW-S3 and EW-S4 can all be met, resulting in Outcome “A” on Figure 6-1. However, there is additional risk in pursuing this alternative because there is a possibility that the shutdown criterion for EW-S4 (see Section 6.4.1) might not be met in the absence of extraction at EW-S1 through EW-S3. If that occurred, it would eliminate the potential to achieve outcomes “A,” “B” or “C” on Figure 6-1 in the short-term (i.e., it would delay potential elimination or substantial streamlining of the current GWTF), and would complicate subsequent decisions. The decision framework illustrated on Figure 6-1 allows for a more straightforward decision-making process.

6.2 RECOMMENDATIONS TO REDUCE COSTS

6.2.1 ESTIMATED COST SAVINGS FOR POTENTIAL SCENARIOS

The optimization review team has not provided specific recommendations to reduce costs for operating the P&T system in its current form (for example, treatment plant upgrades) because continued P&T operation for more than 1 year (at most) is considered unlikely. However, the recommendations described in Section 6.1 (i.e., extraction for up to 1 year with monthly monitoring) are expected to result in one of several potential outcomes (labels “A,” “B” and “C” on Figure 6-1) that will have much lower long-term costs relative to the current P&T system. Possible outcomes and associated estimates for potential costs savings include the following:

- *Outcome “A” on Figure 6-1.* A likely potential outcome is that P&T operations at this site will be terminated within 1 year (and perhaps much less than 1 year). If that occurs, the current cost of \$345,600 per year would likely be reduced to approximately \$65,000 per year (assuming \$25,000 per year for project management and \$40,000 per year groundwater monitoring). Thus, cost would be reduced by approximately \$280,000 per year for this scenario versus the current P&T system.
- *Outcome “B” on Figure 6-1.* Another potential outcome is that P&T extraction can be limited to source area wells EW-S1 through EW-S3 within 1 year, and the associated flow rate would allow for a simpler treatment approach. The current cost of \$345,600 per year would likely be reduced to approximately \$115,000 per year (assuming \$65,000 per year for the scenario with no P&T described above, plus an additional \$50,000 per year associated with management and operation of a smaller P&T system as detailed in Section 6.4.2). Thus, cost would be reduced by approximately \$230,000 per year for this scenario versus the current P&T system. It is expected that treatment plant modifications for this scenario would require up-front costs of approximately \$50,000, with payback achieved in much less than 1 year.

- *Outcome “C” on Figure 6-1.* Another potential outcome is that additional source area remediation (likely to consist of excavation and disposal) may be required in a targeted area to enable the complete shutdown of P&T operations. Based on the size of the targeted area, the up-front costs might range from less than \$100,000 to \$500,000 or more, as discussed in Section 6.4.2. These up-front costs would be offset by annual savings of approximately \$280,000 per year that would result from complete termination of P&T operations (as discussed in Outcome “A” above). Thus, the payback period might range from less than 1 year to as much as several years for this scenario.
- *Outcome “D” on Figure 6-1.* An unexpected outcome would be that downgradient extraction well EW-S4 needs to continue operating because the remaining source area is sufficiently strong and the capture provided by EW-S1 through EW-S3 is not sufficient. If this outcome occurs after the first year, it would then be appropriate to re-visit the CSM, and to optimize the current GWTF since continued P&T operation would be required.

6.2.2 DELAY TREATMENT PLANT UPGRADES

For the likely outcomes described in Section 6.2.1, the current treatment system would not be operated in its current form for more than 1 year (and perhaps much less than 1 year). Therefore, the optimization review team recommends that any currently planned upgrades to the P&T system be delayed if at all possible. Any such upgrades that can ultimately be avoided, by delaying the upgrades until the treatment plant is eliminated, would result in additional costs savings (not quantified by the optimization review team).

6.3 RECOMMENDATIONS FOR TECHNICAL IMPROVEMENT

No recommendations are provided for technical improvement.

6.4 CONSIDERATIONS FOR GAINING SITE CLOSE OUT

The monthly sampling of select wells (described in Section 6.1) will provide critical information for evaluating remedy effectiveness and determining an appropriate path to site closure in a timely manner. A suggested decision framework in the form of a flowchart (Figure 6-1) illustrates how decisions on terminating the P&T activities and or conducting additional investigation and remediation of the source area can be made based on data collected over the next year in conjunction with shutdown criteria. Recommendations associated with this suggested decision framework are provided below.

6.4.1 DEVELOP SHUTDOWN CRITERIA FOR EW-S1 THROUGH EW-S4

The optimization review team recommends that the EPA and MassDEP collectively determine appropriate shutdown criteria for the remaining extraction wells. Different parties may have different perspectives on appropriate shutdown criteria for operating extraction wells. Two potential perspectives are provided below for consideration. Other perspectives might also be considered.

- One perspective is to select MCLs as the shutdown criteria for operating extraction wells. This perspective is based on the premise that active remediation with a selected remedy is appropriate until cleanup criteria are met. This perspective provides relative certainty that the contaminant concentrations downgradient of the extraction wells will remain below MCLs in the absence of continued pumping. This perspective also has the benefit of being consistent with the most conservative interpretations of policy.

- A second perspective is to select some value above MCLs as the shutdown criteria for extraction wells (in conjunction with continued monitoring) if risks to receptors are adequately low and or estimates of attenuation indicate that concentrations will be acceptably low (for example, below MCLs) within a specified distance from the area that remains above MCLs. This perspective is premised on recognition of the high cost and resource use of continued extraction and the limited benefit of extracting low level concentrations, as illustrated by the following three key attributes:
 - For settings such as this site, continued extraction of low level concentrations contributes little to plume stability because of the dilution, dispersion and attenuation of low level concentrations that would occur over a short distance from the extraction wells, even in the absence of pumping.
 - Extraction of low level concentrations involves low levels of mass removal.
 - Extraction at this site (even at EW-S1 through EW-S3) occurs downgradient of a source and does not meaningfully decrease the time frame for source reduction.

Adopting this perspective, however, involves establishing the definition of “low level concentrations” and “short distances” downgradient of extraction wells. An evaluation of contaminant transport coupled with regulatory interpretation could be used to establish these definitions. One approach might be to use historically observed attenuation factors from the period before active remediation. For example, prior to remedy pumping, groundwater TCE concentrations in the source area of 40,000 µg/L (for example, EW-S2 from April 2000) resulted in groundwater TCE concentrations of 6,600 µg/L immediately upgradient of Mill Pond (for example, EW-S5 from April 2000). This translates to an attenuation factor of approximately 6. The groundwater TCE concentration downgradient of Mill Pond (EW-M1) during the same time frame was 870 µg/L. This translates to an attenuation factor of over 7 for TCE in groundwater between the upgradient and downgradient edges of Mill Pond. Using these attenuation factors, a TCE concentration of 30 µg/L in the source area would result in a TCE concentration of 5 µg/L at EW-S4 under non-pumping conditions and a concentration below 1 µg/L at EW-M1. Additionally, extraction of 30 µg/L at 3 gpm by EW-S1 through EW-S3 would remove approximately 0.4 pounds of TCE per year that would otherwise attenuate before reaching EW-S4. Based on this analysis, one option might be to discontinue pumping from EW-S1 through EW-S3 when TCE concentrations in these wells are no higher than 30 µg/L. Applying the same logic, a TCE concentration at EW-S4 of 35 µg/L would attenuate to 5 µg/L before reaching the location of EW-M1. Therefore, an alternate option would be to discontinue pumping from EW-S4 when the TCE concentration at this well is approximately 35 µg/L.

- Another potential approach is to consider shutting down the source area extraction wells (EW-S1 through EW-S3) if the extraction wells have groundwater concentrations above the MCLs, but monitoring indicates declining concentrations over time at these extraction wells, and the concentrations at the extraction wells are sufficiently low that it is unlikely that terminating extraction will cause increases in concentrations further downgradient that would be high enough to be of concern.

The monthly sampling suggested in Section 6.1 should help the site team better understand the changes in concentration as contamination migrates from the source area toward Mill Pond. Given a hydraulic gradient of approximately 0.06 ft per ft, a hydraulic conductivity of approximately 50 ft per day, an assumed effective porosity of 0.25, and minimal retardation, the contaminant transport velocity in the area is approximately 10 ft per day. For the distance of approximately 500 ft between the source area and EW-

S4, observable changes in TCE concentrations (if any) resulting from the re-start of EW-S1 through EW-S3 will likely be apparent within 2 to 3 months.

A potential approach for addressing these shutdown criteria is indicated on Figure 6-1. However, determining the shutdown criteria for the extraction wells is not solely a technical decision, thus the optimization review team cannot provide more specific recommendations or opinions. If there is concern or uncertainty about selecting shutdown criteria, the EPA and MassDEP may decide to devise a contingency plan that allows extraction well operation to resume after shutdown if concentrations at pre-determined monitoring points increase above a pre-determined action level. The optimization review team believes that the primary effort involved in implementing this recommendation involves meetings between the EPA and MassDEP. Limited contractor support for these meetings might cost up to \$10,000.

6.4.2 CONSIDER ADDITIONAL REMEDIAL OPTIONS FOR THE SOURCE AREA

The confirmation soil sampling from CSB-10 (5,600 µg/kg between 23 and 25 ft bgs) and CSB-13 (7,000 µg/kg between 3 to 5 ft bgs) suggests that contamination is still present in vadose zone soil that has the potential to result in TCE groundwater contamination orders of magnitude above MCLs. The August 2011 TCE concentration of 78 µg/L in RW-05, further suggests the potential that a source of groundwater contamination remains in this area. It is unclear, however, if these observed soil and groundwater concentrations are isolated and of insufficient mass to serve as a source for an extensive TCE plume above MCLs, or if they merit further attention. The monthly sampling suggested in Section 6.1, in conjunction with the re-start of extraction at EW-S1 through EW-S3, should help the site team evaluate the significance of this remaining contamination. Sampling of RW-05, which is co-located with the observed vadose zone contamination, might help identify maximum source area concentrations, but this well might be relatively isolated. Sampling of EW-S1 through EW-S3 while they operate as extraction wells should provide a representative concentration of TCE that would otherwise migrate from the source area under current conditions (i.e., subsequent to the mass reduction provided by the ISTT remediation).

If the TCE concentrations at RW-05, EW-S1, EW-S2, and EW-S3 collectively indicate that continued extraction is needed (for example, concentrations at the extraction wells are higher than the shutdown criteria established according to the recommendation provided above and or TCE concentrations at RW-05 show an increasing trend), the optimization review team suggests conducting a direct-push technology (DPT)-based high-resolution investigation of the approximately 50-ft by 50-ft area around CSB-10, CSB-13 and RW-05 to collect soil samples for determining the extent of vadose zone contamination. This investigation is only recommended if the interim monthly monitoring coupled with the re-start of EW-S1 through EW-S3 (suggested above) indicates that the source area extraction wells need to continue operation in the long-term. Otherwise, this investigation would not be performed. If this investigation is performed, collecting soil samples via DPT at 10-ft grid spacing and at 3 depth intervals would provide a high degree of resolution of the source extent and magnitude. The optimization review team estimates that this high-resolution site characterization (HRSC) type approach might cost on the order of \$40,000 for planning, field work, laboratory analysis and limited reporting. The site team could alternatively opt for a mobile laboratory and a dynamic work strategy if such an approach can be performed more cost effectively.

The results of the HRSC investigation (if needed) should give the site team a thorough understanding of the extent of residual contamination. The site team could then evaluate if a second attempt at source removal (i.e., polishing) is appropriate or if continued containment by operating EW-S1, through EW-S3 is preferred. The method of treatment of the groundwater extracted from EW-S1 through EW-S3 would be dependent on the status of EW-S4. If EW-S4 continues to operate, the costs noted in Section 5.6 of this report would likely be expected. However, if EW-S4 is no longer operating, the total extraction rate requiring treatment would be approximately 3 gpm. The extracted water from EW-S1 through EW-S3

could then be treated by small GAC vessels, and because these wells are located several hundred feet from Mill Pond, the treated water could be then reinjected into the subsurface immediately downgradient of the extraction wells. Treatment for arsenic should not be required in that case. This would result in a much less costly system with minimal operator attention required (discussed below).

The cost of remediating the vadose zone contamination would be highly dependent on the volume to be treated and the distribution of the contamination. Because ISTT with vapor extraction has already been implemented in the area, the optimization team would not suggest use of an SVE system. The most appropriate option might be excavation with off-site disposal, since ISCO was previously pilot tested and was reportedly not very effective. Assuming an estimated maximum volume of 2,800 cubic yards that might merit remediation (50 ft by 50 ft in area and 30 ft deep) and an estimated cost of \$200 per cubic yard, remediation costs might range as high as \$560,000. However, if the HRSC investigation refined the volume meriting remediation, the costs would be reduced. For instance, an area of 30 ft by 20 ft and 20 ft deep (i.e., approximately 450 cubic yards) might require less than \$100,000 to remediate.

If groundwater extraction from EW-S1 through EW-S3 were to occur in the absence of extraction from EW-S4, approximately \$50,000 in up-front costs might be required to furnish and install bag filters, two 500-lb GAC units, install a small infiltration gallery and modify controls as appropriate. The bag filters and GAC units would be located after the current metals removal system so that some of the dissolved iron in the extracted water can be removed prior to GAC treatment. The multi-media pressure filters, UVOx, and catalytic GAC in the current system would be bypassed. The additional costs for operating the simplified treatment system (i.e., above and beyond the management and monitoring costs for a “monitoring only” remedy) would be under \$50,000 per year assuming the following:

- \$20,000 per year for one 4-hour system check per week, plus occasional longer visits for additional maintenance;
- \$6,500 per year for electrical power (assume 5 kW) to utilized parts of the building;
- Under \$2,000 for quarterly sampling of the influent, mid-GAC, and effluent;
- \$12,000 per year for additional project management, technical support, and minimal reporting; and
- Under \$10,000 per year for miscellaneous project needs.

There is too much uncertainty at present to evaluate either option in more detail. Depending on the results from the monthly monitoring recommended in Section 6.1, additional remediation may not even be appropriate.

6.4.3 POTENTIAL LONG-TERM OPTIONS FOR EW-S4

The optimization review team does not anticipate long-term pumping from EW-S4 because TCE concentrations were low prior to the ISTT remedy, and should decrease below MCLs now that the ISTT remedy has been implemented and EW-S1 through EW-S3 can control the large majority of any remaining contamination once they are operating. If contamination at EW-S4 remains significantly above MCLs for more than 12 months after operation of EW-S1 through EW-S3 begins, then the CSM will need to be revisited. The optimization review team would suggest focusing on controlling plume migration at the source area where flow rates are low and groundwater extraction is several hundred feet from Mill Pond. This would allow the GWTF to be simplified as discussed in the previous section.

Other options for the GWTF would be to replace the multimedia filters with bag filters and to replace the UVOx system with GAC or air stripping. The capital costs of making these changes would likely exceed \$100,000. Given the improving conditions at the site and the likelihood that EW-S4 can be taken off line in a few years or less, it is unclear if there would be complete payback before shutdown of EW-S4 occurs.

6.5 RECOMMENDATIONS RELATED TO GREEN REMEDIATION

Given the focus on site closure (i.e., the expectation that the current P&T system will only operate for a short amount of time), no opportunities for footprint reduction regarding the current P&T system (for example, treatment plant upgrades) were contemplated. However, to the extent P&T operations are terminated or significantly scaled back within a year or less (which is likely based on the discussion above), remedy footprints will be reduced accordingly. The actual footprint reductions will depend on which of the potential outcomes on the decision flowchart presented on Figure 6-1 actually occurs (i.e., similar to the potential cost savings).

6.6 SUGGESTED APPROACH TO IMPLEMENTING RECOMMENDATIONS

The optimization team recommends implementing the recommendations in Section 6.1 and Section 6.4.1. The subsequent recommendations in Section 6.4 would be contingent on the results of those activities, as per the suggested decision framework on Figure 6-1. Cost information for the recommendations is provided in Table 6-1, and potential impacts on environmental footprints from the recommendations are provided in Table 6-2.

Table 6-1. Cost Summary Table

Recommendation	Category	Additional Capital Cost	Change in Annual Cost	Change in Life-Cycle Cost (10 yrs, 3% discount rate)
6.1.1 CONTINUE P&T OPERATION (EW-1 TO EW-4), WITH MONTHLY MONITORING OF SELECT WELLS, FOR UP TO ONE YEAR	Effectiveness	\$20,000*	\$0	\$20,000*
6.1.2 ALTERNATIVE APPROACH – DO NOT OPERATE EW-S1 TO EW-S3 DURING INITIAL MONITORING PERIOD	Effectiveness	Not quantified, but would save some short-term cost if implemented as an alternative to recommendation 6.1.1 (but would also increase risk of not achieving shutdown criteria at EW-S4, which could increase long-term cost)		
6.2.1 ESTIMATED COST SAVINGS FOR POTENTIAL SCENARIOS**	Cost Reduction	<u>Outcome “A”</u> \$0	<u>Outcome “A”</u> \$(280,000)	<u>Outcome “A”</u> \$(2,380,000)
		<u>Outcome “B”</u> \$50,000	<u>Outcome “B”</u> \$(230,000)	<u>Outcome “B”</u> \$(1,905,000)
		<u>Outcome “C”</u> ***	<u>Outcome “C”</u> \$(280,000)	<u>Outcome “C”</u> ***
6.2.2 DELAY TREATMENT PLANT UPGRADES	Cost Reduction	Not quantified		
6.4.1 DEVELOP SHUTDOWN CRITERIA FOR EW-S1 THROUGH EW-S4	Site Closure	\$10,000	\$0	\$10,000
6.4.2 CONSIDER REMEDIAL OPTIONS FOR THE SOURCE AREA	Site Closure	Costs subject to uncertainty. Refer to report text Section 6.4.2.		
6.4.3 POTENTIAL LONG-TERM OPTIONS OF CONTINUED EXTRACTION AT EW-S4 IS NEEDED	Site Closure	No estimates of costs or cost savings.		

*This is the additional cost for the more frequent monitoring at selected wells, The P&T operation is currently planned, so the recommended P&T for up to 1 year does not impact estimated costs for that year.

**For recommendation 6.1.2, the 10-year period is assumed to start after the current P&T operations for up to 1 year that are inherent in recommendation 6.1.1.

***Up-front costs likely to be on the order of \$100,000 to \$500,000, with payback from annual savings within a few years.

Table 6-2. Summary of Effects on Environmental Footprint

Recommendation	Effect on Environmental Footprint
6.1.1 CONTINUE P&T OPERATION (EW-S1 to EW-S4), WITH MONTHLY MONITORING OF SELECT WELLS, FOR UP TO 1 YEAR	Implementation of this recommendation is expected to directly increase the environmental footprint of the in all green remediation categories (due to increased monitoring). However, monitoring with PDBs has a relatively low footprint, and the information gathered from implementing this recommendation should facilitate faster shutdown or modification of the P&T system, which would substantially reduce or eliminate the long-term environmental footprint.
6.1.2 ALTERNATIVE APPROACH – DO NOT OPERATE EW-S1 TO EW-S3 DURING INITIAL MONITORING PERIOD	By eliminating extraction at EW-S1 through EW-S3 for up to 1 year, some reduction in the environmental footprint might be achieved (i.e., due to less electricity use). However, this alternative would also increase risk of not achieving shutdown criteria at EW-S4, which could increase the environmental footprint in the long-term.
6.2.1 ESTIMATED COST SAVINGS FOR POTENTIAL SCENARIOS**	To the extent P&T operations are terminated or significantly scaled back within 1 year or less (which is likely) remedy footprints will be reduced accordingly. The actual footprint reductions will depend on which of the potential outcomes on the decision flowchart presented on Figure 6-1 actually occurs (i.e., similar to the potential cost savings).
6.2.2 DELAY TREATMENT PLANT UPGRADES	To the extent improvements to the GWTF can be avoided, there will be reductions in the transportation of materials, equipment, and personnel required for implementing those upgrades.
6.4.1 DEVELOP SHUTDOWN CRITERIA FOR EW-S1 THROUGH EW-S4	There is no meaningful environmental footprint associated with this recommendation, but developing the criteria will help avoid the environmental footprint of potentially unnecessary future P&T system operation.
6.4.2 CONSIDER REMEDIAL OPTIONS FOR THE SOURCE AREA	<p>If deemed appropriate, targeted aggressive remediation of remaining source material would likely result in a higher environmental footprint in the short term, but would likely reduce the overall footprint of the remedy by reducing the time frame or eliminating the need for P&T operation.</p> <p>If P&T system operation continues but the system is modified, the environmental footprint would be substantially reduced both due to the type of treatment provided and the smaller volume of water requiring treatment.</p>
6.4.3 POTENTIAL LONG-TERM OPTIONS OF CONTINUED EXTRACTION AT EW-S4 IS NEEDED	The options discussed in this recommendation would result in an overall reduction in the environmental footprint.

