



**U.S. Army**  
**Fort Richardson, Alaska**

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**Interim Remedial Action Report**  
**Operable Unit B – Poleline Road**

**April 2003**

**FINAL**

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## ACRONYM LIST

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AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ADN	Anchorage Daily News
ARAR	Applicable or Relevant and Appropriate Requirements
AWQS	Alaska Water Quality Standards
bgs	Below ground surface
CATOX	Catalytic oxidizer
CCREL	U.S. Army Corps of Engineers Cold Region Research and Engineering Laboratory
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CPVC	Chlorinated-polyvinyl chloride
°C	Degrees Celsius
°F	Degrees Fahrenheit
DNAPL	Dense non-aqueous phase liquid
DO	Dissolved Oxygen
DPW	Department of Public Works
DVS	Design Verification Study
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
ES&E	Environmental Science and Engineering
FFA	Federal Facility Agreement
ft/day	Feet per day
ft <sup>3</sup>	Cubic feet
Hg	Mercury
hp	Horse power
HVE	High vacuum extraction
kW	Kilowatt
lb	Pounds
LTM	Long-term monitoring
MCL	Maximum contaminant limit
MEA	Matanuska Electric Association
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
mm Hg	Millimeters of mercury
MP	Monitoring points
mV	Millivolts
MW	Monitoring well
NPL	National Priorities List
OHM	OHM Remediation Services Corporation
OU	Operable Unit
OUB	Operable Unit B (Poleline Road Disposal Area)
PCE	Tetrachloroethene
PID	Photoionization detector

ppbv	Parts per billion-volume
ppm	Parts per million
ppb	Parts per billion
PVC	Polyvinyl chloride
QA	Quality Assurance
QAPP	Quality Assurance Program Plan
QC	Quality Control
RAB	Restoration Advisory Board
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
REDOX	Oxidation reduction potential
RI	Remedial Investigation
RIMP	Remedial Investigation Management Plan
ROD	Record of Decision
SOP	Standard Operating Procedures
SPSH	Six-phase soil heating
SVE	Soil vapor extraction
TBC	To-be-considered
TCE	Trichloroethene
TI	Technical Impracticability
TOC	Total organic carbon
TS	Treatability Study
URS	URS Corporation
USACE	U.S. Army Corps of Engineers, Alaska District
USARK	U.S. Army Alaska
USC	United States Code
VOC	Volatile Organic Compounds
WC	Woodward-Clyde Consultants
yd <sup>3</sup>	Cubic yards

## 1.0 INTRODUCTION

This document presents the Remedial Action Report (RAR) for the U.S. Army at Poleline Road Disposal Area, Operable Unit B (OUB), Fort Richardson, Alaska. The objectives of the remedial action at OUB are designed to ensure the protection of human health and the environment by:

- Reducing contaminant levels in the groundwater to eventually comply with drinking water standards,
- Prevent contaminated soil from continuing to act as a source of groundwater contamination,
- Prevent the contaminated groundwater from adversely affecting the Eagle River surface water and sediments; and
- Minimize degradation of the State of Alaska's groundwater resources at the site as a result of past disposal practices.

The remedial action at Poleline road was performed through a series of successful treatability studies due to budget and contract requirements at the time of implementation. This report presents the remedial action and efforts that have been performed at the Poleline Road Disposal area in order to achieve the objectives of the Record of Decision (ROD).

### 1.1 Fort Richardson Background

Fort Richardson was established in 1940 as a military staging and supply center during World War II and originally occupied 162,000 acres north of Anchorage. In 1950, the Fort was divided between the Army and the Air Force. Today, Fort Richardson occupies approximately 62,000 acres bounded to the west by Elmendorf Air Force Base, to the east by Chugach State Park, to the north by Knik Arm, and to the south by the Municipality of Anchorage (Figure 1). The current mission of Fort Richardson is to support the rapid deployment of Army forces from Alaska to the Pacific Theater.

In June 1994, the U.S. Environmental Protection Agency (USEPA) included Fort Richardson on the National Priorities List (NPL). Following negotiations, the Army, USEPA, and the Alaska Department of Environmental Conservation (ADEC) signed a Federal Facility Agreement (FFA) for Fort Richardson on December 5, 1994. The FFA outlines the approach for a thorough investigation of suspected historical hazardous-substance sources. It also calls for cleanup activities that will protect public health and welfare and the environment in accordance with state and federal laws.

The FFA divided Fort Richardson into four Operable Units (OUs, named with letters A through D) to represent the potential source areas for hazardous substances. The OUs were created based on the amount of existing information, the similarity of contamination, and the level of effort required to complete a Remedial Investigation (RI). In 2000, an

additional Operable Unit, OU-E, was added. This Remedial Action (RA) report focuses on OUB.

## 1.2 Operable Unit B Background

### 1.2.1 Site Location and Description

OUB consists of one site: the Poleline Road Disposal Area (Poleline Road). Poleline Road is located in the north portion of Fort Richardson, approximately one mile south of the Eagle River and 0.6 mile north of the Anchorage Regional Landfill (Figure 2). The site is situated in a low-lying wooded area at Poleline Road and Barrs Boulevard. The site was used as a chemical disposal area from 1950 to 1972. During this time, chemical agent identification sets and other military debris was burned and disposed of in trenches. The chemical sets were neutralized with a mixture of bleach or lime and chlorinated solvents before burial.

### 1.2.2 Hydrogeology and Groundwater Use

Four water-bearing intervals have been identified at Poleline Road: a perched zone, a shallow groundwater zone, an intermediate groundwater zone, and a deep aquifer. The top of the perched interval was encountered at four to ten feet below ground surface (bgs) and is approximately five feet thick. The shallow saturated zone is an average of ten feet thick; the top was encountered at 20 feet to 25 feet bgs. Groundwater in the shallow zone flows in a northeasterly direction. The intermediate zone was encountered at approximately 65 feet to 95 feet bgs. The deep aquifer is an advanced moraine/till complex with a thickness between 3 feet and 40 feet and was encountered at 80 feet to 125 feet bgs. Groundwater elevations indicate that the flow direction in the deep aquifer is locally to the northeast and regionally to the northwest. Hydraulic conductivities were estimated from existing site data and averaged 0.5 feet per day (ft/day) for all saturated zones, except that the intermediate zone averaged 0.05 ft/day. These relatively low hydraulic conductivities suggest that groundwater flow in the site area would not significantly disperse dissolved contaminants.

Data indicates that the deep aquifer below Poleline Road is not connected with the aquifers used for drinking water in the community of Eagle River. It is unlikely that groundwater beneath Poleline Road ever would be used for a drinking water supply. Yield from the intermediate, shallow, and perched saturated zones would be too low to supply an average household. The deep aquifer may provide sufficient yield, but the installation of drinking water wells in the deep aquifer is unlikely based on the anticipated future use of the down-gradient land as a training and recreational area. Currently there are no down-gradient users of this aquifer and while “down gradient” recreation is allowed; no facilities which require the use of groundwater are available.

A four to five acre wetland is present immediately south of the site and several smaller wetlands less than 1 acre are also present in the vicinity. The wetlands present within the vicinity of OUB are classified as palustrine, emergent – persistent and scrub-shrub – broad-leaved deciduous, according to the mapping conventions used in the National Wetlands Inventory. These wetlands are isolated, are not a nursery for fish, and have a low diversity of vegetation. Sediment and surface water samples were collected from the wetland area



adjacent to the site. These samples indicated there is no presence (non-detect) of volatile organic compounds (VOC), chemical warfare material, or chemical warfare material breakdown products. All the remaining analytical results were either non-detect or below the Alaska maximum contaminant level (MCL), the risk based concentration for tap water, or the risk based concentration for residential soil. (WC September 1996).

### 1.2.3 Land Use

The Army uses the land surrounding Pole Line Road for military training activities and recreational purposes. OUB is situated on public domain land that belongs to the United States Department of Interior, Bureau of Land Management. This land is withdrawn from the public domain for military purposes. U.S. Army Alaska holds no deed documents for this land.

## 1.3 Operable Unit B Site Investigation and Remedial Action History

Poleline Road was identified in 1990 through interviews conducted by the Army with two former soldiers who were stationed at Fort Richardson in the 1950s and who recalled the disposal of chemicals, smoke bombs, and Japanese cluster bombs. The disposal location was corroborated by a 1954 United States Army Corps of Engineers map showing a “Chemical Disposal Area” at Poleline Road and by 1957 aerial photography showing trenches in the area. The disposal area was active from approximately 1950 to 1972.

The site was divided further into four disposal areas: Areas A-1, A-2, A-3, and A-4 (Figure 3). Historical information describes how relatively shallow (8 ft to 10 ft deep) trenches were dug and used for the disposal of a wide variety of debris, including chemical agent identification sets (CAIS, training kits). During disposals, a layer of “bleach/lime” was laid in the bottom of the trench, and the disposal materials were placed on a pallet in the trench. Diesel fuel was poured on the materials and ignited with thermal grenades. After burning was complete, a mixture of either bleach or lime, combined with chlorinated solvent carrier (trichloroethene [TCE]; tetrachloroethene [PCE]; and 1,1,2,2-tetrachloroethane), was poured over the materials to neutralize any remaining chemical material.

### 1.3.1 Site Investigation

In 1990 and 1992, site investigations were conducted that included a geophysical survey, soil borings, a soil gas survey, monitoring well installation, groundwater sampling, water level survey, and aquifer (slug) tests (Environmental Science and Engineering [ES&E] 1990, 1991, and 1993).

### 1.3.2 Removal Action

Contaminated debris and soil were removed from Areas A-3 and A-4 during the 1993 and 1994 removal action. During the removal action individual components of CAIS that were issued by the Army Chemical Warfare Service during the 1940s and 1950s were recovered. These CAIS were used to train military personnel in the identification of chemical warfare agents. The depth of the excavated soil varied due to groundwater infiltration. Soils were excavated to a maximum depth of 5 to 14 ft, where groundwater was encountered. During

the removals, sampling indicated the presence of chlorinated solvents, including TCE; PCE; and 1,1,2,2-tetrachloroethane, in soil and groundwater within 20 ft of the surface. Action levels were established for this removal action at TCE (600 milligrams per kilogram [mg/kg]); PCE (100 mg/kg); and 1,1,2,2-tetrachloroethane (30 mg/kg). These levels were based on a  $10^{-5}$  excess cancer risk for residential exposure. Soils that exceeded these action levels were stockpiled in lined containment cells located on Barrs Boulevard southeast of the site. (OHM Remediation Services Corporation 1993 and WC 1994).

Approximately 3,600 cubic yards of soil contaminated with 1,1,2,2-tetrachloroethane, TCE, PCE, and diesel range organics (DRO) was treated using heat injection and vacuum extraction. The treatment system was based on the Fluid Injection with Vacuum Extraction process. The soils were treated to reduce contaminate concentrations below land ban criteria. The specific remediation goals were 6 mg/kg for 1,1,2,2-tetrachloroethane; 6.0 mg/kg for TCE; 6.0 mg/kg for PCE; and 100 mg/kg for DRO. After treatment the soils were stockpiled at the site. (OHM 1999).

