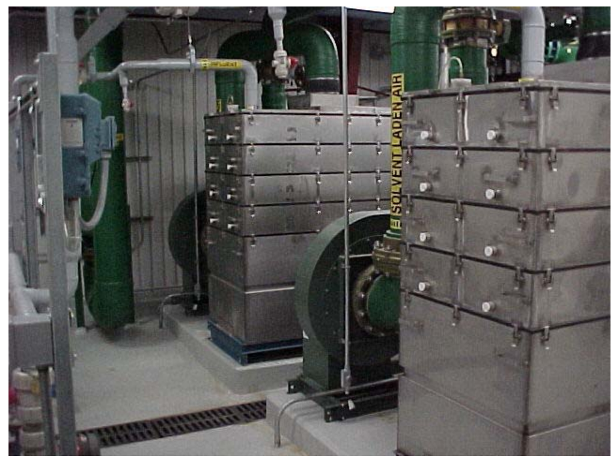
REMEDIATION SYSTEM EVALUATION

SAVAGE MUNICIPAL WATER SUPPLY SUPERFUND SITE
MILFORD, NEW HAMPSHIRE



Report of the Remediation System Evaluation,
Site Visit Conducted at the Savage Municipal Water Supply Superfund Site
March 22-23, 2001

Final Report Submitted to Region 1
September 17, 2001

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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.

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EXECUTIVE SUMMARY

The Savage Municipal Water Supply Superfund Site, located on the western edge of Milford, New Hampshire, consists of a source area and an extended plume that is approximately 6,000 feet long and 2,500 feet wide. The remedy was divided into two operable units (OUs) based on the 1991 plume. OU1, also referred to as the OK Tool Source Area, is the portion of hte plume that had the highest levels of groundwater contamination. OU2 is the remaining portion of the concentrated plume and the dissolved plume. OU1 is a State-lead site with 90% of the funding provided by the Superfund program, and OU2 is a responsible-party site. This RSE pertains only to OU1.

The contamination of the extended plume stems from the operation of four industrial facilities, but the contamination from OU1 stems mostly from the former OK Tool Company that discharged into the subsurface volatile organic compounds (VOCs) including tetrachloroethylene (PCE), trichloroethylene (TCE), 1,1,1 trichloroethane, and various trade name oils and solvents. The source material in OU1 consists of dissolved phase and possible free-phase VOCs.

Remediation in OU1 began in 1998 with the installation of an extraction and treatment system and construction of a slurry wall that completely surrounds the source area. The extraction and treatment system consists of air sparging wells, a soil vapor extraction (SVE) system, four extraction wells (two located inside of the wall and two located outside of the wall), and a treatment plant that began full operation in May 1999. Treated water is returned to the aquifer through three injection wells and one recharge chamber. The plant has operated almost continuously since then with a six month hiatus in the SVE and air sparging systems in the Fall of 2000 due to a pilot study for surfactant use. During the RSE site visit it was discovered that in December 2000 there was an accidental discharge to the recharge chamber of an unknown amount of PCE that had been recovered and stored on site. The contractor is working to characterize this problem with the EPA and State overseeing that work.

Recommendations to improve system effectiveness include the following:

- reconfiguring the system such that recovered solvent is disposed of offsite thereby reducing the potential for accidental releases in the future;
- evaluating the effectiveness of capture provided by the extraction wells located outside of the slurry wall and reporting the results;
- relocating the recharge points beyond the influence of the extraction wells;
- verifying containment offered by the slurry wall;
- analyzing monthly the operations data.

These recommendations will likely require over $65,000 in capital costs and $6,000 in annual costs.

Recommendations to reduce life-cycle costs include the following:

- discontinuing the steam regeneration of the carbon system and replacing the carbon when it is spent would require capital costs of $25,000 but would save approximately $20,000 per year;

- reducing operator labor from 40 hours per week to 16 hours per week would save approximately $99,000 per year; and

- replacing the existing blower for the SVE system with a smaller more efficient one would cost $15,000 up front but may reduce electrical costs by $30,000 per year.

These savings could more than offset the extra costs associated with recommendations to improve the system effectiveness.

Finally, the RSE revealed the need to clarify an exit strategy for the OU1 system, and the RSE team recommends more aggressive source removal possibly through pumping from additional extraction wells.

A summary of recommendations, including estimated costs and/or savings associated with those recommendations is presented in Section 7.0 of the report.

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.

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

Region1	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).

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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 Savage Municipal Water Supply Superfund Site was chosen based on initial screening of the pump-and-treat systems managed by USEPA Region 1 as well as discussions with the EPA Remedal Project Manager for the site and the Superfund Reform Initiative Project Liaison for that Region. This site has relatively high operation cost 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:

Frank Bales, Chemical Engineer, USACE, Kansas City District
Rob Greenwald, Hydrogeologist, GeoTrans, Inc. (EPA TIO's contractor)
Peter Rich, Civil and Environmental Engineer, GeoTrans, Inc.
Doug Sutton, Water Resources Engineer, GeoTrans, Inc.

1.3 DOCUMENTS REVIEWED

Author	Date	Title/Description
US EPA	9/27/1991	Record of Decision, Savage Municipal Water Supply Superfund Site, Milford, NH, September 27, 1991
CDM	6/96	OK Tool Source Area Savage Superfund Site - OU1, Municipal Water Supply Well, Milford, New Hampshire, Conceptual Remediation Design Report Volume 1
US EPA	12/19/1996	Explanation of Significant Differences
CDM	3/23/2000 - 1/16/2001	Progress Reports 26 - 38 (9/1999 - 9/2000) for the OK Tool Source Area Remedial Construction and Operations project.
USGS, Philip T. Harte, et al.	2001	Testing and Application of Water-Diffusion Samplers to Identify Temporal Trends in Volatile-Organic Compounds, USGS Open-File Report 00-196
CDM	2001	Plant operation data for the Savage Superfund Site
USGS	2001	Aquifer sampling data for the Savage Superfund Site

1.4 PERSONS CONTACTED

The following individuals were present for the site visit:

Thomas C. Andrews, P.E., New Hampshire Department of Environmental Services
Richard Goehlert, RPM, EPA Region 1
Darryl Luce, Project Liaison, EPA Region 1
Joe Newton, Plant Operator, CDM, Inc.

1.5 SITE LOCATION, HISTORY, AND CHARACTERISTICS

1.5.1 LOCATION

The site is located at the western edge of Milford, New Hampshire, which is approximately 30 miles from Manchester, New Hampshire. The site includes a plume of tetrachlorethylene (PCE) and other contaminants that stretches approximately 6,000 feet east from the intersection of Route 101 and Elm Street. The plume is bordered to the north and east by the Souhegan river, flows generally to the east in an alluvial aquifer, and has a plume width of approximately 2,000 at the widest point. The site consists of two operable units. Operable Unit 1 (OU1) is State-lead with Superfund money and consists of pump-and-treat, soil vapor extraction, and air sparging systems as well as a slurry wall to address a source area located at the former OK Tool Property. OU2 addresses the extended portion of the plume and is led by the responsible parties. The site layout outlining the plume, OU1, and OU2 is shown on Figure 1-1. The land surrounding the site is a mix of residential, commercial, agricultural, and industrial. This RSE only pertains to OU1.

1.5.2 POTENTIAL SOURCES

Four industrial plants (Hendrix Wire and Cable Corporation, Hitchiner Manufacturing Company, OK Tool Company, and New England Steel Fabricators, Inc.) contributed to the subsurface contamination from the 1940s to the 1980s. Hendrix and Hitchiner remain the only two viable responsible parties and therefore will lead the remediation of OU2. Although chromium, arsenic, polychlorinated biphenyls (PCBs), tetrachloroethylene (PCE), and other volatile organic compounds (VOCs) were used by these manufacturers, PCE remains the contaminant with the highest concentrations and most significant extent. The primary contributor to the PCE contamination appears to have been the OK Tool Company where drains connected solvent tanks to the subsurface. The SVE and pump-and-treat systems of OU1 extract contaminated vapor and groundwater underlying the property. High dissolved concentrations of PCE suggest the presence of freephase PCE in the groundwater in OU1.