ATTACHMENT A: FIGURES FROM EXISTING SITE REPORTS

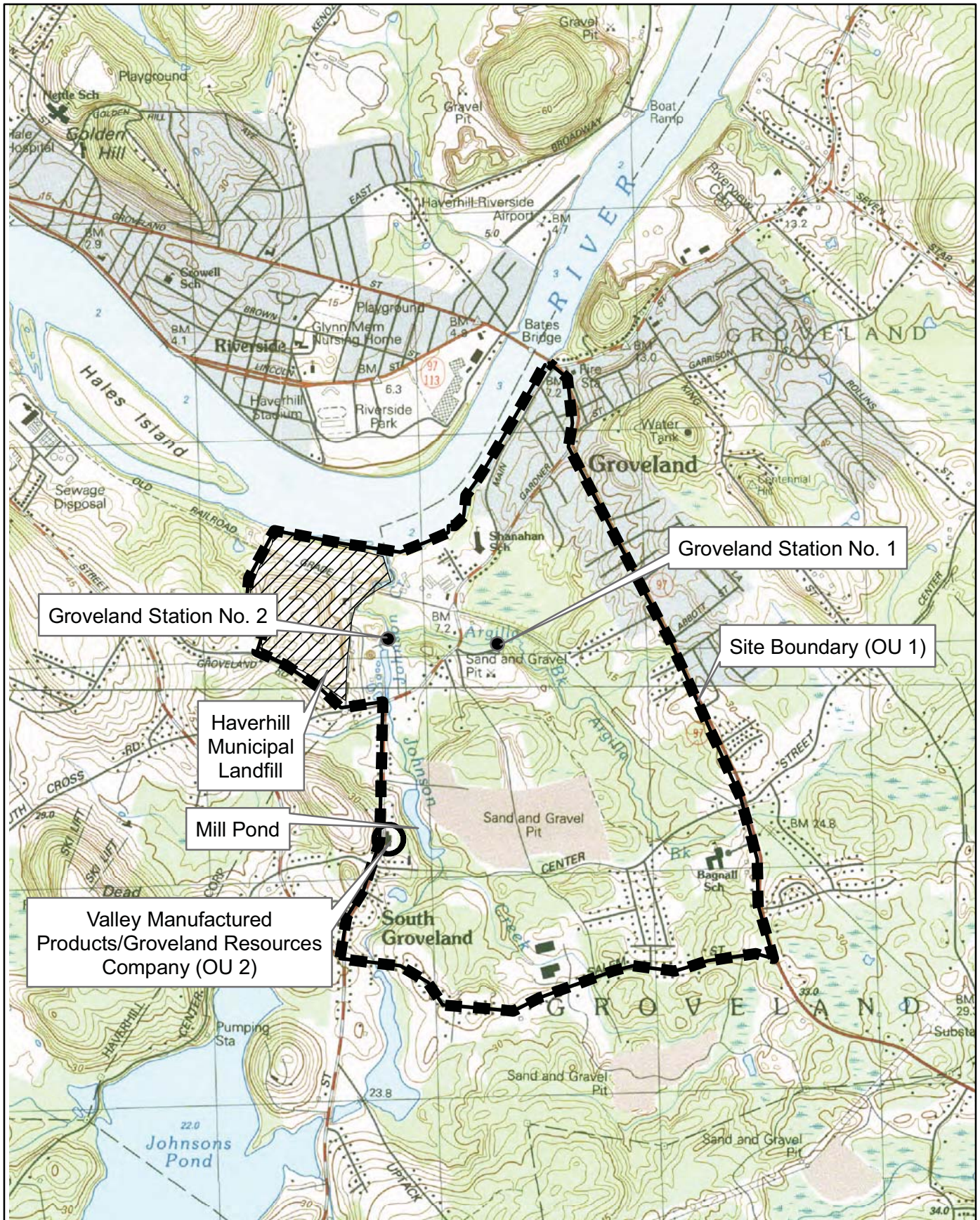


FIGURE
1

GROVELAND WELLS SITE
GROVELAND, MA

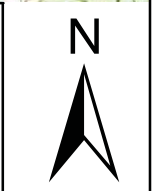
SITE LOCUS PLAN



Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
(978) 683-0891
www.nobisengineering.com

DATE: 5/4/10
PROJECT NO. 80053
FILE NAME: Site Locus Plan.mxd
PREPARED BY: AR
CHECKED BY: DB

Approximate Scale 1"=1,500'



R:\80000 Task Orders\80053 Groveland Wells FYR\Technical Data\CAD\FIGURE 4 VALLEY BLDG DETAILS.dwg

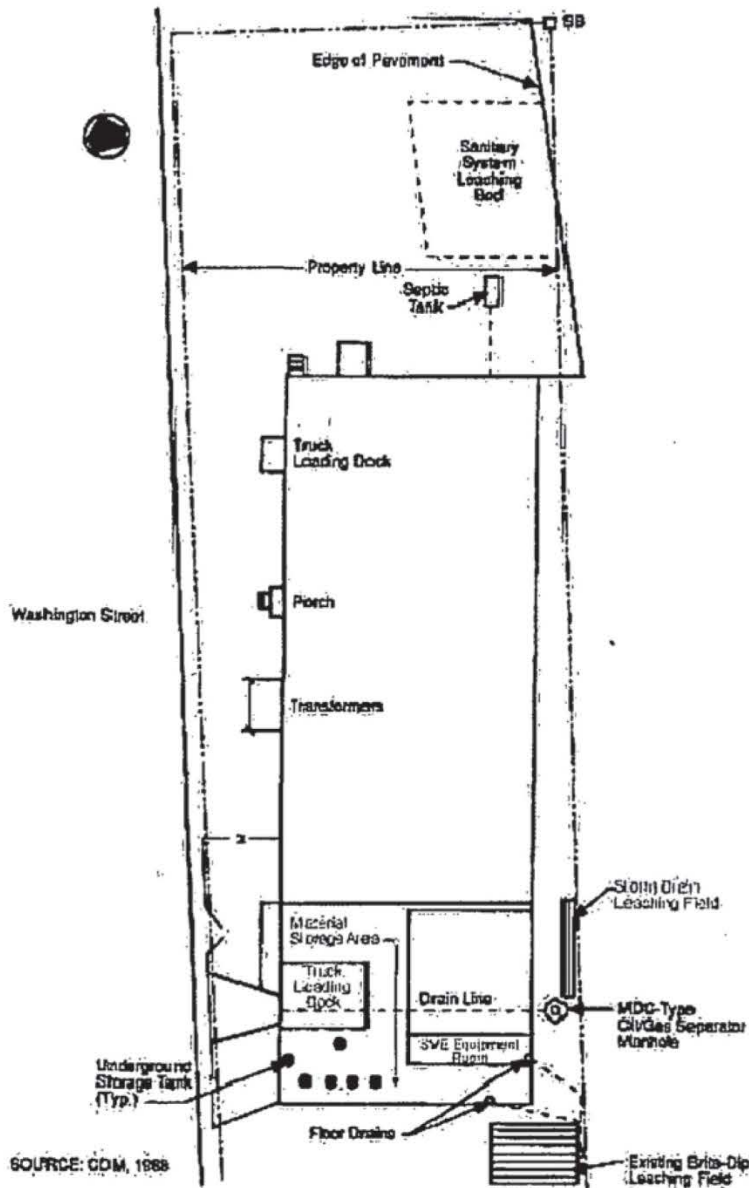


FIGURE 4

VALLEY/GRC BUILDING DETAILS

GROVELAND WELLS
GROVELAND, MASSACHUSETTS



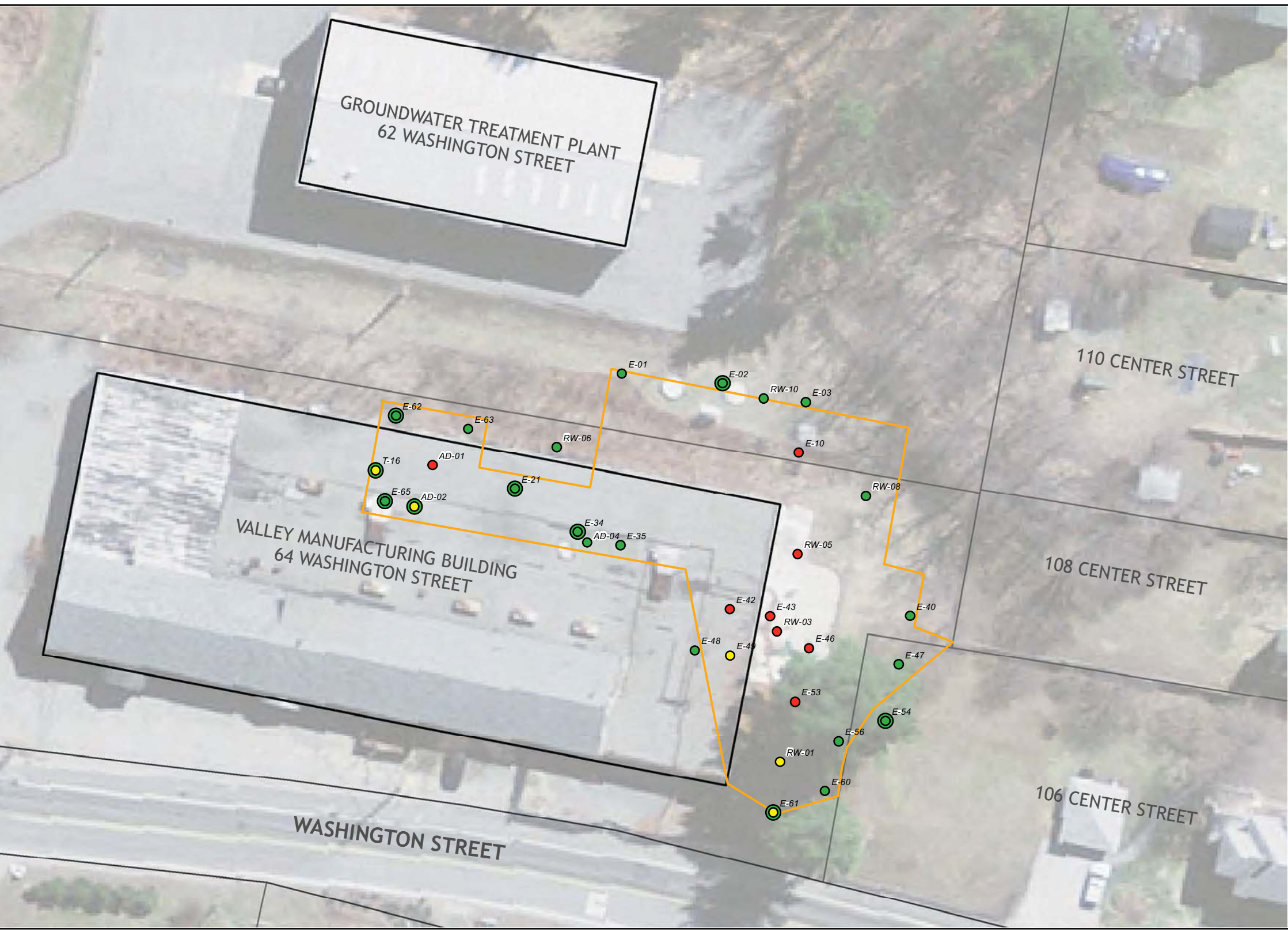
Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
Tel (978) 883-0891
Fax (978) 883-0866
www.nobisengineering.com

PROJECT NO. 80053

DATE: MAY 2010

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Soil Maps\Fig_4-1_Baseline_Soil_TCE_0-11ft.mxd

Boring Location	Start Depth	End Depth	TCE (µg/kg)	Sample Date
AD-01	9	10	1800	7/29/2009
AD-02	7	8	210	7/29/2009
AD-02	9	10	2 J	7/29/2009
AD-04	8	9	5 U	7/30/2009
E-01	0	1	6 U	4/6/2010
E-02	7	8	7 U	3/30/2010
E-02	10	11	56 J	3/30/2010
E-03	9	10	8 U	3/4/2010
E-10	9	10	1200 U	3/22/2010
E-21	6	7	8	3/4/2010
E-21	9	10	3 J	3/4/2010
E-34	7	8	5 U	3/4/2010
E-34	9	10	5 U	3/4/2010
E-35	10	11	5 U	3/9/2010
E-40	9	10	2 J	3/25/2010
E-42	9	10	4600	3/17/2010
E-43	4	5	20000 D	4/2/2010
E-46	4	5	2800	4/12/2010
E-47	3	4	47	3/29/2010
E-48	0	1	8	3/25/2010
E-49	6	7	140	3/25/2010
E-53	0	1	540	4/7/2010
E-54	1	2	26	3/29/2010
E-54	9	10	5 U	3/29/2010
E-56	5	6	5 J	3/31/2010
E-60	1	2	6	3/31/2010
E-61	5	6	250 U	3/31/2010
E-61	10	11	5 U	3/31/2010
E-62	5	6	18	3/16/2010
E-62	8	9	5 U	3/16/2010
E-63	3	4	4 J	3/16/2010
E-65	5	7	0 J	3/3/2010
E-65	9	10	0 J	3/3/2010
RW-01	8	9	82	8/4/2009
RW-03	1	2	940	8/4/2009
RW-05	3	4	11000	8/5/2009
RW-06	6	7	3 J	8/3/2009
RW-08	9	10	2 BJ	8/6/2009
RW-10	8	9	6 U	8/6/2009
T-16	8	9	150	3/22/2010
T-16	10	11	14	3/22/2010



Legend

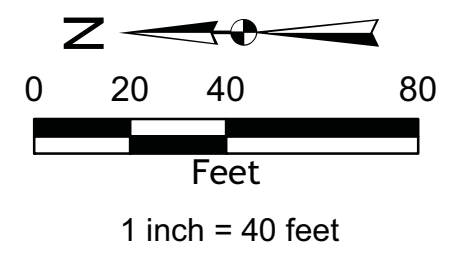
TCE RESULTS 0-11 ft bgs (µg/kg)

- < 77
- 77 - 500
- > 500

- Multiple samples collected within Figure depth range.
- Thermal Treatment Area

Notes:

- The site cleanup goal for TCE in vadose zone soil is 77 µg/kg.
- Qualifiers:
 - U - Not detected above the sample-specific detection limit.
 - J - Quantitation is estimated as it is below the sample-specific detection limit.
 - D - Concentration is reported from a dilution of the sample.
 - B - Analyte detected in laboratory blank.



Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
(978) 683-0891
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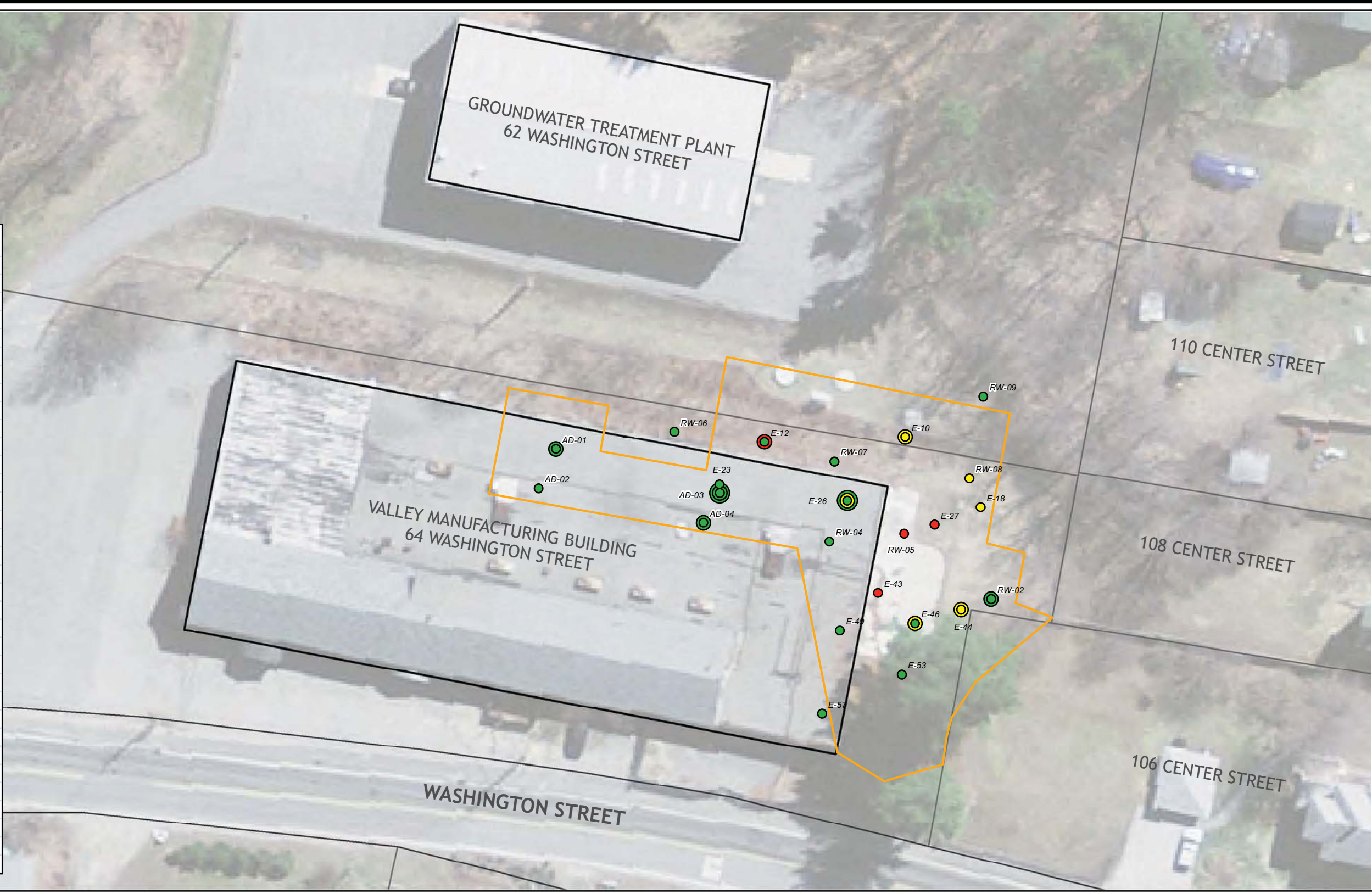
FIGURE 4-1

BASELINE TRICHLOROETHENE RESULTS
IN SOIL - 0-11 FT BGS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Soil Maps\Fig_4-2_Baseline_Soil_TCE_11-26ft.mxd

Boring Location	Start Depth	End Depth	TCE (µg/kg)	Qualifier	Sample Date
AD-01	13	14	6	U	7/29/2009
AD-01	19	20	11		7/29/2009
AD-02	13	14	1	J	7/29/2009
AD-03	11	12	5	U	7/29/2009
AD-03	13	14	5	U	7/29/2009
AD-03	19	20	5	U	7/29/2009
AD-04	13	14	6	U	7/30/2009
AD-04	17	18	5	U	7/30/2009
E-10	11	12	350	U	8/5/2009
E-10	13	14	120		8/5/2009
E-12	14	15	6	U	7/30/2009
E-12	19	20	1400		8/5/2009
E-18	18	19	155	J	8/3/2009
E-23	19	20	5	U	8/6/2009
E-26	15	16	5	J	8/4/2009
E-26	20	21	160		3/16/2010
E-26	25	26	38		3/16/2010
E-27	16	17	1900		3/23/2010
E-43	18	19	1700		3/17/2010
E-44	11	12	410		3/17/2010
E-44	12	13	140	J	3/16/2010
E-46	15	16	10		3/22/2010
E-46	25	26	360		3/22/2010
E-49	18	19	62		3/23/2010
E-53	12	13	6		3/29/2010
E-57	11	12	5	U	3/29/2010
RW-02	14	15	3	BJ	3/8/2010
RW-02	18	19	9	B	4/13/2010
RW-04	18	20	6	U	4/2/2010
RW-05	23	24	7400		4/12/2010
RW-06	18	19	52		4/12/2010
RW-07	18	19	6	U	4/7/2010
RW-08	14	15	220	B	3/25/2010
RW-09	14	15	5	U	3/30/2010



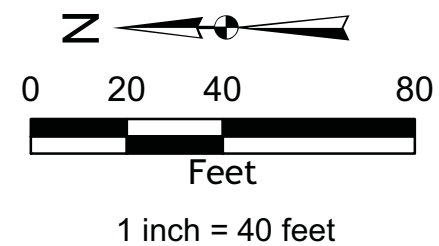
Legend

TCE RESULTS 11-26 ft bgs (µg/kg)	
●	< 77
●	77 - 500
●	> 500

- Multiple samples collected within Figure depth range.
- Thermal Treatment Area

Note:

1. The site cleanup goal for TCE in vadose zone soil is 77 µg/kg.
2. Qualifiers:
 - U - Not detected above the sample-specific detection limit.
 - J - Quantitation is estimated as it is below the sample-specific detection limit.
 - B - Analyte detected in laboratory blank.



