REMEDIATION SYSTEM EVALUATION

OTT/STORY/CORDOVA SUPERFUND SITE
DALTON TOWNSHIP, MUSKEGON COUNTY, MICHIGAN

Report of the Remediation System Evaluation,
Site Visit Conducted at the Ott/Story/Cordova Superfund Site
September 27-28, 2001

Final Report Submitted to Region 5
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

NOTICE

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

EXECUTIVE SUMMARY

The Ott/Story/Cordova Superfund Site occupies approximately 20 acres in Dalton Township, Muskegon County, Michigan. The remedies at the site address contamination stemming from a specialty organic chemical production facility operated under a series of owners from 1957 until 1985. The area surrounding the site is predominantly rural with a residential area downgradient to the southeast of the site along River Road. Little Bear Creek is also located downgradient of the site and has been impacted by site-related contamination. The site has been divided into three operable units:

- OU1 requires containment of site groundwater with extraction wells and prevention of further contamination of Little Bear Creek.
- OU2 requires restoration of the aquifer through treating extracted groundwater.
- OU3 requires excavation and disposal of plant area soils (originally, OU3 required low temperature thermal desorption of excavated soils, but this aspect of the remedy was changed to disposal in a 1998 ROD Amendment).

A single pump and treat system, with two extraction well networks, serves as the remedy for both OU1 and OU2. The OU1 extraction well network of 7 wells is located upgradient of Little Bear Creek and its unnamed tributary and captures site contaminants preventing them from discharging to these surface water bodies. The OU2 extraction well network consists of 3 wells (a fourth well is being installed) and extracts contaminated groundwater from the source area in an attempt to restore the aquifer.

The treatment plant regularly meets the discharge criteria and the pump and treat system has successfully reduced discharge of contaminated groundwater to nearby surface water. As a result, the RSE team does not provide specific recommendations with regard to effectiveness.

Recommendations to reduce life-cycle costs include the following:

- The current diffused air stripper (DAS) units could be replaced with more efficient units such as tray aerators or packed towers. Implementing this recommendation may cost $750,000; however, annual cost savings of approximately $192,000 would result from a reduction in utilities, chemical additions, and potentially powdered activated carbon.
- The site managers should compare the concentrations of ammonia, acetone, and other influent contaminants that require biological treatment against NPDES permit discharge limits. If the influent concentrations of these parameters meet the discharge requirements, then the PACT systems can be bypassed. The remaining contaminants would be removed by the more efficient air stripping units as well as the GAC units that are currently used as a polishing step. Implementing this recommendation would likely cost $400,000 for bypass piping, valving, associated controls, and additional GAC usage; however, annual cost savings of approximately $696,000 would result from a reduction in utilities, labor, and materials.
- The treatment plant could likely be operated effectively with a significant reduction in process monitoring. The associated reduction in onsite analyses would likely allow the laboratory staff to be reduced by one or two technicians. Reducing the laboratory staff could result in savings of

approximately $50,000 per year if two people are required to operate the lab or $100,000 per year if only one person is required to operate the lab.

- The current groundwater monitoring program consists of more than 250 samples collected each year and analyzed for both VOCs and SVOCs. The groundwater monitoring program could be reduced in scale without sacrificing effectiveness. A savings of approximately $55,000 per year may potentially be realized due to a decrease in the analysis costs alone.

- Current site plans include construction of an additional building for storage. Another storage alternative may exist. A large amount of onsite equipment, including two large filter presses and four 400 horsepower blowers, may be transported offsite making space for any storage requirements.

- Although providing an "inherently governmental" presence, oversight provided by USACE could likely be reduced now that the system is operating as expected. The RSE team recommends evaluating the potential to reduce USACE oversight and onsite presence to determine if the cost of $24,500 per month can be reduced.

- At the time of the RSE visit two trailers were onsite to provide office space to USACE and other contractors. Sufficient space should be available in other onsite buildings. As of the finalization of this report, one of the trailers was removed to avoid rental charges.

- Offsite staff from the primary contractor in Kansas City conduct the quarterly sampling for OU3. The onsite staff should conduct sampling to eliminate the costs (approximately $15,000) associated with offsite staff traveling from Kansas City to the site four times a year.

Implementing the recommendations to reduce costs would require initial investments, but savings from operations and maintenance could offset these initial investments.

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

PREFACE

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

The following organizations are implementing this project.

Organization	Key Contact	Contact Information
USEPA Technology Innovation Office (USEPA TIO)	Kathy Yager	11 Technology Drive (ECA/OEME) North Chelmsford, MA 01863 617-918-8362 (phone) 617-918-8427 (fax) yager.kathleen@epa.gov
USEPA Office of Emergency and Remedial Response (OERR)	Paul Nadeau	1200 Pennsylvania Avenue, NW Washington, DC 20460 Mail Code 5201G phone: 703-603-8794 fax: 703-603-9112 nadeau.paul@epa.gov
GeoTrans, Inc. (Contractor to USEPA TIO)	Doug Sutton	GeoTrans, Inc. 2 Paragon Way Freehold, NJ 07728 (732) 409-0344 Fax: (732) 409-3020 dsutton@geotransinc.com
Army Corp of Engineers: Hazardous, Toxic, and Radioactive Waste Center of Expertise (USACE HTRW CX)	Dave Becker	12565 W. Center Road Omaha, NE 68144-3869 (402) 697-2655 Fax: (402) 691-2673 dave.j.becker@nwd02.usace.army.mil

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

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

They were vital in selecting the Fund-lead P&T systems to be evaluated and facilitating communication between the project team and the Remedial Project Managers (RPMs).

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1.0 INTRODUCTION

1.1 PURPOSE

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

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

The Ott/Story/Cordova Site was chosen based on initial screening of the pump-and-treat systems managed by USEPA Region 5 as well as discussions with the EPA Remedial Project Manager for the site and the Superfund Reform Initiative Project Liaison for that Region. This report provides a brief background on the site and current operations, a summary of the observations made during a site visit, and recommendations for changes and additional studies. The cost impacts of the recommendations are also discussed.

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

1.2 TEAM COMPOSITION

The team conducting the RSE consisted of the following individuals:

Frank Bales, Chemical Engineer, USACE, Kansas City District
Mike Crain, Hydrogeologist, USACE HTRW CX
Peter Rich, Civil and Environmental Engineer, GeoTrans, Inc.
Doug Sutton, Water Resources Engineer, GeoTrans, Inc.

1.3 DOCUMENTS REVIEWED

Author	Date	Title/Description
US EPA	9/29/1989	Record of Decision OU1
US EPA	9/29/1990	Record of Decision OU2
Black & Veatch	10/11/1991	Concept Design Analysis, Volume 3
Black & Veatch	7/23/1992	Final Design Analysis Volume One
Black & Veatch	7/23/1992	Final Design Analysis Volume Two
Black & Veatch	4/1997	Groundwater Modeling Report, Optimization of Containment Well Extraction Rates, Ott/Story/Cordova Site, Muskegon, Michigan
EPA	8/13/1997	Five Year Review Report
EPA	2/25/1998	Amendment to Record of Decision OU3
IT Corp.	5/1999	Operation & Maintenance Manual
FTC&H	5/2000	Monthly Operating Report
Black & Veatch	2/2001	Groundwater Summary Report Quarter 20 (December 2000)
Black & Veatch	6/2001	Groundwater Summary Report Quarter 21(March 2001)
FTC&H	7/2001	Monthly Operating Report
FTC&H	8/2001	Monthly Operating Report
FTC&H	3/2001 - 12/2001	Daily Logs

1.4 PERSONS CONTACTED

The following individuals were present for the site visit:

John Fagiolo, EPA Region 5, Remedial Project Manager
Lisa Summerfield, Michigan Department of Environmental Quality, Project Manager
Thomas Berdinski, Michigan Department of Environmental Quality, Surface Water Quality Division
Karl Jaeger, Fishbeck, Thompson, Carr & Huber, Plant Superintendent
Cathy Jaeger, Fishbeck, Thompson, Carr & Huber, Laboratory Manager
Brian Bouwhuis, USACE, Project Manager

1.5 SITE LOCATION, HISTORY, AND CHARACTERISTICS

1.5.1 LOCATION AND HISTORY

The Ott/Story/Cordova Superfund Site occupies approximately 20 acres in Dalton Township, Muskegon County, Michigan. The remedies at the site address contamination stemming from a specialty organic chemical production facility operated under a series of owners from 1957 until 1985. The area surrounding the site is predominantly rural with a residential area downgradient to the southeast of the site along River Road. Little Bear Creek is also located downgradient of the site and has been impacted by site-related contamination.

The site has been divided into three operable units:

- OU1 requires containment of site groundwater with extraction wells and prevention of further contamination of Little Bear Creek.

- OU2 requires restoration of the aquifer through treating extracted groundwater.

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It should be noted that during the RSE visit, the contractor was involved in the third phase of a Variable Operations Plan (VOP) designed to determine the sensitivity of plant effectiveness under various operational parameters. Although operational parameters were different than normal during this RSE visit, this did not inhibit the RSE team in becoming familiar with system operation. This RSE report focuses on pump-and-treat system under its typical operating conditions rather than those adjusted during the VOP.

1.5.2 POTENTIAL SOURCES

The site served as an organic chemical production facility from 1957 through 1985 under various owners including the Ott Chemical Company, the Story Chemical Company, and the Cordova Chemical Company. Various chemicals were used to manufacture pharmaceutical intermediates, veterinary medicines, agricultural chemicals, herbicides, dyestuffs, and other products. Waste from the production facilities was discharged to unlined lagoons or stored in drums. Groundwater contamination was first discovered in 1959. By the 1960s, process waters were discharged to Little Bear Creek, then later to the Muskegon River, and finally by about 1974 to the local sanitary sewer (POTW). By the 1970s, the lagoons were only used for cooling waters from the plant and concentrated waste was either incinerated or stored in drums which may have been disposed of onsite.

The contaminants detected in the soil and groundwater include benzene, toluene, xylene, chlorinated solvents (including tetrachloroethylene (PCE), trichloroethylene (TCE), dichloroethylene (DCE), vinyl chloride, and carbon tetrachloride), aniline based compounds, DDT, Arochlor-1248, pesticides and herbicides, arsenic, cyanide, ammonia, acetone, and others. Concentrations of many compounds above 10 ppm suggest the presence of pure product or non-aqueous phase liquid (NAPL).

1.5.3 HYDROGEOLOGIC SETTING

At the site, relatively permeable sand extends from the surface to a depth of approximately 65 feet below ground surface (bgs). Layers of silt and clay lay beneath this sand and provide a partial barrier between the sand and the semi-confined aquifer that begins at approximately 85 feet bgs. This semi-confined aquifer extends to approximately 120 feet bgs and is underlain by clay.

Groundwater is typically found approximately 5 feet below the surface, and groundwater in the upper, unconfined zone typically flows to the southeast and discharges to Little Bear Creek. Estimated recharge to the unconfined aquifer of approximately 6 to 10 inches per year results from precipitation. Water from the semi-confined aquifer has a higher hydraulic head than the water in the overlying unconfined sandy zone and therefore water typically flows upward from this lower zone with more pronounced upward flow near the creek. The hydraulic gradient in the shallow, unconfined zone is approximately 0.008 while that in the lower zone is approximately 0.003.