### 1.3.3 Remedial Investigation

A geophysical survey was performed in 1995 to determine whether any metallic anomalies remained in the recently excavated areas. Results of the survey indicated that all metallic material had been removed. (Cold Region Research and Engineering Laboratory [CRREL] 1994 and 1995).

Sampling was not conducted at Areas A-1 and A-2 because of the potential presence of unexploded ordnance. However, geophysical surveys (including both electromagnetic and ground penetrating radar) of these areas indicate that they contain lesser quantities of buried metallic waste than Areas A-3 and A-4. Sixteen soil borings were drilled around Areas A-1 and A-2 and 74 subsurface soil samples were collected from around the perimeter of Areas A-1 and A-2. Sampling of soil and groundwater surrounding Areas A-1 and A-2 did not detect any compounds or breakdown products associated with ordnance. In addition, sampling detected far lower concentrations of chlorinated solvents than levels detected near Areas A-3 and A-4. (Woodward-Clyde [WC] September 1996 and CRREL 1995).

Woodward-Clyde performed a Remedial Investigation (RI) in 1995. The RI fieldwork involved the collection and analysis of soil, groundwater, sediment and surface water samples from the site and background areas. Samples were analyzed for halogenated solvents, metals, explosives, and chemical warfare materials and their breakdown products. (WC September 1996)

In 1996, Woodward-Clyde (WC 1996b) conducted a human health risk assessment that included groundwater sampling and modeling, and completed an ecological risk assessment.

### 1.3.4 Feasibility Study

A Feasibility Study (URS 1996) was also performed during 1996 to determine remedial alternatives. The six main alternatives were: No action, natural attenuation, containment, interception trench/air stripping/ and soil vapor extraction (SVE), air sparging/SVE and

natural attenuation, and SVE of the hot spot. The “hot spot” is defined by the ROD “as the subsurface area containing greater than 1.0 milligrams per liter of 1,1,2,2-tetrachloroethane in groundwater and/or free-phase solvents.”

### 1.3.5 Remedial Action

The remedial action at Poleline road was performed through a series of successful treatability studies due to budget and contract requirements at the time of implementation.

A treatability study (WC 1997) was conducted in 1997 to evaluate the effectiveness of soil vapor extraction and air sparging. The study also included groundwater sampling and installation of additional soil borings.

In 1997, a design verification study (DVS) (WC 1998) evaluated the effectiveness of six-phase heating as an in situ technology for remediating solvent-contaminated soils. This study also included installation of soil borings.

In 1998 a dual-phased, high vacuum extraction (HVE) treatability study (WC 1999) was performed and in doing so - implemented the remedy selection from the ROD. This phase included groundwater sampling, additional soil borings and monitoring wells.

An additional design verification study (URS 2000 and 2001) was conducted in 1999. The remedial action in accordance with the ROD was implemented in 1998. Based on the success of the six-phase heating study performed in 1997, and per the ROD, enhanced SVE with heating was selected to complete the remedial action. This phase used six-phase heating with SVE for remediating solvent-contaminated soil and groundwater. Additional soil borings were drilled and groundwater samples were collected.

### 1.3.6 Long Term Monitoring

The long-term groundwater monitoring (LTM) program began as part of the initial six-phase heating system. The LTM work plan was finalized in September 1997. Long-term groundwater monitoring program has two objectives, 1) collect data on groundwater contaminant trends, and 2) devise an appropriate long-term site-monitoring plan. Currently, groundwater samples are collected from a network of 22 wells and analyzed for chlorinated solvents and their breakdown products. Sampling is conducted semiannually. Further information on the LTM program can be found in the section 3.5 and section 7.3 discusses the time frame for conducting a trend analyses.

## 1.4 Community Relations

Publicity began in early 1990s with several news stories concerning closure of Eagle River due to discovery of the Poleline Road site and concerning the findings at the site.

The public has been welcome to inspect all relative materials in the Administrative Record throughout the process of selecting the remedy presented in the ROD. Interested citizens were encouraged to comment on the Proposed Plan and remedy selection process following publication of the Proposed Plan in January 1997, during a public meeting held at the

Russian Jack Springs Chalet on January 29, 1997, and throughout the comment period ending February 18, 1997.

Community relations activities that have been conducted for OUB include:

- Conducting community interviews;
- Development of a Community Relations Plan;
- Development of Fact Sheets;
- Posting public notices;
- Conducting public meetings, including site visits;
- Establishment of information repositories and the Administrative Record; and
- Distribution of the Proposed Plan for remedial action at OUB, including a public comment period.

The public has been given the opportunity to participate and comment on ongoing remedial action. Updates on the effectiveness of the remedial action, informational fact sheets, and public notices continue to be made available for the public. The Restoration Advisory Board (RAB) continues to meet quarterly in Anchorage, and interested citizens are invited to participate.

Examples of public opportunities to comment include:

Draft Environmental Assessment (EA) prepared in July 1994 concerning removal of debris and contaminated material from the Poleline Road site. Public notices were placed in the Anchorage Daily News (AND) in June indicating that copies of EA would be available for public review.

Community interviews were conducted in December 1994 in anticipation of developing a community relations plan. Community Relations Plan was developed in 1994.

Initial Environmental Restoration News Letter (Comprehensive Environmental Response, Compensation and Liability Act [CERCLA] Fact Sheets) was published in June 1995. Newsletters (with some exceptions) have been published on a quarterly basis since June 1995.

Along with newsletters, the first CERCLA oriented public meeting was held in June 1995 at the Russian Jack Chalet (this was not the Restoration Advisory Board (RAB) meetings.) These meetings were held quarterly and then the RAB was formed.

Interest in the RAB was solicited for starting in Jan 1996 (first questionnaire for RAB was published in the Environmental Newsletter dated Jan 1996). RAB membership was solicited for in March 1997 by placing notice in the Environmental Newsletter and by placing ads in ADN and Chugiak-Eagle River Star. RAB membership applications were

accepted and the first RAB meeting was held on October 9, 1997. Quarterly RAB meetings have been held since then.

Public Notice for Engineering Evaluation/Cost Analysis (EE/CA) for treatment and disposal of contaminated soil from Poleline Road published in ADN on 18 June 1995.

Proposed Plan for OUB published and put out for public comment in January 1997.

ROD was completed and signed in August 1997.

The Community Relations Plan is in the process of being updated. The current version is available in the information repositories located at the University of Alaska Anchorage Consortium Library, Alaska Resources Library, Fort Richardson Post Library, and the Administrative Record at Building 724 on Fort Richardson.

## 2.0 OPERABLE UNIT B

### 2.1 Record of Decision Requirements

#### 2.1.1 Selected Remedy for OUB

The selected remedy described in the ROD for OUB was High-Vacuum extraction (HVE) and Long-Term Groundwater Monitoring (LTM). The remedy described in the ROD for OU-B included:

- Installing the HVE system within the “hot spot” to decrease contamination and provide hydraulic containment of the area in order to prevent additional contaminant migration down gradient.
- Periodic monitoring of groundwater within and down gradient of the “hot spot”.
- If HVE alone fails to remediate the source area within a reasonable time frame and the Treatability Studies are successful, then one of the successful technologies (i.e., soil heating) for enhanced extraction will be combined with the selected alternative.
- The “hot spot” is defined by the area containing greater than 1 milligram per liter (mg/L) of 1,1,2,2-tetrachloroethane in groundwater (see figure 4).

#### 2.1.2 Major Components of the Selected Remedy

The major components of the selected remedy include the following:

- Treat the “hot spot” through HVE of soil vapor and groundwater in the perched and shallow zones to prevent the main source of contamination from continuing as a threat to groundwater. Soil vapors extracted from the “hot spot” soil will be treated as necessary to meet state and federal air quality standards before release to the atmosphere. Extraction wells will be placed in areas of highest contamination and operated until state and federal maximum contaminant levels (MCLs) and risk-based criteria are achieved in the “hot spot”;
- Treat extracted groundwater through air stripping to achieve state and federal MCLs before discharge;
- Allow natural attenuation of groundwater contamination in areas outside the “hot spot”;
- Evaluate and modify the treatment system as necessary to optimize effectiveness in achieving remedial action objectives (RAOs);
- Monitor groundwater measurements to determine the attainment of RAOs and to detect and thoroughly characterize possible dense non-aqueous phase liquid (DNAPL). The HVE system is expected to operate from seven to twelve years for

soil and shallow groundwater in the “hot spot” and natural attenuation is expected to last 150 years before the remaining groundwater meets state and federal MCLs and risk-based criteria;

- Evaluate the effectiveness of the HVE system to meet long-term restoration goals during initial implementation;
- Conduct Treatability Studies to evaluate innovative technologies with potential to enhance the remedial action, and implement successful innovative technologies if the initial remedy proves ineffective; and
- Maintain institutional controls, including restrictions governing site access, construction, and well development, as long as hazardous substances remain at levels that preclude unrestricted use on site. Implement restrictions on groundwater until contaminant levels are below state and federal MCLs and risk-based criteria.

The institutional control strategy includes the following:

- To ensure long-term effectiveness of this remedy, permanent implementation processes and policies for implementing institutional controls at the site shall be developed for the period of time that the Army is in control of the real property upon which these institutional controls will be effective and during the time, if any, that the real property may be transferred to another federal agency’s responsibility and control. Such processes and policies will be developed through joint EPA, ADEC, and Army negotiations. Once these implementation processes and policies are in place, the ROD will be revised to incorporate such implementation processes and policies;
- To conduct an annual review of the institutional controls being implemented by the Army for this site and shall assess, among other things, the effectiveness of the institutional controls based on a visual “walk-through” of the areas of the site where the institutional controls are in effect and a review of the documents that implement the institutional controls.
- Notify EPA and ADEC in the event that Fort Richardson property is identified as excess to the Army’s needs while hazardous substances remain at or above levels that preclude unrestricted use, and before actual transfer of land management responsibilities to another federal agency or department.

### 2.1.3 Applicable or Relevant and Appropriate Requirements (ARAR)

#### 2.1.3.1 Chemical-Specific Requirements

- Federal Safe Drinking Water Act (40 Code of Federal Regulations [CFR] 141) and Alaska Drinking Water Regulations (18 Alaska Administrative Code [AAC] 80): The state and federal MCL and non-zero MCL goals were established under the Safe Drinking Water Act and are relevant and appropriate for groundwater that is a

potential drinking water source. For the constituents of concern at OUB, state and federal MCLs are equal; and

- Alaska Water Quality Standards (AWQS) (18AAC 70): Alaska Water Quality Standards for Protection of Class (1)(A) Water Supply is applicable to the source area, and Class (1)(B) Water Recreation and Class (1) Aquatic Life and Wildlife (18 AAC 70) are applicable to surface water. Many of the constituents of groundwater regulated by AWQS are identical to state and federal MCLs.