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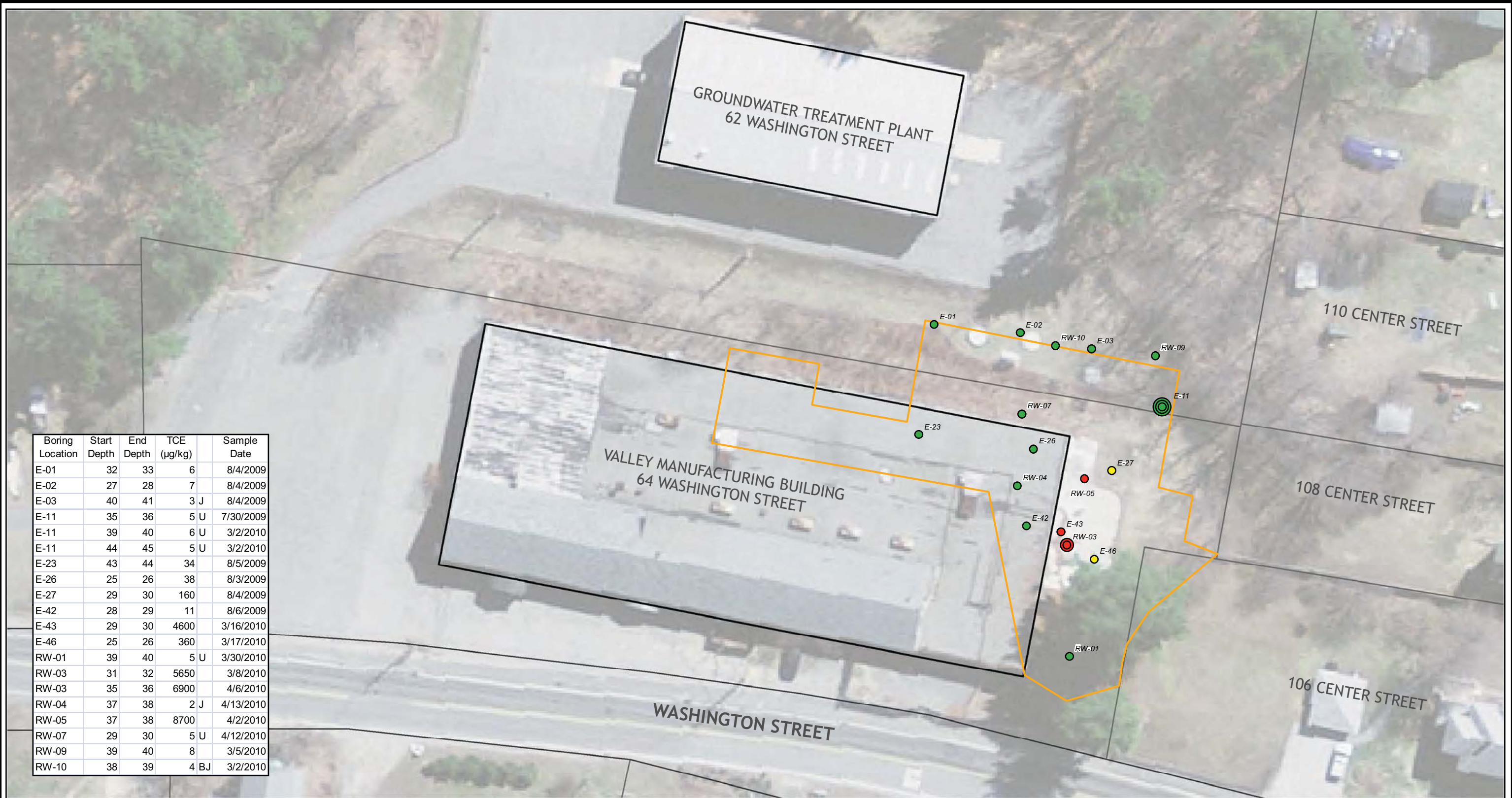
FIGURE 4-2

BASELINE TRICHLOROETHENE RESULTS
IN SOIL - 11-26 FT BGS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH
PROJECT NO. 80037

CHECKED BY: DB
DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA Technical Data - new and previous\GIS\Nobis Maps\Soil Maps\Fig_4-3_BaseLine_Soil_TCE_26-45ft.mxd



Boring Location	Start Depth	End Depth	TCE (µg/kg)	Sample Date
E-01	32	33	6	8/4/2009
E-02	27	28	7	8/4/2009
E-03	40	41	3 J	8/4/2009
E-11	35	36	5 U	7/30/2009
E-11	39	40	6 U	3/2/2010
E-11	44	45	5 U	3/2/2010
E-23	43	44	34	8/5/2009
E-26	25	26	38	8/3/2009
E-27	29	30	160	8/4/2009
E-42	28	29	11	8/6/2009
E-43	29	30	4600	3/16/2010
E-46	25	26	360	3/17/2010
RW-01	39	40	5 U	3/30/2010
RW-03	31	32	5650	3/8/2010
RW-03	35	36	6900	4/6/2010
RW-04	37	38	2 J	4/13/2010
RW-05	37	38	8700	4/2/2010
RW-07	29	30	5 U	4/12/2010
RW-09	39	40	8	3/5/2010
RW-10	38	39	4 BJ	3/2/2010

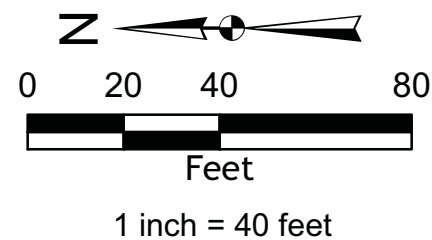
Legend

TCE RESULTS 26-45 ft bgs (µg/kg)	
●	< 77
●	77 - 500
●	> 500

- Multiple samples collected within Figure depth range.
- Thermal Treatment Area

Notes:

1. The site cleanup goal for TCE in vadose zone soil is 77 µg/kg.
2. Qualifiers:
 - U - Not detected above the sample-specific detection limit.
 - J - Quantitation is estimated as it is below the sample-specific detection limit.
 - B - Analyte detected in laboratory blank.



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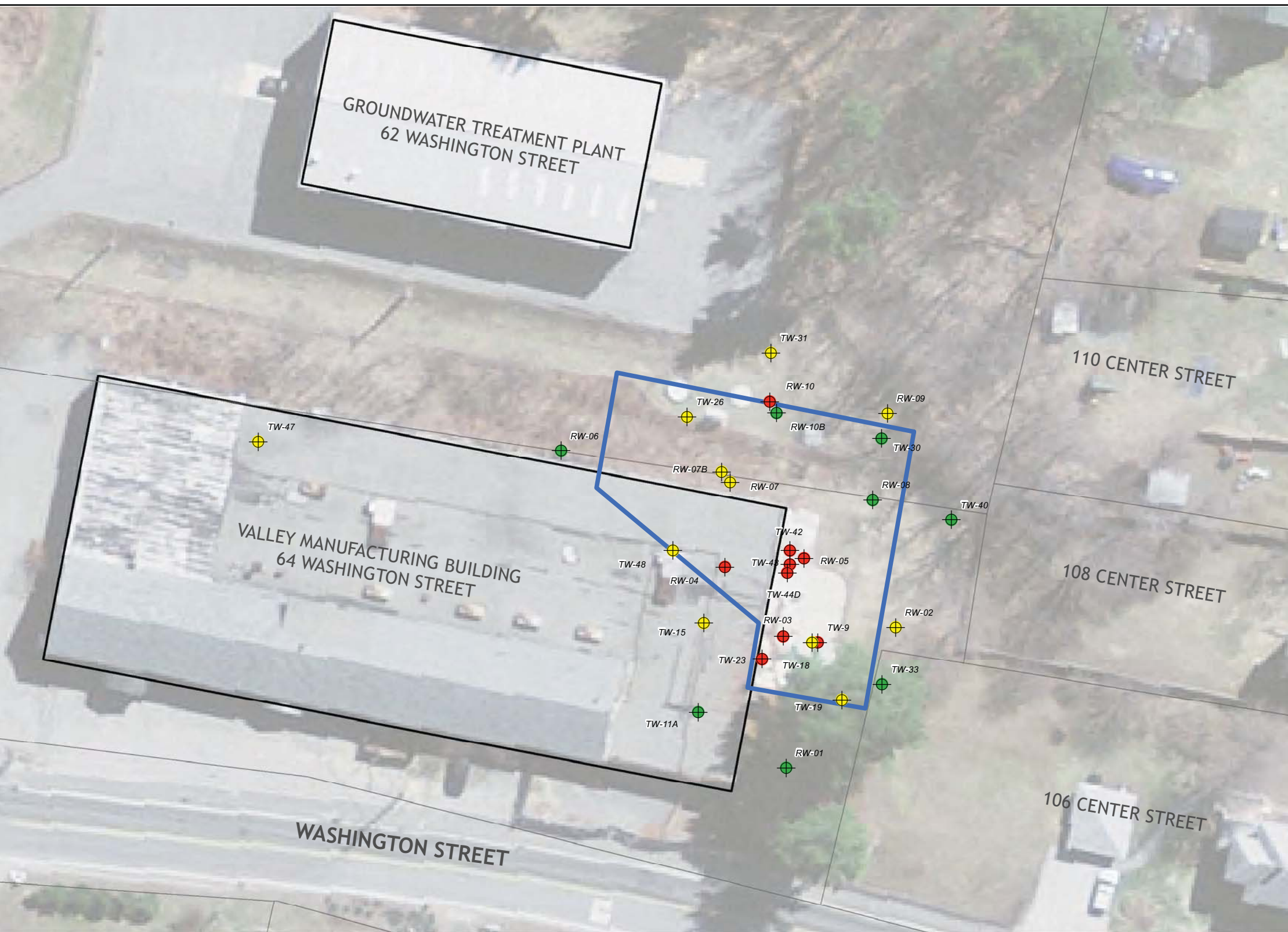
FIGURE 4-3

BASELINE TRICHLOROETHENE RESULTS
IN SOIL - 26-45 FT BGS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\180000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_4-4_Aug_2009_TCE.mxd

Well Location	TCE Results (µg/l)	Sample Date
RW-01	5 U	8/25/2009
RW-02	15	8/25/2009
RW-03	11000 D	8/26/2009
RW-04	290 D	8/24/2009
RW-05	11000 D	8/26/2009
RW-06	5 U	8/25/2009
RW-07	83	8/25/2009
RW-07B	52	8/26/2009
RW-08	4 J	8/25/2009
RW-09	10	8/26/2009
RW-10	390 D	8/26/2009
RW-10B	1 J	8/26/2009
TW-11A	5 JB	6/30/2009
TW-15	43 B	6/29/2009
TW-18	10 B	6/30/2009
TW-19	78 B	6/30/2009
TW-23	300 B	6/30/2009
TW-26	38 B	6/30/2009
TW-30	1 JB	7/1/2009
TW-31	9 B	6/30/2009
TW-33	2 JB	7/1/2009
TW-40	5 U	7/1/2009
TW-42	96000 DB	7/1/2009
TW-43	18000 DB	7/1/2009
TW-44D	1200 DB	7/1/2009
TW-47	8 B	7/1/2009
TW-48	150 B	6/29/2009
TW-9	380 B	6/30/2009



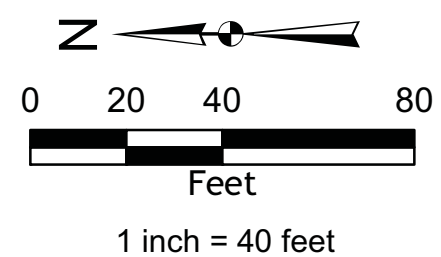
Legend

TCE RESULTS (µg/l)	
	< 5
	5 - 200
	> 200

ISTT Area A Boundary

Notes:

- The site cleanup goal for TCE in groundwater is 5 µg/kg.
- Qualifiers:
 - U - Not detected above the sample-specific detection limit.
 - J - Quantitation is estimated as it is below the sample-specific detection limit.
 - D - Concentration is reported from a dilution of the sample.
 - B - Analyte detected in laboratory blank.



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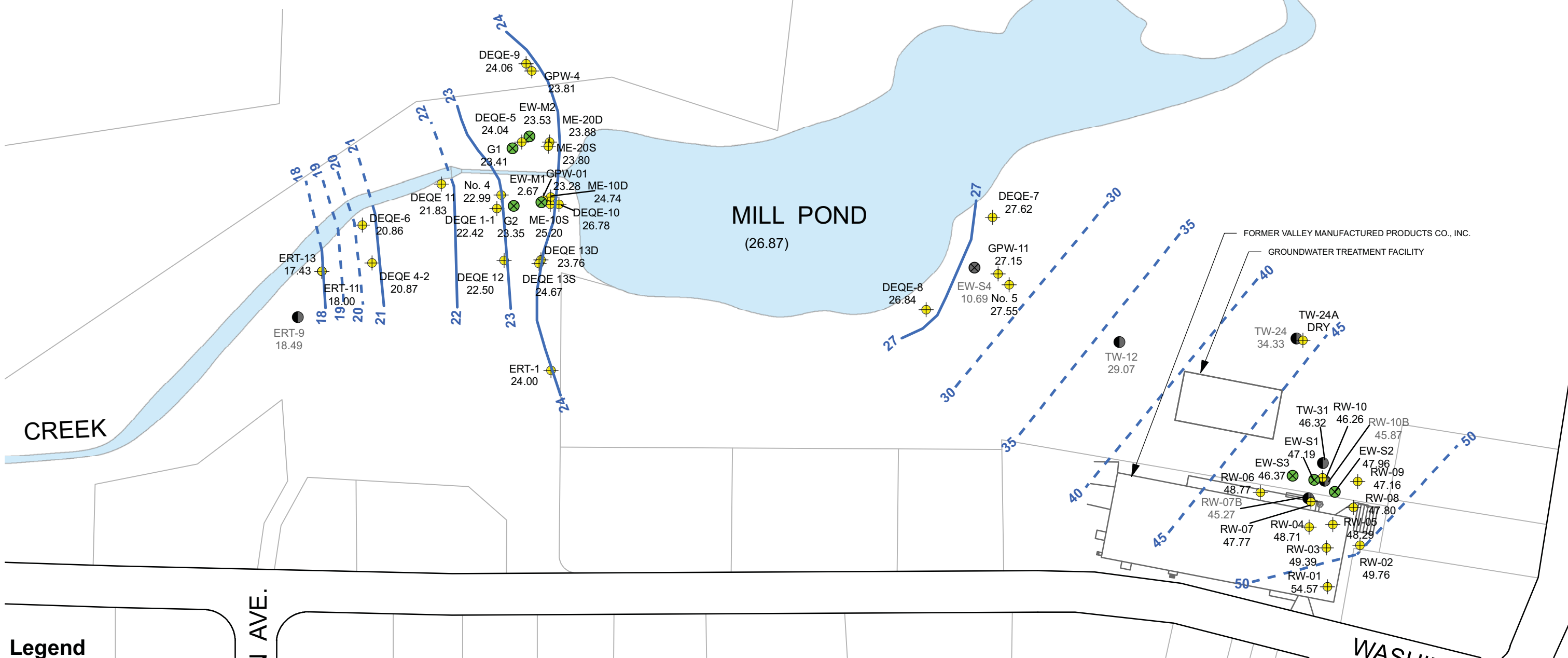
FIGURE 4-4

BASELINE TRICHLOROETHENE RESULTS IN GROUNDWATER GROVELAND WELLS SUPERFUND SITE GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011

Notes

1. The current limits of Mill Pond are typically smaller than depicted, and are subject to seasonal fluctuations.
2. Groundwater contours are based on data collected from monitoring wells under pumping conditions, and are one interpretation of the data. Other interpretations are possible.
3. Measurement Date: April 19, 2010

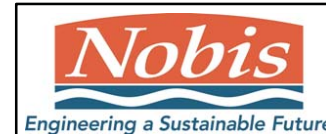


Legend

- | | | | |
|-----------------|--|----------------|---|
| ERT-11
18.00 | Existing Overburden Monitoring Well
Used in 2010 Water Level Monitoring | ERT-9
18.49 | Existing Bedrock Monitoring Well
Used in 2010 Water Level Monitoring |
| EW-M2
23.53 | Existing Overburden Extraction Well | EW-S4
10.69 | Existing Bedrock Extraction Well |
| 22 | Groundwater Contour with Elevation
Dashed Where Inferred | | |



APPROXIMATE SCALE

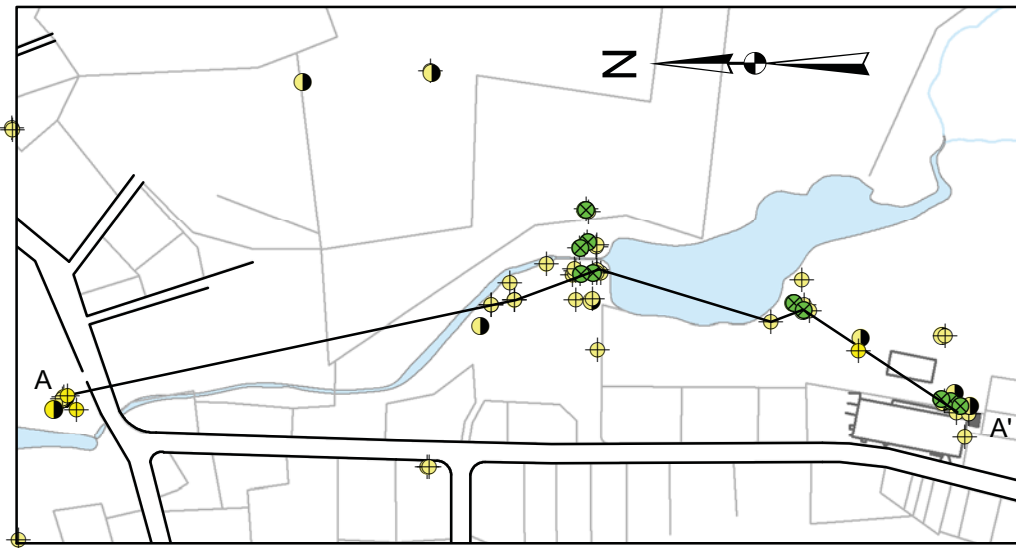


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FIGURE 5-1

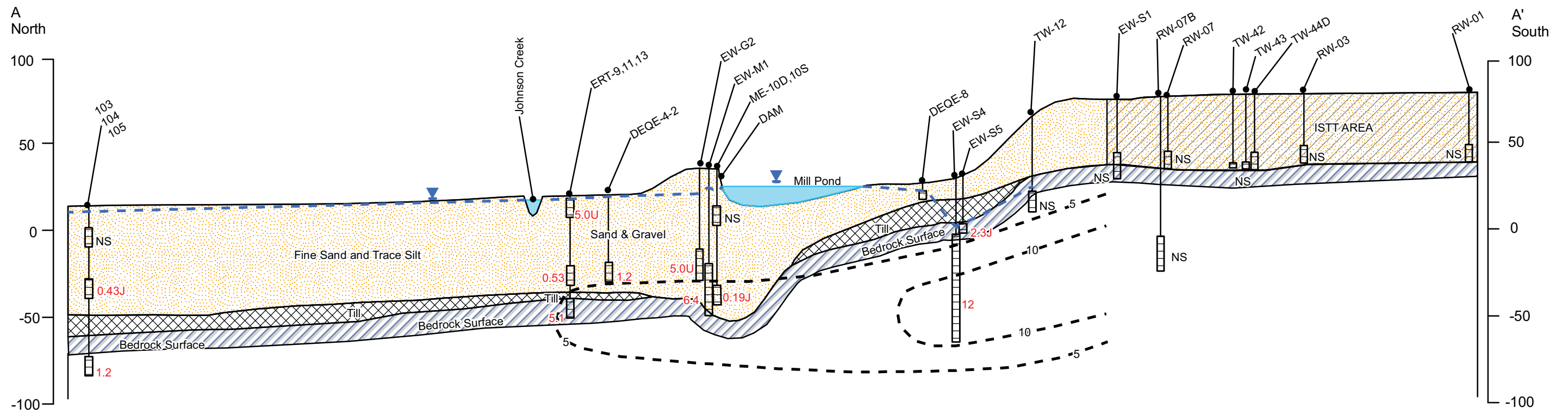
ESTIMATED OVERBURDEN GROUNDWATER
CONTOURS - SPRING 2010
GROVELAND WELLS
GROVELAND, MASSACHUSETTS

