

COST AND PERFORMANCE REPORT

Electrical Resistive Heating at the
Poleline Road Disposal Area, Arrays 4, 5, and 6
Fort Richardson, Alaska

June 2003

SITE INFORMATION

IDENTIFYING INFORMATION [2]

Site Name: Poleline Road Disposal Area (PRDA), Arrays 4, 5, and 6

Location: Fort Richardson, Alaska

Regulatory Context: CERCLA

ROD Date: August 8, 1997

Technology: Electrical Resistive Heating (ERH)

Scale: Field demonstration

TECHNOLOGY APPLICATION [2]

Period of Operation: July through October 1999

Type/Quantity of Material Treated During Application: Source zone - Estimated to be 13,000 tons or 7,333 yd³ based on a treatment area of approximately 110 ft long by 50 ft. wide by 36 ft. deep.

BACKGROUND [2,6]

Fort Richardson, established in 1940 as a military staging and supply center during World War II, is located approximately 10 miles northeast of Anchorage, Alaska and occupies about 56,000 acres. Its current mission is to provide services, facilities, and infrastructure to support the rapid deployment of Army forces. The site was added to the National Priority List (NPL) in June 1994. In December 1994, the Army, the Alaska Department of Environmental Conservation (ADEC), and EPA signed a Federal Facilities Agreement (FFA) to address contamination at the site. The FFA divided Fort Richardson into four Operable Units. This report addresses the use of ERH at the Poleline Road Waste Disposal Area (PRDA) which is part of Operable Unit B (OUB).

The PRDA is a 1.5 acre area that was used as a disposal area from 1950 to 1972. PRDA was divided into four areas: Areas A-1, A-2, A-3, and A-4. Shallow trenches (8 to 10 ft. deep) were used for the disposal of a wide variety of wastes including chemical warfare agents and training materials, smoke bombs, and other materials. During operation, a layer of bleach and lime was placed in the bottom of the trench, with the contaminated materials placed on a pallet in the trench. Diesel fuel was poured on the waste and ignited. After cooling, chlorinated solvents, including trichloroethene (TCE), tetrachloroethene (PCE), and 1,1,2,2-tetrachloroethane (PCA) were mixed with lime or bleach and poured over the materials to neutralize the chemical agents.

Results of a geophysical survey showed that Areas A-3 and A-4 contained the greatest amount of buried waste. Sampling of these areas showed that soil and groundwater has been contaminated with chlorinated solvents including TCE, PCE, and TCA. A removal action was conducted in these two areas in 1993 and 1994 to remove contaminated soil and debris. Soil was excavated to a depth of up to 14 ft (depth at which groundwater was encountered). Excavated soils that exceeded the removal action concentration levels (TCE-600 : g/kg), PCE (100 : g/kg), and TCA (30 : g/kg) were stockpiled for treatment.

Areas A-1 and A-2 were not sampled because of the potential for buried unexploded ordnance. Results of soil and groundwater sampling in surrounding areas showed relatively lower contaminant concentrations, therefore no treatment was performed in them. During the remedial investigation, chlorinated solvents were found in soil and groundwater in Areas A-3 and A-4. TCE, PCE, and PCA were found at levels as high as 2,030 : g/kg for PCA, with the soil determined to be a continuing source of groundwater

contamination. All four main water bearing zones at the site were determined to be contaminated with TCE and PCE at levels as high as 1,900 : g/L for TCE.

To evaluate the effectiveness of potential remedial technologies, a treatability study of SVE and air sparging groundwater was conducted in 1996. The results of the study indicated that SVE had the potential to reduce contamination at the site but that air sparging would not be effective in remediating groundwater contamination.

ERH was then evaluated as a potential remediation technology for the site. Two field demonstrations of ERH were performed at the site. A 1997 ERH field demonstration was used to treat 7,150 tons of soil in Areas A-3 and A-4, and involved three heating arrays (labeled 1, 2, and 3). The results of this demonstration are presented in the report *Cost and Performance Report Soil Vapor Extraction Enhanced by Six-Phase Heating at Poleline Road Disposal Area, OU-B Fort Richardson Alaska*, prepared by the U.S. Army Corp of Engineers, Hazardous, Toxic, Radioactive Waste Center of Expertise.

This report describes the second ERH field demonstration, in Area A-3 using heating arrays labeled 4, 5, and 6, that was conducted from July through October 1999.

