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**Operable Unit 1
Remedial Investigation Report,
Eielson Air Force Base, Alaska**

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June 1994

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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EXECUTIVE SUMMARY

This remedial investigation report for Operable Unit 1 (OU-1) at Eielson Air Force Base presents data, calculations, and conclusions as to the nature and extent of surface and subsurface contamination at the eight source areas that make up OU-1. The information is based on the 1993 field investigation results and previous investigations. This report is the first in a set of three for OU-1. The other reports are the baseline risk assessment and feasibility study. The information in these reports will lead to a Record of Decision that will guide and conclude the environmental restoration effort for OU-1 at Eielson Air Force Base.

The eight source areas that make up OU-1 are the

- ST20—Refueling Loop (which contains three complexes)
 - E-7 Complex (underground transfer pipes near pump house)
 - E-8 Complex (pump house vents)
 - E-9 Complex (underground transfer piping)
- ST48—Power Plant Fuel Leak
 - Abandoned fuel lines (releases during past operations and subsequent leaks because the line was not drained when abandoned)
- ST49—Alert Hangar Fuel Leak
 - Diesel fuel spill from aboveground storage tank into potentially leaking floor drain system piping
- Blair Lakes Target Facility (which contains three source areas)
 - SS50-SS52 (vehicle maintenance ditch and diesel spill)
 - SS53 (fuel spill)
 - DP54 (drum disposal area).

The primary contaminants of concern include fuels and fuel-related contaminants (diesel; benzene, toluene, ethylbenzene, and xylene; total petroleum hydrocarbon; polycyclic aromatic hydrocarbons), maintenance-related solvents and cleaners (volatile chlorinated hydrocarbons such as trichloroethylene), polychlorinated biphenyls, and dichlorodiphenyltrichloroethane (DDT).

The origins of contaminants of concern include leaks from storage tanks, drums and piping, and spills. Ongoing operations and past sitewide practices also contribute to contaminants of concern at OU-1 source areas. These include spraying mixed oil and solvent wastes on unpaved roads and aerial spraying of DDT.

Floating product measurements and soil gas results suggest current sources of contamination exist at both ST20 and the Blair Lakes Target Facility. Identification and repair of current sources are paramount to cleanup. The U.S. Air Force is performing integrity tests on the ST20 fuel supply system, and the results will be available in the near future.

Higher molecular weight polycyclic aromatic hydrocarbons have been detected in surface sediments. These may be from incomplete fuel combustion by vehicles and aircraft, which will be a continuing source as long as Eielson Air Force Base is operated.

Elevated metal concentrations in sediment and groundwater samples from both the main base and the Blair Lakes Target Facility commonly exceed risk-based screening levels. However, the metal concentrations are wide spread and lack a source point; this combined with the regional geology suggests a natural source.

An upper unconfined aquifer and a confined sub-permafrost aquifer have been identified at the Blair Lakes Target Facility. These aquifer systems appear to be hydraulically isolated from each other based on hydrograph data and pumping test results. The lower sub-permafrost aquifer supplies drinking water for the facility. To date, groundwater contamination has only been detected in the upper unconfined aquifer.

The fuel-related contamination in OU-1 has generally decreased in concentration and extent from the 1989 results. All three complexes in ST20 (E-7, E-8, and E-9) as well as the Blair Lakes Target Facility have shown dramatic decreases in concentrations of the benzene, toluene, ethylbenzene, and xylene fractions as well as the semivolatiles, naphthalene and 2-methylnaphthalene, between 1989 and 1993. ST49 and ST48 appear to be in a state of equilibrium where the 1993 concentrations are essentially identical to 1989 results and the extent of the contaminant plumes has neither increased nor decreased. There is not enough data to substantiate a trend, however. Because the samples in 1993 were collected in the spring, the concentrations may be partially affected by dilution caused by groundwater recharge.

Table ES-1 summarizes the results for each OU-1 source area.

TABLE ES.1. Contaminants of Concern Summary				
Source Area	Contaminants of Concern	Groundwater	Surface Soil	Subsurface Sediments
ST20-E7 Interim Remedial Action (IRA)	Antimony ^(a)	X		
	Arsenic ^(b)	X		X
	Beryllium ^(a)	X	X	X
	Cadmium ^(b)	X		
	Chromium ^(b)	X		
	Lead ^(c)	X		
	Manganese ^(b)	X		
	Benzene	X		X
	Ethylbenzene	X		
	Toluene	X		
	Xylene			
	TPH	X		X
	PAHs ^(d)	X	PAHs ^(e)	
ST20-E8	Antimony ^(a)	X		
	Arsenic ^(b)	X		
	Chromium ^(b)	X		
	Manganese ^(b)	X		
	Benzene	X		X
	Ethylbenzene	X		
	Toluene	X		
	Xylene		X	
	TPH		X	X
	PAHs ^(d)	X	PAHs ^(e)	
ST20-E9 (IRA)	Antimony ^(a)	X		
	Arsenic ^(b)	X		X
	Beryllium ^(a)	X		X
	Cadmium ^(b)	X		
	Chromium ^(b)	X		
	Manganese ^(b)	X		
	Benzene	X		
	Chlorobenzene	X		
	Ethylbenzene	X		
	Toluene	X		
	PAHs ^(d)	X	PAHs ^(e)	

TABLE ES.1. Contaminants of Concern Summary

Source Area	Contaminants of Concern	Groundwater	Surface Soil	Subsurface Sediments
ST48 (IRA)	Antimony ^(a)	X		
	Arsenic ^(b)	X		
	Beryllium ^(a)	X		
	Cadmium ^(b)	X		
	Lead ^(c)	X		
	Manganese	X		
	Benzene	X		
	Toulene	X		
	Xylene	X		
	TPH	X		X
	PAHs ^(d)	X	PAHs ^(e)	
ST49 (IRA)	Arsenic ^(b)	X		X
	Beryllium ^(a)			X
	Lead ^(c)	X		
	Manganese ^(b)	X		
	Benzene	X		
	Methylene chloride	X		
	TPH			X
	PAHs ^(d)	X	PAHs ^(e)	
Blair Lakes (SS50, SS51, SS52, SS53, DP54) (IRA)	Arsenic	X		X ^(b)
	Barium	X		
	Beryllium	X		X ^(b)
	Cadmium	X		
	Chromium	X		
	Lead	X		
	Manganese	X		
	Benzene	X		
	Ethylbenzene	X		
	Xylene	X		
	TPH	X		X
	PAHs ^(d)	X		PAH

PAH = polycyclic aromatic hydrocarbon.
TPH = total petroleum hydrocarbon.
(a) No background established.
(b) Statistical t-test indicates the values are not outside of background statistical boundaries.
(c) Does not exceed risk levels but is within 1-4 µg/L of the limit.
(d) PAHs refers to PAHs from fuel sources.
(e) PAHs includes PAHs from exhaust-related sources.

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**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

ACRONYMS

ADEC	Alaska Department of Environmental Conservation
AFB	Air Force Base
ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
bls	below land surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DC	direct current
DCE	dichloroethylene
DDD	2,2-bis(para-chlorophenyl)-1,1-dichloroethane
DDT	dichlorodiphenyltrichloroethane
EM	electromagnetic
EPA	U.S. Environmental Protection Agency
FDEM	frequency-domain electromagnetics survey
FFA	Federal Facility Agreement
FSP	Field Sampling Plan
HQ	hazard quotient
IRP	(U.S. Air Force) Installation Restoration Program
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
msl	mean sea level
NPL	National Priorities List
OU-1	Operable Unit 1
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
POL	petroleum, oil, and lubricant
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RI/FS	remedial investigation/feasibility study
TCE	trichloroethylene
TPH	total petroleum hydrocarbon
UST	underground storage tank
VOC	volatile organic compound

1.0 INTRODUCTION

This remedial investigation report contains the data and methods used to characterize the nature and extent of contaminants and risks posed by the eight source areas in Operable Unit 1 (OU-1) at Eielson Air Force Base (AFB) in Alaska (see Figure 1.1). The investigation was conducted in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the National Contingency Plan (40 CFR 300), and the Federal Facility Agreement (FFA) (EPA et al., 1990) for Eielson AFB.

Eielson AFB developed from an air field originally constructed from 1943 to 1944, during World War II. Immediately following the end of the war, the field was deactivated. In 1947, its use as a strategic base was recognized, and it underwent a major construction program through 1954. Eielson AFB's current mission is to provide tactical air support forces and as part of the Pacific Air Forces.

The environmental impacts from Eielson AFB operations are associated with flight activities (including fueling and maintenance), waste disposal practices, facilities and building maintenance, transportation, and logistics support for base personnel. A major goal of the current effort is to delineate past practice environmental impacts. Impacts from current practices and activities need to be coordinated but are beyond the scope of this CERCLA work.

1.1 PURPOSE

The purpose of the OU-1 remedial investigation field work was to collect the data required to help the Eielson AFB staff meet the requirements in the FFA.

1.2 SCOPE

The scope of this remedial investigation report includes the following:

- Define site contaminants.
- Determine the nature and extent of contamination.
- Develop conceptual models for risks.
- Assess risk to human health and the environment.
- Develop effective remedial alternatives.

The comprehensive baseline risk assessment and feasibility study for remedial alternatives will be included in separate volumes.

The 1993 field investigation methods and results are presented in Appendix I. Note, the appendixes in Appendix I are identified by page number as I.A, I.B, etc.

1.3 ORGANIZATION OF REMEDIAL INVESTIGATION REPORT

- 1.0 Introduction
- 2.0 Analytical Data Collection Program
- 3.0 Physical Characteristics Field Investigations: Geology, Hydrology, and Permafrost
- 4.0 Nature and Extent of Contamination (current data summation by site)
- 5.0 Applicable or Relevant and Appropriate Requirements (current data summation by site)

6.0 References

- Appendix
- I. Field Summary Report
 - II. Groundwater Velocity
 - III. Aquifer Hydraulic Properties - Main Base
 - IV. Analysis of Hydraulic Characterization Tests - Blair Lakes Target Facility
 - V. Permafrost Study - Blair Lakes Target Facility
 - VI. Soil Gas Results
 - VII. T-Tests
 - VIII. Analytical Data
 - IX. Pipeline Leak Test Results

1.4 PREVIOUS INVESTIGATIONS

The five source area locations on the main base are shown in Figure 1.2. There are three source areas at Blair Lakes Target Facility (see Figure 1.3). Previous investigations of OU-1 source areas include reports conducted as part of the Air Force Installation Restoration Program (IRP). These IRP reports are as follows:

- Installation Restoration Program Records Search for Eielson Air Force Base, Alaska (CH2M HILL, 1982)
- Installation Restoration Program Phase II - Confirmation/Quantification Stage 1, First Draft Report for Eielson Air Force Base, Alaska, Alaskan Air Command (Dames & Moore, 1985)
- U.S. Air Force Installation Restoration Program Remedial Investigation and Feasibility Study of the Fuel Saturated Area (SAIC, 1989b)
- Installation Restoration Program Remedial Investigation/Feasibility Study, Stage 3, Eielson Air Force Base, Fairbanks, Alaska, Volumes II (Chapter IV) and III (Chapter IV), Draft Remedial Investigation/Feasibility Study (July 1988 to April 1989), April 1989 (HLA, 1989a)
- Installation Restoration Program Remedial Investigation/Feasibility Study, Stage 4, Draft Report for Eielson Air Force Base, Alaska. Volumes I and II, May 1990 (HLA, 1990).

On November 21, 1989, Eielson AFB was listed by the U.S. Environmental Protection Agency (EPA) on the National Priorities List (NPL). Sixty-four potential source areas were identified on the AFB and divided into six operable units and three source evaluation groups for investigation and remediation. Eight source areas contaminated with petroleum, oil, and lubricant (POL) were assigned to OU-1: source areas ST20, ST48, ST49, SS50, SS51, SS52, SS53, and DP54.

The original draft remedial investigation/feasibility studies (RI/FS) reports (pre-1990) were considered by reviewers to be inadequate. Insufficient data were collected to conduct both a qualitative and quantitative risk assessment. In October 1990, the EPA Region 10, the Alaska Department of Environmental Conservation (ADEC), and the U.S. Air Force entered into an agreement to investigate, and take remedial action when appropriate, at identified sites. The FFA also established a procedural framework and schedule for these responses.

In the FFA, the agencies agreed to take interim remedial actions for the removal of floating petroleum product in the following source areas: ST20 (Refueling Loop), ST48 (Power Plant Fuel Spill Area), ST49 (Building 1300), and SS50 through SS53 (Blair Lakes Target Facility). These source areas are a subset of OU-1 and were collectively called OU-1b (U.S. Air Force, 1993a). A Record of Decision detailing the agreement on the interim remedial actions was finalized September 1992.

In addition to the reports specific to OU-1, a number of technical memos have been produced that address sitewide issues relevant to source area specific remedial investigations. These reports are as follows:

- Background Groundwater Quality, Eielson Air Force Base, Alaska (U.S. Air Force, 1992a)
- Remedial Investigation/Feasibility Study. Operable Units 3, 4, and 5 Management Plan. Eielson Air Force Base, Alaska (U.S. Air Force, 1992b)
- Eielson Air Force Base Site Management Plan (U.S. Air Force, 1993b).

1.5 EIELSON AFB BACKGROUND

Physiography. Eielson AFB is located about 161 km south of the Arctic Circle and 40 km southeast of Fairbanks, Alaska, the closest center of population. The Blair Lakes Target Facility is located about 25 air miles southwest of the main base (Figure 1.1).

All of the main base except for a few eastern portions is located on the Tanana River flood plain, about 5 km east of the braided glacial-fed river. The Tanana River flows northwestward on a relatively low relief glaciofluvial outwash plain extending from the base of the Alaska Range, which is about 161 km south of Eielson AFB. The eastern and northern edges of the base are on the Yukon-Tanana Upland, an area characterized by gently sloping ridges and broad undulating divides. All of the regional drainage is northwestward into the Tanana River, which flows into the Yukon River.

Land Use. Eielson AFB encompasses 19,790 acres of land. The vast majority of the land is undeveloped. Natural areas include approximately 15,835 acres of forests and 560 acres of wetlands and surface water (lakes and ponds). Developed acreage includes 1,744 acres modified by buildings, air fields, pavement, and other facilities as well as 1,180 acres of semi-developed land, such as ammunition storage, antenna fields, road shoulders, picnic areas and athletic fields, and parade and drill grounds.

The Alaskan pipeline, which began operation in 1977, transects the main base (Figure 1.1). A spur of the Alaskan railroad out of Fairbanks brings coal to Eielson AFB and terminates at the power plant.

Topography. The Eielson AFB has a subdued relief with elevations in the developed western portion of the base ranging from 167 to 160 m above mean sea level (msl), with the lower elevations to the northwest. Portions of the undeveloped eastern-most sections of the base extend into the Yukon-Tanana Upland Physiographic Province, which are gentle, forested hills up to 342 m above msl. These areas remain largely undeveloped except for some fuel storage.

Meteorology. Eielson AFB is located in the continental climatic zone that covers interior Alaska. The climate is characterized by large diurnal and annual temperature variations, low precipitation, and low humidity.

Average summer temperatures range between 7° and 16°C. Average winter temperatures range between -26° and -13°C. Extreme temperatures since 1944 were 33°C in June and -53°C in January. The temperature fluctuations from April 1992 through April 1993 are presented in Figure 1.4.

Average annual precipitation is 36 cm, which includes 183 cm of snow. Average monthly precipitation ranges from 1.27 to 6.35 cm, with the most rainfall generally in July and August. The average pan evaporation rate is approximately 36 cm/yr. Figure 1.5 presents a hydrograph showing daily precipitation from April 1992 through April 1993. Snowpack for this period is presented in Figure 1.6.

Surface Water. Tributaries flowing through Eielson AFB include Piledriver Slough to the west, Moose Creek to the east, and French Creek to the northeast. Garrison Slough, which is largely a constructed channel, flows from south to north through the developed portion of the base. Surface drainage all flows to the northwest.

Eielson AFB contains 12 lakes totaling 118 ha, 54 ponds totalling 106 ha, and 40.25 km of freshwater streams (U.S. Air Force, 1984).

Surface water bodies near OU-1 facilities include Garrison Slough near ST20 and ST49, and a surface pond in the center of the refueling loop in ST20. Garrison Slough is channeled through an underground culvert at ST49. There is an inlet sump to the culvert in the field to the south of Building 1300 within ST49.

Eielson AFB Soils. Surficial deposits in the vicinity of Eielson AFB consist primarily of sandy and gravelly loam. Soils occurring on the developed portion of Eielson AFB consist primarily of the Salchaket soil series, which is predominantly sandy loam underlain by a thick layer of coarse sand and gravel (CH2M HILL, 1982). The OU-1 source areas located on the main base are on the flat (from 0 to 2% slope) alluvial plain. Runoff is slow, and the hazard of erosion is slight. The soils are well drained with moderate permeability that is seasonally inhibited by frozen ground. Unfrozen infiltration rates range from 10^{-1} to 10^{-3} cm/sec, based on sieve analysis from OU-2, between approximately May and September. The frozen conditions during spring permit little snowmelt water to infiltrate. Surface flooding recurs annually in April and May.

At the Blair Lakes Target Facility, within the Tanana-Kuskokwim Lowland, the sediments consist of well-stratified and well-sorted porous and very permeable sandy gravels and sands (Pewe et al., 1966). Surface soils generally consist of 60 to 150 cm of sandy gravel fill underlain by 60 to 150 cm of silt or silty sand.

Permafrost. Permafrost is discontinuous in the Fairbanks area, representative of the southern boundary of the permafrost in Central Alaska. Near Fairbanks, permafrost of the undisturbed flood plain can extend from 0.6 m to at least 80 m (Pewe et al., 1982). In developed areas, the depth to permafrost has increased by 7.6 to 12 m because of construction, the presence of utilidors (underground boxes 0.3 to 1.5 m across for water, sewer, and other lines), and heated buildings.

Borehole logs for wells drilled at Eielson AFB during the 1940s and 1950s indicate layers of permafrost in sand and gravel between 4.9 and 37.8 m below land surface (bls). Permafrost was not reported in borehole logs for monitoring wells drilled in the developed part of the base after 1986 (18.3 to 30.4 m bls). Permafrost was encountered in two boreholes located in a less-developed region of the base within Operable Unit 2 (OU-2) ST19, but the horizontal and vertical extent of the permafrost was not determined.

In OU-1 on the main base, no permafrost was encountered in any of the boreholes drilled since 1989. At the Blair Lakes Target Facility, permafrost was encountered in 50SB05, 50SB07, and 50M03 at 2.74, 2.50, and 2.13 m. Well 50M03 was abandoned because no free water was encountered to a depth of 3.6 m.

Geologic Setting. The main base and the Blair Lakes Target Facility are located on the Tanana-Kuskokwim Lowland. The outwash plain consists of a veneer of unconsolidated silt, sands, and gravels, which range from about 92 to 122 m thick, and overlie unconformably the crystalline bedrock (Pewe et al., 1975).

In the area of Eielson AFB, the surficial sediments are recent flood-plain alluvium that consist of well-stratified layers and lenses (facies) of unconsolidated silt, sand, and gravel-sized particles derived from the upstream highlands to the south (Alaska Range). Gravelly facies contain pebbles, cobbles, and

boulders, ranging in size from 60 mm to 90 cm, and consisting of resistant rocks from the southern highlands (Pewe et al., 1966; geologic map of the Fairbanks Quad). The developed portion of the base rests on three predominant sediment types: sand and gravel fill, alluvium (river deposited), and loess (wind deposited).

Bedrock is exposed in the upland areas and consists primarily of two quartz-sericite schists: the Precambrian-aged Birch Creek Schist and the Missippian-aged Totatlanika Schist. The Birch Creek Schist is exposed in the highlands to the east of Eielson AFB and is also exposed approximately 16 km east of the Blair Lakes Target Facility. The Totatlanika Schist is exposed in the highlands approximately 19 km to the south of the Blair Lakes Target Facility. The characteristically uneven exposed schist surfaces (compared with the smooth, low relief flood plain deposits) are weathered to varying depths.

The bedrock schists contain local intrusive igneous rocks, which are often associated with mineral deposits in the area (Pewe et al., 1966). One of these intrusives, composed of mafic and ultramafic rocks, is believed to be part of a metamorphic belt that extends from the Wood River Buttes to an area between the Chena and Salcha Rivers in the Big Delta quadrangle to the east. An intense linear positive magnetic anomaly has been discovered that extends across the alluviated plain and supports this scenario.

Essential minerals in the Birch Creek Schist are quartz, sericite, biotite, plagioclase (commonly albite), potassium feldspar, calcite, dolomite, and amphiboles. Essential minerals for the Totatlanika Schist include microcline, quartz, sericite, chlorite, feldspars, and calcite. The intrusive mafic rocks are composed of diorite (ore mineral constitutes about 5%), sodic labradorite, sodic andesine, pigeonitic augite, and amphiboles.

The interior of Alaska lies at the northern edge of a continuous, seismically active belt that circumscribes the Pacific Ocean. Earthquakes of Richter magnitude 6.0 or greater have occurred approximately every 10 years in interior Alaska. The strongest earthquake recorded in the region was a magnitude 7.75 event that occurred in 1904 in the Kantishna area, about 193 km southwest of Eielson AFB. A 7.3 event in 1937 was centered near Salcha Bluff, located less than 24 km southeast of the base. Eielson AFB is located in what is classified by the U.S. Army Corps of Engineers as a Seismic Zone 3 (HLA, 1991).

Photographs of the Blair Lakes Target Facility are shown in Figure 1.7 to provide an overview of the area.

Surface Water and Groundwater Interactions. Water levels in Garrison Slough measured using staff gage readings were compared with water-level data from groundwater monitoring wells to evaluate the interaction between surface water and groundwater during previous investigations at OU-2 source areas. The highest water level elevation in Garrison Slough was observed in May 1992, and was concurrent with spring runoff and the highest water table at Eielson AFB. In the vicinity of the water treatment plant southwest of ST48, the elevation of surface water in Garrison Slough appears to be higher than the elevation of the water table at all times except during the period of major recharge, from about April 25 to June 25. This suggests that in this area Garrison Slough loses water to the aquifer except in the spring. Garrison Slough is believed to be lower than the water table throughout the year over most of the slough's length and to act as a drain for the shallow aquifer (U.S. Air Force, 1993a).

Groundwater Use. Groundwater is the only source of potable water at Eielson AFB and in the nearby communities. The aquifer in this region has been designated as a sole-source aquifer for drinking water supply. Potable water in the main AFB system is treated to remove iron and sulfide. Ground-

water is also the principal water source for various other industrial, domestic, agricultural, and fire-fighting uses.

The main AFB water supply is from three large-capacity wells (A, B, and D). Well C is maintained as a standby well to supply emergency water in case of a fire. There are also 7 low-capacity wells that provide potable water to remote areas of the base, and 12 additional water wells that provide water to fight fires. Two large-capacity wells provide nonpotable cooling water to the power plant. The base supply wells are completed at depths averaging approximately 33 m. In addition to the base supply wells, there are 41 private wells within a 4.83 km radius of the base, most of which are located north-northwest of the base in or near the community of Moose Creek (HLA, 1991). The groundwater monitoring wells, staff gage, and drinking water wells are shown in relation to the source areas on the main base in Figure 1.8.

Hydrostratigraphic Units. The uppermost aquifer is contained within the unconsolidated sediments that overlie the crystalline basement rock. The aquifer within these sediments is bounded to the northeast by the Yukon-Tanana uplands and is estimated to be from 72 to 80 km wide in the vicinity of Eielson AFB (CH2M HILL, 1982). The aquifer occurs under unconfined (water table) conditions, although discontinuous permafrost layers may act as confining or semi-confining layers in undeveloped areas of the base. Figures 1.9 and 1.10 show the water table at the main base for October 1992, and May 1993, respectively. Figure 1.11 shows the water table maps for Blair Lakes Target Facility for February 1993, and May 1993, respectively.

The thickness of the unconsolidated sediments on the main base are estimated to range from 60 to 90 m (U.S. Air Force, 1993d). Depth to the top of the unconfined aquifer ranges between 1.5 and 4.5 m. Evidence for confining layers within this interval is sparse. In one well drilled near the power plant in source area ST48, a silt layer was encountered between 35 and 41 m (U.S. Army Corps of Engineers, 19__; Stage IV, Vol 1, p 2-15). The final depth of this well was 71.6 m. The lateral extent, continuity, and hydrologic influence of this silt layer over the area of the base are unknown. Considering that these sediments were deposited in fluvial and glaciofluvial environments, this layer is not likely to be laterally continuous. However, there are likely additional unidentified silt layers interspersed both laterally and vertically across the base.

Blair Lakes Target Facility. The Blair Lakes Target Facility is reported in U.S. Air Force (1992a) to be underlain by a saturated, coarse alluvial sand and gravel layer, itself underlain by a permafrost layer of undetermined thickness. The permafrost layer is discontinuous across the site because heated buildings have created "thaw bulbs" locally. Transmissive alluvial sand and gravel deposits occur beneath the permafrost layer and are the source for both old and new water supply wells. This deeper alluvial aquifer is believed to be confined areally by the presence of the overlying permafrost and intercalated fine-grained silt layers. The saturated surficial alluvial deposits appear expected to reflect unconfined aquifer conditions, except where permafrost extends to near land surface causing local perched water conditions.

Demographics. Eielson AFB is a major employer in the Fairbanks area and is contiguous to Fort Wainwright, a much larger Army facility. Eielson AFB employs about 3,400 military personnel and 500 civilians (U.S. Air Force 1987). The total population living and working on the base is approximately 10,000. The total residential population of Eielson AFB is approximately 5,100. Residential and occupational populations are concentrated primarily in the developed portion of the main base.

Long-range demographic and housing/zoning information was not available, and is not compiled as a planning activity, because of the changing nature of military activities and the related base staffing requirements. Generally, military staff reside at Eielson AFB for shorter periods of time than civilian residents.

The main base is active with ongoing base functions, including work, school, and recreational activities. The base contains two elementary schools, one middle school, and one junior-senior high school. There is one childcare center and one medical and dental clinic.

The main base is fenced and guarded. However, most of the source areas, themselves, are unfenced or partially fenced and are accessible to onsite personnel. Several areas of the base are used for recreation, hunting, fishing, picnicking, and camping by onsite personnel and families. The OU-1 source areas are located within the industrial areas of the base, and none are used for recreation.

FIGURE 1.1. Regional Map, Eielson AFB

FIGURE 1.2. Source Area Locations in Operable Unit 1

FIGURE 1.3. Source Areas, Blair Lakes Target Facility

FIGURE 1.4. Daily Minimum and Maximum Temperatures, April 1992- April 1993, Eielson AFB

FIGURE 1.5. Hydrograph of Precipitation, April 1992 - April 1993, Eielson AFB

FIGURE 1.6. Hydrograph of Snowpack, Mid-April 1992 - Mid-April 1993, Eielson AFB

FIGURE 1.7. Photographs of the Blair Lakes Target Facility

FIGURE 1.8. Monitoring Wells, Staff

Gage, and Drinking Water Wells at Main Base

FIGURE 1.9. Water Tat

Table for Main Base, May 1993

FIGURE 1.11. Water Table for Blair Lakes Target Facility, May 1993

2.0 ANALYTICAL DATA COLLECTION PROGRAM

Environmental samples were collected in 1988, 1989, and 1993. The analytical program for the 1988 and 1989 data is reported in draft documents (HLA, 1989b, 1990, 1991). Analytical data from the 1988 and 1989 field investigations did not undergo a validation process. These data, however, were used to develop the analytical objectives for the 1993 field sampling. The effort in 1993 was to verify previous "hits" that exceeded risk-based screening levels and those that appeared unusual [i.e., polychlorinated biphenyl (PCB) in subsurface soil]. The 1993 analytical program objective was to provide data that met project quality control (QC) requirements and was precise, accurate, complete, comparable, and represented the site (U.S. Air Force, 1993c).

The 1993 analytical services were provided primarily by Datachem Laboratories, Salt Lake City, Utah, and included the following categories of analytes:

- Purgeable halocarbons and aromatic volatile organic compounds (VOCs)
- Semivolatile organic compounds
- Total dissolved solids
- Anions
- Alkalinity
- Type of analysis metals.

Selected analytes were analyzed at the following laboratories:

- Soil total petroleum hydrocarbons (TPH) for both gasoline and diesel ranges—Enseco Laboratory, Garden Grove, California
- Soil and groundwater total organic carbon—CH2M Hill Laboratory, Gainesville, Florida
- Soil physical testing—Pacific Northwest Laboratory, Richland, Washington.

See laboratory analyses tables on each source area (Section 4.0) for parameters and analytical methods. Analytical methods, detection limits, and data quality objectives for water analyses are listed in Table 2.1. The same information for soil analyses is in Table 2.2.

The analytical methods proposed are generally considered appropriate, and the detection limit is reasonable for the analyzed matrix. However, detection limits did exceed the concentration limits of concern (i.e., drinking water limits) for some analytes. These are discussed in the Operable Unit 1 Management Plan, Table E.4.7 (U.S. Air Force, 1993c). The laboratory has been asked to supply the actual detection limits for all of the analyses. The actual detection limits are often significantly lower than the contractual detection limits. The values reported below the contractual detection limit were flagged with a "J" qualifier. Data with a "J" qualifier was considered for use in the risk assessment.

2.1 QUALITY ASSURANCE OBJECTIVES

Section 4.3 of the Site Management Plan Quality Assurance Project Plan (Revision 2) (CH2M HILL, 1992b) summarizes the quality assurance (QA) objectives and requirements. Tables E.4.10 and

E.4.11 describe the precision, accuracy, and completeness objectives for the analytical methods selected for OU-1. Also, the QA objectives are summarized for soil and groundwater samples.

QA/QC performed by the laboratory included a method blank, calibration check sample, and laboratory control sample. The laboratory control sample was analyzed at a frequency of either 1 per 20 samples or one per analytical batch, whichever was more frequent.

2.2 SAMPLING PROCEDURES

Sampling procedures are described in Appendix D of the Field Sampling Plan (FSP) (CH2M HILL, 1992b). Sample number, type, frequency, and other considerations were as defined in that document. The QA objectives for the sample collection were done using the protocols for container procurements, and field duplicate and blank samples described in Section 5.0 of the Site Management Plan Quality Assurance Project Plan (Revision 2) (CH2M HILL, 1992b). The frequency of QA sample collection was modified as described in Section 10.1 of the OU-1 QA project plan (CH2M HILL, 1992b).

2.3 DATA VALIDATION

Validation will be done according to EPA procedures. The guidelines for data validation will be the Laboratory Functional Guidelines for Evaluating Organic Analysis and the Laboratory Functional Guidelines for Evaluating Inorganic Analysis. In addition, comments from the data validation memo from OUs-3, 4 and 5 will be considered (U.S. Air Force 1994). To assure the validity of critical analytical data, the following data validation methods will be used.

- The raw data for a minimum of 10% of the selected analyses—chosen at random—will be checked.
- In addition to the minimum 10% random check, raw data identified as critical by the project manager will be checked.
- All blanks, duplicates, and spikes will be evaluated to ensure the data quality objectives specified in the OU-1 Management Plan are achieved.
- The actual quantitation limits will be evaluated to determine the extent to which the values specified in the OU-1 Management Plan are achieved.

The QA/QC parameters will be summarized in the OU-1 data validation memo, currently underway. The memo will include the overall effect of method compliance, holding times, field and laboratory blank results, surrogate recoveries, and matrix spikes on data.

For Organic Selected Analytes. Chromatograms will be examined to determine accuracy of peak identification.

Selected Analytes. The data collected during the 1993 early summer sampling effort were not validated at the time of this report.

Over 200 analytes were analyzed for this report. The screening risk results indicate that only a few of the analytes contribute significantly to human health risks. These include benzene, toluene, ethylbenzene, and xylene (BTEX); chlorobenzene; naphthalene; polycyclic aromatic hydrocarbons (PAH); TPH; as well as arsenic and other metals.

Raw Data Checks. Raw data checks are defined as verifying sample identity, instrument calibration, detection limits, numerical computation, accuracy of transcriptions, and calculations.

Critical Data. Critical data are defined as the data used to identify risk and cleanup levels (e.g., maximum concentration values, minimum concentrations that define the plumes). Other critical data include atypical or unexpected information (e.g., PCB detected in subsurface).

TABLE 2.1. Operable Unit 1 Method, Target Detection Limit, and Quality Assurance Objectives for the Analysis of Groundwater

Parameter	Method	Target Detection Limit (µg/L)	Precision (Relative % Difference)	Accuracy (% Spike Recovery)	Completeness (%)
ST20 (E-7, E-8, and E-9 Complexes), ST48, ST49, Blair Lakes					
Purgeable halocarbons and aromatic volatile organic compounds	5030/8010 5030/8020 ^(a)	1.0	±20	60-140	95
ST20 (E-7, E-8, and E-9 Complexes), ST48, and ST49					
Semivolatile organic compounds ^(b)	3500/8270 ^(b)	CLP ^(b)	CLP ^(b)	CLP ^(b)	95
Blair Lakes					
Total dissolved solids	180.1	10,000	±20	NA	95
Anions	300.0	500	±20	80-120	95
Alkalinity	310.1	NA	±20	NA	95
Total organic carbon	415.1	1,000	±20	80-120	95
ST20 (E-7, E-8, and E-9 Complexes), ST48, and Blair Lakes					
TAL metals			±20	75-125	95
Aluminum, Al	3010/8010	40			
Antimony, Sb	3010/8010	15			
Arsenic, As	3020/7060	0.6			
Barium, Ba	3010/8010	1.0			
Beryllium, Be	3010/8010	0.4			
Cadmium, Cd	3010/8010	1.0			
Calcium, Ca	3010/8010	100			
Chromium, Cr	3010/8010	3.2			
Cobalt, Co	3010/8010	10.0			
Copper, Cu	3010/8010	5.0			
Iron, Fe	3010/8010	50			
Lead, Pb	3020/7421	0.7			
Magnesium, Mg	3010/8010	100			
Manganese, Mn	3010/8010	0.9			
Mercury, Hg	7470	0.2			
Nickel, Ni	3010/8010	40.0			
Potassium, K	3010/8010	500			
Selenium, Se	3020/7740	5.0			
Silver, Ag	3010/8010	10.0			
Sodium, Na	3010/8010	100			
Thallium, Tl	3020/7841	0.9			
Vanadium, Vn	3010/8010	50.0			
Zinc, Zn	3010/8010	10.0			
NA = not applicable.					
(a) U.S. EPA. Test Methods for Evaluating Solid Waste (SW-846), Third Edition, September 1986.					
(b) Contract Laboratory Program (CLP) procedures, QC criteria, and detection limits are defined in the EPA CLP Statement of Work for Organics Analysis, Document Number OLM01.0, March 1990.					
(c) Target values with no matrix effects and assuming levels spiked is significantly greater than the native sample constituents.					

TABLE 2.2. Operable Unit 1 Method, Target Detection Limit, and Quality Assurance Objectives for the Analysis of Soil

Parameter	Method	Target Detection Limit (µg/L)	Precision (Relative % Difference)	Accuracy (% Spike Recovery)	Completeness (%)
ST20 (E-7 and E-9 Complexes) and Blair Lakes					
Purgeable halocarbons and aromatic volatile organics compounds	5030/8010 5030/8020 ^(a)	1	±20	75-130	95
ST20 (E-7, and E-9 Complexes), ST48, ST49, and Blair Lakes					
Semivolatile organic compounds ^(b)	3500/8270 ^(b)	1	±20	75-130	95
Total petroleum hydrocarbons ^(c)	AK101 and AK102 ^(d)	10,000	±50	50-150	95
Blair Lakes					
TAL Metals			±20	75-130	95
Aluminum, Al	3010/6010	40			
Antimony, Sb	3010/6010	15			
Arsenic, As	3020/7060	0.6			
Barium, Ba	3010/6010	1.0			
Beryllium, Be	3010/6010	0.4			
Cadmium, Cd	3010/6010	1.0			
Calcium, Ca	3010/6010	100			
Chromium, Cr	3010/6010	3.2			
Cobalt, Co	3010/6010	10.0			
Copper, Cu	3010/6010	5.0			
Iron, Fe	3010/6010	50			
Lead, Pb	3020/7421	0.7			
Magnesium, Mg	3010/6010	100			
Manganese, Mn	3010/6010	0.9			
Mercury, Hg	7470	0.2			
Nickel, Ni	3010/6010	40.0			
Potassium, K	3010/6010	500			
Selenium, Se	3020/7740	5.0			
Silver, Ag	3010/6010	10.0			
Sodium, Na	3010/6010	100			
Thallium, Tl	3020/7841	0.9			
Vanadium, Vn	3010/6010	50.0			
Zinc, Zn	3010/6010	10.0			
ST20 (E-7, E-8,^(e) and E-9 Complexes), ST48, ST49, and Blair Lakes					
Pesticides and PCBs	3500/8080	1	±20	75-130	95
Total Organic Carbon	EPA 9060	1,000	±20	75-125	95

(a) U.S. EPA. Test Methods for Evaluating Solid Waste (SW-846), Third Edition, September 1986.

(b) Only the base/neutral fraction will be extracted and analyzed. Two soil samples collected at ST20 (E-8 Complex) will be analyzed for semivolatile organic analytes.

(c) Total petroleum hydrocarbons analysis will be conducted on selected samples from ST20 (E-7 and E-9 Complexes), ST48, and ST49.

(d) State of Alaska methods include AK101 (Gasoline Range Organics): January 14, 1993 (Revision 4) and AK102 (Diesel Range Organics): and February 5, 1993 (Revision 2).

(e) Pesticides/PCBs only.

3.0 PHYSICAL CHARACTERISTICS FIELD INVESTIGATIONS GEOLOGY, HYDROLOGY, AND PERMAFROST

3.1 INTRODUCTION

Investigations related to the physical characteristics of the surface and subsurface at Eielson AFB OU-1 source areas are described in this section. These include subsurface stratigraphy, hydrology, and permafrost studies. Studies were specific to each site; for example, permafrost studies were carried out at the Blair Lakes Target Facility, but not at the main base source areas because permafrost is not a feature at these sites.

During the 1993 field season, investigations were carried out at each OU-1 source area to complete the information needed to determine the nature and extent of contamination. This information is also critical for the baseline risk assessment and feasibility studies, which will be documented in separate volumes for the OU-1 source areas.

Soils and Sediments. Technically, soils develop on the exposed surfaces of rocks and sediments by interactions with air, water, and living organisms, both plant and animals. The surfaces are geologically young in this physiographic province, and therefore true soils are thin and not well-developed. Especially on the main base, sand and gravel deposits have been removed from some areas and used as fill in others (e.g., road beds, foundations). According to a review conducted by the Soil Conservation Service and investigations on other Eielson AFB source areas, background chemical characteristics can be adequately described by sampling and analyses of the three major sediment groupings: sand and gravel fill, fluvial sediments (sand and gravel), and loess. Studies to determine the typical background concentrations of metals and TPH have been performed on Eielson AFB fill material, fluvial sediments (commonly but technically incorrectly referred to as "soils"), and loess. Table 3.1 presents the background concentration of selected elements for the three sediment types.

Subsurface Stratigraphy. Most of the subsurface stratigraphy beneath OU-1 source areas is composed of fluvial and glaciofluvial silt, sand and gravel deposits, with the silt fraction typically less than 10%. Soil boring logs for boreholes drilled during the 1993 field sampling effort are provided in Appendix I. The deepest borehole was 65.5 m in depth at ST48 and did not encounter bedrock (penetrate through the glaciofluvial sediments to either the Totatlanika or Birch Creek Schist). Table 3.2 presents the moisture content, grain size (sand, silt, and clay), and lithologic name reflecting texture for selected borehole sediment samples collected during groundwater monitoring well installations at OU-1 sites.

Sediment Profiles. Sediment boring logs for boreholes drilled during the 1993 field sampling effort are provided in Appendix I.

Typically, the upper 1.5 to 3 m are composed of poorly to well sorted, brown to olive, moist, unconsolidated "sand" to "sand with gravel" with some silt. Approximate size distribution for this interval is 30 to 40% fine to coarse sand, and 15 to 30% 2.5- to 5-cm gravel.

From 1.5 to 3 m to 15+ m, the material is typically well to poorly sorted, brown to gray to black, wet, unconsolidated "sandy gravel," with approximately 30% medium to coarse sand sized, and the rest mostly gravel >5 cm. The gravel content generally increases with depth.

The sediments are composed primarily of sand and gravel with cobbles up to 0.2 m in diameter. Silt and clay content is variable, but is generally less than 10%.