PREPARED BY: AR	CHECKED BY: DL
PROJECT NO. 80012	DATE: JANUARY 2010



Horizontal Scale:
1" = 60'

Vertical Scale
1" = 60'



Notes

1. Location of Cross Section A-A' shown on Figures 3-1.
2. The groundwater samples collected from ERT-09 was paired with a field duplicate; the posted value is an average.
3. Monitoring well and extraction well data collected in Fall 2010.
4. All concentrations in µg/L.
5. EW-M1 was not operating on the day water level data was collected.
6. TCE - Trichloroethylene
7. NS - Not Sampled

Legend

- 10 - - - TCE Isoconcentration
- Approximate Groundwater Elevation October 28, 2010
- Well screened interval with TCE concentration depicted.
- ISTT Treatment Area

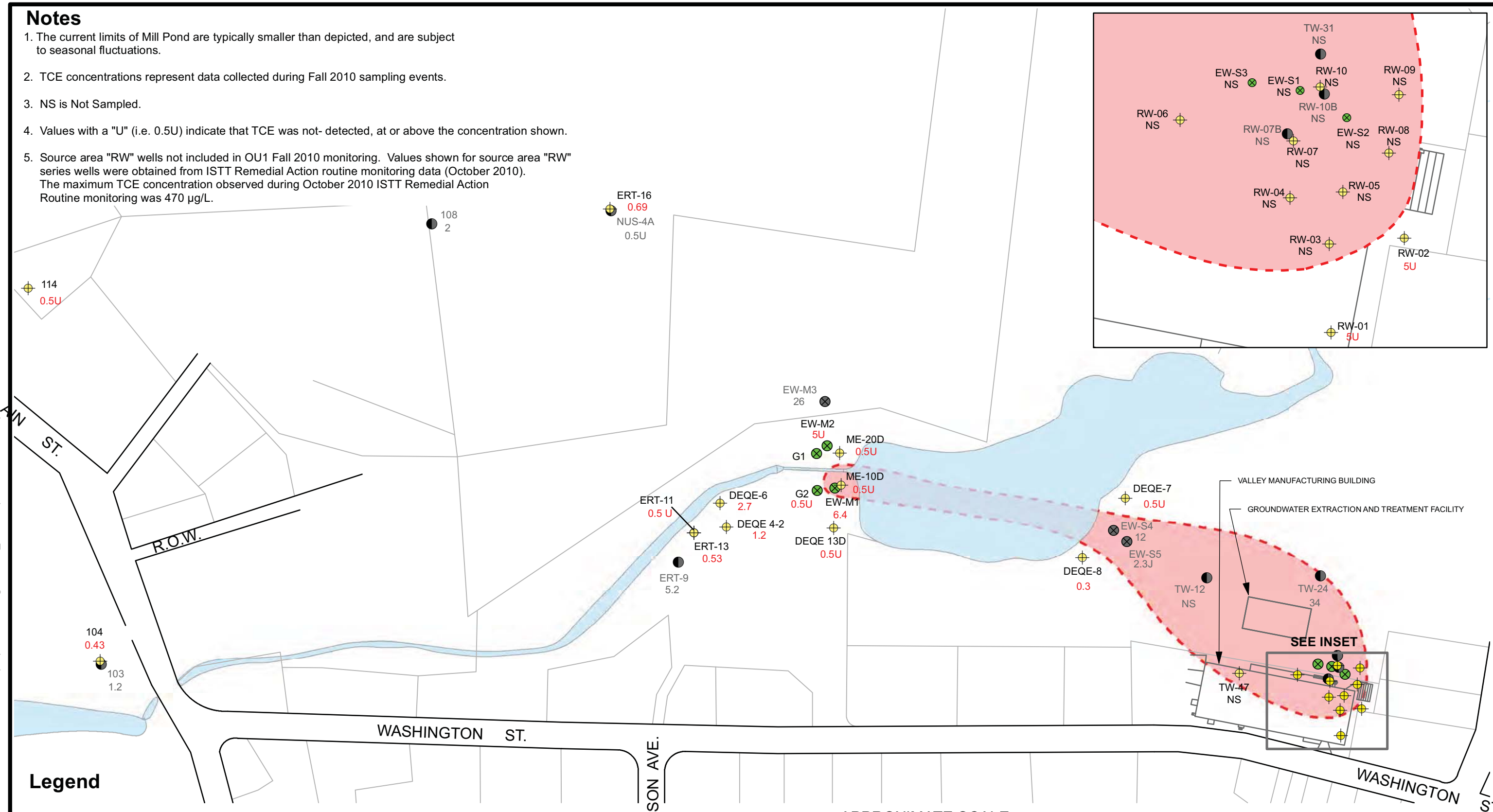
R:\180000_Task Orders\180012 Groveland Wells\Technical Data (TD)\GIS Data\X_SectionAA'.mxd

<p>Nobis Engineering, Inc. 585 Middlesex Street Lowell, MA (978) 683-0891 www.nobisengineering.com</p>	<p>FIGURE 6-2 CROSS-SECTION A - A' & TCE ISOCONTOURS-FALL 2010 GROVELAND WELLS GROVELAND, MASSACHUSETTS</p>	
	<p>PREPARED BY: AR</p> <p>PROJECT NO. 80012</p>	<p>CHECKED BY: DL</p> <p>DATE: JANUARY 2011</p>

Notes

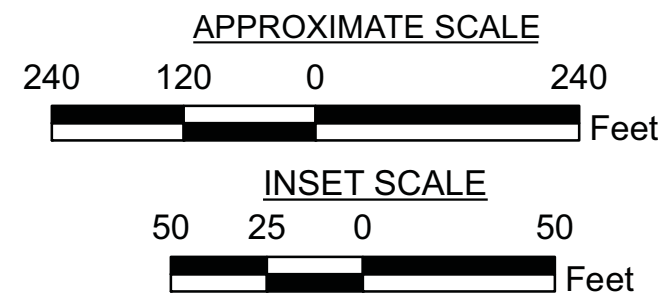
1. The current limits of Mill Pond are typically smaller than depicted, and are subject to seasonal fluctuations.
2. TCE concentrations represent data collected during Fall 2010 sampling events.
3. NS is Not Sampled.
4. Values with a "U" (i.e. 0.5U) indicate that TCE was not- detected, at or above the concentration shown.
5. Source area "RW" wells not included in OU1 Fall 2010 monitoring. Values shown for source area "RW" series wells were obtained from ISTT Remedial Action routine monitoring data (October 2010). The maximum TCE concentration observed during October 2010 ISTT Remedial Action Routine monitoring was 470 µg/L.

R:\180000 Task Orders\80012 Groveland Wells\Technical Data (TD)\GIS Data\Figures\Fall_2010 Report\6-1 Plume Map.mxd



Legend

- | | | | |
|---|--|---|--|
| <ul style="list-style-type: none"> DEQE-8
0.3 EW-M1
6.4 | <ul style="list-style-type: none"> Overburden Monitoring Well with TCE Concentration µg/L (Fall 2010) Overburden Extraction Well with TCE Concentration µg/L (Fall 2010) | <ul style="list-style-type: none"> EW-M3
26 108
2 | <ul style="list-style-type: none"> Bedrock Extraction Well with TCE Concentration µg/L (Fall 2010) Bedrock Monitoring Well with TCE Concentration µg/L (Fall 2010) |
| Estimated Extent of Overburden TCE Concentrations Exceeding MCL in Fall 2010 | | | |



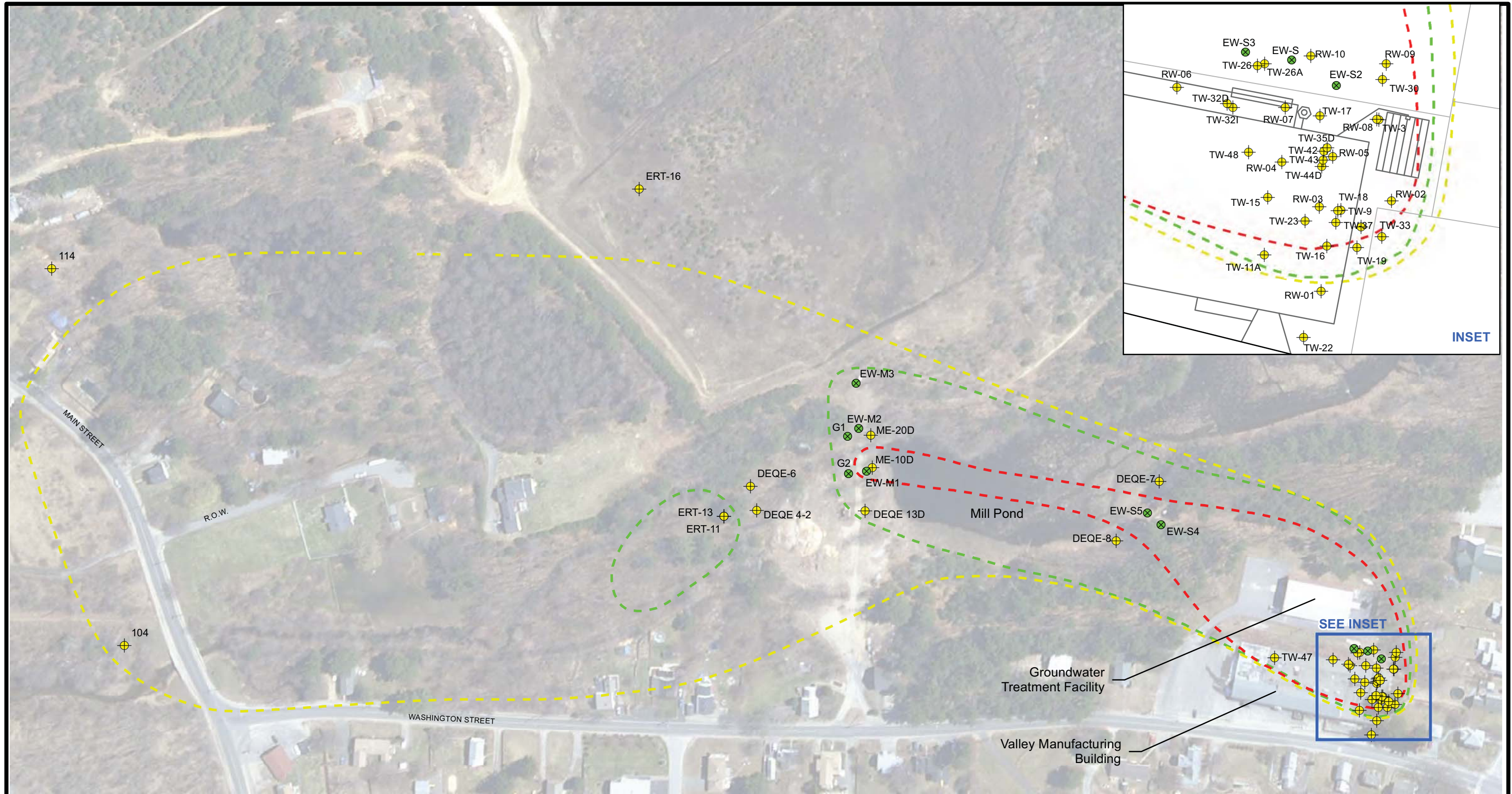
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FIGURE 4

**OVERBURDEN TCE PLUME
FALL 2010
GROVELAND WELLS
GROVELAND, MASSACHUSETTS**

PREPARED BY: AR	CHECKED BY: DB
PROJECT NO. 81015	DATE: 12/21/2011

Path: R:\80000 Task Orders\80037 Groveland Wells RAI\Technical Data - new and previous\GIS\Nobis Maps\Community Involvement Plan\Fig_2-1_Overburden_TCE_Plume.mxd

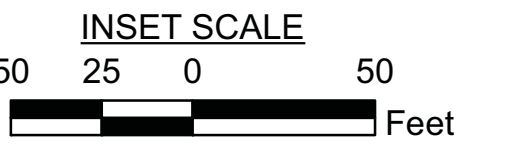
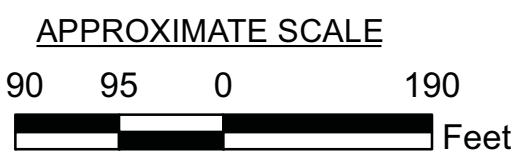


Legend

- DEQE-8 Overburden Monitoring Well
- EW-M1 Management of Mitigation Extraction Well
- Extent of TCE Overburden Plume < 5 µg/L Prior to System Startup in 2000
- Extent of TCE Overburden Plume > 5 µg/L in 2006
- Extent of TCE Overburden Plume < 5 µg/L in 2010



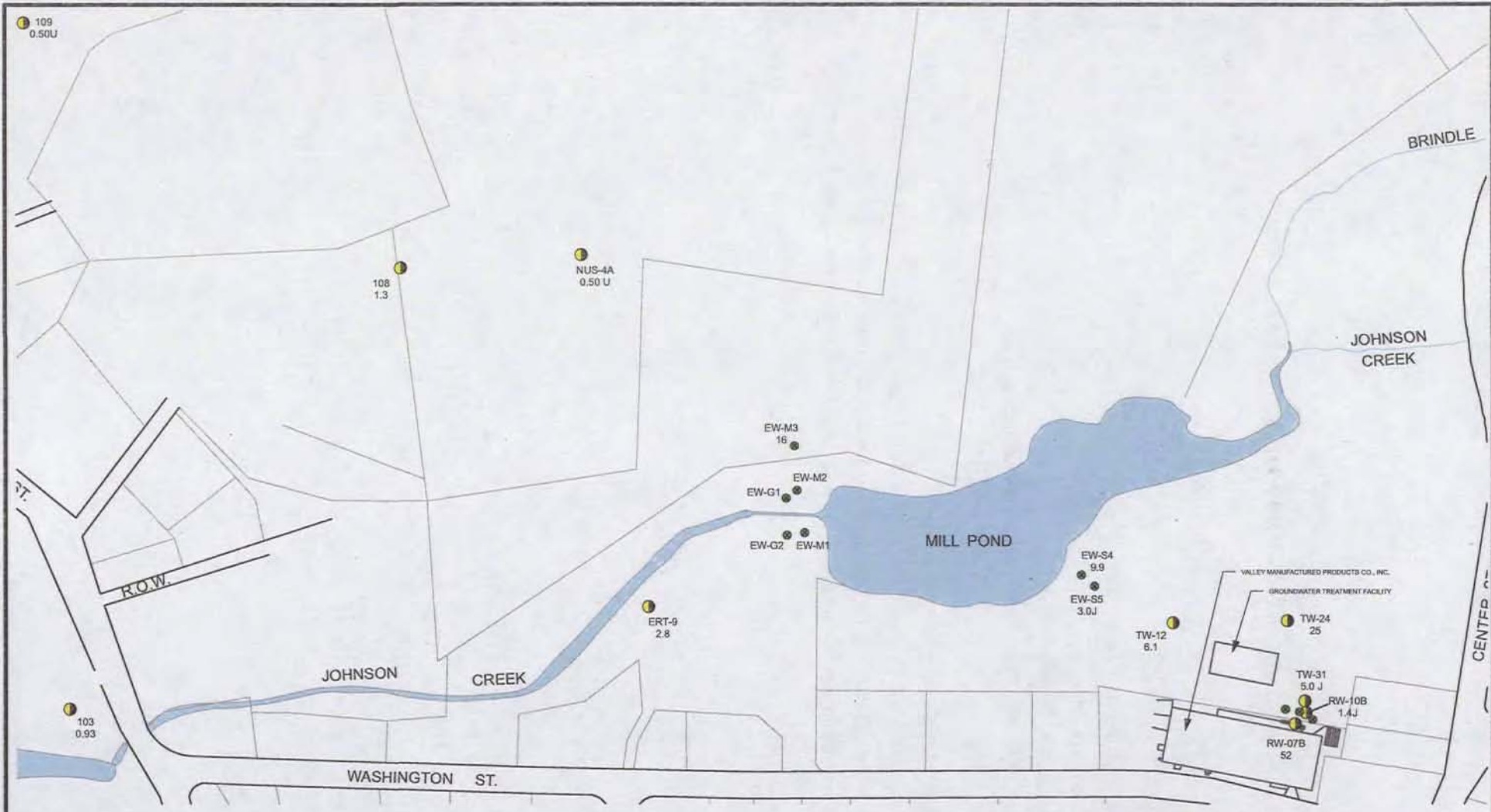
Notes:
1. Aerial photograph provided by MassGIS.



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FIGURE 2-1	
OVERBURDEN GROUNDWATER TRICHLOROETHENE PLUME 2000, 2006, AND 2010 GROVELAND WELLS SUPERFUND SITE GROVELAND, MASSACHUSETTS	
PREPARED BY: JMH	CHECKED BY: LS
PROJECT NO. 80037	DATE: 8/18/2011

R:\90000 Task Orders\80053 Groveland Wells FYR\Technical Data\GIS Data\Figures\BR TCE Concentrations.mxd

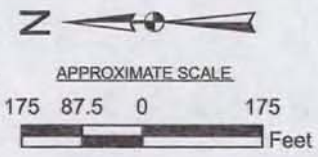


Notes

1. The current limits of Mill Pond are typically smaller than depicted, and are subject to seasonal fluctuations.
2. TCE concentrations shown are for the most recent sampling data available: Fall 2009 for all extraction wells and all monitoring wells located outside the Source Area; Summer 2009 for all monitoring wells located within the Source Area ("RW" wells).

