COST AND PERFORMANCE REPORT

Pump and Treat of Contaminated Groundwater at the
U.S. Aviex Superfund Site
Niles, Michigan

September 1998

EPA

Prepared by:

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

SITE INFORMATION

Identifying Information:

U.S. Aviex Superfund Site
Niles, Michigan

CERCLIS #: MID980794556

ROD Date: September 7, 1988

Treatment Application:

Type of Action: Remedial

Period of operation: 7/93 - Ongoing (Performance Data Collected Through December 1996)

Quantity of material treated during application: 329 million gallons of groundwater treated

Background

Historical Activity that Generated Contamination at the Site: Production of industrial organic chemicals

Corresponding SIC Code: 2869, (manufacture of industrial organic chemicals)

Waste Management Practices That Contributed to Contamination: Ruptured drums, leaking underground pipe

Location: Niles, Michigan

Facility Operations: [1, 2]

- The site, a six-acre parcel of land, operated as a non-lubricating automotive fluids manufacturer, from the early 1960s until 1978. Fluid manufacturing included the repackaging of bulk products and the formulation of new products from bulk ingredients.
- In July 1972, an underground pipe carrying diethyl ether (DEE) broke during excavation activities, releasing an unknown quantity to the soil and groundwater.
- In response to the 1972 pipeline break, U.S. Aviex installed five on-site monitoring wells and supplied affected residences with bottled water. No remedial work was documented from 1972 to 1978.
- In November 1978, a fire ruptured chemical-storing drums. The water used to extinguish the fire washed unknown amounts of chlorinated hydrocarbons onto unpaved areas [1]. Operations at the site ceased in 1978.
- After the 1978 release, U.S. Aviex performed a groundwater investigation. In 1982, U.S. Aviex entered into an agreement with the Michigan Department of Environmental Quality (MDEQ) to construct an on-site pump and treat (P&T) system to contain the identified contamination.
- In November 1983, U.S. Aviex began extraction and treatment of groundwater from two extraction wells as an interim remedy during the remedial investigation. Contaminated soils were left in place.
- In 1983, the site was placed on the National Priorities List (NPL). In 1987, the MDEQ installed an alternate water supply system to affected residences.
- The Remedial Investigation/Feasibility Study (RI/FS) began in 1985, funded by U.S. Aviex. In 1988, U.S. Aviex was declared bankrupt and the RI/FS was completed by the EPA.
- Currently, EPA is further characterizing the site to determine the full extent of the contaminant plume.

Regulatory Context:

- The 1987 interim remedy was constructed under a 1982 agreement with the MDEQ. The performance data presented in this report do not address the performance of the 1983 interim remedy, but does address performance of the current system from July 1993 to December 1996.

SITE INFORMATION (CONT.)

Background (Cont.)

- The Record of Decision (ROD) for the U.S. Aviex site was signed on September 7, 1988, and addressed both on-site and off-site contamination in the soil and groundwater. The selected remedy for soil remediation was soil flushing; however, it was determined after the ROD during pre-design investigations that the soil was clean. No soil flushing was performed.

- 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.

Remedy Selection: The selected remedy for groundwater treatment is extraction of groundwater, followed by treatment through air stripping, with discharge of treated water to nearby surface water.

Site Logistics/Contacts

Site Lead: EPA-Lead 1988-1996
Michigan Department of Environmental Quality (MDEQ)-Lead 1996-Ongoing

Oversight: EPA

Remedial Project Manager:
Ken Glatz
U.S. EPA Region 5
77 West Jackson Boulevard
Chicago, Illinois 60604-3507
(312) 886-1434

State Contact:
Carl Chavez*
MDEQ
PO Box 30426
Lansing, Michigan 48909-7926
(517) 373-8174

* Indicates Primary Contacts

Treatment System Vendors:
EPA Contractor: Jack Brunner*
Tetra Tech EM Inc. (Formerly PRC Environmental Management, Inc.)
200 East Randolph Drive, Suite 4700
Chicago, Illinois 60601
(312) 856-8700
Air Stripping Tower: LANTAC
Construction Subcontractor: ATEC Associates, Inc.
2777 Finley Road, Unit 4
Downers Grove, Illinois 60515

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System: Groundwater

Contaminant Characterization [1, 3, 4, 5, 6]

Primary Contaminant Groups: Volatile organic compounds (VOCs)

- The groundwater contaminants of concern detected at the site are the following VOCs: benzene, 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE),*trans*-1,2-dichloroethene (*trans*-1,2-DCE), DEE, dichlorofluoromethane (DCFM), tetrachloroethene (PCE), 1,1,1-TCA,

MATRIX DESCRIPTION (CONT.)

trichloroethene (TCE), and trichlorofluoromethane (TCFM). Contamination only has been detected in the upper water table aquifer.