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MATRIX DESCRIPTION

MATRIX AND CONTAMINANT IDENTIFICATION [2]

Type of Media Treated: Source zone (saturated and unsaturated)

Primary Contaminant Group: Chlorinated solvents - TCE, PCE, PCA

SITE HYDROGEOLOGY AND EXTENT OF CONTAMINATION [2,6]

The subsurface soil at this site is primarily high density glacial tills, including silty sands with some gravel and a few clay-sized particles. Four water-bearing intervals have been identified at PRDA: a perched groundwater interval, a shallow aquifer, an intermediate aquifer, and a deep aquifer. Zones of high-density tills separate the saturated intervals. Groundwater was encountered at a depth of 4 to 14 ft. bgs. Between 4 and 12 ft. bgs the groundwater encountered was perched, and groundwater encountered below 12 ft. was in the shallow aquifer. The deep aquifer and glacial tills overlie bedrock composed of a hard black fissile claystone with fine sandy siltstone interbeds. Bedrock is encountered from approximately 80 to 170 ft. bgs and has an unknown thickness.

Contaminants in soil and groundwater at the PRDA include TCE, PCE, and PCA. Sampling data indicated that the soil between 16 and 27 ft. bgs had the highest contaminant concentrations. Groundwater contamination was present in all four intervals. In addition, DNAPL has been observed. Table 1 lists the matrix characteristics affecting treatment cost or performance for this application.

Table 1: Matrix Characteristics Affecting Treatment Cost or Performance [2,6]

Parameter	Value	Measurement Procedure
Soil Classification	SP-gravelly sand GP-sandy gravel GM-silty sandy gravel	Unified Soil Classification System
Clay Content and/ or Particle Size Distribution	Low clay content; silt, sand and gravel observed	Visual
Moisture Content	7.3-13.9%	Method 7-2.2, Methods of Soil Analysis
Soil Air Permeability	$1.6 \times 10^{-7} \text{ cm}^2$	Calculated using field measurements and steady state equation

Table 1: Matrix Characteristics Affecting Treatment Cost or Performance [2,6] (continued)

Parameter	Value	Measurement Procedure
Porosity	21-27%	Estimated from soil classification and particle size distribution
Depth bgs or Thickness of Zone of Interest	8 to 35 ft. bgs	Soil and groundwater sampling data
Total Organic Carbon	0.19-0.66%	ASA 90-3.2
Presence of Nonaqueous Phase Liquids (NAPLs)	DNAPL found in a 2" monitoring well (site personnel did not identify separate phase DNAPL in other areas of the site)	Visual
Electrical Conductivity	Acceptable	Not Available

Table 2 lists the contaminants of concern found at the site, the maximum concentration in the groundwater or soil, and the Remedial Action Objectives (see further discussion below under technology performance).

Table 2. Maximum Contaminant Concentrations in Soil and Groundwater Before Treatment and Remedial Action Objective [2]

Contaminant	Maximum Groundwater Concentration (mg/L)	Groundwater Remedial Action Objective (mg/L)	Maximum Soil Concentration (mg/kg)	Soil Remedial Action Objective (mg/kg)
Benzene	0.017	0.005	NA	NA
Carbon Tetrachloride	0.037	0.005	NA	NA
cis-1,2-Dichloroethene	0.73	0.07	NA	NA
trans-1,2-Dichloroethene	0.73	0.1	NA	NA
PCE	0.30	0.005	120	4.0
TCE	7.8	0.005	640	0.015
PCA	18.0	0.052	12,000	0.1

NA - Information not available

TECHNOLOGY SYSTEM DESCRIPTION

TREATMENT TECHNOLOGY [2]

Electrical Resistive Heating (Six-Phase Heating™)

TREATMENT SYSTEM DESCRIPTION AND OPERATION [2,6]

The ERH system used for this demonstration (Figures 1 and 2) was constructed in three phases. The electrode arrays for these three phases were identified as Arrays 4, 5, 6. Each phase included an array of seven electrodes, 3 SVE wells, and two thermocouple. A 300 kW transformer supplied power to the electrodes. The electrodes were spaced approximately 19 ft. apart, and electrodes in one row were offset from electrodes in adjacent rows by approximately 9.5 ft.. Electrodes were installed to a depth of 38 ft. to treat an area approximately 110 ft. long by 50 ft. wide by 35 ft. deep.