1.5.4 DESCRIPTION OF GROUND WATER PLUME

The monitoring events show that the most significant groundwater contamination exists both in the former production area and near the OU1 extraction system over a half mile downgradient. Contamination also may exist between these two locations, but this cannot be confirmed due to the relatively small number of monitoring wells in this intermediate area. Groundwater contamination indicative of NAPL is evident in both the shallow and deeper portions of the unconfined aquifer as well as the semi-confined zone. Groundwater contamination exceeding the cleanup levels by two or more orders of magnitude in the area near the OU1 extraction system is predominantly limited to the lower portion of the unconfined aquifer. Figures 1-1 through 1-3 provide plume maps for total organic compounds in the upper portion of the unconfined aquifer, lower portion of the unconfined aquifer, and the semi-confined aquifer.

2.0 SYSTEM DESCRIPTION

2.1 SYSTEM OVERVIEW

The OU1 ROD included 4 extraction wells proposed to prevent migration of contamination to Little Bear Creek and treatment of extracted groundwater via UV-oxidation, granular activated carbon (GAC), activated sludge, and filtration. The OU2 ROD included additional extraction wells including some closer to the source area. The current system consists of 10 extraction wells, with an additional one planned for operation in October 2001, treated through air stripping, biological treatment, powdered activated carbon, filtration, and GAC.

2.2 EXTRACTION SYSTEMS

The extraction wells comprising the current extraction system are indicated in Figures 1-1 through 1-3. All wells screen the majority of the unconfined aquifer with the exception of EW-9, which screens the semi-confined aquifer. The 10 installed wells have a total design extraction rate of 800 gpm, and EW-11 will have a design flow rate of 40 gpm (although preliminary pump tests suggest it may be capable of extracting at a flow rate of 100 gpm). The extraction system typically operates at or above 700 gpm. A double-walled collection system with a leak detection system transports the water from the extraction wells to the treatment plant through four mains that combine into one prior to entering the plant. The extraction wells have rehabilitation wells installed adjacent to them, and a comprehensive well-maintenance program for ensuring the integrity of the extraction wells.

2.3 TREATMENT SYSTEM

Water from the extraction system is split among two treatment trains that each consist of diffused air stripping (DAS) tanks, addition of a nutrient (phosphoric acid), two stages of aeration and clarification for biological treatment, addition of powdered activated carbon and ferric chloride, sand filtration, and liquid phase GAC. Air from the DAS units and the aeration tanks is treated in a thermal oxidation unit (TOU) before being discharged to the atmosphere. Treated water is transported through piping to a stationary aerator prior to discharge to the Muskegon River. Sludge generated from the biological systems is conditioned and then transported to filter presses before being disposed of as non-hazardous waste. As a whole, the treatment plant is designed for a flow rate of 900 gpm. A diagram of the treatment system provided by the plant operators is included as Figure 2-1.

The treatment system is provided with power by two sets of power lines from two power stations, which decreases the likelihood of interruption in operations due to power failures. Two propane generators have been installed to provide power to the extraction wells in the event of a power outage.

2.4 MONITORING SYSTEM

The monitoring system consists of over 40 monitoring wells in the upper portion of the unconfined aquifer, 43 monitoring wells in the lower portion of the unconfined aquifer, and 12 monitoring wells in the semi-confined system. Water quality monitoring, including samples taken from the 10 extraction wells, is conducted on a quarterly basis with the following schedule:

March	64 samples
June	73 samples
September	62 samples
December	62 samples

All samples are analyzed for volatile organic compounds using method 8260 and semi-volatile compounds using method 8270b and plume maps are generated at three elevations for various contaminants. In addition, on a monthly basis, water levels are collected from 79 wells, including the 10 extraction wells, and potentiometric surface maps are generated at three elevations. These potentiometric surface maps are included in the quarterly groundwater reports.

Sediment and surface water sampling and analysis of Little Bear Creek is conducted on a quarterly basis by the offsite staff of the primary contractor.

Process monitoring, with the exception of air monitoring, is conducted via an onsite laboratory staffed by an onsite lab manager and two chemists. The process monitoring schedule during normal plant operations is provided in Table 2-1. This schedule is not indicative of the sampling conducted during the Variable Operation Plan. The schedule indicates that process water samples are also sent offsite for verification of onsite analysis because the onsite laboratory is not certified.

Table 2-1. Laboratory Analysis Schedule, Ott/Story/Cordova GWTF, Revised 3/20/01

	Identification	Alkalinity	CBOD	Carbon-Biomass	COD	Hardness	NH3-N	TKN	NO3-N	NO2-N	Dissolved O2	pH	Total Phosphorous	Total Solids	Suspended Solids	Suspended Ash	Temp	Specific Conductance	TOC	Volatiles	Semi-volatiles	Pesticides	Mercury	Amen CN	Metals (Cu, Zn, V)	Oxygen Uptake Rate	Dissolved O2 Profile	TCLP	Settleability	Microscope Exam
DAS Influent	1																			W	W									
DAS Influent	1				5d	M	5d				5d	5d			W		5d			W	W									
PACT PCT-201	2	W	W		5d		5d	BW	W	W		5d	5d		W					W	W									
PACT PCT-202	3	W	W		5d		5d	BW	W	W		5d	5d		W					W	W									
1st. Stage aerat. PCT 201	4			W							5d	5d			5d	W	5d									5d	W		5d	5d
1st Stage aerat. PCT 202	5			W							5d	5d			5d	W	5d									5d	W		5d	5d
2nd Stage aerat. PCT 201	6										2d	2d			5d		2d													
2nd Stage aerat. PCT 202	7										2d	2d			5d		2d													
PCT 201 1st clarif. Ovflo	25				5d		5d					5d	5d		5d					W	W									
PCT 202 1st clarif. Ovflo	26				5d		5d					5d	5d		5d					W	W									
Clarifier eff. C-301	8	W	W		5d		5d	BW	W	W		5d	5d		5d					W	W									
Clarifier eff. C-301	9	W	W		5d		5d	BW	W	W		5d	5d		5d					W	W									
Filter influent	10					M									2d															
Filter effluent	11														2d					W	W									
Lead GAC CA 551	12																			W	W									
Lead GAC CA 552	13																			W	W									
NPDES Station	14		W		5d	M	5d				5d	C	4d		4d		C	C		W	W									
NPDES Station	14																		W	W	W	W	SM	W	W					
DAS offgas	15																			M										
TOU exhaust	16																			M										
Site Boundary Air	17																			SA										
PACT PCT 202 offgas	18																			SA										
PACT PCT 201 offgas	19																			SA										
Digestor PCT 201 eff.	20													R																
Digestor PCT 202 eff.	21													R																
Filter press filtrate	22													R																
Filter press cake	23													R																
Stream discharge	24										W	W																R		
RSP-221 discharge	31														5d															
RSP-222 discharge	32														5d															
RSP-321 discharge	33														5d															
RSP-322 discharge	34														5d															
63 Monitoring wells											Q	Q					Q	Q												
63 Monitoring wells																				Q	Q									

Shaded indicates offsite test for contractor

R = as requested

SA = semi-annually

Q = quarterly

M = monthly

SM = semi-monthly

BW = biweekly

W = weekly

5d = 5 days/week

4d = 4 days/week

2d = 2 days/week

C = continuous

(Note: This table is adapted from Table 6.1 from the July 2001 Monthly Operating Report, FTC&H.)

3.0 SYSTEM OBJECTIVES, PERFORMANCE AND CLOSURE CRITERIA

3.1 CURRENT SYSTEM OBJECTIVES AND CLOSURE CRITERIA

Because the pump-and-treat system operates on behalf of both OU1 and OU2, the system must meet the objectives of both operable units.

The objective for OU1 as documented in the 1989 ROD is as follows:

> The response objectives for this operable unit are to intercept and contain contaminated groundwater within the unconfined groundwater system, eliminate potential surface water and air exposure routes by preventing contaminated groundwater discharge into Little Bear Creek and its unnamed tributary, and to ensure that this operable unit [OU1] is fundamentally compatible with future remedial actions at the Ott/Story/Cordova site.

The objective for OU2 as documented in the 1990 ROD is as follows:

> OU2...has as its primary goal the restoration of the aquifer system below and downgradient of the Ott/Story/Cordova Site...The goal of this remedial action [OU2] is to restore all portions of the aquifer so that it may serve as a drinking water resource.

3.2 TREATMENT PLANT OPERATION GOALS

The treatment plant discharges to the Muskegon River; therefore, it must meet the requirements of a NPDES permit. The RSE team did not have a copy of the NPDES permit, but some of the permit requirements can be found in the monthly Discharge Monitoring Reports (DMRs). The following table provides the discharge criteria, as listed in the October 1997 DMR, for various constituents of the extracted water. The October 1997 DMR was chosen as it was one of the earliest monthly reports to provide the discharge criteria and many of the parameters have since been determined as posing a lesser problem and have been switched to “report” status.

NPDES Requirements from October 1997 DMR		
Parameter	**Limit**	
dissolved oxygen	4.0 mg/L	daily minimum
pH	6.0 - 9.0	daily min. and max.
nitrogen, ammonia	20 mg/L	daily maximum
phosphorus, total	0.5 mg/L or 5 lbs/day	monthly average
cyanide (amenable)	47 ug/L	daily maximum
copper	100 ug/L	daily maximum
vanadium	30 ug/L	daily maximum
zinc	870 ug/L	daily maximum
1,2-dichloroethane	report	monthly average and daily maximum

3.3 ACTION LEVELS

For cleanup levels, the 1990 ROD states that the concentration for any carcinogenic contaminant that yields no more than a 1×10^{-6} cancer risk for that contaminant is a desirable cleanup level. Given the presence of multiple carcinogenic substances, the total cumulative risk for all contaminants should be approximately 2×10^{-5}. The ROD also states that the cleanup level should be the more stringent of the MCL, the concentration yielding no more than a 1×10^{-6} cancer risk, National Primary Drinking Water Regulation, or the Michigan Act 307 Type B standard. In 1995, Michigan Act 307 (formerly known as the Michigan Environmental Response Act) was largely replaced by Part 201 of the Natural Resources and Environmental Protection Act (NREPA), 1994 PA 451, as amended ("Part 201"). The U.S. EPA and MDEQ project managers report that they are currently assessing remedy performance and will consider Part 201 standards in updating the action levels for this remedy. The following table provides the levels that apply to the site for some representative contaminants until that update occurs.

Cleanup Goals	
Contaminant	**Cleanup level (ug/L)**
Benzene	1
Chlorobenzene	60
Chloroform	0.19
1,2 Dichlorobenzene	10
1,2 Dichloroethane	0.4
1,1 Dichloroethylene	0.06
Ethylbenzene	30
Tetrachloroethylene	0.7
Toluene	0.7
1,1,1-Trichloroethane	200
Vinyl Chloride	0.015
Xylene(s)	20

4.0 FINDINGS AND OBSERVATIONS FROM THE RSE SITE VISIT

4.1 FINDINGS

The RSE team found an extremely well-operated and maintained groundwater extraction and treatment facility. The RSE team has not seen a Superfund Pump & Treat System that is more efficient, clean and well maintained in the country. The monthly reports were very detailed, thorough and should be used as an example for other projects. The Operations team is commended for their efforts. The observations provided below are not intended to imply a deficiency in the work of the designers, operators, or site managers but are offered as constructive suggestions in the best interest of the EPA and the public. These observations obviously have the benefit of the operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of groundwater remediation have changed over time.