- The index contaminants of the site are DEE, 1,1,1-TCA, and 1,2-DCA.
- The maximum concentrations of the index contaminants detected in on-site wells during a 1985 sampling event (data provided by U.S. Aviex) were 1,1,1-TCA (200,000 µg/L), DEE (5,700 µg/L), and 1,2-DCA (1,600 µg/L). The concentration of 1,1,1-TCA was greater than 60% of its solubility. The maximum concentrations detected in off-site wells during the 1984 sampling event were 1,1,1-TCA (3,000 µg/L), DEE (4,800 µg/L), and 1,2-DCA (1,700 µg/L).
- The concentration of 1,1,1-TCA detected during the 1985 remedial investigation, 200,000 µg/L, is greater than 20% of its solubility limit.
- Figure 1 illustrates contaminant concentrations detected during a 1988 RI/FS sampling episode performed by EPA. The plume extends southwest of the U.S. Aviex property, in the direction of observed groundwater flow.
- Based on the map shown in Figure 1, the initial contaminant plume was estimated to be approximately 18 acres in size. Based on an average depth of 30 feet as measured during the RI/FS and a standard porosity of 0.30, the plume volume in 1988 was calculated for this report to be approximately 53,664,000 gallons.
- From 1996-1997 EPA reexamined the plume. Figure 2 illustrates the plume delineated by data from a December 1996 quarterly sampling event.
- The additional assessment performed in 1997 detected DCA and DEE at concentrations greater than cleanup levels, in wells outside the initially identified plume (see later discussion under performance data assessment).
- DCA has been detected at concentrations above the cleanup level of 90 µg/L up to approximately 2,400 feet northwest of the initial plume boundary.
- DEE has a ROD-specified maximum contaminant level (MCL) of 43 µg/L based on the 1988 MDEQ standard; however, the health-based drinking water (HBDW) standard is currently 3,700 µg/L. No elevated levels of DEE above the current HBDW standard have been detected outside the initial plume. DEE has been detected above the 43 µg/L limit given in the ROD up to approximately 3,900 feet northwest of the initial plume boundary.

Matrix Characteristics Affecting Treatment Costs or Performance [1, 3, 5, 7]

Hydrogeology:

Two distinct hydrogeologic units have been identified beneath this site. The upper water table aquifer is a sand and gravel aquifer which extends from the water table, at approximately 20 feet below ground surface, to approximately 110 feet below ground surface. A discontinuous sandy clay layer divides the upper aquifer from the lower aquifer. Limited data are available on the lower aquifer, but it is known to be an artesian non-flowing aquifer confined by the sandy clay layer in the area of the site. The groundwater flow patterns observed in the confined aquifer are similar to those patterns of the upper aquifer. Replacement residential wells were installed in this aquifer. No contamination has been detected in the lower aquifer in the site vicinity.

MATRIX DESCRIPTION (CONT.)