Legend

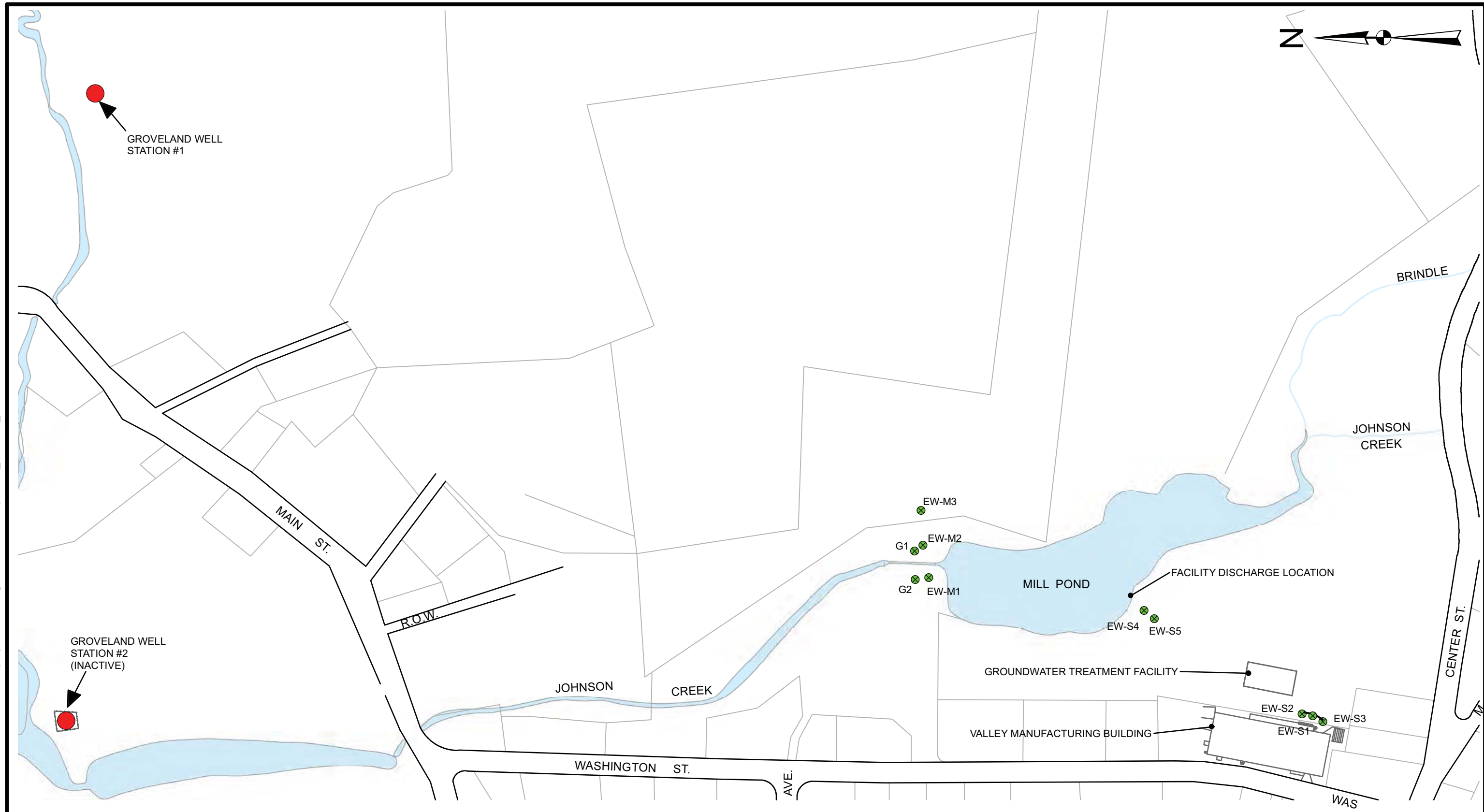
- ERT-9 2.8 Existing Bedrock Monitoring Well Used in 2009 Monitoring with TCE Concentration (µg/L)
- EW-M3 16 Existing Extraction Well with TCE concentration (µg/L)



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FIGURE 7	
BEDROCK GROUNDWATER TCE CONCENTRATIONS - FALL 2009 GROVELAND WELLS GROVELAND, MASSACHUSETTS	
PREPARED BY: AR	CHECKED BY: DL
PROJECT NO. 80053	DATE: MAY 2010

R:\80000 Task Orders\800012 Groveland Wells\Technical Data (TD)\GIS Data\Figures\Fall 2010 Report\2-1_Site Plan_OU1.mxd

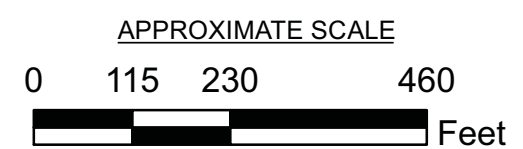


Legend

- ⊗ Existing Extraction Well
- Public Water Supply Well

Notes

1. The current limits of Mill Pond are typically smaller than depicted, and are subject to seasonal fluctuations.



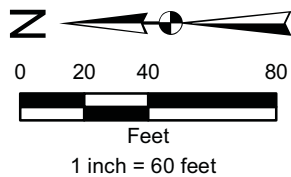
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FIGURE 2	
OPERABLE UNIT 1 SITE PLAN GROVELAND WELLS GROVELAND, MASSACHUSETTS	
PREPARED BY: AR	CHECKED BY: DB
PROJECT NO. 81015	DATE: 12/21/2011



In Situ Treatment Zones

- ISTT Area A, 0 to 45 feet below ground surface (8,460 ft²)
- ISTT Area B, 0 to 25 feet below ground surface (910 ft²)
- ISTT Area C, 0 to 10 feet below ground surface (2,950 ft²)
- ISTT Area D, 0 to 10 feet below ground surface (2,370 ft²)



Notes:

1. Aerial photograph provided by MassGIS

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FIGURE 3-1

**IN SITU THERMAL TREATMENT AREAS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS**

PREPARED BY: JMH

CHECKED BY: LS

PROJECT NO. 80037

DATE: 8/18/2011

Well Location	CIS-1,2-DCE Results (µg/l)	Sample Date
RW-01	5 U	8/25/2009
RW-02	3 J	8/25/2009
RW-03	260 DJ	8/26/2009
RW-04	57	8/24/2009
RW-05	325 DJ	8/26/2009
RW-06	5 U	8/25/2009
RW-07	37	8/25/2009
RW-07B	5 J	8/26/2009
RW-08	5 U	8/25/2009
RW-09	3 J	8/26/2009
RW-10	160	8/26/2009
RW-10B	5 U	8/26/2009
TW-31	5 U	6/30/2009
TW-9	340	6/30/2009
TW-11A	5 U	6/30/2009
TW-15	17	6/29/2009
TW-18	2 J	6/30/2009
TW-19	20	6/30/2009
TW-23	160	6/30/2009
TW-26	8	6/30/2009
TW-30	5 U	7/1/2009
TW-31	5 U	6/30/2009
TW-33	5 U	7/1/2009
TW-40	5 U	7/1/2009
TW-42	1000 U	7/1/2009
TW-43	170	7/1/2009
TW-44D	200 D	7/1/2009
TW-47	1 J	7/1/2009
TW-48	120	6/29/2009



Legend

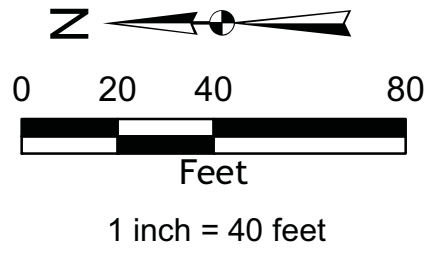
CIS 1,2 DCE RESULTS (µg/l)

●	< 70
●	70 - 200
●	> 200

ISTT Area A Boundary

Notes:

- The site cleanup goal for CIS 1,2 DCE in groundwater is 70 µg/kg.
- Qualifiers:
 - U - Not detected above the sample-specific detection limit.
 - J - Quantitation is estimated as it is below the sample-specific detection limit.
 - D - Concentration is reported from a dilution of the sample.



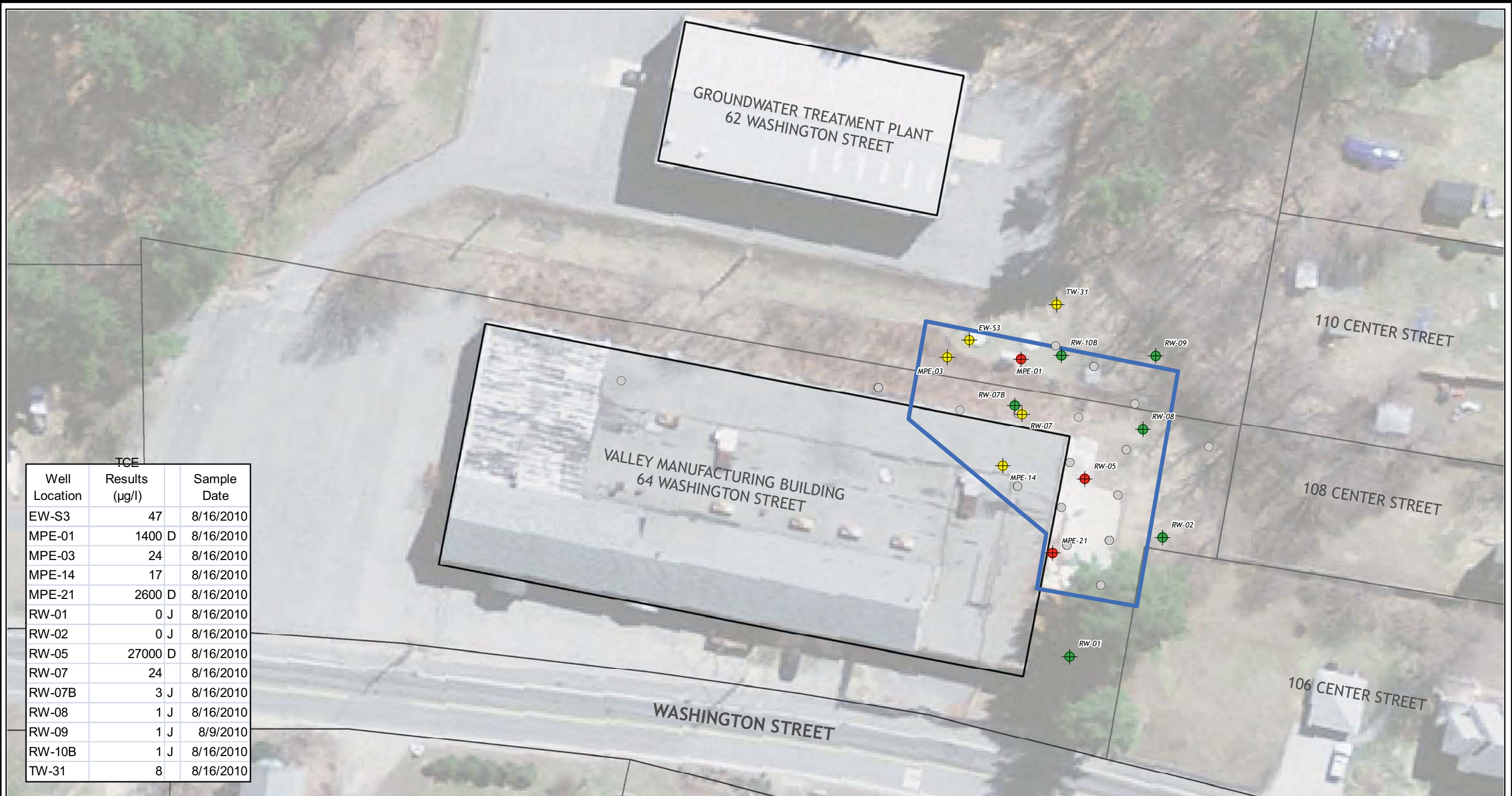
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FIGURE 4-5

BASELINE CIS-1,2-DICHLOROETHENE RESULTS IN GROUNDWATER GROVELAND WELLS SUPERFUND SITE GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\180000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_6-1_Aug_2010_TCE.mxd



TCE

Well Location	Results (µg/l)	Sample Date
EW-S3	47	8/16/2010
MPE-01	1400 D	8/16/2010
MPE-03	24	8/16/2010
MPE-14	17	8/16/2010
MPE-21	2600 D	8/16/2010
RW-01	0 J	8/16/2010
RW-02	0 J	8/16/2010
RW-05	27000 D	8/16/2010
RW-07	24	8/16/2010
RW-07B	3 J	8/16/2010
RW-08	1 J	8/16/2010
RW-09	1 J	8/9/2010
RW-10B	1 J	8/16/2010
TW-31	8	8/16/2010

Legend

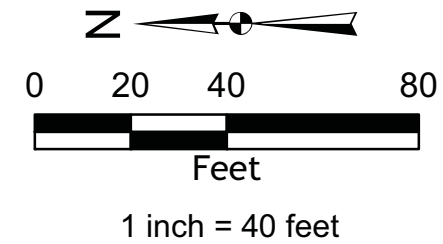
TCE RESULTS (µg/l)

	< 5
	5 - 200
	> 200
	Not Sampled

ISTT Area A Boundary

Notes:

- The site cleanup goal for TCE in groundwater is 5 µg/kg.
- Qualifiers:
 J - Quantitation is estimated as it is below the sample-specific detection limit.
 D - Concentration is reported from a dilution of the sample.

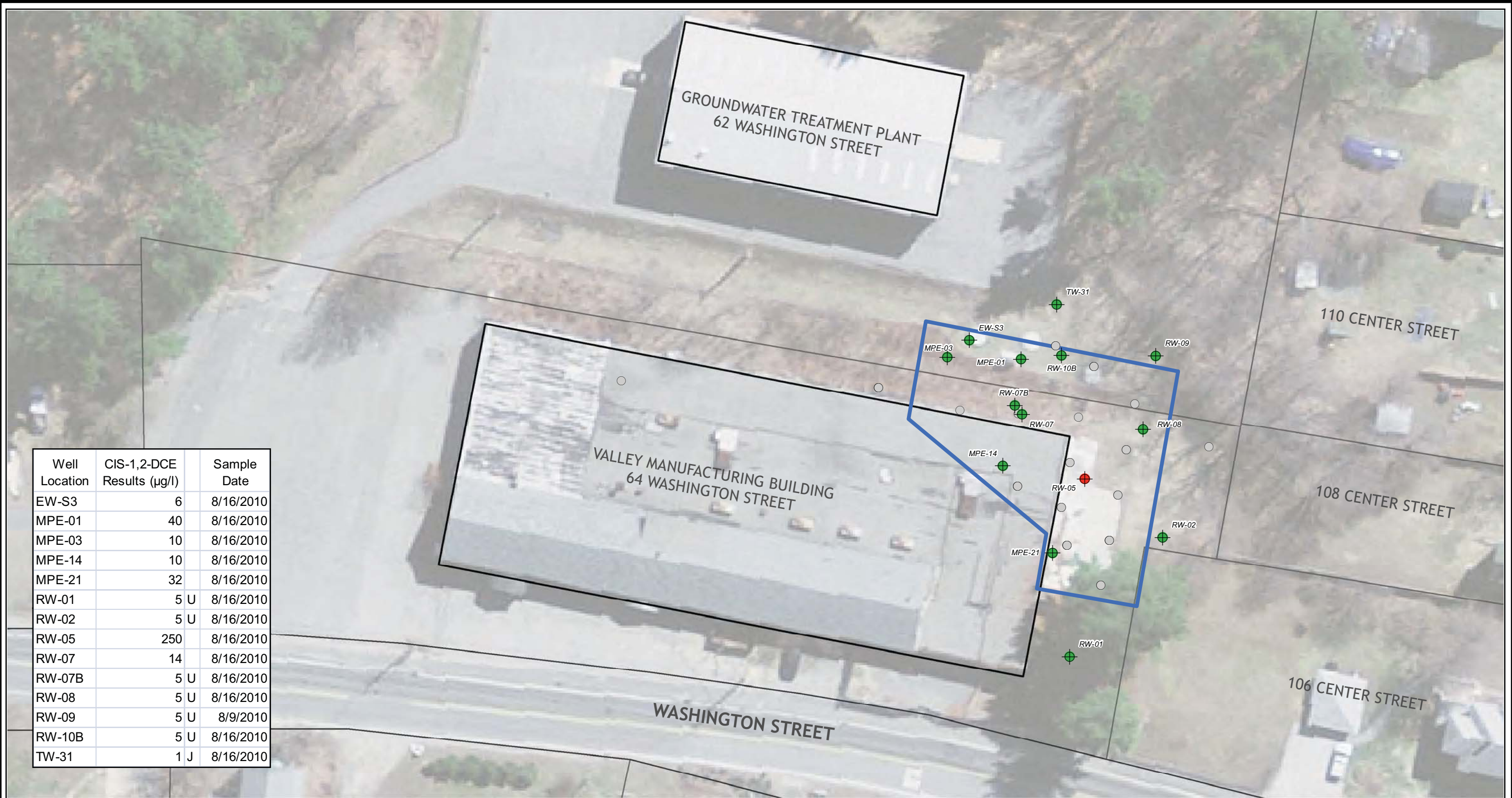


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FIGURE 6-1

ISTT OPERATIONS
 TRICHLOROETHENE RESULTS
 IN GROUNDWATER - AUGUST 2010
 GROVELAND WELLS SUPERFUND SITE
 GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011



Well Location	CIS-1,2-DCE Results (µg/l)	Sample Date
EW-S3	6	8/16/2010
MPE-01	40	8/16/2010
MPE-03	10	8/16/2010
MPE-14	10	8/16/2010
MPE-21	32	8/16/2010
RW-01	5 U	8/16/2010
RW-02	5 U	8/16/2010
RW-05	250	8/16/2010
RW-07	14	8/16/2010
RW-07B	5 U	8/16/2010
RW-08	5 U	8/16/2010
RW-09	5 U	8/9/2010
RW-10B	5 U	8/16/2010
TW-31	1 J	8/16/2010

Legend

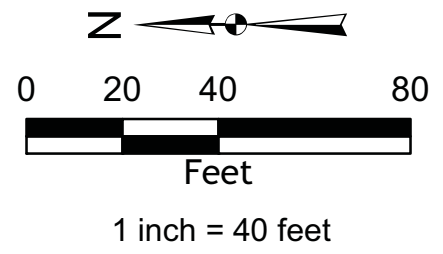
CIS-1,2-DCE RESULTS (µg/l)

	< 70
	70 - 200
	> 200
	Not Sampled

ISTT Area A Boundary

Notes:

- The site cleanup goal for CIS 1,2 DCE in groundwater is 77 µg/kg.
- Qualifiers:
 - U - Not detected above the sample-specific detection limit.
 - J - Quantitation is estimated as it is below the sample-specific detection limit.

