OPTIMIZATION SUPPORT EVALUATION

GREENWOOD CHEMICAL SITE
NEWTOWN, VIRGINIA

Report of the Optimization Support Evaluation,
Site Visit Conducted at the Greenwood Chemical Site
August 7, 2003

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Office of Solid Waste
and Emergency Response
(5102G)

EPA 542-R-04-032
April 2004
www.epa.gov/tio
clu-in.org/optimization

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Greenwood Chemical Site
Newtown, Virginia

NOTICE

Work described herein was performed by GeoTrans, Inc. (GeoTrans) for the U.S. Environmental Protection Agency (U.S. EPA). Work conducted by GeoTrans, including preparation of this report, was performed under S&K Technologies Prime Contract No. GS06T02BND0723 and under Dynamac Corporation Prime Contract No. 68-C-02-092, Work Assignment ST-1-08. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

An Optimization Support Evaluation (OSE) involves a team of expert hydrogeologists and engineers, independent of the site, conducting an evaluation of site operations. It is a broad evaluation that considers the goals of the remedy, site conceptual model, above-ground and subsurface performance, and site exit strategy. In the case of interim remedies (such as this site), an OSE provides recommendations that are applicable to the interim remedy and are considerations for a final remedy. The evaluation includes reviewing site documents, visiting the site for up to 1.5 days, and compiling a report that includes recommendations to improve the system. For an interim remedy, recommendations with cost and cost savings estimates are provided in the following four categories:

- improvements in remedy effectiveness
- reductions in operation and maintenance costs
- technical improvements
- considerations for a final remedy

The recommendations are intended to help the site team identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation and represent the opinions of the evaluation team. These recommendations do not constitute requirements for future action, but rather are provided for the consideration of all site stakeholders. This OSE report pertains to conditions that existed at the time of the OSE site visit, and any site activities that have occurred subsequent to the OSE site visit are not reflected in this OSE report.

The Greenwood Chemical Site (“site”) is an inactive chemical manufacturing facility located in Newtown, Albemarle County, Virginia on VA Route 690 approximately 0.75 miles west of the town of Greenwood, Virginia and approximately 20 miles west of Charlottesville. The area of the Site associated with chemical manufacturing and waste disposal activity comprises approximately 18 acres. A number of removal and remedial actions have occurred to address buried drums and contaminated lagoons. Two lagoons remain at the site, and a ground water P&T system has been implemented as an interim remedy to extract and treat contaminated ground water and to manage the water levels in the remaining lagoons. The site is in the Remedial Investigation/Feasibility Study stage, and a number of items, including plume delineation, remain prior to implementing a final remedy at the site.

In general, the OSE team found a smoothly operating, well-organized treatment plant. The observations and recommendations contained in this report are not intended to imply a deficiency in the work of either the system designers or operators but are offered as constructive suggestions. These recommendations have the obvious benefit of being formulated based upon operational data unavailable to the original designers.

The recommendations to improve effectiveness in protecting human health and the environment include the following:

- The residential wells and surface water that are near and/or downgradient of the site should be sampled. Sampling of the residential wells since the Remedial Investigation, if any, is not well documented. This sampling should help determine if continued migration has allowed contamination to reach these receptors.

- The plume needs further delineation, particularly at the downgradient edge of the plume. Up to six locations for new monitoring wells have been recommended to provide this delineation.

- Once delineation is complete a target capture zone should be developed and capture zone analysis should be conducted. This analysis will help determine the effectiveness of the current remedy and the potential need for additional extraction points.

- A 1,000-pound vapor GAC unit has been used to treat the vapors that gather in the head space of the process tanks. This unit has not been changed or sampled since the plant began operation. If it was deemed important to include this unit in the original design, it is likely important to sample and determine if breakthrough has occurred. A recommendation is made to sample the influent and effluent with a PID.

Implementing these recommendations might cost $200,000 to $250,000 in capital costs and $4,000 to $8,000 in annual costs. However, these costs may be off set by implementing cost reduction recommendations. The cost reduction recommendations are as follows:

- The treatment plant should be able to run effectively with one full-time operator and minimal support from a part-time technician. This would be consistent with other similar Fund-lead sites. Implementing this reduction should reduce costs by approximately $50,000 per year with no capital costs.

- The lagoon sediments should be addressed so that solids loading to the treatment plant can be reduced. Although this will not directly reduce costs, it is the first step in allowing the system to potentially operate without metals precipitation. If metals precipitation can be eliminated, O&M costs might decrease by another $75,000 to $100,000 per year.

- The UV/Oxidation system may be another reason why metals precipitation is required, but the UV/Oxidation system provides little benefit in addressing site contaminants. The GAC units currently provide the bulk of the contaminant removal. The site team should strongly consider bypassing the UV/Oxidation unit, particularly if it will allow metals precipitation to be discontinued. In addition, bypassing the UV/Oxidation system may save an additional $20,000 per year.

- The ground water monitoring program includes redundant sampling. Recommendations are provided that could reduce the monitoring costs by approximately 50%, which might save approximately $20,000 per year.

- The project management, technical support, and reporting costs and scopes of work should be reviewed by the site team to determine if any items can be cut to reduce costs without sacrificing effectiveness. Cost savings for this recommendation are not quantified due to the uncertainty in the current costs and scopes.

The recommendations for technical improvement are primarily focused on improving data management, data analysis, and reporting. The considerations for a final remedy include strategies for continuing to use P&T for plume capture and to use monitoring to demonstrate that capture is adequate. Suggestions regarding aggressive remediation are made in case the site stakeholders are considering this approach for the final remedy. Also provided is a cost-effective alternative to the currently proposed RCRA cap (potentially saving as much as $1.5 million).

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

PREFACE

This report was prepared at the request of EPA Region 3 as part of a project to optimize the Region's pump and treat (P&T) systems that are jointly funded by EPA and the associated State agency. The effort was made possible with the help of the Office of Superfund Remediation and Technology Innovation. The project contacts are as follows:

Organization	Key Contact	Contact Information
USEPA Office of Emergency and Remedial Response (OSRTI)	Kathy Yager	11 Technology Drive (ECA/OEME) North Chelmsford, MA 01863 phone: 617-918-8362 fax: 617-918-8427 yager.kathleen@epa.gov
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1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000, 2001, and 2002 Remediation System Evaluations (RSEs) were conducted at 24 Fund-lead pump and treat (P&T) sites (i.e., those sites with pump and treat systems funded and managed by Superfund and the States). Due to the opportunities for system optimization that arose from those RSEs, EPA Region 3 is expanding efforts to optimize its Fund-lead remedies. Region 3 requested that GeoTrans conduct RSEs at two of its Fund-lead P&T systems: Havertown PCP and Greenwood Chemical. Because GeoTrans has a business relationship with Tetra Tech, the contractor at these two facilities, Optimization Support Evaluations (OSEs) were conducted in place of the RSEs. The OSE process is identical to the RSE process, but the name change indicates the business relationship between GeoTrans and Tetra Tech.

The Remediation System Evaluation (RSE) process (and therefore the OSE process) was developed by the US Army Corps of Engineers (USACE) and is documented on the following website:

http://www.environmental.usace.army.mil/library/guide/rsechk/rsechk.html

An Optimization Support Evaluation (OSE) involves a team of expert hydrogeologists and engineers, independent of the site, conducting an evaluation of site operations. It is a broad evaluation that considers the goals of the remedy, site conceptual model, above-ground and subsurface performance, and site exit strategy. In the case of interim remedies (such as this site), an OSE provides recommendations that are applicable to the interim remedy and are considerations for a final remedy. The evaluation includes reviewing site documents, visiting the site for up to 1.5 days, and compiling a report that includes recommendations to improve the system. For an interim remedy, recommendations with cost and cost savings estimates are provided in the following four categories:

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The Greenwood Chemical site was selected by EPA Region 3 based on the potential to improve the effectiveness of the remedy to protect human health and the environment and/or to reduce the annual costs of operating the remedy. 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.

1.2 TEAM COMPOSITION

The team conducting the OSE consisted of the following individuals:

Peter Rich, Civil and Environmental Engineer, GeoTrans, Inc.
Doug Sutton, Water Resources Engineer, GeoTrans, Inc.
Ken Tyson, Hydrogeologist, GeoTrans, Inc.

The OSE team was accompanied by Kathy Davies and Norm Kulujian from USEPA Region 3.

1.3 DOCUMENTS REVIEWED

Author	Date	Document No./Title
EBASCO	8/1990	Remedial Investigation
USEPA	12/1990	Superfund Record of Decision: Greenwood Chemical, VA
USEPA	3/24/1994	Explanation of Significant Differences, Greenwood Chemical Site, Albemarle County, VA
CH2M Hill	2/1995	Greenwood Chemical Site Data Acquisition Summary Report for the Remedial design for Groundwater
Sunil Pereira - CH2M Hill	11/28/1995	Fax Message
CH2M Hill	4/30/1996	Bedrock Monitoring Well and Extraction Well Installation, Greenwood Chemical Superfund Site, Newtown, VA
CH2M Hill	7/2/1996	Preliminary Analysis of the Bedrock Aquifer Test Results, Greenwood Chemical Superfund Site, Newton, VA
Ogden Remediation Services	10/1996	Final Project Report
CH2M Hill	10/30/1996	Greenwood Data from April - June, 1996
CH2M Hill	8/20/1997	Greenwood Chemical Remedial Design WA No. 90-45-3NP5, Final Design Cost Estimate and Schedule
CH2M Hill	1/1997	Final Preliminary Design Report, Interim Groundwater Treatment Remedy, Operable Unit 2, Greenwood Chemical Site
USEPA	1/23/1998	Five-Year Review Report, Greenwood Chemical Superfund Site, Albemarle County, VA
Norfolk District USACE	10/19/1999	Scope of Work, Line Item 0011 Wastewater Treatment Plant Operation, Contract DACW65-98-C-0024, Engineering During Construction, Greenwood Chemical Superfund Site, Newtown, VA

Author	Date	Document No./Title
USEPA Region III	1/18/2000	Memorandum Re: Greenwood Chemical, Addendum: Revised Ground Water Cleanup Levels
CH2M Hill	1/31/2000	Memorandum - Greenwood Chemical Site OU2 - Comparison of Proposed O&M Costs Vesus Design Phas Annual O&M Cost Estimate
USACE	6/2001	Operation and Maintenance Manual, Greenwood Chemical Superfund Site Groundwater and Lagooon WastewaterTreatment Facility
USACE	1/2002	OU-4 Focused Feasibility Study Report, Greenwood Chemical Company Superfund Site, Newton, Albemarle County, VA
NA	NA	Statement of Work for Operation and maintenance, Greenwood Chemical Site, Albemarle County, VA
NA	NA	Well Completion Logs (BR-1 through BR-6, OB-1 through OB-8) and Well Completion Diagrams (MW-22, MW-23, BR-7, and BR-8).
USACE	1/23/2003	Draft Remedial Action Report for Greenwood Chemical Superfund Site, OU2 Groundwater and Lagoon, Water Treatment Facility, Newton, VA
Tetra Tech, Inc	3-5/2003	Monthly O&M Reports, February - May 2003
OHM Remediation Services Corporation	9/23/1993	Final Report for Greenwood Chemical Site, Greenwood, Virginia

1.4 PERSONS CONTACTED

The following individuals associated with the site were present for the visit:

Phil Rotstein - Remedial Project Manager (RPM), USEPA Region 3
Trish Taylor - Community Relations, USEPA Region 3

Chris Quann - OMI
Gary Funkhouser - OMI

In addition, Eric Newman, who replaced Phil Rotstein as the RPM after the OSE site visit, provided feedback on the draft OSE report during a meeting on February 10, 2004.

1.5 SITE LOCATION, HISTORY, AND CHARACTERISTICS

1.5.1 LOCATION, HISTORY, AND OPERATIONAL DESCRIPTION

The Greenwood Chemical Site (“site”) is an inactive chemical manufacturing facility located in Newtown, Albemarle County, Virginia on VA Route 690 approximately 0.75 miles west of the town of

Greenwood, Virginia and approximately 20 miles west of Charlottesville. The area of the Site associated with chemical manufacturing and waste disposal activity comprises approximately 18 acres. According to the 1998 Five Year Review, the entire parcel of land owned by the Greenwood Chemical Company comprises approximately 34 acres. A site plan that shows current site features and monitoring well locations is provided in Figure 1-1.

A specialty chemical manufacturing plant operated on the site from approximately 1946 to 1985. Site features included up to six process buildings and five disposal lagoons. Starting in 1946, Francis O. Cockerille purchased the property that had formerly been used for agricultural purposes and began operating a small scale batch chemical manufacturing plant at the Site specializing in pharmaceutical intermediates. Dye and paint intermediates, plant growth regulators, and photographic chemicals were also manufactured during plant operations. In April 1985 a toluene vapor leak and fire destroyed one of the process buildings and led to the death of four plant employees. Manufacturing activities ceased following the fire although Greenwood Chemical Company continued to operate a small scale chemical brokerage business at the site for a number of years.