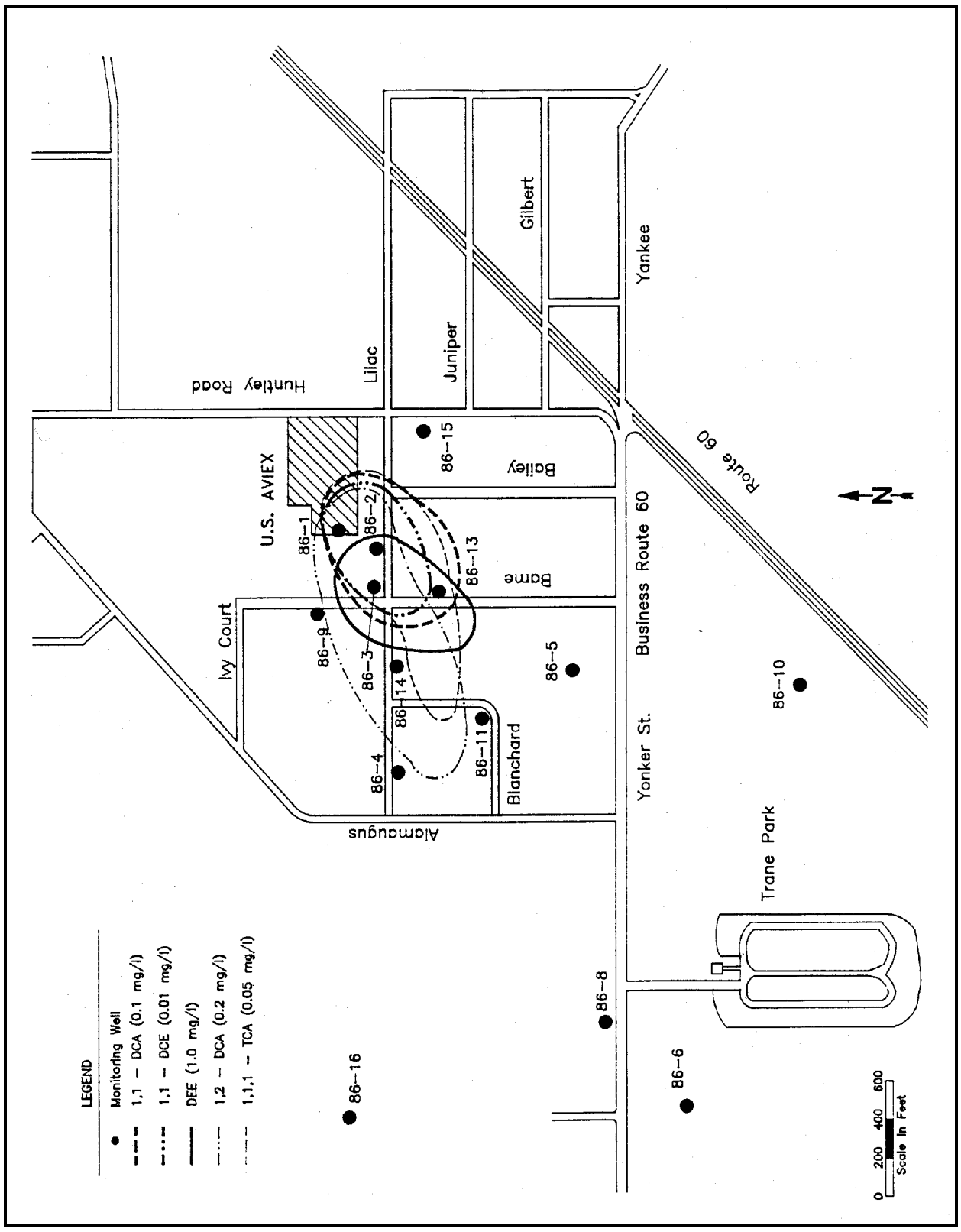

Figure 1. Distribution of Contamination (1988) [7]

MATRIX DESCRIPTION (CONT.)