The U.S. EPA and MDEQ site managers report that they are currently assessing the performance of this remedy (including a comparison of past and present groundwater contamination, flow, and computer models) and will likely revise the remedy’s goals. The U.S. EPA and MDEQ site managers further report that they will consider the 1995 change in state cleanup standards, the remedy operational data to date, cost effectiveness, and overall remedy time period.

4.2 SUBSURFACE PERFORMANCE AND RESPONSE

4.2.1 WATER LEVELS

Water levels are collected from 79 locations (including the extraction wells) on a monthly basis, and these measurements are used to generate potentiometric surface maps in the unconfined and semi-confined systems for each of these events. These potentiometric surface maps are included in the quarterly groundwater monitoring reports.

Water levels southeast of the GWTF consistently indicate a southeasterly flow of groundwater in the unconfined system toward the seven extraction wells located between the source area and Little Bear Creek. Water levels in the deeper semi-confined system also indicate groundwater flow in a southeasterly direction but suggest little or no influence from the extraction wells near the creek. The fate of the groundwater in this lower system may involve discharge to the creek, but a lack of water-level data at this depth and location cannot confirm this.

Water levels in the unconfined aquifer near the GWTF suggest flow to the northwest toward EW-8 and EW-10 indicating some capture of groundwater by these extraction wells.

It should be noted that because the potentiometric surface maps are generated including the water level measurements from active extraction wells, they may be biased in favor of capture. Water levels are lowest in extraction wells and are typically much higher only short distances away from the wells. Thus, a linear interpolation method used in generating the potentiometric surface maps would overestimate drawdown in the water level between the extraction wells and the closest monitoring wells and may bias capture zone analyses.

4.2.2 CAPTURE ZONE

The capture zone of the OU1 extraction system, located between the source area and Little Bear Creek, was analyzed during system design by numerical groundwater modeling and particle tracking. A target capture zone was determined based on knowledge of source areas and groundwater contamination. Various pumping scenarios were then simulated with site model and simulated capture zones were determined through particle tracking. This analysis demonstrated that the simulated capture zone would include the target capture zone if EW-1 through EW-4 pump at 100 gpm and EW-5 through EW-7 pump at 75 gpm. This study also showed that the addition of extraction wells in the source area (EW-8 and EW-9) would not adversely affect capture downgradient of the source area.

In 1997 the model used in design of the extraction system was modified to include a refined model grid and through improved calibration based on pumping and non-pumping scenarios. This modified model was then used to optimize the extraction system by determining the minimum extraction rates that would still provide capture. As a safety factor, these optimized extraction rates were increased by 10%. Particle tracking in simulated groundwater flow under various pumping scenarios indicated that pumping rates in all but two of the wells could be reduced such that the total extraction rate from this 7-well network would be 420 gpm rather than the design rate of 625 gpm. The design, optimized +10%, and actual (August 2001) extraction rates for these 7 extraction wells are summarized in the following table.

Well ID	Design Extraction Rate (gpm)	Optimized Extraction Rate + 10% (gpm)	Actual Extraction Rate for August 2001 (gpm)
EW-1	100	88	94
EW-2	100	77	99
EW-3	100	33	93
EW-4	100	33	99
EW-5	75	82	81
EW-6 (EW-6a)*	75	82	60
EW-7	75	66	83
Total**	**625**	**461**	**609**

* EW-6a is a replacement well for EW-6

** The total represents the total extraction rate for the containment network (OU1) and does not include the water pumped from the source area wells EW-8, EW-9, and EW-10 (OU2).

As is evident from the summarized extraction rates, all of the extraction wells, with the exception of EW-6a are operating near or above extraction rates that demonstrated capture during modeling studies. Furthermore, these extraction rates are more typical of the more conservative design rates rather than the recently derived optimized rates.

4.2.3 CONTAMINANT LEVELS

In the vicinity of the containment extraction network (OU1), monitoring wells that screen the upper portion of the unconfined system or screen the semi-confined system indicate undetectable concentrations. The monitoring wells that screen the lower portion of the unconfined system, however, have shown various responses to pumping. Monitoring wells OW-12 (near EW-1), W-107i and OW-23 (between EW-1 and EW-2), and W-116i (south of EW-5) indicate significant declines in contaminant concentrations indicating capture and progress toward restoration in the vicinity of those areas. On the other hand, contaminant concentrations in W-114i (between EW-4 and EW-5) have increased by a factor of 3 to 4, but the monitoring well appears to be within the capture zone of EW-4 and EW-5.

The concentrations in all but two of the extraction wells (EW-4 and EW-5) have either remained the same or declined since pumping began in 1996 (December 1999 for EW-10). Contaminant concentrations in EW-4 have increased by a factor of 10, and concentrations in EW-5 have increased by a factor of 2. Concentrations of total organic contaminants, especially in EW4, EW-8 and EW-10, however, continue to exceed 5,000 ppb, suggesting the presence of NAPL acting as a continuous source of dissolved phase contamination.

The blended influent concentration of VOCs and SVOCs to the GWTF in August 2001 was approximately 4,000 ppb (approximately 1,500 ppb VOCs and 2,500 ppb SVOCs). With a flow rate of approximate 700 gpm through the system, this translates to over 30 pounds per day of organic contaminants.

In the table below, the estimated treatment plant influent contaminant concentrations from the July 1992 Design Analysis Report are compared to the influent concentrations determined from monitoring the plant process within a year of system startup and over two years after startup. The table demonstrates that the influent concentrations, in general, have not decreased dramatically during plant operations but are orders of magnitude lower than the estimated concentrations that may have been used in designing the treatment plant. These estimated concentrations used in design were reportedly selected to ensure protection of human health and the environment.

Parameter	Units	Design Basis (July 1992)	Actual Influent (January 1998)	Actual Influent (May 2000)
COD	mg/l	1570	73	61
TSS	mg/l	30	39	< 4
Ammonia-nitrogen	mg/l	80	3.8	2.9
Vinyl chloride	ug/l	21,000	120	105
1,2 DCA	ug/l	19,000	363	199
Toluene	ug/l	14,000	482	452
1,1 DCA	ug/l	1,900	86	63
Acetone	ug/l	26	30	25

Xylenes	ug/l	1,700	37	33
1,1,1 TCA	ug/l	1,600	166	176
total SVOCs	ug/l	~15,000	2982	3234

4.3 COMPONENT PERFORMANCE

4.3.1 DIFFUSED AIR STRIPPER BASINS (DAS)

The purpose of the DAS units is to remove VOCs in the influent groundwater prior to being introduced to the PACT system. There are two DAS units arranged in parallel, each unit addresses 350 gpm of influent groundwater and consists of a 31-foot diameter carbon steel tank with a stainless steel bubble diffuser. The diffuser air is provided by a blower capable of providing 5500 cubic feet per minute (cfm) with 400 horsepower drives. The units also receive the offgas from the Powder Activated Carbon (PACT) system into its headspace for piping into the thermal oxidation unit. Three bypass fans draw air from the PACT system into the DAS units.

No fouling of these units have been reported. During normal operating conditions (i.e., not during the VOP) the DAS units provide approximately 80% removal of volatile organic compounds.

4.3.2 THERMAL OXIDATION UNIT (TOU)

The TOU system includes a main exhaust fan with variable speed drive and a 12.5 to 200 horsepower motor to provide the vacuum necessary to induce all contaminated process air from the DAS units into the TOU. There is an inlet demister, followed by the regenerative thermal oxidizer which consists of ceramic media in three vertical heat recovery chambers and a single combustion chamber aligned horizontally across the tops of the recovery chambers. Following the combustion unit is a caustic scrubber to neutralize the hydrochloric acid formed during the combustion process.

The TOU generally operates without incident; however, the exhaust fan motor occasionally shuts down during storm events.

4.3.3 POWDERED ACTIVATED CARBON TREATMENT SYSTEM (PACT)

After the DAS units, each treatment train has a biological/chemical system designed to remove the remaining VOCs as well as the SVOCs. Each system consists of a round, domed multipurpose tank that is 115 feet in diameter with an outside sidewall height of 16 feet, 9 inches. The center of the tank is occupied by a first stage clarifier, and the “donut-shaped” peripheral area around that clarifier is divided into three sections: the first stage aerator, the second stage aerator, and waste activated sludge storage tank (aerobic digester). The second stage clarifier for each system is a stand alone tank outside of the domed structure.

The first stage aeration tank occupies a portion of the outer ring and has a volume of 476,000 gallons. Air is forced into the bottom of the tank through diffusers from a 400 horsepower blower (one blower is used to operate the tanks in both parallel treatment trains). Phosphoric acid is added to the first stage aeration influent to ensure proper nutrients are available for the microbes that digest the contaminants.

The first stage clarifier is located in the center of the system and has a volume of 200,000 gallons. Flow from the first stage aeration enters the tank and is allowed to settle. Clarified water exits over the wall into the second stage aeration basin. The majority of the first stage clarifier settled sludge is recycled to the first stage aeration. Excess material (biomass and powdered activated carbon) is pumped to the aerobic digester.

The second stage aeration system also occupies a portion of the outer ring and has a capacity of 269,000 gallons. This system is also aerated by diffusers in the bottom of the tank. Powdered activated carbon is added at this stage to adsorb toxins and contaminants not readily a consumed by the bacteria population. Polymer is also added at this stage to improve settling. Process water from this stage over flows into the second stage clarifier, which is a stand-alone system 45 feet in diameter and 15 feet tall with a capacity of 175,000 gallons. The majority of the settled sludge in the second stage clarifier is recycled to the second stage aeration tank. Excess material, since it contains significant levels of powdered activated carbon, is “wasted” to the first stage aeration tank.

The aerobic digester tank is a 200,000 gallon portion of the outer ring. The sludge directed to this tank consists of wasted carbon and excess biomass solids. Air is provided to maintain aerobic conditions. Excess water can be decanted to the wastewater sump in the sludge treatment building and returned for treatment to the head of the plant. Waste solids are pumped from this tank to one of three onsite plate and frame filter presses.

As a whole, the PACT system reduces the remainder of the VOCs not removed by the DAS units (including approximately 2 mg/L of ammonia and 30 ug/L of acetone), SVOCs, and COD to concentrations below discharge standards.

4.3.4 POWDERED ACTIVATED CARBON FEED SYSTEM

The powdered activated carbon (PAC) feed system is comprised of a 3,000 cubic foot bulk storage silo, a volumetric rotary-type dry chemical feeder, a wetting chamber and two air driven diaphragm pumps that deliver the carbon slurry to the second stage aeration system. A total of approximately 80,000 pounds of PAC is added to the system each year. This feed system is operator intensive and requires daily maintenance.

4.3.5 TERTIARY FILTER SYSTEM

Second stage clarifier effluent enters the tertiary sand filter storage tank in the groundwater treatment building. Two pumps are provided to move the water through the sand filters. Ferric chloride is injected at a concentration of 10 to 12 ppm into an inline mixer prior to the filters to assist in phosphorus removal within the filters. The tertiary sand filter beds are 80 inches in depth and are continuously backwashed.

These filters have had problems with solids removal in the past, but an increase in the amount of ferric chloride to the current concentration of 10 to 12ppm has improved operation of the filters. The filters now provide approximately 50% removal of total suspended solids.

