

COST AND PERFORMANCE REPORT

Pump and Treat of Contaminated Groundwater at the
King of Prussia Technical Corporation Superfund Site
Winslow Township, New Jersey

September 1998



Prepared by:

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office

SITE INFORMATION

Identifying Information:

King of Prussia Technical Corporation
Winslow Township, New Jersey

CERCLIS # NJD980505341

ROD Date: September 9, 1990

Treatment Application:

Type of Action: Remedial

Period of operation: April 1995 - Ongoing
Data collected through December 31, 1997

Quantity of groundwater treated during application: 151.5 million gallons

Background [1,2,3]

Historical Activity that Generated

Contamination at the Site: Waste disposal and recycling

Corresponding SIC Code: 4953, Sanitary Services - Refuse Systems

Waste Management Practice That

Contributed to Contamination: Discharge of waste to surface impoundment/lagoon; unauthorized dumping

Location: Winslow Township, New Jersey

Facility Operations:

- The 10-acre King of Prussia (KOP) site is located in a light industrial area and is bordered to the northeast, northwest, and southwest by a wooded state park and to the southeast by Piney Hollow Road.
- The KOP Technical Corporation operated as a waste disposal and recycling facility from January 1971 until early 1974.
- Six lagoons were used to process industrial waste. An on-site swale directed site runoff toward the Great Egg Harbor River, located approximately 1,000 feet southwest of the site.
- The swale has been designated a wetlands, and the Great Egg Harbor is used for recreational purposes.
- EPA estimates that, while in operation, the KOP Technical Corporation processed at least 15 million gallons of acid and alkaline waste at this site. Drums of VOCs were buried at the site. Also, trash and

hazardous waste are suspected to have been dumped at the site illegally between 1976 and 1988 after KOP ceased operations.

- Soil and groundwater contamination were detected by the State of New Jersey in 1976. Subsequently, the KOP site was added to the National Priorities List (NPL) in September 1983. As part of initial removal actions conducted from 1985-1989, EPA excavated plastic containers and metal drums.
 - Elevated levels of metals were identified in soils, lagoon sludges, swale sediment, and groundwater at the site. Elevated levels of volatile organic compounds (VOCs) were detected in soils in the drum disposal area and in the groundwater.
 - Soil and sediment were remediated on site by soil washing in 1993. Tankers and buried drums were removed and disposed of off site.
 - A cost and performance report entitled *Soil Washing at the King of Prussia Technical Corporation Superfund Site, Winslow Township, New Jersey* was previously prepared about the soil washing application at this site.
- Regulatory Context:**
- A Record of Decision (ROD) was issued for the site in September 1990 and included remedial activities for operable unit 1 (OU1) for soil and sediment contaminated with metals, OU2 for removal of contaminated soil in the area of the buried drums, and OU3 for groundwater.



SITE INFORMATION (CONT.)

Background (Cont.)

- Site activities are conducted under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), §121, and the National Contingency Plan (NCP), 40 CFR 300.

Groundwater Remedy Selection: The selected remedy for OU4, groundwater remediation, was extraction of groundwater followed by treatment for metals and VOCs to capture the contaminated groundwater and prevent discharge of contaminants to the Great Egg Harbor River. The ROD also designated on-site groundwater treatment to remove contaminants from the collected groundwater, followed by a system to reinject treated groundwater into the aquifer.

Site Logistics/Contacts

Site Lead: PRP

Oversight: EPA

PRP Contact:

Frank Opet*
PRP Coordinator
Johnson Matthey
2001 Nolte Drive
West Deptford, NJ 08066
(609) 384-7222

Remedial Project Manager:

Jon Gorin*
U.S. EPA Region 2
290 Broadway, 19th Floor
New York, NY 10007-1866
(212) 637-4361

Treatment System Vendor:

Operations: Geraghty and Miller, Inc.
Treatment System Vendor: Andco
Environmental Processes, Inc.

*Indicates primary contacts

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System: Groundwater

Contaminant Characterization [1,2,4]

Primary Contaminant Groups: Metals, VOCs

- The contaminants of greatest concern at this site are metals and VOCs. The metals of concern are beryllium, chromium, copper, and nickel. The VOCs of concern are 1,1-dichloroethane (1,1-DCA), *trans*-1,2-dichloroethylene (*trans*-1,2-DCE), 1,1,1-trichloroethane (1,1,1-TCA), trichloroethylene (TCE), 1,1,2,2-tetrachloroethane (1,1,2,2-PCA), tetrachloroethylene (PCE), benzene, toluene, and ethylbenzene.
- Cleanup standards are set for total chromium. Likewise, laboratory analyses test for total chromium. For these reasons, chromium levels tested and regulated at the KOP site are for total chromium.
- Figure 1 illustrates the site layout and the contaminant plumes as delineated using 1993 sampling data. Figure 1 is a compilation of drawings provided by the PRP coordinator. During the 1985-1989 remedial investigation, the metals and VOC plumes were determined to be commingled but originating from different sources.