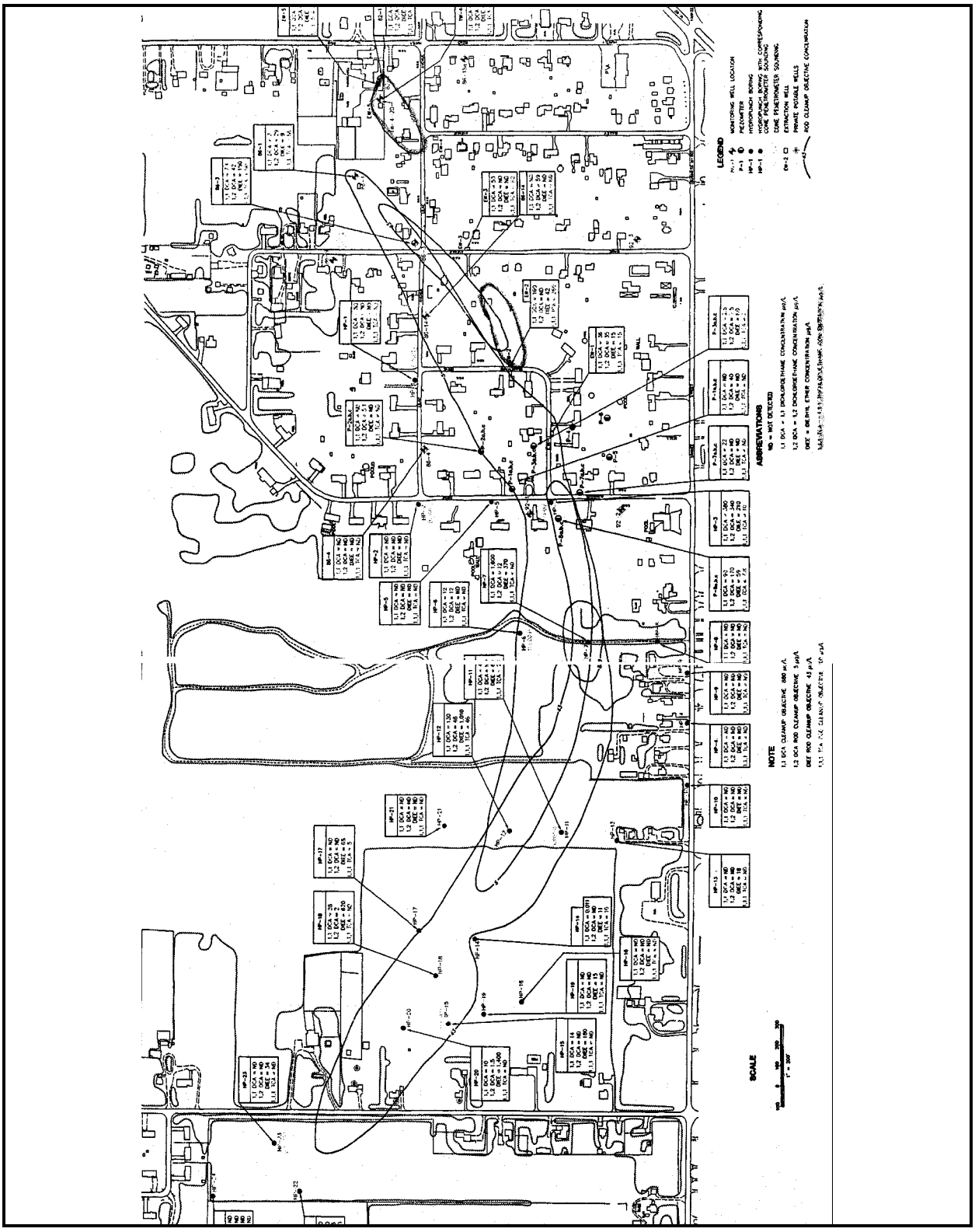

Figure 2. Distribution of Contamination (December 1996) [9]

MATRIX DESCRIPTION (CONT.)

Matrix Characteristics Affecting Treatment Costs or Performance (Cont.)

Groundwater in the site vicinity flows southwest, which concurs with the plume distribution southwest of the source. Prior to startup of remediation in 1993, the contaminant plume migrated further southwest than the previous sampling events indicated. Further characterization has been completed by Tetra Tech EM Inc. for the EPA and MDEQ to determine the extent of the plume, and is reported in their Additional Groundwater Assessment Summary Report.

The additional assessment determined that groundwater in the site vicinity of U.S. Aviex flows southwest, but regionally returns to northwest flow. Further discussion of the assessment is given in the Performance Data Assessment section.

Table 1 includes technical aquifer information.

Table 1. Technical Aquifer Information

Unit Name	Thickness (ft)	Conductivity (ft/day)	Average Velocity (ft/day)	Flow Direction
Upper Aquifer	70-100	9.1 - 45.4	0.5	Southwest*
Lower Aquifer	Not Characterized	Not Characterized	Not Characterized	Not Characterized

* Groundwater flows southwest in the site vicinity, but flows northwest regionally.

Source: [1]

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology

Pump and treat with air stripping

Supplemental Treatment Technology

None

System Description and Operation [2, 3, 5, 8, 10]

Table 2. Extraction Well Data

Well Name	Unit Name	Depth (ft)	Design Yield (gal/min)
EW-1	Upper Aquifer	100	100
EW-2	Upper Aquifer	100	50
EW-3	Upper Aquifer	100	50
EW-4	Upper Aquifer	100	50
EW-5	Upper Aquifer	100	50

Source: [1]

System Description

- In 1982, U.S. Aviex entered into an agreement with the MDEQ to construct a P&T system in an effort to prevent further migration of the groundwater contaminant plume detected both on and off site. The P&T system consisted of two extraction wells, an air stripper, and a force main.
- The extraction wells were placed on site in the area of the 1978 release to hydraulically contain the source. Groundwater was extracted, passed through the air stripper, and pumped to the force main outfall.
- This P&T system was an interim remedy that operated from 1982 until its shutdown in 1988. No monitoring data were available from MDEQ or EPA records for operation

TREATMENT SYSTEM DESCRIPTION (CONT.)

from 1982 until 1988. Therefore, this report does not address the cost or performance of this interim remedy.

- After the RI/FS was conducted in 1985 to characterize contamination in the area and the ROD was signed in 1988, the existing P&T system was modified to meet requirements specified by the EPA in the ROD.

- The two extraction wells constructed as part of the 1982 P&T system were replaced in 1993 by a network of five extraction wells at a depth of 100 feet. Table 2 presents a summary of extraction well data and the specific design extraction rates. The total system design extraction rate is 300 gallons per minute (gpm). Assuming the system is operational 95% of the time and total extraction is 329 million gallons, the actual average volume of water treated is estimated to be approximately 190 gpm.

- The air stripper from the 1982 P&T system was retrofitted to meet the new remedial design requirements. The operating air stripper is 56 feet tall and 4 feet in diameter. Influent wastewater is distributed over a bed of plastic media, 46 feet high, packed in the air stripper. Air introduced at the bottom of the tower passes countercurrent to the groundwater, stripping the contaminants from the groundwater. The effluent vapor from the air stripper is discharged directly to the atmosphere. Treated water from the air stripper is ultimately discharged to the St. Joseph River via an effluent force main to the Bame-Huntley drain in accordance with National Pollutant Discharge Elimination System (NPDES) permit requirements.