4.3.6 GRANULAR ACTIVATED CARBON (GAC) TREATMENT

Process water from the tertiary filters passes through two parallel GAC systems that each consist of two 20,000 pound units arranged in series. Because concentrations of the influent into the filters are usually undetectable or well below the discharge levels for all contaminants of concern, these units are used as an "insurance policy" to ensure the plant always satisfies its discharge criteria. The lead vessel is changed approximately every 6 months due to pressure build up.

4.3.7 SOLIDS HANDLING SYSTEM

Waste sludge from the PACT system is removed from the aerobic digesters to the solids handling process. The sludge can be treated with lime to improve dewatering efficiency; however, it has not been necessary to add lime as the addition of powdered activated carbon provided sufficient dewatering. The system was designed to generate approximately 200 to 350 cubic feet per day; thus, three plate and frame filter presses, each with a capacity of 100 cubic feet, are on site. Actual sludge generation has been approximately 40 cubic feet per day with approximately 40% solids. The sludge is nonhazardous and is disposed of accordingly. The filter press acid wash system has not been necessary to thoroughly clean the filter presses.

4.3.8 ONSITE LABORATORY

The onsite laboratory is staffed by the laboratory manager and two full time chemists. The laboratory is capable of VOC, SVOC, biological, and inorganic analyses. The monitoring schedule for the process monitoring is provided in Table 2-1. The analytical load of the laboratory has increased each year since the beginning of plant operation and may have the ability in 2002 to handle VOC analyses from the quarterly monitoring program.

4.4 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF MONTHLY COSTS

Estimates of the monthly operations and maintenance costs for the OU1 and OU2 extraction and treatment systems, based on values provided by the site RPM from quantity allowances established in the operation contract, are presented in the following table.

Project Management and Support	
Remedial Action Support and project management (Black and Veatch)	$21,000
Remedial Action Support and project management (USACE)	$24,500
Labor	
Labor: operations personnel and on-site lab	$60,000
Labor: non-routine extraction-well maintenance or repair	$4,200

Utilities	
Electricity	$27,500
Natural gas	$6,250
Public Water	$300
Non-utility Consumables and Disposal Costs	
Chemicals and materials for treatment plant	$12,000
Additional maintenance materials	$26,500
Sludge disposal	$600
Well cleaning chemicals	$1,300
Chemical Analysis	
Off-site analytical work	$13,500
Total monthly costs	**$197,650 per month**

4.4.1 PROJECT MANAGEMENT

In addition to management provided by the plant operation subcontractor, project management and support are provided by USACE and their primary contractor Black and Veatch. The project management provided by USACE is primarily administrative, and the nearby USACE office can respond to site incidents more readily than MDEQ personnel in Lansing or U.S. EPA Region 5 in Chicago. In addition, USACE was selected as the oversight agency by U.S. EPA and MDEQ because they are authorized to deal with "inherently governmental" functions.

The U.S. EPA and MDEQ site managers report that they will assess and likely scale back the current scope and role of Black and Veatch.

4.4.2 LABOR

The onsite staff consists of the following 9 positions working 45 hours per week at a monthly cost of approximately $64,000:

- 1 superintendent
- 3 shift operators
- 1 lab manager
- 2 lab technicians
- 1 maintenance position
- 1 administrative assistant.

The August 2001, monthly report provides the following breakdown of time by task:

Activity	Hours	Percentage of Total Hours
Operations	433.5	29%
Preventative maintenance	48	3%
Corrective maintenance	64.5	4%
Laboratory	373.5	25%
Well sampling	205.5	14%
Sludge process	21.5	1.5%
Administrative	307.25	21%
Custodial	28.75	2%
Total	1483 hours	~100%

4.4.3 UTILITIES

Electricity usage comprises the majority of utilities costs (approximately $27,500 per month). The two 400 horsepower blowers used for the activated sludge/PACT process and the air strippers account for approximately 90% of the electricity used on site. The extraction well and transfer pumps account for the large majority of the remaining 10 %. Natural gas usage (approximately $6,250 per month) is primarily for the thermal oxidizer.

4.4.4 NON-UTILITY CONSUMABLES AND DISPOSAL COSTS

The primary chemical additions are phosphoric acid, ferric chloride, and polymer. Together, the cost for these chemicals approaches $12,000 per month or over $140,000 per year.

“Additional maintenance materials” refers to those materials required for operation and maintenance of the plant and onsite laboratory in addition to maintenance of the buildings and grounds. The exact items that fall under this category were not detailed during the RSE. However, the carbon used for the treatment plant do fall under this category. Thus, the monthly costs of $26,500 include an approximate average monthly combined cost of $15,000 for 80,000 pounds of PAC per year and 40,000 pounds of GAC per year.

Sludge disposal costs approximately $600 per month to dispose of an approximate daily average of 40 cubic feet of sludge per day.

Chemicals for well maintenance and rehabilitation generally include acetic acid. The average monthly cost is approximately$1,300 and is used to generate 600 gallons of acid solution that is used approximately twice per week.

4.4.5 CHEMICAL ANALYSIS

Offsite chemical analyses are conducted to satisfy the NPDES permit, verify the analytical results of the onsite laboratory, and analyze the samples from the quarterly sampling events. The monitoring schedule presented in Table 2-1 indicates those samples analyzed offsite. In general, approximately 30 samples are analyzed offsite for the NPDES program, and based on a generic average cost of $150 per analysis, these samples should cost approximately $4,500 per month. Approximately 261 samples are collected each year for the quarterly monitoring events, and each sample is analyzed for VOCs and SVOCs. Given that a year consists of 12 months, this sampling rate is equivalent to approximately 22 samples per month. Given a generic average cost of approximately $125 for each VOC sample and approximately $300 for each SVOC sample, the analyses for the groundwater monitoring, including a number of field and trip blanks, comprise the remaining $9,000 per month for offsite sampling indicated in the above cost table.

4.5 RECURRING PROBLEMS OR ISSUES

The most labor intensive operations are maintaining the PAC feed system and the extraction wells. PAC particles frequently clog in the PAC feed system and require daily attention. The well-maintenance trailer and acid solution are used approximately twice per week to address those wells that show signs of fouling. The current well-maintenance program has been successful in maintaining well yields.

4.6 REGULATORY COMPLIANCE

The monthly reports have not demonstrated any significant non-compliance in the effluent from the plant. However, occasional deficiencies in dissolved oxygen levels and the requirement to improve dissolved oxygen levels in the Muskegon River have resulted in the need to install an aerator near the discharge location. The need to improve dissolved oxygen levels in Muskegon River discharge was identified during NPDES permit development and discussions.

Site managers report that no appreciable violations of the NPDES discharge permit have occurred in the 7 years of construction, start-up, and operation to date. Over time, a number of parameters in the plant discharge have been switched to “report only” status. The State, however, may adjust the permit if major modifications to the plant are performed. The site managers report that the State surface water quality personnel are closely involved and openly communicate in the operation of the remedy.

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

No accidental releases of hazardous chemicals have been documented.

4.8 SAFETY RECORD

The plant has an excellent safety record. Site managers report that no major lost time accidents have occurred and that regular safety audits were conducted throughout the construction, start-up, and operations period to date.

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

5.1 GROUND WATER

Based on a review of the Quarterly Groundwater Monitoring reports and the 1997 capture zone analysis, it appears that the extraction system is effective in achieving the OU1 goals of plume containment and preventing discharge of contaminated groundwater to surface water. However, it appears that a significant mass of contamination may reside in the fine-grained materials in the confining unit and may be acting as a long-term source of contaminants to the unconfined aquifer. Site managers report that this uncertainty is a contributing reason to why U.S. EPA and MDEQ are assessing the remedy goals and remedy operation.

Wells EW-8 and EW-10, and the new EW-11 extraction well are source removal wells near the plant site. EW-8 and EW-10 produce the highest total organic concentrations of all the extraction wells. Their concentrations have decreased 40-50% since each was put into production. Concentrations in the monitoring wells in the area near the GWTF and the Cordova Plant remain extremely high for the most part. Wells on the downgradient edge of the Cordova plant site still show a definite trend of the highest concentrations in the shallow wells and decreasing concentrations in the lower unconfined and confined unit wells. Although the source area wells are removing significant amounts of contaminant mass, it is not clear whether they are effectively controlling all of the migration of contaminants away from the source area.

EW-9 is the only extraction well screened in the confined aquifer. The well serves as both a source area removal well and a containment well. Its operation is coupled with that of EW-8, which is screened in the unconfined aquifer, so that an upward gradient is maintained between the confined and unconfined units. Total organic compound concentrations in EW-9 have held fairly steady at approximately 1500ug/l. It appears to be effectively intercepting the plume and removing mass but the degree of capture being achieved is difficult to determine due to the lack of monitoring wells in the confined aquifer, particularly to the east and west of EW-9.

5.2 SURFACE WATER

Little Bear Creek and its unnamed tributary were impacted by site-related contamination that had migrated from the source area through groundwater prior to implementation of the current remedy. Since the implementation of OU1, the concentrations between the OU1 extraction system and these creeks have decreased indicating that migration of contaminants from the source to the creeks has been significantly reduced through groundwater extraction and treatment.

The effluent from the plant is discharged to a surface water body, Muskegon River. As the plant meets the discharge criteria of the NPDES program, no adverse effects on the river are expected.

5.3 AIR

The thermal oxidizer has performed well and has not caused any releases to the environment. The controls of the entire treatment plant do not allow continued operation if the thermal oxidizer is shut down. Air samples of the thermal oxidizer influent and effluent air are sent offsite monthly for analysis and verify the effectiveness of this unit.

5.4 SOILS

Contaminated soils remain onsite at the location of the old chemical facility to the northwest of the treatment plant. These soils will be excavated and disposed of offsite as part of OU3. Fencing around that old facility prevents public access. A former representative of the most recent site owner is present onsite as a caretaker.

5.5 WETLANDS AND SEDIMENTS

Quarterly sampling performed in the Little Bear Creek sediments has shown a significant decrease in site contaminants since the operation of the pump and treat system has begun. Under OU3, this sampling will continue to determine if further remedial action is required for the contaminated sediments.

6.0 RECOMMENDATIONS

Subsequent to the RSE site visit the site managers informed the RSE team that there is a potential redevelopment/reuse issues at the Ott/Story/Cordova site. The current property owner has expressed interest in donating the land to the Muskegon County, who has expressed an interest in continuing operation of the groundwater treatment facility in order to reduce the industrial users wastewater loading of the Muskegon County POTW.

The RSE team encourages the pursuit of such redevelopment/reuse prospects to the extent that the remedy remains protective and cost-effective. Data and site interviews during the RSE of this site indicated that the treatment plant is currently operating near full capacity. Thus, additional flow from industrial sources would likely represent a small percentage change and should not substantially impact the system. If substantial industrial flows are to be accepted two options will need to be considered: (1) reductions in groundwater extraction at the site or (2) enhancements to the treatment system will be required. The first option should be thoroughly analyzed to ensure the continued protectiveness of the remedy. The second option should be thoroughly analyzed to ensure that the accepted plan for the remedy is cost-effective. In analyzing the cost-effectiveness of the plan, the cost-reduction recommendations below should be considered.