#### 2.1.3.2 Location-Specific Requirements

- Clean Water Act Section 404: Section 404 of the Clean Water Act, which is implemented by EPA and the Army through regulations found in 40 CFR 230 and 33 CFR 320 to 330, prohibits the discharge of dredged or fill materials into waters of the United States without a permit. This statute is relevant and appropriate to the protection of wetlands adjacent to Poleline Road;
- Army Regulation (AR) 200-2 (Environmental Quality), Environmental Effects of Army Actions: This regulation states Department of the Army policy, assigns responsibilities, and establishes procedures for the integration of environmental considerations into Army planning and decision making in accordance with 42 United States Code (USC) 4321 et seq., National Environmental Policy Act of 1969; the Council on Environmental Quality regulations of November 29, 1978; and Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, January 4, 1979; and
- AR 210-20 (Master Planning for Army Installations): This regulation explains the concept of comprehensive planning and establishes policies, procedures, and responsibilities for implementing the Army Installation Master Planning Program. It also establishes the requirements and procedures for developing, submitting for approval, updating, and implementing the Installation Master Plan.

#### 2.1.3.3 Action-Specific Requirements

- Federal Clean Air Act (42 USC 7401), as amended, is applicable for venting contaminated vapors;
- Resource Conservation and Recovery Act (RCRA) (42 USC 6939b[b]) states that contaminated groundwater cannot be injected unless: 1) being done as part of an action under Section 104 or 106 of CERCLA; 2) the contaminated groundwater is treated to “substantially reduce” hazardous constituents before reinjection; and 3) such response action will protect human health and the environment. The selected remedy employs extraction, treatment, and reinjection that substantially improve the condition of the aquifer and meet the substantive intent of this section of RCRA;
- The Safe Drinking Water Act, Underground Injection Control Program, (40 CFR 144) prohibits the movement of contaminated fluid into an underground source of drinking water. However, the act makes a provision for reinjection of treated



groundwater into the same aquifer from which it was drawn pursuant to an action under CERCLA (40 CFR 144.13[c]);

- RCRA (40 CFR 261, 262, 263, 264, and 268); Applicable for identifying, storing, treating, and disposing of hazardous waste;
- Alaska Wastewater Disposal Regulation (18 AAC 72): Section 72.700 addresses the requirements for engineering plans for treatment of wastewater (extracted groundwater), and Section 72.900 addresses permit requirements for operation of wastewater treatment systems; and
- Alaska Air Quality Control Regulations (18 AAC 50): Although onsite remedial actions do not require permitting, the substantive portion of these regulations must be met for the venting of contaminated vapors associated with operation of the air stripping and SVE

#### 2.1.3.4 Information To-Be-Considered

- State of Alaska Petroleum Cleanup Draft Guidance will be used as a TBC for cleanup of petroleum contamination in soils.

## 2.2 Remedial Design Summary

The ROD anticipated the use of Treatability Studies (TS) to determine effective cleanup methodologies. One TS conducted involved the use of six-phase soil heating (SPSH). Treatability studies (or design verification studies) were also conducted using SVE and HVE.

During 1999 an additional TS was conducted using SPSH technology. Six-phase soil heating uses six-phase electricity to resistively heat soils and groundwater and create an in situ source of steam to strip contaminants that are then captured using soil vapor extraction (SVE). Electrodes are connected in a spatially phase-sequenced pattern so that each electrode conducts heat to every other electrode in the formation. This results in a relatively even heating pattern that can be adjusted to site-specific conditions. During the heating process, vapor extraction wells were used to remove steam and contaminant vapors as they are produced. A steam condenser separated the mixture of soil gas vapors, steam, and contaminants extracted from the subsurface into condensate and contaminant-laden vapor.

Figure 5 shows a schematic of the SPSH system used at OUB. The final connection of electrical power included a pad-mounted 300-kilowatt (kW) transformer, a meter base, and a junction box. The junction box provided 12.4-kilovolt (kV) power to the six-phase transformer. The 300-kW transformer supplied 480-volt power to the remaining electrical equipment (condenser, blower, and office trailer).

The SPSH transformer was connected to 21 electrodes that were arranged in three rows with seven electrodes in each row (Figure 6). Electrodes were spaced approximately 19 ft apart. Electrodes in one row were offset from electrodes in adjacent rows by approximately 9.5 ft. This configuration differs from previous SPSH arrays at OUB, which consisted of six electrodes in a circle with the seventh electrode in the center.

### 3.0 CONSTRUCTION ACTIVITIES

This section is organized by the different treatability studies that were conducted at the Poleline Road site. Within each section, a brief description of the action and corresponding result is presented.

#### 3.1 SVE and Air Sparging Test

A soil vapor extraction test was performed at OUB for five days from November 14 to 19, 1996. Soil vapors were extracted through monitoring well MW-14. MW-14 is a four-inch stainless steel monitoring well screened in the perched groundwater interval. The screen extends from nine to 19 ft bgs. A groundwater sampling pump was left in the well during the SVE test so that water mounding would be minimized.

Three monitoring points were installed adjacent to the SVE well. Each monitoring point had two soil gas sampling points and a two-inch PVC well for water level measurements. The shallow soil gas sampling points were 10 feet bgs and the deep soil gas sampling points were 23 feet bgs. The PVC wells were screened in the shallow groundwater interval at the site. The three monitoring points were located at 10, 15, and 25 feet east from the SVE well (MW14). A bailer placed into (monitoring point) MP-2 several days after it was developed had approximately three inches of a dark liquid in the bottom of the bailer. This was the first dense nonaqueous phase liquid (DNAPL) encountered at the site.

Data was recorded during the SVE test at least once every four hours and more frequently at the beginning of the test. Soil gas sampling points were installed at two depths in each of the three monitoring points, for a total of six-soil gas monitoring points. Vacuum readings were measured in the soil gas monitoring points during the SVE test. The shallow points are located about 10 ft bgs. The deep sampling points are located at approximately 23 ft bgs.

Air was injected into the shallow groundwater using a five horsepower blower. Dissolved oxygen, water levels, and soil gas pressure changes were observed in the nearby monitoring points (MP1, -2, and -3). The initial dissolved oxygen levels in the groundwater ranged from four to seven percent. Maximum oxygen levels achieved during the air sparging test ranged from 100 to 155 percent. The oxygen concentrations increased in all three monitoring points.

Extracted soil gas samples were collected during the SVE test with tedlar bags and with summa canisters. The highest concentration of TCE was detected in the first summa canister sample collected (46,000 parts-per-billion-volume [ppbv]). The highest concentration of 1,1,2,2-tetrachloroethane was detected in the fifth summa canister. The first sample was collected approximately five hours after the SVE test began, and the fifth was collected after approximately 29 hours.

The ratio of TCE to 1,1,2,2-tetrachloroethane in the soil gas samples was different from the soil samples collected at MW-14. TCE was generally found at either higher or the same concentrations as 1,1,2,2-tetrachloroethane in the extracted soil gas. TCE was found at

considerably lower concentration than 1,1,2,2-tetrachloroethane in the soil samples collected at MW-14. This difference is a result of the different vapor pressures for TCE (57.8 millimeters of mercury [mm Hg]) and 1,1,2,2-tetrachloroethane (6 mm Hg). Although the TCE is found at lower concentrations in the soil, it is found at higher concentrations in the soil gas because it volatilizes more readily.

The SVE radius of influence was between 25 and 35 ft. For air sparging the radius of influence was between 10 and 20 ft. The amount of solvents removed from the soil during the SVE five-day test was estimated to be about 11.6 pounds (lbs). The total volume of air extracted was 986,580 cubic feet (ft<sup>3</sup>). An estimated 200 gallons of groundwater was removed from the knockout tank during the test.

Additional details and information about the SVE and air sparging tests are found in the *Treatability Study Report* March 1997. (WC March 1997)

### 3.2 Heat Enhanced Soil Vapor Extraction Study (Arrays 1, 2, and 3)

A heat enhanced soil vapor extraction study was performed from July 11 to December 18, 1997 to evaluate the effectiveness of six-phased soil heating (SPSH). SPSH was used to resistively heat the soil. The system combined the emerging technology of SPSH with SVE. Figure 7 shows the locations of the first three arrays.

The three arrays were installed to heat soils from 8 to 38 feet bgs. Each array was heated for a total of six weeks.

<u>Array</u>	<u>Performance period</u>	<u>Diameter of Array</u>
Array 1	July 11, 1997 through August 22, 1997	27 feet
Array 2	August 24 through October 9, 1997	27 feet
Array 3	November 6, 1997 through December 18, 1997	40 feet

Each array was arranged circularly and comprised of six electrodes. Figure 8 shows the SPSH system setup. The electrode depth was selected to ensure that the shallow aquifer, suspected of having the highest concentration of contaminants, was within the heated zone. Each electrode also served as an SVE vent well with a screened interval from 8.5 to 18.5 feet bgs. The screen allows vapors to be pulled from the soil into the electrode. Placing the screen in the upper portion of the electrode ensured that rising steam was captured by the SVE system.

Granular graphite filter material was placed between the electrode/SVE well and the soil, permitting current to flow from the casing to the soil. The granular nature of the graphite allows soil gas to be pulled from the soil into the screened portion of the well. The graphite used in the electrodes is a more dense form of graphite and does not absorb contaminants like activated carbon.

An eight-foot long section of six-inch diameter chlorinated-polyvinylchloride (CPVC) pipe was placed over the upper portion of the casing to electrically isolate the upper eight feet of soil from the electrode. This prevents active heating of the upper eight feet of soil in the array.

Power for arrays 1 and 2 was supplied by a 455-kilowatt (kW) diesel generator, which supplied 3-phase, 480-volt power to the 6-phase transformer and other equipment on site. Power for array 3 was supplied by a 1,200 kW generator. The 6-phase transformer is composed of six single-phase transformers. The transformers convert the 3-phase power supplied by the generator to 6 phases, each 60 degrees out of phase with the next. The output from each single-phase transformer is connected to a single electrode and the center electrode is connected to the neutral electrode on the transformer.

Soil temperature data was collected from thermocouple borings installed in and around each array. Each thermocouple boring was backfilled with cement after installing three thermocouples at different depths.

A 20-horsepower (hp) positive displacement blower was used to pull vapors from the extraction wells. Between the blower and the array was a condenser. The condenser cooled the vapor pulled from the extraction wells, separating the liquid and vapor phases. Condensate from the condenser was preheated and then pumped into an air stripper for treatment. Effluent from the air stripper was discharged to area A-2. Effluent was not released until sampling showed that the air stripper was reducing the concentration of contaminants to levels at or below existing MCLs.

A catalytic oxidizer (CATOX) was used to treat off-gas from the condenser while heating array 1. The CATOX removed solvents in the off-gas by heating the off-gas to 650 degrees Fahrenheit (°F) in the presence of a catalyst. Since the concentration of solvents in the off-gas vapor was less than expected, the CATOX was removed from the site before the first array was completed.