- Groundwater quality is monitored through the five extraction wells and surrounding network of 18 monitoring wells. Groundwater flow is monitored through a network of 10 piezometers.

System Operation

- Quantity of groundwater pumped from aquifer in gallons (gal):

Year	Average Volume Pumped (Gal)
1993	58,850,000
1994	104,650,000
1995	79,720,000
1996	86,120,000
1997	67,290,000

- The site is operational 95% of the time. The treatment system is shut down four times per year or as needed for cleaning of the wells and system maintenance.

- The present extraction system was designed to contain the contaminant plume defined in the 1988 RI/FS and to allow for optimization of groundwater extraction rates from wells in source zone areas and off-property.

- EW-1 is located at the downgradient edge of the plume. Modflow and Randomwalk computer models determined that an extraction rate of 100 gpm from EW-1 would contain the plume. The other extraction wells, also analyzed by computer model, were designed to remove groundwater from areas closer to the source areas.

- The average groundwater extraction rates from 1993 until 1996 for each extraction well are listed below:

Well	Average Pumping Rate (gal/min)
EW-1	133
EW-2	24
EW-3	12
EW-4	16
EW-5	47

- Pumping from EW-1 was increased from 123 gpm in 1994 to 159 gpm in 1996, in an effort to contain the contaminant plume. At system operation startup in 1993, contaminant concentrations were detected

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation (Cont.)

above clean-up levels in wells installed outside the remedial system capture zone to monitor collection system performance. To increase the system capture zone, pumping from EW-1 was increased. This approach has not been completely successful and the extent of the plume was re-investigated. The investigation by the EPA and state concluded that historical contamination existed outside the original plume, as discussed in the Performance Data Assessment section of this report.

- Because low levels of contamination were detected in extraction wells EW-3 and EW-4, these wells were shut down from 1994 through December 1996.
- Pumping from EW-2 was adjusted according to fluctuations in contaminant concentrations from this well. When contaminant concentrations decreased in 1995, pumping was decreased. When contaminant concentrations increased in 1996, pumping increased.
- Well EW-5 is located at the source area of the plume. It has pumped at about 50 gallons per minute from 1994 through December 1996.
- New plastic packing material was put in the air stripper in 1993 because of fouling. The packing media has not been changed since that time.
- Based on additional assessment, several options were identified by the treatment vendor for possible expansion of the treatment system [9].

Operating Parameters Affecting Treatment Cost or Performance

The groundwater extraction rate is a major operating parameter affecting cost or performance for this technology. Table 3 presents the average extraction rate between system start up in July 1993 through December 1996 and the required performance parameters.

Table 3: Operating Parameters

Parameter	Value
Average Extraction Rate	190-280 gpm
Remedial Goal (aquifer)	DEE 43 µg/L 1,1,1-TCA 200 µg/L 1,2-DCA 5 µg/L Benzene 5 µg/L Ethylbenzene 680 µg/L Toluene 2,000 µg/L Xylene 440 µg/L Chloroform 2 µg/L 1,1-DCE 7 µg/L TCE 5 µg/L PCE 0.88 µg/L trans-1,2-DCE 700 µg/L trichlorofluoromethene (TCFM) 32,000 µg/L dichlorofluoromethane (DCFM) 3,000 µg/L
Performance Standard (effluent) NPDES Requirements	DEE 275 µg/L 1,1,1-TCA 120 µg/L 1,2-DCA 560 µg/L Benzene 51 µg/L Ethylbenzene 62 µg/L Toluene 100 µg/L Xylene 40 µg/L Chloroform 43 µg/L 1,1-DCE 3 µg/L TCE 94 µg/L PCE 20 µg/L trans-1,2-DCE 90 µg/L TCFM 20 µg/L DCFM 20 µg/L

Source: [1, 8]

TREATMENT SYSTEM DESCRIPTION (CONT.)

Timeline

A timeline for this remedial project is shown in Table 4.

Table 4: Project Timeline

Start Date	End Date	Activity
1982	---	Interim P&T system installed
1986	---	Interim P&T system shut down and RI/FS completed
9/7/88	---	Record of Decision signed
09/88	09/91	Remedial design
4/92	6/93	Remedial construction, including replacement of interim extraction wells
7/93	---	Remedial system begins operations; quarterly monitoring of groundwater begins
1993	---	Contamination detected in downstream monitoring wells; pumping from EW-1 and EW-5 increased
1997	---	Extent of plume examined

Source: [2, 3, 5]

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards [1]

- The cleanup goals for the site are to remediate the groundwater to levels established by the MDEQ and the maximum contaminant levels (MCL) established by the Safe Drinking Water Act (SDWA); these levels are applied throughout the aquifer. The cleanup goals for DEE, 1,1,1-TCA, and 1,2-DCA are listed in Table 3.