1.5.3 HYDROGEOLOGIC SETTING

The site is relatively flat at approximately 275 feet above sea level and lies in the 100-year flood plain of the Souhegan River. The subsurface consists of approximately 5 feet of rich loam that overlies 60 to 120 feet of glacial outwash, which consists primarily of coarse sands and gravel. Fractured bedrock underlies the outwash and slopes from an approximate elevation of 210 feet in the western portion of the site to 160 feet in eastern portion. The weathered and fractured zones of this bedrock are 30 to 40 feet deep in the western portion and 10 feet deep in the eastern portion. An intermittent layer of glacial till, which is thicker in the west and thinner in the east, lays between the outwash and bedrock.

Groundwater elevations are typically 10 feet below land surface, and typical groundwater velocities range from 1.5 to 2.5 feet per day. Both the Souhegan River and water supply wells significantly affect groundwater flow directions and velocities. The Souhegan River is a losing river in the western portion of the site and becomes a gaining river approximately 1500 feet east of the former OK Tool Property. Local water usage from this aquifer is approximately 2,900,000 gallons per day with the majority of the pumping occurring at fish hatcheries to the north of the Souhegan River.

One of the fish hatchery wells has had concentrations of PCE at 2 ppb suggesting the pumping may be drawing contaminants under the river.

1.5.4 DESCRIPTION OF GROUND WATER PLUME

The PCE plume extends from the former OK Tool property 6,000 feet east with a maximum width of approximately 2,000 feet (see Figure 1-1). Vertical profiling within the slurry wall at OK Tool source area in 1997 revealed dissolved PCE concentrations exceeding 100,000 ppb suggesting the presence of PCE in the form of dense non-aqueous phase liquid (DNAPL). Concentrations outside of the slurry wall were as high as 5,000 ppb before pumping began. In portions inside and outside of the slurry wall dissolved PCE reaches from the water table into the bedrock. In addition, DNAPL may exist in the fractures, especially within the area encircled by the slurry wall. Potential fractures below this encircled area may provide conduit for DNAPL migration outside of the slurry wall regardless of hydraulic containment.

The PCE plume is shown in Figure 1-1. While PCE is the most extensive contaminant of concern, high concentrations of trichlorethylene (TCE) and 1,2 *cis*-dichloroethylene (DCE) are also present.

2.0 SYSTEM DESCRIPTION

2.1 SYSTEM OVERVIEW

The remedy includes a slurry wall for containment of the onsite source area, a groundwater extraction system (2 wells inside slurry wall and 2 outside the wall), a soil vapor extraction system (within the slurry wall), an air sparging system, and a groundwater treatment plant with an associated air exhaust treatment system. The treated ground water can be reinjected inside of the slurry wall through two injection wells or outside of the slurry wall through an injection well and/or an infiltration gallery. The components of the remediation, including the slurry wall, are shown in Figure 2-1.

2.2 EXTRACTION SYSTEM

Two extraction systems were constructed, one for soil vapor and the other for groundwater. The soil vapor extraction system includes an air sparging system to enhance recovery from the SVE system and to help lower ground water concentrations in the source area. Two deep wells, IW-1 and IW-2, extract groundwater from within the slurry wall to maintain an inward gradient from the surrounding river and prolific aquifer. Each of these wells is pumped at 17 gallons per minute. The operator has noted that pumping from IW wells could be significantly increased without exhausting the available water but that these wells are currently limited by their pumps to 25 gpm each. Two extraction wells, EW-1 and EW-2, are outside the slurry wall on the east and are pumped at 25 gpm each in an attempt to remediate the portion of the aquifer in OU1 outside of the slurry wall.

2.3 TREATMENT SYSTEM

The treatment system consists of two equalization tanks, two air stripping units with capacities of 150 gpm each, and a vapor phase carbon unit for treating the off gas of the air stripper and the air recovered from the SVE system. Two boilers are maintained daily to provide steam that can be used to heat the influent into the carbon unit, to regenerate the carbon onsite, and to use steam in the air sparging system. Steam has not been used in the air sparing system to date.

2.4 REINJECTION SYSTEM

There are three injection wells and one recharge gallery. Reinjection within the slurry wall was only done for the first few months of operation. Since then, and at the time of the RSE, reinjection was accomplished through the recharge gallery.

2.5 MONITORING SYSTEM

Groundwater is sampled at least twice per year from approximately 50 sampling points that include piezometers and monitoring wells installed at various depths and locations. The samples are analyzed for VOCs by NHDES, and the cost of these analyses is not included in the project costs for EPA. The extraction wells, plant influent, and plant effluent are sampled monthly and analyzed for VOCs. The costs of these analyses, however, are included in the EPA project costs. The air influent and effluent of the vapor phase carbon are sampled one to two times per month by the plant operator, and the plant operator analyzes the samples onsite for VOCs via gas chromatography. Water levels are measured monthly from approximately 45 locations and daily from the INEEL well located near the center of the area enclosed by the slurry wall.

The locations of the piezometer and monitoring-well clusters mentioned in this report are indicated in Figure 1-2.

3.0 SYSTEM OBJECTIVES, PERFORMANCE AND CLOSURE CRITERIA

3.1 CURRENT SYSTEM OBJECTIVES AND CLOSURE CRITERIA

For the selected remedy, the ROD stipulates a pump-and-treat system extracting 250 gallons per minute (gpm) to contain the migration of contaminants from the source area of the former OK Tool property and an additional 150 gpm from the source area on the Hitchiner property. Groundwater treatment would include metals removal and UV oxidation for contamination at the OK Tool Property, and the treated groundwater would be discharged to the Souhegan River or reinjected into the aquifer.

The ROD also stipulates a pump-and-treat system to address the extended plume. As the extended plume is addressed by the responsible parties, this report does not consider it further. This RSE only pertains to OU1.

An Explanation of Significant Differences (ESD) signed in December 1996 notes that the remedy for the OK Tool source area includes purchase of the property, installation of a slurry wall surrounding a source of contamination, a total of four extraction wells with a cumulative pumping rate of 70 gpm, and installation of a soil vapor extraction system with air sparging. The ESD stipulates that the extracted water would be treated with air stripping and carbon adsorption and would be discharged to the ground through a recharge gallery and injection wells. Thus, the maximum contaminant levels (MCLs) would be the primary, but not the sole, criteria for ground water discharge.

Both the ROD and the ESD make clear that the stated cleanup levels are interim goals until more detailed information is gained through system operation.

Additional objectives for the OU1 pump-and-treat system result from a Consent Decree between the EPA, New Hampshire, and the responsible parties. This decree states that after 20 years of operation of the OU1 pump-and-treat system, the responsible parties may sample for a period of 10 years the portion of OU1 that lies outside of the slurry wall. If contaminant concentrations from this sampling suggest that OU1 will continue to provide a source of contamination to OU2, the responsible parties can abandon remediation efforts in OU2. Thus, the managers of the OU1 system have incentive to restore the aquifer to levels below the maximum contaminant levels (MCLs) in less than 20 years or ensure containment of the contamination.

EPA Region 1 policy does not allow direct release of PCE into the air from the treatment plant. Thus, the site managers maintain an objective to minimize discharge of PCE into the air through the use of a vapor phase carbon adsorption system.

3.2 TREATMENT PLANT OPERATION GOALS

The current contract for operations calls for the plant to operate 24 hours per day, seven days a week while treating water from the four extraction wells. A plant operator attends the site four days per week for a total of 40 hours per week.

3.3 ACTION LEVELS

The groundwater cleanup levels and the discharge limits for treatment plant effluent are the MCLs as established by the Safe Drinking Water Act. For PCE and TCE, the cleanup and discharge limit is 5 ug/L.