The developed portion of Eielson AFB and the vast majority of the contaminant source areas are located on fluvial and glaciofluvial deposits in the lowland area of the base. These sediments are approximately 122 to 183 m thick (Pewe et al., 1975). A few source areas, LF04 and WP38, are located in an upland area to the northeast of the developed portion of the base. Sediments in this area are thinner and contain a higher proportion of silt.

Hydrostratigraphic Units. There is only one aquifer of importance for the OU-1 source areas: the unconfined, anisotropic aquifer, which consists of alluvial sands and gravel. It is 60 to 90 m thick and overlies the Birch Creek Schist crystalline bedrock.

Groundwater Movement.

Main Base. General information on the site and descriptions of identified contaminant source areas can be found in the Site Management Plan (U.S. Air Force, 1993b). These sediments, coarse sands, and gravels with generally less than 10% silt and clay content are expected to display relatively high hydraulic conductivities.

Aquifer hydraulic properties, particularly hydraulic conductivity and effective porosity, are important in determining travel-times of contaminants in groundwater and may also be important in designing remedial actions for cleanup of contaminated groundwater. Hydraulic properties are usually determined by conducting well hydraulic tests such as pumping tests or slug tests. At the main base, 2 pumping tests (HLA, 1989) and 30 slug tests have been performed to determine aquifer hydraulic properties. These tests were conducted between 1988 and 1989 and were reviewed to determine whether correct analytical methods were applied. Appendix III provides the results of the review of these tests and a summary of available information on hydraulic properties at Eielson AFB.

Pumping tests are generally more accurate than slug tests because a greater hydraulic stress is applied to a larger part of the aquifer. One pumping test was conducted at well 54M01 and observation well data were collected at wells 54M02, 54M03, and 54M04. The other test was conducted at wells 54M05, 54M06, 54M07, and 54M08 were used for observation wells. Results of both tests were reanalyzed using updated analysis techniques. A summary of the physical characteristics (e.g., hydraulic conductivity, velocity) is given in Table 3.3.

The two pumping tests resulted in estimates of horizontal hydraulic conductivity ranging from 140.20 m to 384 m/d for the unconfined aquifer. Slug tests at other sites indicated a minimum hydraulic conductivity of 15.24 m/d (HLA, 1991). A range of hydraulic conductivities over three orders of magnitude is not uncommon for an alluvial aquifer, especially where the sediments are graded and where fill may be present (Freeze and Cherry, 1979).

In 1992, the maximum water-level elevation on the main base occurred in May. This maximum was about 0.3 to 0.6 m higher than the minimum water level that occurred in November. The maximum water level coincided with the spring thaw, when runoff from snowmelt peaked. Streams that drain the upland area and are not of glacial origin typically reach their maximum discharge in May, during spring runoff (Anderson, 1970). The water table dropped relatively rapidly after the third week in May, although several smaller peaks were observed near the end of July in all of the monitored wells. These peaks appear to coincide with major rainstorms at Eielson AFB. Daily precipitation data for this reporting period are provided in Figure 1.5. Nearly 2.5 cm of rain fell on July 14, and an additional 1.4 cm fell on July 18. The 1.7 cm that fell on June 2 also appears to be reflected in the transducer data for all wells. Based on this period of record, the aquifer under the base is primarily recharged by the percolation of snowmelt and rainfall. The alluvial aquifer has also been reported to be recharged by the Tanana River, its tributaries, and subsurface flow and runoff from the Yukon-Tanana upland area (Anderson, 1970). The Tanana River's discharge generally peaks in July when the melting of glaciers and snowfields in the Alaska Range is at a maximum (Nelson, 1978). However, the effect of the Tanana River stage on the aquifer at Eielson AFB is not seen in the hydrographs (Figures 1.5 and

1.6), indicating that local recharge during the spring thaw appears to exert the greatest influence on the aquifer at the main base.

In areas of unconsolidated sediments, the influence of permafrost on groundwater recharge will vary widely with the grain size distribution and the unfrozen water content of the sediments. Finer-grained zones with high ice content can impede infiltration while coarse-grained material may not. Unfrozen zones (taliks) that exist below many streams and lakes may penetrate the permafrost completely and allow the recharge of groundwater aquifers at greater depth.

Blair Lakes Target Facility. Hydraulic characterization tests were conducted at the Blair Lakes Target Facility during May 1993. The objective of the hydraulic characterization tests was to get preliminary estimates for hydraulic properties (i.e., transmissivity, hydraulic conductivity) for the shallow alluvial aquifer and the deeper sub-permafrost aquifer that underlie the site. Slug tests were conducted in five wells completed in the shallow alluvial aquifer and one pumping test was conducted in the deeper sub-permafrost aquifer (in the old water supply well). The slug test hydraulic conductivity values ranged from results ranged from 2.9 to 48.2 m/d (Table 3.4). The hydraulic conductivity of the confined aquifer beneath the permafrost layer was approximately 43 m/d (see Appendix IV).

Blair Lakes Target Facility Permafrost Study. One of the objectives of the 1993 field season work was to determine the depth to the top of the permafrost at the Blair Lakes Target Facility in the vicinity of the building complex. Two subsurface resistivity measuring methods were employed: a direct current (DC) resistivity sounding, and a shallow frequency-domain electromagnetics survey (FDEM). From the results it was possible to develop a permafrost contour map for the site, better defining the hydrologic environment.

The DC resistivity method measures resistivity to different depths of investigation by varying the electrode spacing. The shallow FDEM method measures resistivity to only one depth (about 3 m) because the coil spacing is fixed. The FDEM method compliments the former by being more sensitive to lateral changes in permafrost surface. Section 3.7 presents the contours in meters below land surface (bls) for the top of the permafrost based on this study. Appendix V presents the operating principles and procedures, data reduction and results, from which the permafrost contour map was developed.

3.2 SOURCE AREA ST20 E-7 COMPLEX DESCRIPTION

Geology. The near-surface geology (i.e., to a depth of 8.2 m) of E-7 Complex is illustrated in the cross sections. Figure 3.1 shows the location of cross sections, and Figure 3.2 shows the north-south cross-section. The lowest unit shown on the cross sections consists of a sandy gravel. This unit is generally encountered at a depth of between 2.5 and 3 m. However, at well 20M03, this unit is found throughout the entire interval. The upper 2.5 to 3 m consists of a variety of lithologies including silty gravel, sandy gravel, gravelly sand, sand, and silty sand. These units generally average 1-m thick and appear to occur as interfingering lenses.

Permafrost. Permafrost was not encountered during subsurface investigations at the ST20 E-7 Complex. The deepest monitoring well was drilled to a depth of 9.6-m bls.

Hydrology. The water table at the site is contained largely within the sandy gravel and gravelly sand units. However, the distribution of silty sand layers are important because the finer grain size of these units could potentially impede groundwater flow at the site. Silty sands are found in the upper portion of the aquifer in several wells (e.g., 20M09, 20M02). The water table elevation at the site can fluctuate seasonably as much as 0.5 m. The most recent water-level monitoring results are shown in Appendix I. Groundwater is encountered at depths between 1.7 and 2.6-m bls.

Slug tests were conducted in wells 20M02, 20M03, 20M04, and 20M09 to estimate hydraulic conductivities. Data from the tests (HLA, 1989; CH2M HILL, 1993), however, are considered unreliable because of limitations of the slug test method for characterizing high permeability aquifers and, in some cases, because of shortcomings in the data collection and analysis procedures (Appendix III). At best, these tests may provide estimates of the minimum hydraulic conductivity for the test interval, and the actual hydraulic conductivity may be several times higher. The slug tests yielded values ranging from 1 m/d (20M02 and 20M03) to 60 m/d (20M04). A more accurate estimate of the hydraulic conductivity in the area is provided by the long-term pumping test data collected from wells near the southeast corner of the E-7 Complex (54M01 through 54M04). These data have been re-analyzed for this report (Appendix III). Pumping test results indicate a horizontal hydraulic conductivity of about 480 m/d.

A range of hydraulic conductivities was used to calculate the groundwater velocities. This range is based on the re-analysis of the two pumping tests and slug test data that were considered valid (Appendix III). Using this range of hydraulic conductivities, 61.0 to 366 m/d, an effective porosity of 0.3, and horizontal hydraulic gradients calculated from water levels in the source area wells, the mean groundwater velocity ranges from 0.16 to 0.96 m/d at an azimuth direction of 307.6° (see Figure 3.3).

3.3 SOURCE AREA ST20 E-8 COMPLEX DESCRIPTION

Geology. The near-surface geology (i.e., to a depth of 8.1 m) of the E-8 Complex is illustrated in Figures 3.4, 3.5, and 3.6. Figure 3.4 shows the location of the cross sections. Figures 3.5 and 3.6 show the cross sections. The lowest unit shown on the cross sections consists of a sandy gravel. This unit appears to thicken to the east and thin to the west. It is encountered at a depth of 0.6 m in well 20M16, but in well 20M13 it is not found until a depth of approximately 4.3 m. The thinning of this unit to the west corresponds with the appearance of a gravelly sand unit. Figure 3.6 shows the gravelly sand exposed at the surface at well 20M14 and pinching-out between wells 20M06 and 20M15. A silty sand comprises the uppermost 0.5 to 1.5 m at the site (except at well 20M14). This unit appears to thin to the east.

Permafrost. Permafrost was not encountered during subsurface investigations at the ST20 E-8 Complex. The deepest borehole was installed to 9.6-m bls.

Hydrology. The water table at the site is contained largely within the sandy gravel and gravelly sand. However, at well 20M15, the uppermost 0.5 m of the water table consists of silty sand. The finer grain size of the silty sand could potentially impede groundwater flow at the site. Groundwater was encountered at depths between 0.9- to 2.4-m bls. As with all the OU-1 source areas on the main base, a range of hydraulic conductivities is used based on the re-analysis of two pumping tests and slug test data that were considered valid (Appendix III). Using this range of hydraulic conductivities (61.0 to 366 m/d), an effective porosity of 0.3, and gradients calculated from the water-levels in wells, the mean groundwater velocity ranges from 0.16 to 0.99 m/d at an azimuth direction of 319.1° (see Figure 3.3).

3.4 SOURCE AREA ST20 E-9 COMPLEX DESCRIPTION

Geology. The near-surface geology (i.e., to a depth of 8.5 m) of the E-9 Complex is illustrated in Figures 3.7, 3.8, 3.9, and 3.10. Figure 3.7 shows the location of the cross sections. Figures 3.8 through 3.10 show the cross sections. The lowest unit shown on the cross sections is sandy gravel. This unit is generally encountered between 1.5- and 3-m bls. The lithologies above the sandy gravel include sandy gravel, gravelly sand, sand, and silty sand; these appear to generally coarsen from

north to south. This is illustrated in the north-south cross section shown in Figure 3.9. However, well 20M22, which is at the northwest end of the site, contains 4 m of silty sand above the sandy gravel.

Wells 20M25 and 20M07 are approximately only 12 m apart, yet there is a distinct difference in the lithology of the upper 2 m of these wells (see Figure 3.10). Well 20M25 contains a silty sand, however, well 20M07 contains a gravelly sand. This difference is likely the result of gravel backfilling near well 20M07, which is located next to the runway.

Permafrost. Permafrost conditions were not encountered during subsurface investigations at this complex. The deepest monitoring well that records were obtained for was completed to 9.6 m.

Hydrology. The water table is largely contained within the lowermost sandy gravel unit. However, at well 20M22, the uppermost 2.5 m of the water table is contained within the silty sand unit. Because of its finer grain size, this unit may have an effect on groundwater flow at the site.

A slug test was conducted in 1988 at 20M07. When the test data was reviewed for possible re-analysis, the quality of the test was considered marginal. Therefore, the range of hydraulic conductivities that was established for the main base was used in determining groundwater velocities (Appendix III). Using this range of hydraulic conductivities, 61.0 to 366 m/d, an effective porosity of 0.3, and gradients calculated from the water levels in wells, the mean groundwater velocity ranges from 0.20 to 1.23 m/d at an azimuth direction of 330.7°.

3.5 SOURCE AREA ST48 DESCRIPTION

Geology. The near-surface geology of ST48 is illustrated in Figures 3.11, 3.12, and 3.13. Figure 3.11 shows the location of the cross sections. Figures 3.12 and 3.13 show the cross sections. The upper 25 m is dominated by sandy gravel. However, lenses/layers of silt or silty sand frequently occur in this interval. These lenses/layers range from 1 to 3 m thick. An uppermost silty sand layer appears to be almost continuous in the north-south cross-section across the site (see Figure 3.13).

Only two wells at the site penetrated below 10 m. Water supply well D was drilled to a depth of 65.5 m and well 48M05 was drilled to a depth of 18.6 m (see Figure 3.13; because of space limitations, only the upper 36 m of water supply in well D is shown). Sediments between 10 and 35 m are predominantly sandy gravel, gravelly sand, and sand. From 35 to 41 m, a fine silt to gravelly silt is encountered. This unit may restrict groundwater flow. The driller's log for water supply well D notes that the interval from 55 to 58 m was the "second producing horizon." Below this horizon, a silt layer occurs from 58 to 60 m, a fine brown sand (not water bearing) occurs from 60 to 60.3 m, and silty sandy gravel occurs from this depth to the total depth of the well (65.5 m).

Permafrost. Permafrost was not encountered during the recent environmental investigations of ST48. No permafrost conditions were reported in the logs for cooling water supply wells 1 and 2. There was, however, "marginal" permafrost recorded in the drilling logs for water supply well D in 1962 between 5.2 and 19 m.

Hydrology. The water table occurs at a depth of between 3 and 4 m bls. The upper 6 m of the water table at the site is largely contained within the sandy gravel lithology. Floating product is found in one of the wells shown on the cross sections (well 53M03, Figure 3.13).

The distance to groundwater generally ranges between 2.4 to 4.2 m bls. Hydrographs for this area are shown in Figure 3.14. The wells used on the hydrograph are equipped with automatic water-level recorders and are discussed in more detail in Automatic Water-level Measurements Eielson Air Force Base, Alaska September 1991-August 1992 (U.S. Air Force, 1993a). The hydrographs indicate that the

water table had several rapid and relatively high amplitude fluctuations between August and October 1992, suggesting an artificial stress on the aquifer. The fluctuations are believed to be the result of pumping at the water-supply wells in the area. Figure 3.15 shows the locations of the water-supply wells. A water-table map for the site in May 1993 is shown in Figure 3.16. The map indicates a depression on the west side of the power plant near well 53M03. The reason for the depression is unknown but may be a transient result of the pumping regime in the area. Note, this area is also where free product thicknesses appear to be increasing. Both the hydrographs and water-table map indicate that the pumping wells in the area have a significant effect on the groundwater flow in the area.

Influence of Water-Supply Wells. Groundwater flow is influenced by pumping from base supply well D, and to a lesser extent by pumping from the two cooling water supply wells (wells 21 and 22) as evidenced by the skewed equi-potential lines on the local and regional water table maps (see Figures 1.9, 1.10, and 3.16). Well D, which is screened from 31- to 37.7-m bls, is pumped continuously at about 1,000 gal/min. Nearby water supply wells A and B are used when well D is undergoing repair or maintenance, and in the summer during periods of high water demand. The cooling supply wells 21 and 22 are used to supply cooling water to the power plant from about early June to late September. These wells are screened from 23.2- to 36.4-m bls and 25- to 38.1-m bls, respectively. These wells are capable of withdrawing approximately 4,200 gal/min (Figure 3.15).

In addition to the skewing of the equi-potential lines around water supply well D, short-term water-level fluctuations of up to 0.28 m in less than 12 hours appear to originate in the area. Because of the nature of the fluctuations (i.e., rapid changes of relatively large amplitude), the water levels are believed to be artificially induced by the base water supply and possibly the power plant cooling wells. These fluctuations are discernable at least as far away as the OU-2 source area ST11 (460 m) (see Appendix III).

A brief qualitative analysis of water-well responses associated with water-supply pumping activities at the Eielson AFB were examined. Results of the analysis indicate the following.

- Because of the moderate to high transmissivity of the site, water supply pumping activities have far-reaching effects across the site (e.g., in excess of 2,500 m).
- Composite recovery analysis of selected wells following termination of pumping of the water-supply well indicates that the aquifer acts areally as an unconfined aquifer. The fact that the aquifer is unconfined "delays" the transmission of the cone of depression (or recovery) with distance from the water-supply well.

Vertical Hydraulic Gradients. There are a series of wells located within approximately 40 m of water supply well D that are completed at depths of 3.8 to 6.7 m (48M04), 11.4 to 14.5 m (48M05), and 27.1 to 30.2 m (48M06). May 1993 water levels indicated a downward hydraulic gradient while well D was operational. Water-level elevations in the shallow well (48M04) were as much as 0.21 m higher than in the deep well (48M06) in May 1993. Under natural conditions measured elsewhere on base, the hydraulic gradients are negligible (Appendix III).

A slug test was performed in well 48M06 in 1988. The test data were re-analyzed using an oscillating response method (see Appendix III). The calculated hydraulic conductivity for this well is 136.15 m/d. To establish a range of potential groundwater velocities the range of hydraulic conductivities established for the base (61.0 to 366 m/d), an effective porosity of 0.3, and gradients calculated from the water levels in wells were used. Mean groundwater velocity was calculated to be 0.47 to 2.82 m/d in an azimuth direction of 33.3°. Note, the groundwater velocity extremes range from an azimuth direction of 104.7 to 326.5° azimuth. The variation is attributed to the pumping schedules of the pumping wells in the area (see Figure 3.16).

3.6 SOURCE AREA ST49 DESCRIPTION

Geology. The near-surface geology (i.e., to a depth of 9.1 m) of ST49 is illustrated in Figures 3.17 and 3.18. Figure 3.17 shows the location of the cross section. Figure 3.18 shows the cross section. The lowest unit shown on the cross section is sandy gravel. It is encountered at a depth of 2.5 to 4 m, except in well 49MO2, where it comprises the entire interval. The upper 2.5 to 4 m at the site consists of a variety of sediments including sandy gravel, gravelly silty sand, gravelly sand, and silty sand.

The water table at the site is contained largely within the sandy gravel. However, at wells 49M06 and 53M05, the uppermost 1 m of the water table consists of silty sand to gravelly silty sand. The finer grain size of these sediments could potentially impact groundwater flow at the site.

The hydraulic influence on groundwater flow from pumping at the upgradient base water supply well 7 is not known; little influence is anticipated because of the relatively low pumping rates. The hydraulic influence of nearby Garrison Slough on upgradient shallow groundwater flow also is not known. North of the alert hangar, the slough has been routed through a corrugated metal pipe to pass beneath the taxiway. An inlet sump to this pipe is located in the middle of the field north of the alert hangar. This pipe discharges to ponds near the gun clearing butt (south side of OU-2 ST13).

Hydrology. ST49 is located near the wells 54M01 through 50M04, which were used for a long-term pumping test. These pumping test data have been re-analyzed for this report (Appendix III). Pump test results indicate a conductivity of about 480 m/d in this area. Groundwater velocity calculations used the range of hydraulic conductivities established for the main base (61.0 to 366 m/d) along with an effective porosity of 0.3 and gradients calculated from water table elevations to calculate a mean groundwater speed between 0.14 and 0.87 m/d at an azimuth direction of 0.355.9° (Figure 3.19).

3.7 SOURCE AREA BLAIR LAKES TARGET FACILITY DESCRIPTION

Geology. The geology of the Blair Lakes Target Facility is illustrated in Figures 3.20, 3.21, and 3.22. Figure 3.20 shows the location of the cross sections. Figures 3.21 and 3.22 show the cross sections. (west-east) and 3.22 (north-south). Only two wells have been drilled below the 6 m depth, the old water supply well and the new water supply well and, of these two, only the well logs for the new water supply well are available. The new water supply well was completed to a depth of 52.7 m. Sediments found in this well below the 2.5 m depth generally consist of sandy gravel with some ash identified at the 50 to 56.8 m interval.

The upper 2.5 m is dominated by fine-grained deposits (silt, sandy silt, silty clay, gravelly sandy silt). These fine-grained lithologies appear to occur as interfingering 0.5- to 2-m thick lenses/layers. However, 0.25- to 1-m thick gravel layers (silty gravel, silty sandy gravel) may also be present, especially at the land surface. Much of the Blair Lakes Target Facility is built on gravel fill taken locally from pits. Organic- and silt-rich deposits of peat or "muskeg" can be found away from the gravel pad. The gravels in this area have been identified as granite, granodiorite, conglomerate, sandstone, schist, gneiss, quartz, and gabbro (Pewe et al., 1966).

The source area for the sediment deposits at Blair Lakes is primarily the Totatlanika Schist with some contribution from the Birch Creek Schist. In general, the parent material is more mafic than the alluvial outwash at the main base resulting in high background metal concentrations (see Section 1.5, Geologic Setting).

Permafrost. Permafrost across the Blair Lakes Target Facility varies in depth between 2 and 9 m (Appendix V). Permafrost was detected in two borings on the north end of the complex at a depth of

approximately 7.6 m. On the south end of the facility, permafrost was detected at a depth of 9.2 m in the new water supply well and at 2.9 m in a soil test pit near well 50M02. A surface resistivity survey was performed to determine the depth to the top of permafrost in the vicinity of the developed area. The permafrost surface was identified by locating the boundary between the lower resistivity unfrozen topsoil, and the very highly resistive frozen soil beneath it (see Figure 3.23).

The results indicate that the permafrost depth varies significantly, sometimes abruptly, across the site and is closest to the surface on the east side of the building complex. However, many of the shallower models also show a low resistivity layer under the upper frozen layer. Because these soundings were taken in May, this could indicate the upper high resistivity (frozen) layer is part of the active zone that seasonally freezes and thaws.

The resistivity soundings matched physically observed depths to permafrost closely. Permafrost was encountered at 2.9 m in the two soil test pits shown on the map and the resistivity sounding is also approximately at 3 m. The borehole log for the new water supply well shows frozen ground starting at 9.2 m. The model for the resistivity sounding performed next to this well indicates the permafrost top at 4.3 m. However, the next closest sounding, about 75 m to the northwest, yielded a permafrost top of 9.5 m, much closer to the well log value. The variable depth to the permafrost may be the result of several factors including variability of groundcover (including vegetation in summer and snow in winter), sediment grain size distribution, and artificial heat sources particularly under heated buildings and the septic pond. The permafrost extends to a depth of approximately 50 m, based on drilling logs, at which depth there are transmissive alluvial sand and gravel deposits that serve as the source for both the old and new water supply wells.

Hydrology. Depth to groundwater generally ranges between 2.1 to 3 m bls. The elevation of the water table is significantly different between wells 50M08 (222.06 m msl) and 50M01 (220.68 m msl). This difference may be from the distribution of permafrost at the site causing local perched water conditions. Unconfined aquifer conditions are expected for the saturated alluvial deposits above the permafrost layer. Locally perched water conditions, however, can occur where the permafrost extends to near the land surface. Hydrographs of the Blair Lakes Target Facility are shown in Figure 3.24. These hydrographs indicate a spring recharge event that peaked during the first week in May 1993. The water levels do not appear to be influenced by the new water supply well. Well 50M05 is located within 70 m of the new water supply well. The new water supply well operates on a demand basis and is estimated to pump at approximately 24 gal/min, for a total of between 500 and 1,350 gal/d.

The permafrost also appears to act as a confining layer to the deeper alluvial aquifer from which the drinking water well is supplied. During an 8-hour constant discharge test in the old water supply well, no response was detected in a shallow observation well, 50M01, located 5.91 m from the stress well. A drawdown response of 0.03 m was predicted to occur within the first 2 hours of the test if the aquifer was unconfined (see Appendix IV).

Hydraulic conductivity values from six slug test in wells 50M02, 50M04, 50M06, 50M07, 50M08, and 50M10 range from 2.9 to 48.2 m/d (Table 3.4; Figure 3.25). Groundwater velocities range from 0.08 to 1.31 m/d with an azimuth direction of 339.2°.

TABLE 3.1. Background Concentrations of Constituents in Sediments, Eielson AFB

	Number of samples	t value	Arsenic (mg/Kg)	Barium (mg/Kg)	Chromium (mg/Kg)	Copper (mg/Kg)	Iron (mg/Kg)	Lead (mg/Kg)	Manganese (I) (mg/Kg)	Nickel (mg/Kg)	Zinc (mg/Kg)	TPH (mg/Kg)
FILL	21	1.725										
Mean			3.3	57.9	9.5	13.2	9014	3.6	195	12.6	22.7	2.9
Standard Deviation			1.7	13.0	1.7	2.4	1069	0.6	151	2.3	4.3	3.4
Upper Confidence Limit			3.9	82.8	10.1	14.1	9718	3.8	252	13.4	24.4	4.2
FLUVIAL SOIL	60	1.671(2)										
Mean			13.9	141.2	26.0	44.8	26823	10.6	409	31.9	68.2	2.9
Standard Deviation			7.6	55.8	10.9	20.8	10804	4.8	196	12.5	27.8	5.6
Upper Confidence Limit			15.5	153.2	29.3	49.3	29111	11.6	451	34.6	75.2	4.1
LOESS	9	1.890										
Mean			14.1	104.4	35.2	37.8	25822	8.5	339	32.7	59.4	< 1.8
Standard Deviation			4.3	17.6	4.2	5.2	2961	0.9	62	4.2	6.1	NA
Upper Confidence Limit			16.7	195.4	37.8	41.0	27058	9.0	372	35.3	63.1	< 1.8

(1) 10 fill, 43 fluvial, and 9 loess values biased high due to high matrix spike recoveries

(2) t value for 60 degrees of freedom

NA Not applicable

mg/Kg Milligrams per kilogram

Upper Confidence Limit on sample mean calculated as follows: $UCL = \text{Mean} + t \times \text{Std} / \sqrt{n}$

If constituent was not detected, a value of one-half the detection limit was used to calculate the mean and standard deviation.

TABLE 3.2. Physical Characteristics of Sediment Samples from OU-1 Sites

Well	Chain-of Custody Number	Moisture %	Sand %	Silt %	Clay %	Lithologic Description
E-7-1SM	75836	17	93	3	4	Sand
E-7-2SM	75837	16	94	1	5	Sand
E-9-1SM	75838	16	93	2	5	Sand
E-9-2SM	75839	11	95	0	5	Sand
ST48-4SM	75840	5	80	16	4	Loamy sand
ST48-5SM	75841	8	90	5	5	Sand
BL1-1SM	75842	22	52	32	16	Sandy loam
BL1-2SM	75843	22	56	27	17	Sandy loam
BL2-1SM	75844	22	41	42	17	Loam
BL2-2SM	75845	19	42	41	17	Loam
BL3-1SM	75846	15	75	11	14	Sandy loam
BL3-2SM	75847	26	49	35	16	Loam
BL4-1SM	75848	22	67	27	6	Sandy loam
BL4-2SM	75849	18	80	11	9	Loamy sand
BL5-1SM	75850	20	56	35	9	Sandy loam
BL5-2SM	75851	19	38	52	10	Silt loam
BL6-1SM	75852	20	67	26	7	Sandy loam
BL6-2SM	75853	25	38	46	16	Loam
BLTF-1	75876	9	63	28	9	Sandy loam
BLTF-2	75877	21	41	50	9	Silt loam
BLTF-3	75878	20	43	40	17	Loam
BLTF-4	75879	45	5	68	27	Silty clay loam
6E-7-ISM = ST20 E7 E-9-ISM = ST20 E9 ST48-4SM = ST48 BL = Blair Lakes Target Facility. DA = soil vapor points.						

TABLE 3.3. Groundwater Movement

Source Area	Date	Hydraulic Conductivity (m/day)	Effective Porosity %	Hydraulic Gradient (m/m)	Speed (m/day)	Direction (azimuth)	Number of Wells	Mean Speed (m/day)	Weighted Mean Direction (azimuth)
ST20 (E-7)	28-Aug-91	6.10E+01	30	4.48E-02	9.05E-02	319.0	5	1.81E-01	307.6
	27-Sep-91	6.10E+01	30	6.74E-02	1.37E-01	351.1	4		
	28-May-93	6.10E+01	30	1.26E-01	2.55E-01	280.2	11		
	28-Aug-91	3.66E+02	30	4.45E-02	5.43E-01	319.0	5	9.65E-01	307.5
	27-Sep-91	3.66E+02	30	6.73E-02	8.20E-01	351.1	4		
	28-May-93	3.66E+02	30	1.26E-01	1.53E+00	280.2	11		
ST20 (E-8)	22-Jan-92	6.10E+01	30	6.32E-02	1.28E-01	332.4	5	1.85E-01	319.1
	21-May-92	6.10E+01	30	1.25E-01	2.55E-01	305.6	3		
	14-Jul-92	6.10E+01	30	7.56E-02	1.54E-01	325.6	3		
	20-Aug-92	6.10E+01	30	7.16E-02	1.46E-01	323.1	3		
	28-May-93	6.10E+01	30	7.04E-02	1.43E-01	320.1	19		
	22-Jan-92	3.66E+02	30	6.30E-02	7.66E-01	332.4	5	9.91E-01	319.1
	21-May-92	3.66E+02	30	1.28E-01	1.53E+00	305.6	3		
	14-Jul-92	3.66E+02	30	7.56E-02	9.24E-01	325.6	3		
	20-Aug-92	3.66E+02	30	7.20E-02	8.78E-01	323.1	3		
	28-May-93	3.66E+02	30	7.03E-02	8.56E-01	320.1	19		
	28-Aug-91	6.10E+01	30	3.56E-01	7.22E-01	075.3	3	2.04E-01	330.7
ST20 (E-9)	27-Sep-91	6.10E+01	30	8.80E-01	1.75E+00	082.5	3		
	22-Jan-92	6.10E+01	30	9.86E-02	1.98E-01	331.7	3		
	19-Aug-92	6.10E+01	30	8.42E-02	1.71E-01	317.8	5		
	21-Aug-92	6.10E+01	30	1.10E-01	2.23E-01	330.1	8		
	22-Aug-92	6.10E+01	30	1.00E-01	2.04E-01	339.2	4		
	28-Aug-92	6.10E+01	30	1.03E-01	2.10E-01	334.2	4		
	17-Sep-92	6.10E+01	30	1.04E-01	2.12E-01	328.1	4		
	27-Oct-92	6.10E+01	30	9.57E-02	1.94E-01	335.4	4		
	28-May-93	6.10E+01	30	1.11E-01	2.25E-01	327.4	14		
	28-Aug-91	3.66E+02	30	3.55E-01	4.33E+00	075.3	3	1.23E+00	330.7
	27-Sep-91	3.66E+02	30	8.80E-01	1.05E+01	082.5	3		
	22-Jan-92	3.66E+02	30	9.85E-02	1.18E+00	331.7	3		
	19-Aug-92	3.66E+02	30	8.43E-02	1.03E+00	317.8	5		
	21-Aug-92	3.66E+02	30	1.10E-01	1.34E+00	330.1	8		
	22-Aug-92	3.66E+02	30	1.00E-01	1.22E+00	339.2	4		
	28-Aug-92	3.66E+02	30	1.03E-01	1.26E+00	334.2	4		
	17-Sep-92	3.66E+02	30	1.04E-01	1.27E+00	328.1	4		
	27-Oct-92	3.66E+02	30	9.58E-02	1.17E+00	335.4	4		
	28-May-93	3.66E+02	30	1.11E-01	1.35E+00	327.4	14		
ST48	28-Aug-91	6.10E+01	30	1.07E-01	2.18E-01	023.0	6	4.70E-01	033.3
	27-Sep-91	6.10E+01	30	9.92E-02	2.01E-01	026.1	7		
	11-Oct-91	6.10E+01	30	3.02E-01	6.13E-01	024.2	4		
	22-Jan-92	6.10E+01	30	6.24E-01	1.27E+00	045.1	3		
	11-Feb-92	6.10E+01	30	9.17E-02	1.86E-01	013.1	3		
	15-Apr-92	6.10E+01	30	8.15E-03	1.86E-02	104.7	3		
	14-Jul-92	6.10E+01	30	3.14E-01	6.37E-01	326.5	3		
	28-May-93	6.10E+01	30	3.06E-01	6.22E-01	096.6	9		
	28-Aug-91	3.66E+02	30	1.07E-01	1.31E+00	023.0	6	2.82E+00	033.3
	27-Sep-91	3.66E+02	30	9.93E-02	1.21E+00	026.1	7		
	11-Oct-91	3.66E+02	30	3.03E-01	3.69E+00	024.2	4		
	22-Jan-92	3.66E+02	30	6.25E-01	7.62E+00	045.1	3		
	11-Feb-92	3.66E+02	30	9.18E-02	1.12E+00	013.1	3		
	15-Apr-92	3.66E+02	30	8.15E-03	9.94E-02	104.7	3		
	14-Jul-92	3.66E+02	30	3.13E-01	3.81E+00	326.5	3		
	28-May-93	3.66E+02	30	3.05E-01	3.72E+00	096.6	9		

TABLE 3.3. Groundwater Movement (continued)

Source Area	Date	Hydraulic Conductivity (m/day)	Effective Porosity %	Hydraulic Gradient (m/m)	Speed (m/day)	Direction (azimuth)	Number of Wells	Mean Speed (m/day)	Weighted Mean Direction (azimuth)
ST49	28-Aug-91	6.10E+01	30	6.78E-02	1.38E-01	022.0	4	1.45E-01	355.9
	27-Sep-91	6.10E+01	30	6.29E-02	1.28E-01	018.3	4		
	21-Aug-92	6.10E+01	30	8.06E-02	1.64E-01	335.3	6		
	27-Oct-92	6.10E+01	30	8.08E-02	1.64E-01	331.2	3		
	28-May-93	6.10E+01	30	6.51E-02	1.32E-01	002.9	12		
	28-Aug-91	3.66E+02	30	6.78E-02	8.2E-01	022.0	4		
	27-Sep-91	3.66E+02	30	6.30E-02	7.68E-01	018.3	4	8.70E-01	355.9
	21-Aug-92	3.66E+02	30	8.05E-02	9.81E-01	335.3	6		
	27-Oct-92	3.66E+02	30	8.05E-02	9.81E-01	331.2	3		
	28-May-93	3.66E+02	30	6.50E-02	7.92E-01	002.9	12		
Blair Lakes	22-Oct-89	3.05E+00	30	9.27E-01	9.42E-02	349.3	7	8.21E-02	339.2
	25-Feb-92	3.05E+00	30	7.26E-01	7.38E-02	340.8	7		
	18-Jun-92	3.05E+00	30	8.22E-01	8.35E-02	345.5	4		
	01-Sep-92	3.05E+00	30	8.46E-01	8.60E-02	336.7	5		
	28-Dec-92	3.05E+00	30	7.62E-01	7.74E-02	332.7	8		
	11-Feb-93	3.05E+00	30	7.50E-01	7.62E-02	330.4	7		
	18-Feb-93	3.05E+00	30	7.77E-01	7.89E-02	343.1	5		
	24-May-93	3.05E+00	30	8.55E-01	8.69E-02	333.5	9		
	22-Oct-89	4.88E+01	30	9.26E-01	1.51E+00	349.3	7	1.31E+00	339.2
	25-Feb-92	4.88E+01	30	7.26E-01	1.18E+00	340.8	7		
	18-Jun-92	4.88E+01	30	8.21E-01	1.34E+00	345.5	4		
	01-Sep-92	4.88E+01	30	8.46E-01	1.37E+00	336.7	5		
	28-Dec-92	4.88E+01	30	7.61E-01	1.24E+00	332.7	8		
	11-Feb-93	4.88E+01	30	7.50E-01	1.22E+00	330.4	7		
	18-Feb-93	4.88E+01	30	7.76E-01	1.26E+00	343.1	5		
	24-May-93	4.88E+01	30	8.55E-01	1.39E+00	333.5	9		

Notes: The "Date" column contains the date on which the hydraulic head measurements were taken, thus it represents the date of the groundwater velocity.

Hydraulic conductivities used for source areas on the base were obtained from a preliminary analysis of the hydraulic testing reported in Appendix III. The final range reported in Appendix III differs slightly from the values used here. The hydraulic conductivities used for Blair Lakes is the approximate range given in Table IV.2 of Appendix IV.

An effective porosity of 30% was assumed for all source areas.

For more details on the groundwater velocity calculations, see Appendix II.

TABLE 3.4. Blair Lakes Target Facility Aquifer Test Summary

Well	Equivalent Hydraulic Conductivity (m/d)
50M02	9.3
50M04	2.9
50M06	48.2
50M07	4.1
50M08	9.9
50M10	20.0
Old water supply well	43.3

FIGURE 3.1. Cross Section Location, ST20 E-7 Complex

59306043.7

FIGURE 3.2 Subsurface Cross Sections, ST20 E-7 Complex

FIGURE 3.3. Water-Table Map and Groundwater Velocities (E-7, E-8, and E-9), ST20

ST20JMC

FIGURE 3.4. Cross Section Location, ST20 E-8 Complex

FIGURE 3.5. Cross Section West-East (A-A'), ST20 E-8 Complex

S9306043.3

S9306043.8

FIGURE 3.6. Cross Section North-South (B-B'), ST20 E-8 Complex

FIGURE 3.7. Cross Section Locations, ST20 E-9 Complex

FIGURE 3.8. Cross Section West-East (A-A'), ST20 E-9 Complex

80300043.1

FIGURE 3.9. Cross Section North-South (B-B'), ST20 E-9 Complex

S9306043.2

FIGURE 3.10. Cross Section West-East (C-C'), ST20 E-9 Complex

FIGURE 3.11. Cross Section Location, ST48

FIGURE 3.12. Cross Section West-East (B-B'), ST48

FIGURE 3.13. Cross Section North-South (A-A'), ST48

FIGURE 3.14. Hydrographs of Groundwater Monitoring Wells, ST48

FIGURE 3.15. Water-Supply Wells, ST48

FIGURE 3.16. Water-Table Map, May 1993, ST48

FIGURE 3.17. Cross Section Location, ST49

58306043.10

FIGURE 3.18. Cross Section North-South (A-A'), ST49

FIGURE 3.19. Water-Table Map, May 1993, ST49

FIGURE 3.20. Cross Section Location, Blair Lakes Target Facility

FIGURE 3.21. Cross Section West-East (B-B'), Blair Lakes Target Facility

FIGURE 3.22. Cross Section North-South (A-A'), Blair Lakes Target Facility

FIGURE 3.23. Top of Permafrost in Subsurface, Blair Lakes Target Facility (in Meters Below the Groundsurface)

FIGURE 3.24. Hydrograph of Wells, Blair Lakes Target Facility

FIGURE 3.25. Water-Table Map, Blair Lakes Target Facility

4.0 NATURE AND EXTENT OF CONTAMINATION

The following is a discussion of the nature and extent of groundwater and soil contamination identified in the OU-1 source areas. There are eight source areas assigned to OU-1 in the FFA (EPA et al., 1990): ST20, ST48, ST49, SS50, SS51, SS52, SS53, and DP54. For ease of discussion and based on contamination distribution, these source areas have been re-grouped so that ST20 is subdivided into the E-7, E-8, and E-9 Complexes, and SS50, SS51, SS52, SS53, and DP54 are combined into the Blair Lakes Target Facility.

The source areas were originally placed in OU-1 based on the contaminant type that was identified as POL. The initial sampling effort in 1989 focused on the concentrations and distributions of petroleum hydrocarbons although cursory sampling for metals, PCBs, pesticides, and semivolatile compounds was done. The strategy for the most recent sampling effort in May 1993 was to verify previous results that exceeded a risk-based limit and to expand the search for PCBs, pesticides, and semivolatile compounds such as PAHs.

A list of the contaminants of concern for the OU-1 source areas was developed by comparing the highest value detected from sampling data with the risk-based concentrations from EPA's National Contingency Plan (40 CFR 300) and Part A of the Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (EPA, 1989). These risk-based values correspond to a 10^{-6} excess cancer risk and a hazard quotient (HQ) of 1 for systemic toxins (Table 4.1). Metals data were also compared to the established background levels in soils and groundwater for Eielson AFB (CH2M HILL, 1992b) and soil backgrounds for the Blair Lakes sites (this report). Several metals were found to occur at elevated concentrations in both soil and groundwater at OU-1, and many of these metals exceed or are very near risk-based screening concentrations. To determine if the concentrations in the soil and groundwater were above the natural background levels, the site-specific metal concentrations in soil and groundwater were compared statistically to appropriate background values using a t-test (Appendix VII). If the metal was not found to be outside the background population, an asterisk was placed on the metal in the contaminants of concern table.