MATRIX DESCRIPTION (CONT.)

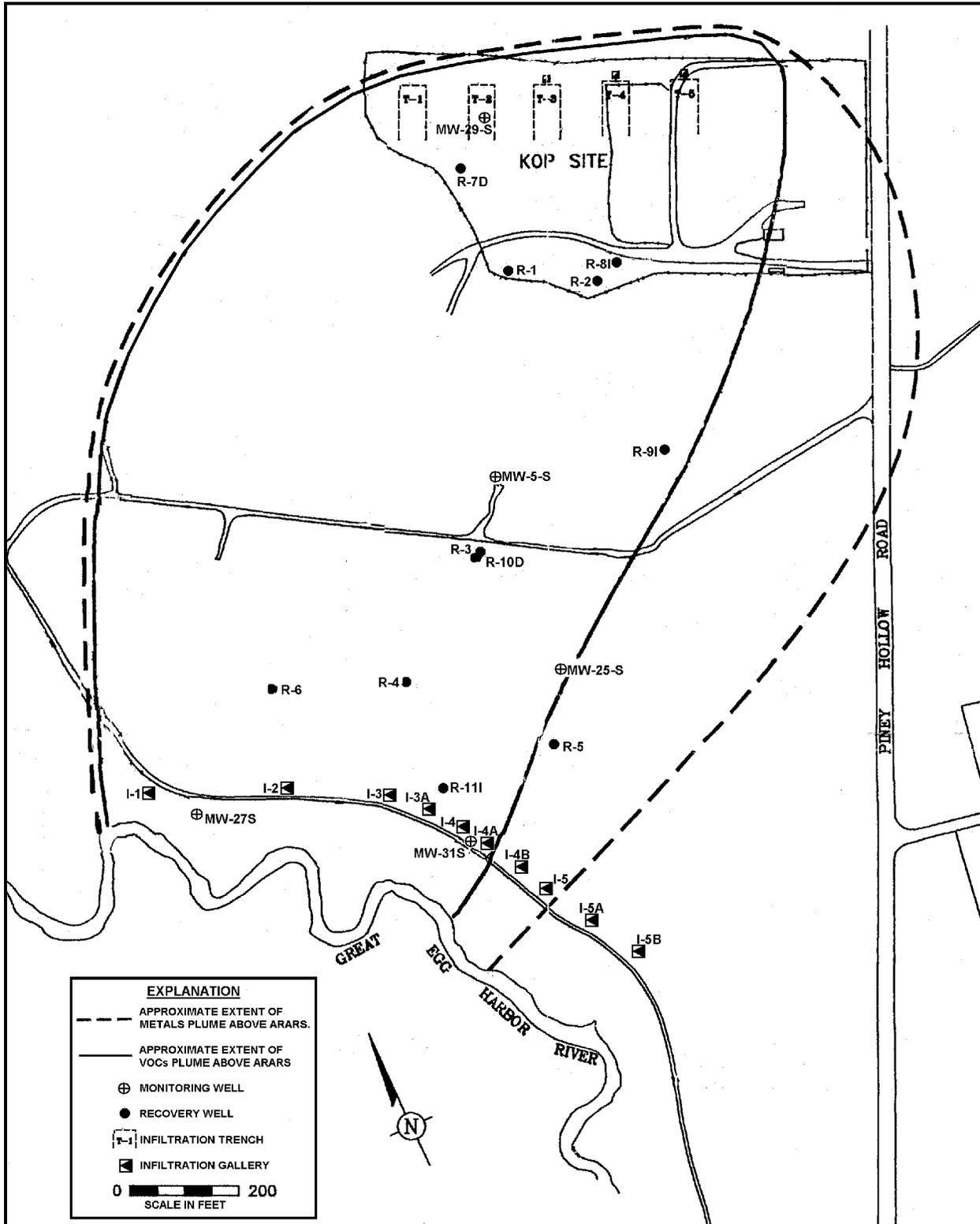


Figure 1. Approximate Areal Extent of Metals and VOCs Plumes (1993) [3]

MATRIX DESCRIPTION (CONT.)

Contaminant Characterization (Cont.)