4.0 FINDINGS AND OBSERVATIONS FROM THE RSE SITE VISIT

4.1 FINDINGS

In general, the RSE team found a well-maintained site with involvement of both the EPA RPM and a manager from the New Hampshire Department of Environmental Services. 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 obviously have the benefit of the operational data unavailable to the original designers.

4.2 SUBSURFACE PERFORMANCE AND RESPONSE

The groundwater extraction system operates smoothly with infrequent shutdowns. The site operator sets the variable rate pumps in IW-1 and IW-2 to extract water at approximately 17 to 20 gpm each and has throttled back significantly the constant rate pumps in EW-1 and EW-2 so that they pump approximately 25 gpm each. Thus, the groundwater extraction system pumps approximately 85 gpm despite a treatment plant capacity of nearly 300 gpm.

The soil vapor extraction (SVE) system has been running less frequently than the groundwater extraction system due a pilot study conducted inside the slurry wall to test the use of surfactants in removing DNAPL at neutral buoyancy. The SVE system and the associated air sparging system were shut down during the fall of 2000 for this study. While the SVE system has been running since the beginning of January, the air sparging system is shut down due to problems with the air compressor.

The entire system was shut down for 10 days at the end of December for the holidays.

4.2.1 WATER LEVELS

Rainfall in the area exceeds 25 inches per year and without pumping from IW-1 and IW-2 groundwater would likely mound within the area enclosed by the slurry wall thereby reducing the wall's effectiveness. The plant operator measures the water levels in all of the monitoring wells (inside and outside of the wall) on a monthly basis and the levels in the INEEL well on a daily basis. He uses those daily measurements from the INEEL alone to adjust the pumping rates of IW-1 and IW-2 and reduce the mounding of groundwater. The USGS monitors PW-8 and PW-9 daily, but these measurements are not reviewed by the plant operator.

4.2.2 CAPTURE ZONES

Potentiometric surfaces have not been plotted to determine the capture zones associated with the slurry wall and the extraction wells or to validate the containment offered by the wall. During the RSE visit the operator mentioned water elevation within the slurry wall varies directly with the elevation of the river. He and the site managers assume this water is seeping in through the bedrock or till below the wall. Pumping tests across the wall have not been conducted.

A calculation of approximate recharge to the area enclosed by the slurry wall compared to the pumping rate within the slurry wall suggests a hydraulic connection between the area enclosed by the wall and the rest of the subsurface. The wall encloses an area of approximately 125,000 square feet, and the Milford area receives approximately 2.5 feet of recharge per year, for a total recharge within the wall from precipitation of 312,500 cubic feet per year or approximately 2.3 million gallons per year (7.481 gallons per cubic foot). Groundwater extraction from within the wall totals approximately 35 gallons per minute or 18 million gallons per year. Thus, groundwater extraction from via pumping exceeds atmospheric recharge by almost an order of magnitude. Given that water levels do not drop significantly within the wall due to pumping at this rate, water is likely entering the enclosed area from the rest of the subsurface suggesting a hydraulic connection either through or under the wall.

4.2.3 CONTAMINANT LEVELS

Vertical profiling in 1997 showed that PCE concentrations in the contaminant "hot spot" (located approximately 100 feet southwest of the center of the area now enclosed by the slurry wall) ranged from 0 to 100,000 ug/L from the water table to the bedrock. When plant operation began in early 1999 concentrations extracted by the IW-1 and IW-2 were 900 and 2000 ug/L, respectively. In EW-1 and EW-2 they were 1400 and 750 ug/L, respectively. Concentrations in these wells at the time of the RSE were much lower: 650 ug/L, 950 ug/L, 400 ug/L, and 150 ug/L, for IW-1, IW-2, EW-1, and EW-2, respectively. Concentrations in a majority of the monitoring wells have also decreased. However, the PCE concentrations in the PW-6 cluster have significantly increased since operation, which is consistent with its location– midway between the hot spot and the interior extraction wells, IW-1 and IW-2. The concentrations at the PW-10 cluster of wells (located on the interior of the slurry wall on the downgradient side) have also increased. Finally, PCE concentrations at PW-14 (located on the eastern edge of OU1) have not significantly increased or decreased since operation.

While concentrations in EW-1 and EW-2 consistently decreased between the beginning of operation and January 2001, the RSE team expects them to rise due to an inadvertent release of PCE above discharge limits into the recharge gallery in November 2000. Already, the effects are noticeable in EW-1 and EW-2, which have shown significant increases in concentration since January 2001.

4.3 COMPONENT PERFORMANCE

4.3.1 WELL PUMPS

The pumps in IW-1 and IW-2 are both capable of pumping up to 25 gpm rather than the current 17 gpm, and the wells would yield significantly more than 25 gpm with stronger pumps. The pumps in EW-1 and EW-2 are throttled back and are capable of producing much more water than their current total of 50 gpm. The pumps are throttled back to minimize the water from each well to the levels necessary for capture as specified in the Explanation of Significant Differences and the design report. No maintenance issues or problems with pumps were identified.

4.3.2 AIR COMPRESSORS/BLOWERS

The SVE system uses a 50-horsepower blower. This is larger than necessary for extracting 300 to 500 standard cubic feet per minute from the SVE wells at a pressure drop of 40 inches of water. The fans on the tray aerators are of adequate power and have functioned with little or no operation problems. The air compressor for the air sparging system, however, was not operational and was in need of repair or replacement at the time of the RSE.

4.3.3 EQUALIZATION TANKS

There are two equalization tanks. As the system runs nearly continuously at a constant flow rate, these equalization tanks are unnecessary. However, little or no sediment has been found in them, and they do not require frequent cleaning.

4.3.4 TRAY AERATORS

Two tray aerators, each with four trays, are installed at the plant. These aerators were designed to cumulatively treat 300 gpm with solvent concentrations of 29 mg/l. The aerators discharge treated water to the building sump, and gravity carries the water to the recharge gallery. There are no carbon polishing filters on this plant as typical operation does not require polishing to meet the discharge requirements. The air discharge is routed to a preheater and then on to a vapor phase carbon unit. Currently, the plant utilizes only one of the tray aerators due to the flow rates and concentrations that are below the design parameters.

4.3.5 VAPOR PHASE GRANULAR ACTIVATED CARBON UNITS

Two vapor phase carbon units are used to treat the off gas from the tray aerators. The influent to these carbon units is heated with a preheater to lower humidity and maximize carbon adsorption efficiency. The carbon units are regenerated approximately once per day by a steam regeneration unit which disposes of the condensed steam and recovered solvent in an onsite storage tank. The discharge from the carbon units is monitored one or two times per month for breakthrough using the onsite GC.

4.3.6 CARBON REGENERATION SYSTEM

The carbon regeneration system includes two boilers, a dual phase separator, and a solvent recovery tank. The regeneration system is designed based on the expected recovery rate of 25 pounds of PCE per day; therefore, the system is currently set to automatically regenerate the active carbon unit each 24 hours of operation. The SVE and groundwater extraction system, however, cumulatively extract only 0.5 to 1 pound of PCE per day suggesting that onsite carbon regeneration may not be necessary or cost-effective. The boilers require a water softening system and monthly service. In addition, the operator blows them down twice per day. In addition to steam regeneration and preheating of the carbon influent, the boilers also provide heat for the building.

Problems with this system stem from disruptions in the steam cycle arising from boiler blow downs. This occasionally results in the steam regeneration system running continuously over an extended weekend and filling the solvent recovery tank with water. Wiring has been altered to prevent this from occurring again. In an attempt to remove the water from the storage tank, the plant operator has recycled the contents of the solvent recovery tank into the equalization tanks and back through the treatment system. This has led to inadvertent releases of dissolved and possibly freephase PCE into the recharge gallery. This is discussed further in Sections 4.7 and 6.1.5.