### 3.2.1 System Monitoring

While the arrays were operating, several parameters were monitored to help track the system performance. Electronic sensors sent data to the on-site computer and monitored the following parameters:

- Condenser off-gas pressure, flow and temperature
- Soil temperatures from thermocouples
- Soil resistivity
- Transformer voltages, amperages, and total power

Other parameters were manually recorded from various gauges. These parameters included:

- Generator amperage

- Fuel levels
- Vacuum at knock out tanks
- Effluent water tank levels
- Off-gas photoionization detector (PID) levels

### 3.2.2 Soil Remediation Effectiveness

Several parameters were monitored to measure the effectiveness of SPSH on the concentration of chlorinated solvents in soil. These parameters included:

- Soil temperatures from thermocouples and
- Condenser off-gas pressure, flow, and temperature

Soil samples were also collected from each array before and after treatment. Figure 9 shows the average mass of contaminants in the soil before and after treatment. Treatment for each array continued for six weeks, and temperature was measured throughout the treatment period.

#### 3.2.2.1 Temperature

Soil temperature data was collected from each thermocouple boring. Figures 10, 11, and 12 graphically depict the changing soil temperatures in each array. The last two digits of the identification number in the graphs represent the depth of the thermocouple. As depicted on the graphs, soil heating was limited to 100 °C. These graphs also show that some soils could be heated to 100 °C within 20 days.

#### 3.2.2.2 Off-Gas

The off-gas samples were collected after the condenser and before the blower and a vacuum dilution valve. Figure 13 presents the condenser off-gas sample results from arrays 1, 2, and 3. The estimated mass of contaminants removed via the off-gas of arrays 1, 2, and 3 was 386, 217, and 138 pounds respectively. Mass removal rates were only calculated for TCE, PCE, and 1,1,2,2-tetrachloroethane, which indicates the aggregate estimate of mass removal under-reports removal of other contaminants.

#### 3.2.2.3 Soil Sample Results

Soil samples were collected while drilling each thermocouple boring. These samples were analyzed for VOCs. Confirmation borings, located adjacent to the four thermocouple borings, were drilled and sampled at the conclusion of each SPSH test. Tables 6-1, 6-2, and 6-3 (Appendix B) present the initial thermocouple boring soil sample results for each array. Tables 6-4, 6-5, and 6-6 (Appendix C), show confirmation sample comparisons and the percent of analyte removed. Figure 14 shows the maximum soil concentration of 1,1,2,2-tetrachloroethane and TCE for each boring. A treatment summary for all three arrays is provided in Table 6-7 (Appendix B). The summary provides information on the amount of

soil treated in each array and the mass of contaminants removed via the off-gas and condensate for each array. The volume of soil was calculated based on the diameter and depth of the soil array. The amount of soil treated differed between the arrays. Arrays 1 and 2 treated approximately 1,260 cubic yards (yd<sup>3</sup>) of soil each, while array 3 treated approximately 2,100 yd<sup>3</sup>.

Listed below is a summary of the before and after treatment soil sample results for arrays 1, 2, and 3.

<b>ARRAY 1 – Soil Sample Results</b>			
<b>COC</b>	<b>Before Treatment (mg/kg)</b>	<b>After Treatment (mg/kg)</b>	<b>Average Percent Reduced</b>
Trichloroethene (Range)	0.91 – 300	0.19-13	93%
Average Value	21.53	1.60	
Tetrachloroethene (Range)	ND (0.05) – 29	ND (0.05) – 0.49	96%
Average Value	2.0		
1,1,2,2-Tetrachloroethane (Range)	0.12 – 1000	ND (0.05) – 26	99%
Average Value	82.34	1.17	

<b>ARRAY 2 – Soil Sample Results</b>			
<b>COC</b>	<b>Before Treatment (mg/kg)</b>	<b>After Treatment (mg/kg)</b>	<b>Average Percent Reduced</b>
Trichloroethene (Range)	1.50 – 270	ND (0.06) – 1.9	97%
Average Value	31.52	0.81	
Tetrachloroethene (Range)	ND (0.05) – 8.10	ND (0.05) – 0.17	94%
Average Value	1.23	0.08	
1,1,2,2-Tetrachloroethane (Range)	0.11 – 110	ND (0.05) – 0.12	99%
Average Value	12.24	1.17	

<b>ARRAY 3 – Soil Sample Results</b>			
<b>COC</b>	<b>Before Treatment (mg/kg)</b>	<b>After Treatment (mg/kg)</b>	<b>Average Percent Reduced</b>
Trichloroethene (Range)	0.11 – 25	0.32-22	93%
Average Value	7.4	0.49	
Tetrachloroethene (Range)	ND (0.05) – 0.77	ND (0.05) – 3.8	Varies
Average Value	0.33	0.58	
1,1,2,2-Tetrachloroethane (Range)	ND (0.06) – 34	ND (0.05) – 57	41%
Average Value	13.10	7.7	

Results for arrays 1 and 2 were similar. Each array had a comparable amount of soil, same treatment time, and similar energy inputs. The only significant difference was array 2 had a lower estimated mass of contaminants before treatment.

Array 3 was not as effective as arrays 1 and 2. This may be due to an increased array size and a less than optimum borehole diameter. Increasing the array diameter results in a larger area of very high temperature soils immediately around the electrode. The high temperatures make it difficult to maintain moisture near the electrode. The dry soils resist efficient flow of electricity from the electrode. When installing electrodes, the diameter of the borehole should be at least as large as the diameter of the very high temperature soils shown by the model. In some cases the maximum after treatment concentrations for array 3 were slightly higher than the before treatment ranges. This is fundamentally due to sampling variability and site conditions rather than impact from the treatment. Overall the average concentrations are considerably lower than before treatment. Two additional confirmation sample borings were installed after treatment at array 3. This provided eight additional confirmation-sampling locations that did not have “pre-treatment” samples for comparison.

### 3.2.3 Groundwater Remediation Effectiveness

The primary goal of the study was to characterize the effectiveness of SPSH at reducing the concentration of chlorinated solvents in soil. The only samples collected during the test that could help characterize the effectiveness of SPSH in groundwater were the condensate samples collected from the condenser.

A combination of soil gas vapors, steam, and water was pulled from the extraction wells and cooled in the condenser separating the liquid (condensate) from the vapor phase.

Sample results and further description of the system test are provided in the report "System Evaluation, Operable Unit B" dated September 23, 1999.

More than 100,000 gallons of condensate was generated from the combination of arrays 1, 2, and 3. It is estimated that 15.2 pounds of Trichloroethene, Tetrachloroethene, and 1,1,2,2-tetrachloroethane was removed in association with the condensate.

### 3.3 HVE Pilot Study

An HVE pilot study was conducted in 1998. Soil gas and groundwater were extracted from two extraction wells. The HVE test ran from March 18, 1998 through October 16, 1998. Approximately one-half million gallons of groundwater were removed by the system and approximately 230 lb of chlorinated solvents. The HVE system primarily removes soil gas from low permeability formations. Groundwater removal is a secondary function of the system. The vacuum extraction well includes a screened section in the zone of contaminated soils and groundwater. It removes contaminants from the vadose zone and to a lesser degree the saturated zone. The system lowers the water table around the well, exposing more of the formation. Contaminants in the newly exposed vadose zone are then accessible to vapor extraction. Once above ground, the extracted vapor or liquid phase organics and groundwater are separated and treated.

Site preparation began in February 1998. Two monitoring wells (MW-23 and MW-24) and two extraction wells (DPE-1 and DPE-2) were installed.

Each well has a 4-inch diameter. The remainder of the system was installed in March 1998. Each extraction well had a 30-ft section of 1-inch PVC tubing that connected to a dual-phase extraction blower. Water and vapors were extracted from the well and pulled into the first moisture separator.

#### 3.3.1 System Monitoring

System monitoring was conducted twice each week for the duration of the HVE system test. During each site visit, oil was added to the generator, PID measurements were taken, and adjustments were made to the drop tubes. Extracted soil gas and groundwater were periodically sampled from the first moisture separator. The samples were analyzed for VOCs.

#### 3.3.2 Soil Remediation Effectiveness

HVE system air samples were collected on March 26, May 8, and June 12, 1998. Results from these samples are presented in Table 5-1 (Appendix B). The air sampling results show that the concentration of solvents in the extracted air decreased during the test. This could indicate that the concentration of solvents in the soil was also reduced or that the system became diffusion limited.

Due to equipment difficulties, exact airflow extraction rates are unavailable. However, since the HVE system is a dual phase system, extraction flow rates from the SVE study could be used to develop an estimate. Based upon the SVE air volume extraction for one



well, which was 9,900 ft<sup>3</sup>/day, the estimated mass removal rate of VOCs from soil gas was approximately 2.5 kg/day per well. Approximately 490 pounds of contaminants were removed from the soil.

### 3.3.3 Groundwater Remediation Effectiveness

Groundwater samples were collected during the test from MW-23 and MW-25, and the moisture separator to monitor the effectiveness of groundwater remediation by the HVE system. Results from the groundwater samples are included in Table 5-2 (Appendix B). The highest results for TCE and 1,1,2,2-tetrachloroethane were 8.3 mg/L and 60 mg/L respectively.

The groundwater samples collected during the test do not clearly indicate that the HVE system was effective at reducing the concentration of chlorinated solvents in the groundwater. Rather than representing groundwater treated by the HVE system, the groundwater samples collected actually represent groundwater moving toward the HVE wells. Groundwater moved toward the HVE wells because of a cone of depression caused by the removal of groundwater from the HVE well.

The concentrations of solvents in groundwater samples collected from MW-23 and -24 were compared to the concentrations of solvents collected from MW-21 and -22. Monitoring wells MW-22 and MW-23 are located outside the HVE treatment area. If the HVE system had reduced the concentration of solvents in the groundwater, then the pattern of solvent concentrations in MW23- and -24 should differ from patterns observed in MW-21 and -22. Since the pattern of solvent concentrations in the wells appears so similar, it does not appear from these data that the HVE system reduced the concentration of solvents in the groundwater appreciably. However, approximately 500,000 gallons of groundwater was removed by the system, which included approximately 230 pounds of chlorinated solvents.

### 3.4 Six Phase Heating Array 4, 5 and 6

This SPSH system was used to heat a region approximately 110 ft long by 50 ft wide by 35 ft deep. The heating zone was divided into three areas: arrays 4, 5, and 6. A buried electric cable powered the SPSH transformer and SVE system. The cable extended from a Matanuska Electric Association (MEA) junction box at the Anchorage Landfill entrance, down Barrs Boulevard, and to the site. The study area was actively heated for nine weeks.

Thermocouples were placed at locations that would be the last to heat. Data collected from the thermocouples show that soil at a depth of 25 ft was heated to approximately 100 °C.