- The metals plume originated from wastes that were dumped throughout the site onto the soil in lagoons and in the former swale. Contamination in the metals plume is evenly distributed, with hot spots around wells 5-S (center of the plume) and 29-S (northern portion of the plume).
- The maximum initial metals concentrations detected by EPA during remedial investigations from 1985-1989 in the shallow, or upper, aquifer were 100 µg/L (beryllium), 1,040 µg/L (chromium), 12,500 µg/L (copper), and 4,670 µg/L (nickel). The metals contamination is 99% contained in the upper aquifer. Cadmium, mercury, and zinc were detected in the shallow aquifer, but at concentrations below concern.
- The upper 10 to 15 feet of the deep aquifer is referred to as the intermediate aquifer. Copper and nickel were the only two compounds that were detected at concentrations of concern in the intermediate aquifer. The maximum initial concentrations of copper and nickel detected during the 1985-1989 remedial investigation in the intermediate aquifer were 3,070 µg/L and 899 µg/L, respectively.
- Chromium was the only metal detected at levels of concern in the deep aquifer. The maximum chromium concentration detected during the 1985-1989 remedial investigation was 77 µg/L.
- The VOC plume originated at the northeastern end of the site in the shallow aquifer, in the former drums location. This area is noted in Figure 1 as the location of the infiltration trenches. Contamination in the VOC plume is concentrated in the northeastern part of the plume, with the highest contamination in well 29-S.
- The maximum initial VOC concentrations detected during the 1985-1989 remedial investigation in the shallow aquifer were 1,1-DCA at 64 µg/L; *trans*-1,2- DCE at 12 µg/L; 1,1,1-TCA at 2,200 µg/L; TCE at 940 µg/L; 1,1,2,2-PCA at 2,900 µg/L; PCE at 2,500 µg/L; benzene at 8 µg/L, toluene at 190 µg/L and ethylbenzene at 80 µg/L [1]. However, PCE was detected at levels as high as 20,000 µg/L during an April 1995 sampling event.
- TCE was the only VOC detected at levels of concern in the deep aquifer. The maximum initial concentration of TCE detected during the 1985-1989 remedial investigations in the deep aquifer was 3 µg/L.

Matrix Characteristics Affecting Treatment Costs or Performance

Hydrogeology [1]:

The site is underlain by unconsolidated Coastal Plain sediments of unconsolidated sands, gravels, and clays. Underlying the sediment formations is relatively low permeability metamorphic bedrock.

Two hydraulic units were identified in the Remedial Investigation/Feasibility Study (RI/FS) at the KOP site. Both of these aquifers are part of the regional Kirkwood-Cohansey Aquifer system. The shallow aquifer begins at 15 feet and extends to approximately 35 feet below ground surface. A 10- to 20-foot semiconfining layer separates the shallow and deep aquifers and is composed predominately of discontinuous silt and clay zones. The deep aquifer extends downward from 50 feet to approximately 250 feet below ground surface. The upper 10 to 15 feet of the deep aquifer is referred to as the intermediate aquifer.



MATRIX DESCRIPTION (CONT.)

Matrix Characteristics Affecting Treatment Costs or Performance (Cont.)

The groundwater flow direction at the KOP site is southwest, towards the Great Egg Harbor River. Lateral groundwater flow in the shallow and deep aquifers is approximately 1 and 0.4 foot per day, respectively. The shallow aquifer discharges to the Great Egg Harbor River, while the deep aquifer may only discharge a minor flow component to the river. Contamination from metals and VOCs are primarily in the shallow aquifer.

There are no residential wells in the vicinity of the site. Two wells, neither of which serve as potable water supplies, are located within a half-mile radius of the site. The nearest residential water wells are located approximately one mile northeast and upgradient of the site.

Tables 1 and 2 present technical aquifer information and well data, respectively.

Table 1. Technical Aquifer Information

Unit Name	Thickness (ft)	Conductivity (ft/day)	Average Linear Velocity (ft/day)	Flow Direction
Shallow	20	56-100	1.0	Southeast
Deep*	200	55-62	0.4	Southeast

*The upper 10-15 feet of the deep aquifer are referred to as the intermediate zone in some reports.

Source: [1]

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology

Pump and treat (P&T) with an electrochemical system and granular activated carbon treatment

Supplemental Treatment Technology

None

System Description and Operation [3.4.8]

Table 2. Technical Well Data

Well Name*	Unit Name	Depth (ft)
R-1S	Shallow	34
R-2S	Shallow	34
R-3S	Shallow	28
R-4S	Shallow	26
R-5S	Shallow	42
R-6S	Shallow	26
R-7D	Deep	95
R-8I	Deep	51
R-9I	Deep	50
R-10D	Deep	92
R-11I	Deep	57

* S denotes well screened in shallow aquifer, I denotes well screened in upper 10-15 feet of the deep aquifer (intermediate), and D denotes well screened in lower portion of the deep aquifer.

Source: [2]



TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation (Cont.)

System Description

- The extraction well system includes 11 wells throughout the plume, as listed in Table 2.
- The shallow recovery wells are designed to pump a total of 175 gpm from the shallow aquifer. The deep and intermediate wells are designed to pump a total of 25 gpm from the deep aquifer. These pump rates were determined using the computer models MODFLOW and MT3D.
- Two recovery wells, R-1 and R-2, were placed in the shallow aquifer near the buried drums area at the northern portion of the plume. Recovery wells R-7D and R-8I were placed in the deep aquifer in the same area.
- Recovery wells R-10D and R-9I were placed in the deep aquifer at the center of the plume, where the greatest metals contamination is located. Recovery well R-3 was placed in the shallow aquifer in the same area.
- Recovery wells R-4, R-5, and R-6 were placed in the shallow aquifer and R-11I in the deep aquifer at the toe of the plume.
- Groundwater is pumped through the wells to an equalization tank to regulate flow. It is then fed into an electrochemical treatment system.
- The electrochemical system, developed by Andco Environmental Processes, Inc., is a heavy metals removal process that can be applied to chromium-, copper-, and nickel-contaminated groundwater. A direct current is conducted through a cell containing carbon steel electrodes, which generates ferrous iron, reducing Cr^{+6} to Cr^{+3} . Trivalent chromium then complexes with hydroxyl groups to form chromium hydroxide, which is insoluble in water. The electrodes are consumed in generating the ferrous ions and require periodic replacement. The reaction occurs at a pH of six to nine. Copper and nickel form insoluble hydroxides and precipitate out at a pH of six