Array 5 was installed from May 18-27, 1999; Array 4 from June 7-15; and Array 6 from July 12-20. The ERH field demonstration was conducted from July to October 1999. Parameters monitored during the demonstration included transformer voltage, amperages, and total power; soil temperature from thermocouples which measured soil temperature at six locations within the treatment areas at depths of 12, 25, and 38 ft; and soil resistivity. Other parameters monitored included vacuum pressure, concentration of VOCs in condensed off-gas, and off-gas vacuum flow. During operation, an on-site computer was used to adjust voltages on the transformer to maintain a power input of 700 to 800 kW. The vacuum applied by the blower was adjusted by opening or closing a vacuum relief valve located just between the condenser and the blower. The system was designed to increase the temperature of the soil to 100°C. The soil temperature achieved during the demonstration ranged from 44 to 100°C. The highest soil temperatures achieved during the demonstration ranged from 55 to 82°C at 12 ft., 98 to 100°C at 25 ft., and 43 to 80°C at 38 ft.. The soil temperature at 38 ft. was less than at 25 ft. because there was less moisture at that depth (moisture was removed from the area by the SVE system) thereby decreasing the soil conductivity.

The SVE system was operated two weeks prior to ERH system start up to allow testing of the SVE system. The SVE system was then shut down until August 1999 (the time at which the output of the ERH system had reached 1099 V). The SVE system was used to remove steam and contaminant vapors. The extracted soil gas vapor was passed through a condenser, a condensate holding tank and an off-gas treatment unit. No information was provided about the type of off-gas treatment.

Condensate and condenser off-gas samples were collected approximately every other day during operation and analyzed for VOCs. Instrument readings and analytical results were used to calculate the mass of contaminants removed via the extracted soil gas and condensate water. Table 3 presents information on the soil temperatures achieved during operation.

Figure 1. Treatment Area and Location of Sampling Points for the Electrical Resistive Heating Treatment at the Fort Richardson Site [2]