The Site was placed on the National Priorties List (NPL) in 1987 because of potential environmental and human health risks. These risks were associated with numerous on-site lagoons, pits and trenches used for the disposal of hazardous substances generated during plant operations. Between 1986 and 1991, EPA conducted two removal actions that included the removal of drums and smaller containers of chemicals (both buried and surface), the removal and treatment of some lagoon water and sludges, and the installation of erosion and sedimentation controls. In August 1990, EPA completed a Remedial Investigation (RI) for the site to characterize the nature and extent of contamination of soils and/or sediments, ground water, and surface water associated with the site. These investigations included geophysical surveying as well as sampling of surface water, ground water (on-site and off-site), soils, and sediments. They also included collection and analysis of soil boring samples at various depths within the lagoon and drum disposal areas, installation and sampling of additional monitoring wells, sampling of residential wells and surface water, and an assessment of hydrogologic conditions.

The site has been divided into four operable units (OUs), as follows.

- OU1 includes contaminated soils associated with seven discrete disposal areas. This remedial action was completed in the Fall of 1996.
- OU2 includes interim action for contaminated ground water and lagoon water. This interim remedy is ongoing.
- OU3 addresses the dismantlement and off-site disposal of former Process Buildings A, B, and C. This remedial action was completed in the Spring of 1993.
- OU4 includes surface and subsurface soils other than those addressed in previous OUs plus final action for ground water. This remedial action will be addressed in an upcoming ROD.

Construction of the P&T system for OU2 began in 1998 and operation began in May 2000. The P&T system serves as an interim remedy that will operate until a final remedy can be implemented. This optimization support focuses primarily on this OU2 P&T system but also includes considerations for a final remedy that will be selected as part of the OU4 ROD.

1.5.2 POTENTIAL SOURCES

The contaminants detected at the site are believed to have originated from poor environmental practices employed during the forty years of chemical operations at the site. Liquid waste was discharged through floor drains in the process buildings that drained into unlined pits adjacent to the buildings. Chemical waste generated by cleaning out process vessels with toluene and other solvents between batch manufacturing operations were flushed out of the buildings through piping and drainage ditches to the waste disposal lagoons. Direct spills to the ground occurred during material handling and manufacturing activities. In addition to these liquid waste disposal practices, drums with hazardous substances were systematically buried on the plant property.

The primary routes of subsurface discharge and the associated impacted media were the following:

- direct discharge via floor drain leakage beneath the process buildings (soils and ground water beneath the buildings)
- seepage from the five unlined treatment lagoons (sediments, soils, and ground water beneath the lagoons)
- overflows from the unlined treatment lagoons (soils and ground water downgradient of the lagoons)
- discharge from approximately 400 deteriorating buried drums (soils and ground water beneath the burial pits).

A significant amount of source removal work has been completed at the site. Contaminated soils were removed from seven discrete disposal areas as part of the remedy for OU1. Contaminant sources associated with the process buildings (including shallow soils beneath the buildings) were removed during the implementation of the OU3 remedy. The remaining sources of ground water contamination include deep soils (i.e., those soils beneath the practical excavation depths achievable during the OU1 and OU3 remedies) and the sediments associated with the remaining treatment lagoons 4 and 5.

The primary constituents of concern at the site (which may be refined as part of the OU4 ROD) are as follows:

VOCs
Acetone
Benzene
Carbon Tetrachloride
Chlorobenzene
Chloroform
1,4-dichlorobenzene (1,4-DCB)
1,2-dichlorobenzene (1,2-DCB)
1,2-dichloroethane (1,2-DCA)
Methylene Chloride
Cis-1,2-dichlorethene (cis-1,2-DCE)
Tetrachloroethene (PCE)
Trichloroethene (TCE)
Toluene
Vinyl Chloride

SVOCs
Naphthalene
Bis(2-chloroethyl)ether

Metals/Inorganics
Aluminum
Arsenic
Cyanide

Other contaminants, including tentatively identified compounds, are also present at the site.

1.5.3 HYDROGEOLOGIC SETTING

The site is located on the southeastern edge of the Blue Ridge physiographic province and west of the Piedmont physiographic province. The topography of the Site slopes toward an unnamed tributary of Stockton Creek in the southeastern portion of the site. Ground water is present in both the overburden and fractured bedrock aquifers. The saturated thickness of the overburden generally ranges from less than one foot at MW-11 north of the Drum Disposal Area to about 80 ft at the MW-17 well cluster near the former northern warehouse. Within the bedrock, ground water is limited to the interstitial spaces associated with the well-developed bedrock fracture system. There is essentially no intergranular porosity (or primary porosity) in the bedrock. The vertical extent of this fracture system beneath the site could not be determined on the basis of the bedrock NX coring that was done for a select suite of the bedrock wells. The degree of fracturing reportedly decreases significantly below depths of 300 ft below ground surface (bgs). The resource potential of ground water in the site vicinity is probably limited to shallower than 300 ft bgs.

The water table at the site occurs in the overburden, at depths varying from less than 5 feet bgs to more than 35 feet bgs. An exception occurs at well MW-11, where the water table has historically fallen below the bedrock-overburden contact. The position of the water table surface is largely controlled by the local topography, which slopes generally to the southeast. Localized variations in permeability have also created small areas with perched water tables, primarily in the lagoon area and beneath the process buildings. March 2001 water elevation data from the MW-17 and MW-21 clusters suggest that the hydraulic gradient in the overburden at the site is relatively steep at approximately 0.07 feet per foot in a southeasterly direction. The hydraulic gradient in bedrock appears to be approximately 0.02 to 0.03 feet per foot in a southeasterly direction. In general, the vertical ground water flow patterns are downward from the overburden into the shallow bedrock in the northern portions of the site near the former process buildings, and upward in the southern portions of the site where wetlands occur and the water table intersects the ground surface. Within the bedrock, the overall vertical ground water flow pattern is upward from the deep to the shallow zones, indicating that the deep fractured bedrock aquifer may be fed from recharge at higher elevations up-slope from the site.

The hydrogeologic and hydraulic characteristics of both the overburden and bedrock aquifers have been defined on the basis of extensive testing and evaluation activities completed during the RI and earlier investigations. The overburden component consists of saturated soil and saprolite material. Ground water in the overburden occurs primarily in the intergranular pore spaces but can also be found in relict fractures that were present in the parent bedrock material. Hydraulic conductivity (K) values for the overburden vary by two orders of magnitude, as shown below. The lowest K values were associated with wells screened in the upper portion of the overburden. Wells screened just below or across the weathered rock-overburden contact yielded the maximum K values but in general were highly variable, ranging from a low of 1.9×10^{-5} cm/sec at MW-19 to a high of 4.3×10^{-3} cm/sec at MW-11. The chemical weathering of the Pedlar Formation produces a sandy clay material rich in kaolinite with the sand fraction consisting of quartz. Coarse gravel and other residual boulders are also present. For a given profile, the highest permeability should occur near the base of the weathered rock zone, where fracture apertures are likely to still be open. Also at this level, because of the reduced weathering and chemical alteration, the saprolite is likely to have sandy texture with little or no clay.

Monitoring Well	Unit	Well Depth (ft)	Hydraulic Conductivity (K)
			ft/day
MW-1	OB	42	1.17
MW-2S	OB	36	1.37
MW-2D	OB	76	0.74
MW-2D**	OB	-	0.21
MW-3	OB	40	0.40
MW-4	OB	42	0.21
MW-5	OB	17	0.21
MW-7S	OB	19	0.27
MW-7D	OB	41	0.24
MW-10	OB	40	0.11
MW-10D	OB	59	0.05
MW-11*	Rock	41	12.33
MW-12S	Rock	44	7.37
MW-14S	Rock	108	1.17
MW-14S**	Rock	-	3.28
MW-14D	Rock	209	0.27
MW-16S	Rock	72	10.45
MW-16D	Rock	202	1.22
MW-17S	OB	45	0.01
MW-19*	OB	46	0.05
MW-20S**	OB	28	0.11
Geometric Mean	OB		0.26
Geometric Mean	Rock		2.75

Note: All results are based on rising or falling head slug tests unless otherwise indicated
** Well is screened just below or across the weathered bedrock and overburden contact*
*** Data derived from short-term pump test*
OB = Overburden well
Rock = Bedrock well

The geometric mean hydraulic conductivities and hydraulic gradients in the overburden and bedrock combined with a representative porosity suggest a ground water seepage velocity of approximately 0.05 to 0.15 feet per day, with the velocity in the bedrock at the upper end of this range and the velocity in the overburden at the lower end of this range.

Ground water at the site discharges to ground surface at various seeps along the southern portion of the property, discharges to West Stream, and/or continues to flow beneath West Stream and further downgradient. While the existing hydrogeologic characterization of the site is in general quite good, it is hampered by the fundamental complexity of the bedrock fracture network. As a result, it has not been possible to conclusively identify discrete primary contaminant flow paths in the bedrock and the fate of all contaminated ground water at the site.

1.5.4 RECEPTORS

South Pond, East Pond, and West Stream (a tributary to Stockton Creek that runs along the southern boundary of the site) were receptors of contaminated overland flow, but, as discussed above, previous removal actions have addressed the sources of contamination to overland flow and have virtually eliminated this pathway. During the RI, site-related contamination was found in South Pond, but not in the off-site surface water bodies (i.e., East Pond and West Stream). These surface water bodies, however, remain potential receptors of contaminated ground water.

Residents in the vicinity of the site rely on private wells to supply potable water for both domestic and agricultural uses. Approximately 29 supply wells are located within 1 to 2 miles of the site. With one reported exception northeast of the site (upgradient), all of these wells are completed in the bedrock. Completion data are not available for most of these wells, but the RI indicates that most of the wells are completed in bedrock and that the depths typically range from 75 to 250 ft bgs. The RI indicates approximately 5 private wells that are located downgradient (i.e., southeast of the site). The remaining wells, although closer to the site are located in upgradient or side-gradient directions. Water quality monitoring of these wells during the RI did not indicate site-related contamination. Detectable concentrations of some organic contaminants were found, but these analyses were disqualified due to laboratory contamination. A detectable concentration of cyanide (14 ug/L) resulted from one sampling event during the RI but was disqualified based on later sampling with a more appropriate detection limit (5 ug/L).

Therefore, although there is potential for ground water to contaminate private wells, no conclusive evidence was found that such contamination had occurred. Sampling of these wells since 1989, if it has been done, is not well documented.

1.5.5 DESCRIPTION OF GROUND WATER PLUME

The contaminants of concern at the site are primarily VOCs, SVOCs, and metals. The VOC ground water data from September 2002 through June 2003 are shown in Tables 1-1 and 1-2 and VOCs are depicted on Figure 1-2. SVOCs, inorganic compounds, and tentatively identified compounds are not shown. Ground water quality data are not routinely tabulated as part of the site activities. Tables 1-1 and 1-2 were compiled by the optimization support team to provide the basis for analysis in this report. These data have been reviewed and are of sufficient quality for use in this report, but the optimization support team recommends that these data be thoroughly reviewed using a more rigorous QA/QC protocol.

Table 1-1 provides the water quality data for detectable ground water VOC concentrations from September 2002 through June 2003. In order to simplify the depiction of the distribution of these constituents, the mean VOC totals have been calculated in Table 1-2 and posted on Figure 1-2. Figure 1-2 shows that the downgradient extent of the constituent plume extends at least as far as MW-21S and that the exact downgradient plume boundary cannot be determined from these data. Table 1-2 and Figure 1-2 indicate that relatively high VOC concentrations occur at MW-23, MW-18D2, MW-18S, OB-5, and OB-4.

The extent of cyanide and arsenic impacts is limited compared to the impacts from VOCs. Groundwater monitoring data collected in four sampling events between September 2002 and June 2003 indicate that only three wells had cyanide concentrations above the federal MCL of 200 ug/L, and only five wells had arsenic impacts above the future arsenic MCL of 10 ug/L. No wells had arsenic concentrations above the current MCL of 50 ug/L. The extent of aluminum impacts is more difficult to evaluate because there is no federal MCL or other standard for comparison. For reference, however, approximately 10 wells have had concentrations of aluminum exceeding 1,000 ug/L, and eight of these 10 wells are in the overburden. It should be noted that MCLs are used here for reference only. They have not necessarily been chosen as the cleanup standards for the site. The cleanup standards will be set in the OU4 ROD.

The transport of contaminants vertically into the bedrock likely occurred due to infiltration of the contaminated water from the lagoons that caused ground water mounding and a downward driving force. Now that the dissolved contamination from the lagoons has been removed and the water in Lagoons 4 and 5 is managed, this downward driving force is likely no longer present.