to nine. The electrochemical system reduces the chromium and copper concentrations to less than 10 $\mu\text{g/L}$, and nickel concentrations to less than 20 $\mu\text{g/L}$.

- After metals treatment, the water passes through an inclined plate clarifier for sludge separation. Sludge is pumped out, dewatered, and disposed off-site. Clarified water is sent through a set of multimedia filters.
- Filtered water is passed through two packed air stripping towers to remove organics. GAC units were added because TCA, PCE, and TCE did not meet effluent requirements. Since the addition of GAC, the effluent meets requirements.
- Treated effluent is tested for effluent contaminant criteria. Of the effluent, 40% is reinjected through five infiltration trenches upgradient of the plume and 60% is reinjected through 10 infiltration galleries downgradient of the plume.
- Reinjected water works to recharge the aquifer as well as to desorb contaminants from the aquifer material into the groundwater.
- Groundwater is monitored according to the Long Term Monitoring Plan (LTMP), which requires quarterly testing of five monitoring wells and annual monitoring of 13 monitoring wells.

System Operation

- Quantity of groundwater pumped from the aquifer in gallons:

	Total Gallons Pumped	Aquifer
3/95-3/31/96	55.1 million	Shallow and deep
4/1/96-3/31/97	55.5 million	Shallow and deep
4/1/97-12/31/97	40.9 million	Shallow and deep



TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation (Cont.)

- The order of treatment units was optimized for efficiency and minimal operational problems. Metals removal is followed by air stripping and carbon polishing for organics.
- The treatment system has been operational approximately 76% of the time. The major downtime occurred between February 10, 1997 and April 1, 1997 to repair a crack in one filter. Also, during this shutdown, multimedia filter tanks were emptied to allow re-engineering of the system in all tanks and installation of new media in the proper order for maximum filtration [2].
- The agreed time frame of two years and eight months of monitoring under the Long Term Monitoring Plan has ended, and a new proposal will be provided by the PRPs to EPA for sampling in the future [2]. The past monitoring plan will be used until a new one is developed [3].
- According to operations contractor, Geraghty and Miller, Inc., as of December 1997, the groundwater elevations at the site have achieved steady-state under the current pumping scheme. At this point, the groundwater flow and contaminant transport at the site will be reevaluated using MODFLOW and MT3D to evaluate remediation enhancements, including adding or removing extraction wells [5]. The site operator is considering pumping changes.
- Monitoring data indicate that contaminant levels in the deep aquifer are below cleanup criteria [2]. According to the PRP representative, the redeveloped monitoring plan and remediation enhancements may focus on remediation of the shallow aquifer [3]. The requested change is awaiting EPA approval.
- The PRP contact also indicated that, after cleaning the well and changing a pump, pump rates in R-1 were increased in 1998. The organics concentrations in the area of MW-29S decreased as a result of the higher pumping rates.

Operating Parameters Affecting Treatment Cost or Performance

A major operating parameter affecting cost or performance for pump and treat is the extraction rate. Table 3 presents design values for this and other performance parameters.

Table 3. Performance Parameters [1,3]

Parameter	Value	
Design Pump Rate	175 gpm, upper aquifer 25 gpm, lower aquifer	
Performance Standard (Effluent)	Be	4.0 µg/L
	Cd	10 µg/L
	Cr	50 µg/L
	Cu	1,000 µg/L
	Mercury (Hg)	2 µg/L
	Ni	210 µg/L
	Zn	5,000 µg/L
	1,1-DCA	2 µg/L
	<i>trans</i> -1,2-DCE	10 µg/L
	1,1,1-TCA	26 µg/L
	TCE	1 µg/L
	1,1,2,2-PCA	1.4 µg/L
	PCE	1 µg/L
	Benzene	1 µg/L
	Toluene	2,000 µg/L
	Ethylbenzene	50 µg/L
Remedial Goal (Aquifer)	same as Performance Standards	



TREATMENT SYSTEM DESCRIPTION (CONT.)

Timeline

Table 4 presents a timeline for this remedial project.