Additional Information on Goals [1]

- The MDEQ health-based cleanup concentration for DEE is now 3,700 µg/L, not 43 µg/L as given in the ROD. EPA and MDEQ are deciding on future action regarding the cleanup standard for DEE.
- Emissions during operation of the air stripper will not be monitored because influent groundwater contaminant levels are not significant and vapor emissions comply with Clean Air Act and permitting requirements.

Treatment Performance Goals [1]

- The primary goal for the treatment system is to reduce index contaminant concentrations to levels which meet the NPDES requirements listed in Table 3.
- The secondary goal for the treatment system is to create an inward hydraulic gradient to contain the contaminant plume.

Performance Data Assessment [4, 5, 6, 8, 9]

For this discussion and Figures 2 and 3, total contaminant concentration includes concentrations of benzene, 1,2-DCA, 1,1-DCE, trans-1,2-DCE, DEE, DCFM, PCE, 1,1,1-TCA, TCE, and TCFM. In addition, this discussion addresses system performance only for the current P&T system; the interim system (1982-1986) is not included in this assessment.

- Contaminant concentrations have declined but remain above cleanup goals. The maximum concentration of 1,1,1-TCA has dropped from 200,000 µg/L to 400 µg/L, a 99.8% reduction. The maximum concentration of DEE dropped from 5,700 µg/L to 100 µg/L, a 98% reduction. The maximum concentration of 1,2-DCA dropped from 4,800 µg/L to 33 µg/L, a 99% reduction.
- As illustrated in Figure 3, average total contaminant concentrations have also declined, indicating contaminant reduction across the entire plume. The average

TREATMENT SYSTEM DESCRIPTION (CONT.)

Performance Data Assessment (Cont.)

concentration of total contaminants has decreased from 158 to 67 µg/L over 3 ½ years of operation, a 58% reduction. The average concentration of 1,1,1-TCA has decreased from 107 to 40 µg/L over 3 ½ years of operation, a 63% reduction.

- NPDES permit requirements have been met consistently over the 42 months of operation.
- In 1993, contaminants were detected at concentrations above cleanup goals in downgradient monitoring wells beyond the limits of the plume initially identified. The increased pumping rate in EW-1 was not sufficient to recapture the plume.
- The additional assessment, as discussed in the Matrix Description section, found contamination outside of the initial plume. However, the assessment determined the elevated DCA and DEE levels were not due to loss of plume containment. Wells along the perimeter and just outside the extraction well capture zone were not found to contain elevated levels of contaminants, which indicates that plume containment had been maintained. The discovery of contamination outside the originally estimated plume has been attributed to historically elevated levels not discovered during the RI/FS.
- To address the additional contamination, the number of extraction wells may be expanded or innovative remediation may be applied.
- Figure 4 presents the removal of total contaminants through the treatment system from September 1993 to December 1996. Over this period the P&T system removed approximately 664 pounds of total contaminant mass from the groundwater.
- During system startup in the first two months of operation, the contaminant mass removal was low, at 0.064 lb/day. The removal rate increased to 0.65 lb/day in November 1993, as shown in Figure 3. However, as contaminant levels in the groundwater dropped from 1993 to 1995, the removal rate also dropped from 0.65 lbs/day in November 1993 to 0.22 lb/day in December 1995.

Performance Data Completeness

- Data are available for contaminant concentrations in the groundwater in the extraction wells during quarterly sampling events from May 1993 to December 1996. Data are available for contaminant concentrations in the influent to the treatment system from September 1993 to September 1996. Data regarding the additional contamination outside the plume is available in Reference 9.
- Contaminant mass removal, depicted in Figure 4, was determined using analytical results of samples from the influent stream to the treatment plant from each well and the extraction well flow data, along with treatment effluent data, from September 1993 to September 1996.
- The geometric mean of total contaminant concentrations, depicted in Figure 3, was determined using analytical results from annual sampling of extraction wells and monitoring wells. The geometric mean represents the trend of contaminant concentrations across the entire plume.
- All extraction wells within the original plume were used for calculation of the mean concentration. When concentrations below detection limits were encountered, half of the detection limit was used for evaluation purposes.
- No data were available for the interim P&T system (1982-1986); therefore, the system performance was not evaluated as part of this report.

Performance Data Quality

The QA/QC program used throughout the remedial action met the EPA and the MDEQ requirements. All monitoring was performed using EPA-approved methods: SW-846 Methods 601, 602, 624, 625, Hardness, and TDS. The vendor did not note any exceptions to the QA/QC protocols.

TREATMENT SYSTEM DESCRIPTION (CONT.)