Vapors pulled from the extraction wells were cooled in a condenser, separating the liquid and vapor phases. The estimated mass of TCE, PCE, and 1,1,2,2-tetrachloroethane removed via the off-gas was 1,385 pounds, while the mass of the contaminants removed via the condensate was 65 pounds.

Soil and groundwater samples were collected from arrays 4, 5 and 6 before and after soil heating.

### 3.4.1 System Installation

Drilling for installation of electrodes, SVE wells, and thermocouples was conducted in three phases. Seven electrodes, three SVE wells, and two thermocouple installations were completed during each phase. See figure 5.

Installation began with array 5, located in the northern portion of the treatment area. Array 5 drilling was conducted May 18-27, 1999. Drilling of array 4 (center portion of the treatment area) was conducted June 7-15, 1999. Drilling of array 6 (located in the southern portion of the treatment area) was conducted July 12 - 20, 1999.

The following is a list of the boreholes, electrodes, SVE wells, and thermocouples associated with their respective array.

<u>ARRAY</u>	<u>BOREHOLES</u>	<u>ELECTRODES</u>	<u>SVE WELLS</u>	<u>Thermocouples</u>
Array 4	AP-4080 to -4091	E4-1 to -6, & 4N	V4-1 to -3	T4-1 and T4-2
Array 5	AP-4031 to -4042	E5-1 to -6, & 5N	V5-1 to -3	T5-1 and T5-2
Array 6	AP-4092 to -4103	E6-1 to -6, & 6N	V6-1 to -3	T6-1 and T6-2

### 3.4.2 System Monitoring

Several parameters were monitored so the system performance could be evaluated and optimized. Electronic sensors monitored the following parameters.

- Transformer voltages, amperages, and total power
- Soil resistivity
- Soil temperatures from thermocouples

The parameters measured manually include:

- Vacuum at knock out tank
- Off-gas VOC field screening values
- Off-gas vacuum
- Condenser off-gas vacuum, flow, and temperature

Condensate and condenser off-gas samples were collected approximately every other day during operation. Condensate and vapor samples were analyzed for VOCs.

### 3.4.3 Remediation Effectiveness

The effectiveness of the system was evaluated by monitoring the ability of the heat-enhanced soil vapor extraction system to accomplish the following:

- heat soil in the study area,
- increase the removal rate of contaminants, as compared to previous SPSH tests at the site, and
- effectively remove VOCs from the soil and groundwater.

#### 3.4.3.1 Temperature

Soil heating started July 31, 1999 and continued until October 4, 1999. Thermocouples measured soil temperatures at six locations within the treatment area. At each location, temperatures were recorded at depths of 12, 25, and 38 ft. Soil temperature data show that soil at a depth of 25 ft, in most locations, was heated to approximately 100 °C. In the vadose zone, this process reduced the moisture in the soil causing a decrease in the electrical conductivity of the soil. The soil temperatures in the vadose zone decreased during the latter portion of the test because the moisture removed from the soil was not replaced.

#### 3.4.3.2 Off-Gas

Samples of condenser off-gas and condensate were collected approximately every other day while the system was running. Condensate samples were collected after the heat exchanger on the condenser and before the water cooling-tower.

Table 3-7 summarizes the laboratory data for analytes detected in off-gas samples, and Table 3-8 (Appendix C) summarizes the laboratory data for analytes detected in condensate.

Concentrations of the primary VOCs detected in the off-gas and condensate are shown graphically in Figure 15. Concentrations of the primary VOCs generally decreased while the SPSH/SVE system was running. Figure 15 also shows that concentrations of TCE were higher than concentrations of 1,1,2,2-tetrachloroethane in the off-gas; while in the condensate, concentrations of 1,1,2,2-tetrachloroethane were higher than concentrations of TCE. The TCE tends to stay in the vapor phase compared to 1,1,2,2-tetrachloroethane, since TCE is more volatile.

The estimated quantities of the three primary VOCs removed via the condenser off-gas and condensate are:

	Condenser	Condensate
TCE	1,008 lbs	10 lbs
PCE	53 lbs	0.25 lbs
1,1,2,2-tetrachloroethane	324 lbs	55 lbs

Contaminant concentrations were available only when samples were collected. For the days when there were no sample results, the assumed concentration is an average of the previous and subsequent concentrations.

### 3.4.3.3 Soil Sample Results

Prior to SPSH, four soil samples from thermocouple borings (T4-1, T4-2, T6-1, and T6-2) were collected. At these locations, split spoon samples were attempted every 5 ft from depths of 15 to 35 ft. From array 5, soil samples were collected near the groundwater interface (approximately 17 ft bgs) and from the bottom of the boreholes (25 to 35 ft bgs).

After SPSH was completed, soil samples were collected from six confirmation soil borings (C4-1, C4-2, C5-1, C5-2, C6-1, and C6-2). At these locations, split-spoon samples were attempted every 5 ft from depths of 15 to 35 ft. Confirmation borings were located within a couple feet of the thermocouple boring in arrays 4 and 6. Within array 5, the confirmation borings were placed within a couple feet of electrodes E5-3 and E5-6, where the samples collected before SPSH exhibited relatively high levels of contamination compared to other locations within the array 5 area. Tables 3-1, 3-2 and 3-3 (Appendix C), summarize analytical results for VOCs detected in the soil samples.

Data for two samples (00PRDA-004-SL and 00PRDA-007-SL) collected after SPSH were rejected. Sample 00PRDA-004-SL was not considered representative because the soil froze before the sampler could be opened and was thawed to collect a portion for analysis. Data for sample 00PRDA-007-SL was rejected since the sample jar was broken at the laboratory before sample weight had been determined.

A comparison of analytical results for samples collected before and after treatment is presented in Tables 3-4 and 3-5 (Appendix C). Only 1,1,2,2-tetrachloroethane, PCE, and TCE are presented because these compounds had the highest pre-treatment concentrations. Average concentrations for each compound and calculated values for percentages removed are also included in the tables. Approximately 99.9 percent of the 1,1,2,2-tetrachloroethane present before treatment was removed from the soil in the treatment area. Removal of PCE ranged from 79.5 to 99.6 percent. Removal of TCE ranged from 68.5 to 97.2 percent.

Listed below is a summary of the before and after treatment results for arrays 4, 5, and 6.

<b>ARRAY 4</b>			
<b>COC</b>	<b>Before Treatment (mg/kg)</b>	<b>After Treatment (mg/kg)</b>	<b>Average Percent Reduced</b>
Trichloroethene (Range)	0.48 – 640	ND (0.025) – 12	97%
Average Value	82.50	2.28	
Tetrachloroethene (Range)	ND (0.03) – 120	ND (0.024) – 0.12	99.7%
Average Value	15.25	0.05	
1,1,2,2-Tetrachloroethane (Range)	0.21 – 12000	ND (0.03)	99.9%
Average Value	1513.5	ND (0.03)	

<b>ARRAY 5</b>			
<b>COC</b>	<b>Before Treatment (mg/kg)</b>	<b>After Treatment (mg/kg)</b>	<b>Average Percent Reduced</b>
Trichloroethene (Range)	0.94 – 76.0	ND (0.023) – 7.5	83%
Average Value	11.12	1.87	
Tetrachloroethene (Range)	ND (0.04) – 34	ND (0.023) – 0.34	97%
Average Value	3.22	0.09	
1,1,2,2-Tetrachloroethane (Range)	0.043 – 1800	ND (0.019) – 0.36	99.9%
Average Value	124.8	0.08	

<b>ARRAY 6</b>			
<b>COC</b>	<b>Before Treatment (mg/kg)</b>	<b>After Treatment (mg/kg)</b>	<b>Average Percent Reduced</b>
Trichloroethene (Range)	ND (0.07) - 200	ND (0.026) – 63	68.5%
Average Value	26.92	8.48	
Tetrachloroethene (Range)	ND (0.04) – 3.1	ND (0.022) – 0.71	79.5%
Average Value	0.60	0.12	
1,1,2,2-Tetrachloroethane (Range)	ND (0.07) - 530	ND (0.03)	99.9%
Average Value	70.04	ND (0.03)	

#### 3.4.4 Groundwater Remediation Effectiveness

Samples were collected from three monitoring wells (MW-19, -22, and -23) within the treatment area before and after SPSH was conducted. These wells range from 35 to 40.5 ft deep.

Except for the concentration of PCE in the post-treatment sample collected from MW-19, concentration of the three most abundant contaminants of concern (1,1,2,2-tetrachloroethane, PCE, and TCE) are above the RAOs.

A long term monitoring program was established to observe the continuing progress of the groundwater trends.

Listed below is a summary of the before and after treatment groundwater results for Poleline Road. The summary compares data from March 1999 with October 2001.

<b>Groundwater Treatment Effectiveness</b>			
<b>COC</b>	<b>Before Treatment (mg/L)</b>	<b>After Treatment (mg/L)</b>	<b>Average Percent Reduced</b>
Trichloroethene (Range) Average Value	ND (0.001) - 12 1.41	ND (0.00012) – 3.0 0.439	69%
Tetrachloroethene (Range) Average Value	ND (0.001) – 0.16 0.027	ND (0.00011) – 0.046 0.00638	76%
1,1,2,2-Tetrachloroethane (Range) Average Value	ND (0.001) - 47 5.23	ND (0.00014) – 2.1 0.21	96%

### 3.5 Long Term Monitoring

Eleven rounds of groundwater data have been collected from November 1997 through October 2002. In groundwater collected from several wells, the concentrations of primary VOCs (1,1,2,2-tetrachloroethane, TCE, and PCE) were reduced as a result of the SPSH tests in 1997 and 1999. Seven rounds of groundwater samples have been collected since the SPSH system was shut off.

Separate reports for each of the ten groundwater monitoring events are available and included in the administrative record.

## 4.0 CHRONOLOGY OF EVENTS

### 4.1 Summary of Events at OUB

The Poleline Road Disposal Area (OUB) has been the subject of environmental investigations since 1990. A brief history of the site investigations and remedial action history is presented in section 1.3 of this report.

A chronological summary of significant events since the signing of the ROD is provided below.