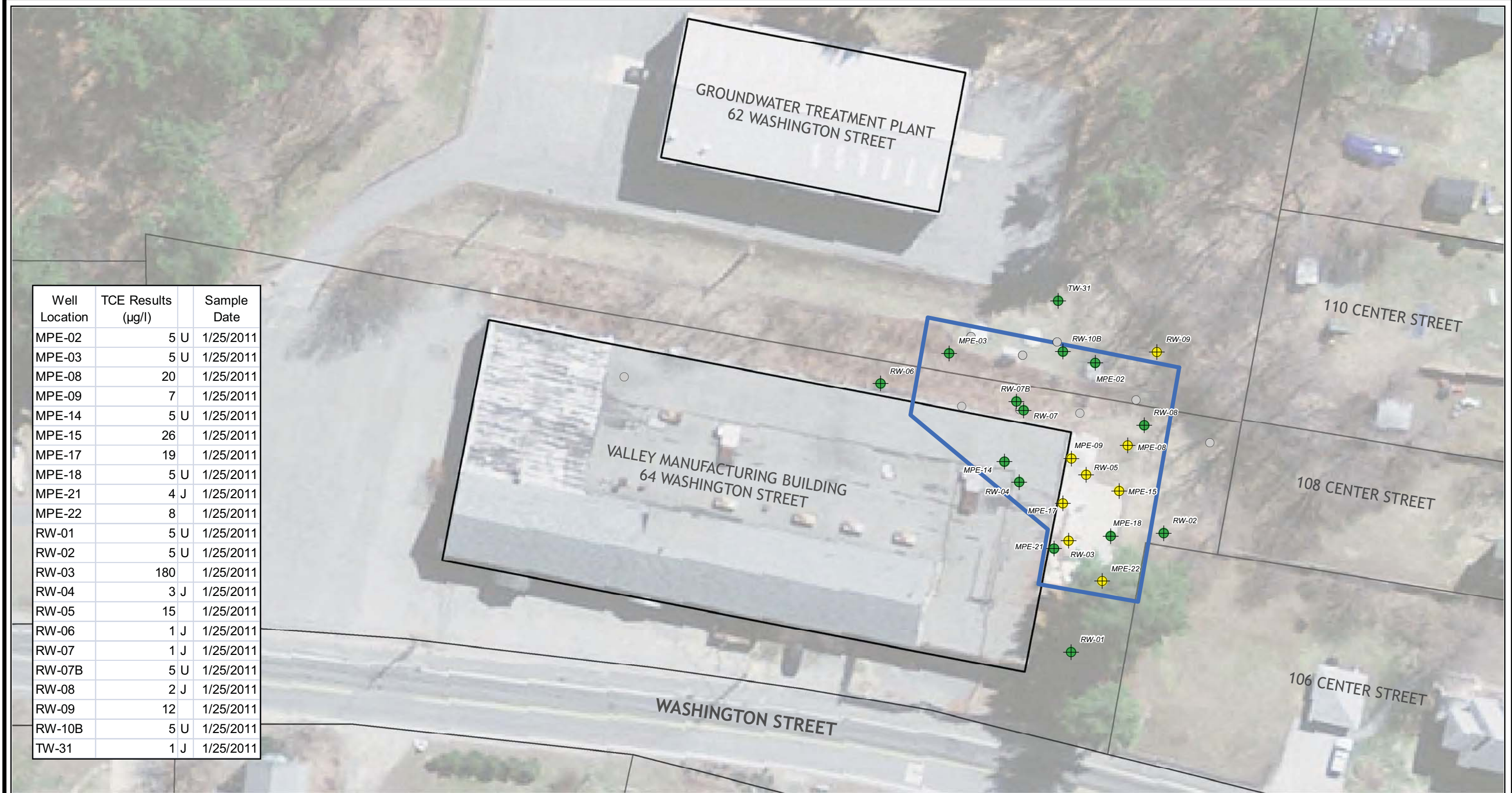


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FIGURE 6-2
ISTT OPERATIONS
CIS-1,2-DICHLOROETHENE
RESULTS IN GROUNDWATER - AUGUST 2010
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Well Location	TCE Results (µg/l)	Sample Date
MPE-02	5 U	1/25/2011
MPE-03	5 U	1/25/2011
MPE-08	20	1/25/2011
MPE-09	7	1/25/2011
MPE-14	5 U	1/25/2011
MPE-15	26	1/25/2011
MPE-17	19	1/25/2011
MPE-18	5 U	1/25/2011
MPE-21	4 J	1/25/2011
MPE-22	8	1/25/2011
RW-01	5 U	1/25/2011
RW-02	5 U	1/25/2011
RW-03	180	1/25/2011
RW-04	3 J	1/25/2011
RW-05	15	1/25/2011
RW-06	1 J	1/25/2011
RW-07	1 J	1/25/2011
RW-07B	5 U	1/25/2011
RW-08	2 J	1/25/2011
RW-09	12	1/25/2011
RW-10B	5 U	1/25/2011
TW-31	1 J	1/25/2011



Legend

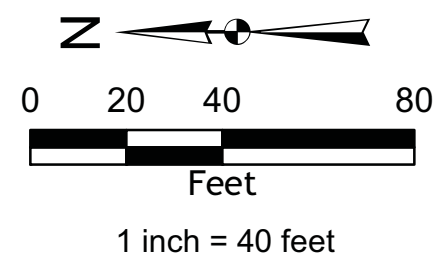
TCE RESULTS (µg/l)

	< 5
	5 - 200
	> 200
	Not Sampled

ISTT Area A Boundary

Notes:

- The site cleanup goal for TCE in groundwater is 5 µg/kg.
- Qualifiers:
 U - Not detected above the sample-specific detection limit.
 J - Quantitation is estimated as it is below the sample-specific detection limit.



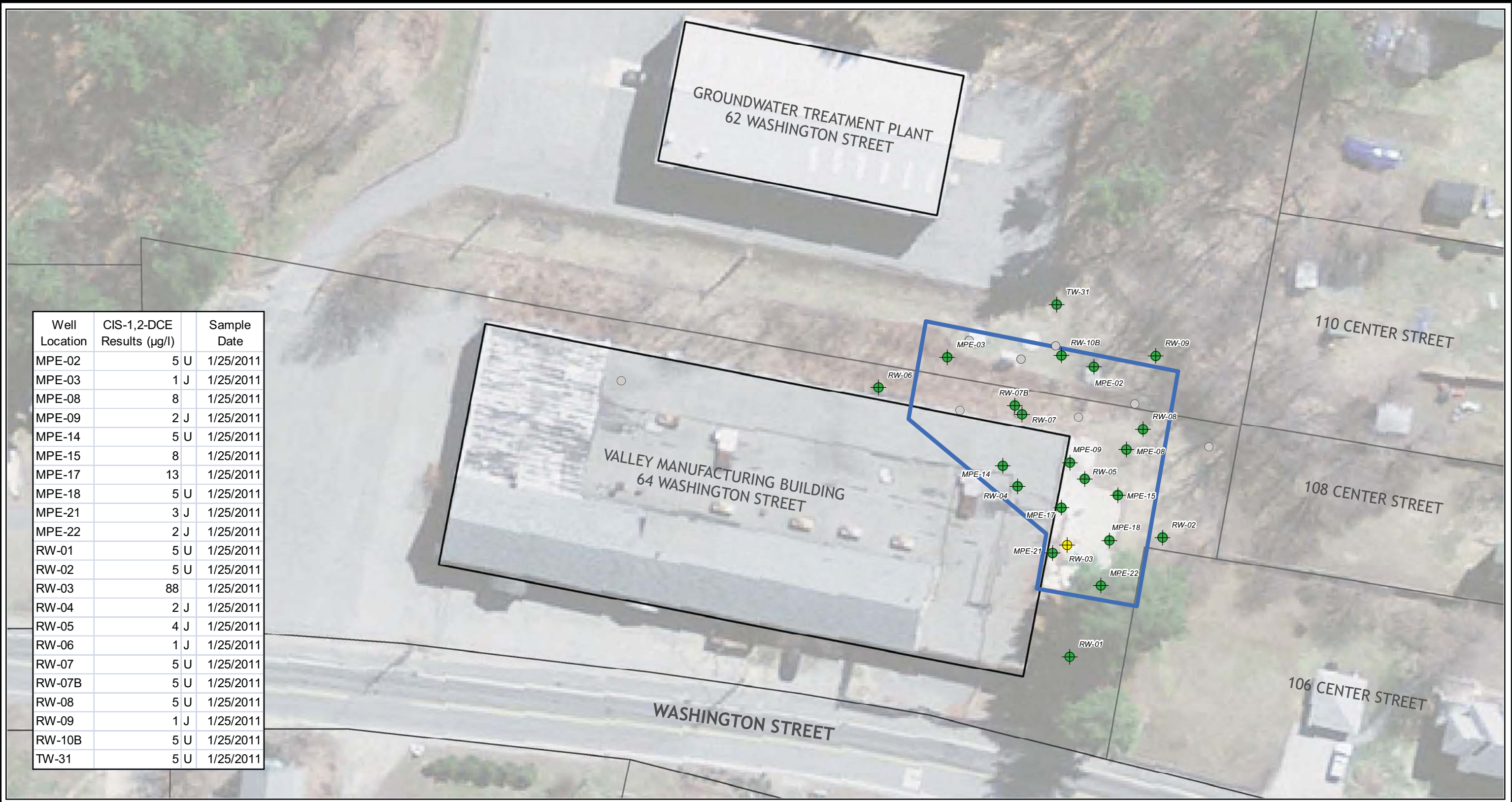
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FIGURE 6-3

ISTT OPERATIONS
 TRICHLOROETHENE RESULTS
 IN GROUNDWATER - JANUARY 2011
 GROVELAND WELLS SUPERFUND SITE
 GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_6-4_Jan_2011_1_2 DCE.mxd 1:05:44 PM



Well Location	CIS-1,2-DCE Results (µg/l)	Sample Date
MPE-02	5 U	1/25/2011
MPE-03	1 J	1/25/2011
MPE-08	8	1/25/2011
MPE-09	2 J	1/25/2011
MPE-14	5 U	1/25/2011
MPE-15	8	1/25/2011
MPE-17	13	1/25/2011
MPE-18	5 U	1/25/2011
MPE-21	3 J	1/25/2011
MPE-22	2 J	1/25/2011
RW-01	5 U	1/25/2011
RW-02	5 U	1/25/2011
RW-03	88	1/25/2011
RW-04	2 J	1/25/2011
RW-05	4 J	1/25/2011
RW-06	1 J	1/25/2011
RW-07	5 U	1/25/2011
RW-07B	5 U	1/25/2011
RW-08	5 U	1/25/2011
RW-09	1 J	1/25/2011
RW-10B	5 U	1/25/2011
TW-31	5 U	1/25/2011

Legend

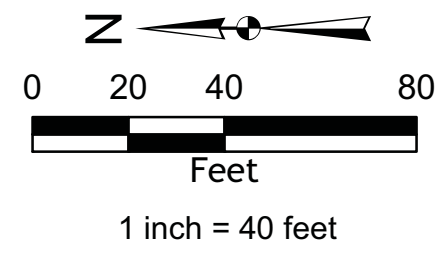
CIS-1,2 DCE RESULTS (µg/l)

	< 70
	70 - 200
	> 200
	Not Sampled

ISST Area A Boundary

Notes:

- The site cleanup goal for CIS 1,2 DCE in groundwater is 70 µg/kg.
- Qualifiers:
 U - Not detected above the sample-specific detection limit.
 J - Quantitation is estimated as it is below the sample-specific detection limit.



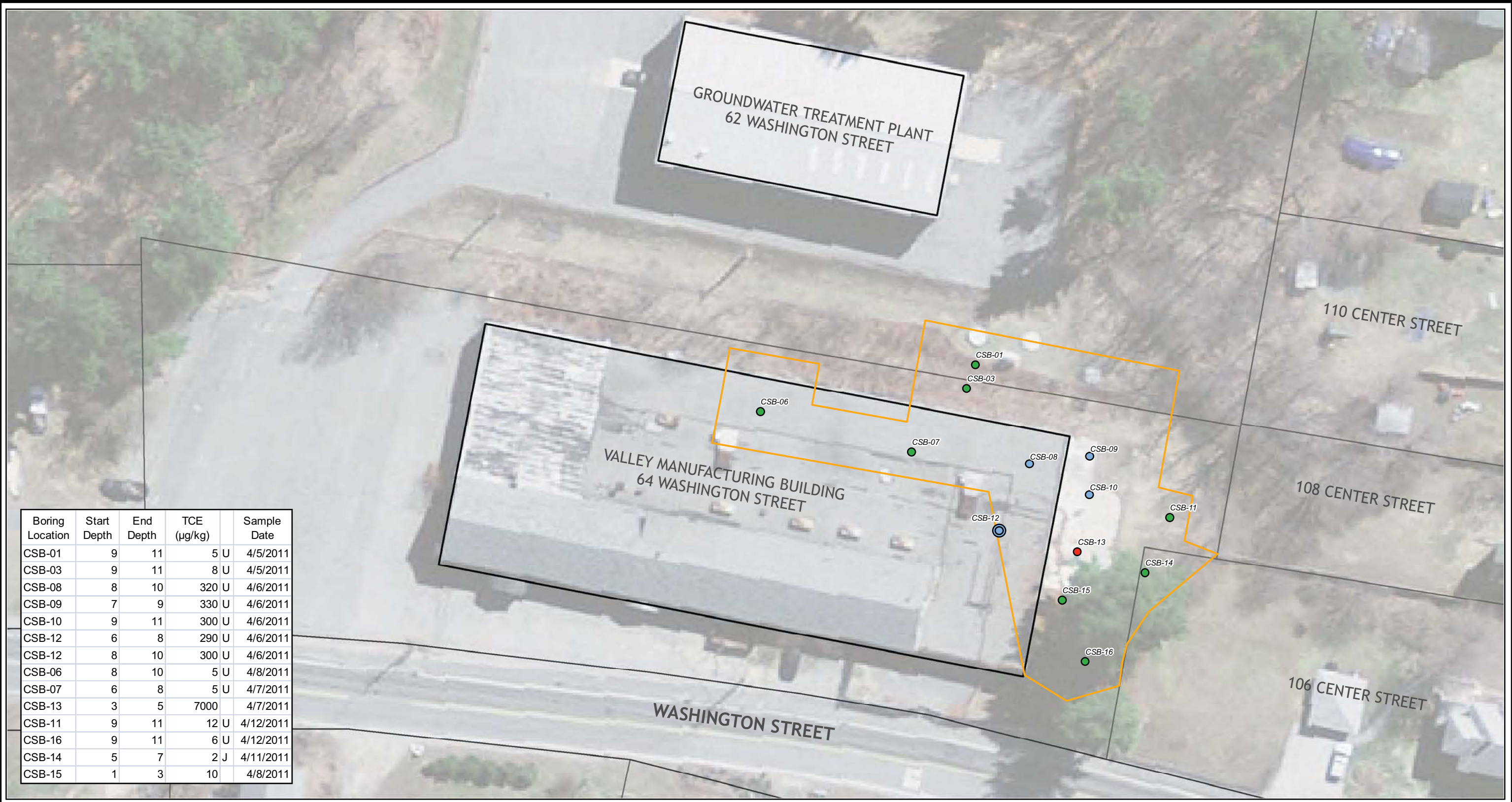
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FIGURE 6-4

ISTT OPERATIONS
 CIS-1,2-DICHLOROETHENE RESULTS
 IN GROUNDWATER - JANUARY 2011
 GROVELAND WELLS SUPERFUND SITE
 GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous GIS\Nobis Maps\Soil Maps\Fig_7-3_Confirmation_Soil_TCE_0-11ft.mxd 9/16/2011 1:19:47 PM



Boring Location	Start Depth	End Depth	TCE (µg/kg)		Sample Date
CSB-01	9	11	5	U	4/5/2011
CSB-03	9	11	8	U	4/5/2011
CSB-08	8	10	320	U	4/6/2011
CSB-09	7	9	330	U	4/6/2011
CSB-10	9	11	300	U	4/6/2011
CSB-12	6	8	290	U	4/6/2011
CSB-12	8	10	300	U	4/6/2011
CSB-06	8	10	5	U	4/8/2011
CSB-07	6	8	5	U	4/7/2011
CSB-13	3	5	7000		4/7/2011
CSB-11	9	11	12	U	4/12/2011
CSB-16	9	11	6	U	4/12/2011
CSB-14	5	7	2	J	4/11/2011
CSB-15	1	3	10		4/8/2011

Legend

TCE RESULTS
0-11 ft BGS (µg/kg)

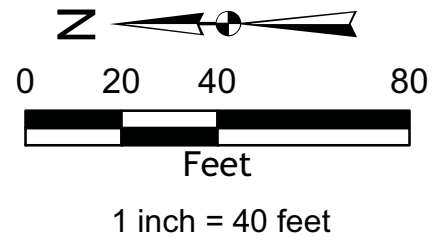
- < 77
- 77 - 500
- > 500
- 290 - 330 U

● Multiple samples collected within Figure depth range

Thermal Treatment Area

Notes:

- The site cleanup goal for TCE in vadose zone soil is 77 µg/kg.
- Qualifiers:
 - U - Not detected above the sample-specific detection limit.
 - J - Quantitation is estimated as it is below the sampling-specific detection limit.



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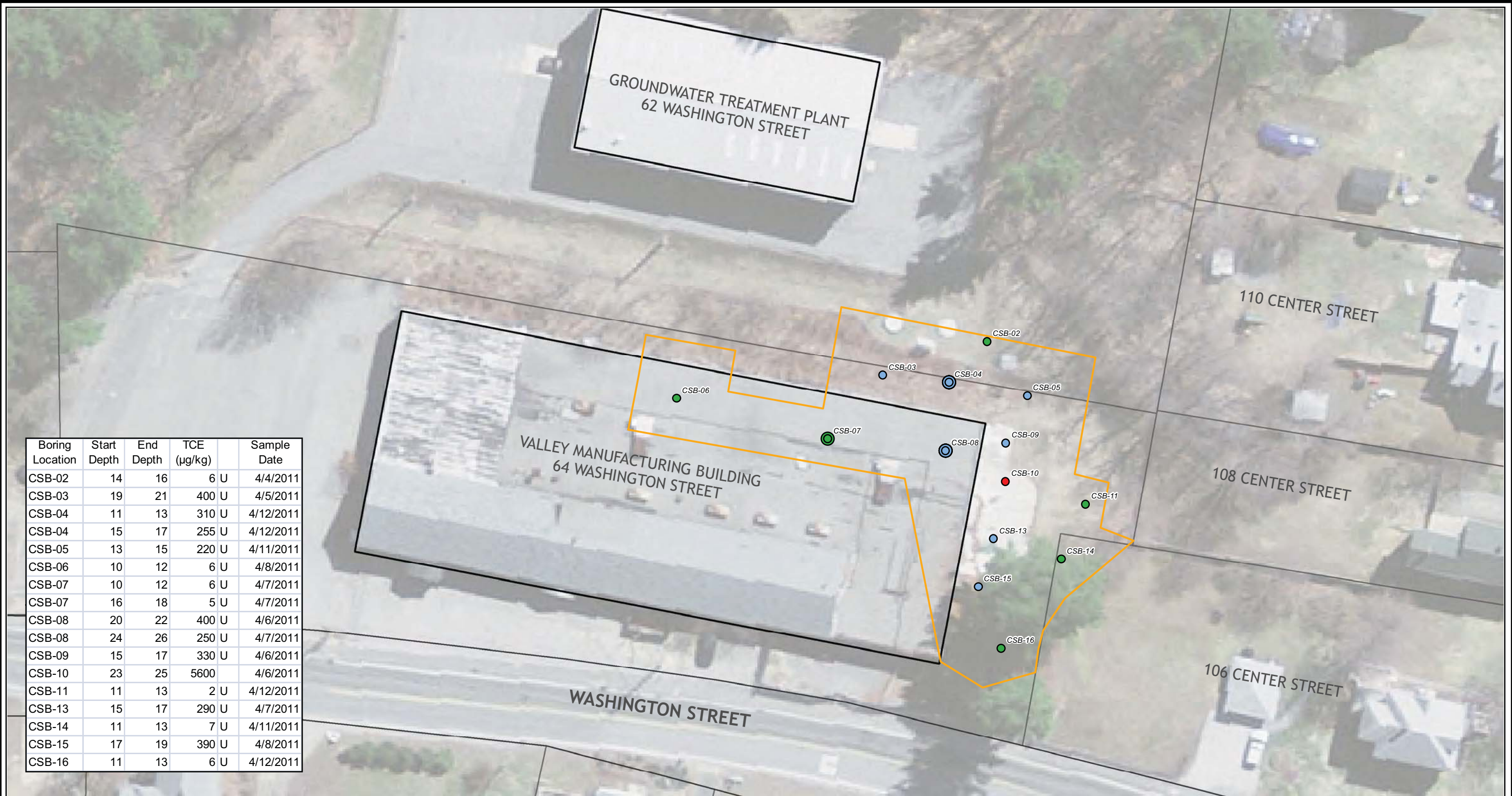
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FIGURE 7-3

CONFIRMATION SOIL SAMPLING
TRICHLOROETHENE - 0-11 FT BGS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Soil Maps\Fig. 7-4_Confirmation_Soil_TCE_11-26ft.mxd 8/26/2011 1:29:57 PM



Boring Location	Start Depth	End Depth	TCE (µg/kg)	Qualifiers	Sample Date
CSB-02	14	16	6	U	4/4/2011
CSB-03	19	21	400	U	4/5/2011
CSB-04	11	13	310	U	4/12/2011
CSB-04	15	17	255	U	4/12/2011
CSB-05	13	15	220	U	4/11/2011
CSB-06	10	12	6	U	4/8/2011
CSB-07	10	12	6	U	4/7/2011
CSB-07	16	18	5	U	4/7/2011
CSB-08	20	22	400	U	4/6/2011
CSB-08	24	26	250	U	4/7/2011
CSB-09	15	17	330	U	4/6/2011
CSB-10	23	25	5600		4/6/2011
CSB-11	11	13	2	U	4/12/2011
CSB-13	15	17	290	U	4/7/2011
CSB-14	11	13	7	U	4/11/2011
CSB-15	17	19	390	U	4/8/2011
CSB-16	11	13	6	U	4/12/2011