4.3.7 CONTROLS

The plant is competently controlled. The system can operate with little operator attention needed except for process monitoring (sampling and GC analysis). The controls are set up with 14 alarms that result in shutdown of the extraction and treatment systems and a call through an autodialer to the plant operator. The automation of the plant is sufficient for remote operation.

4.4 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF COSTS

Current monthly invoices range from $26,000 to $30,000 for an annual cost of over $350,000 per year. The budget for the next operating year is $517,000 but this is expected to be reduced. Despite plant operation for two years, the contract specifies both construction and operation and maintenance (O&M) costs. Therefore, monthly costs include both O&M and construction related tasks including providing as-built and record drawings. The most significant costs associated with the site are utilities and labor associated with plant operation.

The following chart provides a breakdown of regular monthly costs. Approximate upper limits are shown for gas and electric costs.

operator labor (40 hours per week)	$15,000
operator per diem	$1,500
Project Management (for O&M only)	$2,500
Boiler chemistry testing and servicing	$150
Analytical (treatment-system water only)	$450
Landscaping	$350
Computer maintenance	$200
Control support	$250
Electric	$4,000
Gas	$2,500
Water	$250
Phone and cell phone	$100
Approximate total monthly costs	$27,750

4.4.1 UTILITIES

The utility costs are summarized in Section 4.4. Gas expenses appear to fluctuate significantly, ranging from under $1,000 to over $2,500. These fluctuations correspond to seasonal changes but are also influenced by rising gas prices. Gas usage during the summer months appears to be approximately 33% less than gas usage during the winter months indicating that the boilers for steam generation account for the majority of gas usage in the winter and nearly all of the gas usage in the summer.

Electrical expenses in the year 2000 ranged from just over $1,000 to over $4,000. This range is likely due to air conditioning in the summer months and varying use of the SVE and air sparging systems.

4.4.2 NON-UTILITY CONSUMABLES AND DISPOSAL COSTS

The only consumables at the plant are those associated with conditioning the water for the boiler. As demonstrated in Section 4.4, these costs are minimal. As of yet, the plant has not disposed of PCE off site.

4.4.3 LABOR

Currently, the plant operator works four days per week for a total of 40 hours per week and stays locally in a hotel. Project management includes approximately one site visit per month and minimal work on monthly reports. Additionally, there are likely costs associated with construction that are not included in Section 4.4.

4.4.4 CHEMICAL ANALYSIS

Because NHDES does the analysis for the aquifer sampling and the operator uses onsite gas chromatography for air sampling the only analytical costs are for plant influent and effluent.

4.4.5 OTHER COSTS

Since installation of the wall and the pump-and-treat system, EPA has funded modeling efforts conducted by the USGS. These modeling results have been used by the RPM to analyze remediation strategy with respect to the Consent Decree governing the remediation in OU2. These costs are currently about $10,000 per year. In addition, significant funding from EPA has been made available for assistance in the surfactant pilot study. These costs have been as high as $5,000 per month.

4.5 RECURRING PROBLEMS OR ISSUES

The notable recurring problems are 1) occasional extended, unattended steam regeneration that fills the storage tank with water and 2) the broken air compressor for the air sparging system. The first of these problems is discussed further in Sections 4.7, 6.1.5, and 6.2.1. The second problem is discussed in Section 6.3.2.

4.6 REGULATORY COMPLIANCE

Since the operation began in early 1999, the plant has generally met the discharge criteria set by the ROD. However from April through July 2000 and October 2000 through January 2001, the discharge level of 5 ug/L for PCE was exceeded and is being investigated by the New Hampshire

Department of Environmental Services.

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

The RSE team determined that the high PCE concentrations that were observed in the effluent result from recycling of solvent through the treatment system. Multiple times the steam regeneration unit has operated unattended over the weekend and filled the remainder of the 1,000-gallon solvent-storage tank, which had over 100 gallons of freephase PCE. In an attempt to remove the excess water, the plant operators recycled the contents of the solvent storage tank through the treatment system. Given that the air stripper is unable to treat water at such high concentrations, significant masses of PCE (likely including freephase PCE) were discharged from the plant through the recharge gallery. In one instance, the contents of the tank were "trickled" into the equalization tanks that precede the air strippers, and in another event the contents were "dumped" into the equalization tanks.

These high effluent concentrations were reported in tables within the monthly reports, as is typically done for all effluent concentrations, but no special notice or mention accompanied the results.

4.8 SAFETY RECORD

The plant appears to have had an excellent safety record.

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

The ROD stipulates restriction of groundwater use and monitoring of soils, sediments, and surface water in the area in an attempt to protect the public.

5.1 GROUND WATER

The area overlying and surrounding the PCE plume is a mix of residential, commercial, agricultural, and industrial property with heavy water usage. Groundwater usage in the area at the time of the ROD was approximately 2,900,000 gallons per day with the heaviest usage coming from the fish hatcheries to the north of the Souhegan River. PCE has been detected in fish hatchery wells at concentrations up to 2 ug/L. The Savage Municipal Water Supply Well is currently owned by the State and is not currently used as it does not have well-head treatment. While well-head treatment has been suggested for this well, local authorities are not interested in pursuing it.

Residences in the area, including the mobile home park downgradient of the source area, have been on city water since before plant operation. This city water is obtained from wells unaffected by the site contamination.

Although pumping continues in OU1 both inside and outside of the slurry wall, containment of contaminants within the slurry wall or within OU1 in general, has not been verified.

5.2 SURFACE WATER

Surface water in the area consists primarily of the Souhegan River which is a gaining river on the downgradient side of the contamination. It is therefore impacted by the contaminated groundwater but to an unquantified level as shown by sampling records for the site that do not indicate current detectable contamination of the river. Other surface water in the area consists of a drainage channel used by the Hendrix and Hitchiner facilities on the other side of Elm Street. This drainage channel is not influenced by contamination in OU1. A surface water body southwest of the Savage well, termed the Savage Pond in the ROD, is recharged from the groundwater and had detectable levels of PCE, TCE, and 1,2 DCE at the time of the Remedial Investigation.

5.3 AIR

Air discharged from the treatment system is the only potential source of contaminants in the air from this site. However, the plant treats less than one pound of PCE per day and removes this from the air discharge with carbon adsorption. Thus, air from the treatment plant does not pose a threat to the public. Even if the air discharge were not treated with carbon the release of one pound per day through the air discharge would be insignificant compared to typically permitted discharges.

According to the site managers, there were reports of detectable PCE concentrations at the nearby police station to the west of the site. The SVE system may be required to prevent PCE vapors from migrating to the building.

5.4 SOILS

Contaminated surface soils are not present at the site. In addition, a fence surrounds the site to prevent access by the public.

5.5 WETLANDS AND SEDIMENTS

PCE and other VOCs were detected in the sediments of the Savage Pond at the time of the Remedial Investigation. VOC contamination of sediments near the permitted outfall of the Hitchiner facility were also detected during the Remedial Investigation. The RSE team is unaware of any recent samples taken from either of these two locations.

6.0 RECOMMENDATIONS

6.1 RECOMMENDED STUDIES TO ENSURE EFFECTIVENESS

6.1.1 DISPOSE OF ALL RECOVERED SOLVENT OFFSITE

In at least two episodes throughout 2000, the operator (or substitute operators) recycled recovered solvent through the treatment system because the storage tank, which contained solvent, had filled up with water from the steam regeneration unit. Because the treatment system is not designed to remove free product from the influent water, the contents of the solvent tank should not be recycled through the system. Recommendation 6.2.1, which suggests removal of the steam regeneration unit and off-site disposal of carbon, would eliminate the necessity of an onsite storage tank and therefore remove the potential hazard of releasing its contents into the subsurface.

6.1.2 DETERMINE CAPTURE ZONE OF EXTRACTION WELLS

The capture zones of EW-1 and EW-2 should be evaluated to ensure their operation meets the requirements of the remedy in the most efficient manner possible. Additional investigation and evaluation of the present contaminant masses and the recovery hydraulics is necessary to attain the maximum effect of the recovery and recharge system.