<u>DATE</u>	<u>EVENT</u>
September 14, 1997	ROD for OUA and B signed
September 15, 1997	Final, Long Term Monitoring (LTM) Work Plan.
October 6, 1997	Soil "Hotspot" Delineation at OU-B. Describes proposed boring locations to further delineate the soil hotspot.
October 17, 1997	Technical Memorandum, Six Phase Soil Heating. Describes elements of the six-phase heating system and results from the first array.
November 1997	First Long-Term Groundwater Monitoring (LTM) Sampling Event
December 5, 1997	OPERABLE UNIT B REMEDIAL DESIGN/REMEDIAL ACTION STATEMENT OF WORK This document describes the strategy for managing post-Record of Decision (ROD) activity and provides the implementation schedule for remedial design/remedial action (RD/RA)
June 1998	Second Long-Term Groundwater Monitoring (LTM) Sampling Event
October 1998	Third Long-Term Groundwater Monitoring (LTM) event
March 1999	Fourth Long-Term Groundwater Monitoring (LTM) event
April 1, 1999	Final Remedial Action Report: Soil Stockpile Remediation. Reviews the results of remediating 3,600 cubic yards of contaminated stockpiled soil.
October 1999	Fifth Long-Term Groundwater Monitoring (LTM) event
November 12, 1999	Technical Memorandum – Installation of Array 5. Describes the field procedures used and analytical results.
April 2000	Sixth Long-Term Groundwater Monitoring (LTM) event

<b><u>DATE</u></b>	<b><u>EVENT</u></b>
October 2000	Seventh Long-Term Groundwater Monitoring (LTM) event
March 2001	Revised Final Report, Design Verification Study, Arrays 4, 5, and 6. The DVS evaluates the performance of the SPSH system in reducing the concentration of chlorinated solvents in groundwater at the site.
April 2001	Eighth Long-Term Groundwater Monitoring (LTM) event
October 2001	Ninth Long-Term Groundwater Monitoring (LTM) event
April/May 2002	Tenth Long-Term Groundwater Monitoring (LTM) event
October 2002	Eleventh Long-Term Groundwater Monitoring (LTM) event

#### 4.2 Cleanup Goals at OUB

The cleanup goals at OUB continue to be in accordance with the ROD signed in 1997. The Remedial Action Objectives (RAOs) are shown below (ROD 1997).

1. Reduce contaminant levels in the groundwater to comply with drinking water standards;
2. Prevent contaminated soil from continuing to act as a source of groundwater contamination;
3. Prevent the contaminated groundwater from adversely affecting the Eagle River surface water and sediments; and
4. Minimize degradation of the State of Alaska's groundwater resources at the site as a result of past disposal practices.

The two tables below summarize the chemical specific cleanup goals for groundwater and soil at the site.

<b>REMEDIAL CLEANUP GOALS FOR GROUNDWATER</b>				
<b>Contaminant of Concern</b>	<b>Max Detected Concentration (mg/L)</b>	<b>Most Recent Result from Oct 2001 LTM (mg/L)</b>	<b>Remedial Action Objective (mg/L)</b>	<b>Source of RAO<sup>a</sup></b>
Benzene	2.9	0.0053	0.005	MCL
Carbon Tetrachloride	2.6	0.003	0.005	MCL
cis-1,2-Dichloroethene	37	1.1	0.007	MCL
trans-1,2-Dichloroethene	12	0.17	0.1	MCL
Tetrachloroethene (PCE)	11	0.046	0.005	MCL
Trichloroethene (TCE)	220	3.0	0.005	MCL
1,1,2,2-Tetrachloroethane	1,900	2.1	0.052*	MCL

Source: Table 5-1 1997 ROD

a – State and federal maximum contaminant level (MCL) for drinking water



\*The cleanup level of 0.052 mg/L established for 1,1,2,2-PCA in groundwater appears to have been the result of a transcription error. The RBC for 1,1,2,2-PCA at the time the ROD was written was 0.0052 mg/L. The risk assessment and groundwater fate and transport model both used the value of 0.0052 mg/L for 1,1,2,2-PCA to estimate the time to reach clean up levels. The groundwater model estimated that it would take about 150 years for groundwater concentrations to reach the cleanup levels (0.0052 mg/L for 1,1,2,2-PCA). Although an incorrect RBC was identified in the ROD, this change does not affect the scope, performance, or long-term reliability of the remedy. The remedy is protective since IC's are in place to prevent the use of groundwater as a drinking water source. The most recent version of the U.S. EPA Region 3 RBC table now has an RBC equal to 0.0053 mg/L (tap water) for the 10<sup>-4</sup> excess cancer risk. This RBC has not changed significantly since the risk assessment and groundwater modeling were conducted. This change does not call into question the validity of the original assessment work.

<b>REMEDIAL CLEANUP GOALS FOR SOIL</b>			
<b>Contaminant of Concern</b>	<b>Max Detected Concentration (mg/kg)</b>	<b>Remedial Action Objective (mg/kg)</b>	<b>Source of RAO</b>
Tetrachloroethene	159	4.0	RBC
1,1,2,2-Tetrachloroethane	2,030	0.1	RBC

Source: Table 5-2 1997 ROD

## 5.0 PERFORMANCE STANDARDS AND CONSTRUCTION QUALITY CONTROL

The remedial action objectives and cleanup goals are listed above in section 4.2.

### 5.1 Comparison to Remedial Action Objectives

Remedial Action Objectives (RAO) for 1,1,2,2-tetrachloroethane and PCE in soil were established in the Record of Decision (ROD) for OUB. The RAO for 1,1,2,2-tetrachloroethane in soil is 0.1 mg/kg and the RAO for PCE in soil is 4 mg/kg.

In the treatment area, approximately 99.9 percent of the 1,1,2,2-tetrachloroethane present before treatment was removed from the soil. Removal of PCE ranged from 79.5 to 99.6 percent. Removal of TCE ranged from 68.5 to 97.2 percent.

Before SPSH, 15 of the 17 soil samples collected from arrays 4 and 6 had 1,1,2,2-tetrachloroethane concentrations above the RAO. After SPSH, all 19 samples collected from those two arrays were below the RAO. In array 5, 14 of the 16 soil samples collected before SPSH had 1,1,2,2-tetrachloroethane concentrations above the RAO. After SPSH, eight confirmation samples were collected. Six were non-detect, one was below the RAO, and one of the eight samples collected from this area contained a 1,1,2,2-tetrachloroethane concentration (0.36 mg/kg) above the RAO of 0.1 mg/kg.

Before SPSH only 1 of 17 soil samples collected from arrays 4 and 6 had a PCE concentration above the RAO. After SPSH, the PCE concentration in all 19 samples from these two arrays were below the RAO of 4 mg/kg. In array 5, 2 of the 16 soil samples collected before SPSH had PCE concentrations above the RAO. After SPSH, none of the eight samples collected were above the RAO for PCE.

The ROD for OUB did not establish an RAO for TCE in soil. The ROD indicates that the RAOs for 1,1,2,2-tetrachloroethane and PCE were derived from risk based concentrations (RBC). For comparison purposes only, the RBC for TCE in 1999 was 0.015 mg/kg. For all three arrays (4, 5, and 6), a total of 60 samples were collected before and after SPSH. All but one post-treatment sample (from array 5) had a detection of TCE. Post treatment concentrations however are generally lower than the pre-treatment samples.

See Tables 3-4, 3-5, and 3-6 (Appendix C) for summary of the before and after soil results from arrays 4, 5, and 6.

Through the remedial actions that have occurred at OUB as a series of treatability studies, the remedial action objectives have been achieved for soil. Thus far, monitoring shows that no off-source migration of contaminants is occurring and that the remedial actions that have occurred at OUB are effective in protecting human health and the environment. In accordance with the ROD, groundwater will be monitored to determine if the contaminants are naturally attenuating.

## 5.2 Sampling Strategy

Previous studies, investigations, and remedial actions have shown that VOCs are the contaminants of concern at OUB. Therefore, groundwater samples were analyzed for VOCs by EPA Method 8260. There have been 23 monitoring wells sampled during the long-term groundwater-monitoring program. These are shown on figure 3. MW-4, MW-14, MP-3 and PZ-1 are no longer monitored since they are dry. MW-17 is the background well and sampled for natural attenuation parameters. The following provides the rationale for each monitoring well at the time they were chosen (WC September 1997).

<b>WELL ID</b>	<b>SCREENED INTERVAL</b>	<b>RATIONALE FOR SAMPLING</b>
MW-1	Deep	MW-2 is co-located w/MW-1, MW-1 has detections, MW-2 is ND
MW-2	Shallow	Clean at the time of selection, relatively close to source
MW-3	Shallow	Only well in this area
MW-4	Intermediate (dry)	Only intermediate well just downgradient of source
MW-5	Shallow/Intermediate	Screened across two intervals but no other shallow wells in this area
MW-6	Deep	Closest downgradient deep well to source area
MW-7	Deep	Only deep well in this area
MW-8	Shallow	Only well in this area
MW-9	Deep	Location to potentially define limit of deep plume
MW-12	Shallow	Downgradient shallow interval
MW-13	Shallow	Near edge of plume in shallow interval
MW-14	Perched (dry)	Only well in perched interval
MW-15	Shallow	Farthest downgradient shallow well
MW-16	Deep	Deepest and furthest downgradient well
MW-17	Shallow	Background well: For natural attenuation parameters, MW-17 will be substituted for one of the other wells (specific well will depend on field conditions: it will be one with insufficient water.)
MW-19	Shallow	South of A-3, no other wells in this area
MW-20	Shallow	New well potentially at NE edge of shallow plume
MW-21	Shallow	New well at edge of hot spot
MW-22	Shallow	New well potentially at W edge of shallow plume
MW-23	Shallow	New well added in 1998
MW-24	Shallow	New well added in 1998
PZ-1	Shallow (dry)	Near source, large water column
MP-3	Shallow (dry)	Shallow well in source area

### 5.3 Assessment of Data Quality

The overall objective of the QA program is to establish procedures for obtaining data of known and acceptable quantity. These procedures were established in the QAPP and have been followed for this project.

#### 5.3.1 Quality Assurance/Quality Control (QA/QC) Procedures

QA/QC procedures as outlined in the Quality Assurance Program Plan (QAPP) of the *Long-Term Groundwater Monitoring Workplan (WC September 1997)* have been followed for the long-term monitoring portions of this project.

The Remedial Investigation Management Plan (RIMP) for OUB (WC 1995) covered the QA/QC procedures for the remedial action program supplemented by the following work plans:

Treatability Study Work plan Technical Memorandum (WC October 8, 1996)

Addendum to Treatability Study Work plan Technical Memorandum (WC October 30, 1996)

Work Plan Technical Memorandum Characterization and Design Verification Study (WC May 1997)

Work Plan Technical Memorandum Design Verification Study Array 4, 5, and 6 (WC August 1999)

The overall objective of the QA program is to establish procedures for obtaining data of known and acceptable quantity. These procedures were established in the QAPP and have been followed for this project.

#### 5.3.2 Quality Assurance Project Plan

Two Quality Assurance Program Plans (QAPP) were developed for OUB - Poleline Road as part of the *Remedial Investigation Management Plan (WC July 1995)* and for the *Long-Term Groundwater Monitoring Workplan (WC September 1997)*. The QAPPs outline a procedure to assure production of high quality data that meet regulatory requirements and accurately characterize measurement parameters. They provide the protocol for measuring, controlling and documenting data and data quality.

#### 5.3.3 Data Quality Objectives

The QAPP describes the procedures that are necessary to assure the needed precision, accuracy, completeness, representativeness, and comparability of the data gathered at OUB.

## 6.0 FINAL INSPECTION AND CERTIFICATIONS

### 6.1 RA Contract Inspections

No “official” pre- or final inspections for OUB have been conducted. However, representatives of EPA, ADEC, and the Army inspected the remediation process at various times since the remedial action work began and are involved in all decisions concerning remedial action at the site.