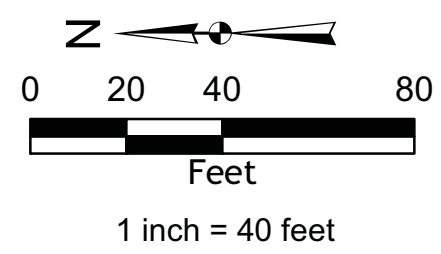
Legend

TCE RESULTS
11-26 ft bgs (µg/kg)

●	< 77
●	77 - 500
●	> 500
●	220 - 400 U

● Multiple samples collected within Figure depth range.
 — Thermal Treatment Area

Notes:
 1. The site cleanup goal for TCE in vadose zone soil is 77 µg/kg.
 2. Qualifiers:
 U - Not detected above the sample-specific detection limit

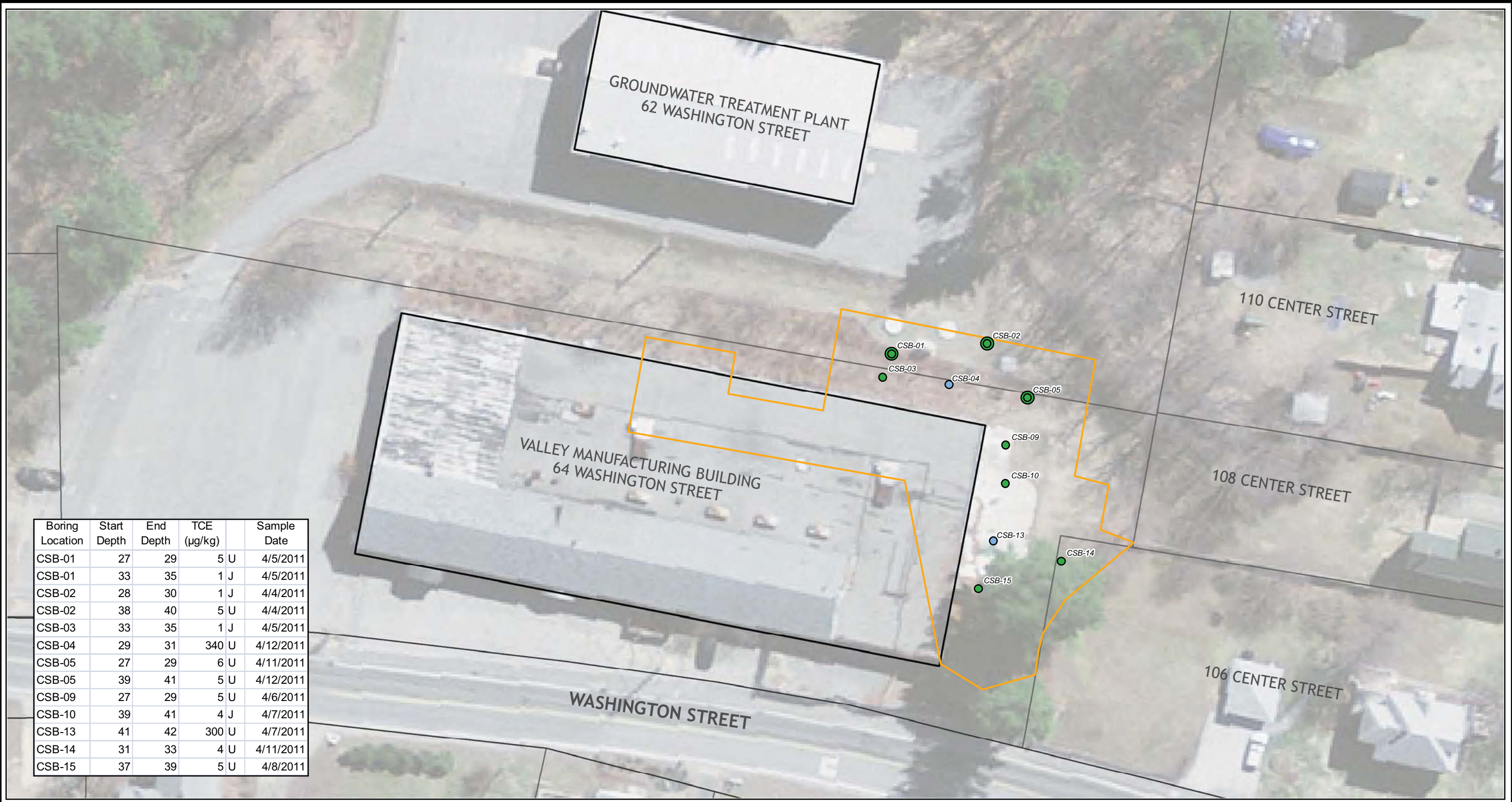


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FIGURE 7-4
 CONFIRMATION SOIL SAMPLING
 TRICHLOROETHENE - 11-26 FT BGS
 GROVELAND WELLS SUPERFUND SITE
 GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Fig_7-5_Confirmation_Soil_TCE_26-45ft.mxd 8/26/2011 1:31:29 PM



Boring Location	Start Depth	End Depth	TCE (µg/kg)	Sample Date
CSB-01	27	29	5 U	4/5/2011
CSB-01	33	35	1 J	4/5/2011
CSB-02	28	30	1 J	4/4/2011
CSB-02	38	40	5 U	4/4/2011
CSB-03	33	35	1 J	4/5/2011
CSB-04	29	31	340 U	4/12/2011
CSB-05	27	29	6 U	4/11/2011
CSB-05	39	41	5 U	4/12/2011
CSB-09	27	29	5 U	4/6/2011
CSB-10	39	41	4 J	4/7/2011
CSB-13	41	42	300 U	4/7/2011
CSB-14	31	33	4 U	4/11/2011
CSB-15	37	39	5 U	4/8/2011

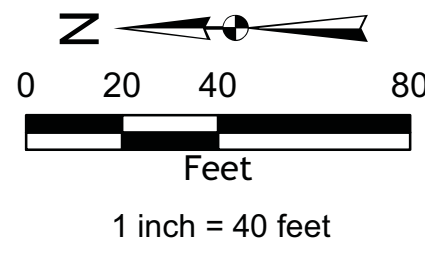
Legend

TCE RESULTS
26-45 ft bgs (µg/kg)

●	< 77
●	77 - 500
●	> 500
●	300 - 340 U

- Multiple samples collected within Figure depth range.
- Thermal Treatment Area

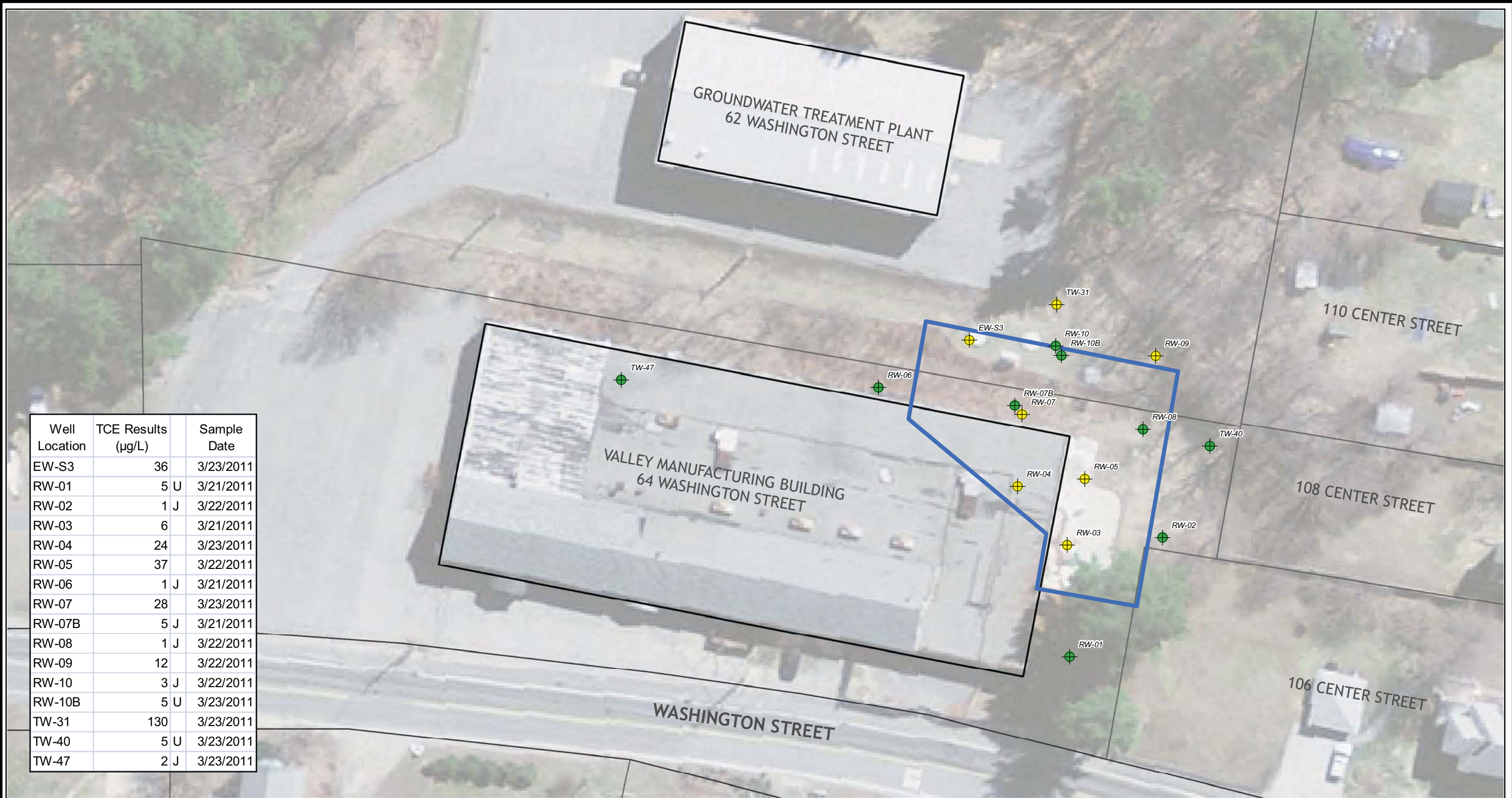
Notes:
 1. The site cleanup goal for TCE in vadose zone soil is 77 µg/kg.
 2. Qualifiers:
 U - Not detected above the sample-specific detection limit.
 J - Quantitation is estimated as it is below the sample-specific detection limit.



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FIGURE 7-5
 CONFIRMATION SOIL SAMPLING
 TRICHLOROETHENE - 26-45 FT BGS
 GROVELAND WELLS SUPERFUND SITE
 GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011



Well Location	TCE Results (µg/L)	Sample Date
EW-S3	36	3/23/2011
RW-01	5 U	3/21/2011
RW-02	1 J	3/22/2011
RW-03	6	3/21/2011
RW-04	24	3/23/2011
RW-05	37	3/22/2011
RW-06	1 J	3/21/2011
RW-07	28	3/23/2011
RW-07B	5 J	3/21/2011
RW-08	1 J	3/22/2011
RW-09	12	3/22/2011
RW-10	3 J	3/22/2011
RW-10B	5 U	3/23/2011
TW-31	130	3/23/2011
TW-40	5 U	3/23/2011
TW-47	2 J	3/23/2011

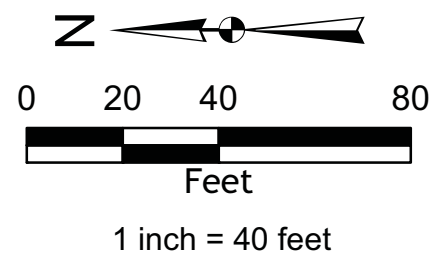
Legend

TCE RESULTS (µg/l)	
	≤ 5
	5 - 200
	> 200

ISTT Area A Boundary

Notes:

- The site cleanup goal for TCE in groundwater is 5 µg/l.
- Qualifiers:
 U - Not detected above the sample-specific detection limit.
 J - Quantitation is estimated as it is below the sample-specific detection limit.

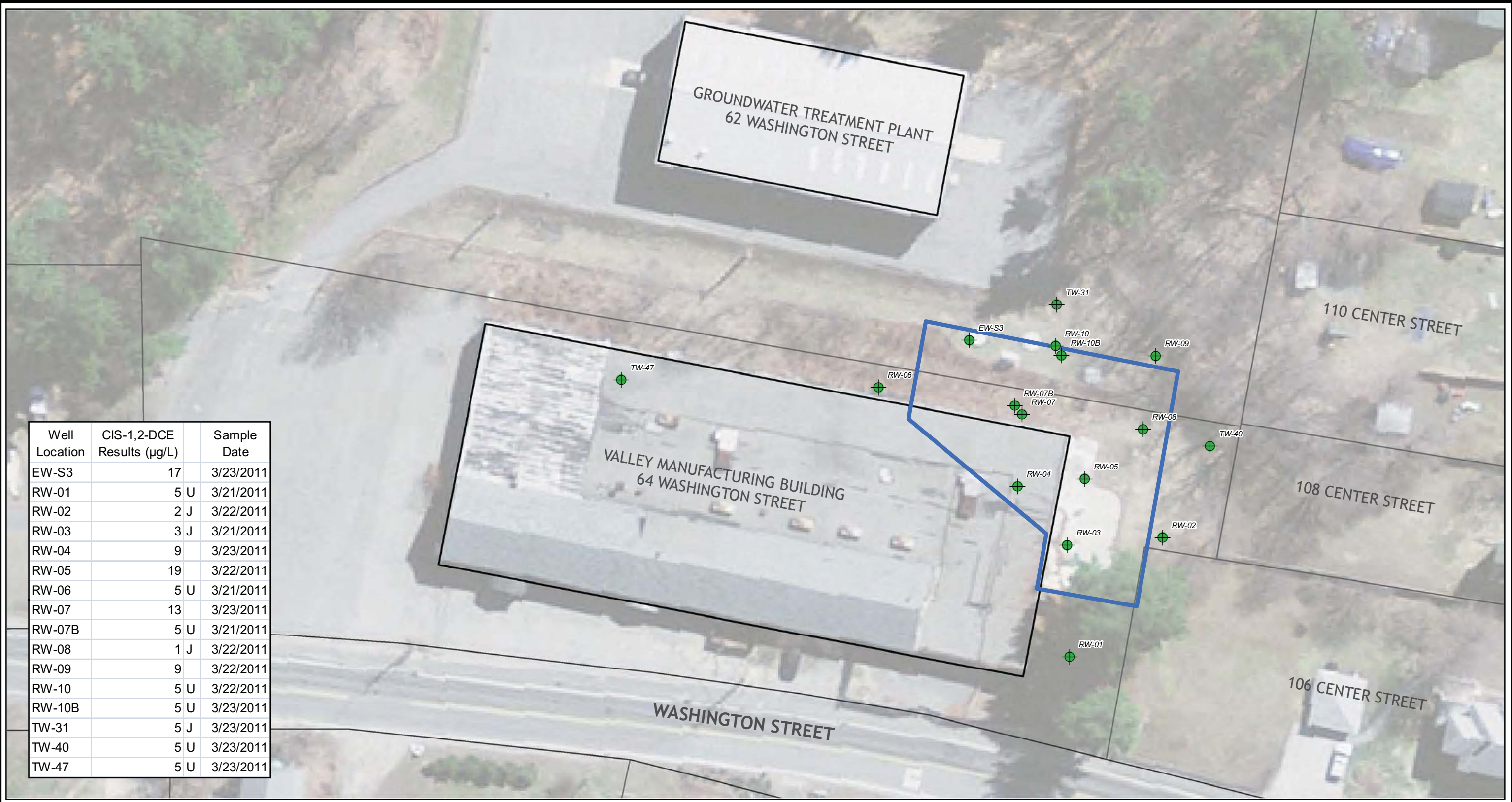


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FIGURE 7-6

CONFIRMATION GROUNDWATER SAMPLING EVENT NO. 1 TRICHLOROETHENE RESULTS MARCH 21-23, 2011 GROVELAND WELLS SUPERFUND SITE GROVELAND, MASSACHUSETTS	
PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_7-7_Mar_2011_1_2 DCE.mxd 9/19/2011 12:04:47 PM



Well Location	CIS-1,2-DCE Results (µg/L)	Sample Date
EW-S3	17	3/23/2011
RW-01	5 U	3/21/2011
RW-02	2 J	3/22/2011
RW-03	3 J	3/21/2011
RW-04	9	3/23/2011
RW-05	19	3/22/2011
RW-06	5 U	3/21/2011
RW-07	13	3/23/2011
RW-07B	5 U	3/21/2011
RW-08	1 J	3/22/2011
RW-09	9	3/22/2011
RW-10	5 U	3/22/2011
RW-10B	5 U	3/23/2011
TW-31	5 J	3/23/2011
TW-40	5 U	3/23/2011
TW-47	5 U	3/23/2011

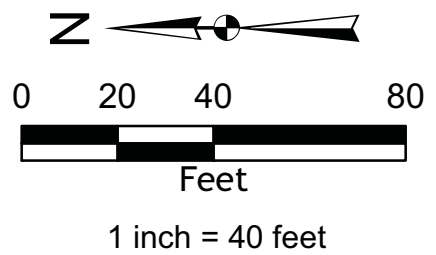
Legend

CIS 1,2 DCE RESULTS (µg/l)	
	< 70
	70-200
	> 200

ISTT Area A Boundary

Notes:

- The site cleanup goal for CIS 1,2 DCE in groundwater is 70 µg/l.
- Qualifiers:
 U - Not detected above the sample-specific detection limit
 J - Quantitation is estimated as it is below the sample-specific detection limit.



