

REMEDIATION SYSTEM EVALUATION

**BREWSTER WELL FIELD SUPERFUND SITE
BREWSTER, NEW YORK**



Report of the Remediation System Evaluation,
Site Visit Conducted at the
Brewster Well Field Superfund Site
October 30, 2001

Final Report Submitted to Region 2
April 8, 2002



NOTICE

Work described herein was performed by GeoTrans, Inc. (GeoTrans) and the United States Army Corps of Engineers (USACE) for the U.S. Environmental Protection Agency (U.S. EPA). Work conducted by GeoTrans, including preparation of this report, was performed under Dynamac Contract No. 68-C-99-256, Subcontract No. 91517. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

This document (EPA 542-R-02-008t) may be downloaded from EPA's Technology Innovation Office website at www.epa.gov/tio or www.cluin.org/rse.

EXECUTIVE SUMMARY

The Brewster Well Field, located on the northern bank of the East Branch Croton River (the “River”), was found in 1978 to be contaminated with chlorinated volatile organic chemicals (CVOCs) including tetrachloroethene (PCE), trichloroethene (TCE) and dichloroethene. Alben Dry Cleaners was determined to be a significant source of the groundwater contamination. Source remediation— consisting of excavation and offsite disposal of sediments, sludge, and contaminated soil from the dry well located adjacent to the dry cleaners— was completed by 1991. Two separate air stripping systems have been constructed and are currently operating:

- The area north of the River, associated with the Brewster Well Field, had a packed tower air stripper installed in 1984 to provide treatment of the Village’s water supply. The system continues to operate and supply water.
- The area south of the River, where the original source of the contamination was located, had a Ground Water Management System (GMS) installed in 1991, and operated continuously since 1996, for the purpose of ground water containment and restoration.

The focus of this RSE is the GMS, which is located to south of the River.

The GMS consists of ground water extraction from four wells, above-ground treatment via air stripping, and discharge to the East Branch of the Croton River. The combined flow of water from the four wells is typically 45 to 50 gpm.

Ground water contamination with MTBE is also present on site. The source of MTBE contamination was located at Savino’s Towing, Inc. and has been removed and the ground water concentrations for this contaminant are below the State water quality standards. System monitoring includes sampling for MTBE for tracking purposes only and should not affect operation of the GMS system. It should be noted that research on MTBE health impacts is ongoing and there is a reasonable likelihood that the MCL might be lowered. Therefore, site managers should consider the role of the GMS if MTBE concentrations are found to exceed the MCLs in the future.

In general, the RSE team found a well operated system. The goal of the system, according to the ROD, is both containment and aquifer restoration. The RSE team believes the containment objective may not currently be met, and although peak concentrations have declined over time, the RSE team believes that by the current system is not optimized for aquifer restoration. With a modified system, however, aquifer restoration is likely achievable.

The RSE team feels that a current site conceptual model should be developed, documented, and updated on a regular basis. Furthermore, the operating system and associated goals should be consistent with this conceptual model. The following issues should be addressed by the conceptual model:

- What are the roles of the two air stripping systems in achieving containment of the contaminant plume and restoration of the aquifer? How do these two systems affect each other hydrogeologically? Does pumping from one system prevent the other system from achieving its goals?
- What is the “target capture zone” for the system south of the site?

- What is the actual capture zone of the existing system, and how does it compare to the target capture zone?
- Are impacts north of the River near TH-7 being drawn to the village wells or the extraction system south of the River, or discharging to the River?
- Will the current system achieve the ROD goal of aquifer restoration at locations near DGC-19I, DGC-7I and TH-7 (which are impacted and appear to be distant from the current extraction wells)?
- What are contaminant levels (and plume extent) south of the current extraction system?
- Why are the “hot spot” areas and overall plume extent for PCE and TCE different than those for cis-1,2-DCE and vinyl chloride?
- Does ground water south of the River discharge to the River, flow under the River, or both?
- How long will it likely take to meet the ROD objective of aquifer restoration with the current system?
- What steps could be considered to improve the likelihood of achieving aquifer restoration, and/or decreasing the time to aquifer restoration?

Other recommendations to improve system effectiveness include the following:

- Conduct a GeoProbe investigation of shallow and intermediate ground water south of extraction well EW-1, followed by installation and ground water sampling of two to four monitor wells in that area.
- Define the “target capture zone”.
- Superimpose the “target capture zone” with the capture zone interpreted from existing data (and potentially, in the future, data from additional points and/or river stage measurements).
- Refine the site conceptual model based on the results of the recommendations above.
- Replace extraction wells EW-2 to EW-4 with up to three new wells located to the east of extraction well EW-1.

These items might require approximately \$242,500 in capital expenditures to complete, but the annual costs associated with them have been included in the reduced oversight costs that are discussed below.

Recommendations to reduce costs include the following:

- Clearly define the oversight tasks and reduce costs over time (potential savings of \$60,000 per year).

- Switch analysis method for VOCs from EPA524.2 to EPA 8260B (potential savings of \$15,000 per year).
- Reduce costs for sampling labor, equipment, and contractor travel (potential savings of \$20,000 to \$25,000).
- Replace third-party notification system with an autodialer (potential savings of \$1,000 per year).

These cost savings of approximately \$100,000 per year can be accomplished with almost no capital expenditure (approximately \$5000).

Recommendations for technical improvement have also been suggested.

Finally, the RSE team applauds efforts to consider alternative remediation approaches (e.g., HRC) suggested by site managers. Until the improvements in effectiveness and costs suggested above are made, a major investment in other technologies available at this time does not appear warranted. Furthermore, pilot testing of alternate remedies should only be performed if scale-up costs to a full-scale system are calculated and appear favorable in a cost-benefit analysis versus a revised extraction system.

PREFACE

This report was prepared as part of a project conducted by the United States Environmental Protection Agency (USEPA) Technology Innovation Office (TIO) and Office of Emergency and Remedial Response (OERR). The objective of this project is to conduct Remediation System Evaluations (RSEs) of pump-and-treat systems at Superfund sites that are “Fund-lead” (i.e., financed by USEPA). RSEs are to be conducted for up to two systems in each EPA Region with the exception of Regions 4 and 5, which already had similar evaluations in a pilot project.

The following organizations are implementing this project.

Organization	Key Contact	Contact Information
USEPA Technology Innovation Office (USEPA TIO)	Kathy Yager	11 Technology Drive (ECA/OEME) North Chelmsford, MA 01863 phone: 617-918-8362 fax: 617-918-8417 yager.kathleen@epa.gov
USEPA Office of Emergency and Remedial Response (OERR)	Paul Nadeau	1200 Pennsylvania Avenue, NW Washington, DC 20460 Mail Code 5201G phone: 703-603-8794 fax: 703-603-9112 nadeau.paul@epa.gov
GeoTrans, Inc. (Contractor to USEPA TIO)	Doug Sutton	GeoTrans, Inc. 2 Paragon Way Freehold, NJ 07728 (732) 409-0344 Fax: (732) 409-3020 dsutton@geotransinc.com
Army Corp of Engineers: Hazardous, Toxic, and Radioactive Waste Center of Expertise (USACE HTRW CX)	Dave Becker	12565 W. Center Road Omaha, NE 68144-3869 (402) 697-2655 Fax: (402) 691-2673 dave.j.becker@nwd02.usace.army.mil

The project team is grateful for the help provided by the following EPA Project Liaisons.

Region 1	Darryl Luce and Larry Brill	Region 6	Vincent Malott
Region 2	Diana Cutt	Region 7	Mary Peterson
Region 3	Kathy Davies	Region 8	Armando Saenz and Richard Muza
Region 4	Kay Wischkaemper	Region 9	Herb Levine
Region 5	Dion Novak	Region 10	Bernie Zavala

They were vital in selecting the Fund-lead P&T systems to be evaluated and facilitating communication between the project team and the Remedial Project Managers (RPM's).

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
PREFACE	iv
TABLE OF CONTENTS	vi
1.0 INTRODUCTION	1
1.1 PURPOSE	1
1.2 TEAM COMPOSITION	2
1.3 DOCUMENTS REVIEWED	2
1.4 PERSONS CONTACTED	2
1.5 SITE LOCATION, HISTORY, AND CHARACTERISTICS	3
1.5.1 LOCATION AND HISTORY	3
1.5.2 POTENTIAL SOURCES	3
1.5.3 HYDROGEOLOGIC SETTING	4
1.5.4 DESCRIPTION OF GROUND WATER PLUME	4
2.0 SYSTEM DESCRIPTION	6
2.1 SYSTEM OVERVIEW	6
2.2 EXTRACTION SYSTEM	6
2.3 TREATMENT SYSTEM	6
2.4 MONITORING SYSTEM	7
3.0 SYSTEM OBJECTIVES, PERFORMANCE AND CLOSURE CRITERIA	9
3.1 CURRENT SYSTEM OBJECTIVES AND CLOSURE CRITERIA	9
3.2 TREATMENT PLANT OPERATION GOALS	9
3.3 ACTION LEVELS	10
4.0 FINDINGS AND OBSERVATIONS FROM THE RSE SITE VISIT	11
4.1 FINDINGS	11
4.2 SUBSURFACE PERFORMANCE AND RESPONSE	11
4.2.1 WATER LEVELS	11
4.2.2 CAPTURE ZONES	11
4.2.3 CONTAMINANT LEVELS	11
4.3 COMPONENT PERFORMANCE	13
4.3.1 EXTRACTION WELLS AND PUMPS	13
4.3.2 AIR STRIPPER	13
4.3.3 DISCHARGE LINE	13
4.3.4 CONTROLS	13
4.4 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF MONTHLY COSTS	13
4.4.1 UTILITIES	14
4.4.2 NON-UTILITY CONSUMABLES AND DISPOSAL COSTS	14
4.4.3 LABOR	14
4.4.4 CHEMICAL ANALYSIS	15
4.5 RECURRING PROBLEMS OR ISSUES	15
4.6 REGULATORY COMPLIANCE	15
4.7 TREATMENT PROCESS EXCURSIONS AND UPSETS, ACCIDENTAL CONTAMINANT/REAGENT RELEASES	15
4.8 SAFETY RECORD	15

5.0	EFFECTIVENESS OF THE SYSTEM TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT	16
5.1	GROUND WATER	16
5.2	SURFACE WATER	16
5.3	AIR	16
5.4	SOILS	17
5.5	WETLANDS AND SEDIMENTS	17
6.0	RECOMMENDATIONS	18
6.1	RECOMMENDATIONS TO IMPROVE EFFECTIVENESS	18
6.1.1	DEVELOP A PRELIMINARY BUT COMPREHENSIVE UPDATED CONCEPTUAL MODEL OF GROUND WATER FLOW AND CONTAMINANT TRANSPORT	18
6.1.2	ADDITIONAL PLUME DELINEATION SOUTH OF EW-1	19
6.1.3	DEFINE THE "TARGET CAPTURE ZONE"	20
6.1.4	INTERPRET ACTUAL CAPTURE WITH RESPECT TO THE "TARGET CONTAINMENT ZONE"	20
6.1.5	DEVELOP A REVISED CONCEPTUAL MODEL	21
6.1.6	REPLACE EW-2 TO EW-4 WITH NEW EXTRACTION WELLS	21
6.2	RECOMMENDED CHANGES TO REDUCE COSTS	22
6.2.1	CUT MANAGEMENT EXPENSE	22
6.2.2	REDUCE SAMPLING AND ANALYSIS, EQUIPMENT RENTAL, AND TRAVEL/PER DIEM COSTS	24
6.2.3	REPLACE ELECTRONIC MONITORING SYSTEM WITH AN AUTODIALER	25
6.3	MODIFICATIONS INTENDED FOR TECHNICAL IMPROVEMENT	25
6.3.1	INSTALL NEW UNDERGROUND DISCHARGE LINE	25
6.3.2	IMPROVE TO ANNUAL O&M REPORTS	25
6.3.3	ENSURE VAPORS FROM ACETIC ACID WASH COMPLIES WITH OSHA STANDARDS	26
6.3.4	MEASURE THE AIR FLOW THROUGH THE AIR STRIPPER	26
6.4	MODIFICATIONS INTENDED TO GAIN SITE CLOSE-OUT	27
6.4.1	CONTINUE EVALUATING ALTERNATIVE REMEDIAL OPTIONS	27
6.5	UNUSED EQUIPMENT	28
6.6	SUGGESTED APPROACH TO IMPLEMENTATION OF RECOMMENDATIONS	28
7.0	SUMMARY	29