2.0 SYSTEM DESCRIPTION

2.1 SYSTEM OVERVIEW

The ground water extraction system recovers ground water from five bedrock extraction wells (BR-2, BR-6, BR-7, BR-8, and MW-23) that are depicted in Figure 1-1. Each well is piped to the plant separately with a flow meter on each line. In addition, a floating pump assembly allows for extraction from Lagoon 5 (Lagoon 4 is hydraulically connected to Lagoon 5) to prevent overflow during precipitation events. The treatment system provides for metals and solids removal, destruction of organic contaminants via UV oxidation, and sorption of remaining organic contaminants to GAC. Treated effluent is discharged to the West Branch of Stockton Creek, located south of the site.

2.2 EXTRACTION SYSTEM

Consistent with the function of an interim remedy, the wells are not specifically positioned for plume capture. Rather, they are positioned and designed for the purpose of mass removal in the high-concentration areas of the ground water plume. Information on the extraction system is summarized in the following table, including average extraction rate and VOC mass removal rate.

Extraction Well	**Extraction Interval**			**Average Extraction Rate***	**Mean Total VOC Concentration****	**Mass Removal Rate**	**% Mass Removed**
	Top (ft bgs)	Bottom (ft bgs)	Total (ft)	(gpm)	(ug/l)	(lbs/day)	
BR-2	37	77	40	3.7	34	0.002	3.0%
BR-6	52	70	18	3.0	644	0.023	34.3%
BR-7	107	126	19	2.3	300	0.008	11.9%
BR-8	51	112.4	61.4	0.5	226	0.001	1.5%
MW-23	94	122.8	28.8	1.2	2,311	0.033	49.3%
Lagoon				0.3			
Total				**11**	**512*****	**0.067**	**100%**

** Average extraction rate is for the operating period of January through May 2003 calculated by taking the total gallons extracted and dividing by the total time during that 151-day period.*
*** Indicated concentrations are averages of results from four sampling events between September 2002 and June 2003.*
**** This blended concentration accounts for different flow rates from different wells.*

As is evident from the above table, the VOC mass removal rate was approximately 0.07 pounds per day or 26 pounds per year. The majority of this contaminant mass is carbon tetrachloride and chloroform.

Based on data from the same period, removal of inorganics and SVOCs is substantially lower. For example, metals removal from the extraction wells is approximately 0.002 pounds per day (primarily aluminum), and removal of cyanide (0.0005 pounds per day) and arsenic (undetectable) is even more negligible. Based on the average flow rate above and average blended influent concentrations from February through May 2003, the removal of aluminum is approximately 0.03 pounds per day, with the increase presumably due to pumping from the lagoon. Also based on the influent data, the removal of bis(2-chloroethyl)ether is approximately 0.002 pounds per day.

2.3 TREATMENT SYSTEM

The treatment plant was designed for a flow rate of 50 gpm and a maximum hydraulic capacity of 60 gpm. The treatment plant consists of the following components for treatment of the extracted ground water.

- One 12,600 gallon flow equalization tank
- Two tanks in series for chemical addition, pH adjustment, and flocculation
- One inclined plate clarifier with a sludge thickening compartment, and pumps to both recirculate and waste sludge
- One gravity dual-media filter
- One UV oxidation system with hydrogen peroxide addition
- Two GAC units in series to remove hydrogen peroxide and organic contaminants not removed by the UV oxidation system
- An effluent/backwash storage tank
- One plate-and-frame filter press and sludge holding tank for dewatering solids settled out in the clarifier
- Chemical feed systems including: caustic and sulfuric acid for pH adjustment, ferric chloride for enhancing iron co-precipitation, polymer for enhancing floc formation, body feed for solids handling, and hydrogen peroxide for oxidation in the UV system
- Instrumentation and electrical panels, including telemonitoring and control systems
- A pre-engineered building to house the entire treatment system

The influent is combined in the 12,600-gallon equalization tank. From the equalization tank water is pumped to the rapid mix and flocculation tank where ferric chloride, caustic, and polymer are added. The water then flows to a plate clarifier for solids settling and then through three auto-backwashing gravity filters in series. Following the gravity filters the water flows to a final pH adjustment tank, to the 30 KW UV/Ox unit, and then to two 2,000-pound GAC units in series. Following the GAC units, process water flows to a final effluent/backwash storage tank and then by gravity to the surface water outfall (West Branch of Stockton Creek). System sludge is collected in a 4,600 gallon tank and dewatered with a filter press. System tanks are vented through vapor phase GAC units.

2.4 MONITORING PROGRAM

Treatment process monitoring is conducted monthly at the following locations along the treatment train for the specified parameters:

- SL-1: Influent (VOCs, SVOCs, metals)
- SL-2: Clarifier effluent (metals)
- SL-3: Filter effluent / UV oxidation influent (VOCs, SVOCs, metals)
- SL-4: UV Oxidation effluent / GAC influent (VOCs, SVOCs)
- Effluent (VOCs, SVOCs, metals)

Ground water monitoring is conducted monthly at the extraction locations and quarterly at 23 well locations, including the extraction wells. The wells are sampled for VOCs, SVOCs, and metals. Periodic sampling might also be conducted at the local residential wells, but this sampling, if it is done, is not well documented. All samples are shipped to an off-site laboratory for analysis. The process monitoring data are reported in the O&M Reports, and remaining data are reported in quarterly monitoring and/or periodic reports.

3.0 SYSTEM OBJECTIVES, PERFORMANCE AND CLOSURE CRITERIA

3.1 CURRENT SYSTEM OBJECTIVES AND CLOSURE CRITERIA

According to the OU-2 ROD (1990), the primary objectives of the OU-2 interim remedy are as follows:

- initiate the reduction of toxicity, mobility, and volume of ground water contaminants
- minimize the migration of the ground water contaminants toward residential wells
- obtain information about the response of the aquifer to remediation measures in order to define ground water cleanup goals that are practicable for the site and a time-frame for meeting those goals
- restore water quality in Lagoons 4 and 5

Because the final ground water cleanup goals (and the time frame for meeting those goals) could not be determined in time for the issuance of the OU2 ROD, the ground water pump and treat system was designated as an interim remedy. A ROD selecting the final remedial action for ground water at the site will be issued in the future to define the ground water cleanup goals and to modify the remedy as necessary. Based on information provided during the site visit, the final ROD will specify ARARs for the site. Because the site-specific ARARs have not yet been developed, this report uses for reference the Federal MCLs and the site-specific risk-based criteria defined in a January 2000 Region 3 memo. Neither of these reference concentrations will necessarily be the ARARs.

Contaminant	**Federal MCLs (ug/L)**	**Risk-Based Criteria (ug/L)**
Acetone	-	172.07
Arsenic	10*	0.01
Benzene	5	0.29
Bis(2-chloroethyl)ether	-	-
Bis(2-ethylhexyl)phthalate	-	0.42
Carbon tetrachloride	5	-
4-Chloroaniline	-	31.29
Chlorobenzene	-	27.79
Chloroform	-	0.12
Cyanide	200	103.24
1,2-Dichloroethane	-	0.11
Di-n-butyl phthalate	-	249.95
Methylene Chloride	-	1.58
Napthalene	-	10.96

Contaminant	Original ROD Cleanup Levels (ug/L)	Revised Cleanup Levels (Risk-based) (ug/L)
Napthaleneacetic Acid	-	7.82
Tetrachloroethene	5	0.09
Tetrahydrofuran	-	344.14
Toluene	1,000	53.22
Trichloroethene	5	0.87
2,4,6-Trichlorophenol	-	1.08
Xylene	10,000	10,324.29

** effective January 23, 2006*

3.2 TREATMENT PLANT OPERATION STANDARDS

The treatment plant discharges to a drainage swale which drains into West Stream, a tributary of Stockton Creek. In accordance with its National Pollutant Discharge Elimination System (NPDES) permit, the plant operators are required to sample the effluent on a monthly basis, and the effluent must meet the following surface water discharge criteria as reported in the Discharge Monitoring Reports for select compounds.

Contaminant	Discharge Levels (ug/L)
Inorganic Compounds	
Aluminum	87
Copper	9.2
Cyanide (total)	7.6
Zinc	65

Contaminant	Discharge Levels (ug/L)
Organic Compounds	
Benzene	77.5
Bis(2-chloroethyl)ether	1.4
Carbon tetrachloride	90.8
Chlorobenzene	21,000
Chloroform	NL
1,2-Dichloroethane	NL
Methylene Chloride	1,600
Napthalene	90.7
Tetrachloroethene	NL
Toluene	256
Trichloroethene	NL

**NL means not listed*

It should be noted that the discharge criteria for many compounds are greater than the MCLs and/or risk-based criteria. Although the MCLs and the risk-based criteria will not necessarily be the site cleanup levels, this finding suggests the possibility that the future site cleanup levels will be lower than the discharge levels.

4.0 FINDINGS AND OBSERVATIONS FROM THE OSE SITE VISIT

4.1 FINDINGS

In general, the OSE team found a smoothly operating and well-organized treatment plant. The observations provided below are not intended to imply a deficiency in the work of the system designers, system operators, or site managers but are offered as constructive suggestions. These observations obviously have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of ground water remediation have changed over time.

4.2 SUBSURFACE PERFORMANCE AND RESPONSE

4.2.1 WATER LEVELS

Although water levels from the site monitoring wells are collected and reported on a monthly basis, they are not used to generate potentiometric surface maps. Therefore, it is difficult to evaluate ground water flow patterns under current pumping conditions. Water elevation data from the tables in the monthly reports, however, can be used to provide a preliminary look at the hydraulic gradients at the site. As stated in Section 1.5.3 of this report, the water levels from March 2001 under pumping conditions (chosen because none of the monitoring wells were dry) indicate a hydraulic gradient in the overburden to the southeast with a magnitude of approximately 0.07 feet per foot and in the bedrock to the southeast at approximately 0.02 to 0.03 feet per foot. These estimates of the horizontal gradients should be verified, however, by developing and evaluating potentiometric surface maps. The water elevation data from 2001 also show upward vertical gradients throughout the site.

4.2.2 CAPTURE ZONES

Although one of the goals of this interim remedy is to minimize the migration of site-related contamination toward residential wells, this interim system is not designed to provide extensive or complete capture of the plume. Nevertheless, it is useful to evaluate the degree of capture, especially when considering a final remedy. Much of the information needed to evaluate a capture zone at this site has been collected, but those data have not been processed, plotted, or analyzed in submitted reports.

At this site, the plume has not been fully delineated and a target capture zone has not been established. As indicated in Figure 1-2, contamination is present above site-specific standards (and above MCLs) at MW-21S and MW-21D. Contamination (albeit at low concentrations) is also present in BR-2, which is an extraction well that marks the furthest downgradient sampling point (in recent sampling events) on the western side of the property. Many of the deep wells at the site also have contamination with no deeper wells to provide delineation. MW-7D and MW-21D are examples of such wells. The concentrations at MW-7D and MW-21D are higher than at MW-7S and MW-21S (respectively), and it is possible that concentrations below MW-7D and MW-21D might actually increase with depth. The MW-14 cluster, which is adjacent to the MW-7 cluster, has bedrock wells which are deeper than those of the MW-7 cluster, but the sampling data from the past year (4 quarters) indicate that the MW-14 cluster has not been sampled.

Pumping tests have been conducted at bedrock extraction wells BR-6, BR-7, and BR-8 in 1996 as part of the design effort. Drawdown was observable in downgradient wells, however, this information is not sufficient to evaluate capture. First, drawdown in an observation well does not confirm that capture is provided at that well. Second, the extraction wells are pumped at substantially lower extraction rates during P&T operation than they were during the pump tests.

A water budget analysis might provide the best preliminary indication of the degree of capture at this site. The following parameter values are relevant.

- The hydraulic gradient at the site is approximately 0.02 (bedrock) to 0.07 (overburden) feet per foot. To be conservative, the higher value is used.
- The geometric mean of the hydraulic conductivity is 2.75 feet per day (bedrock) and 0.26 feet per day (overburden). To be conservative, the higher value is used, especially since the pumping is occurring within the bedrock.
- The saturated thickness is approximately 50 feet, and the width of the site and known extent of contamination is approximately 800 feet.
- On average, approximately 11 gpm (2,100 ft^3 per day) is extracted from the site extraction wells.

Assuming infiltration from precipitation and/or from the underlying formation is accounted for in the observed hydraulic gradients, the amount of water extracted is equal to the amount of water flowing through a given cross-section of the aquifer:

$$Q = KiWb$$

where *K* is the hydraulic conductivity, *i* is the hydraulic gradient, *W* is the width of the cross-section, and *b* is the saturated thickness. This equation can be rearranged to solve for the width.

$$W = \frac{Q}{Kib} = \frac{2{,}100\ {}^{ft^3}\!/_{day}}{2.75\ {}^{ft}\!/_{day} \times 0.07 \times 50\ ft} = 220\ \ ft$$

This result suggests that the width of capture is approximately 220 feet; however, this result is based on a number of the simplifying assumptions. The above calculation suggests that capture of all ground water flowing through the site may not be provided, but given the simplifying assumptions that were made, further analysis is merited.