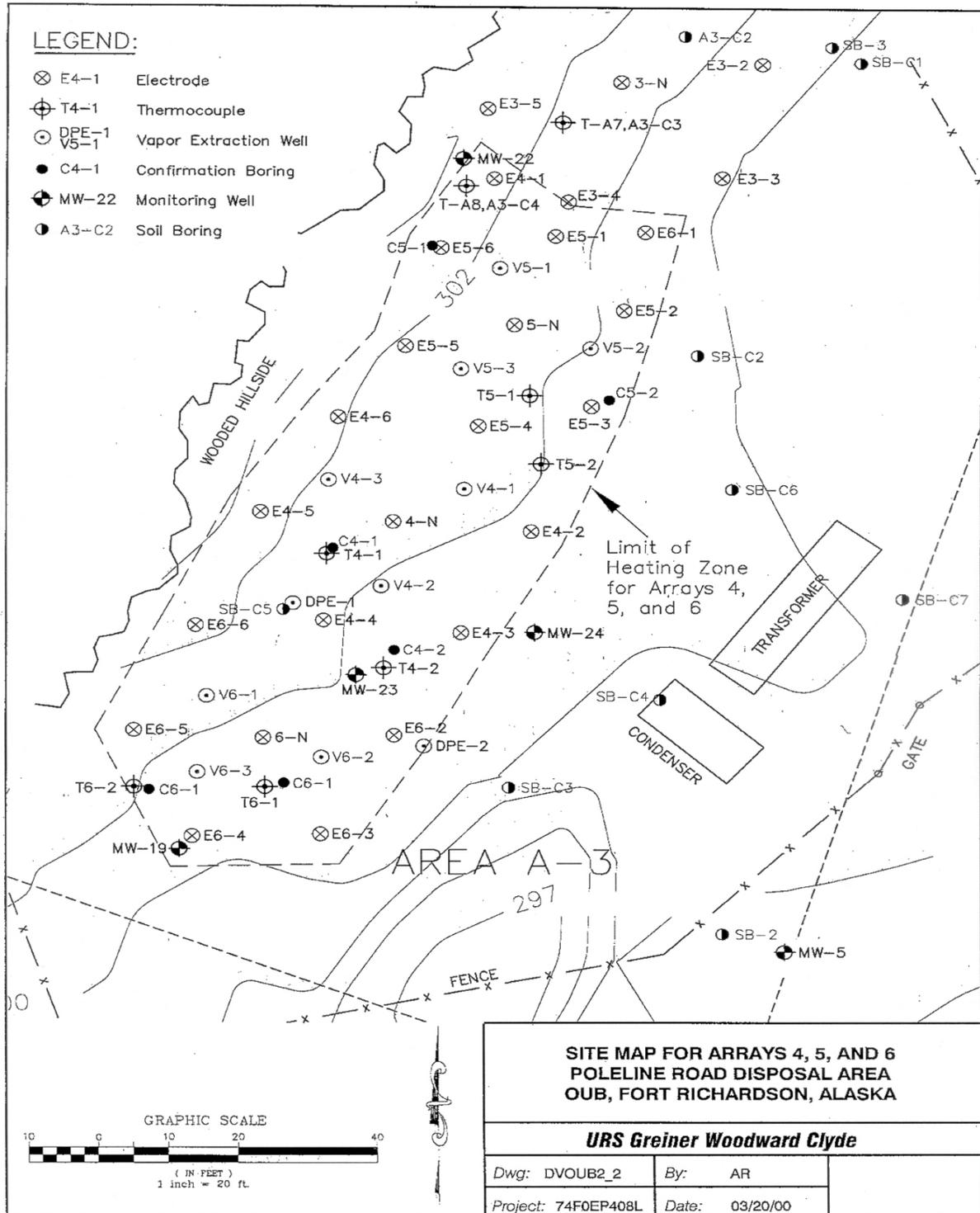


Figure 2. Process Flow Diagram of Electrical Resistive Heating System Used at the Fort Richardson Site [2]

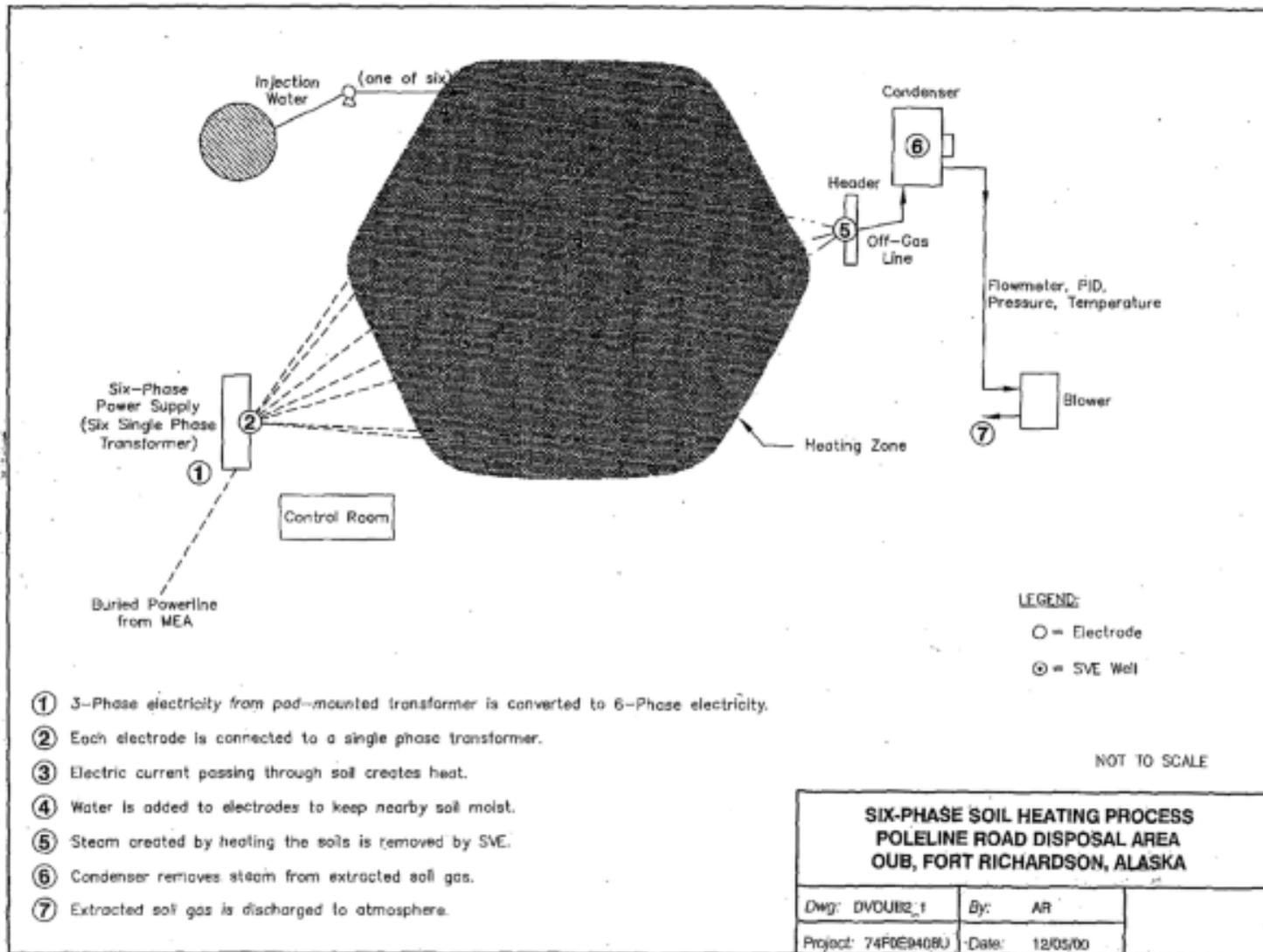


Table 3. Temperature Achieved During ERH Operation [2]