The recommendations below pertain to the current P&T system at the Ott/Story/Cordova site. The RSE team recognizes efforts on behalf of the site managers to assess and optimize the system and encourage the site managers to consider the following recommendations in their assessment. The RSE team also recognizes that redevelopment/reuse issues may play a role in future operations and maintenance of the site. The RSE team encourages immediate consideration of these recommendations and the associated potential cost savings so that cost-benefit analyses of future redevelopment/reuse plans can account for the potentially optimized system that could result from implementing the following recommendations.

Cost estimates provided for the following recommendations 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 RECOMMENDED STUDIES TO ENSURE EFFECTIVENESS

The groundwater treatment facility continues to regularly meet discharge requirements. An example of the consistency and quality of the treatment is the evolution of the Discharge Monitoring Report. Many of the individual constituents on that report are now listed as “report” (i.e., report the daily maximum concentration or monthly average concentration) demonstrating the confidence of the regulator in the treatment plant. Thus, the RSE team has no recommendations regarding the effectiveness or performance of the treatment plant.

In addition, based on a review of the Quarterly Groundwater Monitoring reports and the capture zone analysis conducted in 1997, it appears that the extraction system is effective in achieving the OU1 goals of plume containment and preventing discharge of contaminated groundwater to surface water. Organic concentrations in the majority of the monitoring wells screened in the upper unconfined unit near the creek have dropped to undetectable levels and concentrations in many of the wells screening the lower portion of the unconfined unit are decreasing. Surface water and sediment samples collected from the creek ten months after startup of the extraction system showed dramatic decreases in the concentrations of organic contaminants. Recent organic concentrations in surface water were at or near undetectable levels. South of EW-2, the groundwater gradient appears to be toward the wells from the creek. Along the southern boundary represented by wells EW-4 through EW-7, most of the monitoring wells in the upper unconfined unit downgradient of the extraction system have decreased to undetectable levels. Thus, the RSE team has no recommendations regarding the effectiveness performance of the OU1 extraction system.

However, in the opinion of the RSE team, it is unlikely that the current pump and treat system will achieve the OU2 objective of groundwater restoration in a reasonable time frame due to the possible presence of contamination in the confining unit that is apparently acting as a continuing source of dissolved phase contamination. Given that this issue impacts the exit strategy of the site, it is discussed further in Section 6.4 “Recommendations to Gain Site Closeout”.

6.2 RECOMMENDED CHANGES TO REDUCE COSTS

6.2.1 REPLACE DAS UNITS WITH TRAY AERATORS OR PACKED TOWERS

Replacing the current DAS units with tray aerators or packed towers would increase VOC removal at a lower cost. The current DAS system uses a 400 horsepower blower and provides approximately 80% removal of VOCs. Two tray aerators, each rated at 500 gpm a piece, could remove 99% of VOCs using a total of two 20 horsepower fans. This improved removal of VOCs from the process water may also allow for discontinuing the addition of PAC to the activated sludge system. Currently, the addition of PAC is gauged based on the concentrations of VOCs and SVOCs leaving the activated sludge system, and the improved air stripping would remove the VOCs. The remaining SVOCs would easily be removed through biological activity or through the subsequent treatment in the GAC units if the lead GAC unit is replaced more frequently. With the elimination of PAC addition, the use of polymer could also be reduced as it is typically used to improve the removal of the PAC via filtration. Finally, elimination of PAC addition will also result in a reduction in the volume of generated sludge.

Considerations with replacing the DAS are fouling issues, loading to the thermal oxidizer and locating these units onsite. During the RSE visit, it was noted that no scaling or precipitation is apparent in the existing DAS system, and the RSE team anticipates that fouling for tray aerators or packed towers should not present a greater fouling problem than that of the existing DAS system. The thermal oxidizer costs and operation will not change due to the increased loading after initial adjustments are made. The smaller drives and blowers and the new tray aerators could fit in the existing blower building or packed towers could be located near the existing DAS units.

The estimated cost to replace the DAS units is $750,000, but the associated reduction in electrical utilities (assuming $0.07 per kilowatt hour) would result in a monthly cost savings of approximately $10,000. The elimination of PAC usage would decrease monthly costs by approximately $10,000, but an increase in the frequency of GAC replacements (perhaps by a factor of 3) would be required resulting in an increase in monthly costs of approximately $10,000. Thus, no net savings from a reduction in carbon usage would be expected. However, chemical usage and sludge volume could reduce by 50% providing a savings of over $6,000 per month. Thus, a total monthly savings of approximately $16,000 or an annual savings of approximately $192,000 could be realized, and this modification should pay for itself in less than four years. The possibility of reducing plant labor should also exist given that the PAC feed system requires substantial maintenance on a daily basis. By comparison, maintenance for two tray aerators should be less than 8 hours per month.

6.2.2 REEXAMINE NPDES PERMIT AND POTENTIALLY BYPASS PACT SYSTEM

Improving VOC removal to 99% would allow all remaining VOCs (with the exception of acetone) to be easily addressed by the GAC polishing step at the end of the treatment train. The remaining contaminants of concern in the process water would be SVOCs, acetone, and ammonia. SVOCs are easily addressed by adsorption to GAC whereas removal of acetone and ammonia require biological treatment at this plant. At influent rates of approximately 30 ug/L, acetone is well below Water Quality Based Effluent Limit of 500 ug/L stated in the 1989 ROD. If the discharge criteria for acetone is similar to that stated limit the influent concentrations of acetone are well below the effluent limits and biological treatment is not necessary for meeting the discharge criteria for acetone. The average ammonia concentration in the extracted groundwater is approximately 2 mg/L, which is extremely low compared to effluent limit of 20 mg/L specified in the October 1997 Discharge Monitoring Report (subsequent reports specify that this parameter need only be reported). If the discharge criteria for acetone is substantially greater than the influent concentration of 30 ug/L and the discharge criteria for ammonia is, in fact, 20 mg/L the treatment plant could reliably treat the extracted groundwater and satisfy the discharge criteria without the entire PACT system at substantial savings.

If this is the case, then the treatment system would be comprised of air stripping, filtration, and GAC adsorption. Without the PACT system, the second 400 horsepower blower and chemical additions would not be required. Also, for this simplified system the onsite laboratory may not be required. The samples that are currently collected and sent to an offsite lab for the NPDES program would likely be sufficient for monitoring operational effectiveness and predict potential operational or discharge problems. In addition, other operations and maintenance labor could be reduced. For example, the onsite staff of 9 people likely could be reduced to an onsite staff of 3 to 4 people consisting of a plant manager, operator, and one or two maintenance people.

The capital costs associated with bypassing the PACT system, including design work and implementation, could be as high as $400,000. However, substantial savings in O&M could be realized. The following O&M cost savings (beyond those provided in Section 6.2.1) should result:

- Eliminating the use of the second 400 horsepower blower could save approximately $11,000 per month.
- Eliminating the addition of phosphoric acid, polymer, and ferric chloride should result in addition savings of approximately $6,000 per month.
- Although not specifically quantified by the RSE team, eliminating the onsite laboratory may save up to $2,000 per month in materials and supplies.

- A reduction in the labor force to a staff of three or four would likely decrease the monthly labor costs by $25,000. The resulting labor cost of approximately $39,000 would be required for a plant manager, operator, and one or two maintenance people to be onsite 40 to 45 hours per week.

Thus, in total, simplifying the system should result in additional savings of $58,000 per month or $696,000 per year. This annual savings would easily offset the costs of implementation within a year. Combining this annual cost savings with those provided in Section 6.2.1, simplifying the system would result in an overall cost savings of $888,000 per year.

6.2.3 REDUCE PROCESS MONITORING AND ANALYSIS

Regardless of the recommendations in 6.2.1 and 6.2.2, the sampling and analysis of the process water could likely be reduced without sacrificing effectiveness. The current process sampling schedule, including those samples sent offsite for the NPDES program, is depicted in Table 2-1. During the RSE, the plant operator mentioned that wasting rate, phosphoric acid, ferric chloride, and PAC addition are the primary aspects of the system that can be controlled and are controlled by the plant operator. The wasting rate is modified every few months, and the phosphoric acid addition is modified approximately once a month based on the phosphorous concentration in the first stage clarifier. Ferric chloride addition does not require much adjustment, and the PAC addition is modified less frequently than once a month based on VOC and SVOC concentrations prior to the GAC. Thus, it appears that the sampling conducted for the NPDES permit and possibly a limited number of additional samples analyzed onsite may be sufficient for effective plant operation. As a result, the analytical work conducted in the onsite laboratory could likely be reduced. Substantial cost savings would result due to a decrease in the technician labor— approximately $100,000 per year would be saved if a single person could operate the laboratory at reduced capacity or approximately $50,000 per year would be saved if two people were required. Additional savings in laboratory supplies would also be expected.

6.2.4 REDUCE GROUNDWATER MONITORING AND ANALYSIS

A number of monitoring wells consistently have undetectable levels of organic compounds, particularly in the upper portion of the unconfined unit. The sampling frequency for many of these wells has already been reduced to once per year, with many of the wells being sampled only during the March sampling round. However, there is some opportunity to make further reductions. During the March 2001 sampling round, 26 of the 64 wells sampled had undetectable concentrations. Of those 26 wells with undetectable concentrations, 14 of them are both located in the upper portion of the unconfined aquifer and sampled once per year. Some these wells can be eliminated completely from the monitoring program, either because they are located close to each other (ex. W-104s and W-105s) or because they are well outside the plume (ex. MW-33s and MW-34s). Two wells in the upper portion of the unconfined unit (W-13s and W-16s) are sampled three times per year (in every quarter except March). This may be due to access problems during the late winter months or simply to keep the number of wells sampled during the March round to a reasonable number. In either case, these wells could be reduced to a semi-annual sampling schedule with no adverse impact on the ability to recognize the meaningful trends in the data. Because of their locations, conditions are not likely to change at either well and both could be reduced to semiannual or even annual sampling.

In the lower portion of the unconfined unit, well K31d is sampled quarterly and has consistently yielded undetectable concentrations since 1998. In addition, well K3d is sampled three times per year (every quarter except for March) and has consistently yielded undetectable concentrations over the past four sampling events. Monitoring in both of these wells can be reduced to annually. A few other wells in the lower portion of the unconfined unit can also be eliminated altogether or at least reduced to annual sampling due to their proximity to other monitoring wells or to extraction wells. These wells include W-105i, OW-12, OW-23, and W-121i.

Four of the wells in the semi-confined unit (W-123d, MW-23d, MW-16d, and MW-34d) are sampled every March and have had undetectable concentrations for two or more years. Sampling of these four wells could be eliminated completely. In addition, the quarterly sampling of MW-12d has consistently yielded undetectable concentrations, and sampling of this well can be eliminated from the monitoring program.

In general, with 21 quarters of data, it is clear that the quarterly sampling of wells within the plume is not necessary to determine the concentration trends. Annual sampling of wells within the plume, including the extraction wells, would be sufficient for trend analysis. With the specific mentioned reductions in monitoring and this general recommendation to reduce the sampling frequency, the monitoring program recommended by the RSE team consists of quarterly sampling in approximately 20 wells and annual sampling in approximately 65 wells. Thus, a total of 125 samples would be collected and analyzed each year instead of the approximate 260 wells that are currently sampled. Given that the samples are analyzed for both VOCs and SVOCs at a total cost of $425 per sample ($125 for VOCs and $300 for SVOCs), this recommendation could result in an annual savings of over $55,000 per year in analysis costs alone.