Potentiometric surface maps generated during pumping conditions would be helpful in evaluating ground water flow directions toward extraction wells. Such maps have not been generated, however. Concentration trends in wells downgradient of the expected capture zone can be used to evaluate capture if sufficient data have been collected to provide a trend. A review of data from quarterly ground water monitoring from September 2002 through June 2003 suggests increasing concentrations for individual VOCs in MW-21D. If MW-21D is beyond the capture zone of BR-6, then this increase is a likely indication that capture is not provided. On the other hand, if MW-21D is within the capture zone of BR-6, then the increase would indicate that contamination is passing through MW-21D on a path toward BR-6. Additional data (beyond four quarters) is likely necessary before attempting to establish a trend.

Capture is difficult to evaluate, particularly in bedrock aquifers and aquifers with varying hydrogeologic zones (e.g., overburden and bedrock). A preliminary analysis of site data (a water budget analysis and preliminary look at concentration trends) suggests that capture may not be complete and that contamination is potentially migrating downgradient beyond MW-21D and perhaps in other locations.

4.2.3 CONTAMINANT LEVELS

Comparing the ground water monitoring results that are discussed in the 1990 ROD with recent ground water monitoring results suggests that the contaminant concentrations in site monitoring wells have not changed substantially since the RI phase. The highest concentrations are found in both the overburden and bedrock in the former lagoon area. Downgradient of the lagoons, concentrations are approximately an order of magnitude lower than concentrations in the former lagoon area, but concentrations generally increase at depth (MW-7D vs. MW-7S and MW-21D vs. MW-21S). The one year of quarterly data reviewed during this evaluation did not show a significant trend in influent concentrations, though a significant trend would not necessarily be expected over a one-year period. Influent concentrations, however, appear similar to the expected concentrations sampled during the design phase in 1996.

Based on the configuration of the plume, the average extraction rate, and the average influent concentration, it appears that the interim P&T remedy is doing little to restore the aquifer (i.e., extracting less than 0.1 pounds per day of contaminant mass).

4.3 COMPONENT PERFORMANCE

4.3.1 EXTRACTION SYSTEM WELLS, PUMPS, AND HEADER

Each of the five extraction wells includes a 0.5 horsepower submersible centrifugal pump that can be controlled both at the well or at the plant, high and low level set points, individual HDPE piping to the treatment plant, and an electromagnetic flow meter. During the evaluation site visit, the site team did not reference any problems with fouling or other complications associated with the ground water extraction system.

The extraction system also includes a floating extraction assembly for Lagoon 5. Lagoons 4 and 5 are hydraulically connected, and pumping from the floating assembly prevents the lagoons from overflowing during precipitation events. The ground water extraction data presented in Section 2.2 of this report suggest that the extraction from the lagoons (approximately 0.3 gpm) only accounts for approximately 3% of the total treatment system influent, but at any one time, the flow rate from the lagoons may be as high as 9 gpm and may comprise closer to 50% of the total system influent. Extraction from the lagoons will likely continue until the sediments are excavated or are demonstrated to meet cleanup standards.

4.3.2 EQUALIZATION/INFLUENT TANK AND METALS REMOVAL SYSTEM

Extracted ground water and lagoon water flows into the 12,600-gallon equalization tank before being pumped to the rapid mix and flocculation tanks. Blended influent samples are collected from the equalization tank. The tank has both high and low level controls that shut off and restart the extraction system, respectively.

The metals removal system consists of a rapid mix tank, flocculation tank, clarifier, multimedia gravity filters, and pH readjustment. Caustic and ferric chloride are added to the rapid mix tank. The pH is maintained around 8.0 and the ferric chloride addition ranges between 10 mg/L and 70 mg/L with an average of around 25 mg/L. Both caustic and polymer are added to the flocculation tank, and pH in that tank is maintained at around 8.5. Sludge from the clarifier is removed approximately twice a week. The effluent from the clarifier is gravity fed through three multimedia filters that are aligned in series. These filters are backwashed automatically every 4 to 5 hours when extraction is occurring from the lagoons and every 8 to 10 hours when no extraction is occurring from the lagoons. After the filters, the pH is readjusted with the addition of sulfuric acid.

The metals removal system, and specifically the rapid mix tank, is the rate-limiting step of the entire treatment plant. Although the system was designed with a hydraulic capacity of 60 gpm, the maximum flow rate achievable is actually about 35 gpm due to limited capacity of the metals removal system.

Head space from these tanks is vented through a 1,000-pound vessel of vapor phase GAC that has not been sampled or replaced since the system began operation in May 2000.

4.3.3 UV/OXIDATION SYSTEM

The UV/Oxidation system includes one 30 kW UV lamp and the addition of approximately 50 mg/L of hydrogen peroxide. Although this unit is designed to provide the primary removal of organics, the removal efficiency for carbon tetrachloride, chloroform, 1,2-dichloroethane, and bis(2-chloroethyl)ether is generally quite low. The following table represents the average removal efficiencies for each of these compounds over a four month period in 2003.

Contaminant	Average Removal Efficiency (2/2003 - 5/2003)
Carbon tetrachloride	20%
Chloroform	23%
1,2-Dichloroethane	69%
bis(2-chloroethyl)ether	79%

As is evident from the above table, the majority of the mass of carbon tetrachloride and chloroform is not removed by the UV/Oxidation system. In fact, during two of the four months more carbon tetrachloride was removed due to aeration in the equalization and metals removal tanks than was removed by the UV/Oxidation system. According to design documents, chloroform and 1,2-dichloroethane were not expected to require treatment, and the relatively low removal efficiencies were expected for both carbon tetrachloride and bis(2-chloroethyl)ether.

4.3.4 GAC

There are two 2,000-pound GAC units aligned in series. The first unit is used primarily for destruction of residual peroxide from the UV/Oxidation step, and the second unit is used for removal of organics. The second unit is replaced approximately every 8 months when the chloroform and carbon tetrachloride concentrations reach approximately 25 ug/L each. This set concentration is a compromise between extending the life of the GAC and meeting the discharge requirements. There is no discharge limit for chloroform, and the discharge limit for carbon tetrachloride is 90.8 ug/L.

4.3.5 EFFLUENT TANK AND DISCHARGE

Prior to discharge to surface water under a NPDES permit, the process water empties into an effluent tank (8,550 gallons) where it can be sampled or returned to the head of the plant. The effluent tank water also serves to backwash the multimedia filters and the GAC units.

4.3.6 SOLID WASTE HANDLING SYSTEM

The solid waste handling system includes a 6,000-gallon waste tank for collecting backwash waste, a 4,000-gallon sludge holding tank, a filter press, and associated pumps. The filter press has a 10 cubic foot nominal capacity and dewaters sludge to approximately 35% solids.

4.3.7 SYSTEM CONTROLS

System controls include a programmable logic controller (PLC), a computer, and an autodialer. Over 16 alarms are designed to activate the autodialer.

4.4 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF MONTHLY COSTS

The annual O&M costs were reported to be approximately $450,000 per year. A breakdown of the O&M costs is provided in the following table.

Item Description	Estimated Cost
Labor: Project management, technical support, and reporting	$100,000 per year*
Labor: Plant operator (two full-time operators)	$200,000 per year
Labor: Ground water monitoring	$50,000 per year**
Utilities: Electricity	$35,000 per year
Non-utility consumables (GAC)	$7,500 per year
Non-utility consumables (UV/Oxidation accessories and chemicals)	$28,000 per year**
Chemical Analysis	N/A***
Routine maintenance	$25,000 per year**
Discharge fees and waste disposal	less than $5,000 per year**
Total Estimated Cost	**~$450,000**

** Estimated by the evaluation team based on other reported costs and approximate total cost .*
*** Estimated by the evaluation team based on approximate scope and/or professional judgment.*
**** Analyses are provided by the Contract Laboratory Program, and costs are not incurred by the site.*

4.4.1 UTILITIES

Electricity is the primary utility, and the UV/Oxidation unit comprises approximately half of the electricity usage. On an average month, approximately 45,000 to 50,000 kWh is used at the site at a cost of approximately $0.06 per kWh. The UV/Oxidation unit has a 30 kW lamp that operates continuously, using approximately 21,000 kWh per month. The remaining electrical usage is for extraction and process pumps, ventilation, and the air compressor for the sludge handling.

4.4.2 NON-UTILITY CONSUMABLES AND DISPOSAL COSTS

Non-utility consumables consists of chemical usage, GAC replacement, and accessories for the UV/Oxidation unit. More than 80% of the cost for chemical usage is likely due to caustic, ferric chloride, sulfuric acid, and polymer associated with the metals removal. The remainder is for hydrogen peroxide. GAC replacement costs approximately $5,000 per replacement of a 2,000-pound GAC unit every 8 months. The accessories for the UV/Oxidation unit cost approximately $8,000 per year. Therefore, the total cost for operating the UV/Oxidation unit (electricity and accessories) is approximately $25,000 per year for electricity, accessories, and hydrogen peroxide.

There is no direct charge for discharging the treated water to surface water, and charges for solid waste disposal are likely low because the waste is classified as non-hazardous.

4.4.3 LABOR

Only the labor costs associated with the two plant operators were provided. The labor costs and scopes of work associated with project management, reporting, and ground water sampling were not provided during the site visit because the contractor was not present. Based on the total O&M cost of approximately $450,000, the costs for the other O&M items, and the scope of the ground water monitoring program, the evaluation team assumes that project management, technical support, and reporting might cost $100,000 per year and that ground water monitoring might cost $50,000 per year. The $100,000 and $50,000 cost estimates by the OSE team, therefore, are not entirely based on scope. They are largely based on the total O&M cost that was provided.

4.4.4 CHEMICAL ANALYSIS

Chemical analysis is provided by the Contract Laboratory Program. Therefore, the costs are incurred by EPA but are not directly assigned to the site.

4.5 RECURRING PROBLEMS OR ISSUES

The site team did not highlight any recurring problems or issues associated with O&M.

4.6 REGULATORY COMPLIANCE

The treatment plant regularly meets its discharge criteria.

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

No excursions or accidents were reported during the evaluation site visit.

4.8 SAFETY RECORD

The site team did not report any accidents or injuries at the site.

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

5.1 GROUND WATER

Ground water at the site (and likely downgradient of the site) remains contaminated, and potential exposure routes to this contamination include using the water for drinking or other purposes, discharge of water to the surface where direct contact would be possible, and potentially contaminant vapors that may volatilize and travel through the vadose zone to the surface. The site is currently open space that is surrounded by fencing. Therefore, drinking contaminated water, direct contact with contaminated water, and vapor issues should not be a problem within the confines of the site. Off-site, residential supply wells and West Stream are likely the potential receptors that are at the greatest risk. Sampling of residential wells and West Stream during the RI did not reveal the presence of site-related contamination, but a number of years may have passed since this sampling was completed. The most downgradient wells at the site are contaminated, and the extent of contamination further downgradient of these wells is not known.

It is understood that this is an interim remedy, but the potential for impacts to receptors demonstrates the need for evaluation and potential modifications of the interim remedy until a final remedy is selected and implemented.

5.2 SURFACE WATER

As of the RI, surface water had not been impacted with site-related contamination. However, this sampling took place approximately 15 years ago. With continued migration of contamination, the potential still exists for impacts to surface water or to ground water discharging to the surface in seeps. The original primary threat to surface water contamination (overland flow of contaminated water) has been eliminated from previous removal actions and maintenance of the water level in the remaining lagoons.

5.3 AIR

Although site contaminants include VOCs, it is unlikely that above-ground air quality is compromised because the site and the area downgradient is open space and any vapor contamination that migrates to the surface would attenuate due to mixing in the atmosphere and exposure to sunlight. Limitations on the use of space overlying the plume would likely be sufficient at protecting human health and the environment in the future, if implemented.

5.4 SOILS

Soil contamination is primarily addressed through other operable units at this site. The OSE team understands that much of the soil contamination has been removed, but that some arsenic contamination in limited areas may remain as indicated by dead vegetation. Because the site is fenced exposure to this contamination has likely been prohibited. Solutions to remaining contamination could include removing the surficial contamination or covering the contamination to prevent direct contact. The site team is suggesting the application of a RCRA subtitle C cap over a 6 to 7 acre area. The OSE provides another, more cost-effective option in Section 6.4 of this report.

5.5 WETLANDS AND SEDIMENTS

The sediments of many of the lagoons have been excavated and the lagoons have been backfilled. Future plans include addressing the remaining contamination in Lagoons 4 and 5. This course of action appears to be protective of human health and the environment.