To evaluate the capture zones of EW-1 and EW-2, plume maps should be generated semi-annually as aquifer VOC samples are collected and potentiometric surface maps should be generated monthly as water levels are measured. Each quarter, the most recent plume map should be compared to the potentiometric surface maps generated during that quarter. For capture of the plume, hydraulic gradients should indicate flow toward the extraction wells for all areas of the plume. An initial cost of $15,000 may be required to generate CADD site maps and previous plume and potentiometric surface maps. Generating these maps with data collected in the future and interpreting them in a quarterly report may increase annual costs by approximately $4,000 per year. It should be noted that if the potentiometric surface maps are not sufficiently resolved to determine the capture zone, the USGS model of the site may be helpful in capture zone analysis.

In addition to measuring and interpreting the water levels, the PCE concentrations from the PW-12, PW-13, PW-14, and MW-16 clusters should be tracked over time. If the capture offered by EW-1 and EW-2 is sufficient, then concentrations in these sampling points should decrease. Previous PCE concentration trends in these sampling points indicate at least partial capture.

- Analysis of the PCE concentration from NHDES sampling of PW-12s shows an order of magnitude increase in PCE concentration in November 2000. This increase could be correlated with releases of PCE into the recharge gallery located on the surface approximately 150 feet to the west. If sampling from this well continues to show a rise, it is likely that the contamination is coming from the recharge gallery and is not captured by the extraction wells.

- The rest of the PW-12 wells, which are located deeper in the aquifer, have shown a decrease in PCE concentration from July 1998 through November 2000.

- Over the same time period, PCE concentrations in PW-13S and PW-13M have also decreased, but the PCE concentrations in PW-13D have remained relatively high.

- Concentrations in the PW-14 cluster have not changed significantly between July 1998 and November 2000.

- Concentrations in the MW-16 cluster have decreased over the same time frame.

Thus, the extraction wells appear to prevent PCE from migrating downgradient through the deeper portions of the glacial outwash; however, they may not provide capture in the bedrock (PW-13R) or in the shallow portions of the aquifer near the recharge gallery. Because sampling and analysis is conducted by the NHDES, no costs are expected from this recommendation. However, if it becomes evident that freephase PCE in the recharge gallery provides a contaminant source, a new extraction well may be required approximately 150 feet to the north of EW-1. Tracking of the contaminant trends in the extraction wells, analyzing the trends quarterly, and reporting the results could increase annual costs by $2,000 per year.

6.1.3 MOVE RECHARGE POINTS BEYOND INFLUENCE OF EXTRACTION WELLS

The current location of the recharge gallery provides a significant source of water and, in the future, may feed clean water toward the extraction wells. Moving the recharge from the current gallery to a new one closer to the river will reduce the amount of clean water collected by the extraction system. The associated piping is expected to cost approximately $20,000. Internal costs to EPA for scoping and contracting the work will also be incurred.

6.1.4 VERIFY EFFECTIVENESS OF SLURRY WALL

Currently, the operator is using only the INEEL well to gauge the containment offered by the slurry wall. While this offers a method of determining the water level at one point within the wall, it does not accurately determine the hydraulic gradient across the wall boundary. Rather, containment should be determined from the hydraulic gradients obtained from measuring water levels weekly in the following piezometer pairs: PW-10M and PW-11M, PW-5M and PW-2M. Extraction rates from IW-1 and IW-2 should be adjusted weekly such that the hydraulic gradients evaluated from these water-level measurements ensure flow directed into the area enclosed by the wall.

Water levels measured from these piezometers on September 6, 2000 suggest containment at these locations with the exception of the deep portion of the glacial outwash and bedrock screened by PW-5(D and R) and PW-2(D and R). This may present an avenue for contamination to be transported beyond the source area enclosed by the slurry wall.

Additionally, to determine the effectiveness of the slurry wall, a pumping test should be conducted by extracting water from IW-1 and IW-2 at 25 gpm for 48 hours and measuring the time-varying response of the water levels in the following piezometers: PW-8M, PW-9M, PW-10(M and D), PW-11(M and D), PW-5(S, M, D, and R), PW-2(S, M, D, and R). The wall is effective if water levels in piezometers PW-9M, PW-11(M and D), and PW-2(S, M, D, and R) have a significantly reduced response compared to the water levels in piezometers PW-8M, PW-10(M and D), and PW-5(S, M, D, and R). The cost of conducting and analyzing this pumping test is approximately $30,000.

6.1.5 INTERPRET MONTHLY AQUIFER AND TREATMENT SYSTEM DATA

The monthly reports, jointly written by the plant operator and the contractor's project manager include little or no analysis of the data. This is especially evident in four of the monthly reports reviewed by the RSE team during the site visit. These four reports showed that plant effluent exceeded the MCLs for PCE established by the Safe Drinking Water Act, but these effluent concentrations only appeared in a table. They were not highlighted or described in the text. While no specific discharge permit from the State of New Hampshire applies to this site, these effluent concentrations were in violation of the ROD.

Aquifer contaminant sampling data and water level measurements should also be analyzed to ensure the effectiveness of the slurry wall and the containment of the plume outside of the wall by EW-1 and EW-2. The monthly interpretation of operations and aquifer data should be summarized by the contractor in a section of the monthly report and then reviewed independently and in a timely manner by the EPA RPM and state manager. The cost of these monthly analyses by the contractor should be covered by the present costs of project management.

6.2 RECOMMENDED CHANGES TO REDUCE COSTS

The large deviation between current operating conditions and the design values (i.e., pumping rates and influent concentrations) impacts the cost effectiveness of the system operation. The following recommendations suggest opportunities to reduce costs without reducing system effectiveness.

6.2.1 DISCONTINUE ONSITE STEAM REGENERATION OF CARBON SYSTEM

The actual VOC removal rate from the groundwater and SVE systems combined is about 0.75 pounds per day, or 50 times less than the design rate. The continued operation of the steam regeneration unit is costly and not required given the actual VOC loading. The most recent gas bill reviewed by the RSE team was dated March 29, 2001 and suggested delivery charges of $0.3741/therm for the first 400 therms and $0.3191/therm for the remaining therms. In addition, the cost of the gas was $0.9428/therm. Assuming the gas usage from the summer months when no heating of the plant was required, it appears that the boilers require approximately 1,500 therms per month for steam regeneration. Calculating the monthly cost for natural gas with these figures results in expenditures of nearly $2,000 per month. At a conservative granular-activated-carbon (GAC) usage of 5 pounds of GAC to 1 pound of VOC and $3 per pound of GAC, about $4,000 would be required annually for GAC replacement. Thus, discontinuing use of the steam regeneration unit would save approximately $20,000 per year. Additionally, the steam regeneration unit requires much of the operator's time. Thus, removal of this system would allow for a reduction in labor costs. Purchase and installation of the necessary liquid phase carbon units would likely cost approximately $25,000 excluding costs for scoping and contracting the work; however, savings in natural-gas costs, after accounting for carbon replacement, should pay for this capital expenditure in less than a year. The cost for removal of the equipment for the current steam regeneration system would likely cost an additional $10,000, but this removal is not necessary to implement the recommendation.

Although the boilers are also currently used for heating the air stream entering the carbon and the building, smaller, more efficient heating sources can be used instead. The cost of heating the air system should be weighed against the cost of GAC efficiency. Without heating, the GAC costs could increase to $8,000 per year. Heating of the building could be reduced due to a reduction in time spent by the operator at the plant.