List of Tables

Table 7-1. Cost summary table

List of Figures

Figure 1-1 Site vicinity
Figure 1-2 PCE in ground water, November 2000
Figure 1-3 cis-1,2-DCE in ground water, November 2000
Figure 2-1 Shallow ground water elevations, September 1999
Figure 2-2 Intermediate ground water elevations, September 1999

1.0 INTRODUCTION

1.1 PURPOSE

In the *OSWER Directive No. 9200.0-33, Transmittal of Final FY00 - FY01 Superfund Reforms Strategy*, dated July 7, 2000, the Office of Solid Waste and Emergency Response outlined a commitment to optimize Fund-lead pump-and-treat systems. To fulfill this commitment, the US Environmental Protection Agency (USEPA) Technology Innovation Office (TIO) and Office of Emergency and Remedial Response (OERR), through a nationwide project, is assisting the ten EPA Regions in evaluating their Fund-lead operating pump-and-treat systems. This nationwide project is a continuation of a demonstration project in which the Fund-lead pump-and-treat systems in Regions 4 and 5 were screened and two sites from each of the two Regions were evaluated. It is also part of a larger effort by TIO to provide USEPA Regions with various means for optimization, including screening tools for identifying sites likely to benefit from optimization and computer modeling optimization tools for pump and treat systems.

This nationwide project identifies all Fund-lead pump-and-treat systems in EPA Regions 1 through 3 and 6 through 10, collects and reports baseline cost and performance data, and evaluates up to two sites per Region. The site evaluations are conducted by EPA-TIO contractors, GeoTrans, Inc. and the United States Army Corps of Engineers (USACE), using a process called a Remediation System Evaluation (RSE), which was developed by USACE. The RSE process is meant to evaluate performance and effectiveness (as required under the NCP, i.e., and "five-year" review), identify cost savings through changes in operation and technology, assure clear and realistic remediation goals and an exit strategy, and verify adequate maintenance of Government owned equipment.

The Brewster Well Field Superfund Site was chosen to receive an RSE based on an initial screening of the pump-and-treat systems managed by USEPA Region 2 as well as discussions with the Superfund Reform Initiative Project Liaison for that Region. This site has high operation costs relative to the cost of an RSE and a long projected operating life. This report provides a brief background on the site and current operations, a summary of the observations made during a site visit, and recommendations for changes and additional studies. The cost impacts of the recommendations are also discussed.

A report on the overall results from the RSEs conducted for this system and other Fund-lead P&T systems throughout the nation will also be prepared and will identify lessons learned and typical costs savings.

1.2 TEAM COMPOSITION

The team conducting the RSE consisted of the following individuals:

Ed Mead, Chemical Engineer, USACE HTRW CX
Rob Greenwald, Hydrogeologist, GeoTrans, Inc.
Peter Rich, Civil and Environmental Engineer, GeoTrans, Inc.
Doug Sutton, Water Resources Engineer, GeoTrans, Inc.

1.3 DOCUMENTS REVIEWED

Author	Date	Title
GHR Engineering	7/1986	Remedial Investigation Report
USEPA	9/30/1986	Record of Decision
Ebasco	4/20/1989	Final Remedial Design
Kemron	10/22/1998	Monthly Report (September 1-30, 1998)
Sevenson	3/8/2000	Draft 1999 Annual Report
Kemron	4/9/1999	Monthly Report (February 1-28, 1999)
Sevenson	3/21/2000	Monthly Report (February 1-29, 2000)
Sevenson	4/25/2000	Draft 2000 Annual Report
Sevenson	7/27/2000	Monthly Report, Partial (June 1-30, 2000)
Army Corp of Engineers (Handed out During RSE Site Visit)	2001	Table of VOC Compound List

1.4 PERSONS CONTACTED

The following individuals (in addition to the RSE team) were present for the site visit:

Lisa Wong - EPA RPM
Arbor Drinkwine - USACE Kansas City District, Project Manager
Dawn Cermak - Sevenson (Contractor to ACOE)
Lou Gasparini - Local subcontractor to Sevenson
Mike Scorca - EPA Region II Hydrogeologist
John LaPadula - EPA Region II (Observer)
Vince Pitruzello - EPA Region II (Observer)
Julia Kissner - USACE Kansas City District (conducting 5-yr review)
Frank Bales - USACE Kansas City District (conducting 5-yr review)
Dave Nelson - USACE Kansas City District (conducting 5-yr review)

1.5 SITE LOCATION, HISTORY, AND CHARACTERISTICS

1.5.1 LOCATION AND HISTORY

The Brewster Well Field (the Site) is approximately three-quarters of a mile east of the Village of Brewster in Putnam County, New York. An illustration of the Site vicinity is presented in Figure 1-1. The land to the north and west is largely residential while most of the land south of the site area is occupied by commercial or light industrial facilities.

The Brewster Well Field, located on the northern bank of the East Branch Croton River (the “River”), supplies water to approximately 2,200 people. In 1978 the well field was found to be contaminated with chlorinated volatile organic chemicals (CVOCs) including tetrachloroethene (PCE), trichloroethene (TCE) and dichloroethene (DCE). A remedial investigation was completed in 1986, and a Record of Decision was signed in September, 1986. The RI/FS suggested that Alben Dry Cleaners was a significant source of the ground water contamination. Source remediation, consisting of excavation and offsite disposal of sediments, sludge, and contaminated soil from the dry well located adjacent to the dry cleaners, was completed by 1991.

Two separate air stripping systems have been constructed and operated:

- The area north of the River, associated with the Brewster Well Field, had a packed tower air stripper installed in 1984 to provide treatment of the Village’s water supply. The system continues to operate and supply water.
- The area south of the River, where the original source of the contamination was located, had a Ground Water Management System (GMS) that consists of four extraction wells and an air stripper. The system was installed in 1991 and has operated continuously since 1996 for the purpose of ground water containment and restoration.

The focus of this RSE is the GMS, which is located to south of the River.

1.5.2 POTENTIAL SOURCES

The former Alben Cleaners, located south of the River and about 900 ft. south of Well Field No. 1, was identified in the RI as likely being the main CVOC contaminant source. This location is indicated on Figure 1-1. Other minor sources of VOCs and petroleum compounds are present in the vicinity. The dry well at Alben Cleaners was removed in 1990, and confirmation sampling was conducted. The working conceptual model for the site is that the source of contamination has been removed.

Ground water contamination with MTBE is also present on site. Savino’s Towing, Inc. was identified as the location of the source of MTBE contamination. The source has been removed and the ground water concentrations for this contaminant are below the State water quality standards. System monitoring includes sampling for MTBE for tracking purposes only and should not affect operation of the GMS system. It should be noted that research on MTBE health impacts is ongoing and there is a reasonable likelihood that the MCL might be lowered. Therefore, site managers should consider the role of the GMS if MTBE concentrations are found to exceed the MCLs in the future.

1.5.3 HYDROGEOLOGIC SETTING

The subsurface hydrogeology is quite complex, as detailed in the RI report, and consists of unconsolidated sediments overlying bedrock. During the RI, deep wells installed into the bedrock showed no contamination. All recovery wells at the site are screened in the unconsolidated sediments. Recharge primarily occurs through rainfall/snowmelt and through flow from surrounding areas.

As detailed in the RI, ground water flow south of the River (i.e., from the source area near Albens Cleaners) is to the north. Under natural conditions, discharge would be to the River from both the north and the south (i.e., the River would be a gaining stream). However, due to historic and continuing pumping at the Village Well Field wells north of the River, the River in the vicinity of the site likely becomes a losing river to the well field, which in turn allows passage of water beneath the River from the south. This would explain the mechanism for historic contamination at the village wells north of the River from a source area south of the River. The hydraulic connection of ground water north and south of the River was demonstrated by pumping tests in the RI (pumping north of the River caused responses south of the River), and by recovery tests by Kemron described in the September 1998 monthly report (turning off the extraction wells south of the River caused a response north of the River).

The RI describes the ground water flow pattern south of the River as a complex interaction between the well field (drawing ground water to the north) and the impacts of the River which cause ground water to flow in a west/southwest direction as underflow. The RI describes a ground water divide differentiating these two types of flow. This complex pattern has been further complicated by the recovery wells that have been pumping south of the River since 1996.

The River flows to the southwest and contributes to the Croton Falls Reservoir approximately 3.5 miles downstream. Three thousand feet to the east of the Site (upstream), the River is impounded to form the East Branch Croton Reservoir, part of New York City's Croton Watershed reservoir system. Approximately 3,000 feet to the northeast of the site, Bog Brook, a tributary to the East Branch Croton River, is impounded to form Bog Brook Reservoir, also owned by New York City. The degree of connection between ground water and the East Branch Croton River is unclear. In the ROD it states that PCE was detected at 2 to 4 ug/l in surface water near the I-84 overpass, which could indicate an interchange of ground water and surface water. However, it could also have been due to potential discharge from a culvert northeast of Alben Cleaners. Also, the fact that the River loses water to the Village Well Field to the north does not preclude the possibility that it still gains water (impacted by chlorinated hydrocarbons) from the south.

1.5.4 DESCRIPTION OF GROUND WATER PLUME

Chlorinated VOCs (PCE of 166 ug/l and TCE of 5ug/l) were found in Village Well Field samples in August 1978, and the results were confirmed in September 1978. Well Field No. 1 was found to have greater impacts than Well Field No.2. At the time of the RI, the highest level of PCE seen at any well was 5600ug/l at Well 6I (south of the River) in October 1985. In 1979, PCE of nearly 2000 ug/l was also detected in TH-7, north of the River.

The 2000 Annual Report provides contour maps for the following constituents:

PCE
TCE
cis-1,2-DCE
MTBE

The PCE and cis-1,2-DCE maps are presented in Figure 1-2 and 1-3 of this RSE report. Selected observations from these figures include the following:

- Maximum concentrations of PCE are below 1000 ug/l, which is reduced from the 1979-1985 levels reported in the RI.
- Of the four extraction wells, only EW-1 is located in one of the areas with the highest PCE contamination onsite, while EW-2 through EW-4 are not.
- Impacts of PCE and cis-1,2-DCE are significant at TH-7, located north of the River.
- cis-1,2-DCE impacts are significant further to the east than the PCE plume (particularly DGC-7I).
- The current remediation wells (EW-1 to EW-4) are not located near TH-7 (north of the River) or DGC-7I (impacted by cis-1,2-DCE), or DGC-19 (impacted by PCE and cis-1,2-DCE).
- The extent of ground water contamination is unknown to the south (i.e., upgradient) of EW-1. DGC-19 is located directly between the former source and EW-1 and has concentrations of 79 ppb PCE and 211 ppb cis-1,2 DCE. No wells are located to the west of DGC-19 (south of EW-1) to delineate the extent of this contamination.