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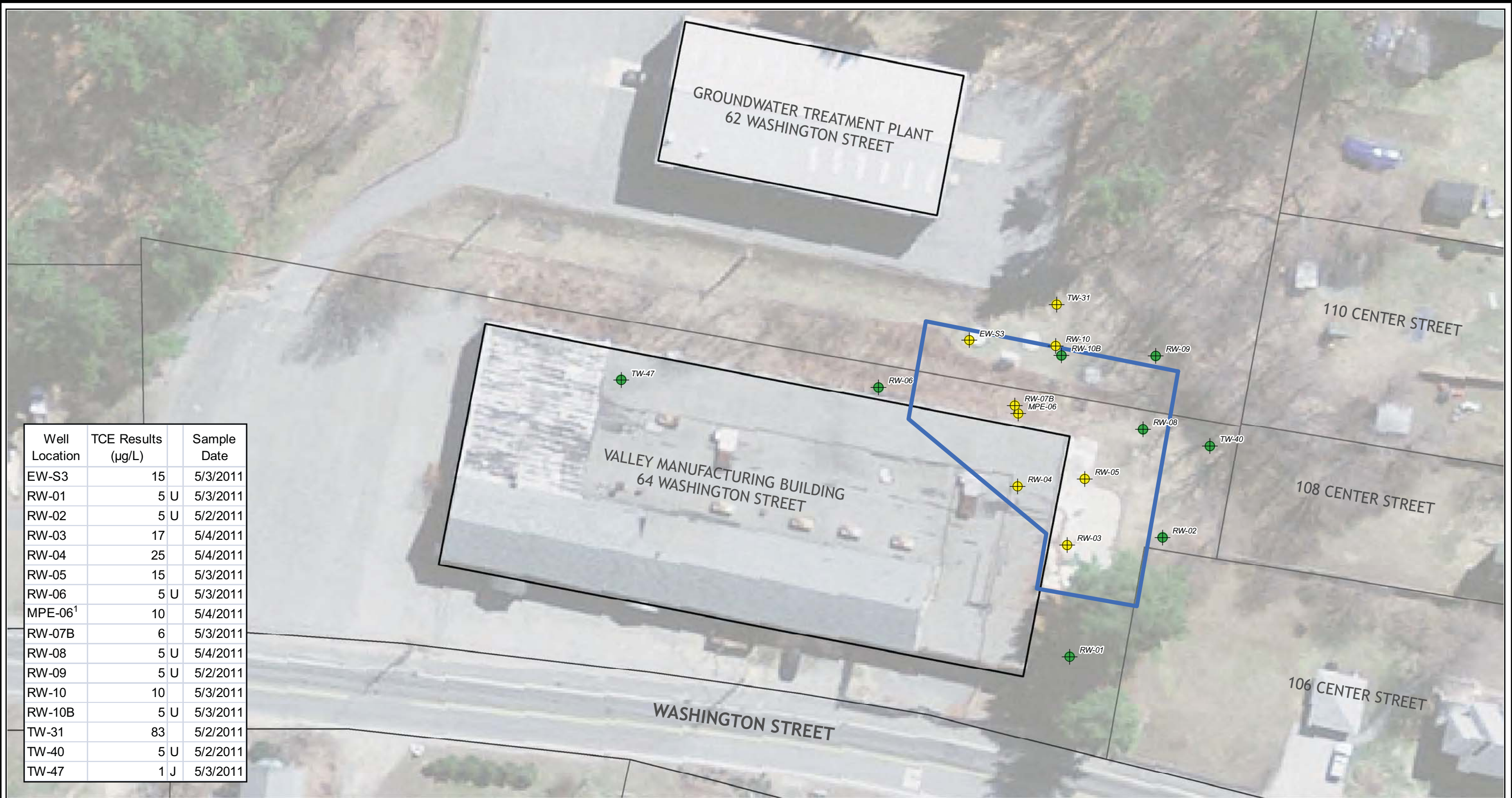
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FIGURE 7-7

CONFIRMATION GROUNDWATER SAMPLING EVENT NO. 1
 CIS-1,2-DICHLOROETHENE RESULTS
 MARCH 21-23, 2011
 GROVELAND WELLS SUPERFUND SITE
 GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\180000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig.7-8_May_2011_TCE.mxd



Well Location	TCE Results (µg/L)	Sample Date
EW-S3	15	5/3/2011
RW-01	5 U	5/3/2011
RW-02	5 U	5/2/2011
RW-03	17	5/4/2011
RW-04	25	5/4/2011
RW-05	15	5/3/2011
RW-06	5 U	5/3/2011
MPE-06 ¹	10	5/4/2011
RW-07B	6	5/3/2011
RW-08	5 U	5/4/2011
RW-09	5 U	5/2/2011
RW-10	10	5/3/2011
RW-10B	5 U	5/3/2011
TW-31	83	5/2/2011
TW-40	5 U	5/2/2011
TW-47	1 J	5/3/2011

Legend

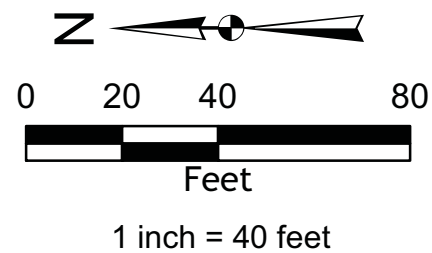
TCE RESULTS (µg/l)

- ≤ 5
- 5 - 200
- > 200

ISTT Area A Boundary

Notes:

1. Well MPE-06 was used as a substitute for RW-07 during the Confirmation Groundwater Sampling Event No. 2 only.
2. The site cleanup goal for TCE in groundwater is 5 µg/l.
3. Qualifiers:
 U - Not detected above the sample-specific detection limit
 J - Quantitation is estimated as it is below the sample-specific detection limit



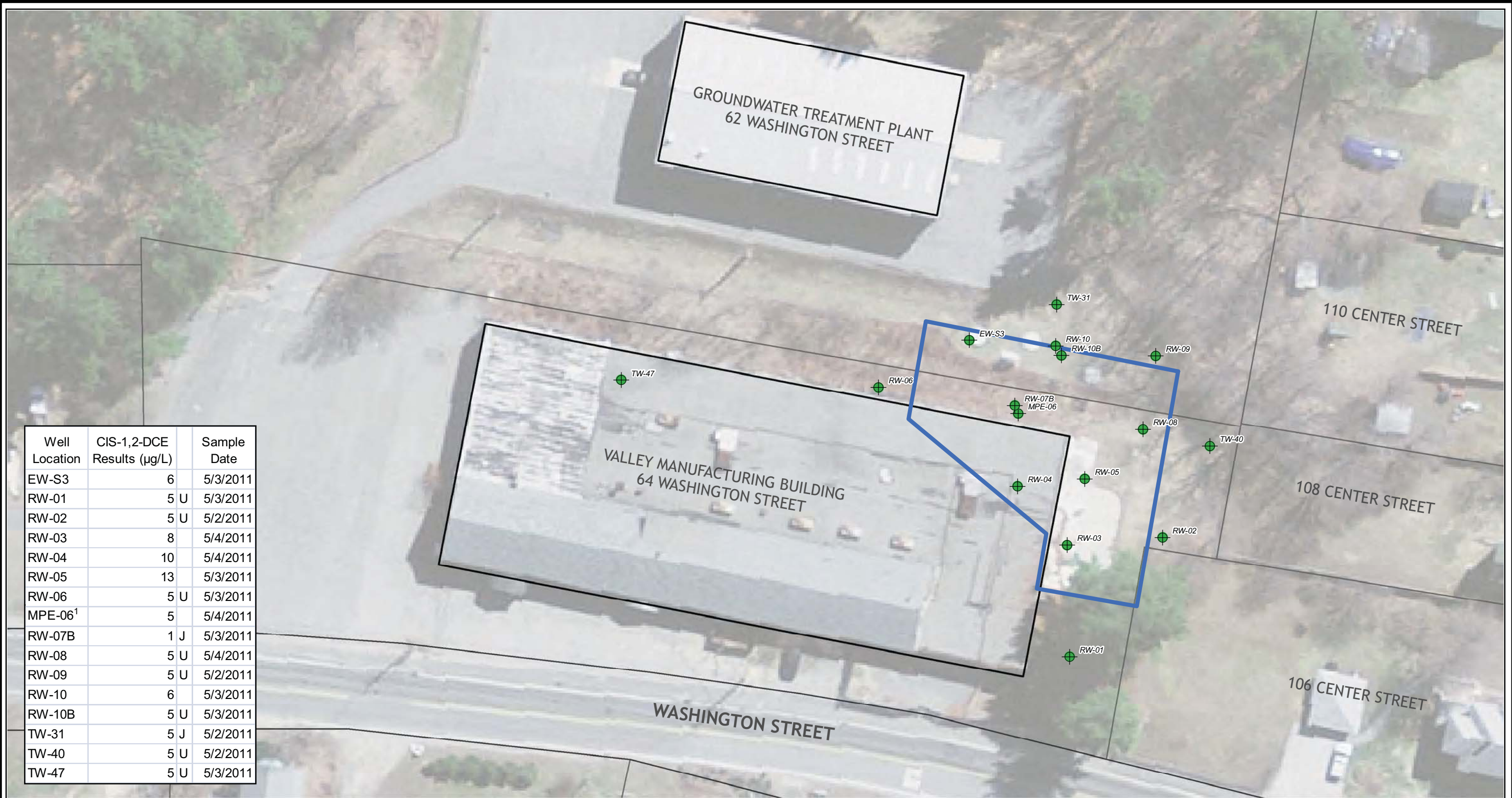
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FIGURE 7-8

CONFIRMATION GROUNDWATER SAMPLING EVENT NO. 2
 TRICHLOROETHENE RESULTS
 MAY 2-4, 2011
 GROVELAND WELLS SUPERFUND SITE
 GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_7-9_May_2011_1_2.DCE.mxd 9/19/2011 12:05:48 PM



Well Location	CIS-1,2-DCE Results (µg/L)	Sample Date
EW-S3	6	5/3/2011
RW-01	5 U	5/3/2011
RW-02	5 U	5/2/2011
RW-03	8	5/4/2011
RW-04	10	5/4/2011
RW-05	13	5/3/2011
RW-06	5 U	5/3/2011
MPE-06 ¹	5	5/4/2011
RW-07B	1 J	5/3/2011
RW-08	5 U	5/4/2011
RW-09	5 U	5/2/2011
RW-10	6	5/3/2011
RW-10B	5 U	5/3/2011
TW-31	5 J	5/2/2011
TW-40	5 U	5/2/2011
TW-47	5 U	5/3/2011

Legend

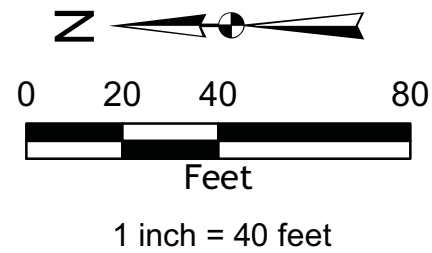
CIS 1,2 DCE RESULTS (µg/l)

- < 70
- 70 - 200
- > 200

ISTT Area A Boundary

Notes:

1. Well MPE-06 was used as a substitute for RW-07 during the second confirmation sampling event only.
2. The site cleanup goal for CIS 1,2 DCE in groundwater is 70 µg/l.
3. Qualifiers:
 U - Not detected above the sample-specific detection limit
 J - Quantitation is estimated as it is below the sample-specific detection limit



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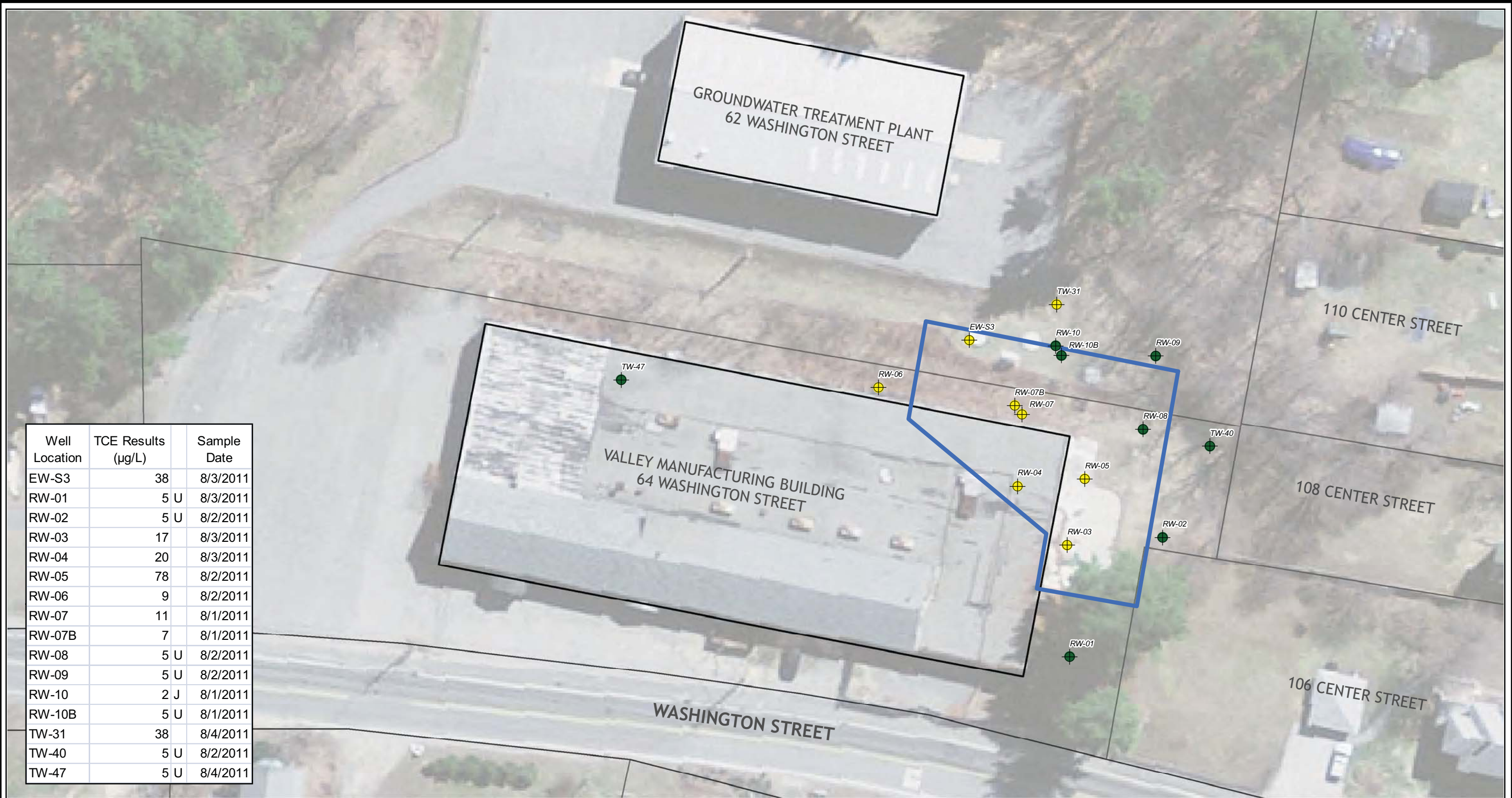
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FIGURE 7-9

CONFIRMATION GROUNDWATER SAMPLING EVENT NO. 2
 CIS-1,2-DICHLOROETHENE RESULTS
 MAY 2-4, 2011
 GROVELAND WELLS SUPERFUND SITE
 GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\800000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig.7-10_Aug_2011_TCE.mxd



Well Location	TCE Results (µg/L)	Sample Date
EW-S3	38	8/3/2011
RW-01	5 U	8/3/2011
RW-02	5 U	8/2/2011
RW-03	17	8/3/2011
RW-04	20	8/3/2011
RW-05	78	8/2/2011
RW-06	9	8/2/2011
RW-07	11	8/1/2011
RW-07B	7	8/1/2011
RW-08	5 U	8/2/2011
RW-09	5 U	8/2/2011
RW-10	2 J	8/1/2011
RW-10B	5 U	8/1/2011
TW-31	38	8/4/2011
TW-40	5 U	8/2/2011
TW-47	5 U	8/4/2011

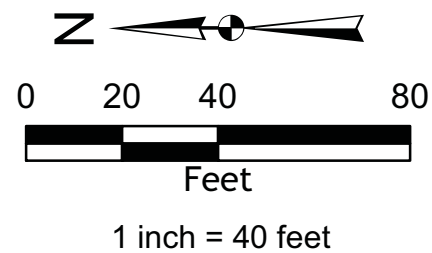
Legend

TCE RESULTS (µg/l)	
	< 5
	5 - 200
	> 200

ISTT Area A Boundary

Notes:

- The site cleanup goal for TCE in groundwater is 5 µg/l.
- Qualifiers:
 U - Not detected above the sample-specific detection limit
 J - Quantitation is estimated as it is below the sample-specific detection limit



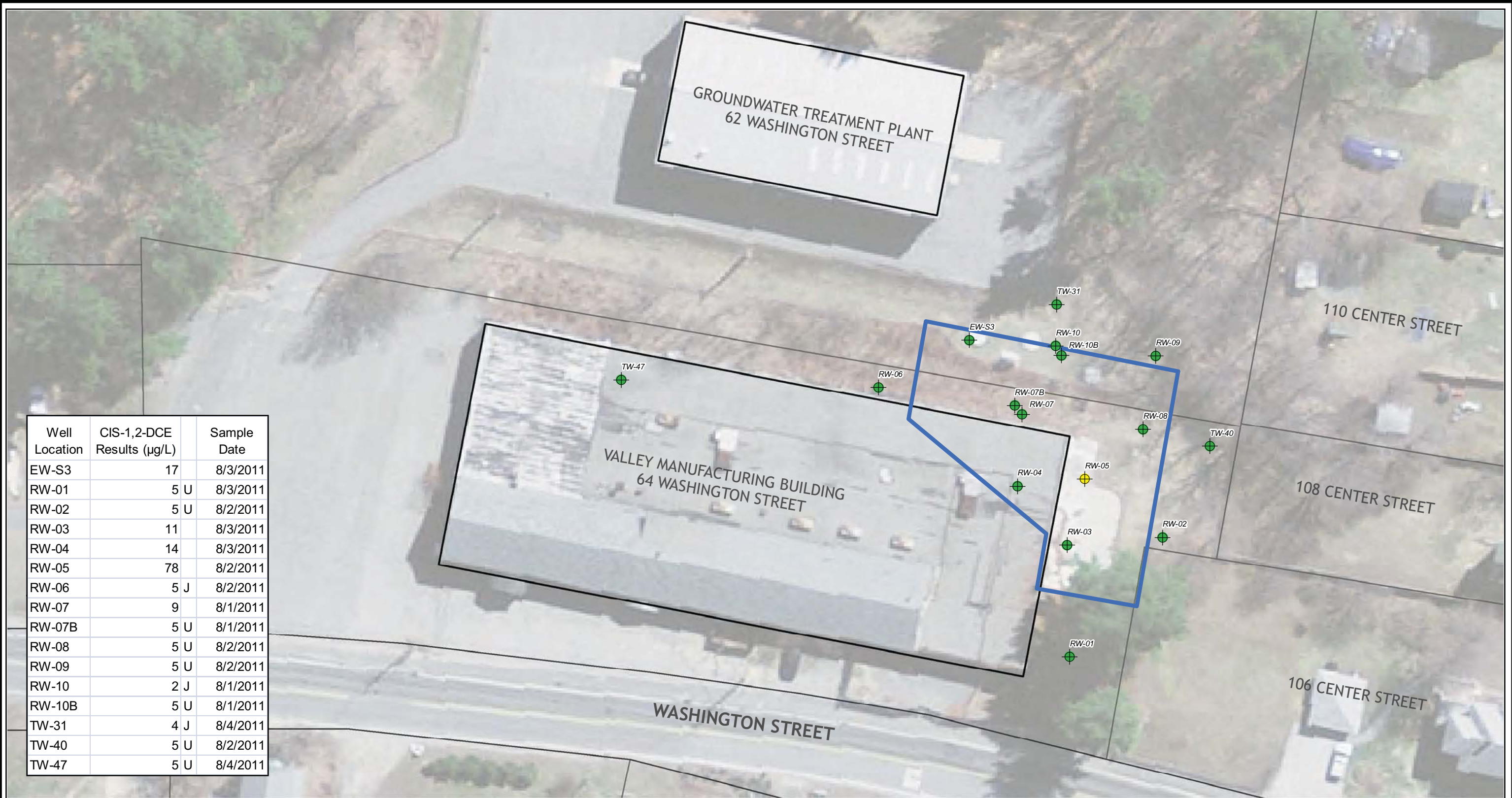
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FIGURE 7-10

CONFIRMATION GROUNDWATER SAMPLING EVENT NO. 3
 TRICHLOROETHENE RESULTS
 AUGUST 1-4, 2011
 GROVELAND WELLS SUPERFUND SITE
 GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\800000 Task Orders\80037 Groveland Wells RA Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig. 7-11_Aug. 2011_1,2 DCE.mxd 9/19/2011 12:07:06 PM



Well Location	CIS-1,2-DCE Results (µg/L)	Sample Date
EW-S3	17	8/3/2011
RW-01	5 U	8/3/2011
RW-02	5 U	8/2/2011
RW-03	11	8/3/2011
RW-04	14	8/3/2011
RW-05	78	8/2/2011
RW-06	5 J	8/2/2011
RW-07	9	8/1/2011
RW-07B	5 U	8/1/2011
RW-08	5 U	8/2/2011
RW-09	5 U	8/2/2011
RW-10	2 J	8/1/2011
RW-10B	5 U	8/1/2011
TW-31	4 J	8/4/2011
TW-40	5 U	8/2/2011
TW-47	5 U	8/4/2011

Legend

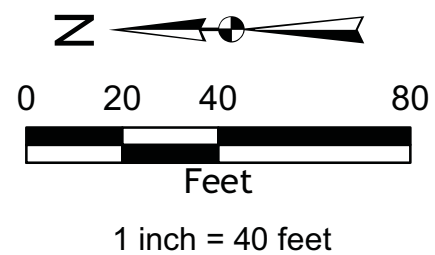
CIS 1,2 DCE RESULTS (µg/l)

	< 70
	70 - 200
	> 200

ISTT Area A Boundary

Notes:

- The site cleanup goal for CIS 1,2 DCE in groundwater is 70 µg/l.
- Qualifiers:
 U - Not detected above the sample-specific detection limit
 J - Quantitation is estimated as it is below the sample-specific detection limit



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FIGURE 7-11

CONFIRMATION GROUNDWATER SAMPLING EVENT NO. 3
 CIS-1,2-DICHLOROETHENE RESULTS
 AUGUST 1-4, 2011
 GROVELAND WELLS SUPERFUND SITE
 GROVELAND, MASSACHUSETTS

PREPARED BY: JH

CHECKED BY: DB

PROJECT NO. 80037

DATE: September 2011