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

6.1.1 SAMPLE RESIDENTIAL WELLS AND SURFACE WATER

Based on the documents reviewed as part of this optimization effort and discussions during the OSE visit, the OSE team cannot determine the frequency that residential wells and off-site surface water have been sampled since the RI. It has been more than 15 years since the RI, which is a sufficient amount of time for substantial contaminant migration to potentially occur. As a result, we recommend that residential wells (particularly those downgradient of the site), off-site surface water, and on-site seeps be sampled for both VOCs and inorganics and that this sampling be documented. To be conservative, it may be worthwhile to sample select residential wells every year or two years. For cost estimating purposes, a total of 15 residential well samples and 10 surface water samples are assumed on an bi-annual basis (i.e, every two years). However, this is only an assumption, and the site team may determine more comprehensive or simplified program. Reviewing site documents and developing a work plan for this effort might cost $10,000 and collecting samples might cost $8,000 for each event. The data would be summarized in periodic reports that are further discussed in Section 6.3. It is assumed that the Contract Laboratory Program will be used for analysis, though it may be prudent to use an alternative (at least for the first event) that can provide a faster turnaround time. If residential wells are impacted, point-of-entry treatment systems may be required.

6.1.2 DELINEATE THE CONTAMINANT PLUME

The primary objective of the final remedy should include containment of contaminated ground water so that further contaminant migration can be prevented. However, before this can be accomplished, the extent of contamination needs to be determined. Of primary importance is the contamination found at MW-21S and MW-21D. There are contaminant concentrations at these wells that are above MCLs, and the concentrations increase with depth. Therefore, the downgradient edge of the plume has not been determined and the depth of the plume at MW-21D (which is completed to 53 feet bgs) has not been determined.

We recommend installing additional monitoring wells for delineation. Two clusters of monitoring wells at three depths should be installed downgradient of MW-21D (perhaps 200 to 400 feet downgradient depending on accessibility). The shallow and intermediate wells in each of these clusters might be completed to depths that are comparable to MW-21S and MW-21D. The depths of the deeper wells in each of the clusters would likely need to be determined in the field, but sampling MW-14D prior to the drilling event may provide useful information. MW-14D is located approximately 200 feet upgradient of MW-21D but the elevation of the base of the screen for MW-14D is 140 feet deeper than that of MW-21D. The data reviewed by the OSE team suggested that MW-14D has not been sampled recently. Depending on the results from MW-14D, the site team might consider drilling to a depth of 100 to 200 feet bgs, using a straddle-packer assembly to isolate and sample various fracture intervals, sending samples off-site for analysis, and then installing a screen at an appropriate interval. Ideally, these deeper wells would provide the necessary delineation at depth. The suggested depth of 100 to 150 feet will hopefully be sufficient. These wells should be sampled for VOCs and inorganics in an attempt to find the downgradient edge of the plume. We estimate that installing these wells, including a work plan, oversight, sampling (two events), and a small report, might cost approximately $150,000 to $200,000 depending on the depths of the wells. Future sampling of these wells is discussed in Section 6.2.4 of this report.

Additional deep wells could be added near the heart of the plume, but at this stage of the remedy, if contamination is not migrating off-site at depth near MW-21D or the other clusters that are recommended above, additional deep wells in the heart of the plume are likely not necessary. The OSE team might recommend adding additional deep delineation wells at the heart of the plume if aquifer restoration were an immediate goal. However, the OSE team believes that the current focus should be placed on capture.

6.1.3 DETERMINE A TARGET CAPTURE ZONE AND CONDUCT A CAPTURE ZONE ANALYSIS

Once the plume has been delineated near MW-21D, the site team should have enough information to determine an appropriate target capture zone. Capture at MW-21D may or may not be required, depending on the outcome of the delineation activities suggested in 6.1.2.

The new wells suggested in Section 6.1.2 should help determine an appropriate target capture zone. In addition to evaluating capture for the entire site, the site team may wish to evaluate capture near the plume “hot spot” near MW-23 and the MW-18 cluster. By containing this contamination, it may eventually allow the downgradient portion of the plume (near the MW-7 and MW-21 clusters) to clean up. If these downgradient areas eventually reach ARARs, then it may be possible to discontinue the extraction from BR-6 at that time.

Evaluations such as those discussed in Section 4.2.2 can be used to evaluate capture. Site data can be reviewed to conduct a more thorough water budget. Ground water elevations can be plotted and potentiometric surface maps developed to analyze ground water flow directions and interpret capture zones. All historic water quality data (rather than just the four quarters reviewed as part of this report) can be used to develop trend analysis in various wells. Ground water modeling and particle tracking could be used but should be postponed until the above steps are taken and existing data is fully evaluated. The site team could use hydrogeologists from the EPA Ground Water Forum for assistance. A good starting point is *Elements for Effective Management of Operating Pump and Treat Systems* (EPA 542-R-02-009).

Once the target capture zone has been determined and actual capture has been interpreted, the site team can determine if additional extraction is needed and how to achieve that additional extraction. Given the poor productivity of the site extraction wells, additional extraction wells may be required. The costs for additional extraction wells or redevelopment of the current wells is not provided. The cost for the capture zone analysis, including development of an appropriate target capture zone, may be as high as $40,000. Future capture zone analyses and the associated costs are discussed in Section 6.3.1.

6.1.4 CONSIDER SAMPLING INFLUENT AND EFFLUENT TO VAPOR PHASE GAC THAT IS USED FOR TREATING VAPORS IN HEAD SPACE OF REACTION TANKS

The plant operators indicated that there is a 1,000-pound vapor phase GAC unit that is used to treat the contaminant vapors that accumulate in the equalization and reaction tanks. This unit has been in place since the plant began operating and has not been sampled. If it was deemed important to include this unit in the original design, it would be prudent to sample the influent and effluent air stream through this unit once or twice per year with a PID to determine if breakthrough has occurred. This recommendation could be easily implemented by plant operator at no additional cost.

6.2 RECOMMENDATIONS TO REDUCE COSTS

6.2.1 REDUCE OPERATOR LABOR

Current operator labor includes two full-time operators at a cost of about $200,000 per year. This amount of labor should not be necessary. Other, similar treatment systems that are not as well designed or automated require only one full-time operator, with occasional help from a part time technician. The Selma Pressure Treating Site in Region 9 and the Havertown PCP site in Region 3 are primary examples. The Greenwood system is very similar to the one found at Groveland Wells in Region 1, and only one operator is required at that site. The OSE team suggests reducing operator labor to one full-time operator with part-time support (perhaps 8 hours per week) from a technician. This reduction in labor should reduce costs by approximately $50,000 per year or more.

6.2.2 ADDRESS REMAINING LAGOON SEDIMENTS AND DISCONTINUE EXTRACTION FROM LAGOONS ON AN EXPEDITED SCHEDULE

Until the sediments from Lagoons 4 and 5 are fully addressed (i.e., removed, remediated, or determined clean), pumping from the lagoons will need to continue. This lagoon pumping substantially increases the amount of solids entering the treatment plant as is evidenced by the increased backwashing frequency during lagoon pumping. This increased solids means that more solids need to be removed both to meet discharge standards and to protect the UV/Oxidation system. Because solids removal (particularly the metals precipitation aspect) requires substantial labor, chemical usage, and disposal, it is expensive and should be eliminated when possible. Addressing the lagoon sediments, backfilling the lagoons, and discontinuing the lagoon pumping is the first stage in potentially eliminating metals precipitation and the associated costs. Filtration alone might be sufficient to meet discharge standards if the lagoon pumping is discontinued. The costs and cost savings for this recommendation is not quantified.

6.2.3 CONTINUALLY AIM TO ELIMINATE METALS REMOVAL AND THE UV/OXIDATION SYSTEM

If metals precipitation were not required, labor costs could be further reduced (from those mentioned in Section 6.2.1) by another $75,000 to $100,000 per year. Other smaller reductions may result from decreased use of chemicals. Therefore, it is in the best interest of EPA to avoid metals precipitation, if possible. Currently, metals removal is required for two reasons. The first is to meet discharge standards for aluminum, and the second is to protect the UV/Oxidation system.

As mentioned above, influent aluminum concentrations will likely decrease when lagoon pumping is discontinued. Although pumping from other locations (perhaps to enhance capture) might temporarily increase aluminum concentrations, over time, these concentrations will likely decrease. This decrease generally results because the oxidative state of the aquifer near the new extraction wells changes, favoring precipitation of the metals in-situ. The OSE team has witnessed a number of treatment plants where metals precipitation was originally incorporated but was not necessary after only a few months or years of operation. The Oconomowoc Electroplating and Claremont Polychemical Sites are examples. Even if influent aluminum concentrations are above discharge standards, it is possible that metals precipitation may not be necessary and filtration alone will reduce these concentrations. Filtration does not have the same labor requirements as metals precipitation, especially when the backwashing is automated as it is at the Greenwood plant.

Solids removal is often required for UV/Oxidation units because the turbidity associated with the solids interferes with the associated photochemical reactions. The OSE team has seen treatment plants where UV/Oxidation systems operated effectively without metals removal, but it is possible that metals removal may be required at the Greenwood Chemical site for the sole purpose of protecting the UV/Oxidation unit. For this reason, the OSE team suggests that the site team evaluate the need for the UV/Oxidation system. Currently, that system provides very little mass removal given the chemicals and energy it needs to operate. Section 4.3.3 provides a table of the poor removal efficiencies associated with this unit and shows that the GAC provides the bulk of the mass removal. Even if influent concentrations were to increase, it is difficult to argue that UV/Oxidation is the appropriate treatment technology for the site. GAC is currently replaced due to carbon tetrachloride and chloroform breakthrough, but bypassing the UV/Oxidation system would not likely substantially increase this replacement frequency given that the removal efficiency for those two contaminants by UV/Oxidation is only about 20%. Eliminating the UV/Oxidation system would remove another reason for metals precipitation and would also save approximately $20,000 per year (even after the conservative assumption that the GAC replacement frequency would double).

The OSE team understands that UV/Oxidation was originally included because of its ability to destroy a wide range of contaminants and that some unknown chemicals might be present at the site. If the possibility exists for discontinuing metals precipitation at the site, and protection of the UV/Oxidation system is the only reason why metals precipitation cannot be eliminated, it would be more cost effective to further research the constituents in the influent than it wold be to continue with UV/Oxidation. Furthermore, chloroform and carbon tetrachloride are two primary examples that relying on UV/Oxidation to treat unknown chemicals is not necessarily protective.

6.2.4 OPTIMIZE GROUND WATER MONITORING PROGRAM

The ground water monitoring program currently consists of quarterly sampling at 23 wells including the five extraction wells. Although Section 6.1.2 discussed the need for additional sampling locations for plume delineation, much of the current sampling appears redundant. The OSE team has the following recommendations with regard to optimizing the monitoring program.

- MW-17S and MW-17D are upgradient wells that have had undetectable concentrations in all sampling events reviewed as part of this evaluation effort. Given that there are no known upgradient sources, it is reasonable to eliminate sampling of these two wells or to reduce sampling to once every year or two years.

- MW-10S, MW-10D, OB-4, OB-5, MW-18S, MW-18D1, and MW-18D2 are monitoring wells in the hot spot. The concentrations in these wells are expected to decrease as contaminant mass is removed from the subsurface, but as is documented earlier in this report, that mass removal is exceptionally small. Aquifer restoration, if it does occur, will occur over decades. Furthermore, water quality monitoring of these points would not be used for evaluating capture. Tracking progress at these wells, therefore, can be accomplished on an annual basis rather than a quarterly basis. Sampling at these 7 locations should be reduced to annual.

- OB-1 and OB-2 are similar in nature to the seven locations above but are part of a different hot spot (i.e., the drum disposal area). The sampling at these wells should be reduced to annual.

- OB-7, MW-7S, MW-7D, MW-21S, and MW-21D are in good locations to evaluate capture. OB-7, MW-7S, and MW-7D should show a continuous decline in concentrations toward background if capture of upgradient contamination by BR-8 and MW-23 are successful. MW-21S and MW-21D should provide insight into capture provided by BR-6. Therefore, sampling at these locations should continue on a relatively frequent basis, but semi-annual sampling (not quarterly sampling) is sufficient. If further trend analysis suggests that MW-21S and/or MW-21D are in the capture zone of BR-6, then sampling at these locations can be reduced to annual in the future, and the evaluation of capture could be left to the downgradient wells that are proposed in Section 6.1.2. It should be noted that changes in the extraction system might change the monitoring wells that are most suitable for evaluating capture.

- MW-4 and MW-6 have undetectable or extremely low concentrations of contaminants and may be helpful in continuing to evaluate capture from upgradient extraction. Sampling of these wells, like others useful for evaluating capture can be sampled semi-annually, without losing valuable information about the site.

- The seven wells recommended in Section 6.1.2 should be added to the monitoring program. They should be monitored quarterly in the first year and semi-annually thereafter. The two additional sampling events that would provide quarterly sampling in the first year are included in the costs of implementing Section 6.1.2.