Thermocouple Location	Depth (ft)	Highest Temperature Achieved (°C)	Date
T4-1	12	80	Sept 26, 1999
T4-1	25	100	Sept 26, 1999
T4-1	38	61	Oct 10, 1999
T5-1	12	78	Oct 3, 1999
T5-1	25	98	Oct 3, 1999
T5-1	38	55	Oct 10, 1999
T6-1	12	77	Oct 10, 1999
T6-1	25	100	Sept 26, 1999
T6-1	38	100	Oct 3, 1999
T4-2	12	80	Oct 3, 1999
T4-2	25	100	Sept 26, 1999
T4-2	38	58	Oct 3, 1999
T5-2	12	82	Sept 14, 1999
T5-2	25	100	Aug 15, 1999
T5-2	38	63	Sept 14, 1999
T6-2	12	55	Oct 2, 1999
T6-2	25	87	Oct 3, 1999
T6-2	38	43	Oct 8, 1999

TIMELINE [1,2]

- August 1997 Record of Decision signed
- June - December 1997 First ERH treatment application
- July - October 1999 Second ERH treatment application

TECHNOLOGY SYSTEM PERFORMANCE

PERFORMANCE OBJECTIVES [2,6]

The objective of this field demonstration was to evaluate the effectiveness of ERH in reducing the concentration of chlorinated solvents in groundwater. Performance of the system was evaluated by monitoring the ability of the system to:

- Heat the soil in the study area

- Increase the removal rate of contaminants, as compared to previous ERH tests conducted at the site
- Effectively remove VOCs from the soil and groundwater

The remedial action criteria were established in the ROD, based on MCLs in the State of Alaska, and are listed by contaminant in Table 2.

TREATMENT PERFORMANCE [2]

Performance data for the ERH system included mass removal data, groundwater concentration data, and soil concentration data. Groundwater monitoring data are available for three wells in the area treated: MW-19, MW-22, and MW-23. In addition, four soil borings were collected from the treatment area and analyzed before treatment: T4-1, T4-2, T6-1 and T6-2.

The mass of TCE, PCE, and PCA removed by the system was estimated based on the estimated mass removed via the off-gas and condensate. The estimated mass of TCE, PCE, and PCA removed in the off-gas was 1,008 pounds, 53 pounds, and 324 pounds, respectively. The estimated mass of TCE, PCE, and PCA removed in the condensate was 10 pounds, 0.25 pounds, and 55 pounds, respectively.

Tables 4 and 5 present data on concentrations of contaminants in groundwater and soil, respectively, for samples collected before ERH treatment (March 1999), and after the treatment was completed (November 1999).

Table 4. Groundwater Performance Data for ERH at the Fort Richardson Site [2]

Analyte	Remedial Action Objective (mg/kg)	Month Sampled	Concentration and Detection Limit (mg/L)		
			MW-19	MW-22	MW-23
Benzene	0.005	March	ND(0.001)	ND(0.01)	ND(0.01)
		November	ND(0.001)	ND(0.001)	ND(0.001)
Carbon tetrachloride	0.005	March	ND(0.001)	ND(0.01)	ND(0.01)
		November	ND(0.001)	ND(0.001)	ND(0.001)
Cis-1,2-dichloroethene	0.07	March	0.014	0.180	0.230
		November	0.01	0.058	0.300
Trans-1,2-dichloroethene	0.1	March	0.006	0.060	0.230
		November	0.0013	0.015	0.036
PCA	0.052	March	0.690	2.800	17.000
		November	0.850	0.810	0.100
PCE	0.005	March	0.007	0.062	0.072
		November	ND (0.001)	0.029	0.0010
TCE	0.005	March	0.280	1.700	3.100
		November	0.021	1.600	0.970

Table 5. Soil Performance Data for ERH at the Fort Richardson Site[2]

Analyte	Remedial Action Objective (mg/kg)	Month Sampled	Concentration and Detection Limit (mg/kg)			
			T4-1	T4--2	T6-1	T6-2
PCA	0.1	March	12,000	67	530	0.07
		November	ND (0.03)	ND (0.034)	ND (0.033)	ND (0.032)
PCE	4.0	March	120	1	3.1	0.09
		November	0.012	0.098	0.71	ND (0.032)
TCE	0.015	March	640	6	200	1.7
		November	12	0.087	63	0.84

As shown in Table 4, groundwater contaminant concentrations generally decreased between March 1999 and November 1999, with PCA, PCE and TCE decreasing an average of 49 percent, 75 percent and 56 percent, respectively. Concentrations of PCA in groundwater from MW-19 increased between March and November 1999. According to the vendor, because only a portion of the contaminated area was treated, and MW-19 was on the edge of the treatment area, this increase may have been due to contaminant migration from outside the treatment area. Concentrations of cis-1,2-dichloroethene, a breakdown product of TCE, increased in MW-23. As of November 1999, concentrations of PCA, PCE, TCE, and cis-1,2-DCE were above the remedial action objectives in groundwater.