6.2.5 REMOVE EXCESS EQUIPMENT AND DO NOT CONSTRUCT THE PLANNED STORAGE BUILDING

A large amount of unused equipment is stored onsite and can be removed if additional storage space is required. A new building should not be constructed for additional storage space. Three filter presses with a capacity of 100 cubic feet are onsite, but only 40 cubic feet are processed each day. Thus, only one filter press is required. Current practice is to alternate use of each of the filter presses. Only one filter press should be used and the other two should be removed to allow for storage space.

The blower building houses six 400 horsepower blowers, but only two are used, and if recommendations 6.2.1 and 6.2.2 are implemented, then none of these blowers would be used. The unused blowers should be removed if storage space is required. Other equipment can also be removed such as the filter press acid wash system and lime feed. Other equipment that will be not be needed after implementing the recommendations in 6.2.1, 6.2.2, and 6.2.3 should also be removed and made available to other Fund-lead P&T systems that may need the equipment (see Section 6.5).

6.2.6 EVALUATE POTENTIAL REDUCTION IN ONSITE PRESENCE OF USACE

Now that the system has been operating for over 4 years and has consistently met discharge requirements, oversite from USACE could likely be reduced. Current costs are approximately $24,500 per month (approximately 13% of the total site costs) and involves onsite representation of USACE approximately three times per week. Adequate oversite may be provided by less frequent site visits. If other cost-reducing recommendations are implemented, the system will be simplified and should require even less oversite.

6.2.7 REMOVE TRAILERS FROM THE SITE

At the time of the RSE site visit, two large office trailers remained at the site, and the RSE team recommended removing at least one of them because adequate space can be made in other buildings and the costs of the trailer rentals can be eliminated. One trailer continues to be used by USACE for administrative purposes and the other, which was maintained by a technical support partner of the operations subcontractor, has been removed.

6.2.8 HAVE ONSITE STAFF CONDUCT SAMPLING FOR OU3 AND EVALUATE FOR POTENTIAL REDUCTION OF SAMPLING

Although a substantial staff of 9 people of the operations subcontractor are onsite each day, sampling and the surface water and sediments in OU3 are conducted by the offsite staff of the primary contractor. This sampling could be conducted by the onsite staff and sent to the primary contractor accordingly. This would save the labor and costs associated with the staff of the primary contractor traveling from Kansas City to the site four times per year. If a staff of two individuals is required to conduct the OU3 sampling over a period of 3 days, and an additional day is required for travel each way, then approximately $15,000 could be saved each year by having the onsite staff do the sampling. These cost reductions would result primarily from eliminating labor costs associated with travel and lodging and per diem required over the three to four day period.

6.3 MODIFICATIONS INTENDED FOR TECHNICAL IMPROVEMENT

6.3.1 ESTABLISH CONSISTENT SAMPLING METHOD

There has been a substantial effort made to improve the quality and efficiency of the groundwater sampling program by installing dedicated bladder pump systems in many of the more frequently sampled wells and utilizing low flow sampling methods. These efforts are commendable. However, there is still significant variation in sampling methods between different groups of wells, which likely introduces greater variability to the data and may make it difficult to correlate concentrations between wells. This could potentially lead to erroneous conclusions about the performance of the remediation system. Some wells are sampled with peristaltic pumps and others are sampled with bailers. This is due to several factors, such as sampling frequency, depth to water and well construction/condition issues. The comparability of data between wells sampled with the dedicated bladder pumps and peristaltic pumps, both utilizing low-flow methods, is probably fairly good. However, it is difficult to compare data from the wells sampled with bailers to data generated from either of the other two methods. It would be much more preferable to arrive at a single method for sampling all the wells that do not have dedicated pumps that will produce data of comparable quality to the dedicated systems.

Due to the depth to water in some of the wells, some type of portable down-hole pump would probably be the best alternative. The plant staff indicated that some of the wells would not accommodate the dedicated pump system due to well alignment problems or small-diameter casings. However, bladder pump systems have recently come on the market in diameters as small as 0.5 inches that may overcome some of those problems. The Groundwater Summary Report refers to the Micropurge dedicated sampling pumps, which is a trademark name for pump systems made by QED Environmental. The same firm markets portable pump systems in diameters as small as 0.75 inches that operates off the same controller unit as many of their other pumps, so the capital investment for the new pump would be relatively small. If there are wells that will not accommodate the small diameter pump, due to the condition of the well, serious consideration should be given as to whether those wells are suitable for sampling. They may need to be replaced with a new well, replaced in the program by substituting another well in the same area, or just eliminated from the program altogether.

Modification of the sampling method and purchasing of materials and a portable pump, approximately $2,000, should be delayed until the number of monitoring wells or frequency of monitoring has been reduced as suggested in Section 6.2.4.

6.3.2 MODIFY PROGRAM FOR WATER-LEVEL MEASUREMENT

Monthly water levels are collected in 79 wells and piezometers. The data that have been collected over the last five years show normal seasonal fluctuations of 1-5 feet. Since the baseline has been well established, the frequency of measurement could easily be decreased to quarterly during normal system operation without affecting the ability to evaluate the effectiveness of the system. Selected wells that have proven to be located in more dynamic parts of the aquifer may need to remain on a monthly schedule if the additional data has an impact on the operation of the extraction system. Likewise, when changes are made in the operation of the extraction system such as changing pumping rates or adding or removing an extraction well, water levels should be taken at least monthly within the area influenced by the change until the system reaches a new equilibrium. Any affects of short-term shutdowns for maintenance or well rehabilitation will have negligible effect on the groundwater flow system and would not create the need for increased monitoring frequency.

Water levels are also collected in the extraction wells and are used to construct water level contour maps and assess the degree of capture. The water levels for the extraction wells are measured in the piezometers installed in the extraction well filter pack. It would be more appropriate to use the water levels in the three rehabilitation wells surrounding the well for contouring purposes and evaluating the effectiveness of the capture system. The water level in the filter pack is affected by the head loss at the borehole wall and vertically converging flow immediately surrounding the well. Because of these effects, the water level in the filter pack will not be representative of the water level in the formation and will overestimate the degree of capture being achieved. The water levels from the three rehabilitation wells could be averaged to arrive at a single value or one of the three wells could be selected as representative of the location based on past water level records.

The costs associated with this recommendation are negligible. It is likely that a reduction in the frequency of measuring water levels will decrease labor potentially making it easier for the site to operate with a smaller staff.

6.4 MODIFICATIONS INTENDED TO GAIN SITE CLOSE-OUT

6.4.1 ESTABLISH AGREEMENT BETWEEN THE OU2 REMEDY AND THE ROD

The pump and treat system at the Ott/Story/Cordova site addresses two operable units: OU1, which has an objective of plume containment in the unconfined aquifer, and OU2, which has an objective of aquifer restoration. In the opinion of the RSE team, it is unlikely that the current pump and treat system will restore groundwater to its beneficial use in a reasonable time frame due to the possible presence of contamination in the confining unit that apparently acts as a continuing source of dissolved phase contamination. The site managers should consider if the remedy will achieve the OU2 goals of restoration. One strong possibility for addressing the possible discrepancy between the remedy and the associated goals is to consider modification of the OU2 goal from aquifer restoration to plume containment.

If this avenue is considered, three main approaches could be taken:

- the OU2 extraction system could be shutdown leaving the OU1 wells to contain the plume at the downgradient location;
- the OU2 extraction system could continue operating to extract mass and provide the current extent of capture; and
- the capture zones of the OU2 extraction system can be analyzed to determine if it is adequately containing the source area and the system can be augmented if with additional pumping if necessary. This approach has no direct added benefit to protection of human health and the environment, but if the source area is adequately contained, it may facilitate the potential use of effective aggressive source removal technologies that may be developed in the future.

Unless substantial savings in O&M can be demonstrated by shutting down the OU2 extraction system (and that seems very unlikely), the RSE team does not endorse that approach. In order to determine the better of the two remaining approaches, the RSE team recommends that a preliminary capture zone analysis and cost-benefit analysis be conducted on the OU2 extraction system.

Because the OU2 extraction wells had a goal of aquifer restoration and not containment, the capture zones of these wells have not been thoroughly analyzed. It is evident that EW-8 through EW-10 (and EW-11 when it begins operating) capture the source area plume to some degree, but it is unclear to what extent. A thorough analysis of capture should be included in the site managers' current assessment of the remedy and should include the following steps for both the confined and semi-confined aquifers:

- delineating the source area through analysis of groundwater samples;
- determining a target capture zone based on the high concentration areas that should be contained;
- developing potentiometric surface maps from water level measurements;
- estimating the capture zone according to these potentiometric surface maps; and

- comparing the target capture zone with the estimated one.

This preliminary analysis should give an indication of the degree to which contaminants are being captured by the OU2 system. If this analysis indicates capture is incomplete, the need for additional pumping and possibly additional wells should be weighed against the costs of adding those wells and treating the additional extracted water. It should be noted that while contamination in the unconfined system that eludes the OU2 extraction system will likely be captured by the OU1 extraction system, this is not the case for contamination in the semi-confined aquifer. The OU1 wells, do not screen the semi-confined aquifer; therefore, if EW-9 does not provide adequate containment of the deep contamination, the deep plume could continue to migrate unabated. Thus, a more thorough analysis of the EW-9 capture zone, including modeling of the groundwater flow, may be warranted.

6.5 SUGGESTED APPROACH TO IMPLEMENTATION OF RECOMMENDATIONS

A number of the above recommendations can be implemented immediately and concurrently. However, due to the relatively high cost savings, complexity, and time sensitivity of some recommendations compared to others, some recommendations should take precedence. One of the most immediate concerns is addressed by Recommendation 6.2.5. With the large amount of building space onsite, there is no need to construct a new storage building as planned. Rather, unused equipment should be removed as discussed in Section 6.2.5 to provide adequate storage space. Recommendations 6.2.3 (reduce process monitoring), 6.2.4 (reduce groundwater sampling program, 6.2.6 (evaluate the potential for reduction in USACE oversight), 6.2.7 (remove the trailers), and 6.2.8 (have onsite staff conduct OU3 sampling) are relatively simple to implement and may be accomplished before the next groundwater sampling event.

Due to the potential for significant cost savings , the site managers should clarify the discharge criteria for those parameters that must be addressed by the biological treatment (e.g., ammonia and acetone). If the influent of the plant is below this discharge criteria, the PACT system should be bypassed and the system simplified as discussed in Section 6.2.2. If ammonia and acetone do require treatment in order to meet the discharge criteria, then the PACT system must remain in operation. However, the DAS units could be replaced by an efficient air stripper and the PAC addition can be eliminated as discussed in Section 6.2.1. If the PACT system can be bypassed but implementing the change requires a new decision document, other aspects of system simplification (such as replacement of the DAS units with the air strippers) should not be delayed.

As the above recommendations are implemented Recommendations 6.3.1, 6.3.2, and 6.4.1 should be implemented as time permits. That is, they should be implemented as soon as possible but should not interfere with implementation of the other recommendations. Similarly, delays with the other recommendations should not delay implementation of these recommendations.

7.0 SUMMARY

In general, the RSE team found a well-operated treatment system. The observations and recommendations mentioned are not intended to imply a deficiency in the work of either the designers or operators but are offered as constructive suggestions in the best interest of the EPA and the public. These recommendations have the obvious benefit of the operational data unavailable to the original designers.