### 6.2 Health and Safety

A Health and Safety Plan is included in the work plans developed for each field season. No health and safety problems have been encountered during construction or operation. All personnel requiring access to the site are required to have a current Hazwoper certification.

### 6.3 Institutional Controls

Institutional controls have been put into place at Poleline Road. Institutional controls such as limitations on access, water use, excavations, and property transfers are supplementing engineering controls for both short-term and long-term management to prevent and limit human and environmental exposure to hazardous substances, pollutants, and contaminants. Locked gates limit access to the site.

U.S. Army Alaska Institutional Control Standard Operating Procedures (SOP) (APVR-RPW (200-1) and a Memorandum on Institutional Controls [APVR-RPW-EV (200-1c)], from Major General James J. Lovelace – U.S. Army – Alaska, establishes the procedures, responsibilities, and policies for complying with institutional controls at Fort Richardson. This document has been provided in Appendix D to this report along with the current Excavation Clearance Request (USARK Form 81a). This document is reviewed and reissued approximately every two years with the change of command at U.S. Army – Alaska.

### 6.4 Exit Strategy

The Long-Term Monitoring Plan will define the conditions under which various parts of the program covered in the ROD are managed and continued. Modification of the LTM Plan will be made in accordance with the process described in the following paragraphs.

Operation of the plan will be evaluated annually by the project managers and continue until the RAOs are achieved. The project managers will review the parameters of the plan with the results and determine whether they are performing as intended (continuing to make progress toward achieving the RAOs). The project managers will further determine whether the plan is operating efficiently and cost-effectively.

Based on the results of the annual evaluation, the project managers will set the operating parameters of the plan for the next year. The Army will then operate the LTM as agreed over the coming year, making adjustments as they consider reasonable and in accordance with agreements made during the last annual evaluation. If the project managers can not

reach concurrence on the operating parameters, operating parameters previously agreed to will be followed until the issue is resolved in accordance with the dispute resolution procedures incorporated in the Federal Facility Agreement.

## 7.0 OPERATION & MAINTENANCE ACTIVITIES

To ensure the remedial action objectives were achieved, the ROD established the following goals for monitoring at Poleline Road (ROD 1997).

- To ensure that no off-source migration of contaminants is occurring;
- To indicate contaminant concentrations and compliance with state and federal MCLs; and
- To indicate whether remedial action is effective or needs modification.

Monitoring has shown that no off-source migration of contaminants is occurring and that the remedial actions that have occurred at OUB are effective in protecting human health and the environment. Natural attenuation will be monitored until the groundwater contaminant concentrations achieve compliance with state and federal MCLs.

### 7.1 Monitoring Activities

Eleven rounds of groundwater data have been collected from October 1995 through October 2002. During this time, several remedial activities occurred at the site that may have impacted the concentration of contaminants in the groundwater. The primary concentrations of VOCs (1,1,2,2-tetrachloroethane, TCE, and PCE) in groundwater were reduced as a direct result of the SPSH tests in 1997 and 1999. Because of the slow groundwater flow at the site, it may take from months to years for the concentration of contaminants in groundwater to be impacted at wells away from the test area. To-date, seven rounds of groundwater samples have been collected since the SPSH system was turned off.

### 7.2 Natural Attenuation/LTM

Natural attenuation is the physical, chemical and biological processes that, unaided by human intervention, reduces the concentration, toxicity or mobility of contaminants in the environment. Natural attenuation processes include biodegradation, hydrolysis, sorption, dispersion, dilution and volatilization. The behavior of organic and inorganic contaminants, inorganic minerals, and microbial populations is affected by the geochemistry of the subsurface environment. Primary geochemical parameters that characterize the subsurface include:

- Alkalinity
- Temperature
- pH
- Oxidation-reduction potential (REDOX)
- Dissolved constituents (including electron acceptors)
- The physical and chemical characterization of the solids
- Microbial processes

The most important of these in relation to biological processes are:

- Alkalinity
- REDOX
- The concentration of electron acceptors
- The chemical nature of the solids

Selected parameters were measured to help identify what types of natural processes may be degrading contaminants at the site. Laboratory results for analysis of selected natural attenuation parameters are summarized in Table 5-13 (Appendix D), and field measurements are summarized in Table 5-14 (Appendix D).

Three bacteria count tests (heterotrophic plate count, oil degrading bacteria, and sulfate reducing bacteria) were completed on groundwater samples collected in 1996. The results indicated virtually no bacterial populations in groundwater at the site. Based on these results, no additional tests for bacterial populations have been completed.

### 7.2.1 Alkalinity

Carbon dioxide generated during biodegradation causes an increase in alkalinity. Thus, biologically active portions of a contaminant plume may be identified in the field by their increased alkalinity (compared with background levels), and alkalinity can be one of the parameters used to identify where to collect biologically active core material.

Alkalinity is a general water quality parameter used to measure the buffering capacity of water. Alkalinity can help to maintain groundwater pH because it buffers the groundwater against acids generated through the biodegradation process. However, during aerobic respiration, denitrification, iron III and sulfate reduction, the total alkalinity should increase.

The alkalinity of water sampled from the background well (MW-17) was 130 mg/L in October 2001. Alkalinity values for samples collected from the shallow aquifer in ranged from 106 to 208 mg/L. Alkalinity in water from monitoring well MW-5 (shallow-intermediate aquifer) was 148 mg/L, and water sampled from the deep aquifer had alkalinity values of 110 to 262 mg/L. The alkalinity of the water where high concentrations of VOCs are found is not significantly higher than the alkalinity of water with no detectable concentrations of VOCs.

### 7.2.2 Oxidation-Reduction Potential (REDOX)

The REDOX of groundwater is a measure of electron activity that indicates the relative ability of a solution to accept or transfer electrons. Most REDOX reactions in the subsurface are microbially catalyzed during metabolism of native organic matter or contaminants. According to Wilson, et al. (1996), when the REDOX is less than 50 millivolts (mV) against Ag/AgCl, a reductive pathway is possible. The REDOX measurements taken in October 2001 were greater than 50 mV, in samples from ten of the 19 locations monitored.



### 7.2.3 Electron Acceptors

In order to identify the predominant microbial and geochemical processes occurring *insitu* at the time of sample collection, it is critical to measure the available electron acceptors. The nitrates and sulfates that are naturally found in most groundwater, will subsequently be used as electron acceptors once the oxygen is consumed. Oxidized forms of iron and manganese can be used as electron acceptors before sulfate reduction, and their reduced forms scavenge oxygen to the extent that strict anaerobes (some sulfate reducers and all methanogens) can develop. Sulfate is found in many depositional environments, and sulfate reduction may be very common in contaminated groundwater. In environments where sulfate is depleted, carbonate becomes the electron acceptor, with methane gas produced as an end product.

### 7.2.4 Dissolved Oxygen

If biodegradation occurs in an oxygen rich environment, then aerobic respiration is the primary process. If biodegradation occurs in an oxygen poor environment, then anaerobic degradation is the primary process. Once DO concentrations are less than 0.5 mg/L, anaerobic process begin to dominate the biodegradation processes. In an anaerobic environment, microbes utilize nitrate/nitrite, ferrous/ferric iron and sulfate instead of oxygen in respiration. There was no detectable level of dissolved oxygen from four of the monitoring wells (MW-6, MW-13, MW-19, and MW-24) measured in October 2001. This suggests that the appropriate conditions necessary for reductive pathways are present. Dissolved oxygen measurements in water from the other 15 wells ranged from 1.72 to 15.69 mg/L.

### 7.2.5 Sulfate

For reductive pathways, the optimum concentration for sulfate is less than 20 mg/L. Sulfate concentrations in samples from the 19 locations monitored in October 2001 ranged from 0.5 to 85.6 mg/L and were less than 20 mg/L at 15 of the locations.

### 7.2.6 Ferrous Iron

Iron is utilized by the microbes once the dissolved oxygen and nitrate / nitrite compounds have been depleted. Reductive pathways are possible when the concentration of ferrous iron is greater than about 1 to 1.5 mg/L. Ferrous iron was detected in samples from 9 of the locations monitored in October 2001. Concentrations of ferrous iron ranged from 0.8 to 8.0 mg/L and were greater than 1.5 mg/L at seven of the locations.

### 7.2.7 Temperature, Specific Conductance, and pH

Temperature and pH affect biodegradation of contaminants. Although biological growth can occur over a wide range of temperatures, most microorganisms are active primarily between 50°F and 95°F. Groundwater temperatures measured during the October 2001 round of sampling ranged from 38.8°F to 53.0°F. Temperatures near MW-22 were elevated above normal values due to the soil-heating project completed in 1999.

An optimum pH range for most microorganisms is between 6.0 and 8.0. Many microorganisms, however, can tolerate a pH range of 5 to 9. Most groundwater in uncontaminated aquifers has a pH in the range of 5 to 9. Active oxidation of sulfides may cause pH levels to be as low as 4.0. In carbonate-buffered groundwater, pH values may be as high as 9.0. Measured pH during the October 2001 round of groundwater sampling ranged from 6.59 to 9.73 with water from the shallow aquifer having slightly lower values (6.62 to 8.19) than water from the deep aquifer (7.26 to 9.73).

#### 7.2.8 Chloride

Inorganic chloride accumulates as a result of reductive dechlorination. In aquifers with a low background of inorganic chloride, the concentration of inorganic chloride should increase as the chlorinated solvents degrade. The sum of the inorganic chloride plus the contaminant being degraded should remain relatively consistent along the groundwater flow path.

The concentration of chloride in groundwater from the background well (MW-17) was 3.2 mg/L in October 2001. Chloride concentrations in samples from the shallow and shallow-intermediate aquifers ranged from 1.3 to 20.5 mg/L with the higher concentrations occurring in samples from monitoring wells that also had high concentrations of VOCs. Chloride concentrations in samples from the deep aquifer ranged from 1.7 to 37.3 mg/L. The relatively high anomalous value of 37.3 mg/L occurred in the sample from monitoring well MW-16. Previous chloride data for samples from this well also were anomalously high.

#### 7.2.9 Ammonia

Ammonia as nitrogen was detected in four of the groundwater samples collected from the shallow aquifer (0.29 to 0.52 mg/L), the shallow-intermediate aquifer (0.49 mg/L), and the deep aquifer (0.24 mg/L).

#### 7.2.10 Sulfide

A reductive pathway is possible when the concentration for sulfide is greater than 1 mg/L. Sulfide was detected in samples collected from 14 locations in October 2001 but concentrations were all less than or equal to 1 mg/L.

#### 7.2.11 Total Organic Carbon

Total organic carbon (TOC) represents a source of carbon and energy that drives dechlorination and influences contaminant migration. Optimum values for TOC are greater than 20 mg/L. TOC was detected in samples collected from 17 locations in October 2001 but the concentration was never greater than 7.8 mg/L. TOC concentrations in samples from the shallow aquifer ranged from 0.7 mg/L to 7.8 mg/L. The TOC concentration for the sample from the shallow-intermediate aquifer was 4.5 mg/L. TOC concentrations in samples from the deep aquifer ranged from 0.6 mg/L to 4.7 mg/L.