For sites that can impact surface water, contaminant concentrations in wells immediately upgradient of the surface water were compared to the ambient groundwater quality standards. Total petroleum hydrocarbon (TPH) levels above 100 ppm in soil were also considered a contaminant of concern based on ADEC suggested cleanup guidelines. If the sampling data exceeded any of these comparison concentrations (i.e., excess cancer risk), the HQ, or the maximum concentration limit (MCL) allowed by regulation, the constituent was entered into the table as a contaminant of concern. This table represents a conservative estimate of the contamination present at the OU-1 sites (Table 4.2).

The first half of this chapter discusses the contaminants of concern on an operable unit scale. Source area specific discussions are then covered in the second half of the chapter. Where possible, the data is presented in tables to make this chapter easier to use as a reference guide. Where greater detail is required, the reader is referred to the appendixes.

A comprehensive testing of the fueling system at the refueling loop (ST20; E-7, E-8, and E-9) was performed in the summer of 1993. The results are summarized in Appendix IX. Problems identified in the fueling system were either repaired, or the system was taken out of service. No current leaks are identified. In addition, a project to replace the fuel piping has been proposed by the U.S. Air Force.

4.1 SOURCE AREA ST20 E-7 COMPLEX DESCRIPTION

The ST20 E-7 Complex is one of three refueling complexes located at the west end of the refueling loop at the southeast end of the runway (see Figure 1.2). The E-7 Complex consists of the asphalt pad centered along the taxiway with adjacent unpaved areas of gravel and grass. The complex is served by a fuel pump house (Building 1315) with three associated 190,000-L JP-4 underground storage tanks (UST) and one 95,000-L defueling UST along with fueling and defueling transfer pipes.

The large area enclosed by the taxiway loop, north of the complex, contains surface water ponds. Garrison Slough is approximately 300 m southwest of the complex. The relationship of the E-7 Complex to the other two complexes is shown in Figure 1.2.

The majority of aircraft refueling operations are conducted at the refueling loop, and numerous fuel spills have occurred there in the past. The source of contamination at the E-7 Complex is believed to be leaks in the subsurface JP-4 fueling and defueling transfer pipes. Contaminants typically associated with JP-4 fuel include TPHs, volatile compounds (BTEXs), semivolatile compounds (naphthalenes), and trace metals.

The site was identified as a potential source area in 1982 during the phase I records search (CH2M HILL, 1982). In 1984, one monitoring well was installed (W-3) as part of the phase II, stage 1 investigation (Dames & Moore, 1985). In 1986, a phase IV-A1 field investigation was conducted in which monitoring wells (20A-1 through 20A-3) were installed, and soil and groundwater samples were collected and analyzed (SAIC, 1989b).

A stage 3 field investigation was conducted at the source area from July through October 1988. The investigation included a soil gas survey, installing 11 monitoring wells (20M02 through 20M05, 20M09, 20M010, 53M04, and 54M01 through 54M04) and 13 product probes, conducting aquifer tests, and sampling and analyzing soil and groundwater (HLA, 1989a). Four of the wells (54M01 through 54M04) were used for a long-term (17-hour) pump test; 54M01 was the pumping well and 54M02 through 54M04 were observation wells. A subsequent stage 4 field investigation was conducted from August through November 1989 (HLA, 1990). During this investigation, surface soil and surface water samples were collected, groundwater probes were installed to define the downgradient extent of groundwater contamination, two additional monitoring wells were completed, and soil from the new boreholes and groundwater from new and existing wells were sampled. Water levels and product thickness were also measured periodically in 1991 and 1992 as a part of the ongoing sitewide investigation at the base (CH2M HILL, 1992b).

A field investigation conducted in May 1993 included monitoring water-levels and product thicknesses in the monitoring wells and product probes, and collecting sediment and water samples (appendixes, this report).

4.1.1 Interim Actions

Floating petroleum products were encountered in 1972 in a 6-m test hole at the E-7 pump house (CH2M HILL, 1982). In July 1987, a 30-cm-thick layer of floating product was observed in a ditch excavated during maintenance work on an underground defueling line immediately north of the E-7 pump house. Three static recovery wells subsequently were installed in the leak area and operated until February 1988; 3,350 L of JP-4 fuel were recovered before flow to the system became restricted (HLA, 1990). Another static recovery well was installed in late 1988; as of December 1989, approximately 40 L of fuel had been recovered (HLA, 1990). The recovery well was abandoned sometime before October 1991.

Bioventing, described in the IRA Record of Decision (EPA, 1992b), was selected as the interim remedial action for the ST20 E-7 Complex. A bioventing treatability study is being conducted by Battelle Columbus at the ST20 E-7 Complex and will run until December 1993. Three plots are being tested for enhanced microbial degradation of fuel hydrocarbons in soil.

In addition to the ongoing interim remedial actions at the E-7 Complex, the U.S. Air Force plans to conduct a tank integrity and pipeline leak detection investigation of USTs and associated transfer piping in May and June 1993. Results are in Appendix IX.

4.1.2 Data Summary

The analytical parameters for all of the previous sampling events are summarized in Table 4.3. The results for soil and groundwater are summarized in Appendix VIII. Product thickness measurements are listed in Table 4.4. Monitoring well construction and sampling information are summarized in Table 4.5.

4.1.3 Contaminants of Concern

The contaminants of concern for the ST20 E-7 Complex are listed in Table 4.1.

4.1.4 Floating Product

The source of the floating product observed in 1988 is believed to be a subsurface leak that occurred near the 90-degree elbows in the 250-mm JP-4 supply line and the 100-mm JP-4 defueling line. The leak was reportedly repaired in 1988 (HLA, 1990). Tank and piping tightness testing is planned for summer 1994. The testing should help indicate the possibility of leaks near the pipeline. In 1988 and 1989, up to nine wells and product probes reported product; one of these wells, 20M04, had a reported thickness of 51.8 cm. In May 1993, product thickness was detected in only one well, 20M04 (65.2 cm), and in one product probe, 20PP12 (12.19 cm). The lateral extent of the product has diminished, but product thickness has increased slightly from 1989 at the well 20M04. Figure 4.1 illustrates the decrease in the areal extent of the measurable product. No recharge tests have been conducted in these wells.

4.1.5 Fuel-Related Contaminants

Soil. Twelve soil samples were analyzed for VOA in 1986; nine soil samples were analyzed for VOA during stage 3 (1988-1989); three soil samples were analyzed for VOA in 1993. No subsurface TPH contamination in excess of 100 mg/kg was identified in soil. However, areas of elevated TPH and BTEX are likely to be present near the free product pool, where smearing of the floating product caused by seasonal changes in the water table is expected to have occurred (smear zone).

The PAH, 2-methylnaphthalene, was detected in subsurface soil at well 53M04 in the 1989 sampling. A soil boring drilled adjacent to the well in May 1993 could not verify the original "hit." None of the samples from the soil boring detected any semivolatile organic materials. In addition, PAHs and semivolatile organic materials were not detected in well 20MW27, installed in 1993. Both the soil boring and the new well were drilled adjacent to the taxiway, an area suspected of surface PAH contamination. This data indicate the PAH contamination near the E-7 Complex may be localized if present.

Groundwater. The source of BTEX and PAH contamination in groundwater is thought to be associated with floating product. The downgradient extent of benzene contamination in groundwater has been defined by the groundwater probe and monitoring well data collected in 1988, 1989, and 1993. A comparison of data for 1988, 1989, and 1993 shows that benzene concentrations within the plume

are decreasing. The highest concentration of benzene in 1989 was 12,000 µg/L in well 53M04. In 1993, the concentration in this well was 200 µg/L. A similar trend is found throughout the area. The benzene concentrations appear to be naturally degrading.

4.1.6 PCBs

The PCB 1254 was detected in well 53M04 at a concentration of 70 µg/L during the 1989 sampling effort. A soil boring drilled adjacent to the well in May 1993 could not verify the original "hit" of PCB. In addition, a new well, 20MW27, did not detect any PCBs. A composite surface soil sample and sediment sample from the pond hydraulically downgradient from the site also did not detect any PCB contamination for the E-7 Complex. No PCB contamination at the E-7 Complex could be confirmed.

4.1.7 Pesticides

Soil. Pesticides were used extensively on the base until 1966. Some aerial spraying of the pesticide dichlorodiphenyltrichloroethane (DDT) was conducted. Because DDT decomposes slowly and is highly immobile, traces of it along with its decomposition products, 2,2-bis(para-chlorophenyl)-1,1-dichloroethane (DDD) and dichloroethylene (DDE), would be expected to be found over relatively wide areas of the base, particularly in surface soil along surface water bodies and in sediments.

Five soil and sediment samples were taken for DDD. It was detected three times; the concentrations ranged from 5.8 to 570 µg/kg. Five soil and sediment samples were taken for DDT. It was detected twice; the concentrations ranged from 2 to 1,500 µg/kg.

Background. The background values for DDD and DDT were established under the sitewide program from 15 sample locations, located at various locations basewide, using both surface water and surface water sediment samples. In the surface water, DDD was detected nine times. The mean concentration of DDD detected was 0.0188 µg/L. DDT was not detected in surface water. In sediment samples of surface water, DDD was detected eight times. The mean concentration of DDD was 87.4 µg/kg. DDT was detected four times. The mean concentration of DDT was 97.3 µg/kg.

4.1.8 Bis(2-ethylhexyl)phthalate in Groundwater

Bis(2-ethylhexyl)phthalate was detected in groundwater in 1993 at well 53M04 (1,000 µg/L). The risk-based level^(a) is 0.6 µg/L. This chemical is a plasticizer found in polyvinyl chloride (PVC) pipe and plastic sampling equipment and could be the result of either the deterioration of the PVC well casing or sampling equipment.

4.1.9 Metals

For metals, ST20 has been treated as one source area to work with statistically significant populations of data.

Soil. Metals that exceed risk-based levels in soil are arsenic and beryllium. Arsenic was detected above the soil screening value of 400 µg/kg in soil from wells 20MW13 and 20MW27. The highest value detected, and the only value over the background upper confidence level, was 6,300 µg/kg in well 20MW13. The background upper confidence level for arsenic in soil is 3,900 µg/kg.

Beryllium was detected above the risk-based level of 100 µg/kg in soil in wells, 20MW27, 20MW13, and 20MW26, as well as in sediments from the refueling loop pond. The highest value was in the

(a) See Table 4.2.

sample taken from the pond sediments at 600 µg/kg. The other results ranged from 140 to 180 µg/kg. There is no background established for beryllium on the main base.

No human-caused sources of beryllium can be identified. Beryllium concentrations exceed the MCL of 100 µg/kg in soil at many of the source areas in OU-1. Because of the wide-spread occurrence of beryllium and the limited industrial use of beryllium, it is believed to be naturally occurring in the sediments at Eielson AFB.

Groundwater. The metals that exceed or are very near a risk-based level are antimony, arsenic, beryllium, cadmium, lead, and manganese in water. The arsenic concentration at well 20M12 was 71 µg/L in unfiltered samples; this is above the MCL of 50. A t-test evaluation with one-tail analysis (see Appendix VII) shows the arsenic concentrations are within background statistical boundaries. Further, the generalized wide-spread nature of the metal, like many others, seems to indicate the point sources are natural.

Antimony and beryllium each exceed the relatively low risk levels of 5 and 0.02 µg/L, respectively. These metals have no background values established for the site. In addition, the detection limits of 34 µg/L are above the risk-based screening values. Therefore, where detected, these metals automatically exceed the screening values. Taken collectively the metals were widely detected, and there were no major spikes associated with either metal indicating they are background values.

Cadmium has a risk-based screening level of 5 µg/L (MCL). Although the contractual detection limit is 34 µg/L, actual values detected were reported. For all 1993 data, the range of cadmium was 4.7 to 9.3 µg/L. These values are just below or above the MCL. The upper confidence level of the background data is <10 µg/L. The values detected in ST20 E-7 Complex do not exceed 10 µg/L.

The lead concentration at well 53M04 is elevated at 12 µg/L; within an area of free product, this suggests possible contamination. However, this value is still below the MCL of 15 µg/L. Background mean is 3.1 µg/L in groundwater.

Manganese levels occasionally exceed the risk-based levels of 1,000 µg/L in water. The background groundwater value for the base is 1,555 µg/L. The highest concentration of manganese detected in the monitoring wells was 3,700 µg/L in well 20M15. High manganese concentrations are wide spread with no apparent trends suggesting a point source as might be expected of most artificial contamination. The OU-2 baseline risk assessment found a linear relationship between the concentrations of iron and manganese. Manganese is often present in solid solution in minerals containing iron. This relationship and the wide-spread nature of manganese indicates that this is a naturally occurring mineral in the Eielson and Fairbanks area, and there has been no relationship found between elevated concentrations of manganese and pollution.

4.1.10 Conceptual Model

See Figures 4.3 and 4.4.

4.2 SOURCE AREA ST20 E-8 COMPLEX DESCRIPTION

The ST20 E-8 Complex is one of three refueling complexes located at the east end of the refueling loop at the southeast end of the runway (see Figure 1.2). The E-8 Complex consists of an asphalt-covered pad centered along the taxiway with adjacent unpaved areas of gravel and grass. The complex is served by a fuel pump house (Building 1321), three 190,000-L JP-4 USTs, one 95,000-L defuel UST, and several fueling and defueling transfer pipes (see Figure 4.4). The large area enclosed by the taxiway loop, north of the complex, contains several ponds with dense willow and birch forests

and tall grass. Garrison Slough is approximately 300 m southwest of the pump house. The relationship of the E-8 Complex to the other two complexes is shown in Figure 1.2.

The majority of the aircraft refueling operations are conducted at the refueling loop, and numerous fuel spills have occurred in the past. As early as 1972 when a test hole was drilled to a depth of approximately 6 m at the fuel pump house, a hydrocarbon layer was detected floating on the water table (CH2M HILL, 1982). The source of contamination at the E-8 Complex is believed to be surface spills of JP-4 jet fuel resulting from overfilling storage tanks. Overfilling historically involved discharge of excess fuel through vent pipes on the pump house roof. Contaminants typically associated with JP-4 fuel include TPH, volatile compounds (BTEX), and semivolatile compounds (naphthalenes).

The site was identified as a potential source area in 1982 during the phase I records search (CH2M HILL, 1982). In 1986, a phase IV-A field investigation was conducted in which three monitoring wells (20B-1 through 20B-3) were installed, and soil and groundwater samples were collected (SAIC, 1989b).

A stage 3 field investigation was conducted at the source area from July through October 1988 in which a soil gas survey was conducted, an aquifer test was performed, one monitoring well (20M06) was installed, and soil and groundwater samples were collected for chemical analysis (HLA, 1989a). A subsequent stage 4 investigation was conducted from August through November 1989 (HLA, 1990). During this investigation, surface soil samples were collected, product probes and groundwater probes were installed, seven additional monitoring wells (20M013 through 20M19) were completed, and soil from the new boreholes and groundwater from new and existing wells was sampled. Water levels and product thickness were also measured periodically in 1991 and 1992 as part of the ongoing sitewide investigation of the base (CH2M HILL, 1992b).

A field investigation conducted in May 1993 included 1) monitoring water-levels and product thicknesses in the monitoring wells and product probes and 2) collecting sediment and water samples (Appendix I).

4.2.1 Interim Actions

Floating petroleum products were encountered north of the pump house during a field investigation in September 1989; however, no product was found at the same location during earlier field investigations in 1988 or later in 1991. No interim remedial action was selected for the ST20 E-8 Complex in the IRA Record of Decision (EPA, 1992b); however, the U.S. Air Force conducted a tank integrity and pipeline leak detection investigation of USTs and associated transfer piping in May and June 1993. Results of these integrity tests are described in Appendix IX.

4.2.2 Data Summary

The analytical parameters for all of the previous sampling events are summarized in Table 4.6. The results for soil and groundwater are summarized in Appendix VIII. Product thickness measurements are listed in Table 4.7. Monitoring well construction and sampling information are summarized in Table 4.8.

4.2.3 Contaminants of Concern

The contaminants of concern for the E-8 Complex are listed in Table 4.1.

4.2.4 Floating Product

No floating product was detected in any wells or product probes during May 1993 (see Figure 4.5). Product thickness measurements in 1989 indicated floating product in five wells and product probes

with thicknesses of up to 17.7 cm in well 20M06. No product was detected in this well in subsequent measurements in 1991 or in 1993.

The original source of floating product is suspected to be spills through vents on the pump house roof associated with overfilled storage tanks and/or leaking underground fuel lines. Hydrocarbon fingerprint analyses performed on the product sample from well 20M06 in 1989 indicated the presence of C₈-C₁₃ hydrocarbons.

4.2.5 Fuel-Related Contaminants

Soil. During the 1988 study, TPH was detected at concentrations greater than 100 mg/kg in surface and subsurface soil samples from boring 20M06; BTEX compounds were also detected. In 1989, TPH concentrations greater than 100 mg/kg were detected in 1) surface and subsurface samples from a boring 40 m south of boring 20M06 and 2) subsurface (approximately 1 m depth) samples in a boring 30 m to the northeast of 20M06.

In both borings, TPH concentrations increase near the water table. This is probably a result of the original free phase liquid being smeared over an area near the top of the water table by water table fluctuations. This could have resulted in high soil TPH values in the area around well 20M06. BTEX compounds associated with floating product also are expected to be present in subsurface soils within the smear zone. No additional soil samples were collected during the May 1993 sampling.

Groundwater. BTEX compounds have been detected in the groundwater from well 20M06 near the fuel pump house. The extent of benzene contamination in groundwater is defined by groundwater probe and monitoring well data collected in 1989 and 1993. The highest concentrations of benzene have historically been in well 20M06. The 1993 levels in this well were 570 µg/L. This level of concentration is similar to the 481 µg/L concentration in 1989. A comparison of data from 1989 and 1993 indicate that the benzene concentrations are stable and the benzene plume does not appear to be migrating with groundwater as would be anticipated. The BTEX constituents have not been detected in the downgradient wells 20M15 and 20M16 (Figure 4.4).

Toluene, ethylbenzene, and xylenes were detected in groundwater; the highest concentrations occurred in well 20M06. The MCLs for ethylbenzene and toluene are exceeded in the 1993 data set for well 20M06.

Semivolatile organic compounds (2-methylnaphthalene and naphthalene) and TPH typically associated with JP-4 jet fuel were found in the groundwater sample from well 20M06 in 1989. However, these constituents were not observed in 1988 or 1993. Naphthalene or 2-methylnaphthalene were not detected in any of the wells in 1993.

4.2.6 Pesticides

Soil. One sample was collected for pesticides. The pesticide sample was collected as a composite surface soil sample from near the pond located on the north-east side of the site. No pesticides were detected in this sample.

4.2.7 Bis(2-ethylhexyl)phthalate In Groundwater

Bis(2-ethylhexyl)phthalate was detected in groundwater at well 20M06 in 1989. Also during 1989, bis(2-ethylhexyl)phthalate was found in sampling blanks. This chemical is a plasticizer found in PVC pipe and plastic sampling equipment and could be the result of either the deterioration of the PVC well casing or sampling equipment. It is not believed to be present in the aquifer.

4.2.8 Metals

The metals that exceeded risk-based levels^(a) in the E-8 Complex were antimony, arsenic, chromium, and manganese in groundwater. These metals are very similar to the metals in the E-7 Complex. Antimony does not have a background value established for it and exceeds the risk-based screening level of 5 in well 20M06 (71 µg/L). The distribution and range of values suggest antimony is a background metal.

Arsenic, chromium, and manganese are generally found to exceed their respective risk-based screening levels. However, using a t-test to statistically determine if these metals exceed background, they were all found not to be outside the background distribution at a confidence level of 95%.

4.2.9 Conceptual Model

See Figures 4.3. and 4.4.

4.3 SOURCE AREA ST20 E-9 COMPLEX DESCRIPTION

The E-9 Complex at ST20 is one of three refueling complexes, located along the north-northeast side of the refueling loop at the southeast end of the runway (see Figure 1.2). The E-9 Complex consists of an asphalt-covered pad centered along the taxiway with adjacent unpaved areas of gravel and grass. The complex is served by a fuel pump house (Building 1305), three 190,000-L JP-4 USTs, one 95,000-L defuel UST, and several fueling and defueling pipes (see Figure 4.6). Hangars are present hydraulically downgradient of the site along the northeast edge of the complex, and an aircraft maintenance shop lies to the northwest. Two storage tanks, a 10,000-L diesel fuel tank (removed in 1992) and a 5,000-L fuel oil tank, are located near these hangars. The closest water supply well (No. 8) is located 300 m to the northeast of the pump house. A visual inspection of the well indicated the pump wiring has been removed and is no longer in service. Personnel from the U.S. Air Force indicate the well is no longer in use and is slated for abandonment.

The majority of aircraft refueling operations are conducted at the refueling loop, and numerous fuel spills have occurred in the past. The source of the contamination is believed to be leaks in sub-surface JP-4 fuel lines north and east of the pump house. Contaminants typically associated with JP-4 fuel include TPH, volatile compounds (BTEX), and semivolatile compounds (naphthalenes).

The site was identified as a potential source area in 1982 during the phase I records search (CH2M HILL, 1982). In 1986, a phase IV-A field investigation was conducted in which three monitoring wells (20C-1 through 20C-3) were installed, and soil and groundwater samples were collected (SAIC, 1989b).

A stage 3 field investigation was conducted at the source area from July through October 1988. The investigation included a soil gas survey, installation of three monitoring wells, and collection of soil and groundwater samples (HLA, 1989a). A subsequent stage 4 investigation was conducted from August through November 1989 (HLA, 1990). During this investigation, 12 soil borings were drilled, 14 product probes and 28 groundwater probes were installed, 1 recovery well (20M25) and 5 additional monitoring wells (20M20 through 20M24) were completed, slug tests were performed, and soil and groundwater were sampled. Water levels and product thickness have been measured periodically in 1991 and 1992 as part of the ongoing sitewide investigation at the base (CH2M HILL, 1993b).

A field investigation conducted in May 1993 included monitoring water levels and product thicknesses in the monitoring wells and product probes and the collection of sediment and water samples (Appendix I).

(a) See Table 4.2.

Eielson AFB Liquid Fuels Department records indicate three spills at the E-9 Refueling Loop. These leaks are shown on Figure I.3 in Appendix I. Leak 1 was detected August 1988 and repaired June 1989. The leak was extensive; the amount of fuel lost is unknown. After the leak was repaired, a leak test was done on the piping. During this test, contractors noticed fuel seeping up through cracks further out on the tarmac (Leak 2). The age of this leak is unknown. This leak was repaired in June 1989. Leak 3 was discovered near the refueling building in June 1992 and repaired in July 1992. It occurred in the line to the defueling tank. The amount leaked is unknown.

4.3.1 Interim Actions

EA Engineering, Science and Technology is the contractor implementing the OU-1b interim actions. In August and September 1992, a total of 13 new product probes (20PP101-10PP113) were installed by EA to investigate the lateral distribution of the free product plume. Four test trenches were excavated in August 1992 to test the feasibility of removing free product and one extraction trench was then built in September 1992. A single recovery well (20RW04) was installed. To date, no petroleum products have been recovered from either the extraction trench or recovery well. The product is apparently at lower pore pressures than atmospheric and is not flowing into the recovery structures. A passive skimmer was placed in well 20M25 and has recovered approximately 5 gal of petroleum product as of April 1993. In addition to the probes and recovery structures, seven vadose wells and one deep air injection well was installed to support potential future vapor extraction and bioventing interim remedial actions at the E-9 Complex.

In addition to the ongoing remedial activities at the E-9 Complex, integrity tests on the fuel storage tanks and leak detection investigations of associated transfer piping are planned for May and June 1993. Results of this testing are described in Appendix IX.

4.3.2 Data Summary

The analytical parameters for all of the previous sampling events are summarized in Table 4.9. The results for soil and groundwater are summarized in Appendix VIII. Product thickness measurements are listed in Table 4.10. Monitoring well construction and sampling information are summarized in Table 4.11.

4.3.3 Contaminants of Concern

Contaminants of concern for ST49 are listed in Table 4.1.

4.3.4 Floating Product

The data show no clear trends in measured product thickness. For instance, at product probe 20PP72 measurements taken 9 days apart in August 1992 varied by as much as 5.8 cm. The fluctuating water table and variable soil lithologies result in continuous changes in apparent product thickness. Multiple leaks in underground fueling/defueling lines and ongoing remediation efforts also affect the vertical and horizontal distribution of floating product. One measurement of note during the 1993 sampling was product probe 20PP119 in which 98.15 cm of product were measured. This probe is located adjacent to one of the underground fuel storage tanks. If this measurement can be confirmed, it may indicate a new leak at the tank. The data collected in May 1993 is compared to measurements made in September 1992 (see Figure 4.7).

The source of the floating product at the E-9 Complex is believed to be subsurface leaks from JP-4 fuel pipelines and tanks. The known extent of the floating product is near the pump house at the edge of the runway. Because of the site access restrictions along the runway, however, the floating product may extend out under the tarmac. Jet fuel seeping from the tarmac during pipe integrity

testing, the high concentrations of BTEX detected in recent soil gas surveys on the tarmac (see Figure 4.8), and the shape of the benzene isoconcentration lines (see Figure 4.6) suggest at least one source emanating from the tarmac.

4.3.5 Fuel-Related Contaminants

Soil. The TPH and BTEX contamination was detected in subsurface soils within a 60-m radius of the pump house. The extent of subsurface soil contamination east of well 20M07, or south and east of the pump house, has not been defined and is likely related to the floating product associated with releases from underground pipelines.

The highest concentrations of TPH and volatile constituents of fuel detected in subsurface soil samples (1.5-2.0 m) in 1988 were located at well 20M01 (see Figure 4.8). A number of subsurface soil samples were collected in 1989, in the vicinity of the pump house and the floating product plume. The TPH concentrations detected in a number of samples were above the 100 mg/kg Alaskan cleanup level.

Groundwater. The source of BTEX and naphthalenes in groundwater is thought to be associated with floating product. The highest concentrations of BTEX and naphthalenes were measured in 1989. The concentrations of these contaminants were substantially lower in 1993.

The benzene plume in 1989 extended up to 180 m downgradient of the E-9 pump house. The area of highest benzene concentration is located near well 20M07 where floating product has been found. Low concentrations of the BTEX constituents were also detected downgradient of well 20M23 in 1989. In 1993, the concentrations and extent of the plume were substantially smaller (Figure 4.9). Benzene concentrations in wells 20M01 and 20M07 near the floating product have decreased as much as 100 and 85%, respectively. Also, the benzene concentrations in the downgradient wells (20M22, 20M23, and 20M24) have fallen below the MCL of 5 µg/L. The only increase in concentration was noted in well 20M08 (from 98.4 to 440 µg/L). In general, the benzene plume and concentrations in groundwater do not appear to be moving between 1989 and 1993 and are in general decreasing. The benzene in the groundwater is concentrated around the pump house, and there is an order of magnitude drop in concentration values on the other side of the runway (between wells 20M08 and 20M23).

The newly detected leaks in the fueling system, however, could substantially increase the concentrations of BTEX and naphthalenes in the groundwater.

4.3.6 PAHs

Soil. A number of semivolatile organic compounds were detected in surface and subsurface soil samples from soil borings and monitoring well boreholes collected in 1989. Concentrations ranged from 0.04 mg/kg for acenaphthylene to 4.8 mg/kg for fluoranthene. These PAH compounds were detected in soil samples collected in the area of floating product and near paved areas. The compounds detected in the samples are common constituents of asphalt, JP-4 fuel, and jet emissions. Two subsurface soil samples collected in 1989 along the road encircling the pump house contained common constituents of JP-4 fuel (2-methylnaphthalene and naphthalene). Other heavier (three or more aromatic rings) PAHs (including anthracene, benzo(a)anthracene, and benzo(b)fluoranthene) were found in surface samples and wells on or adjacent to the tarmacs and runways. To verify this distribution pattern, PAH was extensively sampled at the E-9 Complex in May 1993 around the tarmac and runways. Results from these samples indicate that the indicator PAH, benzo(a)anthracene, exceeds the 10^{-6} excess cancer risk (EPA 19xx) at most locations surrounding the taxiway (see Figure 4.9).

Common sources of lower molecular weight PAHs are refined petroleum products, such as jet fuel and asphalt. Naphthalenes are commonly present in JP-4 fuel, and this is the likely source of the PAHs detected in subsurface soil samples collected in the area of floating product. Because PAHs are soluble in organic solvents, jet fuel spilled on the runway could solubilize to release higher molecular weight PAHs from the asphalt and disperse them onto adjacent surface soil with the spilled fuel. PAHs also occur in diesel and aircraft exhaust from incomplete combustion.

4.3.7 Pesticides

Pesticide analyses were performed on a composite surface soil sample, and surface and subsurface soil samples taken from the newly installed monitoring well 20MW26. A DDT concentration of 50 µg/kg was found in the surface composite sample. A trace amount of DDT (5.2 µg/kg) was also reported for the surface sample from the new well. The composite surface sample also contained 9.6 µg/kg DDE and 25 µg/kg DDD. No pesticides were detected in the subsurface sample. Complete analytical results can be found in Appendix VIII.

4.3.8 Bis(2-ethylhexyl)phthalate in Groundwater

Bis(2-ethylhexyl)phthalate was detected in groundwater in well 20M01 in 1989 and in wells 20M07 and 20M08 in 1993. The risk-based level is 0.6 µg/L and the highest concentration detected was 160 µg/L in well 20M07. This chemical is a plasticizer found in PVC and plastic sampling equipment and could be the result of either the deterioration of the PVC well casing or sampling equipment.

4.3.9 Metals

Soil. Metals that exceed risk-based levels in soil are arsenic and beryllium. Arsenic was detected above the soil screening value of 400 µg/kg in sediment from well 20MW26 (4,600 µg/L). The background upper confidence level for arsenic in soil is 3,900 µg/kg.

Beryllium was detected above the risk-based level of 100 µg/kg in soil in well 20M06 (180 µg/kg surface and 170 µg/kg subsurface). No background was established for beryllium on the main base.

Groundwater. The metals that exceed the risk-based screening levels in groundwater for the E-9 Complex are antimony, arsenic, beryllium, cadmium, chromium, and manganese. Of these metals antimony and beryllium each exceed the relatively low risk levels of 5 and 0.02 µg/L, respectively, and do not have background values established for the site. The detection limits for these metals are above the risk-based screening values and therefore were detected, these metals automatically exceed the screening values. Taken collectively, the metals were widely detected and no major spikes were associated with either metal.

Arsenic, cadmium, chromium, and manganese are generally found to exceed their respective risk-based screening levels. However, using a t-test to statistically determine if these metals exceed background, they were all found not to be outside the background distribution at a confidence level of 95%.

4.3.10 Conceptual Model

See Figures 4.3 and 4.4.

4.4 SOURCE AREA ST48 DESCRIPTION

ST48 is located in the east-central portion of Eielson AFB, near the intersection of Division Street and Industrial Drive (see Figure 1.2). The site is adjacent to a coal-generated power plant, an ash storage house, active railroad lines, and abandoned belowgrade fuel lines. Groundwater wells in the area include two cooling water supply wells and the main base drinking water supply well (well D).

The abandoned gasoline and diesel fuel lines reportedly served as delivery lines from bulk storage tanks to an old military service station located at the intersection of Division Street and Wabash Avenue. The suspected source of hydrocarbon contamination is leakage from the fuel lines (POL lines) where they pass beneath Industrial Drive. The fuel pipelines were drained and purged when they were taken out of service at the fuel station. Primary contaminants of concern associated with the fuel leakage include BTEX, PAHs, and TPHs.

4.4.1 Interim Actions

Interim remedial actions were implemented in 1992 and included the installation of a vacuum extraction system for removal of floating product. The nature of the free product at ST48 made the vacuum extraction system inappropriate for the site. Two wells at the site were subsequently retrofitted with blowers to 'biovent' the area. Remediation system performance data were not available at the time this document was prepared.

4.4.2 Data Summary

ST48 was not identified during the phase I 1982 records search but was selected for field investigation following Phase II Stages 1 and 2 Confirmation/Quantification Reports (Dames & Moore, 1985, 1988). Before selection as a site, however, 17 soil gas samples were collected in 1987 and analyzed for volatile organic compounds (VOCs). The samples were collected in the vicinity of the abandoned POL line and railroad crossing within ST48 but were investigated as part of a field investigation for OU-2, source area 18 (SAIC, 1989a).

In 1988, as part of IRP phase II, stage 3, sediment samples were collected from soil borings and test pits, eight monitoring wells were installed and sampled, a borehole was geophysically logged, a soil gas survey was conducted, and two slug tests and one pump test were conducted (HLA, 1989a).

In 1989, as part of IRP phase II, stage 4, additional soil borings were drilled and soil samples collected for TPH field screening and laboratory analysis. Both groundwater probes and product probes were installed and sampled, one new monitoring well drilled, and groundwater samples from monitoring wells and base water supply well D were collected. Groundwater levels and floating product thicknesses were also measured.

Water level and product thickness measurements from selected groundwater probes, product probes, and monitoring wells were measured in August 1991.

A field investigation conducted in May 1993 included monitoring water levels and product thicknesses in the monitoring wells and product probes, and the collection of sediment and water samples (Appendix I).

Table 4.12 summarizes laboratory analyses performed, and Appendix VIII summarizes analytical results from soil and groundwater sampling events, respectively. Table 4.13 lists product thickness measurements. Table 4.14 summarizes well construction and sampling information. A complete discussion of the data can be found in the stage 3 and stage 4 RI/FS reports (HLA, 1989a, 1990).

4.4.3 Contaminants of Concern

Contaminants of concern for ST48 are listed Table 4.1.

4.4.4 Free Product

Product thickness south of the Industrial Drive and Division Street intersection appears to have peaked during 1989 to 1991. The floating product level in product probe 48PP09 decreased from 46.0 cm in 1991 to 12.5 cm in 1993. Measured product thicknesses in well 48M01 also decreased from 24.4 cm in 1991 to 0.0 cm in 1993. Two other probes and one well (48PP13, 48PP67, and 48M03) in this same area showed no floating product in May 1993. However, floating product, north of Industrial Drive and Division Street near the ash storage house, appears to be increasing. Product probe 48PP28 had 43.6 cm of floating product and well 53M03 had 5.49 cm. Both of these measurements are the highest recorded at these locations. No floating product was detected in probe 48PP27, which is also near the ash house.

The source of the free product and associated BTEX and TPH contamination in subsurface soil and groundwater is thought to be the abandoned fuel lines near the intersection of Industrial Drive and Division Street. The lines may have leaked during operation and/or provided a source from residual fuel in the line after being abandoned. Thickness measurements of free product have historically been centered at two bends in the fuel line in the vicinity of the intersection of Industrial Drive and Division Street. The floating product near the ash house does not appear to have a pipe or tank source and no evidence of a surface spill in this area exists.

4.4.5 Fuel-Related Contaminants

Soil. The TPH above 100 mg/kg was identified in surface and subsurface soil from three areas in 1989. In 1993, TPH was not detected above the 100 mg/kg guideline for soil (see Figure 4.10). However, TPH was detected in the new well 48M08 (4.9 mg/kg) and near the coal piles (11 mg/kg). The highest concentration of TPH (19,500 mg/kg) was measured at 4 to 4.4 m bls near the eastern edge of the free product area. Subsurface soils with TPH in excess of 100 mg/kg can be expected to cover an area near the free product in the "smear zone." The maximum surface soil TPH concentration, 550 mg/kg, was observed in a soil boring adjacent to well 48M01.

In May 1993, soil samples from a soil boring near well 53M03 detected fuel-related PAHs in the soil at a depth confirming the PAH hits detected in well 53M03 during the 1989 sampling. Kerosene was detected at 380,000 µg/kg and naphthalene was detected at 15,400 µg/kg in the soil boring adjacent to well 53M03 at 3.5 to 4 m bls. The 1989 data indicate that fuel-related PAHs were detected in a soil test pit excavated just east of the free product area, where 42,000 µg/kg 2-methylnaphthalene and 21,000 µg/kg naphthalene were detected at 4 to 4.4 m bls. The fuel-related PAHs are believed to be associated with the free product and are detected in soils within the smear zone of the water table.

Groundwater. A maximum benzene concentration of 7,100 µg/L (field laboratory screening value) was detected in 1989 from a groundwater probe west of well 53M03. The probe was located near the abandoned fuel line crossing beneath Division Street. A 1989 maximum benzene concentration of 1,390 µg/L was detected in groundwater from well 48M01, near the middle of the free product area (see Figure 4.11). The concentration in this well dropped to 910 µg/L in 1993. Ethylbenzene and toluene were detected in groundwater probes near the free product pool at concentrations exceeding their respective MCLs in 1989. The 1993 benzene plume extends from the free product area to the drinking water well. Detectable amounts of benzene have been reported in water supply well D in the past year. The water supply well appears to be creating a downward hydraulic gradient that is pulling the benzene down through the aquifer to the screened interval of the supply well (31.2-37.7 m). Trans-dichloroethylene was detected in two wells in 1993 (see Figure 4.12).

Fuel-related semivolatile compounds in groundwater are highest in well 48M01; in 1989, 140 µg/L 2-methylnaphthalene and 270 µg/L naphthalene were detected; in 1993, the values were 130 µg/L and 250 µg/L respectively. Well 53M03 also had detectable amounts of naphthalene (150 µg/L) (see Figure 4.13) and 2-methylnaphthalene (80 µg/L). The fuel-related semivolatile compounds are detected only in the areas where floating product has been measured in the past.

Soil Gas. Results of the 1987 soil gas survey completed at ST48 indicated the presence of total BTEX up to 2 ppm (SAIC, 1989a). A localized soil gas anomaly (see Figure 4.14) is centered near the abandoned POL pipeline and Division Street and trends northeast to southwest. Results of the 1988 soil gas survey indicated the presence of BTEX compounds in the vadose zone at concentrations up to 43 ppm (total BTEX). The soil gas plume extended northeastward from the intersection of Industrial Drive and Division Street, and split to the north and east around the power plant. A 1993 soil gas survey in the area along the abandoned pipeline indicated the highest concentrations of soil gas near the 90 degree bends in the abandoned pipeline (1,700 to 2,000 ppm). One soil gas survey point located near the ash house indicated low concentrations of total volatile hydrocarbons (5 ppm) (see Figure 4.14).

4.4.6 PAHs

Soil. High molecular weight PAHs were detected in a surface soil sample at the new well 48M08. Anthracene, benzo(a)anthracene, and several other four-ringed PAHs were present in the surface sample. The highest concentration was benzo(a)pyrene at 970 µg/kg. This exceeds the MCL of 60 µg/kg in soil. The well location is adjacent to Division Street and PAHs are very likely associated with the vehicular traffic along this street. During the 1993 sampling, a surface soil sample was collected from near the coal piles to assess the PAHs in coal; there were no detectable concentrations of semivolatile organic materials in this sample.

4.4.7 PCBs

The PCB 1254 was detected at 240 µg/kg in a subsurface soil sample at well 53M03 during the 1989 sampling. A soil boring installed adjacent to the well in May 1993 did not detect PCBs in any of the three soil samples (surface, 2 m, 3.6 m) collected.

4.4.8 Pesticides

The DDT in surface soil was found above its lowest ARARs^(a) at this site. No pesticides were found in the subsurface soil. A DDT concentration of 180 µg/kg was found in the composite surface soil sample (sample number ST48-2S). This is below 205 µg/kg, the concentration corresponding to a 10⁻⁶ cancer risk for DDT in soil. The DDT decay products DDD and DDE were also detected at 63 µg/kg and 47 µg/kg, respectively. No other pesticides were detected in the composite sample. Soil samples taken from the newly installed well (48MW08) adjacent to the composite soil sampling location show minor amounts of DDD and DDE at 0.5 m depth, while DDT was not found (sample number ST48-4S). At a depth of 2.1 m in this same well, no pesticides were detected (sample number ST48-5S). No other soil samples were analyzed for pesticides at this site. The soil sampling locations are shown in Figure 4.15 and the results are in Appendix VIII.

4.4.9 Chlorinated Solvents

The volatile compound, trans-dichloroethylene [a degradation product of trichloroethylene (TCE)], was detected by field laboratory screening in two groundwater probes on the western edge of the product pool at concentrations up to 490 µg/L (field laboratory screening) (see Figure 4.12). In 1993,

(a) See Table 4.2.

trans-dichloroethylene was detected in well 53M03 at a concentration of 2.4 µg/L. The 1993 analytical results also indicate that TCE is present in low concentrations across ST48. The highest concentrations are in the upgradient well 48M07 (2.1 µg/L); this suggests a source area upgradient of ST48. A dry well that was used to dispose of contaminants was identified in ST18, which is hydraulically upgradient of ST48 (CH2M HILL, 1992a). The dry well is located north of Building 3423. This well is currently not operational and was scheduled for removal in 1993 (CH2M HILL, 1992a). Both trans-dichloroethylene and trichloroethane were detected in concentrations below MCLs; they are mentioned here because TCE has been detected in the drinking water supply well D.