The concentrations of TCE are much lower than PCE, although the extent is similar. The cis-1-2-DCE is a breakdown product of the PCE and/or TCE, and suggests that in-situ biodegradation is occurring at the site.

Vinyl chloride is not mentioned in detail in the Annual Report for 1999 and 2000, other than sporadic detections in system influent of approximately 1 to 3 ug/l. However, a data sheet with concentrations at individual wells handed out during the RSE site visit indicates significantly elevated concentrations of vinyl chloride at several wells (up to 277 ug/l at DGC-19I in November 2000, and up to 121 ug/l at well TH-7 in November 2000). Vinyl chloride is also a degradation product of PCE/TCE, and this again indicates that substantial biodegradation is occurring.

2.0 SYSTEM DESCRIPTION

This discussion pertains to the GMS operated south of the River, which is the focus of this RSE.

2.1 SYSTEM OVERVIEW

The system has been continuously operated since 1996. It consists of ground water extraction from four wells, above-ground treatment via air stripping, and discharge to surface water. These components, plus the monitoring of the system, are described in more detail below.

2.2 EXTRACTION SYSTEM

The four extraction wells (EW-1, EW-2, EW-3, and EW-4) are screened 21.5 to 36.5 ft bgs and have 3/4 HP Gould submersible pumps. The pumps have amperage shutoffs. Discharge from the wells is currently piped to the treatment system by a cast iron header. The cumulative extraction rate from these four wells is approximately 45 to 50 gpm. Flow meters are not installed on individual extraction wells; thus, extraction rates for each of these wells cannot be determined.

2.3 TREATMENT SYSTEM

Water is pumped from the four extraction wells to the top of an air stripper. The stripper tower is a Hydro Group 30" dia. packed tower and is filled with 25 feet of one inch Norton plastic intalox saddles. The combined flow of water from the four wells is typically 45 to 50 gpm. The treated water is discharged from the bottom of the air stripper to a sump with an outlet pipe that conveys the water to the East Branch of the Croton River. The air stripper is located outside the building. Air to the air stripper is provided by two parallel belt driven centrifugal blowers located inside the treatment building. The air flow-rate to the air stripper is not measured, and no estimate of the air flow-rate was available.

The processed ground water passes out of the bottom of the air stripper column into a clearwell, that provides flow equalization and level control. The effluent from the clearwell then flows by gravity through a buried 4-inch pipe to either the eight passive injection wells (historically inactive) or to a PVC effluent line that discharges to an outfall to the East Branch Croton River. A gate valve that is operated via a valve box outside the building directs flow to either the injection wells or the outfall. A concrete waste sump has been included within the facility to provide for multipurpose use of the system. These uses may include storage of water generated during system start-up or draining for maintenance of the column. A sump pump has been included to allow stored water or processed water to be recycled through the system, discharged to the outfall, or pumped to a truck for offsite disposal. The sump pump is used for the acid wash of the air stripper, a 24-hour processed that is completed once per quarter.

The system was originally designed such that treated water would be reinjected through a series of wells, cross-gradient from the extraction wells. The intended purpose was to promote flushing of the impacted portion of the aquifer. The designed reinjection system never worked effectively due to almost immediate clogging, so discharge was instead directed to the East Branch Croton River, approximately 150 feet from the treatment system, through an underground four-inch pipe. The underground discharge

line and valves are currently fouled by calcium carbonate, so discharge is currently occurring through a temporary above-ground PVC line.

2.4 MONITORING SYSTEM

Routine inspection and sampling activities at the Brewster site consist of weekly inspections, monthly inspections, monthly sampling, quarterly inspections and sampling, and an annual sampling event.

Weekly

Weekly inspections are performed by Mr. Lou Gasparini under subcontract to Severson. No sampling is performed unless a monthly effluent sample failed for a SPDES discharge limitation parameter.

Monthly

Monthly inspections and sampling activities are performed by Severson personnel and Mr. Lou Gasparini, and include:

- Effluent sampling and analysis for EPA Method 524.2 constituents plus Benzene, Toluene, Ethylbenzene, Xylenes, (BTEX), Methyl tert-Butyl Ether (MTBE), and Iron
- Depth to water measurements in monitor well DGC-7S and injection wells IW-6, IW-8, IW-10 and IW-12
- Pressure readings from extraction wells, total gallons extracted, and other various operating parameters
- Site inspection and general system inspection including inspection of air-handling system and air filters

Quarterly

Quarterly inspections and sampling are performed by Severson personnel, and have included:

- Influent and effluent sampling and analysis for EPA Method 524.2 constituents plus BTEX, MTBE, Iron, Calcium, Sodium, Manganese, Chloride, total and fecal coliform bacteria
- General site inspection
- Depth to water in 26 monitoring wells and 4 injection well locations (not currently used for injection)

Beginning with the March 2001 sampling event, quarterly events will also include sampling of ground water at the 4 extraction wells, 8 monitor wells and 3 surface water locations.

Annual

Annual sampling is performed by Severson personnel and has included all quarterly activities with the following additions/modifications:

- Sample 30 monitoring wells, 2 injections wells, 3 points of the surface waters of the Croton River and the 4 extraction wells for EPA Method 524.2 constituents plus BTEX, MTBE and Iron, Calcium, Sodium, Manganese, and Chloride
- Depth to water in 32 monitoring wells and 4 injection wells locations (not currently used for injection)

Starting November 2000 sampling event, annual events will incorporate the new ground water and surface water sampling being performed quarterly, plus sampling of 8 additional ground water monitoring wells. Subsequent annual sampling events will occur in December of each year.

Drafts of the annual reports for 1999 and 2000 were made available to the RSE team. It should be noted that those annual reports do not include important data collected during the monitoring events, such as:

- table(s) listing water level measurements with well names, screened intervals, measuring elevations (i.e., tops of casings), dates, and depths to water
- table(s) listing measured concentrations at monitoring wells (a subset of those data are listed on some figures).

Also, the draft 2000 Annual report, does not include any presentation of water level maps from which flow directions can be interpreted. However, such maps were included in the draft 1999 Annual Report for shallow water levels (see Figure 2-1) and intermediate water levels (see Figure 2-2).

3.0 SYSTEM OBJECTIVES, PERFORMANCE AND CLOSURE CRITERIA

This discussion pertains to the GMS operated south of the River, which is the focus of this RSE.

3.1 CURRENT SYSTEM OBJECTIVES AND CLOSURE CRITERIA

According to the ROD, the public health and environmental objectives of the Remedial Investigation and Feasibility Study were as follows:

- provide a safe, reliable water supply, meeting EPA standards, to the Village of Brewster
- contain the plume of contamination to mitigate further contamination of public water supplies
- restore ground water quality at and in the vicinity of the Brewster Well Field to acceptable levels (NYS ground water standards)

Based on these objectives, the ROD calls for the following actions:

- Continued operation of the existing on-site packed column air stripping system at the Well Field to provide to the Village a water supply that exceeds applicable or relevant and appropriate standards, thereby providing a very high level of public health protection.
- Design and construction of a ground water management system, consisting of extraction wells, treatment of the extracted water by an additional off-Site air stripper, and reinjection of the treated water, to contain the plume of contamination and restore ground water quality south of the East Branch of the Croton River.

3.2 TREATMENT PLANT OPERATION GOALS

The Brewster GMS treatment system must meet discharge limits for eleven organic constituents, plus iron, in order to comply with the SPDES program. The constituents listed are

SPDES Parameters	SPDES Limit (ug/l)
Vinyl Chloride	10
Trans-1, 2-Dichloroethene	10
1,1-Dichloroethane	10
Cis-1,2-Dichloroethene	10
Chloroform	10
1,1,1-Trichloroethane	10
Trichloroethene	10
Tetrachloroethene	10
Chlorobenzene	10
1,1,2,2-Tetrachloroethane	10
1,2-Dichlorobenzene	10
Iron, Total	4000

Effluent is also measured monthly for benzene, toluene, ethylbenzene, xylene (Total), and MTBE. These are not specifically contaminants of concern at the Brewster Site but are compared to Federal and State MCLs for tracking purposes.

3.3 ACTION LEVELS

The ROD specifically refers only to Federal and State standards for ground water concentrations of TCE (a federal standard of 5 ug/l and a state standard of 10 ug/l at the time of the ROD). The state standard has since been reduced to 5 ug/l. The current federal and state standards, as reported in the draft annual reports, are provided in the table below.

VOCs:	MCL (EPA) ² ug/l	MCL (NYS) ³ ug/l	ROD Criteria (ug/l)
Vinyl Chloride	2	2	- ⁷
Trans-1, 2-Dichloroethene	100	5	- ⁷
1,1-Dichloroethane	7	5	- ⁷
Cis-1,2-Dichloroethene	70	5	- ⁷
Chloroform	100 ⁵	100 ⁵	- ⁷
1,1,1-Trichloroethane	200	5	- ⁷
Trichloroethene	5	5	5
Tetrachloroethene	5	5	- ⁷
Chlorobenzene	100	5	- ⁷
1,1,2-2-Tetrachloroethane	NA	5	- ⁷
1,2-Dichlorobenzene	600	5	- ⁷
Benzene	5	5	- ⁷
Toluene	1,000	5	- ⁷
Ethylbenzene	700	5	- ⁷
Xylenes, total	10,000	5	- ⁷
Methyl tert-butyl ether	- ⁴	50	- ⁷
Inorganics:			
Iron, Total	300 ⁶	300 ⁶	- ⁷
Calcium	-	NA	- ⁷
Manganese	50 ⁶	300 ⁶	- ⁷
Sodium	-	NA	- ⁷
Total Chloride	-	250,000	- ⁷
Other Field Parameters:			
Total Coliform Bacteria	-	Any positive sample	
Temperature	-	-	--
pH	-	-	--
Conductivity	-	-	--
Turbidity	-	-	--
Dissolved Oxygen	-	-	--

- Notes:
- 1 Table based on 2000 Annual Report (Sevenson)
 - 2 MCL = maximum contaminant level taken from National Primary Drinking Water Standards as established by the USEPA
 - 3 MCL = maximum contaminant level from 10 NYCRR Part 5, Subpart 1, Section 51
 - 4 Not included as part of the USEPA's Primary Drinking Water Standards.
 - 5 Total Trihalomethanes (chloroform, bromoform, bromodichloromethane and dibromochloromethane)
 - 6 If both manganese and iron are present, the total concentration of both metals should not exceed 500 ug/l (manganese is secondary standard).
 - 7 Not a ROD Parameter

4.0 FINDINGS AND OBSERVATIONS FROM THE RSE SITE VISIT

4.1 FINDINGS

The RSE team found a maintained and functional facility. The observations and recommendations given below are not intended to imply a deficiency in the work of the designers, operators or site managers but are offered as constructive suggestions in the best interest of the EPA and the public. These recommendations have the benefit of several years of operating data unavailable to designers or site managers.

4.2 SUBSURFACE PERFORMANCE AND RESPONSE

4.2.1 WATER LEVELS

According to the draft 2000 Annual Report, the following water level measurement events occurred during 2000:

- monthly at DGC-7S and injection wells IW-6, IW-8, IW-10 and IW-12
- quarterly at total of 23 wells (does not specify which wells)
- annually (in November 2000) at total of 36 wells (does not specify which wells)

These water level measurements are not reported in the draft Annual Report, and equipotential maps from the quarterly and/or annual events are also not provided in the annual report. However, water level maps were provided in the draft 1999 Annual Report based on measurements in September, 1999 (see Figures 2-1 and 2-2). Flow patterns are discussed in Section 4.2.2.