- Monitoring of the extraction wells could continue quarterly. This sampling does not require substantial labor since the wells are continuously purged, the data are useful in evaluating what each well is contributing to the plant influent, and laboratory analysis is provided at no cost to the site.

- Although no cost savings would result for the site, the site team could consider reducing the sampled parameters at various wells to VOCs only. Relative to the other classes of contaminants at the site, VOCs have the highest concentrations relative to federal MCLs (or other potential reference standards). VOCs are also very mobile in the subsurface. Therefore, for evaluating capture, analyzing downgradient locations for VOCs would likely should be sufficient. Sampling for SVOCS and/or inorganics may need to continue at some locations such as the extraction wells and those monitoring wells where these constituents are a concern.

The above sampling program represents a decrease from approximately 72 monitoring well samples per year (18 monitoring wells quarterly, excludes extraction wells) to approximately 37 monitoring well samples per year. This marks a nearly 50% decrease in sampling and should therefore allow a nearly 50% decrease in sampling labor and supplies. If the OSE team estimated cost for current ground water sampling of $50,000 per year is correct, implementing this recommendation should result in a cost savings of approximately $20,000 per year or more.

Monitoring of water levels in all site wells should proceed semi-annually. The resulting data should be used to develop potentiometric surface maps that can be used for analyzing capture and marking potential changes in ground water flow due to changes in pumping and/or infiltration.

6.2.5 EVALUATE PROJECT MANAGEMENT/TECHNICAL SUPPORT/REPORTING COSTS

The OSE team was not provided with project management, technical support, and reporting costs or general scopes of work for the site. It does appear, however, that the plant operates consistently with little or no technical problems and that there are few other complications or ongoing evaluations directly associated with the P&T system. The site team should likely review the scopes of work and costs associated with project management, technical support, and reporting to determine if there are items that can be eliminated or optimized to save costs without sacrificing effectiveness. The OSE team hesitates to include any specific estimates of any immediate potential cost savings associated with this recommendation. It is hoped, however, that reduced costs can result in one to two years.

6.3 MODIFICATIONS INTENDED FOR TECHNICAL IMPROVEMENT

6.3.1 IMPROVE REPORTING BY INCLUDING UPDATED FIGURES, TECHNICAL ANALYSIS, AND A SUMMARY

Monthly reports are provided on treatment system operations. These reports include daily logs, process monitoring data, work summaries, extraction rates, the Discharge Monitoring Reports, various operational parameters throughout the treatment system, and ground water elevations at site monitoring wells. This information is important to share, but the reports could be modified to improve readability and value to EPA. Reporting for the site could be divided into two separate types of reports: monthly O&M reports and semi-annual or annual ground water reports.

The monthly reports should include information associated with the treatment plant, including the Discharge Monitoring Reports, process monitoring data, and flow rates. Some text should accompany these reports to summarize the highlights, such as problems encountered, changes made to the treatment plant, etc. Treatment plant upsets or discharge exceedances should be highlighted, and actual mass loading of contaminants to the treatment plant from extracted ground water should be compared to design specifications, and where possible, treatment efficiencies should be calculated. In addition, tables should be added that summarize historical process monitoring. The text and tables should draw EPA’s attention to any noteworthy issues.

The ground water monitoring report could be submitted semi-annually in association with each ground water sampling event. The reports should include tables of water quality data that indicate both current and historical data. Samples that have concentrations above cleanup levels should be highlighted. The new data should also be used to develop a plume map similar in nature to Figure 1-2 of this report. The plume map should include the target capture zone. Water levels should be used to develop potentiometric surface maps to indicate ground water flow, and if possible, the interpreted capture zone should be indicated as well. In addition to evaluating capture, these maps could be used to identify data gaps and present potential locations for piezometers. To augment the evaluation of capture, concentration trends at key wells expected to be downgradient of the capture zone should be plotted and included in each semi-annual report. Finally, the semi-annual ground water report should include a discussion regarding the performance of the remedy relative to its objectives.

For more information on what should be included in reports, the site team is referred to *Elements for Effective Management of Operating Pump and Treat Systems* (EPA 542-R-02-009). The estimated cost of implementing this recommendation is approximately $15,000 in capital costs to develop templates for figures and tables and $45,000 per year for compiling the reports and providing the necessary data analysis. However, it appears that the current project management/reporting and ground water sampling costs should accommodate the improved reporting scope without additional funding. In the future, it may be possible to move from semi-annual to annual reporting. This might reduce the annual cost by approximately $10,000 per year.

6.3.2 TABULATE GROUND WATER MONITORING DATA AND MANAGE DATA ELECTRONICALLY

The ground water monitoring data from this site should be managed electronically and tabulated for easy reference and data analysis. The ground water monitoring data provided to the OSE team was in hard copy laboratory reports. As a result, the data from each sample and from each event were on a different page. This made it extremely difficult to evaluate concentration trends in wells and to compare concentrations from different wells. The OSE team generated a table from four quarters of data that were provided as part of this optimization effort. This table is provided along with this report and can be used as a starting point. Although tabulation of data is discussed in Section 6.3.1, this issue is sufficiently important to mention as a separate item. The cost for implementing this change is already provided in Section 6.3.1.

6.4 CONSIDERATIONS FOR A FINAL REMEDY

6.4.1 A SUGGESTED APPROACH FOR USING P&T AS A FINAL REMEDY

Cleanup standards have not been developed for the site, but if the risk-based standards that are presented in Section 3.1 (or similarly low standards) are adopted, it will make it extremely unlikely that the existing technologies could be used to restore the aquifer to beneficial use in a reasonable time frame (i.e., many decades). In particular, standards such as 0.29 ug/L for benzene, 0.09 ug/L for PCE, and 0.01 ug/L for arsenic would be particularly difficult to achieve. An appropriate remedial strategy for this site would likely involve P&T to provide hydraulic capture and monitoring to demonstrate that capture is adequate. If a P&T remedy is selected as the final remedy for the site, the following considerations would be particularly relevant.

The OSE team suggests that a P&T remedy focus on achieving and maintaining cost-effective capture over the long term. Focusing on mass removal would likely increase overall cost but probably would not substantially reduce the cleanup time. It may be effective to include extraction wells near the source area (i.e., near MW-23), but the primary benefit would likely be containment of that source area rather than mass removal. Containing the source area may allow the downgradient portions of the plume to reach ARARs faster and allow the possibility of discontinuing pump from some extraction wells.

To help minimize costs over the long term, all efforts should be made to rely on GAC and to avoid metals precipitation and the use of UV/Oxidation. The monitoring program, project management, and data analysis should also be streamlined as much as possible. If the system is substantially simplified (i.e., rely on filtration and GAC only) it may be possible to reduce total O&M costs to approximately $200,000 per year. However, the ability to reach this level of simplification is not yet known due to uncertainties in the result of implementing the other recommendations.

If the site team moves forward with aggressive source removal technologies the best approach might be the use of targeted pumping events at hot spot wells. Because a treatment system is on site, the extracted water could be fed into the equalization system and treated at minimal cost. In-situ chemical oxidation would not likely be beneficial. As has been demonstrated by the UV/Oxidation system, some of the contaminants with the highest concentrations (i.e., carbon tetrachloride) are quite resistant to oxidation.

Bioaugmentation or nano-scale iron injection might address some of the chlorinated compounds, but would not address other compounds. Air sparging would not be appropriate given the fractured bedrock environment.

6.4.2 AN ALTERNATIVE TO THE PROPOSED RCRA CAP

During the site visit, EPA indicated that there is a plan to place a RCRA cap across 6 to 7 acres of the site to reduce exposure to remaining soil contamination and reduce infiltration. This plan might require approximately $2 million. A better approach would likely be to remove the remaining surface contamination (which is reportedly approximately 2 acres) or to provide a geotextile fabric and a 3-foot to 5-foot layer of clean material over the contamination and stabilize it with vegetation or material that is conducive to anticipated future land uses. The purpose of these efforts would be to prevent direct contact with soil contamination, and for this purpose, this covering would be as effective as the RCRA cap. The cost for this approach might be approximately $500,000, an estimated potential savings of approximately $1.5 million.

With regard to infiltration and other issues, the OSE team provides the following information for consideration:

- If selection of ARARs and the final remedy suggest that a P&T system will likely operate indefinitely, there is little reason to prevent infiltration across the site because an effective P&T system would capture contamination that is leached by infiltration. A RCRA cap would reduce leaching associated with infiltration of precipitation, but changes in the water table (caused by infiltration of rain upgradient of the site) might also cause ground water to come into contact with contaminated soil even if a cap is present.

- A RCRA cap would reduce the amount of infiltration in the area of the plume and therefore the amount of ground water that requires containment. The RI states that the site receives approximately 44 inches of precipitation each year. For a 7-acre area, this translates to an influx rate of approximately 16 gpm, but much less (perhaps about 25%) probably infiltrates to ground water. Even if all 16 gpm entered the aquifer and required extraction and treatment (which is unlikely), the overall difference in the cost of operating the P&T system would not likely offset the extra cost of installing the RCRA cap. Even if differential in the cost of operating the P&T system with and without the presence of the RCRA cap was $60,000 per year (a conservative value), it would take approximately 25 years to pay off the RCRA cap. If the comparison is made considering net present value, the payoff time would be even longer. A more realistic value for an increase in annual costs due to increased extraction of 16 gpm is likely under $35,000, which would result in a pay off time for the RCRA cap of 40 years or longer. An increase in annual costs due to increased extraction of about 4 gpm (25% of 16 gpm) would be negligible in comparison with the cost of the RCRA cap.

- Construction of this cap will cause substantial sediment runoff issues during construction, and it would alter the amount of surface runoff in the future. By choosing the alternative approach suggested above, these environmental problems and the large associated costs can be avoided. Allowing infiltration to continue will actually help clean soils at the site and transfer remaining contamination to the ground water for remediation (albeit over a number of years/decades).

The OSE team therefore recommends that the site team better understand the final ground water remedy, target capture zone, hydraulic requirements for capture, and the various cost implications for either cap option before proceeding with the RCRA cap.

6.5 SUGGESTED APPROACH TO IMPLEMENTATION

Implementation of the recommendations in Section 6.1 are of primary importance and should be implemented first. Implementation of recommendations in Section 6.2.1, 6.2.2, and Section 6.2.4 should also be given a relatively high priority as well as Section 6.3.1 and 6.3.2, but not at the expense of the recommendations in Section 6.1. The recommendations from Section 6.2.3 and 6.2.5 will be somewhat contingent on the results of implementing other recommendations and should therefore be postponed until more information is available.

The ideas in Section 6.4 are for consideration and assistance in planning the final remedy. These ideas should likely be considered prior to developing the ROD for the final remedy, but there are no specific recommendations to be implemented.

7.0 SUMMARY

In general, the OSE team found a smoothly operating well organized treatment plant. The observations and recommendations contained in this report are not intended to imply a deficiency in the work of either the system designers or operators but are offered as constructive suggestions. These recommendations have the obvious benefit of being formulated based upon operational data unavailable to the original designers.

The recommendations to improve effectiveness include sampling at known potential receptors, delineating the plume, evaluating capture, and the sampling the effluent process air from a vapor GAC unit that treats the vapors in the head space of the reaction tanks. The recommendations to reduce cost include reducing operator labor to one full-time operator with minimal support from a part-time technician, addressing the lagoon sediments in order to reduce solids entering the treatment plant, continually evaluating the need for metals removal and UV/Oxidation, optimizing the ground water monitoring program, and evaluating costs associated with project management/technical support/reporting. The recommendations for technical improvement are directed at improving reporting and data management. The considerations for the final remedy include a suggested approach for using P&T and a cost-effective alternative to constructing a 6-7 acre RCRA cap.

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 30-year period for each recommendation both with discounting (i.e., net present value) and without it.