As shown in Table 5, concentrations of PCA, PCE and TCE in soil decreased from March to November 1999. PCA and PCE were reduced to below the remedial action objectives. However, TCE concentrations remained above the remedial action objective, with concentrations ranging from 0.087 to 63 mg/kg.

Temperature data collected from thermocouples at the site showed that soil and groundwater temperatures could be increased to 100°C, however, this temperature was not consistently achieved throughout the treatment area. The temperature in Array 6 was only raised to 90°C for a short time, and the percent reduction in this array was the lowest of the three arrays.

The residual groundwater contaminant plume is being monitored in 22 groundwater wells on a quarterly basis. This monitoring includes two wells in the area treated, MW-19 and MW-23. Figures 3, 4, 5, and 6 show the concentrations of TCE and PCA in these wells in November 1997 and April 2001, respectively.

In MW-19, concentrations of both contaminants were greater than 100 : g/L before treatment. After treatment, the concentrations of each of these contaminants was reduced to less than 1 : g/L. In MW-23, concentrations of both contaminants were greater than 1,000 : g/L before treatment. After treatment, the concentrations of these contaminants remained at more than 100 : g/L.

Figure 3. Residual Groundwater Plume Monitoring Data at the Fort Richardson Site: TCE in MW-19 (log scale) [7]

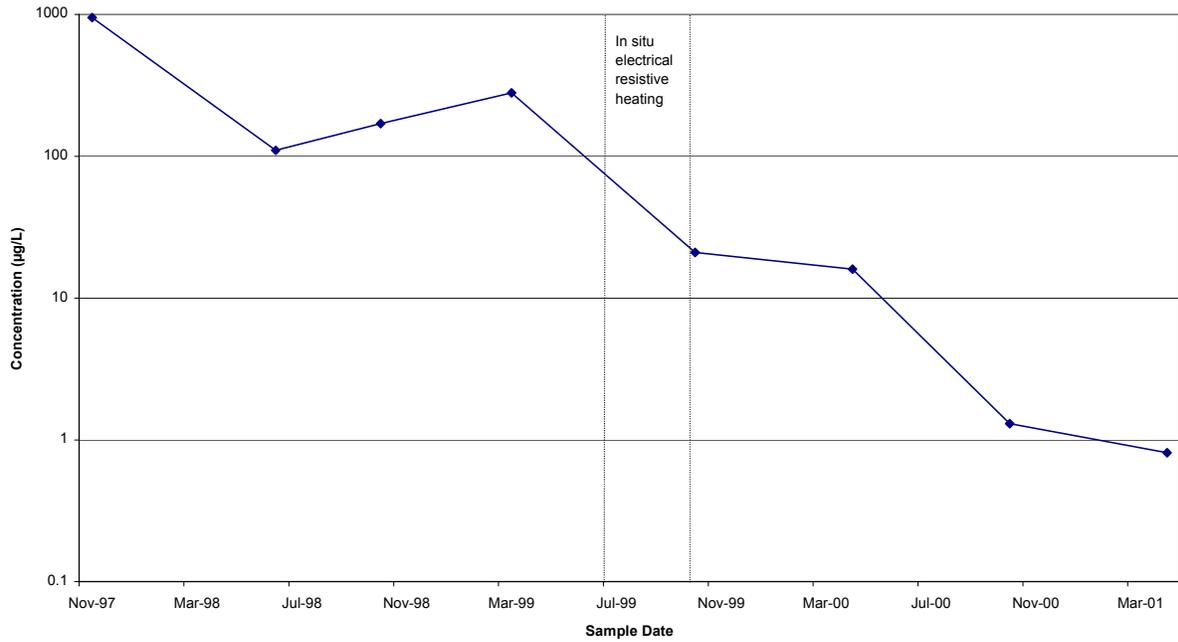


Figure 4. Residual Groundwater Plume Monitoring Data at the Fort Richardson Site: PCA in MW -19 (log scale) [7]