4.2.2 CAPTURE ZONES

Figure 2-1, which pertains to the “shallow wells”, appears to indicate flow to the southwest, from the River towards the extraction wells (EW-1 to EW-4), but no water level measurements are available in the shallow zone directly north of the extraction wells. In the intermediate wells (Figure 2-2), however, ground water appears to flow towards the River to the northeast, except in the immediate vicinity of the extraction wells. In each case, the interpretation is severely limited by the number of measurement points, and interpretation of discharge into or out of the River is also limited by lack of river stage measurements.

During the RSE visit, the site managers indicated that capture was likely not sufficient under current pumping conditions to prevent impacted ground water from flowing to the north, into or beneath the River.

4.2.3 CONTAMINANT LEVELS

Based on the draft 2000 Annual Report, influent concentrations to the air stripping system for key constituents are as follows:

Constituent	Influent During 2000 (ug/l)	Discharge Limit (ug/l)	Federal MCLs (ug/l)	NYS MCLs (ug/l)
PCE	80 - 132	10	5	5
TCE	5 - 8	10	5	5
cis-1,2-DCE	36 - 47	10	70	5
trans-1,2-DCE	ND - 0.7	10	100	5
vinyl chloride	ND - 3	10	2	2

Based on a table handed out during the RSE visit, the following concentrations were observed at the extraction wells in November 2000 and March 2001:

	EW-1	EW-2	EW-3	EW-4	Max Concentration in Other Wells
PCE (ug/l)	385/793	20/60	20/21	3/12	93/158
TCE (ug/l)	11/22	4/10	4/4	ND/2	28/54
cis-1,2-DCE (ug/l)	103/195	25/72	ND/13	ND/2	388/448
trans-1,2DCE (ug/l)	1	ND	ND	ND	4
vinyl chloride (ug/l)	3/5	ND/3	ND/ND	ND/ND	277/45

Because individual flow rates at the wells cannot be monitored, it is assumed that flow rate is roughly equal from all four wells. If that is the case, than the vast majority of mass being removed by the system is being removed by EW-1. Minor amounts of mass are being removed by the other extraction wells.

By comparing the concentrations at the extraction wells to the maximum concentration at other wells, it appears that the current extraction wells are not ideally located for addressing maximum concentrations of cis-1,2-DCE and vinyl chloride in the aquifer.

The table handed out during the RSE visit also indicated concentrations at wells existing in 1985 and 1994. Peak concentrations of PCE were much higher (more than 1000 ug/l at DGC19I and DGC-6I) in 1985 and 1994 than observed recently. The same is true for TCE (89 to 311 ug/l at DGC-19I and DGC-6I in 1985 and 1994). Therefore, peak concentrations have gone down over time. This may be due to any or all of the following:

- removal of the source and dilution of the plume by hydrodynamic dispersion
- mass removed by the ground water pump-and-treat system
- in-situ biodegradation

It would be difficult, if not impossible, to quantify the contribution of these processes.

4.3 COMPONENT PERFORMANCE

4.3.1 EXTRACTION WELLS AND PUMPS

Only the total system flow rate is available, since there is no way to attach individual flow meters to the wells as constructed. During the year 2000 the total flow rate averaged 37.6 gpm. This is a decrease from previous years, which were typically 45-50 gpm (e.g., 44.7 gpm in 1999). This has been attributed to the scale buildup in the effluent drain line.

The extraction well vaults are prone to flooding and offer limited access for maintenance and adjustments. The pumps have been replaced one time each over the 5 years since continuous operation began.

4.3.2 AIR STRIPPER

The packing in the air stripper becomes fouled with calcium carbonate deposits. To prevent plugging the column is cleaned quarterly by shutting down the wells and re-circulating acetic acid through the column packing for 24 hours. The acid re-circulation sump and the discharge sump are located inside the treatment building. After cleaning the used acid is diluted and discharges slowly to the River. The distribution plate for the air stripper is removed and treated with a bleach solution once per year. No iron fouling has occurred, but the air stripper at the Village Well Field across the River experiences iron fouling. Because the air flow-rate through the air stripper was not available, it may or may not be at the optimum rate.

4.3.3 DISCHARGE LINE

The effluent line leading from the air stripper discharge sump to the River has recently plugged with calcium carbonate. The Corps of Engineers Kansas City District personnel are evaluating the problem and are considering adding a sequestering agent to the water to prevent the effluent line from plugging, which could also eliminate the need for periodic cleaning of the air stripper packing. They are reportedly designing a new discharge line, and discharge is currently occurring through a temporary above-ground PVC line.

4.3.4 CONTROLS

Currently electronic controls automatically call a third-party service if there is a problem with the system.

4.4 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF MONTHLY COSTS

In the ROD, the anticipated capital cost for the system south of the River was estimated at \$164K and O&M cost was estimated at \$27K/year. The actual O&M is about \$360,000 per year (based on information provided by the USACE project manager), which is more than 10 times what the ROD projected. Even if the estimated amount is adjusted for inflation, the current amount is many times higher than that projected in the ROD.

The following cost breakdown was presented by the USACE project manager:

administration, oversight, review, QA, analysis (Army Corps)	\$120,000/yr
subcontractor project management	\$12,000/yr
reporting	\$62,000/yr
sampling analysis and labor (ground, surface, and process water)	\$67,000/yr
equipment rental	\$15,000/yr
weekly operator checks	\$9,000/yr
electric power	\$15,000/yr
phone	\$1,500/yr
electronic monitoring service for emergencies	\$1,000/yr
tower acid rinse	\$12,000/yr
site maintenance	\$10,000/yr
travel/per diem	\$21,000/yr
repairs and field supplies	\$6,000/yr
shipping	\$6,000/yr
miscellaneous	\$2,500/yr
	<hr/>
	\$360,000/yr

4.4.1 UTILITIES

As stated above, the utilities costs are predominantly electricity associated with the pumping wells and air stripper and total approximately \$15,000 per year.

4.4.2 NON-UTILITY CONSUMABLES AND DISPOSAL COSTS

The dominant costs in this category are associated with the acid wash, equipment rental, and site maintenance.

4.4.3 LABOR

Labor is the major cost at this site. The management costs associated with the Army Corp of Engineers is accounts for 30% to 40% of the total costs. Other labor costs are associated with sampling, reporting, and site visits by a local subcontractor.

4.4.4 CHEMICAL ANALYSIS

Based on the monitoring program summarized in Section 2.4, approximately 100 samples are collected from the site each year. Additional samples for analysis include trip blanks, field blanks, and duplicates. Approximately 25 such additional samples are likely analyzed per year. Given the analytical methods used (EPA 524.2 plus BTEX compounds) this likely translates to analytical costs of approximately \$30,000 to \$35,000 per year.

4.5 RECURRING PROBLEMS OR ISSUES

Originally, fouling of the air stripper required re-packing (performed in 1997 and 1998). Subsequent procedures put in place, involving quarterly washes with acetic acid, have remedied this problem, and no additional re-packings have been performed since 1998. During the RSE visit the building had a strong acid smell from a recent acetic acid wash. This occurs because the acid re-circulation sump and the discharge sump are located inside the treatment building.

During the RSE visit it was stated that quarterly ground water sampling events (12 wells) sometimes takes up to 8 days to complete because of extended time for stabilization of parameters in the field. In discussions subsequent to the RSE site visit, the USACE project manager confirmed that this is an anomaly characteristic of initial sampling events and does not accurately represent recent or upcoming sampling events.

4.6 REGULATORY COMPLIANCE

Clogging in the air stripper caused exceedances of discharge standards in 1998. Subsequent procedures put in place involving regular washes of the air stripper with acetic acid and regular washes of the air stripper influent distributor with bleach have remedied this problem.

4.7 TREATMENT PROCESS EXCURSIONS AND UPSETS, ACCIDENTAL CONTAMINANT/REAGENT RELEASES

None were noted during the RSE site visit.

4.8 SAFETY RECORD

The system has an excellent safety record with no documented injuries with the exception of contact with poison ivy.

5.0 EFFECTIVENESS OF THE SYSTEM TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT

5.1 GROUND WATER

One goal of the system south of the River is containment. However, containment has not been sufficiently demonstrated in the annual O&M reports, and when queried during the RSE visit, site managers stated that the current system was likely not achieving containment.

Another goal of the system south of the River is aquifer restoration. It appears that peak levels of PCE and TCE have been decreasing since continuous system operation began in 1996. However, it is not clear that those concentrations are the result of the pump and treat system. The stable or increasing concentrations of cis-1,2-DCE and vinyl chloride during that period indicate that in-situ biodegradation is an important, if not the most significant, cause of those peak concentration reductions.

It appears unlikely that the current system will achieve the restoration goal. Three of the wells are removing water with relatively low concentrations (only EW-1 appears to be removing ground water with high concentrations). It is not likely that the current system will be effective at restoring the aquifer near some of the most impacted wells, particularly those impacted significantly by cis-1,2-DCE and/or vinyl chloride (DGC-19, DGC-7I, TH-7).

5.2 SURFACE WATER

Hydraulic containment at the southern edge of the River is likely not achieved, and some shallow ground water impacted by VOCs likely discharges to the River from the south. Based on the volatile nature of the contaminants and the relatively low concentrations in ground water, it is not likely that such discharge would cause negative impacts to the surface water. The site team reports that quarterly sampling of surface water for VOCs repeatedly show undetectable concentrations.

5.3 AIR

Vapor phase carbon is not employed at this site. Based on the low influent concentration of approximately 100 to 200 ug/l of total VOC's, at a rate of 50 gpm, the total mass per day removed by the stripper and released to the atmosphere can be approximated as follows:

$$200 \text{ ug/l} * 50 \text{ gpm} * 3.785 \text{ L/gal} * 2.2\text{lb}/1\text{E-9 ug} * 1440 \text{ min/day} = 0.1 \text{ lbs/day}$$

This is not likely to cause any negative impacts.

5.4 SOILS

Contaminated soil was removed as part of the source remediation. Further evaluation of soils contamination was not addressed during the RSE.

5.5 WETLANDS AND SEDIMENTS

Wetlands and sediments were not specifically addressed during the RSE. However, to the extent that hydraulic containment at the southern edge of the River is not achieved, and some shallow ground water impacted by VOCs discharges to the River from the south, there is a potential for impacts to sediments in the River and/or wetlands along the River. Also, if pumping is shifted to the east, there is a potential for pumping to result in de-watering of some wetland areas that may not be impacted by pumping from the current system.

6.0 RECOMMENDATIONS

Cost estimates provided herein have levels of certainty comparable to those done for CERCLA Feasibility Studies (-30/+50%), and these cost estimates have been prepared in a manner consistent with EPA 540-R-00-002, A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, July 2000.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

As stated in Section 5.1, the current system is not entirely effective with respect to the ROD objectives, which are containment and aquifer restoration.

The recent site documents do not include or reference a clearly stated conceptual model of ground water flow and contaminant transport at the site. A site conceptual model should identify all key issues and/or components of the system that must be understood to adequately assess system effectiveness and evaluate progress towards meeting the ROD objectives. The process should include the following steps:

- state a preliminary conceptual model that identifies gaps in site understanding
- collect information to address the gaps in site understanding
- refine the conceptual model based on the newly collected data

Furthermore, the site goals and associated target capture zone should be consistent with the conceptual model. Sections 6.1.1 through 6.1.6 present recommendations to improve the site conceptual model and the system as a whole.