TABLES

Table 1-1. Summary of Recent Ground Water Monitoring Results for VOCs (Part 1 of 2)

Monitoring Well	Formation Screened	Date	Acetone		Benzene		Carbon tetrachloride		Chlorobenzene		Chloroform		1,2-DCB		1,2-DCA		cis-1,2-DCE		PCE		TCE		Toluene		VC	
MCL*			-		-		5		-		-		600		-		70		-		-		1,000		2	
RBC*			172.07		0.29		-		27.79		-		-		0.11		-		0.09		0.87		-		-	
Units			ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	
BR-2**	Bedrock	9/2002	ND		0.27	J	**6.4**		0.91	J	ND		ND		ND		ND		**1.2**		**3.1**		ND		ND	
		12/2002	ND		**0.31**	**J**	**15.0**		2.0		12.0		ND		ND		ND		**1.8**		**3.4**		ND		ND	
		3/2003	ND		**0.89**	**J**	**10.0**		3.1		11.0		ND		**0.33**	**J**	ND		**1.9**		**3.9**		ND		ND	
		6/2003	ND		ND		**30.0**		0.28	J	13.0		ND		ND		0.31	J	**1.8**		**2.6**		ND		ND	
BR-6**	Bedrock	9/2002	ND		**20.0**		**140.0**		**91.0**		160.0		ND		**50.0**		25.0		**13.0**		**98.0**		ND		2.0	J
		12/2002	ND		**18.0**		**300.0**		**79.0**		150.0		13.0		**36.0**		20.0		**12.0**		**62.0**		ND		1.7	J
		3/2003	ND		**16.0**		**180.0**		**81.0**		110.0		13.0		**41.0**		20.0		**9.9**	**J**	**71.0**		ND		ND	
		6/2003	ND		**23.0**		**220.0**		**120.0**		190.0		ND		**51.0**		36.0		**16.0**		**78.0**		ND		**2.6**	**J**
BR-7**	Bedrock	9/2002	ND		ND		**150.0**		ND		8.8		ND		ND		ND		ND		ND		ND		ND	
		12/2002	ND		ND		**250.0**		ND		5.7	J	ND		ND		ND		ND		ND		ND		ND	
		3/2003	ND		ND		**400.0**		4.1	J	10	J	ND		ND		ND		ND		ND		ND		ND	
		6/2003	ND		ND		**340.0**		ND		11	J	ND		ND		ND		ND		ND		ND		ND	
BR-8**	Bedrock	9/2002	ND		ND		**40.0**		12.0		11.0		11.0		**110.0**		38.0		**15.0**		**100.0**		ND		ND	
		12/2002	ND		ND		**31.0**		6.8		6.1		4.9	J	**40.0**		4.6	J	**14.0**		**91.0**		ND		ND	
		3/2003	ND		ND		**20.0**		11.0		4.2		6.4		**60.0**		22.0		**11.0**		**66.0**		ND		ND	
		6/2003	ND		ND		**20.0**		2.1	J	5.0		3.8	J	**33.0**		14	J	**9.4**		**74.0**		ND		ND	
MW-23**	Bedrock	9/2002	ND		**240.0**		**1500.0**		**230.0**		92.0		ND		**47.0**		ND		**29.0**		**57.0**		ND		ND	
		12/2002	ND		**190.0**		**2100.0**		**170.0**		ND		ND		ND		ND		**30.0**		**42.0**		ND		ND	
		3/2003	ND		**200.0**		**1900.0**		**180.0**		88.0		ND		**38**	**J**	ND		**25.0**		**42**	**E**	ND		ND	
		6/2003	ND		**200.0**		**1500.0**		**160.0**		100.0		ND		**27**	**J**	ND		**18**	**J**	**29**	**J**	ND		ND	
OB-1	Overburden	3/2003	ND		**2.4**	**J**	ND		8	J	260.0		ND		ND		2.7	J	**12.0**		**29.0**		ND		ND	
		6/2003	ND		**65.0**		ND		**77.0**		1110.0		ND		ND		ND		**17.0**		**28.0**		1.0	J	ND	
OB-2	Overburden	9/2002	ND		**96.0**		1.7	J	**140.0**		32.0		ND		ND		6.3		**16.0**		**28.0**		ND		ND	
		12/2002	ND		**120.0**		3.9	J	**190.0**		31.0		ND		ND		7.9		**22.0**		**29.0**		ND		ND	
		3/2003	ND		**86.0**		3.2	J	**150.0**		ND		ND		ND		9.3		16.0		10.0		ND		ND	
		6/2003	ND		**64.0**		ND		**93.0**		ND		ND		ND		6.4		9.5		8.8		ND		ND	
OB-4	Overburden	9/2002	**2600**	**J**	**310**	**J**	**ND**		**630**	**J**	ND		ND		ND		ND		ND		ND		**21000.0**		ND	
		12/2002	ND		**220**	**J**	**ND**		**470**	**J**	ND		ND		ND		ND		ND		ND		**17000.0**		ND	
		6/2003	54.0		**0.64**	**J**	ND		2.3		ND		ND		**0.78**	**J**	ND		ND		**1.1**		2.3		ND	
OB-5	Overburden	9/2002	**890.0**		**110.0**				**820.0**		74.0		220.0		**580.0**		ND		**20.0**	**J**	**710.0**		**1200.0**		**50.0**	**J**
		12/2002	120	J	**46.0**		**640.0**		**640.0**		53.0		210.0		**340.0**		ND		**28.0**	**J**	**920.0**		270.0		**45.0**	**J**
		3/2002	ND		**12.0**	**J**	ND		**590.0**		35	J	240.0		**230.0**		ND		**27**	**J**	**1400.0**		13	J	**39**	**J**
		6/2003	ND		ND		ND		**440.0**		ND		190.0		**120.0**		ND		**52**	**J**	**2000.0**		ND		ND	
OB-7	Overburden	9/2002	ND		**22.0**		**110.0**		**150.0**		21.0				**88.0**		20.0		**13.0**		**190.0**				ND	
		12/2002	ND		**18.0**		**64.0**		**130.0**		20.0		21.0		**81.0**		20.0		**8.0**		**140.0**				ND	
		6/2003	6.4	J	**9.7**		**47.0**		**84.0**		12.0		0.70	J	**52.0**		17	J	**6.1**		**100.0**		ND		0.68	J

ND indicates sample was "not detected" above a detection limit of 1.0 ug/l

J indicates "estimated value"

Values above the cleanup standard are **bold**

* MCLs and RBCs (risk-based criteria) are provided for reference only. Actual cleanup standards have not been determined.

** Well is used as an extraction well

Table prepared by OSE team. Data should be reviewed thoroughly prior to use in making further site decisions.

Table 1-1. Summary of Recent Ground Water Monitoring Results for VOCs (Part 2 of 2)

Monitoring Well	Formation Screened	Date	Acetone	Benzene	Carbon tetrachloride	Chlorobenzene	Chloroform	1,2-DCB	1,2-DCA	cis-1,2-DCE	PCE	TCE	Toluene	VC
MCL*			**-**	**-**	**5**	**-**	**-**	**600**	**-**	**70**	**-**	**-**	**1,000**	**2**
RBC*			**172.07**	**0.29**	**-**	**27.79**	**-**	**-**	**0.11**	**-**	**0.09**	**0.87**	**-**	**-**
Units			**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
MW-4	**Overburden**	6/2003	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-6/6R	**Overburden**	9/2002	ND	ND	ND	0.3 J	0.32 J	ND	ND	0.43 J	**0.62 J**	0.55 J		ND
		12/2002	ND	ND	ND	0.4 J	0.41 J	ND	ND	0.96 J	**1.2**	0.74 J		ND
		3/2003	ND	ND	ND	ND	1.1	ND	ND	1.2	**1.1**	0.87 J	ND	ND
		6/2003	ND	ND	ND	ND	0.78 J	ND	ND	0.87 J	**1.0**	**1.6**	ND	ND
MW-7S	**Overburden**	9/2002	ND	**2.7**	**30.0**	22.0	5.9	5.8	**11.0**	0.43 J	0.033 J	**6.1**	ND	ND
		12/2002	ND	**1.6**	**27.0**	13.0	5.4	3.7	**6.0**	ND	0.058 J	**3.7**	ND	ND
		3/2003	ND	**3.1**	**41.0**	25.0	7.9	5.8	**13.0**	0.63 J	**0.78 J**	**5.1**	ND	ND
		6/2003	ND	**4.5**	**67.0**	**32.0**	11.0	ND	**7.5**	1.1 J	**1.6 J**	**8.7**	ND	ND
MW-7D	**Overburden**	9/2002	ND	**29.0**	**220.0**	**120.0**	29.0	22.0	**59.0**	18.0	**6.8 J**	**55.0**		ND
		12/2002	ND	**23.0**	**190.0**	**100.0**	23.0	17.0	**48.0**	18.0	**5.8**	**50.0**		ND
		6/2003	ND	**14.0**	**110.0**	**77.0**	14.0	ND	**38.0**	16.0	**5.1**	**35.0**	ND	ND
MW-10	**Overburden**	6/2003	ND	ND	ND	**0.33 J**	ND	ND	ND	ND	19.0	ND	ND	ND
MW-10D	**Overburden**	9/2002	ND	**8.8 J**	ND	**1100.0**	ND	13 J	ND	ND	ND	ND	ND	ND
		12/2002	ND	ND	ND	**710.0**	ND	11 J	**6.0 J**	ND	ND	ND	ND	ND
MW-17S	**Overburden**	6/2003	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-17D	**Bedrock**	9/2002	ND	ND		ND			ND	ND	ND	ND		ND
		12/2002	ND	ND		ND			ND	ND	ND	ND		ND
		6/2003	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-18S	**Overburden**	3/2003	ND	**39.0**	**6.7 J**	**470.0**	67.0	84.0	**680.0**	ND	**15 J**	**190.0**	ND	**8.9 J**
		6/2003	ND	**36.0**	ND	**370.0**	60.0	73.0	**540.0**	ND	**16 J**	**230.0**	ND	**11 J**
MW-18D1	**Bedrock**	3/2003	ND	**13.0**	**10.0**	**180.0**	12.0	1.2 **J**	**190.0**	**76.0**	**13.0**	**140.0**		**3.5**
		6/2003	ND	**16.0**	**15.0**	**230.0**	9.0 J	35.0	**230.0**	**97.0**	**23.0**	**260.0**	ND	**7.2 J**
MW-18D2	**Bedrock**	9/2002	ND	**45.0**	**11.0 J**	**570.0**	21.0	83.0	**620.0**	**190.0**	**39.0**	**480.0**		**8.1 J**
		12/2002	ND	ND	**28.0**	**430.0**	25.0	52.0	**380.0**	**170.0**	**39.0**	**420.0**		**7.9 J**
MW-21S	**Overburden**	9/2002	ND	**1.8**	ND	21.0	4.0	12.0	**13.0**	17.0	**37.0**	**20.0**		**2.1**
		12/2002	14.0	**0.55 J**	ND	4.2	2.6	1.1	**5.8**	8.8	**3.2**	**5.1**		0.92 J
		3/2003	ND	ND	ND	ND	1.0	ND	ND	1.2	**0.46 J**	**0.97 J**	ND	ND
		6/2003	ND	**1.3**	0.35 J	25.0	2.3	13.0	**14.0**	18 J	**22.0**	**16.0**	0.20 J	1.9 J
MW-21D	**Bedrock**	9/2002	ND	**1.8**	1.2	14.0	1.5	4.9	**3.0**	24.0	**17.0**	**14.0**		**3.0**
		12/2002	ND	**2.6**	**7.6**	22.0	6.0	5.2	**12.0**	9.8	**7.3**	**43.0**		1.5
		3/2003	ND	**5.2**	**13.0**	**52.0**	12.0	11.0	**41.0**	8.7	**7.1**	**93.0**	ND	1.3 J
		6/2003	ND	**5.9**	**14.0**	**52.0**	12.0	ND	**36.0**	9.2 J	**6.7**	**110.0**	ND	ND

ND indicates sample was "not detected" above a detection limit of 1.0 ug/l

J indicates "estimated value"

Values above the cleanup standard are **bold**

* MCLs and RBCs (risk-based criteria) are provided for reference only. Actual cleanup standards have not been determined.

** Well is used as an extraction well

Table prepared by OSE team. Data should be reviewed thoroughly prior to use in making further site decisions.