6.2.2 REDUCE OPERATOR LABOR

Over half of the system expense is associated with the onsite full-time operator. The operator spends a significant portion of time 1) checking and adjusting the boilers so that steam can be available for vapor heating and GAC regeneration and 2) performing air analysis via gas chromatography on 4 samples approximately every 2 weeks. As stated above, the steam regeneration system is not necessary and its removal would significantly reduce onsite labor. The air analysis is also not necessary and its removal would further reduce onsite labor. To maintain the current level of effectiveness, a PID (photo-ionization detector) could be used to determine GAC breakthrough. The required operator time after removing these unnecessary processes, but including the water level measurements discussed in Section 6.1.2, is 16 hours per week or less. This reduction in labor potentially could result in approximate savings of $7,500 per month in labor and an additional $750 per month in operator travel expenses. These monthly savings translate to approximate annual savings of $99,000. The system operator should be located within 1 hour driving time from the site for cost-effectiveness and timely response to any alarm conditions.

6.2.3 REPLACE THE BLOWER WITH A SMALLER, MORE EFFICIENT MODEL

The existing 50 horsepower blower accounts for more than half of the electrical costs and is not necessary to extract up to 500 cubic feet per minute of soil vapor at a head of about 40 inches of water. An EG&G Rotron model DR909 of 15 horsepower can provide the current extraction rate with significantly less power consumption. Replacing this blower would cost approximately $15,000, including installation, but would result in substantial savings in electrical costs. The rates for electricity at the Savage site are "stepped" and have varied over the past year. The first 500 KWh are generally charged around $0.14/KWh, the next 1,000 KWh are generally charged at $0.10/KWh, and the remainder is charged around $0.09/KWh. There is also a demand charge of approximately $8.50/KW. Operating a 50-horsepower blower instead of a 15-horsepower blower requires an extra 35 horsepower. Assuming a motor efficiency of approximately 75%, this translates to approximately 35 KW. Over the course of a 30-day month, this approximately translates to an extra 25,000 KWh. At the lowest step rate, this would translate to over $2,200 per month. In addition, the reduction in required power will yield a decrease in the demand charge of approximately 35KW × $8.50/KW = $298. Thus, total savings of $2,500 per month or $30,000 per year could result from replacing the 50- horsepower blower with a 15-horsepower blower. These cost savings will pay for the new blower within one year.

6.2.4 REQUEST A SURVEY OF ELECTRICITY USAGE

Request that the local electric utility conduct a free, onsite survey of electricity usage with suggestions for further reductions.

6.3 Modifications Intended for Technical Improvement

6.3.1 Improve Invoicing at State Level to Ensure Timely Delivery of Monthly Updates

Over the past year, there has been consistent delay of approximately 6 months between an operational month and submission of the monthly report to the state manager. During the RSE, it was suggested that the contractor was postponing submission of the monthly reports to NHDES because of delays in NHDES processing the invoices from the contractor. Efforts should be made on both the state and contractor ends to accelerate the transfer of monthly reports to the state manager and the EPA RPM. This will result in a more timely analysis of the data by the RPM and state manager allowing them to potentially identify any problems or developments.

6.3.2 Repair or Replace Air Compressor for Air Sparging System

The air sparging system has not operated for approximately six months or more. A majority of this downtime results from required shutdown during a pilot study conducted onsite in association with EPA Headquarters. However, the last two months of downtime results from mechanical problems with the air compressor. The air compressor should be replaced or repaired so that the air sparging system can operate. The costs of repair are unknown; however, a new system could likely be purchased for approximately $15,000.

6.4 Modifications Intended to Gain Site Close-Out

6.4.1 Clarify Exit Strategy and Closure Criteria

A clear exit strategy should be determined for the site that adheres to both the ROD and the Consent Decree discussed in Section 3.1. Based on interviews during the RSE site visit, the state is anticipating shutting the extraction system down or significantly reducing the extraction rate in March 2009 when the site is transferred from EPA to the New Hampshire Department of Environmental Services. The slurry wall installed at the site may justify reduced operation at this time but only if it is demonstrated to effectively contain the VOC source area. Currently, the effectiveness of the wall is not well established. As the plant operator mentioned, the water levels inside the wall change with the stage of the river suggesting the river and aquifer outside of the wall are hydraulically connected to the area inside of the wall. Even without the influence of the river, recharge from rain will provide a continuing source of approximately 2 million gallons of water per year within the wall that must be removed. The pumping tests and water level measurements suggested in Recommendation 6.1.4 will more clearly demonstrate the effectiveness of this slurry wall. If the wall is effective, the exit strategy can be based on the concentrations outside of the wall. However, if the wall is ineffective, the exit strategy should account for DNAPL within the wall that may act as a continuing source of VOCs.

A further need for clarification of the present exit strategy is that the ROD stipulates only interim cleanup levels until more data is collected from the site. Additionally, according to the RPM, the Consent Decree stipulates that the responsible parties from OU2 can abandon cleanup duties after 30 years if at that time OU1 can still potentially act as a continuing source of contamination that prevents OU2 from reaching cleanup levels.

6.4.2 AGGRESSIVE MASS REMOVAL

DNAPL within the slurry wall would provide a continuing source of dissolved phase VOCs. Given that groundwater likely travels beneath the slurry wall, other methods of source control or source removal should be investigated. Once the treatment system operation and associated costs are at a suitable level with a clear schedule of operation and maintenance requirements, additional mass removal efforts from within the wall (and potentially near the recharge gallery) should be considered. Various strategies are suggested in the following two subsections.

6.4.2.1 STRATEGY #1: PUMPING FROM THE "HOT-SPOT" WELLS

The most logical and least costly option is to pump groundwater from one to five of the 17 wells installed in the source area during the surfactant pilot study and to treat this water in the air stripper, which has a capacity of 150 gpm. Putting the other air stripper into service would allow for a total capacity of 300 gpm, allowing significant pumping through both these new wells and the existing extraction wells. Due to the large number of possible pumping configurations, this new extraction system should be flexible, allowing pumping configurations to change to maximize mass removal. This flexibility can be achieved by laying pipe underground from the equalization tanks to a location central to all of "hot-spot" wells. Fittings should be installed on the well-end of this piping to allow pumps to be connected via hoses. The light weight and flexible nature of the hoses will allow the pumps to be moved from one well to another. The cost of purchasing and installing single-wall permanent piping along with the hoses and fittings is approximately $6,000. This cost estimate does not include costs internal to EPA for scoping and contracting the work.

It is important to note that pumping from the "hot spot" may result in extraction of freephase PCE from the subsurface. Therefore, the equalization tanks in the treatment plant should be replaced with a single tank that will prevent freephase PCE from passing through the rest of the treatment system. This is required because the tray aerators are not capable of removing freephase PCE and from the process water, and discharge excursions could result if freephase PCE is extracted from the subsurface and not separated from the process water. A replacement tank that can be pumped from the top (rather than drained from the bottom) or that can have baffles installed will suffice. The approximate capital costs for installing a new tank is approximately $10,000. Once again, this cost estimate does not include costs internal to EPA for scoping and contracting the work.

Annual costs also are likely to increase. For example, continuous operation of five additional 5-horsepower pumps and the blower for the second tray aerator would increase the cost of utilities by approximately $3,000 per month. Thus, at a minimum, if this pumping strategy is employed from May through October annual costs are likely to increase by $18,000 per year.

This pumping strategy would be augmented by the air sparging system once the compressor is repaired. Additionally, the onsite boilers would allow the potential use of steam injection to enhance source removal, albeit at a higher cost due to the use of natural gas.

Preliminary estimates suggest that the recommendation to replace onsite steam regeneration of the carbon with offsite regeneration is still valid and cost effective despite increase pumping and chemical loading. The extraction system currently pump water with a blended concentration of approximately 750 ug/L at 84 gpm to the treatment plant. This corresponds to a daily chemical loading of approximately 0.75 pounds of PCE per day. Pumping from the hot spot wells or increasing the flow from EW-1 and EW-2 could double or even triple this flow rate. In addition, an increase in the concentration of the plant influent would be expected with pumping from the hot spot wells. This increase would likely be significant at first but water from EW-1 and EW-2 would continue to dilute the influent and high concentrations would decrease shortly after pumping commenced.