Table 4. Timeline

Start Date	End Date	Activity
9/29/90	---	ROD signed
8/94	---	Remedial Design completed
3/93	11/93	Soil washing performed
4/95	Ongoing	Groundwater extraction, treatment, and quarterly monitoring
Ongoing	---	Recalibration of groundwater models, reanalysis of extraction well placement, consideration of remedial alternatives

Source: [1-3]

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards

The remedial goal for the site is to reduce concentrations of contaminants at the site to below the Maximum Contaminant Levels (MCLs) set by the New Jersey Safe Drinking Water Act and the Primary Drinking Water Standards. The required cleanup levels are listed above in Table 3 and are applied throughout both the shallow and deep aquifers, as measured in all monitoring wells [1].

Treatment Performance Goals

- Effluent discharged from the treatment system must meet the remedial goals listed in Table 3 for reinjection [1].
- The extraction system is designed to create an inward hydraulic gradient to contain the plume [1].

Performance Data Assessment [2,3]

For the purpose of this analysis, metals include beryllium, cadmium, chromium, copper, mercury, and zinc and total VOCs include 1,1-DCA, trans-1,2-DCE, 1,1,1-TCA, TCE, 1,1,2,2-PCA, PCE, benzene, toluene, and ethylbenzene.

- Cleanup goals for metals and VOCs appear to have been met in the deep aquifer. Cleanup goals for metals and VOCs have not been met overall in the shallow aquifer;

however, cleanup goals for VOCs have been met in all but two wells in the shallow aquifer.

- Figures 2 and 3 depict the trend of metals and VOC concentrations, respectively, in the shallow aquifer groundwater.
- Based on groundwater monitoring data, the plume appears to have been contained.



TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Assessment (Cont.)

Metals

- Metals concentrations in the shallow aquifer have been reduced to levels below cleanup goals in some wells. Metals goals have been met at the southwest end of the plume.
- Figure 2 illustrates metals concentrations in individual wells with contamination above cleanup goals and the average metals concentrations in the shallow aquifer from September 1994 to March 1997. The concentrations of metals decreased in all wells from September 1994 to April 1995; however, concentrations fluctuated in wells 25-S and 5-S. Well 5-S, located at the center of the site, has the highest concentrations of metals.
- Below are the remaining constituents above cleanup goals in the shallow aquifer:
 - The maximum concentration of beryllium has been reduced by 35%, from 100 µg/L in April 1994 to 65 µg/L in December 1997, above the cleanup goal of 4 µg/L.
 - The maximum concentration of chromium has been reduced by 87%, from 1,040 µg/L detected during the 1985-1989 remedial investigation to 137 µg/L in December 1997, above the cleanup goal of 50 µg/L.
 - The maximum concentration of copper has been reduced by 77%, from 12,500 µg/L detected during the 1985-1989 remedial investigation to 2,900 µg/L in December 1997, above the cleanup goal of 1,000 µg/L.
 - The maximum concentration of nickel has been reduced by 62%, from 1,100 µg/L detected during the 1985-1989 remedial investigation to 680 µg/L in December 1997, above the cleanup goal of 210 µg/L.

VOCs

- In the shallow aquifer, VOC contaminant levels have decreased overall.
- VOC contamination is concentrated in the source areas of wells 5-S and 29-S. Figure 3 illustrates that the VOC concentrations in wells 5-S and 29-S fluctuate, primarily because of fluctuating PCE and 1,1,1-TCA concentrations in the former drum area.
- Wells 5-S and 29-S are the only wells with elevated levels of *trans*-1,2-DCE and 1,1,1-TCA. The remainder of the wells show low levels of TCE, 1,1,2,2-PCA, PCE, and TCE, but no detectable levels of the other organics of concern.
- Below are data on individual VOCs in the shallow aquifer:
 - The concentrations of 1,1-DCA in the shallow aquifer have met cleanup goals. The maximum concentration of 1,1-DCA in the shallow aquifer was reduced from 64 µg/L detected during the 1985-1989 remedial investigation to levels below detection limits in December 1997 (cleanup goal is 2 µg/L).
 - The maximum concentration of *trans*-1,2-DCE in the shallow aquifer has increased from 12 µg/L detected during the 1985-1989 remedial investigation to 160 µg/L in December 1997 (cleanup goal is 10 µg/L).
 - The maximum concentration of 1,1,1-TCA fluctuated from 2,200 µg/L detected during the 1985-1989 remedial investigation to 4,670 in September 1997 to 2,420 in December 1997 (cleanup goal is 26 µg/L).
 - The maximum concentration of 1,1,2,2-PCA has been reduced from 2,900 µg/L detected during the 1985-1989 remedial investigation to 190 µg/L in December 1997 (cleanup goal is 1.4 µg/L).