The treatment plant regularly meets the discharge criteria and the pump and treat system has successfully reduced discharge of contaminated groundwater to nearby surface water. As a result, the RSE team does not provide specific recommendations with regard to effectiveness. The RSE team does, however, make several recommendations that, if implemented, could result in significant cost savings. These recommendations include replacing the current diffused air strippers with a more efficient model, reexamining the NPDES permit and potentially bypassing the PACT system, and reducing process and aquifer monitoring. With regard to technical improvement of the site operations, the RSE team recommends modifying the monitoring well sampling and the water-level measurement programs. Finally, it is the opinion of the RSE team that the OU2 remedy will not likely meet the objective of aquifer restoration as stated in the 1990 ROD due to the presence of subsurface contamination that may act as a continuing source of dissolved phase contamination. The RSE team recommends that the site managers consider if the remedy will achieve the OU2 goals of restoration. The RSE team provides strategies that may assist the site managers in bringing the remedy and goals into agreement.

Recommendations, and estimated cost increases/decreases associated with those recommendations, are presented in Table 7-1.

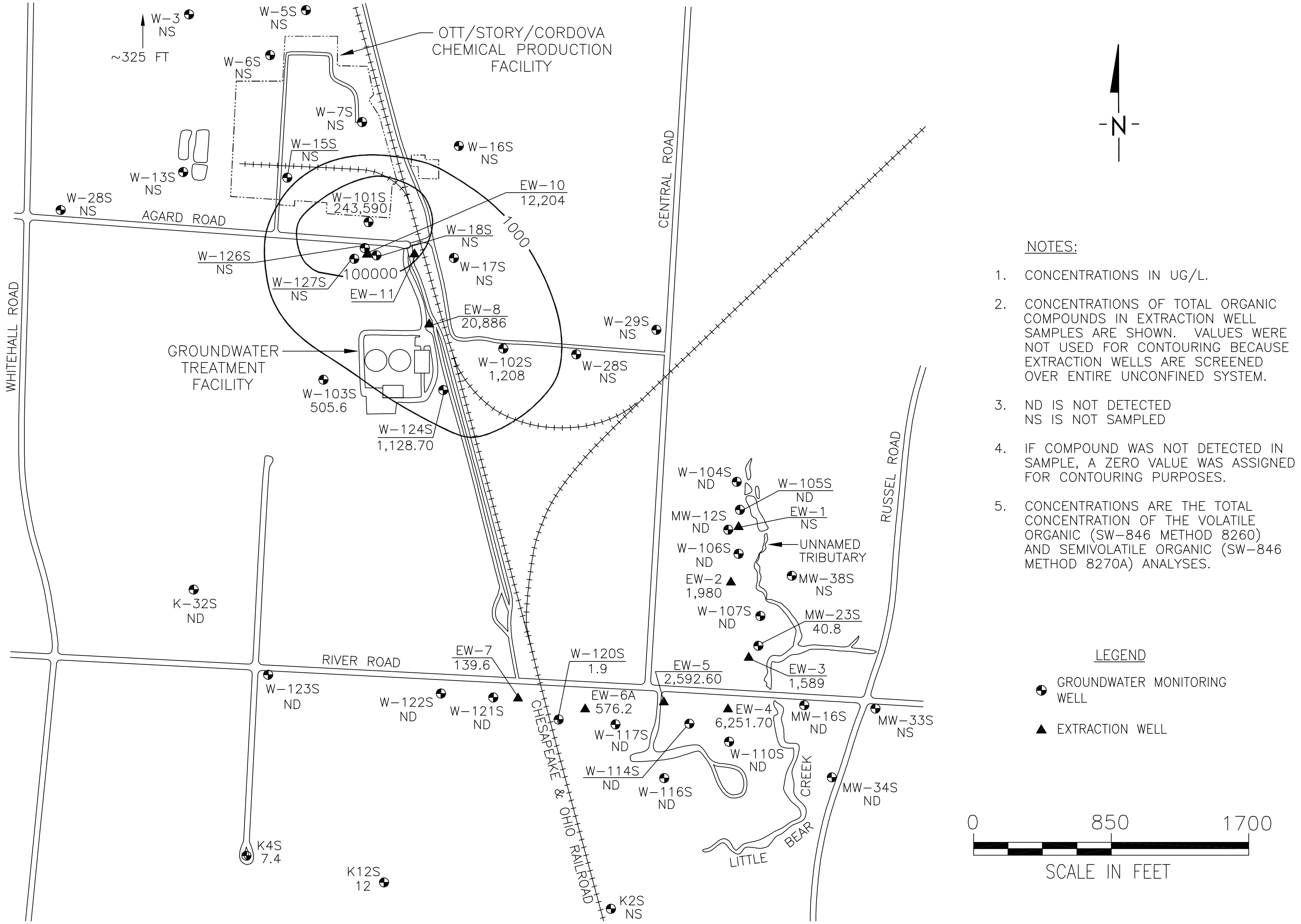
Table 7-1. Cost Summary Table

Recommendation	Reason	Estimated Change in Capital Costs	Estimated Change in Annual Costs	Estimated Change in Lifecycle Costs *	Estimated Change in Lifecycle Costs **
6.2.1 Replace DAS units with tray aerators or packed towers	Cost Reduction	$750,000	($192,000)	($5,010,000)	($3,094,000)
6.2.2 Reexamine NPDES permit and potentially bypass PACT system	Cost Reduction	$400,000	($696,000)	($20,480,000)	($11,215,000)
6.2.3 Reduce process monitoring and analysis	Cost Reduction	$0	($50,000) to ($100,000)	($1,500,000) to ($3,000,000)	($806,000) to ($1,612,000)
6.2.4 Reduce aquifer monitoring and analysis	Cost Reduction	$0	($55,000)	($1,650,000)	($886,000)
6.2.5 Remove excess equipment and do not construct the planned storage building	Cost Reduction	Not quantified	Not quantified	Not quantified	Not quantified
6.2.6 Evaluate potential reduction in onsite presence of USACE	Cost Reduction	Not quantified	Not quantified	Not quantified	Not quantified
6.2.7 Remove trailers from the site	Cost Reduction	Not quantified	Not quantified	Not quantified	Not quantified
6.2.8 Have onsite staff conduct sampling for OU3	Cost Reduction	$0	($15,000)	($450,000)	($242,000)
6.3.1 Establish consistent sampling method	Technical improvement	$2,000	$0	$2,000	$2,000
6.3.2 Modify program for water-level measurement	Technical improvement	$0	$0	$0	$0
6.4.1 Establish agreement between the OU2 remedy and ROD	Site Closeout	Not quantified	Not quantified	Not quantified	Not quantified

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. SITE LAYOUT OF THE OTT/STORY/CORDOVA SUPERFUND SITE INDICATING SAMPLING AND ANALYSIS RESULTS OF THE UPPER PORTION OF THE UNCONFINED AQUIFER FROM THE MARCH 2001 SAMPLING EVENT.

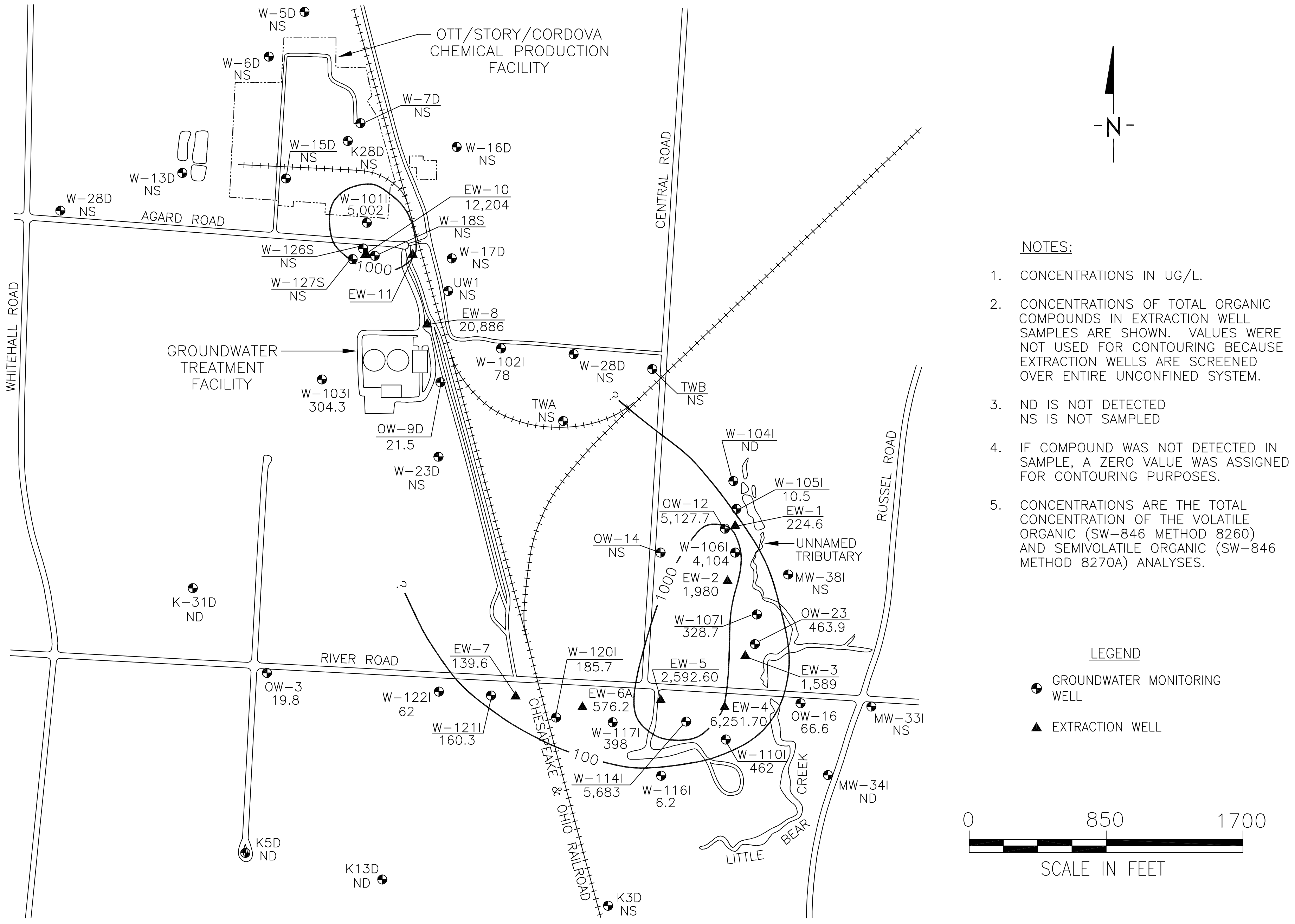


NOTES:

1. CONCENTRATIONS IN UG/L.
2. CONCENTRATIONS OF TOTAL ORGANIC COMPOUNDS IN EXTRACTION WELL SAMPLES ARE SHOWN. VALUES WERE NOT USED FOR CONTOURING BECAUSE EXTRACTION WELLS ARE SCREENED OVER ENTIRE UNCONFINED SYSTEM.
3. ND IS NOT DETECTED
   NS IS NOT SAMPLED
4. IF COMPOUND WAS NOT DETECTED IN SAMPLE, A ZERO VALUE WAS ASSIGNED FOR CONTOURING PURPOSES.
5. CONCENTRATIONS ARE THE TOTAL CONCENTRATION OF THE VOLATILE ORGANIC (SW-846 METHOD 8260) AND SEMIVOLATILE ORGANIC (SW-846 METHOD 8270A) ANALYSES.