Assuming pumping from the hot spot wells brings the total flow rate to 150 gpm (the capacity of one of the air strippers) and the influent concentration increases by a factor of three, the chemical loading to the vapor phase carbon would be approximately 4 pounds of PCE per day or approximately 1,500 pounds of PCE per year. Conservatively, this would translate to 7,500 pounds of carbon per year at an annual cost of $22,500. This is lower than the annual cost of $24,000 due to the natural gas used for steam regeneration although the cost savings is substantially less. However, further benefits arise from discontinuing steam regeneration. First, regenerating carbon offsite eliminates the hazards associated with storing recovered PCE onsite. Second, eliminating the steam regeneration system allows for a decrease in operator labor that could save as much as $99,000 per year.

As an initial step in planning to pump from the hot spot wells, a select number of them should be sampled for VOCs to determine the concentration. The results from this sampling could then be used to project the influent concentrations when pumping from these wells. Such projections should include dilution by water from the other wells and decreases in concentrations within the hot spot wells as pumping progresses. Including labor, these wells could be sampled and the analyzed at an independent laboratory for approximately $3,000.

6.4.2.2 STRATEGY #2: CHEMICAL OXIDATION OF "HOT-SPOT"

Another possibility for source removal is *in situ* chemical oxidation. A September 1998 EPA publication titled Field Applications of In Situ Remediation Technologies, Chemical Oxidation (EPA 542-R-98-008) documents the use of *in situ* chemical oxidation at other sites contaminated with PCE and other VOCs. The following table provides three particular sites discussed in this document and the chemical technology used to address PCE contamination.

Site	Technology
Westinghouse Savannah River Site, Aiken, SC	Fenton's Reagent (Geo-Cleanse®)*
Canadian Forces Base Borden, Ontario, Canada	Potassium permanganate
Dry Cleaning Facilities, Hutchinson, KS	Ozone (C-Sparge™)

*It should be noted that Fenton's Reagent could adversely affect the slurry wall.

The facility at the site already has many of the elements necessary for delivering the oxidizing agents. For example, the reinjection wells RW-1 and RW-2 and extraction wells IW-1 and IW-2 are in good locations for addressing the "hot spot" with Fenton's reagent or potassium permanganate. According to the design proposal these wells are made of carbon steel with stainless steel well screens. Similarly, the air sparging wells are in a good location for addressing the "hot spot" with ozone. This existing infrastructure would significantly reduce the cost of treating the source area "hot spot" with chemical oxidation. The first step in addressing this strategy is to conduct an initial investigation which may include developing a site profile and supplying it to vendors of the technology. This initial investigation should be used primarily to determine the cost effectiveness of the approach and should cost approximately $25,000. The costs of implementing the strategy likely would be significantly higher and would depend on the extent of treatment. It should be noted that because DNAPL PCE may have spread to the bedrock, effective delivery of oxidants may be difficult, which would limit the success of this more expensive process.

6.5 UNUSED GOVERNMENT-OWNED EQUIPMENT

If the recommendation suggested in Section 6.2.1 is implemented, a vapor phase carbon system with steam regeneration will no longer be used. This equipment could be used at future Fund-lead sites or at current Fund-lead sites where contaminant loading has changed since the original design. If the recommendations suggested in Sections 6.2.2 and 6.2.3 are implemented, a gas chromatograph and a 50-horsepower blower also would be unused.

6.6 SUGGESTED APPROACH TO IMPLEMENTATION

The suggested recommendations could be implemented in the following manner. With the exception Recommendations 6.2.2, 6.4.2.1, and 6.4.2.2, all Recommendations can be implemented immediately and concurrently. Initial efforts should focus on 6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.1.5, and 6.3.1 as they pertain to protection of human health and the environment. Efforts should then focus on recommendations 6.2.1, 6.2.3, and 6.2.4 which involve cost reductions. Work associated with 6.2.1, installing new vapor phase carbon units to replace the existing steam regeneration carbon system, may include sampling of the “hot spot” wells (part of Recommendation 6.4.2.1) as future operations may include extracting groundwater from these wells. Once onsite steam regeneration is eliminated the boilers are no longer necessary as heating for the building can be provided by unit heaters. With the removal of the boilers, the operator labor can be reduced (6.2.2). Finally, once the above recommendations have been implemented and the system has reached steady-state operation, efforts can be focused on the Recommendations 6.3.1, 6.4.1, 6.4.2.1 and 6.4.2.2, which focus on exit strategy and aggressive mass removal.

7.0 SUMMARY

In general, the RSE team found a smoothly running treatment system and well-maintained site. The observations and recommendations mentioned 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 have the obvious benefit of the operational data unavailable to the original designers.

Several recommendations are made to enhance system effectiveness, reduce future operations and maintenance costs, improve technical operation, and gain site close out. The recommendations to enhance effectiveness include an improved sampling program to determine the extent of a new source area and to determine the containment offered by the extraction wells and the slurry wall. Recommendations to reduce costs include discontinuing steam regeneration of carbon and replacing used carbon, replacing the existing blower for the soil vapor extraction system with a smaller unit, and reducing operator labor. Finally, recommendations promoting site closure include developing a clear exit strategy that ensures human and ecological protection and considering more aggressive source removal. Table 7-1 itemizes all of the recommendations as well as the cost (or cost savings) and reason for each one.

Table 7-1. Cost Summary Table

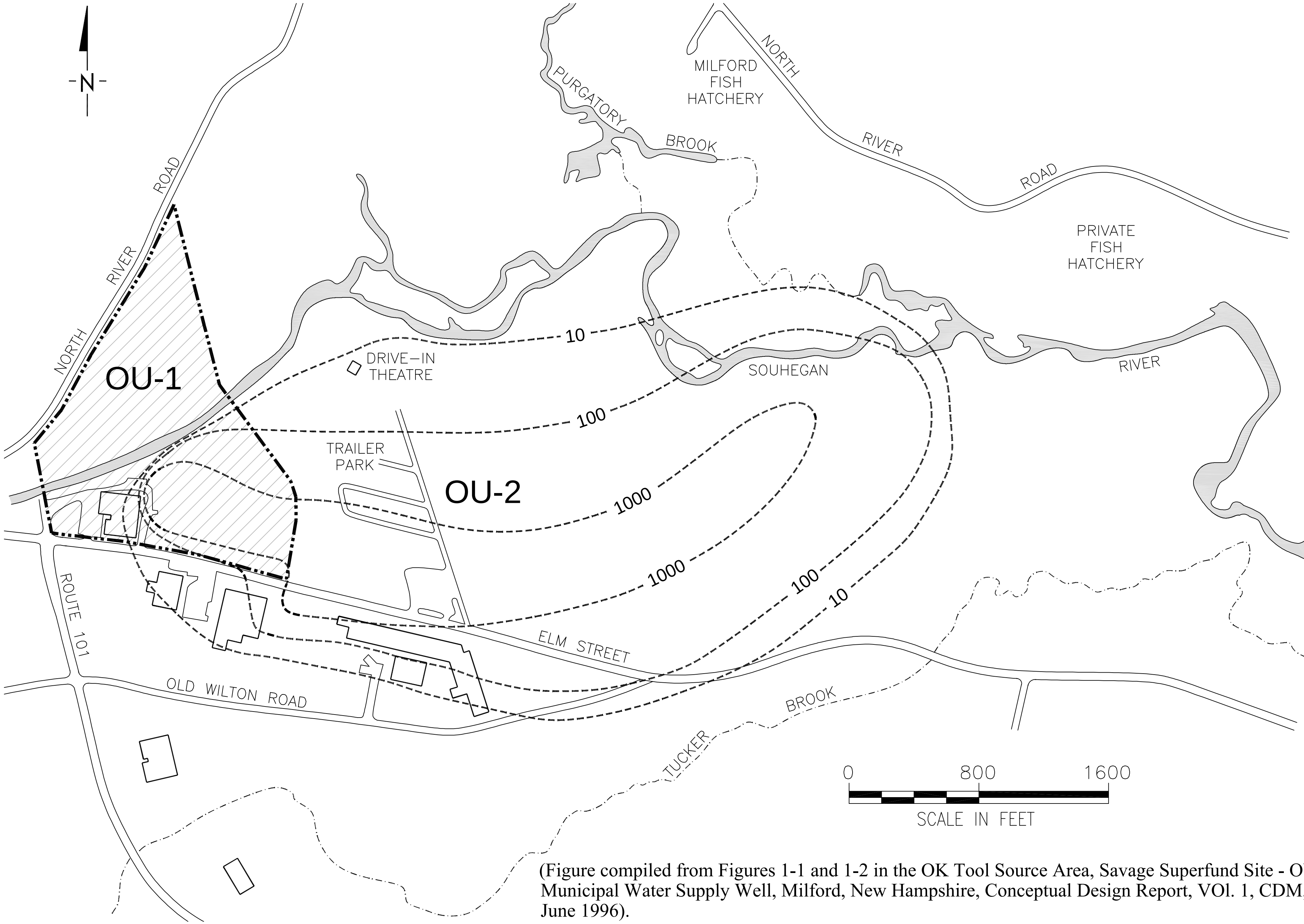
Recommendation	Reason	Estimated Change in			
		Capital Costs	Annual Costs	Lifecycle Costs *	Lifecycle Costs**
6.1.1 Dispose of recovered solvent offsite	Effectiveness & Simplicity	$0	$0	$0	$0
6.1.2 Evaluate capture zones through data analysis	Effectiveness	$15,000	$6,000	$195,000	$112,000
6.1.3 Move recharge points beyond influence of extraction wells	Effectiveness	$20,000	$0	$20,000	$20,000
6.1.4 Verify effectiveness of slurry wall	Effectiveness	$30,000	$0	$30,000	$30,000
6.1.5 Interpret treatment system data	Effectiveness	$0	$0	$0	$0
6.2.1 Discontinue steam regeneration of carbon system	Cost Reduction	$25,000	($20,000)	($575,000)	($297,000)
6.2.2 Reduce operator labor	Cost Reduction	$0	($99,000)	($2,970,000)	($1,600,000)