Table 1-2. Summary of Total Mean VOC Values

Monitoring Well	Formation Screened	Acetone	Benzene	Carbon tetrachloride	Chlorobenzene	Chloroform	1,2-Dichlorobenzene	1,2-DCA	cis-1,2-DCE	PCE	TCE	Toluene	VC	Total Mean VOCs
MCL*				**5**			**600**		**70**			**1000**	**2**	
RBC*		**172.07**	**0.29**		**27.79**			**0.11**		**0.09**	**0.87**			
Units		**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
BR-2**	**Bedrock**	0.5	0.49	15.35	1.57	9.13	0.5	0.46	0.45	1.68	3.25	0.5	0.5	34.4
BR-6**	**Bedrock**	0.5	19.25	210.00	92.75	152.50	6.75	44.50	25.25	12.73	77.25	0.5	1.70	643.7
BR-7**	**Bedrock**	0.5	0.5	285.00	1.40	8.88	0.5	0.5	0.5	0.5	0.5	0.5	0.5	299.8
BR-8**	**Bedrock**	0.5	0.5	27.75	7.98	6.58	6.53	60.75	19.65	12.35	82.75	0.5	0.5	226.3
MW-23**	**Bedrock**	0.5	207.50	1750.00	185.00	70.13	0.5	28.13	0.5	25.50	42.50	0.5	0.5	2311.3
OB-1	**Overburden**	0.5	33.7	0.5	42.5	685.0	0.5	0.5	1.6	14.5	28.5	0.8	0.5	827.1
OB-2	**Overburden**	0.5	91.50	2.33	143.25	16.00	0.5	0.5	7.48	15.88	18.95	0.5	0.5	297.9
OB-4	**Overburden**	884.8	176.9		367.4	0.5	0.5	0.6	0.5	0.5	0.7	12667.4	0.5	14100.4
OB-5	**Overburden**	252.8	52.2	213.7	622.5	40.6	215.0	317.5		31.8	1257.5	370.9	33.6	3408.0
OB-7	**Overburden**	2.5	16.6	73.7	121.3	17.7	10.9	73.7	19.0	9.0	143.3	0.5	0.6	488.6
MW-4	**Overburden**	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	6.0
MW-6	**Overburden**	0.5	0.5	0.5	0.4	0.7	0.5	0.5	0.9	1.0	0.9	0.5	0.5	7.4
MW-7S	**Overburden**	0.5	3.0	41.3	23.0	7.6	4.0	9.4	0.7	0.6	5.9	0.5	0.5	96.8
MW-7D	**Overburden**	0.5	22.0	173.3	99.0	22.0	13.2	48.3	17.3	5.9	46.7	0.5	0.5	449.2
MW-10	**Overburden**	0.5	0.5	0.5	0.33	0.5	0.5	0.5	0.5	19.0	0.5	0.5	0.5	24.3
MW-10D	**Overburden**	0.5	4.7	0.5	905.0	0.5	12.0	3.3	0.5	0.5	0.5	0.5	0.5	963.5
MW-17S	**Overburden**	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	6.0
MW-17D	**Bedrock**	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	6.0
MW-18S	**Overburden**	0.5	37.5	3.6	420.0	63.5	78.5	610.0	0.5	15.5	210.0	0.5	10.0	1450.1
MW-18D1	**Bedrock**	0.5	14.5	12.5	205.0	10.5	18.1	210.0	86.5	18.0	200.0	0.5	5.4	781.5
MW-18D2	**Bedrock**	0.5	22.8	19.5	500.0	23.0	67.5	500.0	180.0	39.0	450.0		8.0	1810.3
MW-21S	**Overburden**	3.9	1.0	0.5	12.7	2.5	6.7	8.3	11.3	15.7	10.5	0.4	1.4	74.6
MW-21D	**Bedrock**	0.5	3.9	9.0	35.0	7.9	5.4	23.0	12.9	9.5	65.0	0.5	1.6	174.1

* MCLs and RBCs (risk-based criteria) are provided for reference only. Actual cleanup standards have not been determined.

Listed concentrations are averages of concentrations presented in Table 1-1.

A value of 0.5 ug/L is used for all NDs

Table prepared by OSE team. Data should be reviewed thoroughly prior to use in making further site decisions.

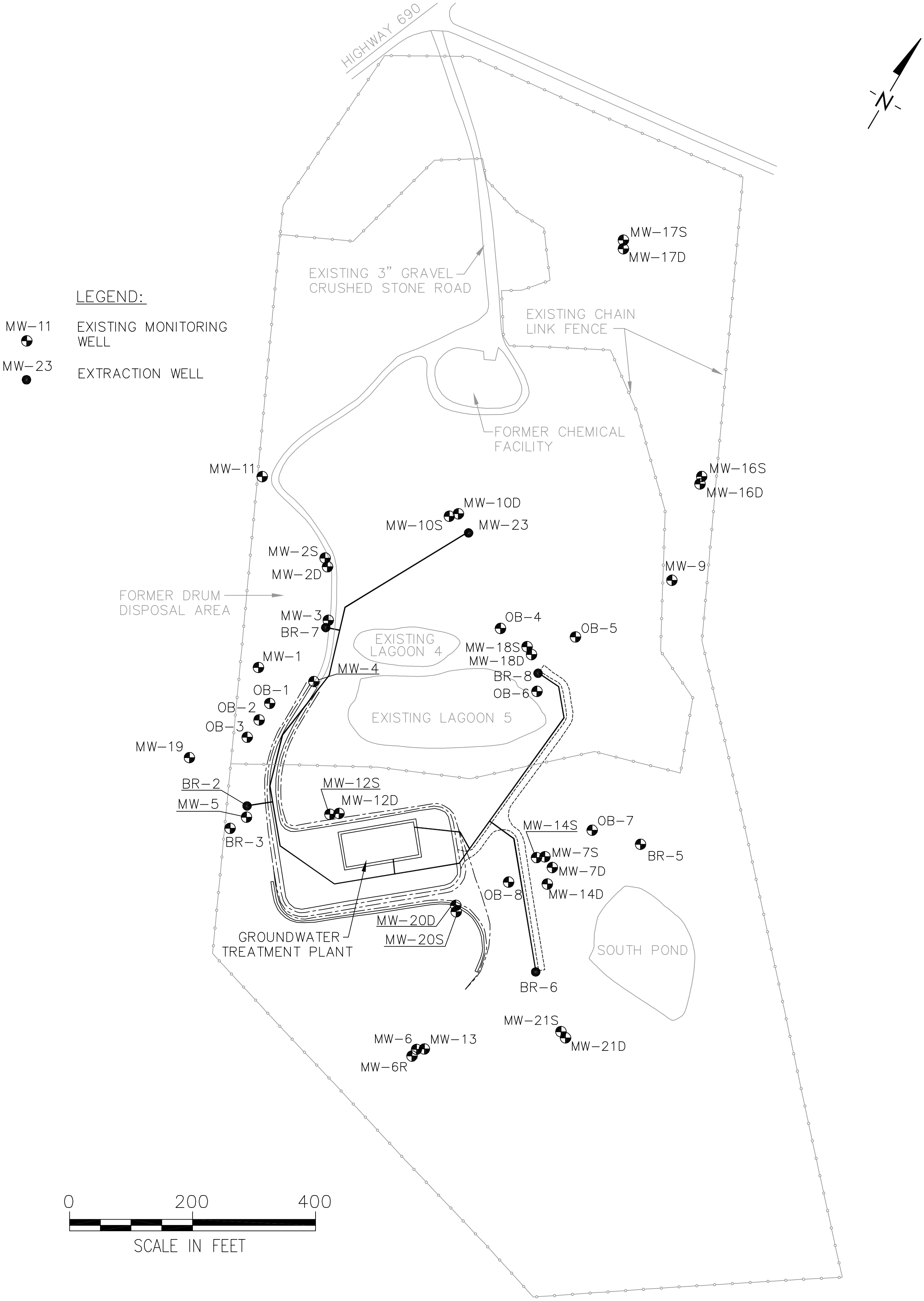
Table 7-1. Cost Summary Table

Recommendation	Reason	Additional Capital Costs ($)	Estimated Change in Annual Costs ($/yr)	Estimated Change In Life-cycle Costs ($) *	Estimated Change In Life-cycle Costs ($) **
6.1.1 Sample Residential Wells and Surface Water	Effectiveness	$10,000	$8,000	$250,000	$139,000
6.1.2 Delineate the Contaminant Plume	Effectiveness	$150,000 to $200,000	$0	$150,000 to $200,000	$150,000 to $200,000
6.1.3 Determine a Target Capture Zone and Conduct a Capture Zone Analysis	Effectiveness	$40,000	$0	$40,000	$40,000
6.1.4 Consider Sampling Influent and Effluent to Vapor Phase GAC that is used for Treating Vapors in Head Space of Reaction Tanks	Effectiveness	$0	$0	$0	$0
6.2.1 Reduce Operator Labor	Cost Reduction	$0	($50,000)	($1,500,000)	($484,000)
6.2.2 Address Remaining Lagoon Sediments and Discontinue Extraction from Lagoons on an Expedited Schedule	Cost Reduction	Not quantified	Not quantified	Not quantified	Not quantified
6.2.3 Continually Aim to Eliminate Metals Removal and the UV/Oxidation System	Cost Reduction	$0	possibly ($120,000)	possibly ($3,600,000)	possibly ($1,937,000)
6.2.4 Optimize Ground Water Monitoring Program	Cost Reduction	$0	($20,000)	($600,000)	($323,000)
6.2.5 Evaluate Project Management/Technical Support/Reporting Costs	Cost Reduction	Not quantified	Not quantified	Not quantified	Not quantified
6.3.1 Improve Reporting by Including Updated Figures, Technical Analysis, and a Summary	Technical Improvement	$0	$0	$0	$0
6.3.2 Tabulate Ground Water Monitoring Data and Manage Data Electronically	Technical Improvement	$0	$0	$0	$0
6.4.1 A Suggested Approach for Using P&T as a Final Remedy	Site Closeout	Not quantified	Not quantified	Not quantified	Not quantified
6.4.2 An Alternative to the Proposed RCRA Cap	Site Closeout	($1,500,000)	$0	($1,500,000)	($1,500,000)

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

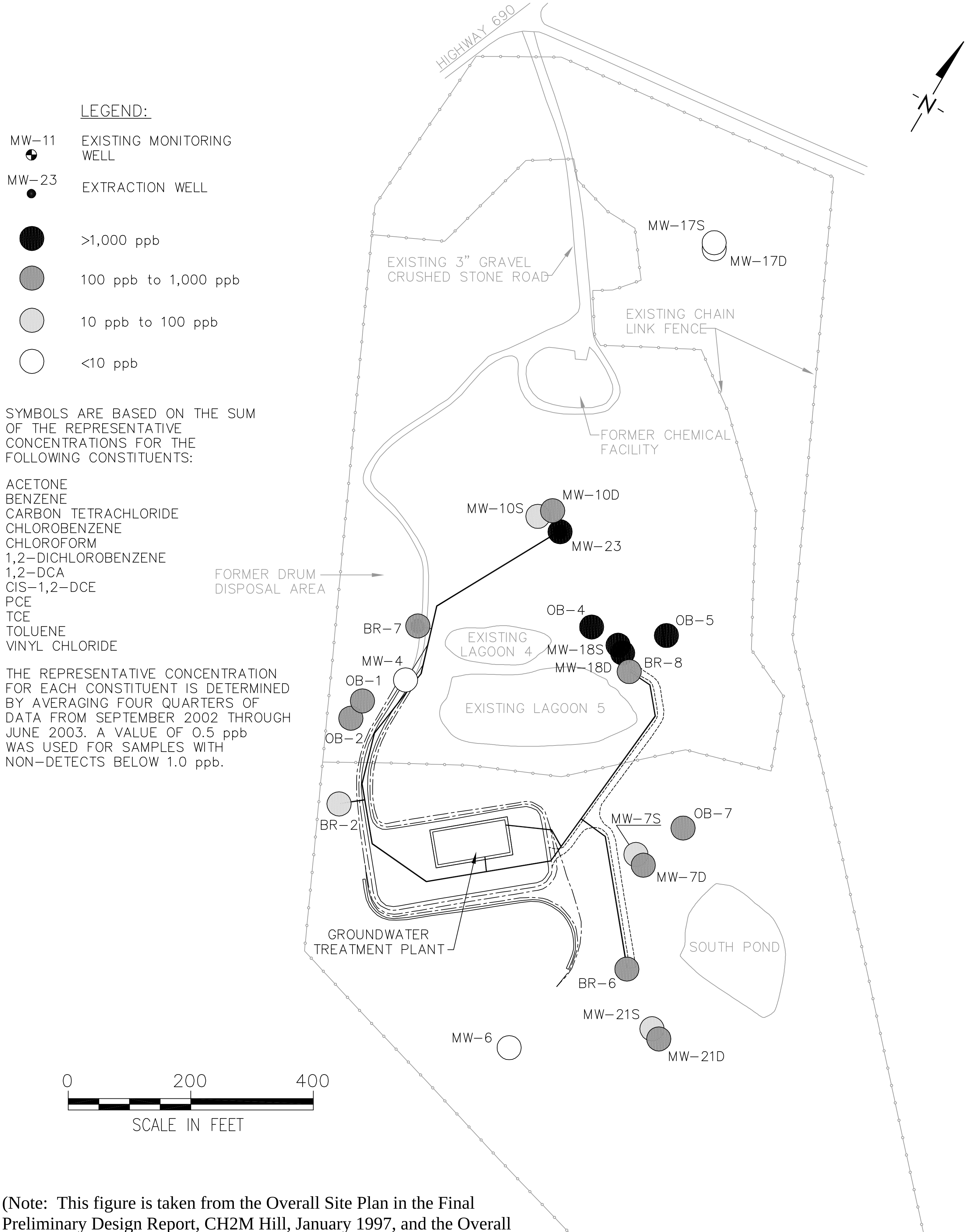
FIGURES

FIGURE 1-1. THE GREENWOOD CHEMICAL SITE AND WELL LOCATIONS.



(Note: This figure is taken from the Overall Site Plan in the Final Preliminary Design Report, CH2M Hill, January 1997).

FIGURE 1-2. EXTENT OF VOC CONTAMINATION.



(Note: This figure is taken from the Overall Site Plan in the Final Preliminary Design Report, CH2M Hill, January 1997, and the Overall Site and Control Plan modified in October 2001, CH2M Hill. Some of the well locations in these referenced figures conflict with eachother. The well locations shown here are approximate and shold be verified by a survey.)