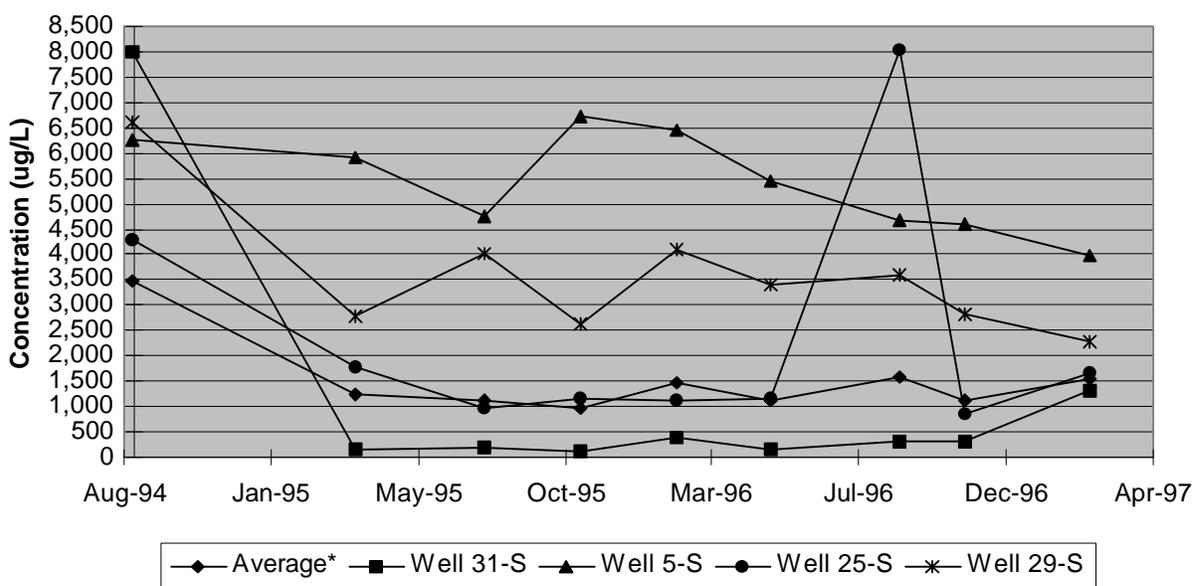
TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Assessment (Cont.)

- The maximum concentration of PCE has fluctuated from 2,500 µg/L detected during the 1985-1989 remedial investigation, to 20,000 µg/L in April 1995, to 15,000 µg/L in February 1996, and most recently to 8,160 µg/L in December 1997, above the cleanup goal of 1 µg/L.
- The maximum concentration of TCE in the shallow aquifer has been reduced from 980 µg/L detected during the 1985-1989 remedial investigation to 310 µg/L in December 1997, above the cleanup goal of 1 µg/L.
- Benzene, toluene, and ethylbenzene have been detected solely in well 29-S. In December 1997, ethylbenzene was detected at a concentration of 1,130 µg/L, above the cleanup goal of 50 µg/L. Benzene was detected at levels below detection limits, below the cleanup goal of 1 µg/L. Toluene was detected at 1,130 µg/L, below the cleanup goal of 2,000 µg/L.

Treatment System

- Effluent monitoring results indicate that during January 1997, VOC concentrations in the treatment effluent were slightly above treatment performance goals. After maintenance during treatment system shutdown, treatment performance goals have been met.
- Figure 4 illustrates concentrations of contaminants in the influent to the treatment system. The metals concentration in the influent varied from 20 µg/L in March 1995 to 5,591 µg/L in July 1996 to 2,532 in October 1997. The VOCs concentration in the influent increased from March to June 1995, from 1,236 to 2,170 µg/L, and primarily declined from June 1995 to October 1997.
- During operation from March 1995 through December 1997, the treatment system removed 1,510 lbs of organics and 3,910 lbs of metals, for a total mass removal of 5,420 lbs. The rate of mass removal declined as the mass in the influent declined.



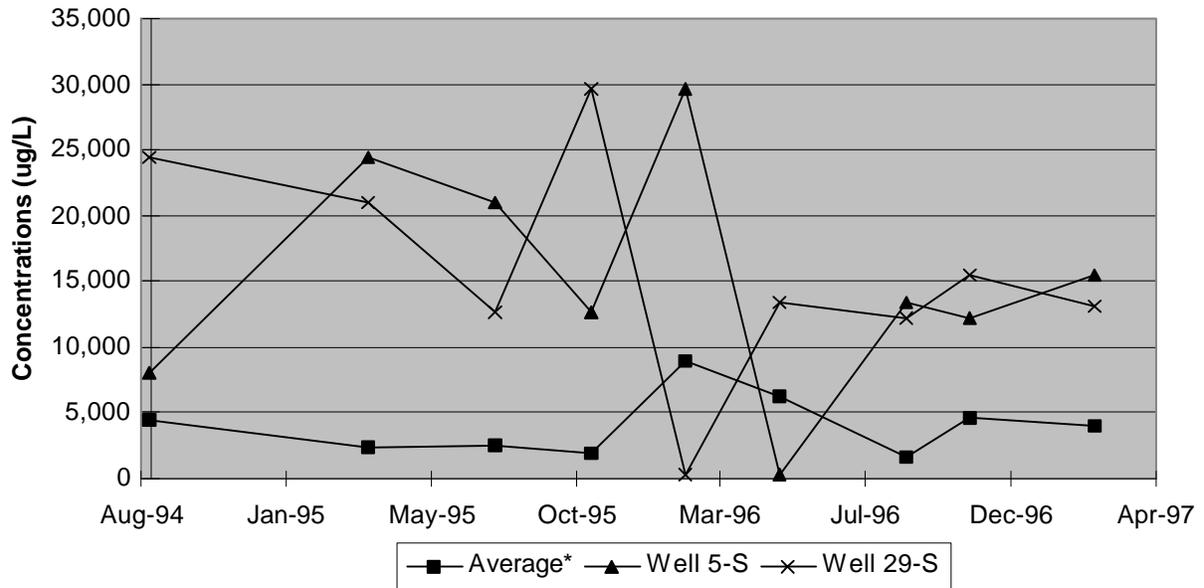
*Average concentrations include wells 5-S, 25-S, 27-S, 29-S, and 31-S