6.1.1 DEVELOP A PRELIMINARY BUT COMPREHENSIVE UPDATED CONCEPTUAL MODEL OF GROUND WATER FLOW AND CONTAMINANT TRANSPORT

The RSE team feels a current site conceptual model should be developed and documented to ensure that all of the site managers agree on the processes governing ground water flow and contaminant transport at the site. This documented site conceptual model will serve a central reference to site managers as decisions are made and progress toward or achievement of system goals are evaluated. The site conceptual model should be derived from interpretation of historical and current site data including, but not limited to, ground water elevations, pump test results, ground water quality, surface water quality, geological cross sections, and surface water elevations. The site conceptual model should be included in the next annual report and revised as necessary in each subsequent annual report. The following questions, and others, should be addressed by the conceptual model?

- What are the roles of the two air stripping systems in achieving containment of the contaminant plume and restoration of the aquifer? How do these two systems affect each other hydrogeologically? Does pumping from one system prevent the other system from achieving its goals?
- What is the “target capture zone” for the system south of the site?

- What is the actual capture zone of the existing system, and how does it compare to the target capture zone?
- Are impacts north of the River near TH-7 being drawn to the village wells or the extraction system south of the River, or discharging to the River?
- Will the current system achieve the ROD goal of aquifer restoration at locations near DGC-19I, DGC-7I and TH-7 (which are impacted and appear to be distant from the current extraction wells)?
- What are contaminant levels (and plume extent) south of the current extraction system?
- Why are the “hot spot” areas and overall plume extent for PCE and TCE different than those for cis-1,2-DCE and vinyl chloride?
- Does ground water south of the River discharge to the River, flow under the River, or both?
- How long will it likely take to meet the ROD objective of aquifer restoration with the current system?
- What steps could be considered to improve the likelihood of achieving aquifer restoration, and/or decreasing the time to aquifer restoration?

The site managers may have partial answers to many of these questions and may have discussed them previously, but formulating complete answers based on data and documenting them will ensure a conceptual model that is consistent with the data and acceptable to all site managers and associated technical staff. The conceptual model should also indicate any data gaps, and highlight those data gaps that must be resolved to ensure the remedy is progressing as intended. The goal of future data collection should be, in part, to resolve the issues listed above.

Generating and documenting this conceptual model should require approximately \$7,500. As mentioned previously, the associated text should be included in the next annual report. Updates to the conceptual model should be included in the subsequent annual reports and should cost approximately \$2,500 to develop and document (in addition to costs associated with collecting actual data that would be the bases for the modifications).

6.1.2 ADDITIONAL PLUME DELINEATION SOUTH OF EW-1

Based on the plume maps presented in the annual reports, there are no monitoring wells south (i.e., upgradient) of extraction well EW-1. DGC-19 is located directly between the former source and EW-1 and has concentrations of 79 ppb PCE and 211 ppb cis-1,2 DCE. However, no wells are located to the west of DGC-19 (south of EW-1) to delineate the extent of this contamination. Since EW-1 extracts water with high concentrations of contaminants, it is important to determine the level of impacts, and the extent, of the plume in that direction. A prudent approach would be to perform a GeoProbe investigation of shallow and intermediate ground water south of EW-1. Approximate cost for that investigation might be \$35,000. Based on the results of that investigation, 2 to 4 new monitor wells might be installed (for preliminary cost estimates in this RSE, assume one shallow well and one intermediate well). Capital costs for that might be \$40,000, and additional monitoring costs associated with those wells might be \$5,000 per year. Consideration should also be given to delineating the plume to the northwest of TH-7. Ground

water in this vicinity presumably flows to the Village Well Field where it is extracted and treated. Obtaining water levels from this location would also help in developing potentiometric surfaces and evaluating capture provided by the Village Well Field. A more thorough review of existing data should help site managers determine the necessity of this additional monitoring location.

6.1.3 DEFINE THE “TARGET CAPTURE ZONE”

To assess the ability of the GMS to meet the containment objective in the ROD, the area to be contained must be clearly established and plotted on a figure (based on recent plume maps). Both vertical and horizontal extent of the plume and all constituents of concern should be considered. Because the Village Well Field is located within the contaminant plume (as evidenced by contamination in the extracted water) and is pumping at approximately 200 gpm, it is infeasible for the GMS (which pumps up to 50 gpm) to contain the entire plume. The GMS, however, can contain a portion of the plume and thereby reduce the migration of contamination to the Village Well Field. The target capture zone should consider these hydrogeologic limitations and the remedy goals. Although the ROD requires containment of the area to the south of the River, the site managers may feel the ground water contamination around TH-7 should also be contained. Assuming the Village Well Field air stripper continues to operate effectively, protectiveness should be maintained in either case.

The specific target capture zone should be clearly outlined on a current plume map and must consider all contaminants of concern (including PCE, TCE, cis-1,2 DCE, and vinyl chloride). If concentrations fluctuate between sampling events, a number of recent sampling events should be considered when selecting the target capture zone. This process should include input from the RPM, EPA hydrogeologist, and contractor. Previous site documents and data, including risk analyses, should be considered. The conceptual model recommended in Section 6.1.1 and the data from sampling points recommended in Section 6.1.2 should also be considered. The target capture zone should be included in the next annual report, and the cost for document/data review, discussion, and outlining of the target capture zone should not exceed \$10,000.

6.1.4 INTERPRET ACTUAL CAPTURE WITH RESPECT TO THE “TARGET CONTAINMENT ZONE”

Reliable potentiometric surface maps should be developed using water level data collected from piezometers and monitoring wells. Water levels from both shallow and intermediate zones should be considered. This map, however, should not include water levels taken from operating extraction wells because the reduced water levels in these wells inaccurately represent the water levels in the surrounding aquifer, thereby biasing the analysis in favor of capture. Arrows indicating ground water flow directions and the interpreted capture zone should be provided on this map. Then, the interpreted capture zone should be superimposed on the “target capture zone”. If the actual capture zone encompasses the target capture zone, then adequate containment is suggested. This capture zone analysis should confirm that contaminated ground water is not discharging to the East Branch Croton River.

It should be noted that while this approach provides the best preliminary analysis for capture, insufficient data set may exist. Additional data points may be needed (i.e., new piezometers, river stage measurements, elevations of wetlands, etc.). Additional monitoring wells and piezometers may need to be installed for clearly resolving the potentiometric surface in heterogeneous formations. For example, piezometer pairs can be installed in specified locations to resolve the direction of ground water flow in that location of the aquifer. Installing continuous water-level recorders for river stage measurements and for selected piezometers, for a specified time period, might add valuable information and should also be considered. In the process of reviewing the data and conducting the capture zone analysis, previous

reports should be reviewed to determine if the site wells need to be re-surveyed with respect to a common reference point.

The capture zone analysis with the potentiometric surface should be augmented by other lines of evidence including concentration trends in monitoring wells. Sentinel monitoring wells located downgradient of the extraction system should show decreasing trends in contaminant concentrations over time if capture is adequate. Increases in concentrations, or persistent high concentrations, likely indicate a lack of capture. For example, the relatively high concentrations in TH-7, might indicate that contamination continues to migrate beyond the extraction system and under the River toward the Village Well Field.

Approximate flow budgets should also be considered. For example, the Village Well Field extracts approximately four times more water than the GMS. If the two extraction systems are located in the same formation, the Village Well Field may have a capture zone four times larger than the GMS. Data from pump and recovery tests may yield additional information about the zones of influence of these extraction systems, but it should be noted that a zone of influence does not necessarily correspond to the capture zone.

Developing a ground water flow model and using particle tracking in the simulated flow fields can also be used in evaluating capture. The consideration of a ground water flow model should be postponed until the preliminary capture zone analysis is complete and data gaps are identified. Once complete, a better understanding of the modeling needs will be better understood. Developing a ground water flow model may not be necessary or cost-effective at this site. As a guideline, costs for developing for this site and properly calibrating it, if necessary, should not exceed a one time cost of \$35,000, and use of the model and recalibrating it, once developed, should not exceed \$10,000 per year.

This capture zone analysis should initially focus on the interpretation of existing data. Once the analysis is complete, significant data gaps can be identified and additional piezometers can be considered, if necessary. A base map for the site already exists, and potentiometric surfaces have been generated in the past. Development of the new potentiometric surface map, identification of ground water flow directions, consideration of concentration trends in sentinel wells, consideration of pump test data and approximate flow budgets, interpretation of the capture zone, comparison of the interpreted capture zone to the target capture zone, and documentation of the entire process in the next annual report should require approximately \$15,000. Conducting subsequent capture zones once a year and documenting them in the annual report should cost approximately \$5,000. The cost of installing additional monitoring points is not included in these costs as the number of necessary points cannot be determined without conducting the preliminary capture zone analysis and identifying the crucial data gaps.

6.1.5 DEVELOP A REVISED CONCEPTUAL MODEL

Once the items in Section 6.1.1 to 6.1.5 are complete, a revised conceptual model should be developed and clearly stated and/or referenced in future site documents (i.e., the annual reports). The cost of these revisions and documentation is included in Section 6.1.1.

6.1.6 REPLACE EW-2 TO EW-4 WITH NEW EXTRACTION WELLS

As noted in the RSE report, extraction wells EW-2 to EW-4 are pumping ground water at relatively low concentrations, while impacted areas further east (DGC-19, DGC-71) are not located close to any extraction wells. Based on the revised conceptual model, perhaps one to three new extraction wells should be installed, to the east of EW-1. Any new extraction well should include pitless adapters and separate electrical vaults or risers at each extraction well (unlike the present wells, which have limited

access and poorly conceived electrical connections). Water from each extraction well should be routed to the treatment building in individual HDPE lines. Flow from each well can then be metered at the treatment building (unlike the present system, where individual flow rates cannot be measured). EW-1 should be retrofitted in a similar manner. EW-2 to EW-4 should probably be decommissioned.

The specific locations of these new wells should consider containment of the plume, mass recovery, and potential de-watering of the wetlands. Before proceeding, the appropriate target capture zone (Section 6.1.2) should be determined and a preliminary capture zone analysis of the current system should be completed. Updated plume maps and analysis of concentration trends in monitoring wells should also be analyzed before proceeding. Finally, a wetlands evaluation may be required to determine the potential for de-watering the wetlands from new extraction wells. The scope and goal of the wetlands evaluation should be narrow and clearly defined with a specified time frame. Prior to the evaluation, site managers should discuss the relative priorities of containing the plume, remediating the aquifer, and maintaining the wetlands. Data likely exist from previous pump and recovery tests that will help determine the expected drawdown in the wetlands due to current pumping efforts and potential future pumping efforts.

If new wells are installed south of the river to contain the plume south of the River, the concentrations in TH-7 and points north of the River will eventually decrease due to degradation and extraction and treatment by the Village Well Field. If wells are installed north of the river to contain the contamination near TH-7, additional costs will be required to pipe the water beneath the River, but the contamination would be addressed directly by the GMS. Alternative technologies could be considered for addressing the contamination near TH-7, but the costs of installing and operating the systems may not outweigh the benefits, primarily because the Village Well Field and associated air stripper will continue to extract and treat the water. Furthermore, these technologies would likely require continued operation of the GMS.

Site managers should aim to have the extraction wells relocated by the end of fiscal year 2003. This gives ample time to conduct the steps outlined above, including addressing the data gaps by installing new monitoring points and collecting and interpreting additional rounds of water levels. The site managers should layout a schedule for achieving this goal, complete with contingencies for delays that are expected.

Approximate capital costs for installing the wells, vaults, and piping might be \$125,000. The total flow rate may be the same as the current system, but the air stripper (perhaps with minor modifications) can handle additional flow from new wells if necessary. The cost of the wetlands evaluation and other planning should be completed for under \$20,000.