4.4.10 Metals

Antimony, arsenic, beryllium, cadmium, lead, and manganese exceeded risk-based levels^(a) in groundwater. No metals exceeded risk-based levels in soil.

Arsenic levels are above 10 µg/L, the level equal to the HQ of 1, in all samples except for one unfiltered sample (48M03) and two filtered samples (48M01 and 48M03). The maximum detected was in an unfiltered sample from well 53M03 (38 µg/L). The distribution of arsenic occurs both upgradient and downgradient of the free product with the highest filtered result (14 µg/L) occurring at well 48M07 located upgradient of the free product. The distribution of arsenic in the groundwater basewide appears to be wide spread (U.S. Air Force 1992b, 1993b). Although arsenic has been reported in trace amounts in some fuels, there does not appear to be a significant source that could account for the widely distributed concentrations.

The highest measured concentrations of lead in ST48 were in an unfiltered sample from well 53M03 (14 µg/L) (see Figure 4.10). The filtered sample from this same well did not detect lead. The unfiltered value was significantly above the background mean for lead (3.1 µg/L) but is below the MCL of 15 µg/L. Well 53M03 is also located within the area of free product.

Virtually every sample for manganese is well above the risk-based level of 1,000 µg/L, both filtered and unfiltered (see Figure 4.11). In addition, the manganese fails the statistical t-test comparisons with background (Appendix VII). The elevated manganese is spatially widely distributed and is associated with elevated iron concentrations. Iron is at levels up to 70,000 µg/L. There appears to be a linear correlation (CH2M HILL, 1992a) between iron and manganese suggesting a reducing environment (see Figure 4.11). Considering the spatial distribution and the association with iron, manganese is suggested to be a natural constituent of the local water.

Antimony and beryllium each exceed the relatively low risk levels of 5 and 0.02 µg/L, respectively, and do not have background values established for the site. The detection limits for these metals are above the risk-based screening values and therefore were detected; these metals automatically exceed the screening values. Taken collectively, the metals were widely detected and no major spikes were associated with either metal. This indicated the metals are background.

The MCL (screening level) for cadmium in groundwater is 5 µg/L. There were two wells in ST48 that exceeded this value: 48M03 (5.8 µg/L) and 48M07 (6.2 µg/L). These values, however, do not exceed the upper confidence level for site background of <10 µg/L.

In 1989, the only metal samples collected were from well 53M03. Data from this well indicates that iron, manganese, and dissolved residue (total dissolved solid) concentrations exceeded their respective secondary MCLs and calculated maximum background levels. Total lead, barium, copper, magnesium, manganese, vanadium, and zinc were also all detected above the calculated maximum background values in 1989. A verification sampling in 1993 did not verify the 1989 results. Well 53M03 is located adjacent to the fly ash loading area for the power plant and it is conceivable that the

(a) See Table 4.2.

1989 sample may have been contaminated from the fly ash operations. A table with some of the residual metal concentrations in the fly ash at the site are shown in Table 4.15.

4.4.11 Conceptual Model

See Figure 4.3.

4.4.12 Fate and Transport

ST48 is located in the east-central portion of Eielson AFB. Arctic diesel leaks in the abandoned fuel lines beneath the intersection of Industrial Drive and Division Street are suspected sources of the hydrocarbon contamination. The quantity of fuel released at the site and time frame associated with the initial release are unknown. A drinking water supply well (well D) is adjacent to the source area.

Floating product was observed in the vicinity of the source in 1988 and 1991, but no free product was detected in 1992 (U.S. Air Force, 1993). At monitoring wells, benzene concentrations range from 0.34 to 1,330 $\mu\text{g/L}$ in 1989, and 3.01 to 1,390 $\mu\text{g/L}$ in 1989 and 1991 (U.S. Air Force, 1993). Soil benzene concentration of 0.112 mg/kg of dry soil was detected at a depth of 4.0 to 4.4 m at sampling site 48TP04 (U.S. Air Force, 1993). As indicated by the groundwater benzene isopleths (U.S. Air Force, 1993), a considerable area was affected by the fuel leaks.

Based on this description of the site and other available information, the events surrounding the contamination were modeled using the following assumptions.

- Benzene is used as the indicator chemical because of all of the BTEX components, it is the most mobile and toxic constituent.
- The source area is the area where floating product was observed in 1991 (60 m by 30 m) (U.S. Air Force, 1993).
- Because base water supply well D (screen depth of 29 to 35 m) is in the direction of the groundwater flow from ST48, an analysis is performed from the waste site to well D located 171 m from the center of the contaminated ST48 area (U.S. Air Force, 1993). Because detection levels ($< 0.2\text{--}1.4 \mu\text{g/L}$) of benzene were monitored at well D, a front-line of benzene plume has reached well D.
- Because source contaminants are concentrated at/near a groundwater table (smear zone), the assessment addresses contaminant movement from the waste site, through the saturated zone, and to well D.
- Because a typical screen-depth of monitoring wells is 6.1 m, the vertical (z) dispersivity was set to assure that benzene was fully mixed within the top 6.1 m of the saturated zone.
- Because groundwater benzene concentration isopleths (based on 1989 data) are available, this analysis uses the concentration-isopleths to help calibrate the model. The groundwater benzene concentrations (at selected distances along the groundwater flow path) will be extrapolated from the isopleths and assumed as centerline concentrations for the purpose of model calibration.
- Because groundwater benzene levels monitored in 1993 show insignificant change in the concentration isopleths of 1989, the constant contaminant seepage from the source was assumed. The current contamination emanating from the site is assumed to be constantly seeping from the weathered residual fuel because of rainfall and snowmelt recharge.

Site and Contaminant Data Used for the Transport and Fate Assessment. The groundwater model associated with the MEPAS methodology was used to model the transport of benzene at ST48. Table 4.16 presents the parameters, values for each parameter, and references associated with each value that was used in the assessment. The benzene contamination plume (U.S. Air Force, 1993) was used to estimate the benzene inventory in the saturated zone. The soil benzene concentration of 0.112 mg/kg of dry soil (measured at sampling site 48TP04) was used to estimate the benzene inventory in the vadose zone at the site. As noted earlier, the lower screen-depth of 6.1 m was assumed as the thickness (mixing depth) of contamination.

The pore-water velocity determined from the model calibration was 50 cm/d for ST48. It is at the low end of the range of 47 to 282 cm/d given in Table 3.3.

Application Results and Discussion. Results associated with the modeling exercise are presented in Table 4.17 and Figures 4.18 and 4.19. Table 4.17 also presents information employed in the modeling exercise. Columns 2 through 4 in line 1 present the longitudinal distances (Lx) in the direction of the groundwater flow from the center of the source (U.S. Air Force, 1993). Line 2 presents the longitudinal (x) and lateral (y) dispersivities. The x- and y-dispersivities are assumed to be proportional to the travel distance Lx. The proportionality constants are determined by a calibration exercise and presented in line 7 (Table 4.17). Lines 3 and 4 present the distribution coefficients and mass flux for benzene. The values in the lines 2 through 4 are the results of the calibration exercise. Lines 5 and 6 present groundwater benzene concentrations ($\mu\text{g/L}$) extrapolated from the isopleths and predicted from the modeling exercise, respectively.

The calibrated distribution coefficient (i.e., 4.0 mL/g) in line 3 is an order of magnitude larger than the theoretical Kd value based on K_{oc} and an assumed percent organic content of 0.5%. The K_{oc} value for benzene is 83 mL/g¹⁹ resulting in estimated distribution coefficient of 0.4 mL/g.

The result of the initial calibration for benzene is presented in Figure 4.18. It was assumed that the initial fuel leak occurred in 1979 (indicated by model calibration) and that the initial contaminant mass moved directly into the saturated zone. The benzene concentration profile is associated with calibration runs to locations, which are 50, 100, and 145 m from the source (see Table 4.17). The open circles indicate the benzene concentrations obtained from the isopleths at the selected distances from the source. The solid line represents the benzene concentrations predicted by the model at varying distances from the source. As noted by Figure 4.18, a front-line of the plume may exist about 170 m from the source. The benzene concentration drops one-order-of magnitude as groundwater travels 50 m at the location between 50 m and 100 m from the source (see also Table 4.17). A peak of the plume is calculated to be moving toward well D at a rate of 2.2 cm/d (i.e., pore-water velocity/R_f = 50 cm/d / 22.3 = 2.2 cm/d).

An analysis was also performed for simulating potential centerline contaminant levels at well D (171 m from the source). As with the previous analyses, it was assumed that benzene was constrained to the top 6.1 m of the aquifer. The simulated temporally varying concentration for benzene at well D are presented in Figure 4.19. As noted earlier, benzene has reached well D. The results also indicate that the benzene concentration may reach the MCL of 5 $\mu\text{g/L}$ within a few years. Because the modeling assessment assumes that no decay processes (e.g., volatilization, degradation, transformation) occur, the concentrations may reach the MCL level later than predicted. The simulated peak concentration is about 300 $\mu\text{g/L}$ and may pass well D in year 40 (i.e., year 2019). No data are available to confirm or dispute these results. Although the benzene fate and transport evaluation performed here is a preliminary order-of-magnitude analysis, the results suggest that the benzene level can rise above the MCL of 5 $\mu\text{g/L}$ at well D, under the conditions used in the model simulation.

4.5 SOURCE AREA ST49 DESCRIPTION

ST49 is located just south of the main runway, in the southern portion of the base, as shown in Figure 1.2. The source area includes Building 1300 and the adjacent taxiway, which together comprise a deactivated combat alert hangar complex. The facility has its own auxiliary electrical generator, septic system, and water supply. A utility room houses the generator and a 2,080-L aboveground day tank, which supplies diesel fuel for the generator. The aboveground tank is supplied by two 38,000-L underground fuel storage tanks located on the south end of the hangar. A 568 L/min base production well (well 7), serving the secondary main system, is located approximately 183 m east (hydraulically upgradient) of the site.

4.5.1 Interim Actions

The U.S. Air Force contracted installation of a 13-cm-diameter monitoring well adjacent to the utility room (well 49GMW). The date of installation is not known. The well was later converted to a static recovery well to help remediate the floating product. The well was periodically pumped down by base personnel in 1989, and small quantities of product were recovered (HLA, 1990).

The interim remedial action selected for ST49 in the IRA Record of Decision (EPA, 1992b) was free product extraction. This action included the installation of five additional groundwater/product probes, and a 100-mm product recovery well. Three of the probes and the recovery well were installed on the north end of the hangar; the remaining two probes were installed next to the USTs on the south end of the hangar. No specific details of the recovery well operation and/or other remedial measures currently underway are available. Product recovered to date is approximately 95 L.

In addition to the ongoing interim remedial actions at ST49, the U.S. Air Force planned to conduct a tank integrity and pipeline leak detection investigation of USTs and associated transfer piping in May and June 1993 (see Appendix IX).

4.5.2 Data Summary

ST49 was chosen for field investigation following Phase II Stages 1 and 2 Confirmation/Quantification Reports (Dames & Moore, 1985, 1988). This area was not identified during the phase I records search.

The initial (IRP phase II, stage 3) field investigation of ST49 was performed in 1988. This investigation included collecting soil samples from soil borings, installing and sampling five monitoring wells and two production wells, installing product probes, conducting a soil gas survey, and performing borehole geophysical logging of two monitoring wells.

In 1989, IRP phase II continued with stage 4 that included collecting surface and subsurface soil samples for TPH field screening and laboratory analyses, installing and sampling groundwater probes, installing product probes, drilling a new monitoring well and a product recovery well, collecting groundwater samples from monitoring wells, conducting a seismic refraction survey to map permafrost areas, and measuring groundwater levels and floating product thicknesses (HLA, 1990).

Water level and product thickness measurements from selected groundwater probes, product probes, and monitoring wells were collected in August 1991 with more extensive monitoring in May 1993. The May 1993 investigation also collected soil and groundwater samples (Appendix I).

Table 4.18 summarizes laboratory analyses performed, and Appendix VIII summarizes analytical results from soil and groundwater sampling events, respectively. Table 4.19 lists product thickness measurements. Table 4.20 summarizes well construction and sampling information.

4.5.3 Contaminants of Concern

Contaminants of concern for ST49 are listed in Table 4.1.

4.5.4 Free Product

A free product area has been observed at the north end of the hangar and north of the utility room in three monitoring wells (wells 49M02, 49M06, and 49GMW) and in two product probes. From 1988 to 1991, free product thickness has declined in well 49M02 from 0.655 to 0.19 m. Except for a slight increase during late summer and fall of 1992, overall floating product levels have been declining since 1988. No floating product was detected during May 1993.

The suspected source of the free product is the 2,080-L day tank located in the utility room. The spilled fuel may have been flushed to a floor drain in the utility room on the east side of the hangar. The drain reportedly was connected to the onsite septic system leach field at the time of the spill; however, no product was observed in the septic tank after the spill. The possibility exists that the floor drain into which the fuel emptied either had a leaky piping system or was never connected to the sanitary system. In either case, fuel product was allowed to enter subsurface soils and groundwater.

Two underground tanks on the south end of the hangar have also been considered as a potential source of the free product. The tanks are being tested during June and July. Product probes installed next to the tanks did not detect contamination. The BTEX compounds were detected by the soil gas survey in 1988 around the septic system drain field at the south end of the hangar but were not seen around the free product. This finding may suggest that fuel-related compounds have been flushed to the septic system in the past via the hangar floor drain system. It also suggests that the diesel fuel has weathered, leaving little residual BTEX compounds to migrate into surrounding soils or groundwater.

4.5.5 Fuel-Related Contaminants

Soil. No BTEX compounds were detected in soils from ST49 in 1989 or 1993. The 1993 sample locations included surface soil near well 49M05, near the inlet sump to Garrison Slough, in Garrison Slough, in composite samples, and in a soil boring near well 50M05. TPH was detected in small amounts near the inlet sump and in a soil boring near well 53M05 (7.6-11 µg/L) for diesel- and gasoline-ranged organic materials. These results do not confirm the maximum recorded TPH concentration of 263 mg/kg from well 53M05 in 1989 (see Figure 4.20).

The maximum surface soil TPH concentration (1,100 mg/kg) was observed in 1989 in well boring 49M02 immediately below the asphalt cover.

Kerosene and naphthalene were detected in sediment samples from Garrison Slough at the outfall 400 m from the inlet sump at ST49 at 63 and 130 µg/L respectively. These samples also contained heavier PAHs (see Section 4.5.6). The source of the contamination could be transport of surface contamination from ST49 entering the inlet sump at ST49. The inlet sump drains the field to the north of the alert hangar and channels the water to Garrison Slough.

Groundwater. Except for benzene, no BTEX constituents were found above the screening levels (Table 4.2) in groundwater. Benzene exceeded the screening level of 0.6 µg/L in several wells, but was detected above the MCL of 5.0 µg/L only in well 49M02 at 8.2 µg/L (see Figure 4.21). The distribution of benzene indicates there may be as many as three sources. The first from the area of free product, the second near the runway at well 49M05, and the third near the runway at well 49M04. Surface sampling for TPH near well 49M05 did not indicate any surface spills in this area and no known underground piping exists to provide the source.

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Fuel-related semivolatile compounds in groundwater were highest in well 49M02, located within the free product area. Up to 117 µg/L of 2-methylnaphthalene was detected in 1988 and up to 140 µg/L in 1993. Kerosene was also present in the well at 2,800 µg/L in 1993. Trace amounts of kerosene (4.2 µg/L) were also present in well 49M06 in 1993. Petroleum hydrocarbons were detected at a maximum of 32.3 mg/L in groundwater from well 49M05 during 1989.

Soil Gas. Soil gas survey results from 1988 indicated low-level BTEX compounds (up to 5.86 ppm maximum total BTEX) in soil vapor around the septic tank drain field on the south end of the hangar. A 1993 soil vapor survey on the north end of the hangar indicated only traces of volatile hydrocarbons (170 ppm) near well 49M02 (see Figure 4.22).

4.5.6 PAHs

Soil. The high molecular weight PAHs associated with exhaust and asphalt were detected in surface soil samples along the runway on the west side of the alert hanger and in a field near well 49M01. The highest concentrations were for fluoranthene (960 µg/L) at the surface near well 49M03. The suspected source of these PAHs are idling jets and/or dissolving of the asphalt from fuel spills along the runway. The distribution is located primarily along the taxi- and runways.

PAHs were also detected in the sediment sample collected from the outfall 400 m north of the inlet sump that drains the field north of the alert hanger. The highest concentrations were fluoranthene at 14,000 µg/kg. Trace amounts of fluoranthene (41 µg/kg) were also detected in Garrison Slough upgradient of ST49 where Garrison Slough is channeled under the runway and past the ST49 sump. This suggests at least some of the contamination detected in the slough sediments may enter the slough upgradient of ST49.

Some phthalates were also detected in the 1993 samples. They include bis(2-ethylhexyl)phthalate at 730 µg/L in the soil near well 49M01. These are believed to be the result of deteriorating PVC well casing or sampling equipment or laboratory contamination.

Groundwater. See Figure 4.24.

4.5.7 Pesticides

Soil. Pesticide samples at ST49 were collected from surface soils near well 53M05 and the sump that drains the field north of the alert hanger, as well as a composite surface soil sample and two sediment samples from Garrison Slough both upgradient and downgradient of ST49. Nearly all of the samples taken from the surface and in slough sediments had some traces of pesticides (see Figure 4.23).

In the composite surface soil sample, chlordane, DDD, DDE, and DDT were all detected. Chlordane concentrations were 2,100 µg/kg, DDD concentrations were 850 µg/kg, DDE concentrations were 240 µg/kg, and DDT concentrations were 2,900 µg/kg. The composite soil sample recorded the highest concentrations of pesticides at the site, with the exception of one slough sediment result for DDD at 1,000 µg/kg. The surface soil sample taken adjacent to well 53M05 and the sump (sample number ST49-5S) had a DDT concentration of 380 µg/kg, and a DDD concentration was 410 µg/kg as above. Aldrin, beta-BHC, and DDE were also detected, but at concentrations below their corresponding lowest ARAR^(a). No pesticides were detected in the subsurface soil sample taken at this same location (sample number ST49-6S).

The sediment sample taken in Garrison Slough adjacent to the composite soil sample (sample number ST49-7S) had a chlordane concentration of 180 µg/kg, which is above the 10⁻⁶ cancer risk concentration of 53.5 µg/kg and the 2.00 µg/kg MCL. DDD was also detected but at a concentration below its corresponding lowest ARAR. The sediment sample taken from Garrison Slough at the north end of

(a) See Table 4.2.

the site (sample number ST49-8S) contained a total of eight pesticide compounds. Chlordane and DDD were found at concentrations of 1,200 µg/kg and 1,300 µg/kg, respectively, both of which exceed all the corresponding ARARS. Dieldrin was also found at a concentration of 50 µg/kg, which exceeds the 10⁻⁶ cancer risk concentration of 40 µg/kg. Alpha-BHC, DDE, DDT, heptachlor, and methoxychlor were also detected but at concentrations below their corresponding lowest ARARS. The soil sampling locations are shown in Appendix I. Complete analytical results are in Appendix VIII.

4.5.8 Chlorinated Solvents

Several chlorinated VOCs including TCE, 1,1,1-TCA, 1,1-DCA, trans-1,2-DCE, and trichlorofluoromethane were detected in 1988 and 1989. Of these compounds, only TCE was detected above its MCL at a concentration of 14 µg/L in 1988 (well 53M05) and 6.93 µg/L in 1989 (well 49M05). The concentration of TCE in well 49M05 in 1993 was 8.2 µg/L. The 1993 data indicated trace amounts of TCE detected around ST48; however, all the values were at levels below the method detection limit and have "J" qualifiers. No other chlorinated VOCs were above the detection limits.

4.5.9 Metals

The metals that exceeded the screening values groundwater at ST49 were arsenic, lead, and manganese. The metals that exceeded the screening values in soil were arsenic and beryllium.

Soil. A comparison of the mean soil concentrations for arsenic indicates that while arsenic exceeds the risk-based levels^(a) for soil, the concentrations at the site are below the mean background values (9,330 µg/kg site mean to 13,868 µg/kg background mean). This data supports the conclusion that the source is not site specific and may be naturally elevated in the area.

Note, beryllium was detected in the 1989 samples at 49M01SA and 49M01SB. The detected concentrations in this well were 10 times the risk-based level of 100 µg/kg. Samples taken in 1993 (ST49_7S and ST49_8S) detected no beryllium onsite. There is insufficient data to draw any conclusion about beryllium at this time.

Groundwater. The background mean concentration for arsenic in groundwater is 8.4 µg/L. The mean of the tested wells is 7.5 µg/L. The highest measured concentration reported from the site sample is 19 µg/L while the high in background sample is 56 µg/L. This data suggest that arsenic is within the background limits.

Lead in one sample (SL_2) was reported at 11 µg/L; this is above the background mean. However, this is below the proposed MCL of 15 µg/L and within one standard deviation of the highest background value.

Manganese at ST49 is typically elevated, with equivalent concentrations in both filtered and unfiltered samples. The t-test, one-tail data would indicate no statistical variation between background values and the test sites.

4.5.10 Conceptual Model

See Figure 4.3.

4.5.11 Fate and Transport

ST49 is located west of ST20, in the southern portion of the base. A spill of diesel fuel from a 550-gallon aboveground day tank in a utility room is a suspected source of the TPH and BTEX contamination. Free product has been observed at/near the suspected source (i.e., in monitoring wells

(a) See Table 4.2.

49M02, 49M06, and 49GMW, and two product probes) (U.S. Air Force, 1993). A small amount of product was reported to be recovered from well 49GMW (U.S. Air Force, 1993). The quantity of diesel fuel released at the site and the time frame associated with the initial release are unknown.

At ST49, surface and subsurface soils at/near the source are contaminated with TPH; no BTEX constituents were detected in soils (U.S. Air Force, 1993). In the saturated zone, the maximum benzene concentration in groundwater was 8.2 $\mu\text{g/L}$, which was detected in well 49M05. A base production well (No. 7) is located approximately 183 m upgradient of ST49 (U.S. Air Force, 1993).

Based on this description of the site and other available information, the events surrounding the contamination were modeled using the following assumptions.

- Because no water supply well exists downgradient of ST49, downgradient distance that would be impacted by the source will be determined.
- The temporal distribution of leaching contamination was such that the environment experienced an immediate and noticeable degree of contamination over a limited period of time to the saturated zone. The initial contamination into the saturated zone is assumed to occur over a region where floating product was observed (U.S. Air Force, 1993).
- The groundwater model is calibrated using the benzene concentrations at well 49M05 because 1) the well 49M05 is in the direction of the groundwater flow and 2) time-varying benzene concentrations (2.47 $\mu\text{g/L}$ in 1989, 8.2 $\mu\text{g/L}$ in 1993) were recorded. Because the benzene concentration of 8.2 $\mu\text{g/L}$ is the maximum concentration at ST49, this represents a conservative assessment.
- Because source contaminants (e.g., TPH) are concentrated at/near a groundwater table, the assessment addresses contaminant movement from the waste site, through the saturated zone, and to downgradient wells.
- Because time-varying concentrations for benzene are available, a rate of contaminant seepage from the source (i.e., flux rate) is estimated through model calibration exercises.

Site and Contaminant Data Used for the Transport and Fate Assessment. The groundwater model associated with the MEPAS methodology was used to model the transport of benzene at ST49. Table 4.21 presents the parameters, values for each parameter, and references associated with each value that was used in the assessment. The MEPAS transport and fate analysis used the benzene concentrations at well 49M05 to calibrate the model. The length and width of the source area were estimated from the region where floating product was discovered (U.S. Air Force, 1993). The initial benzene mass at the source was determined by the model calibration exercise. Considering the fluctuating groundwater table and screen intervals of the monitoring wells (i.e., 1.80-7.5 m), the vertical dispersivity was set to assure that benzene is fully mixed within the top 6.1 m of the saturated zone. Pore-water velocities estimated for ST49 range from 14.5 to 87.0 cm/d (Table 3.3). The pore-water velocity of 14.5 cm/d is used in this analysis to minimize dilution effect.

Application Results and Discussion. The MEPAS transport and fate analysis used the benzene concentrations at well 49M05 to calibrate the model. Results associated with the modeling exercise are presented in Table 4.22 and Figures 4.25 and 4.26. Table 4.22 presents information used in the modeling exercise. Line 1 presents the travel distance (L_x) to well 49M05 from the center of the source. As noted earlier, it was assumed that contaminant (benzene) has been moving from the source to monitoring well 49M05. Line 2 presents the x- and y-dispersivities. The x- and y-dispersivities are assumed to be proportional to the travel distance L_x . The proportionality constants were determined by the model calibration exercise and are presented in line 4. Line 3 presents the distribution coefficient for benzene that was used in the modeling exercise. This coefficient is a calibrated value and an order of magnitude larger than the theoretical value estimated based on K_{oc} .

and an assumed organic content of 0.5%. Using the K_{oc} of 83 mL/g (Streng and Peterson, 1989) for benzene, the K_d value is calculated to be 0.4 mL/g (i.e., $83 \times 0.005 = 0.4$). The larger K_d value was needed to describe the slow migration of benzene at ST49. The flux rate for benzene was also determined by the model calibration exercise. Benzene was estimated to be released at a rate of 800 g/yr for 10 years, followed by a sharp decrease in the flux rate. Because the time frame of its initial leak to groundwater is unknown, it was assumed that the initial fuel leak occurred in 1972.

The result of the initial calibration for benzene is presented in Figure 4.25. The solid line is the benzene concentration profile associated with calibration runs to well 49M05 (110 m from the center of the source). The open circles represent the benzene concentrations measured at well 49M05 in 1989 and 1993. The result indicates that a peak of benzene plume (35 μ g/L) would pass well 49M05 at year 55 (year 2027).

Figure 4.26 shows simulated groundwater benzene (peak) concentrations varying with longitudinal travel distance from the source. It was assumed that benzene was constrained to the top 6.1 m of the aquifer. As noted by Figure 4.26, the benzene plume would travel 400 m before the peak concentration decreases below the MCL of 5 μ g/L. Under the conditions used in this modeling exercise, the benzene level is predicted to stay below MCL at a downgradient well located 400 m from the ST49 source.

The benzene fate and transport evaluation performed here is a preliminary assessment, as such, it represents an order-of-magnitude analysis and only provides preliminary information. Because the modeling assessment assumes that no decay processes (e.g., volatilization, degradation, transformation) occur, actual concentrations may be smaller than the predicted concentrations. Accordingly, the downgradient distance affected by ST49 can be much shorter. No data are available to confirm or dispute this conclusion.

4.6 SOURCE AREA BLAIR LAKES TARGET FACILITY DESCRIPTION

Source areas SS50, SS51, SS52, SS53, and DP54 are located at the Blair Lakes Target Facility. A brief description of each source area is presented below:

SS50—Blair Lakes Vehicle Maintenance

Heating oil spill at storage tank and abandoned buried fuel lines.

SS51—Blair Lakes Ditch

A 1-cm-thick layer of diesel fuel found floating on water in a ditch excavated between generator building and fuel pump island. Source of fuel leak is unknown.

SS52—Blair Lakes Diesel Spill

Diesel fuel spill (quantity unknown) from failure of 40-mm pipe connecting main diesel fuel storage tanks to 2,100-L aboveground day tanks near generator building.

SS53—Blair Lakes Fuel Spill

Unknown quantity of fuel spilled from fuel bladders placed in an approximate 18-m by 18-m area northeast of the tank farm.

DP54—Blair Lakes Drum Disposal Site

Reported drum disposal area. Existence of drums not substantiated.

The Blair Lakes Target Facility is an offbase facility located approximately 40 km southwest of Eielson AFB (see Figure 1.2). The site is remote and can be reached in summer by helicopter or in winter by

an ice bridge across the Tanana River. The site includes a vehicle maintenance shop, aboveground diesel and gasoline (MoGas) tank farm (and associated product delivery lines), generators, and storage outbuildings on a central gravel pad area. Aircraft target ranges, heliports, and drum disposal areas are located outside the gravel pad area (see Figure 1.3). The original Blair Lakes water supply well, located in the southeast corner of the Vehicle Maintenance Building, was taken out of service after a strong petroleum taste and odor were detected. The well casing is split near the surface, which may have provided a pathway for surface contamination to enter the well. Potable water for the facility is now supplied by a new water supply well located hydraulically upgradient (south) of the central facility area.

4.6.1 Data Summary

Source areas SS50 through SS54 at Blair Lakes were designated by base personnel during a 1987 site visit. Two rounds of field investigations were conducted during 1988 and 1989 (IRP RI/FS Phase II, Stage 3 and Stage 4). The 1988 Stage 3 field investigation included installing five monitoring wells, collecting soil and groundwater samples, conducting a surface geophysical electromagnetic (EM) survey, and performing a soil gas survey (HLA, 1989a). The subsequent stage 4 field investigation during the summer of 1989 included installation of four additional monitoring wells, installation of groundwater probes and product probes, collection of soil and groundwater samples, and followup surface geophysical (EM and GPR) surveys (HLA, 1990).

In 1992, interim remedial actions included installation of six additional product/groundwater probes (drive points), three shallow product recovery wells, and two recovery trenches in the vicinity of the vehicle maintenance shop and the generator building (see Figure 1.3). Automatic water-level recorders were placed in five wells including the old water supply well in February 1993. In May 1993, aquifer tests were conducted in seven wells including the old water supply well. Also, surface geophysics surveys were performed (EM and resistivity) to determine the depth to permafrost. Further, soil and groundwater samples were collected (Appendix I).

Table 4.23 summarizes laboratory analyses performed, and Appendix VIII summarizes analytical results from soil and groundwater sampling events. Table 4.24 lists product thickness measurements. Table 4.25 summarizes well construction and sampling information.

For the fuel-related contamination, SS50 through SS52 are sufficiently similar in nature, and close in proximity, to group together. SS53 and DP54 will be addressed separately. The PCB, pesticide, and metals contamination will be discussed as a single Blair Lakes site.

4.6.2 PCBs and Pesticides

Trace amounts of aldrin, alpha-BHC, and endosulfan II were detected but at concentrations well below their corresponding lowest ARARs^(a). No pesticides at concentrations above an ARAR were detected in surface soil samples taken at the Blair Lakes Target Facility. The soil sampling locations are shown in Appendix I.

4.6.3 Bis(2-ethylhexyl)phthalate In Groundwater

Bis(2-ethylhexyl)phthalate was detected in well 50M01 at 5.2 µg/L in 1993. This chemical is a plasticizer found in PVC pipe and plastic sampling equipment and could be the result of PVC well casing or sampling equipment deteriorating. Bis(2-ethylhexyl)phthalate has not been previously detected at the Blair Lakes Target Facility.

(a) See Table 4.2.

4.6.4 Metals

The Blair Lakes Target Facility is located in a sufficiently different terrain from the base to warrant establishing metal background levels in soil. The source area for the sediment deposits at the Blair Lakes Target Facility is primarily the Totatlanika Schist with some contribution from the Birch Creek Schist.

In general, the parent material is more mafic than the alluvial outwash at the main base resulting in potentially higher background concentrations in some metals (i.e., chromium and barium). Mafic minerals generally break down preferentially and can be anticipated to contribute to the sediment and groundwater concentrations.

The metals that exceed risk-based levels^(a) for groundwater are arsenic, barium, beryllium, cadmium, chromium, lead, and manganese. The metals that exceed the risk-based levels in sediment are arsenic and beryllium.

Soil. Beryllium was detected at 623 µg/kg in the soil at well 50M02 that exceeds mean background (462 µg/kg). There are two samples from the background soil pits that exceed 700 µg/L. No human-caused source of beryllium can be identified. The risk-based level of concern is 100 µg/kg for beryllium.

Background arsenic in soil established for the Blair Lakes Target Facility was 9,541 µg/kg. The risk-based level for arsenic in soil is 400 µg/kg. There were no results that were below the risk-based level. The area appears to be naturally very high in arsenic.

Groundwater. The highest concentrations of arsenic (31 µg/kg) are at well 50M08, where iron, manganese, and magnesium are also elevated. This concentration exceeds the risk-based level of 10 µg/L (see Figure 4.27).

Barium in well 50M08 is right at the MCL of 1,000 µg/L. Barium is also detected in all the other monitoring wells but at nearly equivalent levels, demonstrating the wide-spread presence of the metal in groundwater. Barium is suggested to be a naturally occurring metal at the site as evidenced by the high background concentrations in soil, and the wide-spread occurrence.

Beryllium was detected in four of the nine wells sampled. The screening level for beryllium in groundwater is 0.02 µg/L (excess cancer risk of 10⁻⁶). The highest concentrations were measured in a sample from well 50M08 at 2.4 µg/L. The wells with detectable amounts of beryllium were widely distributed and a point source cannot be identified. It is not apparent, however, if beryllium is naturally occurring. Not enough data is available to draw a suitable conclusion.

One location (50M06) has cadmium at a level of 9.3 µg/L in an unfiltered sample, just over the MCL of 5 µg/L. There is no cadmium detected in filtered samples. Iron and manganese are also elevated in this well suggesting a reducing environment. In the absence of cadmium in solution, a reasonable assumption is that the cadmium is a part of the local sediment, not related to a pollutant. Further, zinc, lead, and cadmium are common accessory metals in mineral deposits.

Well 50M08 has a concentration of 100 µg/L, equal to the MCL for chromium. This result is from an unfiltered sample, the filtered sample was 5 µg/L. Considering the high background soil levels for chromium, and the high concentrations for most metals in groundwater from this well, high chromium is believed to be from natural sources.

(a) See Table 4.2.

Concentrations of lead at the Blair Lakes Target Facility are statistically higher than the background at the base. The hits are wide spread and, like the concentrations of manganese, seem to be sitewide. Unlike elevated lead levels in the other source areas, the values of lead at the Blair Lakes Target Facility seem to be elevated away from floating product. This indicates that the lead is naturally high in this area.

Lead and manganese both have high concentrations compared to background values at the Blair Lakes Target Facility. The manganese concentrations are not statistically different while the lead concentrations are.

Further, the same wide-spread pattern seems evident for the manganese as for the lead. In association with high iron, it would seem plausible, once again, that manganese is elevated in this area.

4.6.5 Source Areas SS50-SS52

4.6.5.1 Interim Action. Remediation efforts consisting of three product recovery wells and two extraction trenches were implemented in 1992. As of April 1993, approximately 927 L of product have been recovered.

4.6.5.2 Floating Product. The floating product is isolated to an area around the vehicle maintenance buildings and historically product thicknesses are greatest in well 50M01 and product probe 50PP03 (see Figure 4.28). Within this area there are no clear trends evident in the product thickness measurements. As with the ST20 E-9 Complex, multiple leaks in underground fueling/defueling lines and ongoing remediation efforts could be affecting the vertical distribution of floating product.

The primary source for the floating product is the diesel fuel spill. According to ADEC files, the spill occurred at a failed fuel line elbow just outside the tank farm. Additional leaks, both reported and unreported, have occurred in the lines around the day tank supplying fuel to the vehicle maintenance building. Recent excavation by the U.S. Air Force around the pump island has revealed leaking piping and TPH contamination.

4.6.5.3 Fuel-Related Contamination.

Soil. BTEX compounds were detected in soil samples from most of the soil borings drilled in 1988, with highest concentrations reported at depths near the water table. Benzene concentrations were highest in the vicinity of the fuel pump island, while ethylbenzene, toluene, and total xylenes were highest in the vicinity of the vehicle maintenance building. The highest total BTEX concentration (approximately 1,900 mg/kg) was measured in soils from the 50M01 boring. Fuel-related semivolatile compounds were detected in soil samples collected in the area of floating product and the fuel pump island. Concentrations of PAHs tend to increase with depth; compounds detected in the highest concentrations (2-methylnaphthalene and naphthalene) are some of the lighter, more soluble constituents associated with fuel products. Concentrations of TPH in surface soil exceed 1 00 mg/kg around most of the tank farm perimeter, the fuel pump island, and the southeast side of the vehicle maintenance area, and in an isolated area near well 50M06. The maximum surface soil concentration was 3,350 mg/kg at a boring adjacent to well 50M01. Concentrations of TPH in subsurface soil exceed 100 mg/kg in the area between the western edge of the tank farm and the fuel pump island, and in the area of the free product. The maximum subsurface soil concentration was 91,800 mg/kg at boring 50M01 (1.4 - 1.8 m bls).

Fuel-related PAH contamination was detected in two of four soil samples analyzed for semivolatile compounds. These samples were collected from around the generator building where there have

been numerous reports of leaking fuel lines. The sample collected between the building and the diesel day tank had the highest concentrations of PAHs. Kerosene was detected at 910,000 $\mu\text{g/kg}$ and naphthalene at 43,000 $\mu\text{g/kg}$.

Groundwater. Two areas of high benzene concentrations exceeding 5 $\mu\text{g/L}$ were located between the vehicle maintenance shop and the day tanks (50M01) and west of the tank farms (50M05). The 1993 benzene concentrations at these locations are 28 $\mu\text{g/L}$ and 290 $\mu\text{g/L}$, respectively. The present concentrations of benzene in the groundwater at well 50M01 have decreased since the high in 1989 of 335 $\mu\text{g/L}$. The concentrations at well 50M05 have also decreased from the high in 1989 of 1,018 $\mu\text{g/L}$. In general, all the fuel-related contaminants have decreased by nearly an order of magnitude between 1989 and 1993 (see Figure 4.29).

Fuel-related semivolatile compounds and TPH in groundwater were detected during the 1988, 1989, and 1993 sampling rounds in wells 50M01 and 50M05. Concentrations of 2-methylnaphthalene, naphthalene, and TPH increased by more than an order of magnitude between 1988 and 1989 in well 50M01, but then decreased again in the 1993 sampling to 36 $\mu\text{g/L}$ naphthalene in 50M01 and 190 $\mu\text{g/L}$ naphthalene in 50M05. The risk-based screening value for naphthalene is 100 $\mu\text{g/L}$. The chemical, 2-methylnaphthalene, was not detected in any wells in 1993 (see Figure 4.30).

The source(s) for the contamination at well 50M01 is believed to be the persistent leaks in the lines between the diesel day tanks and the vehicle maintenance shop. The high benzene concentration at well 50M05 (located cross gradient of the tank farm and upgradient of the fuel pump island) may indicate an unknown source. Periodic scraping and regrading of the main pad and tank farm fill has likely spread any surface spills over an area broader than the original spill(s). Leaks in the underground fuel piping at the pump island or leaks in the tank farm liner have been suggested as other potential sources for subsurface TPH contamination in this vicinity. These sources also are suspected to be contributing to the elevated BTEX compounds found in well 50M05 groundwater. ADEC records also suggest that TPH-contaminated soil may be present up to 30 m southeast of the tank farm. Possible sources include fuel-contaminated soils that were spread to this area by regrading activities and/or discharge from an existing french drain system that drained the tank farm area.

Soil Gas. BTEX was detected in soil gas between the vehicle maintenance shop and the tank farm during the 1988 soil gas survey. Concentrations of total BTEX in soil gas ranged from 0.28 to 30.4 ppm. The highest detection was reported near well 50M05, approximately 10 m west of the tank farm.

4.6.6 Source Area SS53

This site was designated by base personnel during a 1987 site visit. An unknown quantity of fuel spilled from fuel bladders placed in an approximate 18-m by 18-m area northeast of the tank farm.

4.6.6.1 Free Product. No free product has been detected in wells 50M02 or 50M07.

4.6.6.2 Fuel-Related Contamination

Soil. A surface soil sample collected in 1993 at the reported fuel bladder spill for diesel and gasoline-ranged organic materials had 5.8 mg/kg of diesel and no detectable concentrations of gasoline. TPH was detected in a surface sample taken from well 50M02 at 22.2 mg/kg in 1989. No TPH has been detected in the subsurface at wells 50M02 or 50M07 or in a test pit located at the reported fuel spill site. These TPH concentrations are well below the Alaska State cleanup standards (100 mg/kg diesel and 50 mg/kg gasoline). TPH was, however, detected above the Alaskan guidelines in surface soil beneath the tank farm where two tanks were removed in early 1993. Concentrations for TPH-gasoline

Concentrations for TPH-gasoline and diesel in the surface soil were 100 and 200 mg/kg respectively. The subsurface samples did not exceed the Alaskan guidelines for gasoline and diesel (77 and 47 mg/kg) in the subsurface.