Figure 2. Metals Contaminant Concentrations in the Shallow Aquifer (September 1994 - March 1997) [2]



U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office

TREATMENT SYSTEM PERFORMANCE (CONT.)



*Average concentrations include wells 5-S, 25-S, 27-S, 29-S, and 31-S

Figure 3. VOC Contaminant Concentrations in the Shallow Aquifer (September 1994 - March 1997) [2]

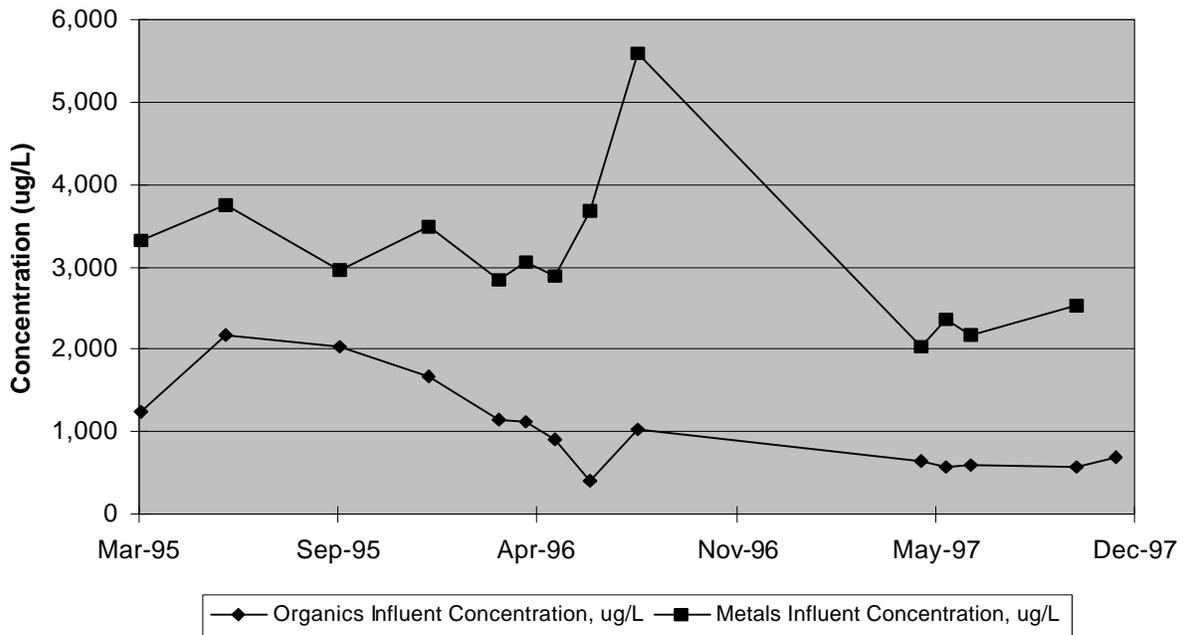


Figure 4. Influent Concentrations to the Treatment System (March 1995 - November 1997) [2]



TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Completeness

- For the contaminant concentrations shown in Figures 2 and 3, quarterly monitoring data were used from September 1994 through March 1997. Annual monitoring data from a separate subset of wells are available from the PRP site contact. However, because the annual data used in conjunction with the quarterly data would not have represented a continuous data set for analysis, these data were not used for Figure 2 and 3 analyses.
- A geometric mean of contaminant concentrations was used to represent the trend of contaminant concentrations across the site for Figures 2 and 3.
- Contaminant concentrations in the influent shown in Figure 4 were reported in quarterly monitoring reports for March 1995 through November 1997.
- Mass removal calculations were reported in quarterly monitoring reports for March 1995 through November 1997.

Performance Data Quality

The QA/QC program used throughout the remedial action met the EPA and the State of New Jersey requirements. All monitoring was performed using EPA-approved methods, and the site contact did not note any exceptions to the QA/QC protocols [2].

TREATMENT SYSTEM COST

Procurement Process

- The PRPs contracted with Geraghty & Miller, Inc. to construct and operate the remedial system, under the oversight of EPA. Geraghty & Miller, Inc. contracted with Andco Environmental Processes, Inc. to provide and install the treatment system.