6.2 RECOMMENDED CHANGES TO REDUCE COSTS

In the experience of the RSE team, an air-stripping system that pumps less than 100 gpm and treats concentrations on the order of several hundred ppb of VOC's (i.e., requires only sporadic attention for operation such as the weekly, monthly, quarterly O&M schedule currently employed) should cost \$200K/yr or less (compared to the \$400K/yr identified for this site). Sites vary in complexity and the technical assistance required, but specific opportunities for cost reduction at this site are presented below.

6.2.1 CUT MANAGEMENT EXPENSE

The U.S. Army Corps Of Engineers (USACE) costs for administration, oversight, review, QA and analysis of about \$120,000 per year represent 30 to 40 percent of the site O&M costs. From discussions with the EPA and USACE project managers, the RSE team understands that these oversight costs cover costs associated with contracting and management oversight of the subcontractor in addition to technical

oversight. The technical oversight contributes to the interpretation in the annual reports and to other technical evaluations associated with making site decisions. Examples of technical oversight include evaluating alternative technologies such as the use of hydrogen-releasing compound (HRC); planning for wetlands evaluations; planning, preparing, and proposing a ground water flow model; and considering alternate extraction well locations. In addition, costs are included for other plans or reports including a sampling and analysis plan and remedial action work plan.

Although lumping all of these items into a single oversight task allows the USACE project manager to freely allocate funds from one item to the next as necessary, this lumping of funds makes it difficult to determine the level of effort and cost associated with the individual components. Thus, even as individual components are completed, the technical oversight costs could remain the same. A more specific scope for this technical oversight task will help the EPA RPM track and evaluate the costs of each item and reduce the costs over time as items are completed.

The RSE team does not know the level of effort or cost required within the USACE framework for contracting and management oversight of the subcontractor. Assuming 15% of the non-USACE costs, this oversight could be provided for \$36,000 per year.

Approximately \$62,000 is budgeted for reporting, and the USACE project manager indicated that approximately \$50,000 of it is allocated to the subcontractor for preparing the reports. The remainder is presumably available for technical oversight that is typically required only for the annual report. Recommendations 6.1.1 through 6.1.6 highlight items that should be included in the annual reports and provide cost estimates for those items. In addition to those items, the RSE team estimates that approximately \$6,000 per year might be required for technical oversight on the annual report.

In addition to the above items, technical oversight could be provided for evaluating new strategies or technologies to augment or replace the current GMS. Such evaluations should be limited in scope and conducted every couple of years as technology options become available. A preliminary evaluation of approximately \$5,000 is likely sufficient to determine if a technology is worth pursuing further. This preliminary evaluation should consist of contacting vendors of the technologies to determine costs for application. Although pilot studies may be considered as a preliminary step, the costs for applying the technology site wide should be considered. If a site-wide application is considered too costly, then even a pilot test is generally not worth pursuing. Having the site conceptual model on hand and detailed annual reports will help the site team determine the technologies worth considering and communicating site features to vendors. Once again, these preliminary evaluations should only occur every couple of years as necessary and should be limited in scope rather than being a continuous, broad or general task.

Accounting for the costs of the items specified in Section 6.1 and those items included in this section, suggested oversight costs can be summarized as follows:

Item	Annual Costs for 1st Year after RSE	Annual Costs for Subsequent Years after RSE
Management oversight	\$36,000	\$36,000
Oversight on annual reports	\$7,500	\$6,000
Evaluation of alternate technologies	\$5,000	\$5,000
Conceptual model	\$7,500	\$2,500
Target capture zone	\$10,000	\$0

Item	Annual Costs for 1st Year after RSE	Annual Costs for Subsequent Years after RSE
Capture zone analysis	\$15,000	\$5,000
Wetlands evaluation	\$20,000	\$0
Ground water flow model	\$0	contingent on need*
Subtotal	\$101,000	\$54,500
10% contingency for a conservative estimate	\$10,100	\$5,450
Total	~\$110,000	~\$60,000

* A model may not be necessary or cost-effective for the site. Analysis of the existing data will help determine the need. See Section 6.1.4 for guidelines on estimated costs for development, model updates, and simulations.

Thus, over the next two or three years, the oversight costs should reduce by approximately 50% from \$120,000 per year to approximately \$60,000 per year.

6.2.2 REDUCE SAMPLING AND ANALYSIS, EQUIPMENT RENTAL, AND TRAVEL/PER DIEM COSTS

The costs of the VOC analysis by EPA Method 524.2 plus BTEX and MTBE analysis are about twice that of the commonly used EPA 8260B. It should be straightforward to justify switching to EPA 8260B, which is widely used at Superfund sites. Changing analysis methods would yield a cost savings of about \$15,000 per year. The site managers conveyed to the RSE team that the EPA Method 524.2 is used due to a state mandate because of the potential for connecting the plant effluent to the water supply. Because this connection may take years to occur or may never happen, Method 8260B should be used until the connection becomes a reality. Method 8260B should also be used for aquifer and surface water samples as it generally is for other Superfund Sites. The detection limits for 8260B and 524.2 are the same so a loss of information should not occur. The site managers should discuss the motivations for changing methods with the state so that the sampling can proceed cost effectively with no sacrifice to system effectiveness.

The costs reported for sampling and analysis (\$67,000), equipment rental (\$15,000), and travel/per diem (\$21,000) are presumably used to conduct the monthly inspections and the quarterly and annual sampling events. Therefore, the total cost is \$103,000.

In discussions subsequent to the RSE, the USACE project manager confirmed that 3 days were required for the quarterly sampling events and that delays in low-flow sampling due to the stabilization of turbidity do not continue to prolong the sampling events. At this rate, the annual event should be completed within 5 days. Thus, a total of 14 sampling days are required per year at this site. An additional 8 days are required for the monthly checks. An additional 4 days for two staff can be assumed for mobilization and demobilization. Based on the professional experience of the RSE team and information gathered from RSEs at other Superfund sites, a competitive cost for labor and equipment for sampling at is approximately \$2,000 per day. This includes two staff working 10-hour days, transportation, per diem, and equipment rentals. For a monthly inspection (including the sampling of the effluent), assuming a billing rate of approximately \$60 per hour, a 12-hour day, transportation, per diem, and equipment, the cost should come to under \$1,200. The approximate total costs for labor, equipment, and travel associated with sampling and monthly inspections should therefore be consistent with those outlined in the following table.

Item	Calculation	Cost
Quarterly and annual sampling	\$2,000/day x 14 days	\$28,000
Monthly inspections	\$1,200/day x 8 days	\$9,600
Mobilization and demobilization	\$2,000/day x 4 days	\$8,000
Subtotal		\$45,600
Additional contingency for a conservative estimate	10%	\$4,6560
Total		~\$50,000

The sampling and monthly inspection costs should be reviewed and compared to these estimated costs. The total current costs are approximately \$103,000. Given the above costs of \$50,000 plus costs for sample analysis (currently estimated at approximately \$30,000 to \$35,000), savings of approximately \$20,000 to \$25,000 per year could likely be expected in addition to the estimated \$15,000 per year that can be saved by changing the analytical method.

6.2.3 REPLACE ELECTRONIC MONITORING SYSTEM WITH AN AUTODIALER

Using an autodialer system with direct dialing to inform the system operator of site alarms is as effective as the current third party electronic monitoring service. Installation of an autodialer for less than \$5,000 will eliminate the \$1,000 per year fees for the electronic monitoring. The cost benefit of this recommendation should be evaluated before proceeding.

6.3 MODIFICATIONS INTENDED FOR TECHNICAL IMPROVEMENT

6.3.1 INSTALL NEW UNDERGROUND DISCHARGE LINE

A new 6-inch diameter underground HDPE discharge line with no valves should be installed from the treatment building to the River outfall. This line would be expected to operate for at least 5 years based on the previous discharge line. The cost of installing this line should be less than \$10,000. This line should not require detailed design for installation. Designing and installing an acid wash or sequestering system solely for protecting this line is not cost effective. Installing a larger diameter line with minimal design effort will solve the problem because the current quarterly acid washing of the air stripper has kept the system operating at high efficiency. The new discharge line will probably not experience fouling problems. Furthermore, this line will provide extra capacity in case higher flow rates are needed for plume capture. Any further study of alternate fouling prevention studies should be suspended at least until the new extraction system (i.e., with new wells) is operational.

6.3.2 IMPROVE TO ANNUAL O&M REPORTS

The annual reports should include a number of items pertinent to O&M. With respect to ground water monitoring and system performance, the following are items that should be included:

- table(s) reporting water level data, including well name, screened interval, measuring elevation (i.e., top of casing), date, depth to water, and ground water elevation
- table(s) listing measured concentrations at monitoring wells
- potentiometric surface maps, including interpretations of ground water flow directions and interpreted capture zone (superimposed on a “target capture zone”)
- updated plume maps with the target capture zone identified and interpretation of changes to the plume extent and magnitude
- time-series plots of concentrations in extraction and monitoring wells and interpretation suggesting the progress of aquifer restoration, or if sentinel wells, the adequacy of plume capture
- the site conceptual model with any updates
- a comprehensive well information table (name, date installed, ground elevation, top of casing, total depth, screened interval, aquifer classification, etc.)
- total amount of water extracted, a time series plot of the estimated mass removed, and a associated interpretation with respect to the system goal of aquifer restoration

A description of the well name convention, as it pertains to the aquifer that is screened (if in fact it does so) would also be helpful. Other information is also pertinent and should be included as necessary. For example, including a description of recently evaluated alternative remedial strategies may be appropriate. It should be noted that some of these items are already included in the annual reports. The costs for reporting and technical oversight were discussed in Sections 6.1 and 6.2.

6.3.3 ENSURE VAPORS FROM ACETIC ACID WASH COMPLIES WITH OSHA STANDARDS

The acetic acid vapors in the treatment building seem strong, especially during the acid wash. Efforts should be taken to ensure that the vapors within the building comply with OSHA standards. Compliance will be a function of exposure which consists of both concentration and duration of exposure. The first steps in such an analysis are to note the time that the individuals are in the treatment building following the acid wash, to determine the concentration of the solution used, and to determine the applicable standards, OSHA Permissible Exposure Limit (PEL) and short-term exposure limit (STEL). These steps are not time consuming and could be accomplished for a negligible increase in annual cost. Further actions should be taken, if these initial steps suggest over exposure.

6.3.4 MEASURE THE AIR FLOW THROUGH THE AIR STRIPPER

Measuring the air flow with a thermal anemometer or pitot tube may provide the opportunity to optimize the air stripper. It may be determined that the capacity of the air stripper can be improved. There is a long run of duct from the blower to the air stripper that is ideal for sampling flow rates. The stripper operates effectively when the packing is clean, so the measurement is not urgent. The measurement can be conducted during a monthly or quarterly or site visit for under \$500.

6.4 MODIFICATIONS INTENDED TO GAIN SITE CLOSE-OUT

6.4.1 CONTINUE EVALUATING ALTERNATIVE REMEDIAL OPTIONS

The RSE team notes three categories of approaches to future remedial strategy ranging from passive to aggressive depending on future monitoring and the results of the revised conceptual model development. At this time, the RSE team favors the moderate approach.

Passive Approach: Switch to Monitored Natural Attenuation

This passive approach becomes valid if further conceptual model development suggests that site-related contamination will not adversely impact any receptors. This might require development of a numerical flow and transport model, to demonstrate that migration of contaminants is sufficiently slow to allow natural degradation of the contamination before it reaches any receptors. This would require a well-calibrated transport model (which might be a challenge given the complex hydrogeology at the site) and reliable evidence regarding in situ degradation of site-related contaminants. The high percentage of PCE breakdown products, especially on the east side of the plume, indicate the possibility for degradation of chlorinated solvents. Additional data to confirm and quantify the degradation rate is being collected and evaluated. However, it should be noted that reductive dechlorination may successfully transform PCE to TCE, TCE to DCE, and DCE to vinyl chloride. These daughter products are as significant or possibly more significant hazards for human and environmental health and vinyl chloride is more effectively degraded in aerobic conditions. Thus, complete degradation of chlorinated aliphatic compounds such as PCE to harmless constituents would ideally involve anaerobic conditions to transform these compounds to vinyl chloride, and then aerobic conditions to transform vinyl chloride to harmless end products.