Several fuel-related semivolatile organic compounds (acenaphthene, 2-methylnaphthalene, and phenols) were detected in soil at concentrations ranging from 0.05 to 1.1 ppm; toluene (0.31 mg/kg) and xylene (0.20 mg/kg) were the only BTEX compounds (50M02).

Groundwater. No BTEX compounds have been detected in groundwater at well 50M02 (1988, 1989, or 1993), and only low concentrations were detected at well 50M07, ranging from 0.99 ppb for ethylbenzene to 11.3 ppb for xylenes in 1989. No BTEX compounds were detected in samples from 1993. No fuel-related semivolatile compounds have been detected in either wells 50M02 or 50M07.

Soil Gas. Soil gas survey results from 1988 indicated the presence of BTEX compounds (total BTEX 0.49 ppm at 50SV03) in one of four probes placed around the north end of the fuel bladder/tank farm area.

4.6.7 Source Area DP54

Drums of unknown material were reportedly buried in an area west of the main Blair Lakes Target Facility. However, a geophysical survey designed to locate buried metal did not indicate the presence of drums in DP54. Twenty groundwater probes were installed to field screen groundwater near suspected areas of buried metal indicated by the GPR surveys. Toluene was detected at 1 ppb in three groundwater probes installed at the south end of the facility, next to the cargo helipad road. No aromatic or chlorinated VOCs were detected in groundwater probes installed at the north end of the facility. Additionally, no contaminants of concern have been identified in wells 50M09 and 50M04 located adjacent to DP54 in samples collected as recently as 1993. Personal interviews by the base personnel indicate that there are conflicting anecdotal accounts of the drums' existence. There is currently no good evidence to suggest that any drums are buried in the DP54 site.

4.6.8 Conceptual Model

See Figure 4.3.

Because of its isolated setting, the logistical constraints to gain access, and the type of ongoing operation, the Blair Lakes Target Facility may require special consideration with respect to determining an appropriate risk scenario. The screening risk assessment assumed a residential scenario; an industrial scenario may be more appropriate and will be considered for the baseline risk assessment.

4.6.9 Fate and Transport

Site SS53 is located at the Blair Lakes Target Facility within OU-1 at Eielson AFB. The source of contamination is the area surrounding the helicopter fuel bladder area (U.S. Air Force, 1993). It appears that fuel was spilled on the pad around the shed that houses pumping equipment for defueling. The quantity of fuel spilled at the site and the time frame associated with the initial spill are unknown.

In 1993, diesel concentration of 5.8 mg/kg was measured in surface soil (BLTF-3) collected from the helicopter fuel bladder area, diesel was not detected in subsurface soil near the water table (BLTF-4). The groundwater monitoring well 50M02 is located downgradient of the suspected source area. At well 50M02, the groundwater TPH and BTEX concentrations analyzed in 1989 are all below detection limits; toluene was detected at 0.11 µg/L in 1993.

Based on this description of the site and other available information (U.S. Air Force, 1993), SS53 was modeled using the following assumptions.

- Source area is the helicopter fuel bladder area that covers approximately 165 m².
- Because no water supply well exists downgradient of SS53, a modeling simulation was performed at well 50M02 located 18.4 m from the center of SS53.
- Benzene is used as the indicator chemical because it is the most mobile and toxic constituent of all of the BTEX components. Because diesel was detected (at 5.8 mg/kg) in surface soil (BLTF-3) at the source area, it is assumed benzene has been released from the diesel contaminated soil. Because the benzene content of arctic diesel (0.22%) is considerably higher than that of diesel #1 and #2 (0.004%), the use of arctic diesel as a contaminant source provides a conservative assessment.
- Because no information exists at SS53 from which a benzene distribution coefficient (Kd) can be estimated, the Kd value from the ST19 assessment [i.e., 0.1 mL/g (U.S. Air Force, 1993)] will be used. With an assumed organic content (foc) of 0.5% and a reported Koc of 83 mL/g, the Kd value calculated using the theoretical formula ($Kd = Koc \times foc$) is 0.42 mL/g. Because the smaller Kd value generally increases the flux rate of contaminant, it is a conservative analysis.
- The infiltration leaching rate is 0.01 cm/d, assuming approximately 20% of local precipitation is infiltrated to groundwater system.
- The estimated pore-water velocity is in the range between 8.21 and 131 cm/d (see Table 3.3). The smaller pore-water velocity generally minimizes dilution and maximizes the contaminant concentration in groundwater, as such it is a conservative analysis.
- In the partially saturated zone, the peak travel time associated with benzene can be estimated using the following equation:

$$t = z R_f \theta / i$$

Where t is the peak travel time, i is the infiltration leaching rate (Darcian flow velocity), θ is the soil moisture content, z is the travel distance to groundwater table, R_f is the retardation factor given by the relationship, $R_f = 1 + (Kd \beta / \theta)$. With an infiltration leaching rate (i) of 0.01 cm/d, a bulk density (β) of 1.5 g/cm, a travel distance to groundwater table (z) of 213 cm, and a moisture content (θ) of 16%, the plug flow travel time in the unsaturated zone for benzene can be estimated as 18 years. This travel time indicates that any spilled mass of contamination would have arrived at the groundwater table.

- In the saturated zone, the peak travel time associated with benzene can be estimated using the following equation:

$$t = x R_f / u$$

Where R_f is the retardation factor given by the relationship, $R_f = 1 + (Kd \beta / n_e)$, t is the peak travel time to the well, u is the pore-water velocity, x is the travel distance to well 50M02, β and n_e are the bulk density and effective porosity, respectively. With pore-water velocities of 8.2 to 131 cm/d, a bulk density of 1.6 g/cm, an effective porosity of 30%, and a travel distance to well 50M02 of 18.4 m, the peak travel time associated with benzene can vary from 20 days to 1 year. This calculation indicates that, after contaminant enters the groundwater aquifer, the contaminant could reach well 50M02 in less than 1 year.

- The modeling scenario associated with this site is the constant contaminant seepage from the weathered residual product, and the assessment addresses contaminant movement from the waste site, to the saturated zone, and to well 50M02.
- The source mass inventory for a constituent (benzene) can be estimated using the following equation:

$$M = (C_d \theta + C_p \beta) LWH \quad (1)$$

where M = contaminant mass existing at the source

θ = soil moisture content

β = bulk density

L = source length

W = source width

H = source depth

C_d = dissolved contaminant concentrations

C_p = particulate contaminant concentrations.

C_d and C_p are given respectively as

$$C_d = C_{Tp} \beta / (\theta + \beta K_d) \quad (2)$$

and

$$C_p = C_{Tp} \beta K_d / (\theta + \beta K_d) \quad (3)$$

where C_{Tp} = total contaminant concentration.

- The contaminant mass flux from the source (in the partially saturated zone) to the saturated zone can be estimated using the following equation:

$$F = C_d i L W \quad (4)$$

where F = mass flux

i = infiltration leaching rate (Darcian velocity).

Note, equation (4) was also used for benzene mass and flux estimation.

- A modeling was not performed at well 50M07 assuming that the constituents detected at well 50M07 are resulted from the tank farm area contamination, not from the helicopter fuel bladder area.

4.7 SITE DATA USED FOR THE TRANSPORT AND FATE ASSESSMENT

The groundwater model associated with MEPAS was used to model the transport of benzene at SS53. The hydrologic data used in the SS53 study are presented in Table 4.26. The 7.1 g of mass of benzene, reported in Table 4.26, was estimated from the 1) approximate areal extent of source area and depth, 2) diesel-concentration measured at BLTF-3 (i.e., 5.8 mg/kg), and 3) benzene content in arctic diesel (i.e., 0.22%) (U.S. Air Force, 1993). The dispersivities are assumed to be proportional to the travel distance L_x and determined according to Droppo et al. (1989).

4.8 APPLICATION RESULTS AND DISCUSSION

Results associated with the modeling exercise for benzene are presented in Figure 4.26. As noted earlier, monitored benzene concentrations were not available at levels exceeding the detection limit at well 50M02 downgradient of SS53. As such, a conservative assessment was performed by estimating source term conditions (i.e., benzene mass and flux rate). The benzene mass and flux estimated using the equations (1) and (2) are 7.1 g and 0.37 g/yr, respectively.

Figure 4.31 shows the groundwater benzene concentration profiles simulated at well 50M02, which is 18.4 m from the center of the source (see Table 4.26). The solid and dashed lines represent the benzene concentrations at the pore-water velocities of 8.2 and 131 cm/d, respectively. At the pore-water velocity of 8.2 cm/d, the simulated peak concentration is approximately 0.5 µg/L which is below the MCL of 5 µg/L. Trace contamination (0.03 µg/L) is expected at the higher velocity of 131 cm/d at well 50M02.

Source benzene concentration can be estimated using the equation:

$$C_o = \text{Flux} / u n_e W H_m$$

where C_o = source contaminant concentration

u = pore-water velocity

n_e = effective porosity

H_m = the contaminant mixing depth (or well depth) at source area.

With a well depth of 6.1 m, calculated source benzene concentrations are 0.87 and 0.05 µg/L, respectively, at the pore-water velocities of 8.21 and 131 cm/d, which are also below MCL. As noted earlier, toluene (0.11 µg/L) was detected at well 50M02 in 1993. Because an estimated retardation factor (R_f) of benzene (i.e., 1.5) is smaller than that of toluene (i.e., 2.3), if the source area is more contaminated than estimated, any benzene contamination that are consistently higher than detection limit should have already been monitored in well 50M02. With conservatism built into this assessment, no benzene contamination above the MCL would be expected downgradient of this site.

TABLE 4.1. Contaminants of Concern

Source Area	Groundwater	Surface Soil	Subsurface Soil
ST20 E-7	Metals Antimony ^(a) Arsenic ^(b) Beryllium ^(a) Cadmium ^(b) Chromium ^(b) Lead ^(c) Manganese ^(b) Volatiles Benzene Ethylbenzene Toluene Semivolatiles Bis(2-ethylhexyl)phthalate Naphthalene	Metals Beryllium Semivolatiles Benzo(b)fluoranthene Benzo(k)fluoranthene	Metals Arsenic ^(b) Beryllium ^(a) Volatiles Benzene TPH
ST20 E-8	Metals Antimony ^(a) Arsenic ^(b) Chromium ^(b) Manganese ^(b) Volatiles Benzene Ethylbenzene Toluene Semivolatiles Bis(2-ethylhexyl)phthalate	Volatiles TPH Xylene Semivolatiles Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(ghi)perylene Chrysene Indeno(1,2,3-cd)pyrene	Volatiles Benzene TPH
ST20 E-9	Metals Antimony ^(a) Arsenic ^(b) Beryllium ^(a) Cadmium ^(b) Chromium ^(b) Manganese ^(b) Volatiles 1,1-dichloroethane Benzene Chlorobenzene Ethylbenzene Toluene Semivolatiles Naphthalene	Semivolatiles Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(ghi)perylene Chrysene Indeno(1,2,3-cd)pyrene	Metals Arsenic ^(b) Beryllium ^(a) Volatiles Tetrachloroethene Vinyl chloride
ST48	Metals Antimony ^(a) Arsenic ^(b) Beryllium ^(a) Cadmium ^(b)	Semivolatiles Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene	Volatiles TPH

TABLE 4.1. Contaminants of Concern

Source Area	Groundwater	Surface Soil	Subsurface Soil
	Lead(c) Manganese Volatiles Benzene Toluene Xylenes Semivolatiles Bis(2-ethylhexyl)phthalate Naphthalene	Benzo(ghi)perylene Chrysene Indeno(1,2,3-cd)pyrene	
ST49	Metals Arsenic ^(b) Lead ^(c) Manganese ^(b) Volatiles Benzene Methylene chloride Semivolatiles Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Chrysene Indeno(1,2,3-cd)pyrene Bis(2-ethylhexyl)phthalate	Semivolatiles Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(ghi)perylene Chrysene Dibenzo(a,h)anthracene Indeno(1,2,3-cd)pyrene	Metals Arsenic ^(b) Beryllium ^(a) Volatiles TPH
Blair Lakes Target Facility	Metals Arsenic Barium Beryllium Cadmium Chromium Lead Manganese Volatiles Benzene Ethylbenzene TPH Xylenes Semivolatiles Bis(2-ethylhexyl)phthalate Naphthalene		Metals Arsenic ^(b) Beryllium ^(b) Volatiles TPH Semivolatiles Naphthalene
TPH = total petroleum hydrocarbon. (a) No background established. (b) Statistical t-test indicates the values are not outside of background statistical boundaries. (c) Does not exceed risk levels, but is within 1-4 µg/L of the limit.			

TABLE 4.2. Risk-Based Screening Levels

	Concentration Corresponding to 1E-6 Risk		Concentration Corresponding to HQ - 1.0		
	Water (µg/L)	Soil (µg/kg)	Water (µg/L)	Soil (µg/kg)	MCL (µg/L)
VOLATILES					
1,1,1-Trichloroethane	N/A	N/A	2.00E+03	2.00E+07	2.00E+02
1,1,2,2-Tetrachloroethane	9.00E-02	3.00E+03	1.00E+03	8.00E+06	
1,1,2-Trichloroethane	3.00E-01	1.00E+04	1.00E+02	1.00E+06	
1,1-Dichloroethane	N/A	N/A	8.00E+02	3.00E+07	
1,1-Dichloroethene	1.42E-01	1.16E+02	3.15E+01	6.82E+04	7.00E+00
1,2-Dichloroethane	2.00E-01	7.00E+03	N/A	N/A	5.00E+00
Cis-1,2-dichloroethene					7.00E+01
Trans-1,2-dichloroethene					1.00E+02
1,2-Dichloroethene (total)			7.00E+01	1.52E+05	
1,2-Dichloropropane	1.00E+00	9.00E+03	N/A	N/A	5.00E+00
2-Butanone	N/A	N/A	6.00E+02	1.00E+07	
2-Hexanone					
4-Methyl-2-pentanone					
Acetone	N/A	N/A	4.00E+03	3.00E+07	
Benzene	6.00E-01	2.00E+04	1.00E+01	N/A	5.00E+00
Benzyl alcohol	N/A	N/A	1.00E+04	8.00E+07	
Bromodichloromethane	5.00E-01	5.00E+03	7.00E+02	5.00E+06	100 THM
Bromoform	1.00E+01	8.00E+04	7.00E+02	5.00E+06	100 THM
Bromomethane	N/A	N/A	1.00E+01	4.00E+05	
Carbon disulfide	N/A	N/A	3.00E+01	3.00E+07	
Carbon tetrachloride	3.00E-01	5.00E+03	3.00E+01	2.00E+05	5.00E+00
Chlorobenzene	N/A	N/A	5.00E+01	5.00E+06	1.00E+02
Chloroethane	N/A	N/A	3.00E+04	N/A	
Chloroform	3.00E-01	1.00E+05	2.00E+01	3.00E+06	100 THM
Chloromethane	2.00E+00	5.00E+04	N/A	N/A	
Cis-1,3-dichloropropene	4.73E-01	3.87E+02	1.05E+00	2.27E+03	
Dibromochloromethane	1.00E+00	8.00E+03	7.00E+02	5.00E+06	
Ethylbenzene	N/A	N/A	2.00E+03	3.00E+07	7.00E+02
Methylene chloride	1.14E+01	9.28E+03	2.10E+02	4.55E+05	
Styrene	2.00E+00	2.00E+04	7.00E+03	5.00E+07	1.00E+02
Tetrachloroethene	4.73E+01	3.87E+04	3.50E+01	7.58E+04	5.00E+00
Toluene	N/A	N/A	3.00E+03	5.00E+07	1.00E+03
Trans-1,3-dichloropropene	4.73E-01	3.87E+02	1.05E+00	2.27E+03	
Trichloroethane	7.74E+00	6.33E+03		N/A	5.00E+00
Vinyl acetate	N/A	N/A	4.00E+04	3.00E+08	
Vinyl chloride	3.00E-02	3.00E+02	N/A	N/A	2.00E+00
Xylenes (total)	N/A	N/A	8.00E+02	5.00E+08	1.00E+04
SEMIVOLATILES					
1,2,4-Trichlorobenzene	N/A	N/A	2.00E+01	4.00E+05	9.00E+00
1,2-Dichlorobenzene	N/A	N/A	3.00E+02	2.00E+07	6.00E+02
1,2-Diphenylhydrazine	1.06E-01	8.70E+01			
1,3-Dichlorobenzene	N/A	N/A	N/A	N/A	
1,4-Dichlorobenzene	3.00E+00	3.00E+04	2.00E+03	N/A	7.50E+01
2,4,5-Trichlorophenol	N/A	N/A	4.00E+03	3.00E+07	
2,4,6-Trichlorophenol	2.00E+00	6.00E+04	N/A	N/A	

TABLE 4.2. Risk-Based Screening Levels

	Concentration Corresponding to 1E-6 Risk		Concentration Corresponding to HQ - 1.0		MCL (µg/L)
	Water (µg/L)	Soil (µg/kg)	Water (µg/L)	Soil (µg/kg)	
2,4-Dichlorophenol	N/A	N/A	1.00E+02	8.00E+05	
2,4-Dimethylphenol	N/A	N/A	7.00E+02	5.00E+06	
2,4-Dinitrophenol	N/A	N/A	7.00E+01	5.00E+05	
2,4-Dinitrotoluene	1.00E-01	9.00E+02	N/A	N/A	
2,6-Dinitrotoluene	1.00E-01	9.00E+02	N/A	N/A	
2-Chloronaphthalene	N/A	N/A	3.00E+03	2.00E+07	
2-Chlorophenol	N/A	N/A	2.00E+02	1.00E+06	
2-Methylnaphthalene	N/A	N/A	N/A	N/A	
2-Methylphenol	N/A	N/A	N/A	N/A	
2-Nitroaniline	N/A	N/A	N/A	N/A	
2-Nitrophenol	N/A	N/A	N/A	N/A	
3,3'-Dichlorobenzidine	2.00E-01	1.00E+03	N/A	N/A	
3-Nitroaniline	N/A	N/A	N/A	N/A	
4,6-Dinitro-2-methylphenol	N/A	N/A	N/A	N/A	
4-Bromophenyl-phenylether	N/A	N/A	N/A	N/A	
4-Chloro-3-methylphenol	N/A	N/A	N/A	N/A	
4-Chloroaniline			1.40E+01	3.03E+04	
4-Chlorophenyl-phenylether	N/A	N/A	N/A	N/A	
4-Methylphenol	N/A	N/A	N/A	N/A	
4-Nitroaniline	N/A	N/A	N/A	N/A	
4-Nitrophenol	N/A	N/A	N/A	N/A	
Acenaphthene	N/A	N/A	2.00E+03	2.00E+07	
Acenaphthylene	N/A	N/A	N/A	N/A	
Anthracene	N/A	N/A	1.00E+04	8.00E+07	
Benzo(a)anthracene	7.00E-03	6.00E+01	N/A	N/A	2.00E-01
Benzo(a)pyrene	7.00E-03	6.00E+01	N/A	N/A	2.00E-01
Benzo(b)fluoranthene	7.00E-03	6.00E+01	N/A	N/A	2.00E-01
Benzo(ghi)perylene	N/A	N/A	N/A	N/A	
Benzo(k)fluoranthene	7.00E-03	6.00E+01	N/A	N/A	2.00E-01
Benzoic acid	N/A	N/A	1.00E+05	1.00E+09	
Bis(2-chloroethoxy)methane	N/A	N/A	N/A	N/A	
Bis(2-chloroethyl)ether	2.00E-02	6.00E+02	N/A	N/A	
Bis(2-chloroisopropyl)ether	N/A	N/A	1.00E+03	1.00E+07	
Bis(2-ethylhexyl)phthalate	6.00E-01	5.00E+04	7.00E+02	5.00E+06	1.00E+02
Butylbenzylphthalate	N/A	N/A	7.00E+03	5.00E+07	
Chrysene	7.00E-03	6.00E+01	N/A	N/A	2.00E-01
Di-n-butylphthalate	N/A	N/A	4.00E+03	3.00E+07	
Di-n-octylphthalate	N/A	N/A	7.00E+02	5.00E+06	
Dibenz(a,h)anthracene	7.00E-03	6.00E+01	N/A	N/A	2.00E-01
Dibenzofuran	N/A	N/A	4.00E+01	3.00E+05	
Diethylphthalate	N/A	N/A	3.00E+04	2.00E+08	
Dimethylphthalate	N/A	N/A	4.00E+04	3.00E+08	
Fluoranthene	N/A	N/A	1.00E+03	1.00E+07	
Fluorene	N/A	N/A	1.00E+03	1.00E+07	
Hexachlorobenzene	5.00E-02	4.00E+02	3.00E+01	2.00E+05	1.00E+00

TABLE 4.2. Risk-Based Screening Levels

	Concentration Corresponding to 1E-6 Risk		Concentration Corresponding to HQ - 1.0		MCL (µg/L)
	Water (µg/L)	Soil (µg/kg)	Water (µg/L)	Soil (µg/kg)	
Hexachlorobutadiene	1.00E+00	8.00E+03	7.00E+01	5.00E+05	
Hexachlorocyclopentadiene	N/A	N/A	3.00E+02	2.00E+06	5.00E+01
Hexachloroethane	6.00E+00	5.00E+04	4.00E+01	3.00E+05	
Indeno(1,2,3-cd)pyrene	7.00E-03	6.00E+01	N/A	N/A	2.00E-01
Isophorone	2.00E+01	2.00E+05	7.00E+03	5.00E+07	
N-nitroso-di-n-propylamine	1.00E-02	9.00E+01	N/A	N/A	
N-nitrosodiphenylamine(1)	2.00E+01	1.00E+05	N/A	N/A	
Naphthalene	N/A	N/A	1.00E+02	1.00E+06	
Nitrobenzene	N/A	N/A	2.00E+01	1.00E+05	
Pentachlorophenol	7.00E-01	5.00E+03	1.00E+03	8.00E+06	
Phenanthrene	N/A	N/A	N/A	N/A	
Phenol	N/A	N/A	2.00E+04	2.00E+08	
Pyrene	N/A	N/A	1.00E+03	8.00E+06	
TOTAL PETROLEUM HYDROCARBONS					
Total petroleum hydrocarbons			1.26E+03	2.73E+06	
Polychlorinated biphenyls					
Aroclor-1016	1.00E-02	8.00E+01	N/A	N/A	5.00E-01
Aroclor-1221	1.00E-02	8.00E+01	N/A	N/A	5.00E-01
Aroclor-1232	1.00E-02	8.00E+01	N/A	N/A	5.00E-01
Aroclor-1242	1.00E-02	8.00E+01	N/A	N/A	5.00E-01
Aroclor-1248	1.00E-02	8.00E+01	N/A	N/A	5.00E-01
Aroclor-1254	1.00E-02	8.00E+01	N/A	N/A	5.00E-01
Aroclor-1260	1.00E-02	8.00E+01	N/A	N/A	5.00E-01
PESTICIDES					
4,4'-DDD	3.55E-01	2.90E+02			
4,4'-DDE	2.50E-01	2.05E+02			
4,4'-DDT	2.50E-01	2.05E+02	1.75E+00	3.79E+03	
4,4'-Methoxychlor		N/A	1.75E+01	3.79E+04	
Aldrin	5.00E-03	4.00E+01	1.00E+00	8.00E+03	
Alpha-BHC	1.00E-02	1.00E+02	N/A	N/A	
Alpha-chlordane	6.55E-02	5.35E+01	2.10E-01	4.55E+02	
Beta-BHC	5.00E-02	4.00E+02	N/A	N/A	
Delta-BHC	N/A	N/A	N/A	N/A	
Dieldrin	5.00E-03	4.00E+01	2.00E+00	1.00E+04	
Endosulfan I	N/A	N/A	2.00E+00	1.00E+04	
Endosulfan II			7.00E-01	1.52E+03	
Endosulfan sulfate	N/A	N/A	N/A	N/A	
Endrin	N/A	N/A	1.00E+01	8.00E+04	2.00E+00
Endrin ketone	N/A	N/A	N/A	N/A	
Gamma-BHC (lindane)	6.00E-02	5.00E+02	1.00E+01	8.00E+04	2.00E-01
Gamma-chlordane	6.55E-02	5.35E+01	2.10E-01	4.55E+02	2.00E+00
Heptachlor	2.00E-02	1.00E+02	2.00E+01	1.00E+05	4.00E-01
Heptachlor epoxide	9.00E-03	7.00E+01	5.00E-01	4.00E+03	2.00E-01
Methoxychlor	N/A	N/A	2.00E+02	1.00E+06	4.00E+01
Toxaphene	8.00E-02	6.00E+02	N/A	N/A	3.00E+00

TABLE 4.2. Risk-Based Screening Levels

	Concentration Corresponding to 1E-6 Risk		Concentration Corresponding to HQ - 1.0		
	Water (µg/L)	Soil (µg/kg)	Water (µg/L)	Soil (µg/kg)	MCL (µg/L)
METALS					
Aluminum	N/A	N/A	N/A	N/A	
Antimony	N/A	N/A	1.00E+01	1.00E+05	5.00E+00
Arsenic	5.00E-02	4.00E+02	1.00E+01	8.00E+04	5.00E+01
Barium	N/A	N/A	3.00E+03	2.00E+07	1.00E+03
Beryllium	2.00E-02	1.00E+02	2.00E+02	1.00E+06	1.00E+00
Cadmium	N/A	N/A	2.00E+01	N/A	5.00E+00
Calcium					
Chromium	N/A	N/A	2.00E+02	N/A	1.00E+02
Cobalt					
Copper	N/A	N/A	3.00E+03	2.00E+07	1.30E+03
Iron	N/A	N/A	N/A	N/A	
Lead	N/A	N/A	N/A	N/A	1.50E+01
Magnesium					
Manganese	N/A	N/A	1.00E+03	3.00E+07	
Mercury	N/A	N/A	1.00E+01	N/A	2.00E+00
Nickel	N/A	N/A	7.00E+02	5.00E+06	1.00E+02
Potassium					
Selenium	N/A	N/A	1.00E+02	1.00E+06	5.00E+01
Silver	N/A	N/A	1.00E+02	8.00E+05	5.00E+01
Sodium					
Thallium	N/A	N/A	3.00E+00	2.00E+04	1.00E+00
Vanadium	N/A	N/A	3.00E+02	2.00E+06	
Zinc	N/A	N/A	7.00E+03	5.00E+07	
N/A = Toxicity value and/or MCL not available, therefore, "risk-based concentration" and/or "risk at MCL" cannot be calculated. Note: Risk-based concentrations are from the U.S. Environmental Protection Agency's National Contingency Plan (40 CFR 300) and Part A of the Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (EPA 1989).					
Risk-based concentrations calculated based on the soil ingestion pathway only may not be appropriate for chromium, cadmium, elemental mercury, or carcinogenic forms of nickel. This is because of the special issue of their inhalation toxicity being more of a concern than ingestion.					

TABLE 4.3. Laboratory Analyses Performed, ST20 E-7 Complex

Parameter	Analytical Method	Groundwater					Surface Water		Soils				Surface Soil	Sediment
		1984 (a)	1986 (b)	1988 (c)	1989 (d)	1993 (e)	1989 (d)	1993 (e)	1984 (a)	1986 (b)	1988 (c)	1989	1993 (e)	1993 (e)
Halogenated volatile organics	SW-846, 8010	-	-	X ^(f)	-	X	-	X	-	-	-	-	X	X
Aromatic volatile organics	SW-846, 8020	-	-	X	X	X	X	X	-	-	-	-	X	X
Volatile organic compounds	SW-846, 8420	-	X	-	-	-	-	-	-	X ^(f)	X	-	-	-
Semivolatile organic compounds	SW-846, 8270	-	-	X	-	X	-	X	-	-	X ^(f)	-	X	X
Organochlorine pesticides and PCBs	SW-846, 8080	-	-	-	-	-	-	-	-	-	X ^(f)	-	X	X
Hydrocarbon fingerprint	SW-846, 8015	-	-	X	-	-	-	-	-	-	-	-	-	-
Petroleum hydrocarbons	E418.1	-	X	X	X	-	X	-	-	-	X	-	-	-
TPH - gas range	AK101	-	-	-	-	-	-	-	-	-	-	-	X	-
TPH - diesel range	AK102	-	-	-	-	-	-	-	-	-	-	-	X	-
Arsenic	SW-846, 7080	-	-	X ^(f, h)	-	X	-	X	-	-	-	-	X	X
Lead	SW-846, 7421	X ^(f)	-	X ^(f, h)	-	X	-	X	-	-	-	-	X	X
Mercury	SW-846, 7470	-	-	X ^(f, h)	-	X	-	X	-	-	-	-	X	X
ICP metals scan	SW-846, 8010	-	-	X ^(f, h)	-	X	-	X	-	-	-	-	X	X
Total dissolved solids	E180.1	-	-	X	-	-	-	-	-	-	-	-	-	-
Common anions	E300	-	-	X ^(f)	-	-	-	-	-	-	-	-	-	-
Nitrogen	E353.2	-	-	X	-	-	-	-	-	-	-	-	-	-
Oil and grease	E413.20	X	X	-	-	-	-	-	X	-	-	-	-	-
Total organic compounds	E415.1	X	X	-	-	-	-	-	-	-	-	-	-	-
Total organic halogens	SW-846, 9020	X	-	-	-	-	-	-	-	-	-	-	-	-
Moisture	D2218	-	-	-	-	-	-	-	-	-	-	-	-	-

X = analyzed.

- = not analyzed.

(a) Dames and Moore, 1985.

(b) SAIC, 1989b.

(c) HLA, 1989.

(d) HLA, 1990.

(e) Appendix I.

(f) Analysis performed for 53M04 only.

(g) Method E825.

(h) Total and dissolved analyses performed.

(i) Method 239.2.

TABLE 4.4. Floating Petroleum Product Thickness, ST20 E-7 Complex

Well or Probe ^(a)	Date Sampled	Product Thickness (cm)	Comment
20M02	5-28-93	0.00	Product JP-4
20M03	5-28-93	0.00	
20M04	10-30-88	0.00	
	9-5-89	51.8	
	8-21-91	25.9	
	5-28-93	70.4	
20M05	5-28-93	0.00	
20M09	5-28-93	0.00	
20M10	5-28-93	0.00	
20M11	5-28-93	0.00	
20M12	5-28-93	0.00	
20M27	5-28-93	0.00	New monitoring well
20PP08	9-17-89	0.3	
	8-21-91	0.00	
20PP09	9-23-88	21.3	
	9-17-89	23.8	
	8-21-91	0.00	
20PP12	9-23-88	17.7	
	9-17-89	11.3	
	8-21-91	0.00	
	5-28-93	12.2	
20PP14	9-23-88	32.0	
	9-17-89	34.8	
	8-21-91	0.00	
20PP15	9-23-88	19.8	
	9-17-89	15.2	
	8-21-91	0.00	
20PP16	9-23-88	10.1	
	9-17-89	11.9	
	8-21-91	0.00	
20PP17	9-17-89	0.3	
	8-21-91	0.00	
	5-28-93	0.00	
20PP35	9-23-88	0.00	
	9-17-89	0.3	
20PP36	9-23-88	0.00	
	9-17-89	25.3	
53M04	10-30-88	0.00	
	9-6-89	33.5	
	5-28-93	0.00	

M = monitoring well.

PP = product probe.

(a) product probes listed here are all located within the floating product extent.

TABLE 4.5. Monitoring Wells, ST20 E-7 Complex

Well	Constructed By/Year	Well Depth (m bls)	Screen Interval (m bls)	Years Sampled
W-3	Dames & Moore/1985	7.3	1.2-7.3	1985 1986
20A-1	SAIC/1986	9.1	1.2-8.8	1986
20A-2	SAIC/1986	9.6	1.2-8.9	1986 1988
20A-3	SAIC/1986	9.6	1.5-9.1	1989 1993
20M02	HLA/1988	7.6	1.4-7.5	1988 1989 1993
20M03	HLA/1988	7.6	1.4-7.5	1988 1989 1993
20M04	HLA/1988	7.6	1.4-7.5	1988 1989 1993
20M05	HLA/1988	7.8	1.5-7.6	1988 1989 1993
20M09	HLA/1988	8.1	1.8-7.9	1988 1989 1993
20M10	HLA/1988	8.2	2.0-8.1	1988 1989 1993
20M11	HLA/1989	4.4	1.2-4.3	1989 1993
20M12	HLA/1989	4.3	1.1-4.1	1989 1993
20M27	CH2M HILL/1993	5.25	1.3-4.8	1993
53M04	HLA/1988	7.6	1.4-7.5	1988 1989 1993
54M01	HLA/1988	7.9	1.7-7.8	NS
54M02	HLA/1988	7.6	1.4-7.5	NS
54M03	HLA/1988	7.8	1.5-7.6	NS
54M04	HLA/1988	7.8	1.5-7.6	NS

NS = not sampled.
The well installed in 1985 has a 50-mm diameter; wells installed in 1986 have a 100-mm diameter. All of the HLA wells installed in 1988 have a 50-mm diameter; 1989 wells have a 100-mm diameter. Wells 54M01 through 54M04 were installed to collect data on hydraulic properties of the aquifer.

TABLE 4.6. Laboratory Analyses Performed, ST20 E-8 Complex

Parameter	Analytical Method	Groundwater				Soil			Surface Soil	Sediment
		1986 ^(a)	1988 ^(b)	1989 ^(c)	1993 ^(d)	1986 ^(a)	1988 ^(b)	1989 ^(b)	1993 ^(d)	1993 ^(d)
Halogenated volatile organics	SW-846, 8010	-	-	-	X	-	-	-	-	X
Aromatics volatile organics	SW-846, 8020	-	X	X	X	-	-	-	-	X
Volatile organic compounds	SW-846, 8240	X	-	-	-	X ^(a)	X	-	-	-
Semivolatile organic compounds	SW-846, 8270	-	X	X	X	-	-	X	X	X
Organochlorine pesticides and PCBs	SW-846, 8080	-	-	-	-	-	-	-	X	X
Hydrocarbon fingerprint	SW-846, 8015	-	X	-	-	-	-	-	-	-
Petroleum hydrocarbons	E418.1	X	X	X	-	-	X	X	-	-
TPH - gas range	AK101	-	-	-	-	-	-	-	-	-
TPH - diesel range	AK102	-	-	-	-	-	-	-	-	-
Arsenic	SW-846, 7080	-	-	-	X	-	-	-	-	X
Lead	SW-846, 7421	-	-	-	X	-	-	-	-	X
Mercury	SW-846, 7470	-	-	-	X	-	-	-	-	X
ICP metals scan	SW-846, 6010	-	-	-	X	-	-	-	-	X
Total dissolved solids	E160.1	-	X	-	-	-	-	-	-	-
Common anions	E300	-	-	-	-	-	-	-	-	-
Nitrogen	E353.2	-	X	-	-	-	-	-	-	-
Oil and grease	E413.2	X	-	-	-	-	-	-	-	-
Total organic compounds	E415.1	X	-	-	-	-	-	-	-	-
Total organic halogens	SW-846, 9020	-	-	-	-	-	-	-	-	-
Moisture	D2216	-	-	-	-	-	-	-	-	-

X = analyzed.
- = not analyzed.
(a) SAIC, 1989b.
(b) HLA, 1989.
(c) HLA, 1990.
(d) Appendix I.
(e) Method E624.

TABLE 4.7. Floating Petroleum Product Thickness, ST20 E-8 Complex			
Well or Probe	Date Sampled	Product Thickness (cm)	Comment
20M06	9-25-88	0.00	
	9-6-89	17.68	
	10-8-89	15.24	
	8-21-91	0.00	
	5-28-93	0.00	
20M13	5-28-93	0.00	
20M14	5-28-93	0.00	
20M15	5-28-93	0.00	
20M16	5-28-93	0.00	
20M18	5-28-93	0.00	
20M19	5-28-93	0.00	
20PP48	5-28-93	0.00	
20PP49	5-28-93	0.00	
20PP50	5-28-93	0.00	
20PP51	10-8-89	0.31	
	10-27-89	0.31	
	5-28-93	0.00	
20PP52	10-27-89	0.31	
	5-28-93	0.00	
20PP54	5-28-93	0.00	
20PP55	5-28-93	0.00	
20PP56	5-28-93	0.00	
20PP77	5-28-93	0.00	
20PP78	5-28-93	0.00	
20PP79	10-27-89	0.31	
	5-28-93	0.00	
20PP80	10-27-89	0.31	No water present in probe
	5-28-93	ND	
M = monitoring well. ND = not determined. PP = product probe.			

TABLE 4.8. Monitoring Wells, ST20 E-8 Complex

Well	Constructed By/Year	Well Depth (m bls)	Screen Interval (m bls)	Years Sampled
20B-1	SAIC/1986	9.1	1.2-8.8	1986
20B-2	SAIC/1986	9.6	1.2-8.9	1986
20B-3	SAIC/1086	9.6	1.5-9.2	1986
20M06	HLA/1988	7.5	1.2-7.3	1988 1989 1993
20M13	HLA/1989	5.0	1.8-4.9	1989 1993
20M14	HLA/1089	4.9	1.7-4.7	1989 1993
20M15	HLA/1089	4.4	1.2-4.3	1989 1993
20M16	HLA/1989	4.4	1.2-4.3	1989
20M17	HLA/1989	4.1	0.9-4.0	1989
20M18	HLA/1989	3.7	0.5-3.5	1989
20M19	HLA/1989	3.8	0.6-3.7	1989

Wells installed in 1986 have a 100-mm diameter. All of the HLA wells installed in 1988 have a 50-mm diameter; 1989 wells have a 100-mm diameter.

TABLE 4.9. Laboratory Analyses Performed, ST20 E-9 Complex

Parameter	Analytical Method	Groundwater				Soil			Surface Soil	Sediment
		1986 ^(a)	1989 ^(a)	1993 ^(a)	1993 ^(a)	1986 ^(a)	1989 ^(a)	1993 ^(a)	1993 ^(a)	1993 ^(a)
Halogenated volatile organics	SW-946, 8010	-	-	X	-	-	-	X	X	X
Aromatic volatile organics	SW-946, 8020	-	X	X	-	-	-	X	X	X
Volatile organic compounds	SW-946, 8240	X	-	-	X ^(a)	-	-	-	-	-
Semivolatile organic compounds	SW-946, 8270	-	X	X	-	-	-	X	X	X
Organochlorine pesticides and PCBs	SW-946, 8080	-	-	-	-	-	-	X	X	X
Hydrocarbon fingerprint	SW-946, 8015	-	-	-	-	-	-	-	-	-
Petroleum hydrocarbons	E418.1	X	X	-	-	-	-	X	X	-
TPH - gas range	AK101	-	-	-	-	-	-	X	X	X
TPH - diesel range	AK102	-	-	-	-	-	-	X	X	X
Arsenic	SW-946, 7060	-	-	X	-	-	-	X	X	X
Lead	SW-946, 7421	-	-	X	-	-	-	X	X	X
Mercury	SW-946, 7470	-	-	X	-	-	-	X	X	X
ICP metals scan	SW-946, 6010	-	-	X	-	-	-	X	X	X
Total dissolved solids	E160.1	-	X	-	-	-	-	-	-	-
Common anions	E300	-	-	-	-	-	-	-	-	-
Nitrogen	E353.2	-	X	-	-	-	-	-	-	-
Oil and grease	E413.2	X	-	-	-	-	-	-	-	-
Total organic compounds	E415.1	X	-	-	-	-	-	-	X	-
Total organic halogens	SW-946, 9020	-	-	-	-	-	-	-	-	-
Moisture	D2216	-	-	-	-	-	-	-	-	-

X = analyzed.
- = not analyzed.
(a) SAIC, 1989b.
(b) HLA, 1989.
(c) HLA, 1990.
(d) Appendix I.
(e) Method E624.