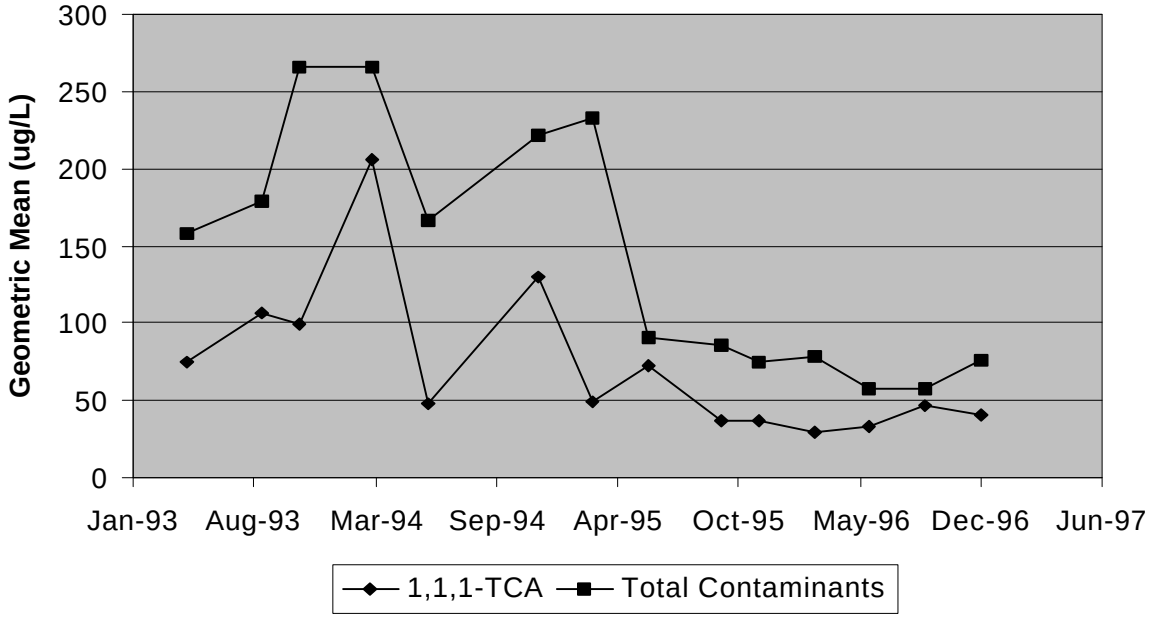

***Figure 3**. Average Contaminant Concentrations from May 1993 until December 1996 [8]*

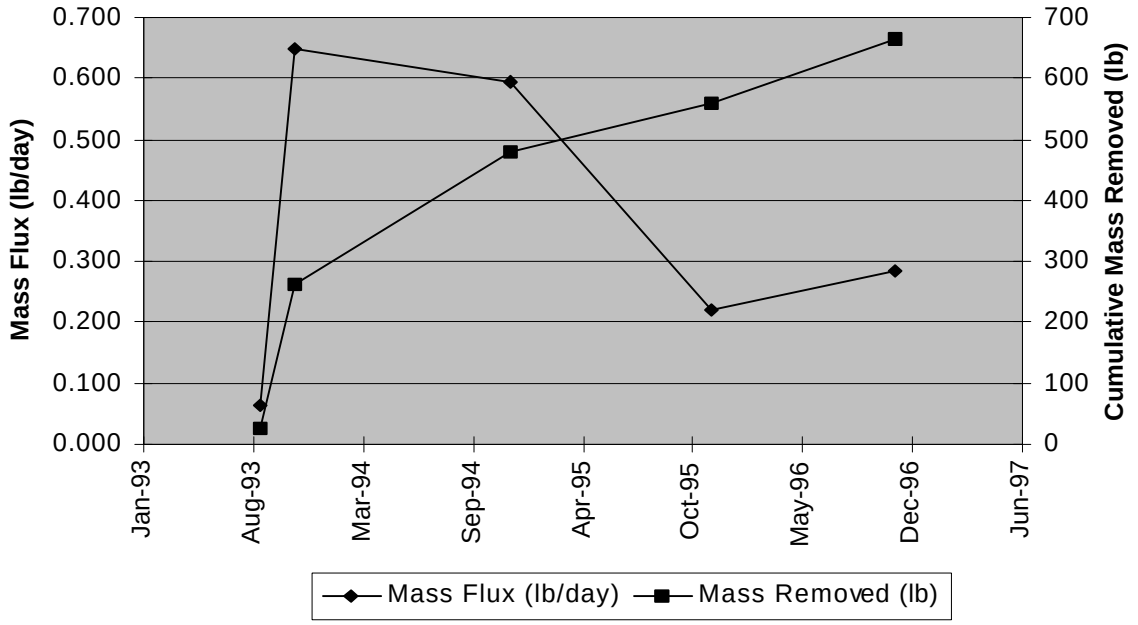

***Figure 4**. Mass Flux Rate and Cumulative Total Contaminant Removal from September 1993 to December 1996 [8].*

TREATMENT SYSTEM COST

Procurement Process

EPA contracted with Tetra Tech EM Inc. (formerly PRC Environmental Management, Inc.) for design and construction oversight. ATEC Associates, Inc. constructed and operated the remedial system.