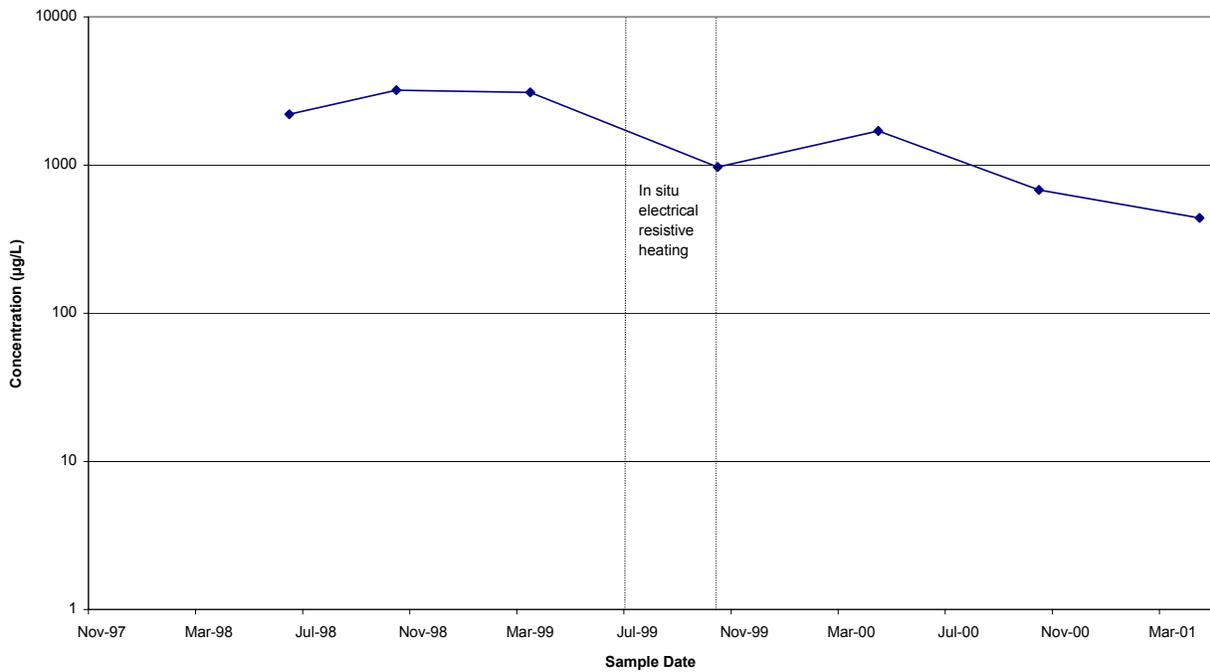


Figure 5. Residual Groundwater Plume Monitoring Data at the Fort Richardson Site: TCE in MW-23 (log scale) [7]