Moderate Approach: Continue With Modified Pump and Treat System

Given the history of impacts at the Village Well Fields and the continuing elevated plume concentrations, pump and treat will likely continue to be required for plume containment. The current system should be modified as per Sections 6.1.1 to 6.1.7. The system can then be used as a containment remedy, with improved mass removal relative to the present system (and thus increased chance of achieving aquifer restoration south of the River). Contamination beyond an appropriate capture zone would be extracted and treated by the Village Well Field system or eliminated by biodegradation.

Aggressive Approach: Enhanced Biodegradation

USACE is currently evaluating the addition of electron donors such as HRC to augment reductive dechlorination. Enhancement of the natural attenuation may be possible, but the cost of the enhancement should be weighed against the potential savings, which would result if pump and treat system operation can be terminated at an earlier date. For the current system, predicting a close out date for the pump and treat system is virtually impossible. However, a revised system may have a better chance of achieving site closeout, and the HRC system should be compared to a revised pump and treat system.

If HRC is to be considered, it should be pilot tested. However, that pilot test should not be conducted until the cost of a full-scale system is approximated. That will include a clear statement of the goals of a full-scale system, and include the area over which a full-scale system would be required. It should include an assessment of whether or not pump and treat will still be required in addition to the HRC. It should also address the potential to drive degradation to a point where vinyl chloride is produced (as is currently observed in some monitor wells), because the resulting anaerobic conditions will not be well suited for biodegradation of vinyl chloride to harmless products.

The RSE team feels that the likely outcome is that a full-scale HRC system will be very expensive, subject to a high degree of uncertainty, and may not preclude the continued operation of a pump and treat system. The RSE team feels that moderate approach (a revised pump and treat system) is likely the most cost-effective approach to achieving the goals stated in the ROD.

6.5 UNUSED EQUIPMENT

The RSE team did not note any unused equipment that could be potentially useful at another site.

6.6 SUGGESTED APPROACH TO IMPLEMENTATION OF RECOMMENDATIONS

Concentrations in ground water have been reduced over time, probably due to a combination of the pump and treat system and natural in-situ biodegradation. The site managers for the Brewster Wellfield Superfund Site are considering alternate remedial strategies, and the RSE team applauds this proactive site management and encourages further consideration of remedial options.

However, the RSE team recognizes that intent of remedy as stated in the ROD (i.e., hydraulic containment and aquifer restoration of the plume south of the River) is not likely to be met by the current system. Therefore, we suggest a series of recommendations in Section 6.1 to improve the conceptual model of ground water flow and contaminant transport at the site, as well as to improve the ability to monitor containment of ground water flowing towards the River from the South. We also recommend additional ground water monitoring in a critical area south of EW-1, and based on the revised conceptual model, replacing some of the existing extraction wells with one to three new extraction wells located to the east of the current wells. These recommendations could feasibly be implemented by the end of fiscal year 2003.

In terms of cost reduction, the RSE team suggests immediate implementation of the cost saving measures in Section 6.2. The replacement of the discharge pipe, and suggested changes to annual O&M reports, should also be implemented immediately.

For site closeout (Section 6.4), we agree that the rate of natural attenuation should be evaluated as a component of the site cleanup. We feel the most effective approach towards gaining site closeout, however, is likely to be improving the effectiveness of the pump and treat system. Until the improvements in effectiveness and costs are made, a major investment in other technologies available at this time does not appear warranted. Pilot testing of alternate remedies should only be performed if scale-up costs to a full-scale system are calculated and appear favorable in a cost-benefit analysis versus a revised extraction system.

7.0 SUMMARY

The observations and recommendations given below are not intended to imply a deficiency in the work of either the designers or operators, but are offered as constructive suggestions in the best interest of the EPA and the public. These recommendations obviously have the benefit of the operational data unavailable to the original designers.

The RSE process is designed to help site operators and managers improve effectiveness, reduce operation costs, improve technical operation, and gain site closeout. Table 7-1 summarizes the costs and cost savings associated with each recommendation. Both capital and annual costs are presented. Also presented is the expected change in life-cycle costs over a 10-year period (at the request of the Site managers) for each recommendation both with discounting (i.e., net present value) and without it.

Table 7-1. Cost Summary Table

Recommendation	Reason	Estimated Change in			
		Capital Costs*	Annual Costs	Life-cycle Costs**	Life-cycle Costs ***
6.1.1 Preliminary conceptual model	Effectiveness	\$7,500	included in 6.2.1	\$7,500	\$7,500
6.1.2 Additional delineation south of EW-1(GeoProbe, new wells)	Effectiveness	\$75,000	included in 6.2.1	\$75,000	\$75,000
6.1.3 Define target containment zone	Effectiveness	\$10,000	\$0	\$10,000	\$10,000
6.1.4 Interpret capture zone	Effectiveness	\$15,000	included in 6.2.1	\$15,000	\$15,000
6.1.5 Revise conceptual model	Effectiveness	\$0	included in 6.2.1	\$0	\$0
6.1.6 New extraction wells	Effectiveness	\$125,000	\$0	\$125,000	\$125,000
6.2.1 Cut oversight expense	Cost reduction	(\$10,000)*	(\$60,000)	(\$610,000)	(\$496,000)
6.2.2 Reduce Sampling and Analysis, Equipment Rental, and Travel/Per Diem Costs	Cost reduction	\$0	(\$35,000) to (\$40,000)	(\$350,000) to (\$400,000)	(\$283,500) to (\$324,000)
6.2.3 Replace alarm monitoring service with autodialer	Cost reduction	\$5,000	(\$1,000)	(\$5,000)	(\$3,100)
6.3.1 Install New Underground Discharge Line	Technical improvement	\$10,000	\$0	\$10,000	\$10,000
6.3.2 Improve to Annual O&M Reports	Technical improvement	included in 6.2.1	included in 6.2.1	\$0	\$0
6.3.3 Ensure Vapors from Acetic Acid Wash Complies with OSHA Standards	Technical improvement	negligible	negligible	negligible	negligible
6.3.4 Measure the Air flow through the Air Stripper	Technical improvement	\$500	\$0	\$500	\$500
6.4.1 Continue evaluating alternative remedial options	Gain site closeout	included in 6.2.1	included in 6.2.1	\$0	\$0

Costs in parentheses imply cost reductions.

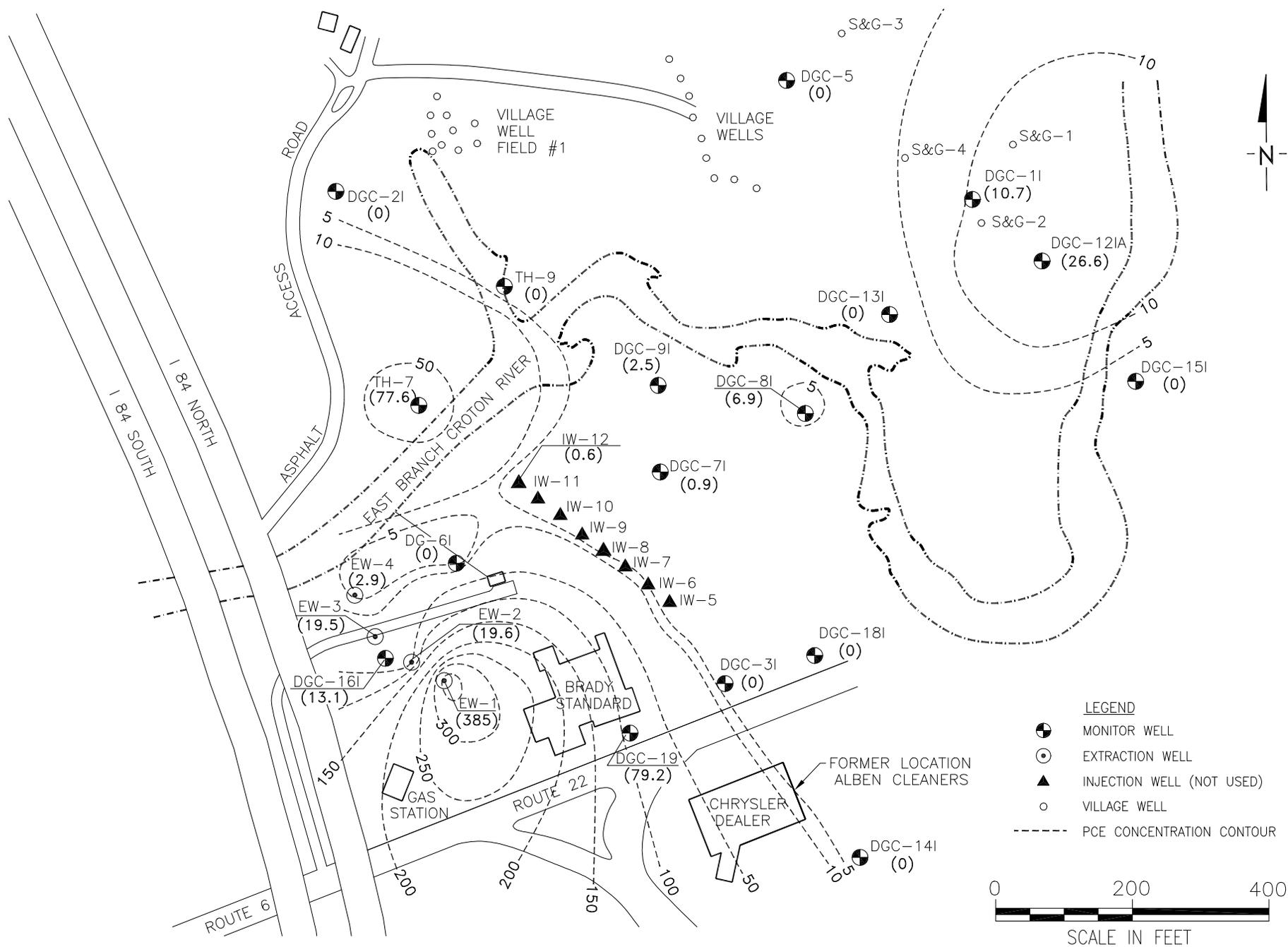
* includes oversight costs and cost savings associated with the first year following the RSE