### 7.2.12 Natural Attenuation at OUB

The natural attenuation data presented and discussed above suggest little if any biodegradation is currently occurring at the site. This could be for several reasons:

- OUB has undergone several rounds of SPSH remediation (a process that causes the soil and groundwater to be heated to the boiling point of water), effectively sterilizing the soil and water,
- Chlorinated solvents are difficult to biologically reduce, and
- No other energy source for the microbes is present.

### 7.3 Trend Analysis

Currently a statically valid trend analysis cannot be performed at this time. There have only been seven rounds of groundwater data collected over the course of three years since the SPSH system has completed. Using the data prior to the SPSH system operation would substantially bias the trend due to the rapid reduction of contaminants experienced over a short duration of time. By the end of the next 5-year review, enough data should be available to perform a trend analysis using regression statistics.

### 7.4 Future Monitoring at Poleline Road OUB

A long-term monitoring program is in place and groundwater at the OUB site will continue to be monitored semi-annually for at least the next two years. By that time, an exit strategy outlining specific sampling requirements will be developed and implemented

At the current time plans are in place to perform additional geophysical investigation and install four new groundwater monitoring wells. These wells will be included in the groundwater model and used to evaluate the natural attenuation of the contaminants at the site.

### 7.5 Five Year Review

A five-year review of remedial activities at OUB will be conducted during 2002 and is expected to be completed by February 2003. The five-year review process will continue no hazardous substances, pollutants, or contaminants remain on site above levels that allow for unlimited use and unrestricted exposure. The five-year review of the long-term monitoring process should assess whether the remedial action is continuing to be protective of human health and the environment and assess whether the remedial action is proceeding in accordance with the ROD. The review will also serve as an opportunity to look at the rate and frequency of the monitoring program.

## 8.0 SUMMARY OF PROJECT COSTS

### 8.1 Comparison of Actual vs. ROD Costs

Comparison of the Actual vs. ROD Costs is difficult. The selected remedy was enhanced immediately with six-phase heating to accelerate and enhance the cleanup of the “hot-spot” and surrounding area. The ROD, while specifying that heating enhancement could be used in addition to the selected remedy, did not specify any estimated costs for this approach. The 1997 ROD estimate stated that the monitoring of the plume would be performed for 150 years, however the estimated amount only included 30 years worth of monitoring. To provide a comparable estimate with the Actual Costs – an adjusted ROD estimate is provided below. This estimate includes monitoring for 150 years at the cost rate indicated in the ROD.

#### 8.1.1 Estimated ROD Costs

The estimated total cost for the preferred remedy (Alternative 6) listed in the ROD is \$4,000,000. This estimated includes \$801,841 for capital costs; \$64,878 per year for annual operations and maintenance (O&M); and \$29,070 per year for annual groundwater monitoring. For estimating purposes, it was assumed that the fencing would be installed around the area of contamination. The estimated time frame for cleanup goals to be achieved in the “hot spot” was seven to twelve years. The estimate for the remainder of the plume to remediate and for monitoring to be performed was 150 years, although the cost estimate includes 30 years of annual operation costs.

#### 8.1.2 Actual Final Costs

Shown below is the project cost summary for the post-ROD period of 1997 to 2002. Capital costs were greater than expected because several treatability studies were undertaken at the site. O&M costs are lower than expected because the electricity costs for operation of the six phase heating arrays could not be adequately captured under the Army accounting system. Monitoring costs will likely be reduced when the exit strategy is developed. Actual monitoring costs included an estimate of the monitoring costs over the next 145 years based on the current cost, frequency, and number of wells.

	ROD Estimate (1997 \$\$)	ROD Estimate (2002 \$\$)	Actual Cost (2002 \$\$)
RA Capital Cost	\$801,841	\$871,311	\$1,883,000
O&M Cost <sup>1</sup>	\$1,946,340	\$2,114,967	\$983,000
Monitoring Cost <sup>2</sup>	\$872,100	\$4,739,864	\$4,676,000
<b>Total Cost<sup>3</sup></b>	<b>\$4,000,000<sup>3a</sup></b>	<b>\$7,726,142<sup>3b</sup></b>	<b>\$7,542,000<sup>3c</sup></b>
Difference between total project costs and total ROD cost in 2002 dollars			\$184,142 (or - 2.4%)

<sup>1</sup>O&M costs were estimated in the ROD were for a 30-year period @ \$64,878 per year

<sup>2</sup>Monitoring costs estimated in the ROD were for a 30-year period @ \$29,070 per year

<sup>3a</sup>Total Costs for the 1997 ROD Estimate of \$4,000,000 included contingency and markups

<sup>3b</sup>Total Costs for the 2002 ROD Estimate of \$ includes Monitoring costs for 150 years and not 30 years

<sup>3c</sup>Actual cost calculated assuming monitoring for another 145 years based on current costs and schedule

## 9.0 OBSERVATIONS AND LESSONS LEARNED

### 9.1 Successes

Several successful treatability studies were conducted at OUB. The first study was a soil vapor extraction system conducted in 1996. This study showed that the contaminants of concern could be removed from the vadose zone. The SVE study was followed by several six-phase soil heating (SPSH) treatability studies. Both studies showed that the SPSH process was capable of removing nearly all of the contaminants of concern from saturated and unsaturated soil. The 1999 study also showed that SPSH could remove contaminants of concern from groundwater. Each of these tests was successful from a technical standpoint.

The SPSH studies were particularly successful from the standpoint that little rebound was observed in the concentration of contaminants in groundwater samples before and after the studies. The following table shows groundwater sampling results for 1,1,2,2-tetrachloroethane from three wells close to the second SPSH study area.

<b>Concentration of 1,1,2,2-Tetrachloroethane</b>			
Well	October 1998 (mg/L)	October 1999 (mg/L)	October 2001 (mg/L)
MW-22	15	0.81	0.31
MW-23	18	0.10	0.14
MW-24	47	0.026	0.14

The table shows that 1,1,2,2-Tetrachloroethane was significantly reduced from October 1998 to October 1999. The cause of this reduction was the SPSH study conducted during the summer of 1999. Results from the October 2001 sampling round are lower for two samples and slightly higher for one.

The remedial actions taken to date are also considered a success as measured by the ROD. The ROD stated that the soil hotspot was to be treated, discharged groundwater was to be treated to MCLs, and natural attenuation would be allowed to occur outside the hotspot. Rather than exclusively using the selected remedy, High vacuum extraction (HVE), SPSH was used to treat the hotspot. Heat enhancement is one of the enhancements to HVE mentioned in the ROD. The HVE system would have operated an estimated 5 to 10 years to reach RAOs in the hotspot. The SPSH studies achieved the “hotspot” reduction goals in much less time. Groundwater discharged to the surface was treated to less than MCLs.

Despite heating soil and groundwater within the treatment zone to the boiling point of water, the remedial actions taken at the site should allow natural attenuation to continue outside the hotspot. Based on contractor staff observations at other similar remediation sites, biodegradation rates resume after heating soil and groundwater with SPSH technology. The biodegradation rates at this site were quite low prior to any remedial actions taking place on site, and likely did not increase or decrease as a result of the remedial actions.

The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used when the ROD was implemented are still valid. No other new information has come to light that would call into question the protectiveness of the remedy.

## 9.2 Lessons Learned

SHP technology was relatively new when first used at Poleline Road. Prior to 1997, this technology had a short history of use, and thus mistakes were made while laying out the equipment for the first test. While attempting to operate the first array, stray electrical voltages prevented the catalytic oxidizer from operating. After failing to correct the problem, the catalytic oxidizer was taken out of service and no further problems were encountered during treatment of the first array.

When the second array was started, stray voltages caused problems with the SPSH transformer. More than a week was spent trying to trace the problem. Rearranging the grounding wires eventually solved the problem.

All of the remediation equipment was moved for the third array. To minimize problems associated with stray voltages, the equipment was placed 30 to 40 feet from the nearest electrode. No problems related to stray voltages occurred during operation of the third array.

The dual-phase extraction study completed during the summer of 1998 showed that further design work would be necessary before installation of a reliable system. The dual-phase system, as installed, was prone to shut down and took several hours to restart. The crux of the problem was the drop tubes used to extract air and water. The bottom of the drop tube was set just above the water table in the well. If water level in the well rose rapidly, the drop tube would be flooded, and unable to further extract either water or air.

The use of treatability studies allows for flexibility in determination of an effective remedial strategy and does not tie the user to a specific strategy that may not work at a specific site.

## **10.0 OPERABLE UNIT CONTACT INFORMATION AND REFERENCES**

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## FIGURES

Figure 1 – Area Vicinity Map

Figure 2 – Site Location Map

Figure 3 – Site Map

Figure 4 – ROD “Hot Spot” Identification Map

Figure 5 - SPSH Process Map

Figure 6 – Site Map for Array 4, 5, and 6

Figure 7 – Site Map for Arrays 1, 2, and 3

Figure 8 – SHP Process Map

Figure 9 – VOC Concentrations Graph

Figure 10 – Array 1 – Temperature Borings

Figure 11 – Array 2 – Temperature Borings

Figure 12 – Array 3 – Temperature Borings

Figure 13 – Arrays 1, 2, and 3: Concentration of VOCs

Figure 14 – Maximum Soil Concentrations per Boring (1,1,2,2-tetrachloroethane & TCE)

Figure 15 – Concentrations of Primary VOCs in Off-Gas and Condensate

Figure 16 – Degradation Pathways of COCs

Figure 17 – 1,1,2,2-tetrachloroethane Isoconcentration Map

Figure 18 – PCE Isoconcentration Map

Figure 19 – TCE Isoconcentration Map

Figure 20 – Long-Term Groundwater Monitoring “Spider” Map for OUB

**APPENDIX A – EPA AND ADEC CONCURRENCES**

Signature Page for ADEC and EPA

SIGNATURES

Signature sheet for the foregoing Interim Remedial Action Report, Poleline Road Operable Unit B, U.S. Army Fort Richardson and with concurrence by the Alaska Department of Environmental Conservation and the U.S. Environmental Protection Agency.

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Dave Croxton, Unit Manager  
Office of Environmental Cleanup  
U.S. Environmental Protection Agency

Date

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Ernesta Ballard, Commissioner  
Alaska Department of Environmental Conservation

Date

**APPENDIX B – TABLES FROM SEPTEMBER 1999, SYSTEM EVALUATION REPORT**

**APPENDIX C - TABLES FROM 2001 DESIGN VERIFICATION STUDY REPORT**

**APPENDIX D – U.S. ARMY ALASKA INSTITUTIONAL CONTROLS**

## **APPENDIX E – RESPONSE TO COMMENTS**