TABLE 4.10. Floating Petroleum Product Thickness, ST20 E-9 Complex

Well or Probe	Date Sampled	Product Thickness (cm)	Comment
20M01	10-30-88 ^(a)	7.62	
	04-09-89 ^(a)	4.27	
	10-10-89 ^(a)	9.14	
	08-21-91	0.00	
	06-17-92 ^(b)	0.00	
	08-03-92 ^(b)	0.00	
	08-28-92 ^(b)	0.00	
	09-17-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
	5-28-93	0.00	
20M07	10-30-88 ^(a)	0.00	
	09-01-89 ^(a)	51.8	
	10-10-89 ^(a)	48.8	
	08-21-91	28.7	
	06-17-92 ^(b)	39.9	
	08-03-92 ^(b)	39.6	
	08-19-92 ^(b)	26.8	
	08-28-92 ^(b)	40.8	
	09-17-92 ^(b)	7.01	
	09-23-92 ^(b)	9.75	
	10-22-92 ^(b)	27.4	
	10-27-92 ^(b)	29.6	
	5-28-93	0.00	
20M08	10-27-92 ^(b)	0.00	
	5-28-93	0.00	
20M20	5-28-93	0.00	
20M21	10-27-92 ^(b)	0.00	
	5-28-93	0.00	
20M22	5-28-93	0.00	
20M23	5-28-93	0.00	
20M25	09-18-89 ^(a)	43.0	
	06-17-92 ^(a)	sheen	
	08-03-92 ^(b)	0.00	
	08-19-92 ^(b)	0.00	
	08-28-92 ^(b)	0.00	
	09-17-92 ^(b)	8.84	
	09-23-92 ^(b)	11.0	
	10-16-92 ^(b)	7.62	
	10-22-92 ^(b)	9.75	
	10-24-92 ^(b)	13.1	
	10-26-92 ^(b)	12.5	
	10-27-92 ^(b)	5.49	
20MW26	5-28-93	0.00	New monitoring well
20PP57	09-10-89 ^(a)	0.84	
20PP58	5-28-93	0.00	
20PP60	09-10-89 ^(a)	6.40	
20PP61	09-10-89 ^(a)	0.00	
	06-18-92 ^(b)	9.14	
	08-03-92 ^(b)	30.5	
	08-19-92 ^(b)	27.7	
	08-28-92 ^(b)	28.0	
	09-17-92 ^(b)	28.7	
	5-28-93	0.31	

TABLE 4.10. Floating Petroleum Product Thickness, ST20 E-9 Complex

Well or Probe	Date Sampled	Product Thickness (cm)	Comment
20M01	10-30-88 ^(a)	7.62	
	04-09-89 ^(a)	4.27	
	10-10-89 ^(a)	9.14	
	08-21-91	0.00	
	06-17-92 ^(b)	0.00	
	08-03-92 ^(b)	0.00	
	08-28-92 ^(b)	0.00	
	09-17-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
	5-28-93	0.00	
20PP71	09-10-89 ^(a)	17.7	
	06-19-92 ^(b)	30.5	
	08-03-92 ^(b)	18.3	
	08-19-92 ^(b)	21.6	
	08-28-92 ^(b)	23.2	
	09-17-92 ^(b)	20.7	
	5-28-93	14.6	
20PP72	09-10-89 ^(a)	17.7	
	06-19-92 ^(b)	25.9	
	08-03-92 ^(b)	15.2	
	08-19-92 ^(b)	14.6	
	08-28-92 ^(b)	20.4	
	09-17-92 ^(b)	17.4	
	5-28-93	5.49	
20PP73	09-10-89 ^(a)	38.4	
	06-19-92 ^(b)	62.5	
	08-03-92 ^(b)	33.5	
	08-19-92 ^(b)	22.0	
	08-28-92 ^(b)	28.7	
	5-28-93	1.83	
			Bottom of probe: 8 ft
20PP74	09-10-89 ^(a)	2.74	
	06-19-92 ^(b)	0.00	
	08-03-92 ^(b)	33.5	
	08-19-92 ^(b)	39.6	
	08-28-92 ^(b)	40.8	
	09-17-92 ^(b)	37.8	
	5-28-93	25.0	
20PP76	09-10-89 ^(a)	34.4	
20PP101	08-20-92 ^(b)		
	08-21-92 ^(b)	0.00	
	08-22-92 ^(b)	0.00	
	08-24-92 ^(b)	0.31	
	08-28-92 ^(b)	0.31	
	09-17-92 ^(b)	0.00	
	5-28-93	0.31	
20PP102	09-17-92 ^(b)	0.00	
	5-28-93	4.88	
20PP103	09-17-92 ^(b)	0.31	
	5-28-93	0.00	
20PP104	09-17-92 ^(b)	0.91	
	5-28-93	16.2	
20PP105	09-17-93 ^(b)	0.00	
	5-28-93	0.00	

TABLE 4.10. Floating Petroleum Product Thickness, ST20 E-9 Complex			
Well or Probe	Date Sampled	Product Thickness (cm)	Comment
20M01	10-30-88 ^(a)	7.62	
	04-09-89 ^(a)	4.27	
	10-10-89 ^(a)	9.14	
	08-21-91	0.00	
	06-17-92 ^(b)	0.00	
	08-03-92 ^(b)	0.00	
	08-28-92 ^(b)	0.00	
	09-17-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
	5-28-93	0.00	
20PP106	08-21-92 ^(b)	0.31	
	08-22-92 ^(b)	0.00	
	08-24-92 ^(b)	0.31	
	08-28-92 ^(b)	0.31	
	09-17-92 ^(b)	0.91	
	5-28-93	3.66	
20PP107	09-17-92 ^(b)	0.00	
	5-28-93	0.00	
20PP108	08-21-92 ^(b)	0.31	
	08-22-92 ^(b)	0.31	
	08-24-92 ^(b)	1.22	
	08-28-92 ^(b)	0.31	
	09-17-92 ^(b)	0.31	
	5-28-93	10.7	
20PP109	08-21-92 ^(b)	0.00	
	08-22-92 ^(b)	0.31	
	08-24-92 ^(b)	0.91	
	08-28-92 ^(b)	0.31	
20PP110	09-17-92 ^(b)	0.00	
	5-28-93	14.6	
20PP111	08-22-92 ^(b)	3.35	
	08-24-92 ^(b)	20.4	
	08-28-92 ^(b)	17.1	
	09-17-92 ^(b)	16.8	
	09-23-92 ^(b)	19.2	
	10-22-92 ^(b)	9.75	
	5-28-93	0.91	
20PP112	09-17-92 ^(b)	0.31	
	5-28-93	22.0	
20PP113	08-22-92 ^(b)	0.00	
	08-24-92 ^(b)	0.91	
	09-17-92 ^(b)	1.22	
	5-28-93	24.1	
20PP114	10-16-92 ^(b)	0.00	
	5-28-93	2.44	
20PP115	10-16-92 ^(b)	0.00	
	5-28-93	0.00	
20PP116	10-16-92 ^(b)	0.00	
	5-28-93	2.13	
20PP117	10-16-92 ^(b)	0.00	
	5-28-93	0.00	
20PP118	10-24-92 ^(b)	30.5	
	10-26-92 ^(b)	31.4	
	5-28-93	10.1	

TABLE 4.10. Floating Petroleum Product Thickness, ST20 E-9 Complex			
Well or Probe	Date Sampled	Product Thickness (cm)	Comment
20M01	10-30-88 ^(a)	7.62	
	04-09-89 ^(a)	4.27	
	10-10-89 ^(a)	9.14	
	08-21-91	0.00	
	06-17-92 ^(b)	0.00	
	08-03-92 ^(b)	0.00	
	08-28-92 ^(b)	0.00	
	09-17-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
	5-28-93	0.00	
20PP119	09-23-92 ^(b)	5.79	
	10-22-92 ^(b)	57.6	
	10-24-92 ^(b)	52.4	
	10-26-92 ^(b)	54.9	
	5-28-93	98.2	
(a) Gauging information collected by HLA personnel.			
(b) Gauging information collected by EA personnel.			

TABLE 4.11. Monitoring Wells, ST20 E-9 Complex

Well	Constructed By/Year	Well Depth (m bls)	Screen Interval (m bls)	Year Sampled
20C-1	SAIC/1986	9.6	1.5-9.2	1986
20C-2	SAIC/1986	9.1	1.4-9.0	1986 1993
20C-3	SAIC/1986	9.6	1.5-9.0	1986
20M01	HLA/1988	7.6	1.4-7.5	1988 1989 1993
20M07	HLA/1988	7.9	1.7-7.8	1988 1989 1993
20M08	HLA/1988	7.9	1.7-7.8	1988 1989 1993
20M20	HLA/1989	4.3	1.1-4.1	1989 1993
20M21	HLA/1989	4.4	1.2-4.3	1989 1993
20M22	HLA/1989	5.2	2.0-5.0	1989
20M23	HLA/1989	4.9	1.7-4.7	1989 1993
20M24	HLA/1989	4.7	1.5-4.6	1989
20M25	HLA/1989	8.2	2.0-8.0	1989
20MW26	CH2M HILL	5.0	1.6-4.9	1993

SAIC wells installed in 1986 have a 100-mm diameter. All of the HLA wells installed in 1988 have a 50-mm diameter. HLA wells installed in 1989 have a 100-mm diameter, except for extraction well 20M25, which has a 200-mm diameter.

TABLE 4.12. Laboratory Analyses Performed, ST48

Parameter	Analytical Method	Groundwater			Soil		Surface Soil	Sediment
		1988 ^(a)	1989 ^(b)	1993 ^(c)	1988 ^(a)	1989 ^(b)	1993 ^(c)	1993 ^(c)
Halogenated volatile organics	SW-846, 8010	X	-	X	-	-	X	X
Aromatic, volatile organics	SW-846, 8020	X	X	X	-	-	X	X
Volatile organic compounds	SW-846, 8240	-	-	-	X	-	-	-
Semivolatile organic compounds	SW-846, 8270	X	X	X	X	-	X	X
Organochlorine pesticides and PCBs	SW-846, 8080	-	-	-	X ^(d)	-	-	X
Hydrocarbon fingerprint	SW-846, 8015	X	-	-	-	-	-	-
Petroleum hydrocarbons	E418.1	X	X	-	X	X	-	-
TPH - gas range	AK101	-	-	-	-	-	X	X
TPH - diesel range	AK102	-	-	-	-	-	X	X
Arsenic	SW-846, 7060	X ^(e,f)	-	X	-	-	X	X
Lead	SW-846, 7421	X ^(e)	-	X	X ^(g)	-	X	X
Mercury	SW-846, 7470	X ^(e,f)	-	X	-	-	X	X
ICP metals scan	SW-846, 6010	X ^(e,f)	-	X	-	-	X	X
Total dissolved solids	E160.1	X	-	-	-	-	-	-
Common anions	E300	X ^(f)	-	-	-	-	-	-
Nitrogen	E353.2	X	-	-	-	-	-	-
Oil and grease	E413.2	-	-	-	-	-	-	-
Total organic compounds	E415.1	-	-	-	-	-	-	-
Total organic halogens	SW-846, 9020	-	-	-	-	-	-	-
Moisture	D2216	-	-	-	-	-	-	-

X = analyzed.

- = not analyzed.

(a) HLA, 1989.

(b) HLA, 1990.

(c) Appendix I.

(d) Analysis only performed on 1 soil sample from well 53M03 boring.

(e) Total and dissolved analyses performed.

(f) Analysis only performed on sample from well 53M03.

(g) Lead analysis performed on all well boring soil samples except well 53M03.

TABLE 4.13. Floating Petroleum Product Thickness, ST48

Well or Probe ^(a)	Date Sampled	Product Thickness (cm)	Comment
18-6	5-28-93	0.00	
48M01	9-23-88	0	
	10-9-89	3.35	
	8-20-91	24.4	
	8-28-91	19.2	
	8-22-91	3.66	
	5-28-93	0.00	
48M03	5-28-93	0.00	
48M04	5-28-93	0.00	
48M05	5-28-93	0.00	
48M06	5-28-93	0.00	
48M07	5-28-93	0.00	
53M03	5-28-93	5.49	
48MW08	5-28-93	0.00	New monitoring well
48PP01	9-23-88	2.74	
48PP06	9-23-88	12.8	
	9-17-89	8.53	
	10-22-89	8.23	
48PP08	9-23-88	18.9	
	11-1-88	21.3	
	9-17-89	21.6	
	10-22-89	24.1	
	8-20-91	22.9	
	10-10-91	22.0	
48PP09	9-23-88	20.7	
	11-1-88	22.9	
	9-17-89	40.2	
	10-22-89	38.7	
	8-20-91	46.0	
	5-28-93	12.5	
48PP11	11-1-88	3.35	
	9-17-89	16.5	
	10-22-89	17.4	
48PP13	5-28-93	0.00	
48PP27	5-28-93	0.00	
48PP28	9-23-88	3.35	
	10-31-88	8.84	
	9-17-89	18.6	
	11-22-89	3.66	
	5-28-93	43.6	
10-1	8-28-91	5.79	
10-8	8-28-91	40.2	
48PP64	11-22-89	0.61	
48PP67	5-28-93	0.00	Bent, obstruction at 8.25 ft
48PP68	11-22-89	3.35	

(a) Additional monitoring wells were installed by Jacobs Engineering during 1992. No product thickness measurements from the new wells were available.

TABLE 4.14. Monitoring Wells, ST48

Well	Constructed By/Year	Well Depth (m bls)	Screen Interval (m bls)	Year Sampled
48M01	HLA/1988	8.7	2.4-8.5	1988 1989
48M02	HLA/1988	7.0	3.8-6.9	1988 1989
48M03	HLA/1988	6.7	3.5-6.6	1988 1989 1993
48M04	HLA/1988	7.0	3.8-6.7	1988 1989 1993
48M05	HLA/1988	14.6	11.4-14.5	1988 1989 1993
48M06	HLA/1988	30.3	27.1-30.2	1988 1989 1993
48M07	HLA/1989	4.9	1.8-4.9	1989 1993
48M08	CH2M HILL/1993	7.0	3.2-6.5	1993
53M03	HLA/1988	6.2	3.1-6.1	1988 1989 1993
18-6	SAIC/1987	6.3	0.2-6.3	1987 1991 1993
All monitoring wells installed in 1988 have a 50-mm diameter; the well installed in 1989 has a 100-mm diameter.				

TABLE 4.15. Fly Ash Results for Coal from the Healy Mine Alaska

Constituent	Sample and Analytical Lab			
	Sample 1 Brooks AFB (mg/L)	Sample 2 Hazen (mg/L)	Sample 3 TAKU-FA-A (mg/L)	Sample 4 TAKU-FA-B (mg/L)
Arsenic	<0.1	0.002	<0.005	<0.005
Barium	1.67	0.763	0.6	<0.4
Cadmium	<0.1	0.057	<0.08	<0.08
Chromium	0.24	0.2	0.07	0.04
Lead	<0.3	0.3	<0.2	<0.2
Mercury	<0.01	<0.0001	<0.05	<0.05
Selenium	0.015	0.001	0.006	<0.005
Silver	<0.1	0.02	<0.04	<0.04

TABLE 4.16. Site Data Used for the Fate and Transport Assessment, ST48

Source-Term Information		
Source-term length	60 m	Estimated
Source-term width	30 m	Estimated
Distance to well D	171 m	Estimated
Benzene mass	153 kg	Estimated
Saturated Zone		
Thickness of contamination	6.1 m	Assumed
Aquifer thickness	60.1 m	Assumed
Pore-water velocity	50.0 cm/d	Modeling
Total porosity	43.7%	Droppo et al., 1989
Effective porosity	30.0%	Assumed
Bulk density	1.60 g/cm ³	Droppo et al., 1989

TABLE 4.17. Results of Model Calibration, ST48

Distance, Lx (m)	50	100	145	Estimated
x-Dispersivity ^(a) (m)	1.25	2.5	3.63	Modeling
y-Dispersivity ^(b) (m)	0.25	0.5	0.73	Modeling
Distribution coefficient, Kd, for benzene (mL/g)	4.0	4.0	4.0	Modeling
Benzene flux rate (g/year)	4800	4800	4800	Modeling
Benzene concentrations from isopleths (µg/L)	1000	100	5	U.S. Air Force, 1994
Model benzene concentration (µg/L)	985	101	5	Modeling
(a) x-Dispersivity = 0.025 (Lx), Lx = travel distance. (b) y-Dispersivity = 0.2 (x-Dispersivity).				

TABLE 4.19. Laboratory Analyses Performed, ST49

Parameter	Analytical Method	Groundwater			Surface Water	Soil		Surface Soil	Sediment
		1988 ^(a)	1989 ^(b)	1993 ^(c)	1993 ^(d)	1988 ^(a)	1989 ^(b)	1993 ^(e)	1993 ^(f)
Halogenated volatile organics	SW-846, 8010	X	X	X	X	-	-	X	X
Aromatic volatile organics	SW-846, 8020	X	X	X	X	-	-	X	X
Nonhalogenated volatile organics	SW-846, 8015	X	-	-	-	-	-	-	-
Volatile organic compounds	SW-846, 8240	-	-	-	-	X	-	-	-
Semivolatile organic compounds	SW-846, 8270	X	X	X	-	-	-	X	X
Polycyclic aromatic hydrocarbons	SW-846, 8310	-	X	-	-	-	-	-	-
Organochlorine pesticides and PCBs	SW-846, 8080	-	-	-	-	X ^(d)	-	X	-
Hydrocarbon fingerprint	SW-846, 8015	X ^(g)	-	-	-	-	-	-	-
Petroleum hydrocarbons	E418.1	X	X	-	-	X	X	-	-
TPH - gas range	AK101	-	-	-	-	-	-	X	X
TPH - diesel range	AK102	-	-	-	-	-	-	X	X
Arsenic	SW-846, 7060	X ^(f,g)	-	X	X	-	-	X	X
Lead	SW-846, 7421	X ^(f,g)	-	X	X	-	-	X	X
Mercury	SW-846, 7470	X ^(f,g)	-	X	X	X	-	X	X
ICP metals scan	SW-846, 6010	X ^(f,g)	-	X	X	X	-	X	X
Total dissolved solids	E160.1	X	-	-	-	-	-	-	-
Common anions	E300	X ^(g)	-	-	-	-	-	-	-
Nitrogen	E353.2	X	-	-	-	-	-	-	-
Oil and grease	E413.2	-	-	-	-	-	-	-	-
Total organic compounds	E415.1	-	-	-	-	-	-	X	-
Total organic halogens	SW-846, 8020	-	-	-	-	-	-	-	-
Moisture	D2216	-	-	-	-	-	-	-	-

X = analyzed.

- = not analyzed.

(a) HLA, 1989.

(b) HLA, 1990.

(c) Appendix I.

(d) Analysis only performed on two soil samples from well 53M05 boring.

(e) Modified SW8015.

(f) Total and dissolved analyses performed.

(g) Analysis only performed on sample from well 53M05.

TABLE 4.19. Floating Petroleum Product Thickness, ST49

Well or Probe ^(a)	Date Sampled	Product Thickness (cm)	Comment
49M01	6-18-92 ^(b)	0.00	
	8-21-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
	5-28-93	0.00	
49M02	9-23-88	39.0	
	10-28-88	65.5	
	9-18-89	18.6	
	8-20-91	18.9	
	6-18-92 ^(b)	4.27	
	8-18-92 ^(b)	11.3	
	8-21-92 ^(b)	8.53	
	8-24-92 ^(b)	9.14	
	10-01-92 ^(b)	12.5	
	10-22-92 ^(b)	23.2	
	10-23-92 ^(b)	23.8	
	10-24-92 ^(b)	17.7	
	10-26-92 ^(b)	20.7	
	10-27-92 ^(b)	18.9	
	11-20-92 ^(b)	19.8	
	01-25-93 ^(b)	14.0	
	02-04-93 ^(b)	13.1	
	02-16-93 ^(b)	13.1	
	02-25-93 ^(b)	11.0	
	5-28-93	0.00	
49M03	6-17-92 ^(b)	0.00	
	8-21-92 ^(b)	0.00	
	5-28-93	0.00	
49M04	6-17-92 ^(b)	0.00	
	8-21-92 ^(b)	0.00	
	5-28-93	0.00	
49M05	6-18-92 ^(b)	0.00	
	8-21-92 ^(b)	0.00	
	5-28-93	0.00	
49M06	9-22-89	2.44	
	8-20-91	0.00	
	6-18-92 ^(b)	0.00	
	8-18-92 ^(b)	0.00	
	8-21-92 ^(b)	0.00	
	10-22-92 ^(b)	0.00	
	5-28-93	0.00	
53M05	6-18-92 ^(b)	0.00	
	8-21-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
	5-28-93	0.00	

TABLE 4.19. Floating Petroleum Product Thickness, ST49

Well or Probe ^(a)	Date Sampled	Product Thickness (cm)	Comment
49GMW	9-23-88	57.6	Headspace reading: 0.00 ppm OVM
	10-28-88	43.3	
	8-20-91	NM	
	6-18-92 ^(b)	64.9	
	8-18-92 ^(b)	9.75	
	8-21-92 ^(b)	12.8	
	8-24-92 ^(b)	14.0	
	10-01-92 ^(b)	5.79	
	10-22-92 ^(b)	0.00	
	10-24-92 ^(b)	0.00	
	10-26-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
	11-20-92 ^(b)	0.91	
	01-13-93 ^(b)	0.61	
	01-25-93 ^(b)	0.91	
	02-04-93 ^(b)	0.31	
	02-16-93 ^(b)	0.31	
	02-25-93 ^(b)	1.22	
	5-28-93	0.00	
49PP24	9-23-88	34.4	Product probe destroyed
	10-28-88	35.7	
	9-22-89	NM	
49PP26	8-21-92 ^(b)	0.00	
	5-28-93	0.00	
49PP40	6-18-92 ^(b)	0.00	
	8-21-92 ^(b)	0.00	
	5-28-93	0.00	
49PP41	6-18-92 ^(b)	0.00	
	8-18-92 ^(b)	0.00	
	8-21-92 ^(b)	0.00	
	10-22-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
	5-28-93	0.00	
49PP42	6-18-92 ^(b)	0.00	
	8-21-92 ^(b)	0.00	
	10-22-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
	5-28-93	0.00	
49PP43	6-18-92 ^(b)	0.00	
	8-18-92 ^(b)	0.00	
	8-21-92 ^(b)	0.00	
	10-22-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
	5-28-93	0.00	
49PP44	5-28-93	0.00	
49PP45	6-18-92 ^(b)	0.00	
	8-21-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
	5-28-93	0.00	
49PP46	5-28-93	0.00	
49PP47	9-22-89	8.53	
49PP101	8-21-92 ^(b)	0.00	
	8-24-92 ^(b)	0.00	

TABLE 4.19. Floating Petroleum Product Thickness, ST49

Well or Probe ^(a)	Date Sampled	Product Thickness (cm)	Comment
49PP102	8-21-92 ^(b)	0.00	
	8-24-92 ^(b)	0.00	
49PP103	8-21-92 ^(b)	0.00	
	8-24-92 ^(b)	0.00	
49PP104	8-21-92 ^(b)	0.00	
	8-24-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
49PP105	8-21-92 ^(b)	0.00	
	8-24-92 ^(b)	0.00	
49PP106	10-23-92 ^(b)	3.66	
	10-24-92 ^(b)	3.05	
	10-26-92 ^(b)	3.66	
	10-27-92 ^(b)	3.05	
	01-13-93 ^(b)	1.52	
	01-25-93 ^(b)	1.52	
	02-04-93 ^(b)	1.52	
	02-16-93 ^(b)	1.83	
49PP107	02-25-93 ^(b)	0.91	
	10-24-92 ^(b)	0.00	
	10-26-92 ^(b)	0.00	
	10-27-92 ^(b)	0.00	
	01-13-93 ^(b)	0.00	
	01-25-93 ^(b)	0.00	
	02-04-93 ^(b)	0.00	
	02-16-93 ^(b)	0.00	
	02-25-93 ^(b)	0.00	

NM = not measured.
 OVM = organic vapor monitor.
 (a) Five additional probes were installed by EA during 1992. No product thickness measurements from the new probes were available.
 (b)

TABLE 4.20. Monitoring Wells, ST49

Well	Constructed By/Year	Well Depth (m bls)	Screen Interval (m bls)	Year Sampled
49M01	HLA/1988	7.3	1.1-7.2	1988 1989 1993
49M02	HLA/1988	9.0	2.7-8.8	1988 1989 1993
49M03	HLA/1988	8.2	2.0-8.1	1988 1989 1993
49M04	HLA/1988	7.6	1.4-7.5	1988 1989 1993
49M05	HLA/1989	5.2	2.0-5.0	1989 1993
49M06	HLA/1989	8.4	2.1-8.2	1989 1993
53M05	HLA/1988	7.6	1.4-7.5	1988 1989 1993

Wells installed in 1988 have 50-mm diameter; well 49M05 has a 100-mm diameter; well 49M06 has an 200-mm diameter.

TABLE 4.21. Site Data Used for the Fate and Transport Assessment, ST49

Source-term Information		
Source-term length	97.5 m	Assumed
Source-term width	41.5 m	Assumed
Distance to monitoring well 49M05	110 m	Estimated
Benzene mass	8 kg	Modeling
Saturated Zone		
Thickness of contamination	6.1 m	Assumed
Pore-water velocity	14.5 cm/day	Estimated
Total porosity	43.7 %	Droppo et al., 1989
Effective porosity	30.0 %	Assumed
Bulk density	1.60 g/cm ³	Droppo et al., 1989

TABLE 4.22. Results of Model Calibration, ST49		
Distance, Lx, to well 49M05 (m)	110	Estimated
x-Dispersivity ^a (m)	5.50	Modeling
y-Dispersivity ^b (m)	1.10	
Distribution coefficient, Kd, for benzene (mL/g)	3.9	Modeling
^a x-Dispersivity = 0.05 (Lx), Lx = travel distance. ^b y-Dispersivity = 0.2 (x-Dispersivity).		

TABLE 4.23. Laboratory Analyses Performed, Blair Lakes Target Facility

Parameter	Analytical Method	Groundwater			Soil		Surface Soil	Sediment
		1988 ^(a)	1989 ^(b)	1993 ^(c)	1988 ^(a)	1989 ^(b)	1993 ^(c)	1993 ^(c)
Halogenated volatile organics	SW8010	X	X	X	-	-	-	X
Aromatic, volatile organics	SW8020	X	X	X	-	-	-	X
Volatile organic compounds	SW8240	-	-	-	X	X ^(d)	-	-
Semivolatile organic compounds	SW8270	X	X	X	X	X	X	X
Organochlorine pesticides and PCBs	SW8080	-	-	-	-	-	X	X
Hydrocarbon fingerprint	SW8015	X	-	-	-	-	-	-
Petroleum hydrocarbons	E418.1	X	X	-	X	X	-	-
TPH - gas range	AK101	-	-	-	-	-	X	X
TPH - diesel range	AK102	-	-	-	-	-	X	X
Arsenic	SW7060	-	-	X	-	-	X	X
Lead	SW7421	X	-	X	X	-	X	X
Mercury	SW7470	-	-	X	-	-	X	X
ICP metals scan	SW6010	X	-	X	X	-	X	X
Total dissolved solids	E160.1	X	-	X	-	-	-	-
Common anions	E300	X	-	X	-	-	-	-
Nitrogen	E353.2	X	-	-	-	-	-	-
Oil and grease	E413.2	-	-	-	-	-	-	-
Total organic compounds	E415.1	-	-	X	-	-	X	-
Total organic halogens	SW9020	-	-	-	-	-	-	-
Moisture	D2216	-	-	-	-	-	X	-
Alkalinity	E310.2	-	-	X	-	-	-	-

X = Analyzed.

- = Not analyzed.

(a) HLA, 1989.

(b) HLA, 1990.

(c) Appendix I.

(d) Analysis performed on only five samples from the borings of the four new monitoring wells.

TABLE 4.24. Floating Petroleum Product Thickness, Blair Lakes Target Facility			
Well or Probe^(a)	Date Sampled	Product Thickness (cm)	Comment
50M01	9-30-88	21.3	Well casing heaved
	8-26-91	12.2	
	02-25-92 ^(b)	9.45	
	03-11-92 ^(b)	9.45	
	06-18-92 ^(b)	70.1	
	08-17-92 ^(b)	18.9	
	08-31-92 ^(b)	25.6	
	09-01-92 ^(b)	25.3	
	09-16-92 ^(b)	29.0	
	09-29-92 ^(b)	27.4	
	10-24-92 ^(b)	21.3	
	10-29-92 ^(b)	19.5	
	11-10-92 ^(b)	18.3	
	12-01-92 ^(b)	0.00	
	12-28-92 ^(b)	14.0	
	01-11-93 ^(b)	15.5	
	02-11-93 ^(b)	16.2	
	02-18-93 ^(b)	15.8	
	5-28-93	46.9	
50M02	10-02-89 ^(b)	0.00	
	02-25-92 ^(b)	0.00	
	12-28-92 ^(b)	0.00	
	5-28-93	0.00	
50M03	5-28-93	0.00	
50M04	10-02-89 ^(b)	0.00	
	02-25-92 ^(b)	0.00	
	06-18-92 ^(b)	0.00	
	12-28-92 ^(b)	0.00	
	02-11-93 ^(b)	0.00	
	02-18-93 ^(b)	0.00	
	5-28-93	0.00	
50M05	10-02-89 ^(b)	0.00	
	10-24-89 ^(b)	0.00	
	02-25-92 ^(b)	0.00	
	06-18-92 ^(b)	0.00	
	09-01-92 ^(b)	0.00	
	12-28-92 ^(b)	0.00	
	02-11-93 ^(b)	0.00	
	02-18-93 ^(b)	0.00	
	5-28-93	0.00	
50M06	10-02-89 ^(b)	0.00	
	02-25-92 ^(b)	0.00	
	12-28-92 ^(b)	0.00	
	02-11-93 ^(b)	0.00	
	5-28-93	0.00	

TABLE 4.24. Floating Petroleum Product Thickness, Blair Lakes Target Facility

Well or Probe ^(a)	Date Sampled	Product Thickness (cm)	Comment
50M07	10-02-89 ^(b)	0.00	
	02-25-92 ^(b)	0.00	
	06-18-92 ^(b)	0.00	
	09-01-92 ^(b)	0.00	
	12-28-92 ^(b)	0.00	
	02-11-93 ^(b)	0.00	
	02-18-93 ^(b)	0.00	
	5-28-93	0.00	
50M08	10-02-89 ^(b)	0.00	
	10-24-89 ^(b)	0.00	
	02-25-92 ^(b)	0.00	
	09-01-92 ^(b)	0.00	
	12-28-92 ^(b)	0.00	
	02-11-93 ^(b)	0.00	
	5-28-93	0.00	
50M09	10-02-89 ^(b)	0.00	
50M10	10-02-89 ^(b)	0.00	
	02-25-92 ^(b)	0.00	
	06-18-92 ^(b)	0.00	
	09-01-92 ^(b)	0.00	
	09-16-92 ^(b)	0.00	
	12-28-92 ^(b)	0.00	
	02-11-93 ^(b)	0.00	
	02-18-93 ^(b)	0.00	
	5-28-93	0.00	
50PP02	5-28-93	12.8	
50PP03	5-28-93	55.8	
50PP04	5-28-93	0.00	
50PP05	5-28-93	0.61	
50PP81	8-26-91	22.9	
50PP85	10-10-91	21.3	
	8-26-91	9.75	
	10-10-91	9.14	
50PP101	08-17-92 ^(b)	20.1	
	08-31-92 ^(b)	26.2	
	09-01-92 ^(b)	26.5	
	09-16-92 ^(b)	24.4	
	09-29-92 ^(b)	26.8	

TABLE 4.24. Floating Petroleum Product Thickness, Blair Lakes Target Facility

Well or Probe ^(a)	Date Sampled	Product Thickness (cm)	Comment
50PP102	08-17-92 ^(b)	21.3	
	08-31-92 ^(b)	5.49	
	09-01-92 ^(b)	14.0	
	09-16-92 ^(b)	20.7	
	10-24-92 ^(b)	11.0	
	10-29-92 ^(b)	9.45	
	11-10-92 ^(b)	3.66	
	12-01-92 ^(b)	9.14	
	12-28-92 ^(b)	9.14	
	01-11-93 ^(b)	9.14	
	02-11-93 ^(b)	11.0	
	02-18-93 ^(b)	10.4	
50PP103	08-17-92 ^(b)	31.1	
	08-31-92 ^(b)	31.1	
	09-01-92 ^(b)	29.9	
	09-16-92 ^(b)	42.1	
	09-29-92 ^(b)	42.1	
	10-05-92 ^(b)	25.9	
	10-24-92 ^(b)	29.9	
	10-29-92 ^(b)	27.4	
	11-10-92 ^(b)	25.3	
	12-01-92 ^(b)	22.6	
	12-28-92 ^(b)	22.6	
	01-11-93 ^(b)	22.9	
	02-11-93 ^(b)	22.3	
	02-18-93 ^(b)	19.2	
50PP104	08-17-92 ^(b)	0.00	
	08-31-92 ^(b)	0.00	
	09-01-92 ^(b)	0.00	
	09-16-92 ^(b)	0.00	
50PP105	08-31-92 ^(b)	2.44	
	09-01-92 ^(b)	2.13	
	09-16-92 ^(b)	19.8	
50PP106	08-17-92 ^(b)	0.00	
	08-31-92 ^(b)	0.00	
	09-01-92 ^(b)	0.00	
	09-16-92 ^(b)	0.00	
(a) Additional product probes were installed by EA during 1992. No product thickness measurements from the new probes were available.			
(b)			

TABLE 4.25. Monitoring Wells, Blair Lakes Target Facility

Well	Constructed By/Year	Well Depth (m bls)	Screen Interval (m bls)	Years Sampled
50M01	HLA/1988	4.9	2.4-4.9	1988 1989
50M02	HLA/1988	5.3	2.1-5.2	1988 1989
50M04	HLA/1988	4.6	1.4-4.4	1988 1989
50M05	HLA/1988	3.4	1.7-3.2	1988 1989
50M06	HLA/1988	4.6	1.4-4.4	1988 1989
50M07	HLA/1989	4.0	1.7-4.0	1989
50M08	HLA/1989	4.3	1.1-4.1	1989
50M09	HLA/1989	4.8	1.6-4.6	1989
50M10	HLA/1989	4.4	1.4-4.4	1989

All wells installed in 1988 have a 50-mm diameter; wells installed in 1989 have a 100-mm diameter.

TABLE 4.26. Site Data Used for the Fate and Transport Assessment, SS53

Source-Term Information		
Source-term length	13.0 m	Assumed
Source-term width	13.0 m	Assumed
Distance to well 50M02	18.4 m	Estimated
Benzene mass based on soil diesel contamination	7.1 g	Estimated
Thickness of contamination	6.1 m	Assumed
Pore-water velocity (permafrost region)	8.2-131 cm/day	Estimated
Total porosity	43.7%	Assumed
Effective porosity	30%	Assumed
Bulk density	1.6 g/cm ³	Assumed
Dispersivity (longitudinal direction)	1.84 m	Droppo et al., 1989
Dispersivity (lateral direction)		Droppo et al., 1989
K _d for benzene	0.37 m 0.41 mL/g	Assumed

FIGURE 4.1. Well and Probe Locations, 1989 and 1993 Product Measurements, Concentrations in Groundwater, ST20 E-7 Complex

FIGURE 4.2. Groundwater Monitoring Wells and Benzene Concentrations in Groundwater, ST20 E-7 Complex

S9302085.1

FIGURE 4.3. (Contd)

FIGURE 4.4. Facilities, Groundwater Monitoring Wells, and Benzene Concentrations in Groundwater, ST20 E-8 Complex

FIGURE 4.6. Facilities, Groundwater Monitoring Wells, and Benzene Concentrations in Groundwater, ST20 E-9 Complex

FIGURE 4.7. Facilities, Groundwater Monitoring Wells, Product Probes, and Floating Product Measurements, ST20 E-9 Complex

FIGURE 4.8. Soil Gas Sampling Points (Total Volatile Organic Compound Concentrations in ppm), May 1993, ST20 E-9 Complex

FIGURE 4.10. Facilities, Groundwater Monitoring Wells, and Total Petroleum Hydrocarbon Soil Concentrations, ST48

FIGURE 4.11. Benzene Concentrations in Groundwater, 1989 Field Season, ST48

FIGURE 4.12. Trichloroethene in Groundwater, May 1993, ST48

FIGURE 4.14. Total Volatile Hydrocarbon Concentrations (ppm) and Soil Gas Survey Locations, 1993 Field Season, ST48

FIGURE 4.15. Pesticides, ST48

FIGURE 4.16. Total Unfiltered Lead Concentrations from Groundwater Monitoring Wells, ST48

FIGURE 4.17. Metal Concentrations in Groundwater, May 1993, ST48

Groundwater benzene concentration varying with longitudinal travel distance at ST48.

FIGURE 4.18. Benzene Concentration Versus Distance, ST48

Temporally varying benzene concentration simulated at Base Supply Well D,
171 m from the ST48 source.

FIGURE 4.19. Benzene Concentration Versus Time, ST48

FIGURE 4.20. Facilities, Nearby Features, Groundwater Monitoring Wells, and TPH Measurements from 1989 Borehole Sediments, ST49

FIGURE 4.21. Facilities, Nearby Features, Groundwater Monitoring Wells, and Benzene Groundwater Concentrations, ST49

FIGURE 4.22. Soil Gas Survey Locations and Total Volatile Hydrocarbon Measurements from the Field Season, ST49

FIGURE 4.23. Pesticides in Soil, May 1993, ST49

FIGURE 4.24. Trichloroethene in Groundwater, ST49

Temporally varying benzene concentration simulated at monitoring well 49M05, 110 m from the ST49 source.

FIGURE 4.25. Benzene Versus Time (Simulated) at Well 49M05 (110 m from ST49 Source)

Simulated peak benzene concentration varying with longitudinal travel distance at ST49.

FIGURE 4.26. Benzene Versus Distance, ST49

FIGURE 4.27. Arsenic, iron, and Manganese in Groundwater, Blair Lakes Target Facility

FIGURE 4.28. Floating Petroleum Product Thickness, Blair Lakes Target Facility

FIGURE 4.29. Benzene Concentrations in Groundwater, Blair Lakes Target Facility

FIGURE 4.30. Naphthalene Concentrations in Groundwater, September and October 1989, Blair Lakes Target Facility

Groundwater benzene concentrations at two different pore-water velocities simulated at well 50M02.

FIGURE 4.31. Benzene Versus Time at Two Different Pore-Water Velocities (Simulated) at Well 50M02

5.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

An important step in the development of preliminary remediation goals is the consideration of potential ARARs that identify acceptable exposure levels for protection of human health and the environment. Under CERCLA, remedial actions must be designed and implemented to attain a degree of remediation consistent with the requirements of federal and state environmental laws, regulations, standards, criteria, and limits that are determined to be legally applicable or relevant and appropriate. ARARs may be chemical specific, location specific, or action specific.

The potential ARARs for remedial activities at OU-1 are discussed in the Site Management Plan (U.S. Air Force, 1993b) and the Operable Unit-1 Management Plan (U.S. Air Force, 1993c). This section includes a general listing of chemical- and location-specific requirements that should be considered for each source area. The identification of action-specific requirements is deferred to the feasibility study, because it depends on the selection of remedial measures.

The important ARAR issues that will need to be addressed in the development of preliminary remediation goals for OU-1 are

- groundwater protection—MCLs and maximum contaminant level goals (MCLG) established under the Safe Drinking Water Act
- surface water (Garrison Slough)—federal AWQC for the protection of aquatic life established under the Clean Water Act, and Alaska Water Quality Criteria for aquatic life and wildlife
- petroleum-contaminated soils—Alaska soil cleanup standards and guidelines established for the remediation of petroleum leaks and spills from USTs and other sources, respectively
- location-specific requirements—special requirements for activities affecting sole-source aquifers, wetlands, and flood plains.

5.1 GROUNDWATER PROTECTION

The National Contingency Plan requires that remediation activities conducted under CERCLA restore groundwater to its beneficial use. Maximum contaminant levels are generally considered relevant and appropriate to groundwater that is or may be used as a source of drinking water. Furthermore, the CERCLA amendments indicate that MCLGs must be attained when they are relevant and appropriate under the circumstances of the release. Although the EPA does not consider zero level MCLGs to be appropriate for CERCLA cleanup, nonzero MCLGs may be relevant and appropriate where multiple contaminants or pathways of exposure may increase risk.

At Eielson AFB, the aquifer system has been designated as a sole-source aquifer that is protected for the beneficial use of drinking water supply. Drinking water standards apply at the point of use and therefore are not applicable to the aquifer. However, the MCLs, and potentially the nonzero MCLGs, may be considered relevant and appropriate to the sole-source aquifer.

5.2 SURFACE WATER

Under CERCLA, federal AWQC must be attained when they are relevant and appropriate under the circumstances of the release. In addition, the State of Alaska has promulgated general water quality

criteria for specific classes of protected water use, and has adopted a nondegradation policy for waters of higher quality than the water quality criteria (18 AAC 70).

The only surface water bordering main base OU-1 source areas is Garrison Slough, a drainage ditch that runs the entire length of the base. Garrison Slough does pass near some of the residential areas on the base.