Recommendation	Reason	Estimated Change in			
		Capital Costs	**Annual Costs**	**Lifecycle Costs ***	**Lifecycle Costs****
6.2.3 Replace the blower with a smaller, more efficient model	Cost Reduction	$15,000	($30,000)	($885,000)	($469,000)
6.2.4 Request survey of electricity usage	Cost Reduction	$0	$0	$0	$0
6.3.1 Improve invoicing at State level to ensure timely delivery of monthly updates	Technical Improvement	$0	$0	$0	$0
6.3.2 Repair or replace air compressor for air sparging system	Technical Improvement	$15,000	$0	$15,000	$15,000
6.4.1 Clarify exit strategy and closure criteria	Gain Site Close Out	$0	$0	$0	$0
6.4.2.1 Pumping from “hot-spot” wells	Gain Site Close Out	$16,000	$18,000	$556,000	$306,000
6.4.2.2 Conduct initial investigation for aggressive mass removal	Gain Site Close Out	$25,000	$0	$25,000	$25,000

Costs in parentheses imply cost reductions.
* assumes 30 years of operation with a discount rate of 0% (i.e., no discount)
** assumes 30 years of operation with a discount rate of 5% and no discounting in the first year

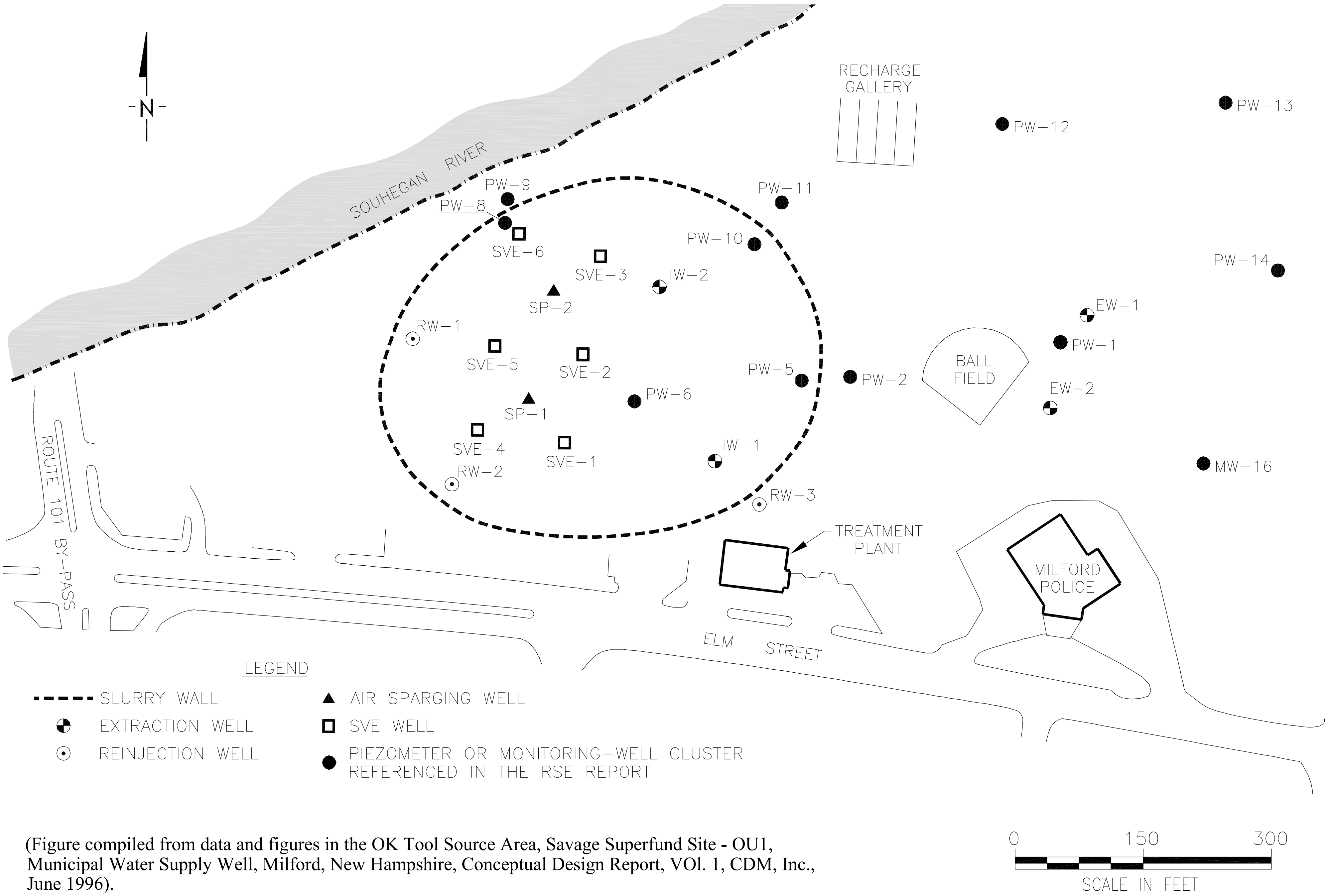
FIGURES

FIGURE 1-1. SITE LAYOUT SHOWING OU1, OU2, AND THE 1990 PCE PLUME (concentrations are in ug/L)



(Figure compiled from Figures 1-1 and 1-2 in the OK Tool Source Area, Savage Superfund Site - OU1, Municipal Water Supply Well, Milford, New Hampshire, Conceptual Design Report, VOl. 1, CDM, Inc., June 1996).

FIGURE 1-2. THE SLURRY WALL AND COMPONENTS OF THE OU1 REMEDIATION AND MONITORING SYSTEMS



(Figure compiled from data and figures in the OK Tool Source Area, Savage Superfund Site - OU1, Municipal Water Supply Well, Milford, New Hampshire, Conceptual Design Report, VOl. 1, CDM, Inc., June 1996).

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