** assumes 10 years of operation with a discount rate of 0% (i.e., no discounting)

*** assumes 10 years of operation with a discount rate of 5% and no discounting in the first year

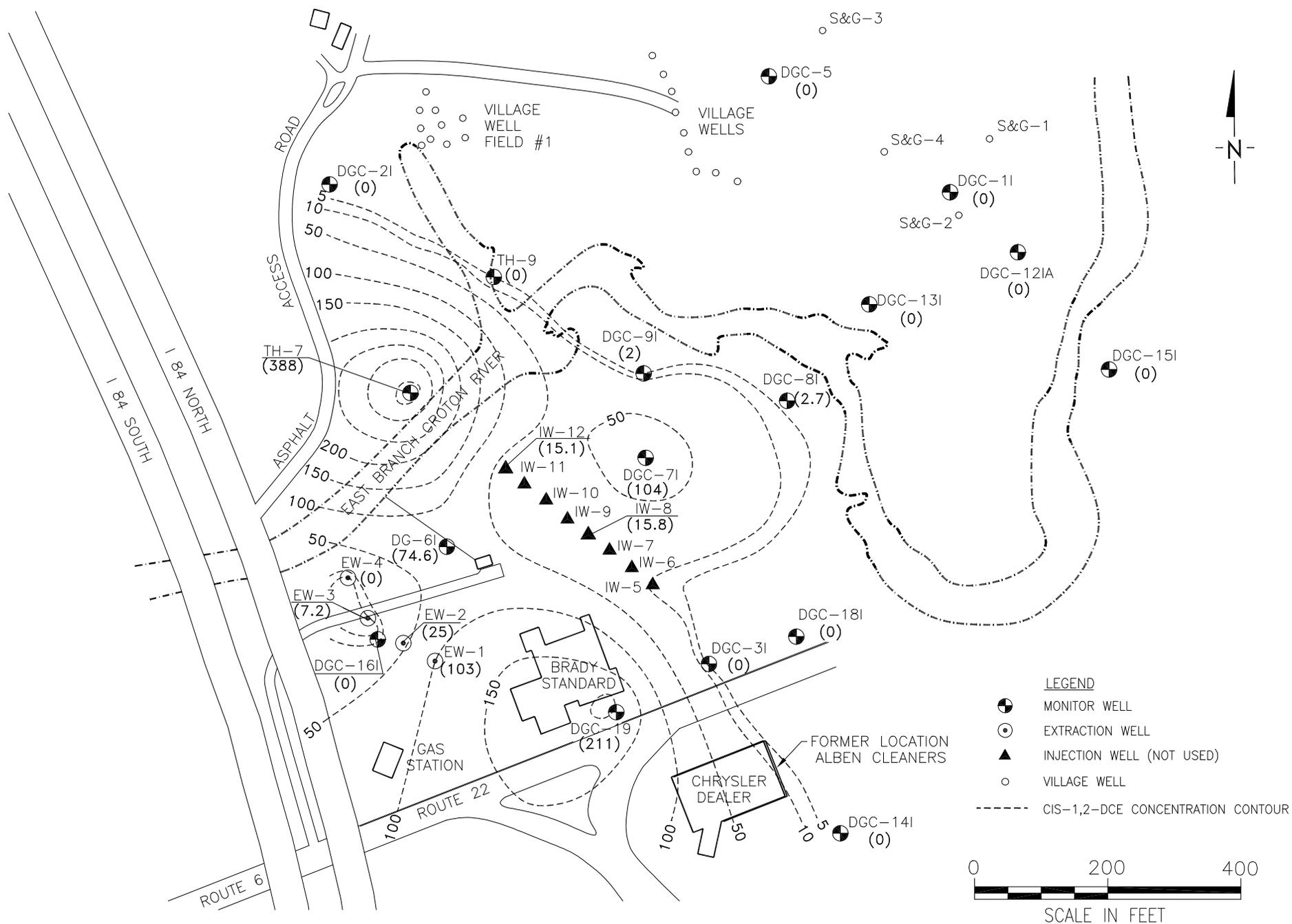
FIGURES

FIGURE 1-2. PCE IN GROUNDWATER, NOVEMBER 2000.



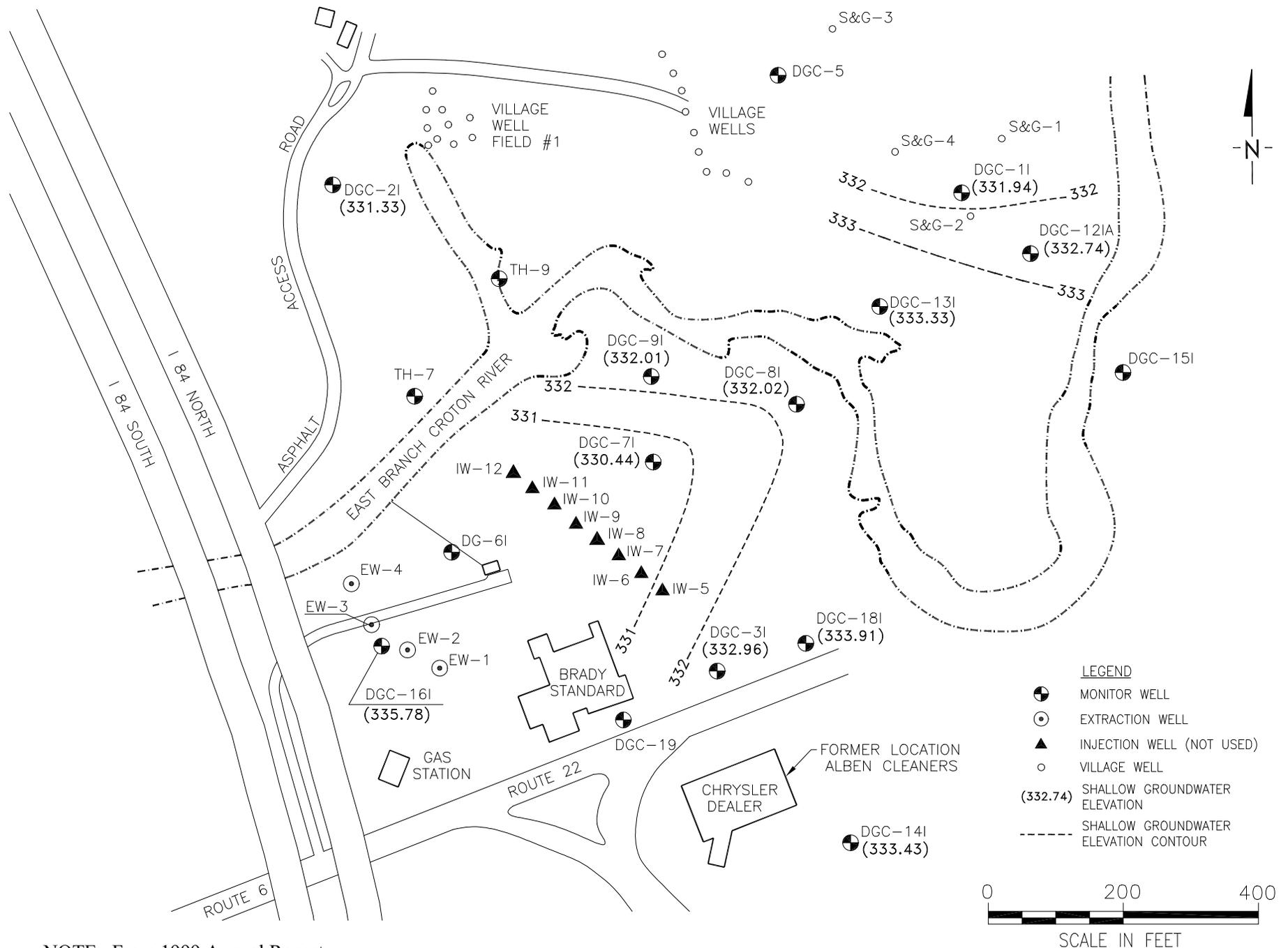
NOTE: From 2000 Annual Report.

FIGURE 1-3. CIS-1,2-DCE IN GROUNDWATER, NOVEMBER 2000.



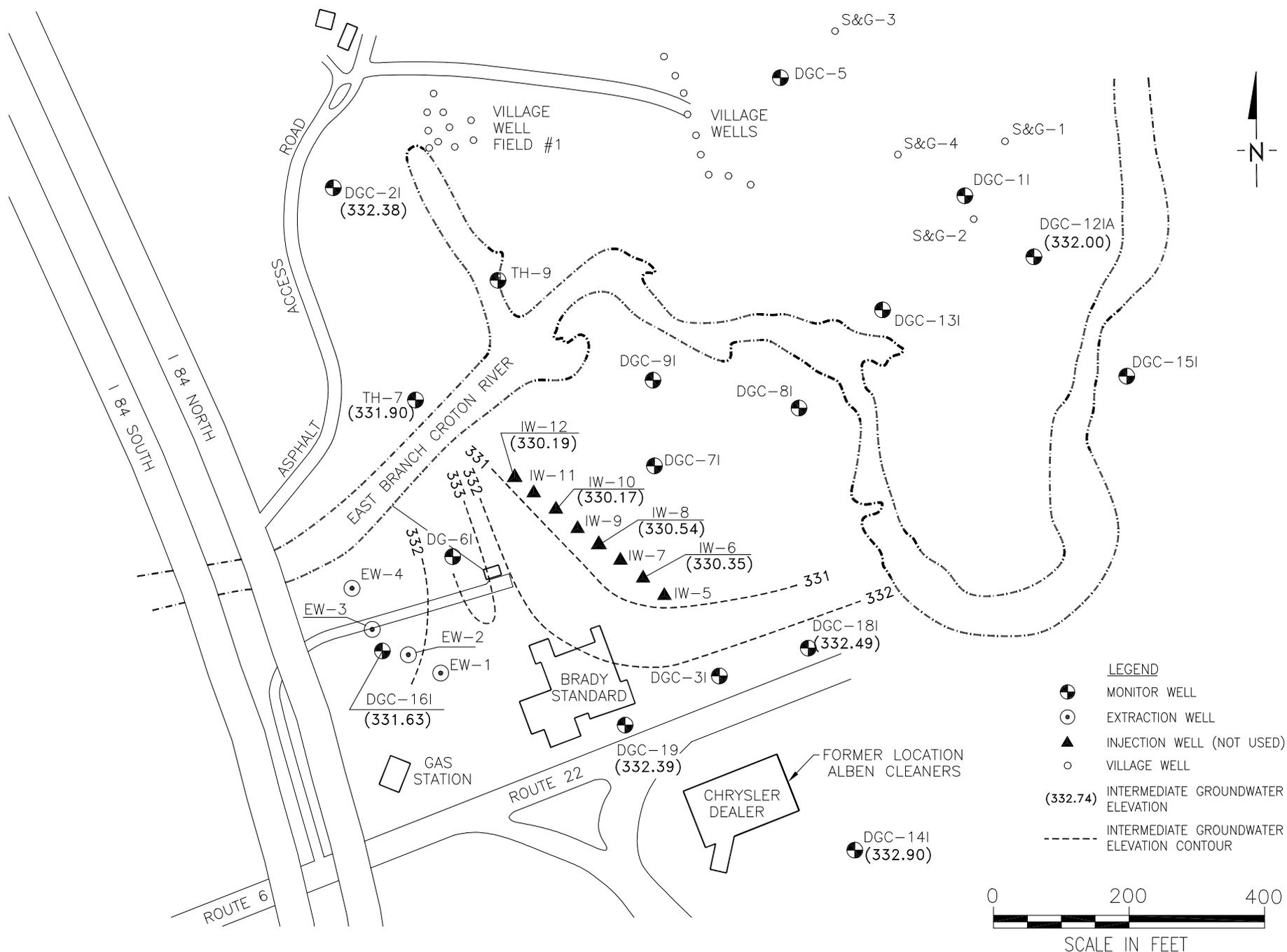
NOTE: From 2000 Annual Report.

FIGURE 2-1. SHALLOW GROUNDWATER ELEVATIONS, SEPTEMBER 1999.



NOTE: From 1999 Annual Report.

FIGURE 2-2. INTERMEDIATE GROUNDWATER ELEVATIONS, SEPTEMBER 1999.



NOTE: From 1999 Annual Report.



U.S. EPA National Service Center
for Environmental Publications
P.O. Box 42419
Cincinnati, OH 45242-2419

Solid Waste and
Emergency Response
(5102G)

542-R-02-008t
October 2002
www.clu-in.org/rse
www.epa.gov/tio