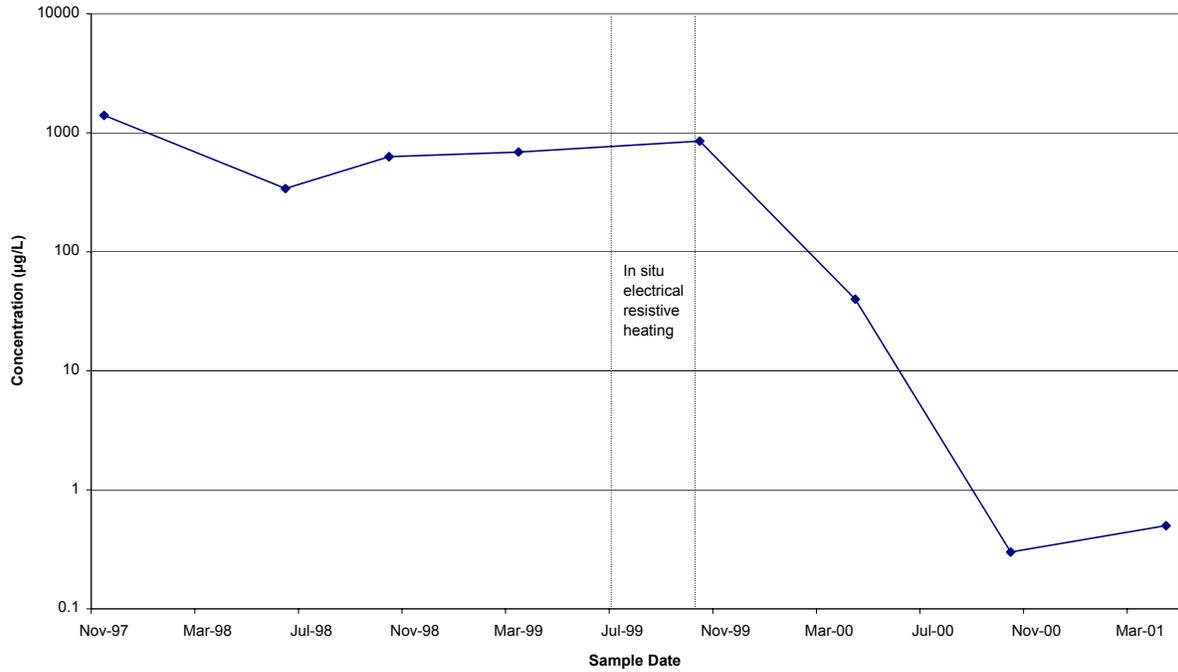
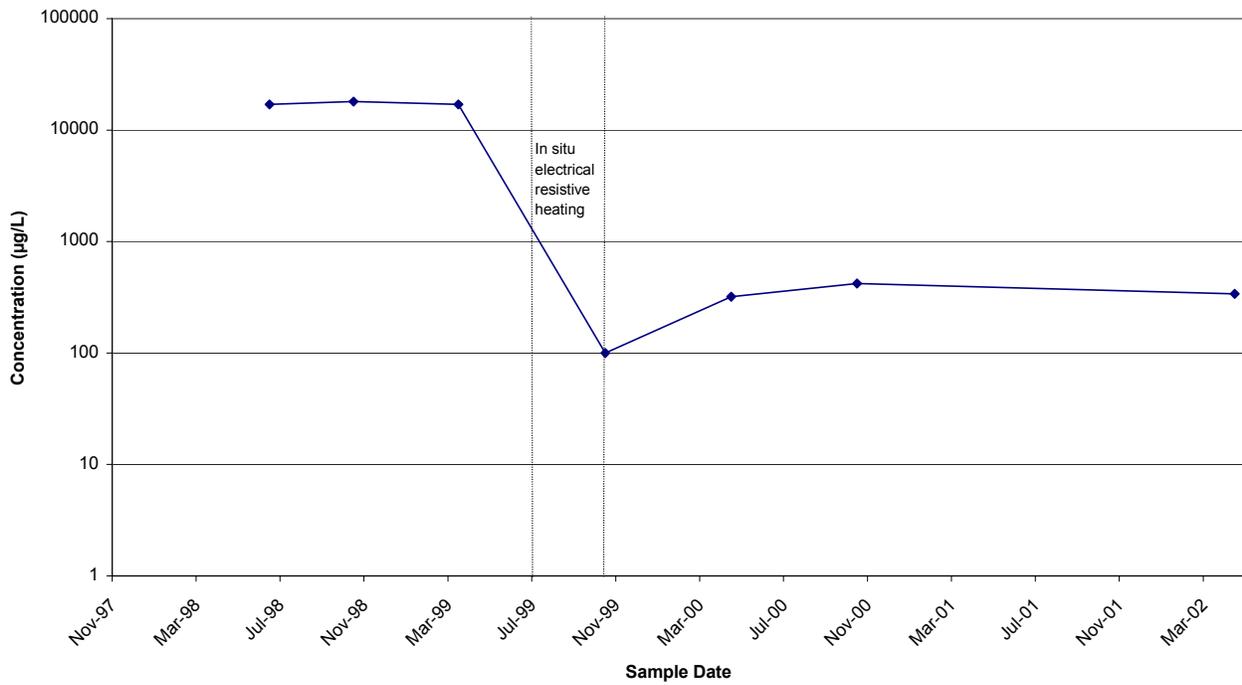


Figure 6. Residual Groundwater Plume Monitoring Data at the Fort Richardson Site: PCA in MW-23 (log scale) [7]



COST OF THE TECHNOLOGY SYSTEM

Cost information was not provided for this application.

OBSERVATIONS AND LESSONS LEARNED

The field demonstration of ERH reduced soil and groundwater contaminant concentrations in Area A-3. Groundwater contaminant concentrations were reduced by as much as 75 percent, though concentrations remained about the remedial action objective for the site. Concentrations of PCA, PCE and TCE in soil decreased during this period. PCA and PCE were reduced to below the remedial action objectives; however, TCE concentrations in soil remained above the remedial action objective.

REFERENCES

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2. URS Corporation. "Design Verification Study Arrays 4, 5, and 6, Operable Unit B, Poleline Road Disposal Area, Fort Richardson, Alaska," Prepared for the Alaska District, U.S. Army Corp of Engineers. March, 2001.
3. URS Corporation. "Long Term Groundwater Monitoring Report, Operable Unit B, Poleline Road Disposal Area, Fort Richardson, Alaska," Prepared for the Alaska District, U.S. Army Corp of Engineers. July, 2001.
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