5.3 PETROLEUM-CONTAMINATED SOILS

The State of Alaska has established cleanup standards for leaks and spills of petroleum products from USTs and non-USTs. These standards are also used by Alaska as numeric guidance for the cleanup of petroleum products from other types of releases (ADEC, 1991). The required cleanup level for a specific spill or leak is determined by the ADEC Regional Supervisor (18 AAC 75.140). The guidance includes numeric soil cleanup target levels for TPH (diesel); TPH (gasoline); benzene; and total BTEX compounds. Note, the TPH cleanup standards were derived from a risk calculation based on benzene and total BTEX-compound concentrations in fresh fuel. Although this methodology may be appropriate for establishing cleanup levels for recent spills, it tends to be overly conservative for old spills, where the volatile (and toxic) components have been removed by weathering. This is especially important for several of the soil contamination areas of OU-1 source areas, where high TPH concentrations are accompanied by low concentrations or nondetection of volatile organic compounds.

5.4 LOCATION-SPECIFIC REQUIREMENTS

Location-specific requirements are standards that may apply or be relevant because the source area is located in a sensitive area. The three types of location-specific requirements discussed below will need to be further evaluated in the selection of remedial alternatives and the conduct of remedial activities.

5.4.1 Sole-Source Aquifer

Designation as a sole-source aquifer allows the federal or state governing agencies to establish special requirements or restrictions to protect the aquifer. Although no special requirements have been established for the Eielson AFB area, remedial alternatives will need to address restoration and protection of the aquifer.

5.4.2 Flood Plain

For activities or facilities located within a flood plain, action must be taken to avoid adverse effects, minimize potential harm, and restore and preserve natural and beneficial values (40 CFR 6).

5.4.3 Wetlands

Designated wetlands are protected under the Clean Water Act. Any remedial activities conducted in wetland areas must be implemented in a manner to avoid adverse effects, minimize potential harm, and preserve and enhance the wetlands to the extent possible. Although permit requirements are waived under CERCLA, excavation or fill would require special planning and might require wetland replacement if a significant area was affected. No designated wetlands are affected by OU-1.

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APPENDIX I - FIELD SUMMARY REPORT

1.0 INTRODUCTION

This section introduces a field summary report about Operable Unit 1 (OU-1) at Eielson Air Force Base (AFB) in Alaska.

During February and May 1993, Battelle, Pacific Northwest Laboratories (BNW) conducted field investigation activities at the Blair Lakes Target Facility within OU-1 for Eielson AFB. The purpose of these field activities was to do the following:

- Install transducers and data loggers in selected wells to monitor long-term water-level fluctuations at the target range.
- Perform surface geophysical surveys to delineate the depth and extent of permafrost beneath the developed portion of the target range.
- Perform hydraulic testing in selected wells to characterize the groundwater flow system beneath the target range and estimate aquifer parameters for this system.

A summary of the field activities is provided in Section 2.0. Detailed analyses of the water-level measurement, surface geophysical survey, and hydraulic testing data are included in Appendixes A, B, and C, respectively.

2.0 FIELD ACTIVITIES AND OBSERVATIONS

On February 18, 1993, BNW and Eielson AFB personnel drove to the Blair Lakes Target Facility via the Tanana River ice bridge. Field investigation activities were completed and the personnel returned the same day.

PNL personnel and equipment were flown by commercial helicopter to the target range on May 20, 1993. Eielson AFB personnel were flown by military helicopter on the same day. Field investigation activities were conducted from May 20 to 23, 1993. Personnel and equipment from BNW returned on May 23, 1993. Daily field activities are summarized in Table I.1.

Field investigation activities were conducted in accordance with the Final Operable Unit 1 Management Plan, Procedures for Ground-Water Investigations (PNL-MA-567), Appendix __, and equipment manufacturer's instructions. Field measurements and observations as well as additions and/or changes to the planned field activities were recorded in field notebooks.

A brief summary of the field investigation and observations is provided for each activity.

2.1 Water-Level Monitoring

Hermit pressure transducers and data loggers were installed in wells 50M10, 50M07, 50M05, 50M04, and the old water supply well. Table I.2 provides a summary of the water-level monitoring background information.

TABLE I.1. 1993 PNL Field Investigation Summary, Blair Lakes Target Facility	
Date	Activity
2/18/93	Installed transducers and data loggers in wells 50M10, 50M07, 50M05, 50M04, and old water supply well.
5/20/93	Performed EM-31 walk-around test survey. Performed DC resistivity test array (sounding 1). Downloaded data loggers at wells 50M07, 50M05, 50M04, 50M10, and old water supply well and reset to 20-minute time increment.
5/21/93	Performed DC resistivity soundings 2 through 6. Performed slug withdrawal tests in wells 50M02, 50M04, 50M08, 50M06, 50M10, and 50M07. Downloaded data loggers before and after slug tests. Reset data loggers to 30-minute time increment. Performed pumping pretest in old water supply well and observation well 50M01.
5/22/93	Performed DC resistivity soundings 7 through 13. Downloaded pretest data from pumping and observation wells. Performed 8-hour constant discharge test in old water supply well. Monitored drawdown and recovery in pumping and observation wells. Performed slug withdrawal test in well 50M07. Located and flagged background soil and TPH pits.
5/23/93	Performed DC resistivity soundings 14 and 15. Ended recovery test and downloaded data loggers. Reset data loggers to 720-minute time increment.
DC = Direct current. TPH = Total petroleum hydrocarbon.	

2.2 Surface Geophysical Surveys

Electromagnetic induction (EMI) and direct current resistivity surveys were performed adjacent to the target range facilities. A total of 1 reconnaissance EMI measurement was collected and 15 resistivity arrays were performed.

2.3 Hydraulic Testing

Two consecutive slug withdrawal tests were performed in wells 50M02, 50M04, 50M08, 50M06, 50M10, and 50M07. A third slug test was performed in well 50M07.

A pumping pretest and recovery were performed in the old water supply well. The pretest was followed by an 8-hour constant discharge test and recovery.

Background soil and total petroleum hydrocarbon pits were located and flagged.

TABLE I.2. 1993 PNL Water-Level Monitoring Background Information, Blair Lakes Target Facility

Well	Coordinates		Screened Depth (ft bls)	Transducer Range (psi)	Service Dates		Data Collection Frequency			
	North	East			From	To	720 min	20 min	30 min	720 min
50M01	99587.1	99803.0	NA		5/20/93	5/21/93		5/20/93		
50M02	99588.4	100046.8	7.0-17.0		5/20/93	Present		5/20/93	5/21/93	5/23/93
50M04	99296.7	99660.5	4.5-14.5	0-15	2/18/93	5/21/93	2/18/93	5/20/93		
50M05	99376.4	99958.4	NA	0-20	2/18/93	Present	2/18/93	5/20/93	5/21/93	5/23/93
50M06	99848.8	99650.9	4.5-14.5		5/20/93	5/21/93		5/20/93		
50M07	99522.2	99979.1	5.7-11.8	0-15	2/18/93	Present	2/18/93	5/20/93	5/21/93	5/23/93
50M08	99257.2	99792.4	3.5-13.5		5/20/93	5/21/93		5/20/93		
50M10	99920.4	99614.9	4.5-14.5	0-15	2/18/93	Present	2/18/93	5/20/93	5/21/93	5/23/93
OWSW	NA	NA	165-185	0-15	2/18/93	Present	2/18/93	5/20/93	5/21/93	5/23/93

NA = Not available.

OWSW = Old water supply well.

Two-second and logarithmic data collection frequencies were used for the slug and pumping tests, respectively.

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APPENDIX I-A - FIELD SUMMARY REPORT

**Field Summary Report: Operable Unit 1
Eielson Air Force Base**

Final

**Field Summary Report
Eielson Air Force Base
1993 OU-1 Field Investigation**

Prepared

by

**CH2M HILL
Corvallis, Oregon**

June 24, 1993

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1.0 INTRODUCTION

During May and June 1993, CH2M HILL conducted field investigation activities for Operable Unit 1 at Eielson Air Force Base. The purpose of the OU-1 investigation was to provide data to:

- improve understanding of the nature and extent of fuel-related contamination at OU-1 source areas
- assess possible sources of sitewide contaminants at OU-1 source areas that are not related to fuel contamination (e.g., PCBs, pesticides, metals, and selected semivolatiles)
- characterize potential human health risks associated with OU-1 source area contaminants
- refine and direct technology screening for the OU-1 Feasibility Study
- aid in selection of an appropriate final remedial action.

This field summary report presents pertinent information needed to document the OU-1 field activities and to evaluate the field and analytical data collected. This introduction is followed, in Section 2, by a summary of field activities conducted at each of the OU-1 source areas. Quality assurance sampling activities are summarized in Section 3. Results of the global positioning system (GPS) survey conducted at the Blair Lakes facility, and other survey data for the main Base source areas, are presented in Section 4. A summary of activities relating to treatment of groundwater sampling purge water and monitoring well development water is provided in Section 5. Health and safety issues are summarized in Section 6. An inventory of materials belonging to the project at the conclusion of the field work is presented in Section 7. Documentation of modifications to the OU-1 Management Plan that occurred as a result of specific conditions encountered in the field are documented in Section 8.

2.0 FIELD ACTIVITIES AND OBSERVATIONS

Mobilization for field work took place from May 9 to May 15, with the field teams beginning work on May 17. Sampling activities took place from May 17 to June 1. Demobilization was accomplished June 1 and June 2. Surveying activities were conducted from May 20 to May 25. Daily field activities are summarized in Table 2.1.

The 1993 field investigation was conducted in accordance with the Final Operable Unit-1 Management Plan, procedures found in the project instructions for groundwater and soil sampling, and in the Site Management Plan FSP, QAPP, and HSP (Revision 5). Sampling locations and analytes are defined in the OU-1 Management Plan. In some instances changes were made to the field activities or procedures due to circumstances encountered in the field. These changes were discussed with the onsite ESO representative and documented in ESO's field change notebook. A summary of changes from the Management Plan are described in Section 8; copies of the documented changes can be found in Appendix A.

Field observations were carefully documented for each investigation activity. Tables 2.2 lists the field notebooks used and their contents. Tables 2.3, 2.4, and 2.5 list the samples collected, depth as appropriate, analyses, laboratory and comments for all samples collected. Soil boring logs, well completion details and well development information for new monitoring wells installed at ST20 E-7 and E-9 and at ST48 are provided in Appendix B. Soil boring logs for the four boreholes drilled at OU-1 main Base source areas that were sampled and abandoned during the OU-1 field work are also provided in Appendix B. A complete set of survey data for OU-1 wells and product probes can be found in Appendix C.

In the following sections, a brief summary of the field activities and observations is provided for each source area.

2.1 ST20 E-7 Refueling Loop

A soil boring was advanced at new monitoring well 20MW27. Soil was sampled from the near surface and from the smear zone. The well was installed with a screen placed across the water table.

Wells 20A-3, 20M02, 20M03, 20M04, 20M09, 20M11, 20M12, 20MW27, and 53M04 were sampled. Well 20M04 contained 2.14 feet of product; product was not detected in any of the other E-7 wells sampled. Well 20M10 was scheduled to be sampled but was frozen; several attempts were made to remove the ice from the well.

A soil boring was advanced near existing Well 53M04. Soil samples were collected at depths near the ground surface and at the smear zone for semivolatile analysis.

Surface water and sediment samples were collected upstream of the pond in the center of the refueling loop. A composite surface soil sample was collected from near the pond for pesticide/PCB analyses. Sampling locations are shown in Figure 1.

Water levels and product thicknesses were measured at all existing wells. Product thickness was measured in two probes near well 53M04. Other probes identified in the literature for this area were not tested because they were inaccessible (in bioventing zone), damaged or buried. The monitoring wells and product probes were surveyed for elevation; well 20MW27 was also surveyed for horizontal coordinates.

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TABLE 2.1
Field Activity Summary
1993 Eielson AFB OU-1 Field Investigation

Page 1 of 2

Date	Activity
5/10-5/15/93	Mobilization
5/17/93	Team orientation, Health and Safety Meeting, Project Instructions, Flightline Instruction, Instrument training. Wells 48M04, 48M05, and 48M06 sampled. Soil boring near 53M03 was drilled and sampled.
5/18/93	Wells 48M07, 18-6, 48M03 and 53M03 were sampled. A duplicate was collected at 53M03. New well 48M08 was drilled, soil sampled, and installed. Two soil borings were advanced and soil sampled: one near 20M14 at ST20 E-8 and the other near well 53M04 at ST20 E-7.
5/19/93	Wells 48M01, 20C-2A, 20M20, 20M01, and 20M21 were sampled. Wells 20MW26 and 20MW27 were drilled, soil sampled, and installed. CH2M Hill auditor Bob Viens conducted an audit of the field activities and documentation procedures. Treated wastewater.
5/20/93	Soil boring near the sump and well 53M05 at ST49 was drilled and soil sampled. Surface soil samples were collected at ST49. Duplicate DA-11 was collected at the composite surface soil location (ST49-4S) and duplicate DA-10 was collected from the directed surface soil location near 49M04 (ST49-10S). Wells 20M07, 20M08, 20M23, 20M24, and 20M06 were sampled. Duplicate sample DA-1 was collected from well 20M06. A records search was conducted for the Base Supply Well D pumping records. Bob Viens completed the performance audit. Molly Netherland, CH2M HILL's health and safety representative, audited the field health and safety procedures. Surveyors completed the vertical and horizontal surveying of ST48. Well 48MW08 was developed. Holding tank #1 of the treatment system was sampled for volatiles. Treated wastewater.
5/21/93	Obtained information on Well 8 for sampling strategies. Sampled holding tank #2 of the water treatment system for volatiles. Developed wells 20MW26 and 20MW27. Surveyors completed the OU-1 Base sites for both vertical elevation and horizontal coordinates as appropriate. Treated wastewater. No sampling was conducted.
5/22/93	Completed weekly report. Treated wastewater.
5/23/93	Emptied holding tanks #1 and #2 to the sewer after receiving the volatile organic analysis results. Surface soil samples were collected from ST48: one directed sample at the coal pile and one composite sample near ST18. Surface soil samples were also collected from the taxiway. An equipment blank of the trowel used to collect surface soil samples was collected. Groundwater samples were collected from wells 20M03, 20M10, 20M11, 20A-3, and 20M12. Equipment for Blair Lakes was organized and packed.
5/24/93	<p>Blair Lakes: Surveying of the horizontal coordinates was performed for the buildings, helipads, wells, product probes, test pits, and other pertinent locations. Wells 50M07, 50M10, and 50M06 were sampled. Background test pits 2 and 5 were hand dug and soil sampled. Test pits 1 and 2 near the tank farm were excavated by backhoe and soil sampled (BLTF-1S - BLTF-4S). Surface soil samples were collected from the passenger helipad (BLD-16S - BLD-19S).</p> <p>Main Base: wells 20M04, 53M04, 20M09, 20MW27, 20M13, and 20MW26 were sampled. Wastewater was treated.</p>

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TABLE 2.1
Field Activity Summary
1993 Eielson AFB OU-1 Field Investigation

Page 2 of 2

Date	Activity
5/25/93	<p>Blair Lakes: Background test pits 1, 3, 4, and 6 were hand dug and soil sampled. Duplicate sample DA-13 was collected from background soil test pit #1 at the surface sampling depth of 6 inches. Surface soil samples were collected from the auxiliary helipad (BLD-8S - BLD-11S). An equipment blank was collected from the trowel used for surface soil sampling. Monitoring wells 50M04, 50M08, New Well, 50M02, and 50M05 were sampled. A full trip blank for 50M04 accompanied sample 50M04. Duplicate sample DA-6 was collected from well 50M08. Surveyor completed the surveying at Blair Lakes. Casings were cut from numerous wells and the new elevations were surveyed.</p> <p>Main Base: Groundwater was collected from wells 53M05, 20M15, 20M14, 49M03, and 20M22. Wastewater was treated.</p>
5/26/93	<p>Blair Lakes: The old base supply well and well 50M01 were sampled. Duplicate sample DA-5 was collected at well 50M01. Four directed surface soil samples were collected from the parking lot and four directed samples from surrounding the generator building. A composite surface soil sample was collected from near the sewage pond. Duplicate sample DA-14 was collected from BLD-14S from the parking lot.</p> <p>Main Base: Wells 49M02, 49M06, and 49M05 were sampled. Wastewater was treated.</p>
5/27/93	<p>Equipment blanks were collected for the peristaltic tubing and the bailer. Wells 48MW08, Well D, and Well 8 were sampled. Surface soil samples were collected from a composites near 20M23, 20M17, and the E-7 refueling loop pond. Surface water and sediment samples were collected from the pond at ST20 E-7. The records search for the Alert Hanger plumbing was conducted.</p>
5/28/93	<p>Water level measurements were taken from all existing OU-1 monitoring wells. Product thicknesses were measured in all existing OU-1 product probes.</p>
6/1/93	<p>Demobilization. Surface water and sediment samples were collected at ST49 from the upstream and downstream locations on Garrison Slough. Product thickness measurements were completed at ST48 and ST20 E-9. Remaining wastewater was treated and sampled.</p>
6/2/93	<p>Demobilization.</p>

Field Summary Report: Operable Unit 1
Eielson Air Force Base

TABLE 2.2
Form Notebooks
1993 Eielson AFB OU-1 Field Investigation

Notebook Title	Book No.	Dates	Contents
Notebook Control	1	5/10 - 6/2	Log of field notebooks and custody.
Quality Control Samples	2	5/17 - 6/2	Log of trip blanks assigned to sampling teams.
Soil Team Site Daily Diary Health and Safety	3	5/17 - 5/20	Drilling Health and safety notebook for all soil borings and well installations.
Groundwater Team Site Diary Health and Safety	4	5/17 - 5/23	Groundwater health and safety notebook for wells 48M04, 48M05, 48M06, 18-6, 48M07, 48M03, 53M03, 20M01, 20M20, 20M21, 20M22, 20C-2, 20M04, 20M07, 20M08, 20M06, 20M02, 20M03, 20M10, 20M11, 20A-3, and 20M12.
Groundwater Quality Sampling Diary	5		Not used because the field summary record accompanying the C-O-C's were used in place of notebooks as directed by ESO.
Sitewide Health and Safety	6	5/13 - 6/2	Contains general sitewide information on health and safety including the noise dosimeter results.
Wastewater Treatment	7	5/17 - 6/2	Contains the treatment information including amount of water treated daily, which tanks the water was delivered to and the dates that the tanks were sampled and dumped.
Soil Team Site Diary Health and Safety	8	5/20 - 5/27	Base surface soil health and safety notebook. Includes surface soil samples collected from source areas ST48, ST49, ST20 E-7, ST20 E-8, and ST20 E-9.
Surface Soil Sampling	9	5/20 - 5/28	Logs the sampling locations, soil descriptions, and samples collected for surface soil samples collected on the Base.
Groundwater Team Health and Safety	10	5/23 - 6/2	Groundwater health and safety notebook for Wells 20M09, 53M04, 20M04, 20MW26, 20M13, 20M14, 20M15, 20MW27, 49M01, 49M02, 49M03, 49M04, 49M05, 49M06, 20M22, 53M05.
Blair Lakes Test Pits and Surface Soil Samples	11	5/24 - 5/26	Contains all soil sampling information for Blair Lakes. Background test pits 1 through 6, tank farm test pits 1 and 2, surface soil samples collected from the helipads, parking lot, generator building and near the sewage pond.
Water Levels	12	5/24 - 5/28	Contains all water level information for Blair Lakes and OU-1 main base source areas. Also contains information on well sampling at Blair Lakes.
Product Probe Thicknesses	13	5/28/93	Contains product thicknesses for all existing OU-1 product probes.
Blair Lakes Groundwater Sampling Health and Safety	14	5/24 - 5/26	Contains health and safety information for sampling wells 50M07, 50M10, 50M06, 50M02, 50M05, 50M08, and 50M04.

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Table 2.3
Surface Water and Groundwater Sample Summary
1993 Eielson AFB OU-1 Field Investigation

Source Area	Well No.	Sample Name	Depth (ft)	Analyses	Laboratory	Cooler ID	Date Collected	Comment
Surface Water Samples								
ST20/E-7	POND	POND		VOC, ICP, AS, PB, HG	DATA CHEM	YELLEPIT	5/27/93	
		POND F		ICP, AS, PB, HG	DATA CHEM	YELLEPIT	5/27/93	Turbidity of unfiltered sample 0.7 NTU
ST49	SLOUGH	SL-1		VOC, ICP, AS, PB, HG	DATA CHEM	PNL EM04	6/1/93	Ponded water 100 yds from culvert - sheen on water
		SL-1F		ICP, AS, PB, HG	DATA CHEM	PNL EM04	6/1/93	
		SL-2		VOC, ICP, AS, PB, HG	DATA CHEM	PNL EM04	6/1/93	Standing water next to outlet of CMP drainline
		SL-2F		ICP, AS, PB, HG	DATA CHEM	PNL EM04	6/1/93	
Groundwater Samples								
ST20/E-7	20A-3	20A-3		VOC	DATA CHEM	CH107	5/23/93	
	20M02	20M02		VOC	DATA CHEM	CH107	5/23/93	
	20M03	20M03		VOC	DATA CHEM	CH107	5/23/93	
	20M04	20M04		VOC, ABNL	DATA CHEM	PNL EM40	5/24/93	Product layer detected; OVM downhole = 468 ppm
	20M09	20M09		VOC, ABNL	DATA CHEM	PNL EM40	5/24/93	
		20M09S		VOC	DATA CHEM	PNL EM40	5/24/93	
		20M09I		VOC	DATA CHEM	PNL EM40	5/24/93	
		20M09D		VOC	DATA CHEM	PNL EM40	5/24/93	
	20M11	20M11		VOC	DATA CHEM	CH107	5/23/93	Well pumped to bottom during purging and allowed to recover.
	20M12	20M12		VOC, ICP, AS, PB, HG	DATA CHEM	CH107	5/23/93	
		20M12F		ICP, AS, PB, HG	DATA CHEM	CH107	5/23/93	
	53M04	53M04		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL EM40	5/24/93	OVM downhole = 149 ppm
		53M04F		ICP, AS, PB, HG	DATA CHEM	PNL EM40	5/24/93	
	20MW27	20MW27		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	CH 106	5/24/93	
		20MW27F		ICP, AS, PB, HG	DATA CHEM	CH 106	5/24/93	
ST20/E-8	20M06	20M06		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL 736	5/20/93	OVM downhole = 37 ppm.
		20M06S	8	VOC	DATA CHEM	PNL 736	5/20/93	
		20M06I	17	VOC	DATA CHEM	PNL 736	5/20/93	
		20M06D	26	VOC	DATA CHEM	PNL 736	5/20/93	
		20M06F		ICP, AS, PB, HG	DATA CHEM	PNL 736	5/20/93	Turbidity unfiltered sample 2.7 NTUs.
	20M13	20M13		VOC	DATA CHEM	CH 106	5/24/93	
	20M14	20M14		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL 502	5/25/93	
		20M14F		ICP, AS, PB, HG	DATA CHEM	PNL 502	5/25/93	

Table 2.3
Surface Water and Groundwater Sample Summary
1993 Eielson AFB OU-1 Field Investigation

Source Area	Well No.	Sample Name	Depth (ft)	Analyses	Laboratory	Cooler ID	Date Collected	Comment
ST20/E-8 (cont.)	20M15	20M15		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL 502	5/25/93	Mosquitos!
		20M15F		ICP, AS, PB, HG	DATA CHEM	PNL 502	5/25/93	
ST20/E-9	20C-2	20C-2		VOC, ICP, AS, PB, HG	DATA CHEM	PNL QUEETS	5/19/93	Frost heave apparent from concrete around base of stick up
		20C-2F		ICP, AS, PB, HG	DATA CHEM	PNL QUEETS	5/19/93	Turbidity of unfiltered sample 34.3 NTUs.
	20M01	20M01		VOC, ABNL	DATA CHEM	PNL QUEETS	5/19/93	No product layer detected; OVM downhole = 180 ppm
	20M07 20M07	20M07		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	DON	5/20/93	No product layer detected; OVM downhole = 340 ppm
		20M07S	11	VOC	DATA CHEM	DON	5/20/93	
		20M07I	18	VOC	DATA CHEM	DON	5/20/93	
		20M07D	27	VOC	DATA CHEM	DON	5/20/93	
		20M07F		ICP, AS, PB, HG	DATA CHEM	DON	5/20/93	
	20M08	20M08		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL 736	5/20/93	Turbidity unfiltered sample 41.2 NTUs
		20M08F		ICP, AS, PB, HG	DATA CHEM	PNL 736	5/20/93	
	20M20	20M20		VOC, ABNL	DATA CHEM	PNL QUEETS	5/19/93	
	20M21	20M21		VOC, ICP, A, PB, HG, ABNL	DATA CHEM	PNL QUEETS	5/19/93	
		20M21F		ICP, AS, PB, HG	DATA CHEM	PNL QUEETS	5/19/93	
	20M22	20M22		VOC	DATA CHEM	PNL 721	5/25/93	
		20M22S	8	VOC	DATA CHEM	PNL 721	5/25/93	
		20M22I	11	VOC	DATA CHEM	PNL 721	5/25/93	
		20M22D	15.2	VOC	DATA CHEM	PNL 721	5/25/93	
	20M23	20M23		VOC, ICP, AS, PB, HG	DATA CHEM	DON	5/20/93	Turbidity unfiltered sample 20.6 NTUs.
		20M23S	7	VOC	DATA CHEM	DON	5/20/93	
		20M23I	11	VOC	DATA CHEM	DON	5/20/93	
		20M23D	15	VOC	DATA CHEM	DON	5/20/93	
		20M23F		ICP, AS, PB, HG	DATA CHEM	DON	5/20/93	
	20M24	20M24		VOC	DATA CHEM	DON	5/20/93	
	W-8	W-8		VOC, ICP, AS, PB, HG	DATA CHEM	CH115	5/27/93	Turbidity unfiltered sample 34.3 NTUs
		W-8F		ICP, AS, PB, HG	DATA CHEM	CH115	5/27/93	

Table 2.3
Surface Water and Groundwater Sample Summary
1993 Eielson AFB OU-1 Field Investigation

Source Area	Well No.	Sample Name	Depth (ft)	Analyses	Laboratory	Cooler ID	Date Collected	Comment
ST20/E-9 (cont.)	20MW26	20MW26		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	CH 106	5/24/93	
		20MW26F		ICP, AS, PB, HG	DATA CHEM	CH 106	5/24/93	
ST48	48M01	48M01		VOC, ICP, AS, PB, HG, ABNL	DATA CHEM	CH102	5/19/93	Product layer detected; OVM downhole = 154 ppm
		48M01F		ICP, AS, PB, HG	DATA CHEM	CH102	5/19/93	
	48M03	48M03		VOC, ICP, AS, PB, HG, ABNL	DATA CHEM	PNLEM042	5/18/93	OVM downhole = 0 ppm
	48M03	48M03S	16	VOC	DATA CHEM	PNLEM042	5/18/93	
		48M03I	20	VOC	DATA CHEM	PNLEM042	5/18/93	
		48M03D	23.5	VOC	DATA CHEM	PNLEM042	5/18/93	
		48M03F		ICP, AS, PB, HG	DATA CHEM	PNLEM042	5/18/93	
	48M04	48M04		VOC	DATA CHEM	PNL 507	5/17/93	shallow nested well
	48M05	48M05		VOC	DATA CHEM	PNL 507	5/17/93	intermediate nested well
	48M06	48M06		VOC	DATA CHEM	PNL 507	5/17/93	deep nested well - purged with bailer
	48M07	48M07		VOC, ICP, AS, PB, HG, ABNL	DATA CHEM	PNLEM042	5/18/93	OVM downhole = 229 ppm
		48M07F		ICP, AS, PB, HG	DATA CHEM	PNLEM042	5/18/93	
	53M03	53M03		VOC, ICP, AS, PB, ABNL, HG	DATA CHEM	AYER	5/18/93	OVM downhole = 203 ppm
		53M03F		ICP, AS, PB, HG	DATA CHEM	AYER	5/18/93	
	48MW8	48MW8		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL 506	5/27/93	
		48MW8F		ICP, AS, PB, HG	DATA CHEM	PNL 506	5/27/93	
	18-6	18-6		VOC	DATA CHEM	AYER	5/18/93	OVM downhole = 0 ppm
	Well D	W-D		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	CH115	5/27/93	Collected sample from faucet in well casing
		W-DF		ICP, AS, PB, HG	DATA CHEM	CH115	5/27/93	
ST49	49M01	49M01		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL 721	5/25/93	
		49M01F		ICP, AS, PB, HG	DATA CHEM	PNL 721	5/25/93	
	49M02	49M02		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL 702	5/26/93	Strong fuel odor, but no product layer detected; OVM downhole = 354 to 150 ppm. Two feet of ice chipped away to expose screened interval
		49M02F		ICP, AS, PB, HG	DATA CHEM	PNL 702	5/26/93	Strong fuel odor, but no product layer detected. Two feet of ice chipped away to expose screened interval
	49M03	49M03		VOC, ABNL	DATA CHEM	PNL 721	5/25/93	Casing heaved and broken above protective outer cover; bailer would not fit - used peristaltic pump to collect samples
	49M04	49M04		VOC, ABNL	DATA CHEM	PNL 721	5/25/93

Table 2.3
Surface Water and Groundwater Sample Summary
1993 Eielson AFB OU-1 Field Investigation

Source Area	Well No.	Sample Name	Depth (ft)	Analyses	Laboratory	Cooler ID	Date Collected	Comment
ST49 (cont.)	49M05	49M05		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	CH108	5/26/93	
		49M05S	7	VOC	DATA CHEM	CH108	5/26/93	
		49M05I	11	VOC	DATA CHEM	CH108	5/26/93	
		49M05D	16	VOC	DATA CHEM	CH108	5/26/93	
		49M05F		ICP, AS, PB, HG	DATA CHEM	CH108	5/26/93	
	49M06	49M06		VOC, ABNL	DATA CHEM	CH108	5/26/93	No product layer detected with interface probe
		49M06S	11	VOC	DATA CHEM	CH108	5/26/93	
		49M06I	20	VOC	DATA CHEM	CH108	5/26/93	
		49M06D	29	VOC	DATA CHEM	CH108	5/26/93	
	53M05	53M05		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL 502	5/25/93	
		53M05S	10	VOC	DATA CHEM	PNL 502	5/25/93	
		53M05I	18	VOC	DATA CHEM	PNL 502	5/25/93	
		53M05D	26.8	VOC	DATA CHEM	PNL 502	5/25/93	
		53M05F		ICP, AS, PB, HG	DATA CHEM	PNL 502	5/25/93	
BLAIR LAKES	50M01	50M01		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	EMO PNL	5/26/93	OVM downhole = 158 ppm
		50M01S	13	VOC	DATA CHEM	EMO PNL	5/26/93	
		50M01D	14.4	VOC	DATA CHEM	EMO PNL	5/26/93	
		50M01F		ICP, AS, PB, HG	DATA CHEM	EMO PNL	5/26/93	
	50M02	50M02		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	EMO PNL	5/25/93	Unfiltered samples very turbid
		50M02F		ICP, AS, PB, HG	DATA CHEM	EMO PNL	5/25/93	
	50M04	50M04		VOC, ICP, AS, PB, HG	DATA CHEM	SATUS	5/25/93	
		50M04F		ICP, AS, PB, HG	DATA CHEM	SATUS	5/25/93	
	50M05	50M05		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL 702	5/25/93	
		50M05F		ICP, AS, PB, HG	DATA CHEM	PNL 702	5/25/93	
	50M06	50M06		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL 722	5/24/93	Water clear during purging; moderately turbid when sampled with bailer.
		50M06F		ICP, AS, PB, HG	DATA CHEM	PNL 722	5/24/93	
	50M07	50M07		VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL 722	5/24/93	OVM downhole = 0 ppm
		50M07F		ICP, AS, PB, HG	DATA CHEM	PNL 722	5/24/93	OVM downhole = 0 ppm, turbidity increased as purging progressed.

Table 2.3
Surface Water and Groundwater Sample Summary
1993 Eielson AFB OU-1 Field Investigation

Source Area	Well No.	Sample Name	Depth (ft)	Analyses	Laboratory	Cooler ID	Date Collected	Comment
BLAIR LAKES (cont.)	50M08	50M08		VOC, ABNL, ICP, AS, PB, HG, IONS, ALK, TDS	DATA CHEM	BI6	5/25/93	Unfiltered samples very turbid
		50M08		TOC	CH2M HILL	CH112	5/25/93	
		50M08F		ICP, AS, PB, HG	DATA CHEM	BI6	5/25/93	
	50M10	50M10		VOC, ICP, AS, PB, HG	DATA CHEM	PNL 722	5/24/93	OVM downhole = 0 ppm; water very turbid during purging and sampling with bailer.
		50M10F		ICP, AS, PB, HG	DATA CHEM	PNL 722	5/24/93	
	NW	NW		VOC, ABNL, ICP, AS, PB, HG, IONS	DATA CHEM	SATUS	5/25/93	
		NWF		ICP, AS, PB, HG	DATA CHEM	SATUS	5/25/93	
	OW	OW		VOC, ABNL, ICP, AS, PB, HG, IONS	DATA CHEM	SATUS	5/26/93	
		OWF		ICP, AS, PB, HG	DATA CHEM	SATUS	5/26/93	

Notes

VOC = volatile organic compounds; ABNL = semivolatile compounds; ICP = ICP metals; AS = arsenic; PB = lead; HG = mercury

Depth of vertical samples is from top of well casing.

E-9/20M01F samples not collected; bottles for metals samples not available at time of sampling; free product not detected.

48M02 apparently buried in coal pile.

20M10 at E-7 Refueling Loop was frozen at time of sampling.

50M09 was not found.

50M011 sample was not collected, screened interval in well was too short.

Table 2.4
Soil Boring and Test Pit Soil Sample Summary
1993 Eielson AFB OU-1 Field Investigation

Source Area	Boring No.	Sample Name	Depth Collected (ft)	Analyses	Cooler ID	Date Collected	Laboratory	Comment
ST20/E-7	E-7SB	E-7-4S	1.0-2.5	ABNL	CH101	5/18/93	DATA CHEM	Boring near 53M04. OVM 0 ppm; split spoon; chain of custody number corrected on bottle
		E-7-6S	4.5-6.0	ABNL	CH101	5/18/93	DATA CHEM	Boring near 53M04. OVM 62 ppm; split spoon
	20MW27	E-7-1S	1.0-3.0	VOC, ICP, AS, PB, HG, ABNL, PEST/PCB	CH103	5/19/93	DATA CHEM	OVM 0 ppm; split spoon
		E-7-1S	1.0-3.0	AK101, AK102	110	5/19/93	ENSECO	OVM 0 ppm; split spoon
		E-7-1S	1.0-3.0	TOC		5/19/93	CH2M HILL	OVM 0 ppm; split spoon
		E-7-1SM	3.0-5.0	MOISTURE	CH103	5/19/93	DATA CHEM	OVM 0 ppm; split spoon
		E-7-2S	5.0-7.0	VOC, ABNL	CH103	5/19/93	DATA CHEM	OVM 0 ppm; split spoon
		E-7-2S	5.0-7.0	AK101, AK102	110	5/19/93	ENSECO	OVM 0 ppm; split spoon
		E-7-2S	7.0-9.0	ICP, AS, PB, HG	CH103	5/19/93	DATA CHEM	OVM 0 ppm; split spoon
		E-7-2S	7.0-9.0	TOC		5/19/93	CH2M HILL	OVM 0 ppm; split spoon
		E-7-2S	10.0-12.0	PEST/PCB	CH103	5/19/93	DATA CHEM	OVM 0 ppm; split spoon
		E-7-2SM	12.0-14.0	MOISTURE	CH103	5/19/93	DATA CHEM	OVM 0 ppm; split spoon
ST20/E-8	E-8SB	E-8-2S	1.0-2.5	ABNL	CH101	5/18/93	DATA CHEM	Boring 3 ft north of 20M14. OVM 0 ppm; split spoon; chain of custody number corrected on bottle
		E-8-3S	5.0-6.5	ABNL	CH101	5/18/93	DATA CHEM	Boring near 20M14. OVM 0 ppm; split spoon
ST20/E-9	20MW26	E-9-1S	1.0-3.0	VOC, ICP, AS, PB	CH103	5/19/93	DATA CHEM	OVM 0 ppm; split spoon
		E-9-1S	1.0-3.0	AK101	110	5/19/93	ENSECO	OVM 0 ppm; split spoon
		E-9-1S	1.0-3.0	TOC		5/19/93	CH2M HILL	OVM 0 ppm; split spoon
		E-9-1S	3.0-5.0	ABNL, HG, PEST/PCB	CH103	5/19/93	DATA CHEM	OVM 0 ppm; split spoon
		E-9-1S	3.0-5.0	AK102	110	5/19/93	ENSECO	OVM 0 ppm; split spoon
		E-9-1SM	3.0-5.0	MOISTURE	CH103	5/19/93	DATA CHEM	OVM 0 ppm; split spoon
		E-9-2S	6.0-8.0	VOC, ICP, AS, PB, HG, ABNL, PEST/PCB	CH103	5/19/93	DATA CHEM	OVM 0 ppm; split spoon
		E-9-2S	6.0-8.0	AK101, AK102	110	5/19/93	ENSECO	OVM 0 ppm; split spoon
		E-9-2S	6.0-8.0	TOC		5/19/93	CH2M HILL	OVM 0 ppm; split spoon
		E-9-2SM	8.0-10.0	MOISTURE	CH103	5/19/93	DATA CHEM	OVM 0 ppm; split spoon
ST48	ST48SB	ST48-1S	1.5-3.0	ABNL, PCB	PNL 704	5/17/93	DATA CHEM	Boring near 53M03. OVM 1.2 ppm; split spoon
		ST48-6S	6.0-7.5	ABNL, PCB	PNL 704	5/17/93	DATA CHEM	Boring near 53M03. OVM 1.3 ppm; split spoon
		ST48-7S	11.0-12.5	ABNL, PCB	PNL 704	5/17/93	DATA CHEM	Boring near 53M03. OVM 126.4 ppm; strong solvent smell. Split spoon

Table 2.4
Soil Boring and Test Pit Soil Sample Summary
1993 Eielson AFB OU-1 Field Investigation

Source Area	Boring No.	Sample Name	Depth Collected (ft)	Analyses	Cooler ID	Date Collected	Laboratory	Comment
ST48 (cont.)	48MW08	ST48-4S	1.0-2.5	VOC, ICP, AS, PB	CH101	5/18/93	DATA CHEM	OVM 0.1 - 0.6 ppm; split spoon
		ST48-4S	1.0-2.5	AK102		5/18/93	ENSECO	OVM 0.1 - 0.6 ppm; split spoon
		ST48-4S	2.5-3.5	ABNL	CH101	5/18/93	DATA CHEM	OVM 0.1 - 0.6 ppm; split spoon
		ST48-4S	2.5-3.5	AK101		5/18/93	ENSECO	OVM 0.1 - 0.6 ppm; split spoon
		ST48-4S	3.5-5.0	HG, PCB/PEST	CH101	5/18/93	DATA CHEM	OVM 0.1 - 0.6 ppm; split spoon
		ST48-4S	3.5-5.0	TOC		5/18/93	CH2M HILL	OVM 0.1 - 0.6 ppm; split spoon
		ST48-4S	5.0-7.0	MOISTURE	CH101	5/18/93	DATA CHEM	OVM 0.1 - 0.6 ppm; split spoon
		ST48-4S	10.0-12.0	MOISTURE	CH101	5/18/93	DATA CHEM	OVM 38 ppm; split spoon
		ST48-5S	10.0-12.0	PEST/PCB	CH101	5/18/93	DATA CHEM	OVM 38 ppm; split spoon
		ST48-5S	10.0-12.0	TOC		5/18/93	CH2M HILL	OVM 38 ppm; split spoon
		ST48-5S	8.0-10.0	VOC, ICP, AS, PB, HG, ABNL	CH101	5/18/93	DATA CHEM	OVM 0 ppm; split spoon
		ST48-5S	8.0-10.0	AK101, AK102		5/18/93	ENSECO	OVM 0 ppm; split spoon
ST49	ST49SB	ST49-5S	1.0-2.5	AK101, AK102	110	5/20/93	ENSECO	OVM 0 ppm; split spoon
		ST49-5S	1.0-2.5	VOC, ABNL, PEST/PCB	CH104	5/20/93	DATA CHEM	OVM 0 ppm; split spoon
		ST49-6S	6.5-8.0	VOC		5/20/93	DATA CHEM	OVM 0.7 ppm; split spoon
		ST49-6S	6.5-8.0	AK101, AK102		5/20/93	ENSECO	OVM 0.7 ppm; split spoon
		ST49-6S	8.0-9.5	ABNL, PEST/PCB		5/20/93	DATA CHEM	OVM 0.7 ppm; split spoon
BLAIR LAKES	Test Pit 1	BL1-1S	0.5	ICP, AS, PB, HG	CH110	5/25/93	DATA CHEM	Sample collected from Blair Lakes test pit #1
		BL1-1S	0.5	TOC	CH112	5/25/93	CH2M HILL	Sample collected from Blair Lakes test pit #1
		BL1-1SM	0.5	MOISTURE	CH110	5/25/93	DATA CHEM	Sample collected from Blair Lakes test pit #1
		BL1-2S	4	ICP, AS, PB, HG	CH110	5/25/93	DATA CHEM	Sample collected from Blair Lakes test pit #1
		BL1-2S	4	TOC	CH112	5/25/93	CH2M HILL	Sample collected from Blair Lakes test pit #1
		BL1-2SM	4	MOISTURE	CH110	5/25/93	DATA CHEM	Sample collected from Blair Lakes test pit #1
	Test Pit 2	BL2-1S	0.5	ICP, AS, PB, HG	CH110	5/24/93	DATA CHEM	
		BL2-1SM	0.5	MOISTURE	CH110	5/24/93	DATA CHEM	
		BL2-2S	3.8	ICP, AS, PB, HG	CH110	5/25/93	DATA CHEM	
		BL2-2SM	3.8	MOISTURE	CH110	5/25/93	DATA CHEM	
	Test Pit 3	BL3-1S	0.5	ICP, AS, PB, HG	SML 84	5/25/93	DATA CHEM	Sample collected from Blair Lakes test pit #3 at depth 6 inches
		BL3-1SM	0.5	MOISTURE	SML 84	5/25/93	DATA CHEM	Sample collected from Blair Lakes test pit #3 at depth 6 inches

Table 2.4
Soil Boring and Test Pit Soil Sample Summary
1993 Eielson AFB OU-1 Field Investigation

Source Area	Boring No.	Sample Name	Depth Collected (ft)	Analyses	Cooler ID	Date Collected	Laboratory	Comment
BLAIR LAKES (cont.)	Test Pit 3	BL3-2S	4	ICP, AS, PB, HG	SML 84	5/25/93	DATA CHEM	Sample collected at Blair Lakes test pit #3 just above water table.
	(cont.)	BL3-2SM	4	MOISTURE	SML 84	5/25/93	DATA CHEM	Sample collected at Blair Lakes test pit #3 just above water table.
	Test Pit 4	BL4-1S	0.4	ICP, AS, PB, HG	BI6	5/25/93	DATA CHEM	Sample collected at Blair Lakes test pit #4 at depth of 5 inches, just below peat layer
		BL4-1SM	0.4	MOISTURE	BI6	5/25/93	DATA CHEM	Sample collected at Blair Lakes test pit #4 at depth of 5 inches, just below peat layer
		BL4-2S	1.8	ICP, AS, PB, HG	SML 84	5/25/93	DATA CHEM	Sample collected at Blair Lakes test pit #4 just above water level
		BL4-2SM	1.8	MOISTURE	SML 84	5/25/93	DATA CHEM	Sample collected at Blair Lakes test pit #4 just above water level
	Test Pit 5	BL5-1S	0.5	ICP, AS, PB, HG	CH110	5/24/93	DATA CHEM	
		BL5-1SM	0.5	MOISTURE	CH110	5/24/93	DATA CHEM	
		BL5-2S	3.6	ICP, AS, PB, HG	CH110	5/24/93	DATA CHEM	
		BL5-2SM	3.6	MOISTURE	CH110	5/24/93	DATA CHEM	
	Test Pit 6	BL6-1S	0.4	ICP, AS, PB, HG	SML 84	5/25/93	DATA CHEM	Sample collected just below peat layer
		BL6-1S	0.4	TOC	CH113	5/25/93	CH2M HILL	
		BL6-1SM	0.4	MOISTURE	SML 84	5/25/93	DATA CHEM	
		BL6-2S	3.8	ICP, AS, PB, HG	SML 84	5/25/93	DATA CHEM	
		BL6-2S	3.8	TOC	CH113	5/25/93	CH2M HILL	
		BL6-2SM	3.8	MOISTURE	SML 84	5/25/93	DATA CHEM	
	Tank Farm Test Pit 1	BLTF-1	0.5	MOISTURE	CH110	5/24/93	DATA CHEM	Tank farm test pit #1; OVM= 66 ppm at 0.5 ft
				AK101, AK102	CH114	5/24/93	ENSECO	Tank farm test pit #1; OVM= 66 ppm at 0.5 ft, strong diesel odor
		BLTF-2	6	MOISTURE	CH110	5/24/93	DATA CHEM	Tank farm test pit #1; OVM = 33 ppm at 6 ft bgs. no permafrost
				AK101, AK102	CH114	5/24/93	ENSECO	Tank farm test pit #1; OVM = 33 ppm at 6 ft bgs. no permafrost

Table 2.4
Soil Boring and Test Pit Soil Sample Summary
1993 Eielson AFB OU-1 Field Investigation

Source Area	Boring No.	Sample Name	Depth Collected (ft)	Analyses	Cooler ID	Date Collected	Laboratory	Comment
BLAIR LAKES (con')	Tank Farm Test Pit 2	BLTF-3	0.5	MOISTURE	CH110	5/24/93	DATA CHEM	Tank farm test pit #2; OVM= 13.8 ppm at 0.5 ft.
				AK101, AK102	CH114	5/24/93	ENSECO	Tank farm test pit #2; OVM= 13.8 ppm at 0.5 ft.
		BLTF-4	9	MOISTURE	CH110	5/24/93	DATA CHEM	Tank farm test pit #2; OVM= 0 ppm at 9 ft; permafrost at 9 ft bgs.
				AK101, AK102	CH114	5/24/93	ENSECO	Tank farm test pit #2; OVM= 0 ppm at 9 ft; permafrost at 9 ft bgs.