Cost Analysis

The costs incurred during initial remedial actions and during the beginning of the RI/FS through 1986 were paid for by U.S. Aviex. MDEQ and EPA provided the remainder of the remedial costs.

Capital Costs [4]

Remedial Construction of 1993 P&T System	
Mobilization and Preparatory Work	$223,833
Monitoring and Analysis	$45,511
Site Work	$354,241
Extraction Wells	$130,731
Vapor Phase Carbon Filter	$8,550
System Construction	$559,954
Decontamination of Equipment and Area	$8,855
Total Remedial Construction	**$1,331,675**

Other Costs [4,5]

Operating Costs from July 1993 until December 1996	
Utilities	$29,110
Sampling and Analytical Services	$238,887
Other Operations and Maintenance	$342,327
Total Operating Expenses	**$610,324**

Other Costs [4,5]

Total Remedial Design	$586,775
EPA Oversight Costs	$170,000
1987 Air Stripper	$25,000
1987 Effluent Force Main Outfall	$50,000

Cost Data Quality

Actual cost data are available from the site manager for this application.

OBSERVATIONS AND LESSONS LEARNED

- The actual cost for groundwater treatment at U.S. Aviex from 1993-1996 was approximately $1,942,000 ($1,332,000 in capital and $610,000 in operations and maintenance), which corresponds to $2,925 per pound of total contaminants removed and $5.00 per 1,000 gallons of groundwater treated.
- The impact of remediation on the plume size is inconclusive because of the new data regarding historically elevated contaminant levels.
- Contamination has been detected in wells downgradient of the plume identified in the RI/FS. As a result, further characterization and expansion of the remedial system is necessary. The further action will increase the cost.
- No performance data are available on the interim P&T system; however, operation of this system before the 1993 P&T system went on line may have impacted the total cost of the remediation. The interim system began remediation and contained part of the source area prior to full-scale remediation.

OBSERVATIONS AND LESSONS LEARNED (CONT.)

Observations and Lessons Learned (Cont.)

- Monitoring data from extraction wells indicate that while maximum contaminant concentrations in the groundwater have dropped significantly (up to 99% for 1,1,1-TCA), they remain above cleanup goals. After four years of P&T operation the rate of contaminant removal has slowed [4]. While no dense non-aqueous phase liquid (DNAPL) has been directly observed during sampling, high initial concentrations of 1,1,1-TCA (greater than 60% of its solubility) indicated the potential presence of DNAPL. DNAPLs act as a constant source of contamination and can replenish groundwater plumes as they slowly desorb and dissolve from saturated sediments into the aqueous phase. If DNAPLs are present, locating and eliminating them would improve the effectiveness of this remedy [6].
- The treatment system achieved a maximum rate of total contaminant removal of 0.65 lb/day during the first year of operation. The total contaminant removal rate has continuously declined since the beginning of operations. By December, 1995, the total contaminant removal rate had declined to 0.29 lb/day. The decline in contaminant removal rate is typical of P&T systems, in that they remove contaminants most efficiently at the beginning of operations, when contaminant levels are highest.

REFERENCES

1. Record of Decision, U.S. Environmental Protection Agency, September 7, 1988.
2. Correspondence with Mr. Carl Chavez, SMU #3 Project Manager, Michigan Department of Environmental Quality. May 5, May 13, and May 22, 1997.
3. Remedial Action Report Completion (RACR), PRC Environmental Management, Inc., January 26, 1994.
4. Ground-Water Cost Analysis, U.S. Environmental Protection Agency, unpublished.
5. Correspondence with Mr. Ron Riesing and Mr. Rick Hersemann, PRC Environmental Management, Inc. (Now Tetra Tech EM Inc.). April 21, May 9, May 15, and November 12 1997; March 24 and April 3, 1998.
6. Dense Nonaqueous Phase Liquids, Halin, Scott G. And J.W. Weaver, U.S. Environmental Protection Agency, March 1991.
7. Remedial Investigation/Feasibility Study, EDI Engineering and Science, 1988.
8. Annual Summary Monitoring Reports, PRC Environmental Management, Inc., 1993-1997.
9. Additional Groundwater Assessment Summary Report, U.S. Aviex Site, prepared by Tetra Tech EM Inc. for EPA Region 5 February 27, 1998.
10. Comments on draft report provided by Ron Riesing, Tetra Tech EM, Inc. May 20, 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 in consultation with the MDEQ. Assistance was provided by Eastern Research Group, Inc. and Tetra Tech EM Inc. under EPA Contract No. 68-W4-0004.