(Figure reproduced from Figure 4.1 of the Groundwater Summary Report--Quarter 21, Ott/Story/Cordova Operable Units 1 and 2, Black and Veatch Special Projects Corp., June 2001).

FIGURE 1-2. SITE LAYOUT OF THE OTT/STORY/CORDOVA SUPERFUND SITE INDICATING SAMPLING AND ANALYSIS RESULTS OF THE LOWER PORTION OF THE UNCONFINED AQUIFER FROM THE MARCH 2001 SAMPLING EVENT.



NOTES:

1. CONCENTRATIONS IN UG/L.
2. CONCENTRATIONS OF TOTAL ORGANIC COMPOUNDS IN EXTRACTION WELL SAMPLES ARE SHOWN. VALUES WERE NOT USED FOR CONTOURING BECAUSE EXTRACTION WELLS ARE SCREENED OVER ENTIRE UNCONFINED SYSTEM.
3. ND IS NOT DETECTED
NS IS NOT SAMPLED
4. IF COMPOUND WAS NOT DETECTED IN SAMPLE, A ZERO VALUE WAS ASSIGNED FOR CONTOURING PURPOSES.
5. CONCENTRATIONS ARE THE TOTAL CONCENTRATION OF THE VOLATILE ORGANIC (SW-846 METHOD 8260) AND SEMIVOLATILE ORGANIC (SW-846 METHOD 8270A) ANALYSES.

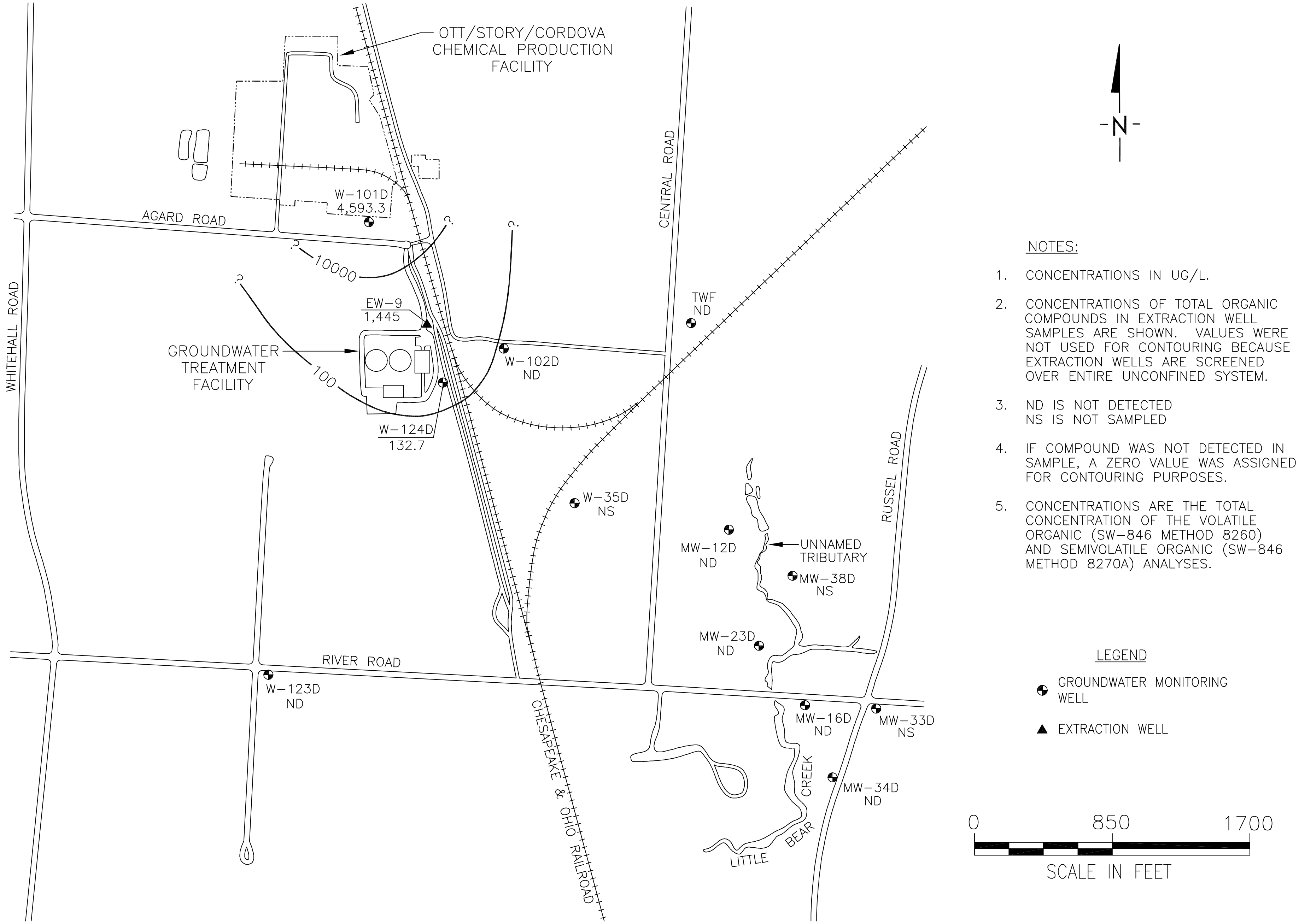
LEGEND

◓ GROUNDWATER MONITORING WELL

▲ EXTRACTION WELL

(Figure reproduced from Figure 4.4 of the Groundwater Summary Report--Quarter 21, Ott/Story/Cordova Operable Units 1 and 2, Black and Veatch Special Projects Corp., June 2001).

FIGURE 1-3. SITE LAYOUT OF THE OTT/STORY/CORDOVA SUPERFUND SITE INDICATING SAMPLING AND ANALYSIS RESULTS OF THE SEMI-CONFINED AQUIFER FROM THE MARCH 2001 SAMPLING EVENT.

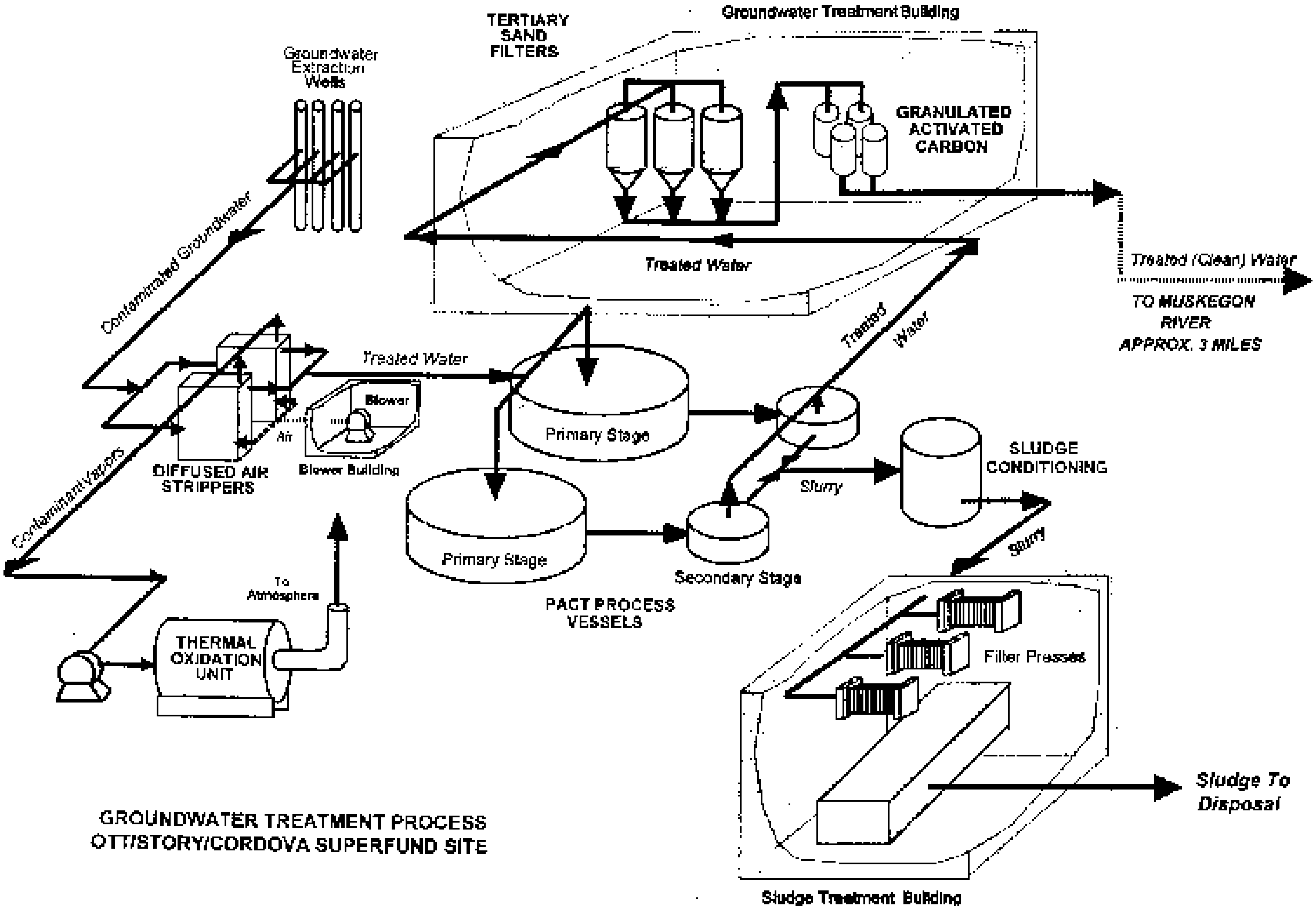


NOTES:

1. CONCENTRATIONS IN UG/L.
2. CONCENTRATIONS OF TOTAL ORGANIC COMPOUNDS IN EXTRACTION WELL SAMPLES ARE SHOWN. VALUES WERE NOT USED FOR CONTOURING BECAUSE EXTRACTION WELLS ARE SCREENED OVER ENTIRE UNCONFINED SYSTEM.
3. ND IS NOT DETECTED
   NS IS NOT SAMPLED
4. IF COMPOUND WAS NOT DETECTED IN SAMPLE, A ZERO VALUE WAS ASSIGNED FOR CONTOURING PURPOSES.
5. CONCENTRATIONS ARE THE TOTAL CONCENTRATION OF THE VOLATILE ORGANIC (SW-846 METHOD 8260) AND SEMIVOLATILE ORGANIC (SW-846 METHOD 8270A) ANALYSES.

(Figure reproduced from Figure 4.7 of the Groundwater Summary Report--Quarter 21, Ott/Story/Cordova Operable Units 1 and 2, Black and Veatch Special Projects Corp., June 2001).

FIGURE 2-1. SITE LAYOUT OF THE OTT/STORY/CORDOVA SUPERFUND SITE INDICATING SAMPLING AND ANALYSIS RESULTS OF THE UPPER PORTION OF THE UNCONFINED AQUIFER FROM THE MARCH 2001 SAMPLING EVENT.



(Note: This figure was provided to the RSE team by the superintendent (FTH&C) of the Groundwater Treatment Facility.)

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