Cost Analysis

- All costs for investigation, design, construction and operation of the treatment system at this site were borne by the PRPs.

Capital Costs [3]

Remedial Construction	
Groundwater Treatment	\$1,743,563
Equipment	\$927,127
Permits	\$31,637
Construction Management	\$234,548
SOP/D&M Manual	\$63,681
Electrical System Construction	\$130,424
Other Subs	\$194,003
Plant Construction	\$131,924
Cultural Resources	\$30,219
Groundwater Control	\$287,703
Well Construction	\$116,166
Recovery System Construction	\$171,707
Total Construction	\$2,031,430

Operating Costs (1995-1997) [3]

Labor	\$325,760
Travel	\$14,325
Disposal (Sludge and Water)	\$2,432
Chemicals	\$49,226
Lab Supplies	\$1,017
Health & Safety Supplies	\$3,941
Administrative Expenses	\$46,950
Maintenance	\$159,542
Utilities	\$181,501
Total Operations	\$784,694
Operations By Year	
March 1995 - April 1995	\$74,230
May 1995 - April 1996	\$393,740
May 1996 - April 1997	\$284,131
May 1997 - April 1998	\$281,298*
*June 1997 - April 1998 costs of \$251,443 not included in unit costs	



TREATMENT SYSTEM COST (CONT.)

Other Costs [3]

Groundwater Investigations	\$250,860
Groundwater Modeling	\$140,718
Western Plume Boundary	\$40,652
Treatability Study	\$87,247
Treatment System Design	\$304,145
Overall Design Management	\$379,473
Well Installation Costs	\$279,617
Total Other	\$1,482,712

Cost Data Quality

Actual capital and operations and maintenance cost data are available from the PRPs for this application.

OBSERVATIONS AND LESSONS LEARNED

- Actual costs for the P&T application at the KOP site were approximately \$2,816,000 (\$2,031,000 in capital costs and \$785,000 in operating and maintenance costs), which corresponds to \$520 per pound of contaminants removed and \$19 per thousand gallons of groundwater treated, based on cost incurred and treatment performed through December 31, 1997.
- Cleanup goals have been met in the deep aquifer, but not the shallow aquifer. Two shallow wells, in source areas, remain contaminated with VOCs. Four wells remain contaminated with metals.
- The concentrations of VOCs and metals in treatment system influent have decreased faster than concentrations in shallow monitoring wells. Concentrations of PCE and 1,1,1-TCA in these wells were higher during the November 1997 sampling than in the baseline sampling, and concentrations of other contaminants in the wells fluctuated, spiking above baseline sampling levels.
- There are several possible explanations for why treatment influent concentrations are falling faster than concentrations in the shallow monitoring wells. Two conditions would allow extracted water to circumvent the more contaminated areas. One is the tendency of contaminants in the groundwater to travel through preferential pathways, as observed at some Superfund sites [6]. Another possible factor is stagnation zones, which develop where low hydraulic gradients are created in overlapping zones of influence from recovery wells and/or from low permeability zones [7]. Stagnation zones and preferential pathways can be counteracted by adjusting the location and pumping rates of the extraction wells. The PRPs are evaluating P&T performance and will consider such adjustments to optimize mass removal and contaminant reduction [3,5].
- While no dense nonaqueous phase liquid (DNAPL) has been directly observed during sampling, high initial concentrations of TCE and PCE indicated its likely presence. If DNAPL is present at this site, it will lead to persistent plumes, as it dissolves continuously into the aqueous phase. Elimination of possible DNAPL sources, if present, could improve the effectiveness of P&T at this site.



REFERENCES

1. Record of Decision, U.S. EPA, Region 2, September 1990.
2. Quarterly Groundwater Treatment Plant Monitoring Reports, Johnson Matthey, January 16, 1998, April 23, 1997, and April 21, 1996.
3. Correspondence with Mr. Frank J. Opet, Johnson & Matthey, January 30, 1997, February 14, 1997, June 5, 1997, July 15, 1997, August 1, 1997, January 15, 1998, and July 17, 1998.
4. Correspondence with Mr. Jack Reich, Andco Environmental Processes, Inc., February 1998.
5. Correspondence with Mr. Steve Feldman, Geraghty and Miller, Inc., January 19, 1998.
6. Surfactant-Enhanced Remediation of a TCE-Contaminated Aquifer, Smith, James A., Sahoo, D., McLellan, H.M., and Imbrigiotta, T.E. Environmental Science and Technology, 1997, V.31, No-12, 3565-3572.
7. Design Guidelines for Conventional Pump-and-Treat Systems, Robert M. Cohen, James W. Mercer, Robert M. Greenwald, and Milovan S. Beljin. EPA Ground Water Issue, September 1997.
8. Comments on draft report provided by Frank Opet, PRP Representative, July 1998.

Analysis Preparation

This case study was prepared for the U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response, Technology Innovation Office. Assistance was provided by Tetra Tech EM Inc. and Eastern Research Group, Inc. under EPA Contract No. 68-W4-0004.

This Page Intentionally Left Blank