Depth collected is feet below ground surface.

VOC = volatile organic compound; ICP = ICP metals; AS = arsenic; PB = lead; HG = mercury; ABNL = semivolatiles; PEST/PCB = pesticides/PCBs; TOC = total organic carbon

Table 2.5
Surface Soil Sample Summary
1993 Eielson AFB OU-1 Field Investigation

Source Area	Sample Name	Date	Analyses	Cooler ID	Laboratory	Comment
ST20/E-7	E-7-3S	5/27/93	PEST/PCB	PNL 16	DATA CHEM	Composite sample collected near pond
	E-7-5S	5/27/93	VOC, ABNL, ICP, AS, PB, HG, PEST/PCB	YELLEPIT	DATA CHEM	
ST20/E-8	E-8-1S	5/27/93	PEST/PCB	PNL 16	DATA CHEM	Composite sample collected near 20M17 - marshy area
ST20/E-9	E-9-3S	5/27/93	PEST/PCB	PNL 16	DATA CHEM	
	E-9-4S	5/23/93	ABNL	PNL 709	DATA CHEM	Sample collected 5 ft from tarmac.
	E-9-5S	5/23/93	ABNL	PNL 709	DATA CHEM	Sample collected 5 ft from tarmac.
	E-9-6S	5/23/93	ABNL	PNL 709	DATA CHEM	Sample collected 5 ft from tarmac.
	E-9-7S	5/23/93	ABNL	PNL 709	DATA CHEM	Sample collected 5 ft from tarmac.
	E-9-8S	5/23/93	ABNL	PNL 709	DATA CHEM	Sample collected 5 ft from tarmac.
	E-9-9S	5/23/93	ABNL	PNL 709	DATA CHEM	Sample collected 8 ft from tarmac.
	E-9-10S	5/23/93	ABNL	PNL 709	DATA CHEM	Sample collected 8 ft from tarmac.
	E-9-11S	5/23/93	ABNL		DATA CHEM	Sample collected 5 ft from tarmac.
	E-9-12S	5/23/93	ABNL	PNL 709	DATA CHEM	Sample collected 2.5 ft from tarmac.
	E-9-13S	5/23/93	ABNL	PNL 709	DATA CHEM	Sample collected 11 ft from tarmac.
	E-9-14S	5/23/93	ABNL	PNL 709	DATA CHEM	Sample collected 5 ft from tarmac.
	E-9-15S	5/27/93	ABNL	PNL 16	DATA CHEM	
	E-9-16S	5/27/93	ABNL	PNL 16	DATA CHEM	Taxiway sample; OVM = 0 ppm
	E-9-17S	5/27/93	ABNL	PNL 16	DATA CHEM	
	E-9-18S	5/27/93	ABNL	PNL 16	DATA CHEM	Taxiway sample; OVM = 0 ppm
	E-9-19S	5/27/93	ABNL	PNL 16	DATA CHEM	Taxiway sample; OVM = 0 ppm
ST48	ST48-2S	5/23/93	PEST/PCB	PNL 709	DATA CHEM	Composite
	ST48-3S	5/23/93	ABNL	PNL 709	DATA CHEM	Sample collected in sampling hole in coal pile at depth 1.8 ft; 5 inch coal cover.
	ST48-3S	5/23/93	AK101, AK102	CH114	ENSECO	Sample collected in sampling hole in coal pile at depth 1.8 ft; 5 inch coal cover.
ST49	ST49-1S	5/20/93	VOC	CH104	DATA CHEM	Sample collected near 49M05
	ST49-2S	5/20/93	VOC	CH104	DATA CHEM	Sample collected near 49M05
	ST49-3S	5/20/93	VOC	CH104	DATA CHEM	Sample collected near 49M05
	ST49-4S	5/20/93	PEST/PCB	CH104	DATA CHEM	Composite sample
	ST49-6S	5/20/93	AK101, AK102	110	ENSECO	53M03 sump; OVM 0 ppm; split spoon
	ST49-6S	5/20/93	VOC, ABNL, PEST/PCB	CH104	DATA CHEM	53M03 sump; OVM 0 ppm; split spoon

Table 2.5
Surface Soil Sample Summary
1993 Eielson AFB OU-1 Field Investigation

Source Area	Sample Name	Date	Analyses	Cooler ID	Laboratory	Comment
ST49 (cont.)	ST49-7S	6/1/93	VOC, ABNL, ICP, AS, PB, HG, PEST/PCB	PNL EM04	DATA CHEM	Sediment from Garrison Slough 7 ft upstream of inlet pipes (no water present)
	ST49-7S	6/1/93	TOC		CH2M HILL	Sediment from Garrison Slough upstream
	ST49-8S	6/1/93	VOC, ABNL, ICP, AS, PB, HG, PEST/PCB		DATA CHEM	Sediment from Garrison Slough downstream at outlet pipe
	ST49-8S	6/1/93	TOC		CH2M HILL	Sediment from Garrison Slough downstream
	ST49-9S	5/20/93	VOC	CH104	DATA CHEM	Sample collected near 49M05
	ST49-10S	5/20/93	ABNL	CH104	DATA CHEM	Sample collected near 49M04
	ST49-11S	5/20/93	ABNL	CH104	DATA CHEM	Sample collected near 49M03
	ST49-12S	5/20/93	ABNL	CH104	DATA CHEM	Sample collected near 49M01
BLAIR LAKES	BLD-7S	5/26/93	PEST/PCB		DATA CHEM	Composite sample collected near sewage lagoon pond and 50M10.
	BLD-8S	5/25/93	PEST/PCB	BI6	DATA CHEM	Sample collected at auxiliary helipad
	BLD-9S	5/25/93	PEST/PCB	BI6	DATA CHEM	Sample collected at auxiliary helipad
	BLD-10S	5/25/93	PEST/PCB	BI6	DATA CHEM	Sample collected at auxiliary helipad
	BLD-11S	5/25/93	PEST/PCB	SML 84	DATA CHEM	Sample collected at auxiliary helipad
	BLD-12S	5/26/93	PEST/PCB	BI6	DATA CHEM	Sample collected at Blair Lakes parking area. OVM = 0 ppm
	BLD-13S	5/26/93	PEST/PCB	SML 84	DATA CHEM	Sample collected at Blair Lakes parking area. OVM = 0 ppm
	BLD-14S	5/26/93	PEST/PCB	BI6	DATA CHEM	Sample collected at Blair Lakes parking area. OVM = 48 ppm
	BLD-15S	5/26/93	PEST/PCB	SML 84	DATA CHEM	Sample collected at Blair Lakes parking area. OVM = 0 ppm
	BLD-16S	5/24/93	PEST/PCB	CH110	DATA CHEM	Sample collected at passenger helipad.
	BLD-17S	5/24/93	PEST/PCB	CH110	DATA CHEM	Sample collected at passenger helipad; sample depth = 6 inches
	BLD-18S	5/24/93	PEST/PCB	CH110	DATA CHEM	Sample collected at passenger helipad.
	BLD-19S	5/24/93	PEST/PCB	CH110	DATA CHEM	Sample collected at passenger helipad.
	BLD-20S	5/26/93	ABNL	BI6	DATA CHEM	Sample collected from side of Generator Bldg. OVM = 0 ppm.
	BLD-21S	5/26/93	ABNL	SML 84	DATA CHEM	Sample collected between Generator Bldg and above ground tanks OVM = 174 ppm
	BLD-22S	5/26/93	ABNL	SML 84	DATA CHEM	Sample collected from side of Generator Bldg
	BLD-23S	5/26/93	ABNL	BI6	DATA CHEM	Sample collected from side of Generator Bldg farthest from tanks

VOC = volatile organic compounds; ABNL = semivolatiles; ICP = ICP metals; AS = arsenic; PB = lead; HG = mercury; PEST/PCB = pesticides/PCBs

2.2 ST20 E-8 Refueling Loop

Monitoring Wells 20M06, 20M13, 20M14, and 20M15 were sampled.

A soil boring was advanced near existing Well 20M14; soil samples were collected at depths near the ground surface and at the smear zone for semivolatile analyses. A composite surface soil sample was collected from a marshy area near 20M17 for pesticide/PCB analyses. Sampling locations are shown in Figure 2.

Water levels and product thickness measurements were conducted on all functioning wells and product probes. No free product layer was detected at any of the E-8 monitoring wells or probes. The wells and product probes were surveyed for elevation.

2.3 ST20 E-9 Refueling Loop

A soil gas survey was performed by EA to identify new sources in the E-9 Complex. Results were used as guidance in locating new Well 20MW26 upgradient of the free product area (i.e. not in an area of volatile contamination). Preliminary results of the soil gas analyses are included as Appendix D. Although a high water table perched over seasonal frozen ground at approximately 2.5 feet interfered with the soil gas analyses, enough data existed to indicate that the location shown in the OU-1 Management Plan was likely upgradient of the site.

Monitoring well 20MW26 was advanced and installed at the proposed location. Organic vapor was not detected above background levels during drilling or from the groundwater extracted from the well in the field. Soil samples were collected at depths near the ground surface and at the smear zone for chemical analyses. The well was screened across the water table.

Monitoring Wells 20C-2, 20M01, 20M07, 20M08 20M20, 20M21, 20M22, 20M23, 20M24, 20MW26, and Base Supply Well 8 were sampled.

Base Supply Well 8 is located in Building 1307 beneath steam piping connected to the utilidor. In 1985, this building was connected to the utilidor and Well 8 was no longer needed. Well 8 is not currently being used as a water supply well. The six-inch-diameter well has a depth of 96 feet. The 3/4 horse power submersible pump is still in the well. There is no longer a starter box for the pump. It is uncertain how deep the pump hangs, although it may be as shallow as 15 feet bgs; peristaltic tubing fed down into the well was obstructed at approximately 15 feet.

Sixteen surface soil samples were collected from various locations along the tarmac for semivolatile analysis. A composite surface soil sample was collected from a strip along the taxiway near 20M23 for pesticide/PCB analysis. Sampling locations are shown in Figure 3.

Water levels were measured in existing wells. Product thicknesses were measured in twenty-four product probes located in the vicinity of the fuel pumphouse. No free product was detected in any of the wells; free product was encountered in several probes in the E-9 Refueling Loop area. The wells and product probes were surveyed for elevation; well 20MW26 was also surveyed for horizontal coordinates. Surveyed product probes are shown in Figure 4.

A records search was conducted to investigate possible fuel spills on either side of the tarmac near ST20 E-9. Eielson AFB Liquid Fuels department records indicated 3 spills at the E-9 refueling loop. These leaks are shown on Figure 3 as areas 1, 2 and 3. Leak 1 was detected August 1988 and repaired in June, 1989. The leak was extensive; the amount of fuel lost is unknown. After the leak was repaired, a leak test was conducted on the piping. During this test, contractors noticed fuel further out on the tarmac seeping up through cracks (Leak #2). The age of this leak is unknown. This leak was repaired in June, 1989. The third leak was discovered near the refueling building in June, 1992 and repaired in July, 1992. It occurred in the line to the defueling tank. The amount leaked is unknown.

Air Force personnel from HVAC were contacted about possible leaks that may have occurred across the tarmac from E-9. There were no records of leaks in that area. The fuel tank that was located near Well 8 has been removed.

2.4 ST48 Power Plant

Boring 48MW08 was advanced and a monitoring well installed. Two soil samples were collected for chemical analyses; one was from near the surface and the other from the smear zone. The well was screened across the water table. Well development was conducted May 20, 1993.

Groundwater samples were collected from wells: 48M01, 48M03, 48M04, 48M05, 48M06, 48M07, 48MW08, 53M03, 18-6, and Base Supply Well D. Well 48M02 is buried beneath the coal piles and could not be located for sampling. There is no record of abandonment for 48M02; it is recommended that this well be abandoned properly. Well 53M03 contained free product; product was not encountered here during previous sampling events.

A soil boring was advanced near existing well 53M03. Three soil samples were collected for semivolatiles and pesticides/PCB analyses. Samples were collected at depths near the ground surface, and 6.5 feet and 10.5 feet below ground surface (bgs).

A surface soil sample was collected 1.8 feet bgs, within the coal pile area, for TPH and semivolatile analyses. A composite surface soil sample was collected from west of the vapor extraction experiment. As instructed by Battelle/ESO, directed surface soil sampling was not conducted for PCBs near transformer sites. Sampling locations are presented in Figure 5.

Water levels and product thicknesses were measured at all existing wells and functioning/accessible product probes. Free product was encountered in Wells 48M01 and 53M03, and in probes 48PP09 and 48PP28. The wells and product probes were surveyed for elevation; new monitoring well 48MW08 was also surveyed for horizontal coordinates.

Records for the pumping of the power plant cooling wells 1 and 2 (see Figure 5) were obtained from the Power Plant Superintendent. Prior to 1991 records were not maintained. Monthly records were available from 1991 to present; however, daily records are not kept. The estimated flow for Well 1 was 4,000 gpm; Well 2 was 2,500 gpm. Records indicate that these wells are used only during summer months (May through September) when water from the cooling ponds is not suitable. The cooling ponds supply the water used during the winter months.

Records for Base Supply well D were obtained from the Eielson AFB Bioenvironmental Group. Daily records are available extending back to 1978.

2.5 ST49 Alert Hanger

Monitoring Wells 49M01, 49M02, 49M03, 49M04, 49M05, 49M06, and 53M05 were sampled.

Surface water and sediment samples were collected from Garrison Slough upstream and downstream of the Alert Hanger. Garrison Slough was not flowing in this area during sampling, but consisted of disconnected areas of ponded water; there was only minimal standing water in the Slough in both sampling locations. Surface water was collected from ponded water in the slough approximately 100 feet upstream of the culvert, and from standing water next to the downstream outlet (CMP drainline). Sediment was sampled next to the inlet and outlet of the CMP drainline. Sampling locations are presented in Figure 6.

Directed surface soil samples were collected from near existing wells 49M01, 49M03, 49M04 for semivolatile analyses. Four directed surface soil samples were collected from the area surrounding Well 49M05 for volatile analyses. A composite surface soil sample was collected from the sides of Garrison Slough upstream from the Alert Hanger for pesticides/PCB analyses.

A soil boring was advanced in a location thought to be near the bend in the subsurface CMP drainline, connecting upstream and downstream sections of Garrison Slough. The boring was located between 53M05 and a partially excavated hole containing a flightline reflector/light foundation and fill material. Location of this excavation corresponded to the map ("inlet sump" in Figure 6). A small perforated portion of buried pipe was exposed in the bottom of the hole; however, it was not determined if this line was part of the CMP line connecting Garrison Slough or the drainline from the western taxiway. Soil samples were collected from depths near the surface and 4.5 feet bgs for TPH, volatiles, semivolatiles, and pesticide/PCB analyses. The ST49 soil boring location is shown in Figure 6.

Wells and existing product probes were surveyed for elevation. Water levels and product thicknesses were also measured. No product layer was detected in any of the monitoring wells or probes in the St49 area.

A records search was conducted by Eielson AFB personnel from HAZMAT to describe the plumbing within the Alert Hanger. The plumbing in the building is connected only to the leach field septic tank. The floor drains are channeled directly to the leach field to the south of the Hanger. The water overflows from the septic tank into the leach field without treatment; leak testing could not be performed. The leach field area smells strongly of hydrogen sulfide gas and biowaste.

2.6 Blair Lakes

Wells 50M01, 50M02, 50M04, 50M05, 50M06, 50M07, 50M08, 50M10, the old Supply Well and the new Supply Well were sampled. Well 50M09 had been destroyed and could not be sampled.

Eight test pits, shown in Figure 7, were dug. Six background soil test pits were hand dug and sampled at depths near the surface and near the water table (may have been perched in some locations). A sand cone density test was attempted on test pit #1 at 6 inches. The soil was too wet and rebounded as soil was removed, resulting in an erroneously high density calculation (166 lbs/cf). Density tests were not attempted at other locations.

Two test pits were excavated in the tank farm area using a backhoe. Two soil samples were collected from each test pit. The second test pit was advanced to permafrost at approximately 9 feet. Soil temperature was measured in each test pit.

Four directed surface soil samples were collected for pesticide/PCB analyses at each of the following areas: passenger helipad, auxiliary helipad, and parking lot. Four directed surface soil samples were collected in the area surrounding the generator building for semivolatile analyses. A composite surface soil sample was collected from near the sewage pond for pesticide/PCB analyses. Sampling locations are shown in Figure 7.

Water levels and product thicknesses were measured in all existing wells and product probes. Free product was encountered at Well 50M01, and at probes 50PP02, 50PP03, 50PP05. Major buildings, wells, the helipads, tanks, and other pertinent features were surveyed for horizontal coordinates using an assumed coordinate system. Assumed coordinates were correlated to four benchmarks surveyed with the global positioning system (GPS). Two of these are shown in Figure 7. Wells and product probes were also surveyed for elevation.

3.0 QA SAMPLE SUMMARY

Travel blanks, field duplicates, equipment blanks, and container blanks were collected as specified in the OU-1 Management Plan Field Sampling Plan, and the project instructions for groundwater and soil sampling.

Travel blanks were used for each shipment that contained samples for volatile organics or BTEX analyses, with the exception of groundwater samples from 48M03 and 48M07. Typically, the travel blank was packed in the morning with the cooler containing sample bottles and accompanied samples as they were collected. The travel blank was then packed with those same samples for shipment. A summary of the travel blanks used each day, and the associated samples, is provided in Table 3.1.

Field duplicate samples were collected for each media and each parameter sampled at a frequency of one in twenty. A summary of the field duplicates, sampling locations, and represented samples is provided in Table 3.2. In some cases, groundwater duplicates were not collected for analyses of total (unfiltered) arsenic and lead; the analytical laboratory (DATA CHEM) provided 500 ml sample bottles for ICP metals only, rather than the 1000 ml bottles needed for ICP metals, arsenic and lead.

Equipment blanks were collected for non-dedicated equipment at a frequency of one in twenty. One equipment blank was collected for each type of dedicated equipment used. A summary of the equipment blanks and the associated samples for non-dedicated equipment is provided in Table 3.3.

Container blanks were prepared by CH2M HILL/LGN for TOC analyses for bottles used to collect groundwater and soil samples at Blair Lakes. Container blanks were not required for wastewater treatment analyses. Bottles containing samples for TPH analyses, supplied by Enseco, were certified to have the highest level of cleanliness. The ESO subcontractor laboratory (DATA CHEM) supplied all other sample containers and were responsible for collecting the other container blanks.

Table 3.1
Travel Blank Summary
1993 Eielson AFB OU-1 Field Investigation

Sample Name	Date Collected	Cooler ID	Volatile Samples Traveling with Blank
20M08FT	5/20/93	PNL 736	20M08, 20M06, 20M06S, 20M06I, 20M06D (Full trip blank including VOC ABNL, ICP, AS, PB, HG)
20M08FTF	5/20/93	PNL 736	20M08FT (Full trip blank including filtered ICP, AS, PB, HG)
48M01FTF	5/19/93	CH102	48M01F (Full trip blank including filtered ICP, AS, PB, HG)
48M01FT	5/19/93	CH102	48M01 (Full trip blank including VOC, ICP, AS, PB, HG, ABNL)
50M04FT	5/25/93	SATUS	50M04 (Full trip blank including filtered VOC, ICP, AS, PB, HG)
50M04FTF	5/25/93	SATUS	50M04F (Full trip blank including filtered ICP, AS, PB, HG)
TB-1	5/25/93	BI6	50M08, DA-6
TB-2	5/24/93	PNL 722	50M10, 50M06, 50M07
TB-3	5/18/93	CH101	EQ-9, ST48-5S, ST48-4S
TB-4	5/17/93	PNL 507	48M05, 48M04, 48M06
TB-5	5/18/93	AYER	18-6, 53M03, DA-2
TB-6	5/20/93	DON	20M23, 20M23S, 20M23I, 20M23D, 20M24, 20M07, 20M07S, 20M07I, 20M07D, DA-1, DA-1S, DA-1I, DA-1D
TB-7	5/19/93	PNL QUEETS	20M21, 20M01, 20M20, 20C-2
TB-8	5/19/93	CH103	E-9-2S, E-9-1S, DA-8, E-7-2S, E-7-1S
TB-9	5/20/93	CH104	ST49-3S, ST49-9S, ST49-2S, ST49-1S, ST49-5S, ST49-6S, EQ-10
TB-10	5/25/93	PNL 502	20M15, 20M14, 53M05, 53M05S, 53M05I, 53M05D
TB-13	5/23/93	CH107	20M02, 20M03, 20M11, 20A-3
TB-14	5/24/93	PNL EM40	53M04, 20M04, 20M09, 20M09S, 20M09I, 20M09D
TB-15	5/25/93	PNL 721	49M04, 49M01, 49M03, 20M22, 20M22S, 20M22I, 20M22D
TB-16	5/24/93	CH106	20M13, 20MW27, 20MW26
TB-17	5/23/93	CH114	EQ-3/ ENSECO
TB-19	5/25/93	CH111	EQ-3/ DATA CHEM
TB-21	5/26/93	PNL 702	DA-3, 49M02
TB-22	5/26/93	CH108	49M06, 49M06S, 49M06I, 49M06D, 49M05, 49M05S, 49M05I, 49M05D
TB-23	5/26/93	EMO PNL	DA-5, 50M01, 50M01S, 50M01D
TB-24	5/27/93		WW-04 (BTEX)
TB-25	5/27/93	CH115	W-D, W-8
TB-26	5/27/93	PNL 506	EQ-2, EQ-1, 48MW8
TB-27	5/27/93	YELLEPIT	EQ-4, POND, E-7-5S
TB-28	6/1/93	PNL-EM04	DA-4, SL-2, SL-1, DA-12, ST49-8S, ST49-7S
TB-29	6/1/93	CVO	WW-05 (BTEX)
TB-99	6/22/93		WW-08 (BTEX)
TB-100	6/14/93		WW-06, WW-07 (BTEX)
	5/18/93	PNLEM042	48M07, 48M03, 48M03S, 48M03I, 48M03D

* Travel blank was not sent with these samples.

VOC = volatile organic compound; ICP = ICP metals; AS = arsenic; PB = lead; HG = mercury; ABNL = semivolatiles

Table 3.2
Field Duplicate Summary
1993 Eielson AFB OU-1 Field Investigation

Name	Duplicate Sample Name	Date Collected	Depth (ft)	Analyses	Cooler ID	Purpose
DA-1	E-7/20M07	5/20/93		VOC, ABNL, ICP, AS, PB, HG	DON	Represents first set of 20 base wells
DA-1F	E-7/20M07	5/20/93		ICP, AS, PB, HG	DON	
DA-1S	E-7/20M07	5/20/93	8	VOC	DON	Set of vertical VOC samples represents 9 base wells sampled for vertical VOCs.
DA-1I	E-7/20M07	5/20/93	17	VOC	DON	
DA-1D	E-7/20M07	5/20/93	26	VOC	DON	
DA-2	53M03	5/18/93		VOC, ICP, HG, ABNL		Represents second set of base wells
DA-2F	53M03	5/18/93		ICP, AS, PB, HG		
DA-3	49M02	5/26/93		VOC, ABNL, ICP, AS, PB, HG	PNL 702	Represents third set of base wells (one well)
DA-3F	49M02F	5/26/93		ICP, AS, PB, HG	PNL 702	
DA-4	SL-2	6/1/93		VOC, ICP, AS, PB, HG	PNL EM04	Represents surface water parameters
DA-4F	SL-2F	6/1/93		ICP, AS, PB, HG	PNL EM04	
DA-5	50M01	5/26/93		VOC, ABNL, ICP, AS, PB, HG	EMO PNL	Represents set of 10 wells sampled at Blair Lakes, well 50M01 located in center of free product area.
DA-5S	50M01	5/26/93	13	VOC	EMO PNL	
DA-5D	50M01	5/26/93	14.4	VOC	EMO PNL	
DA-5F	50M01	5/26/93		ICP, AS, PB, HG	EMO PNL	
DA-6	50M08	5/25/93		VOC, ABNL, ICP, AS, PB, HG	BI6	Collected for upgradient well 50M08
DA-6F	50M08	5/25/93		ICP, AS, PB, HG	BI6	
DA-7						Not used.

Table 3.2
Field Duplicate Summary
1993 Eielson AFB OU-1 Field Investigation

Name	Duplicate Sample Name	Date Collected	Depth (ft)	Analyses	Cooler ID	Purpose
DA-8	E-7-2S	5/19/93	5.0-7.0	VOC	CH103	Represents 15 samples collected during drilling, including 4 samples for VOCs at ST49
DA-8	E-7-2S	5/19/93	7.0-9.0	ICP, AS, PB, HG ABNL	CH103	
DA-8	E-7-2S	5/19/93	5.0-7.0	AK101, AK102	110	Represents samples from 9 main base wells and 2 Blair Lakes samples.
DA-8	E-7-2S	5/19/93	7.0-9.0	TOC	CH103	
DA-8SV	E-7-2SM	5/19/93	12.0-14.0	MOISTURE	CH103	
DA-9	E-9-5S; Taxiway sample	5/27/93		ABNL	PNL 16	Represents 16 taxiway surface soil samples.
DA-10	ST49-10S	5/20/93		ABNL	CH104	Represents 8 directed surface soil samples: 3 from ST49, 1 from ST48, and 4 from Blair Lakes generator area.
DA-11	ST49-4S	5/20/93		PEST	CH104	Represents five composite samples.
DA-12	ST49-8S	6/1/93		TOC		Represents three sediment samples and associated analytical parameters.
DA-12	ST49-8S	6/1/93		VOC, ABNL, ICP, AS, PB, HG, PEST/PCB	PNL EM04	
DA-13	BL1-1S	5/25/93		ICP, AS, PB, HG ABNL	CH110	Represents soil samples collected from 6 background test pits at Blair Lakes
DA-13	BL1-1S	5/25/93		TOC	CH112	
DA-13SV	BL1-1SM	5/25/93		MOISTURE	CH110	
DA-14	BLD-14S	5/26/93		PCB	SML 84	Sample covers 13 soil samples (12 directed/1 composite) at Blair Lakes.

E-7-2S ABNL sample collected at depth 5.0-7.0 ft

Depth of vertical groundwater samples is from top of well casing

VOC = volatile organic compounds; ABNL = semivolatile compounds; ICP = ICP metals; AS = arsenic; PB = lead; HG = mercury; PEST/PCB = pesticides/PCBs

Table 3.3
Equipment Blank Summary
1993 Eielson AFB OU-1 Field Investigation

Name	Date	Analyses	Laboratory	Cooler	Purpose
EQ-1	5/27/93	VOC, ABNL, ICP, HG	DATA CHEM	PNL 506	Dedicated bailer equipment blank
EQ-1F	5/27/93	ICP, AS, PB, HG	DATA CHEM	PNL 506	Portable filter used to filter water for metals samples.
EQ-2	5/27/93	VOC, ABNL, ICP, AS, PB, HG	DATA CHEM	PNL 506	Dedicated peristaltic pump tubing equipment blank.
EQ-2F	5/27/93	ICP, AS, PB, HG	DATA CHEM	PNL 506	Portable filter used to filter water for metals samples.
EQ-3	5/25/93	VOC, ABNL, ICP, AS, PB, HG, PEST/PCB TOC AK101, AK102	DATA CHEM CH2M HILL ENSECO	CH111 CH112 CH114	Decontaminated trowels used to collect Blair Lakes soil samples 5/24/93
EQ-4	5/27/93	VOC, ABNL, ICP, AS, PB, HG, PEST/PCB	DATA CHEM	YELLEPIT	Trowel blank for surface soil and sediment samples collected during surface soil sampling at E-9 taxiway.
EQ-8	5/23/93	ABNL	DATA CHEM	PNL 709	Trowel and spoon blank for surface soil samples collected at E-9 taxiway
EQ-9	5/18/93	AK101, AK102 VOC, ICP, AS, PB, HG, ABNL, PEST/PCB TOC	ENSECO DATA CHEM CH2M HILL	 CH101	Split spoon equipment blank for soil samples collected during monitoring well borehole drilling.
EQ-10	5/20/93	AK101, AK102 TOC VOC, ABNL, ICP, AS, PB, HG, PEST/PCB	ENSECO CH2M HILL DATA CHEM	 CH104	Split spoon equipment blank for samples collected during borehole drilling collected at ST49SB.

VOC = volatile organic compounds; ICP = ICP metals; AS = arsenic; PB = lead; HG = mercury; ABNL = semivolatiles; PEST/PCB = pesticides/PCBs

4.0 SURVEYING SUMMARY

New and existing wells, and existing product probes, in the OU-1 source areas were surveyed between May 20 and 25, 1993. Surveying data are presented in Appendix C.

Wells 48M02 (coal piles) and 50M09 (Blair Lakes) could not be located, and were not surveyed. Several product probes listed in the OU-1 Management Plan had been destroyed and were not surveyed. Product probe survey information is summarized in Table 4.1.

Table 4.1
Summary of Product Probe Information
OU-1 Source Areas

Source Area	Probe No.	Status					
		Damaged/ Destroyed	Buried/ does not exist/ not found	In treatment area	Functional Probe		
					Surveyed	Product Thickness Checked	Product Present
ST20 E-7	20PP08			X			
	20PP09			X			
	20PP10		X				
	20PP11		X				
	20PP12				X	X	X
	20PP13			X			
	20PP14			X			
	20PP15			X			
	20PP16			X			
	20PP17				X	X	
	20PP35				X		
	20PP36			X			
	20PP39		X				
ST20 E-8	20PP48				X	X	
	20PP49				X	X	
	20PP50				X	X	
	20PP51				X	X	
	20PP52				X	X	
	20PP53		X				
	20PP54					X	
	20PP55				X	X	
	20PP56				X	X	
	20PP77				X	X	
	20PP78				X	X	
	20PP79				X	X	
	20PP80				X	X	
ST20 E-9	20PP57	X					
	20PP58				X	X	
	20PP59		X				
	20PP60		X				
	20PP61				X	X	X
	20PP62	X					
	20PP69	X					
	20PP70	X					
	20PP71				X	X	X
	20PP72				X	X	X
	20PP73				X	X	X

Table 4.1
Summary of Product Probe Information
OU-1 Source Areas

Source Area	Probe No.	Status					
		Damaged/ Destroyed	Buried/ does not exist/ not found	In treatment area	Functional Probe		
					Surveyed	Product Thickness Checked	Product Present
ST20 E-9 (cont.)	20PP74				X	X	X
	20PP75		X				
	20PP76		X				
	20PP101				X	X	X
	20PP102				X	X	X
	20PP103				X	X	
	20PP104				X	X	X
	20PP105				X	X	
	20PP106				X	X	X
	20PP107				X	X	
	20PP108				X	X	X
	20PP110				X	X	X
	20PP111				X	X	X
	20PP112				X	X	X
	20PP113				X	X	X
	20PP114				X	X	X
	20PP115				X	X	
	20PP116				X	X	X
	20PP117				X	X	
	20PP118				X	X	X
	20PP119				X	X	X
ST48	48PP01		X				
	48PP02		X				
	48PP03		X				
	48PP04			X			
	48PP05			X			
	48PP06			X			
	48PP07		X				
	48PP08			X			
	48PP09				X	X	X
	48PP10			X			
	48PP11			X			
	48PP12			X			
	48PP13				X	X	
	48PP27				X	X	
	48PP28				X	X	X
	48PP63		X				

Table 4.1
Summary of Product Probe Information
OU-1 Source Areas

Source Area	Probe No.	Status					
		Damaged/ Destroyed	Buried/ does not exist/ not found	in treatment area	Functional Probe		
					Surveyed	Product Thickness Checked	Product Present
ST48 (cont.)	48PP64		X				
	48PP65			X			
	48PP66		X				
	48PP67	X					
	48PP68			X			
ST49	49PP23		X				
	49PP25		X				
	49PP26				X	X	
	49PP40				X	X	
	49PP41				X	X	
	49PP42				X	X	
	49PP43				X	X	
	49PP44				X	X	
	49PP45				X	X	
	49PP46				X	X	
	49PP47		X				
	49PP104				X		
	49PP105				X		
	49PP106				X		
	49PP107				X		
	49PP118				X		
Blair Lakes	50PP01	X			X		
	50PP02				X	X	X
	50PP03				X	X	X
	50PP04				X	X	
	50PP05				X	X	X
	50PP06	X					
	50PP81	X					
	50PP82		X				
	50PP85		X				

Notes:

1 Probes in treatment areas were not investigated during the OU-1 field season

5.0 WASTEWATER TREATMENT SUMMARY

Groundwater from purge and development activities and wastewater from decontamination activities were treated using a small-scale carbon adsorption system. The treated water was discharged into one of three 500-gallon tanks. When the tank was full, a sample was collected for fast-turnaround volatile organics analysis. If the water met discharge standards (10 ppb total BTEX and each volatile constituent below its respective MCL), it was discharged to the sanitary sewer. If the sample did not meet discharge standards, the tank contents were retreated. Copies of the laboratory analytical results are provided in Appendix E.

A total of 2,600 gallons of water was treated through the system. Five samples were collected for analysis prior to completion of the field season. The first three samples met discharge requirements, and the associated waste was disposed to a sanitary sewer. Volatiles were detected in the other two samples; water in tanks from which samples were taken, was retreated using new carbon canisters. Retreated water was sampled from both tanks. The sample from one tank met the discharge requirements and was disposed to the sewer. The sample from the other tank did not, and was retreated and resampled; volatiles were not detected in the sample at levels above the discharge standards and the contents of the tank were discharged to the sewer.

Two carbon canisters were used during the field season. At the request of Battelle, the system was left in place following demobilization; two canisters are presently in use. Eight unused canisters are stored with the wastewater treatment system.

6.0 HEALTH AND SAFETY SUMMARY

Procedures described in the Site Management Plan Health and Safety Plan Revision 5 (SMP-HSP) and the OU-1 Management Plan HSP were followed by the groundwater and soil sampling field teams. All field team members were given an initial health and safety briefing by the field coordinator prior to commencement of sampling activities. Brief meetings were held daily by each team to discuss specific source area health and safety issues.

Air monitoring was conducted by both the groundwater and soil sampling teams. Organic vapor monitoring was conducted approximately every 30 minutes by the groundwater and soil sampling teams while working in the exclusion zone. Organic vapor was not detected above background levels in the breathing zone at any of the sampling locations.

Field workers wore level D personal protective equipment. Based on air monitoring results, upgrade to level C was not required during any of the field activities.

A health and safety audit was conducted on May 20, 1993 by a CH2M HILL health and safety officer. No instances of non-compliance with health and safety planning documents were noted.

7.0 MATERIALS INVENTORY

During demobilization an inventory was made of all materials belonging to the project. The inventory summary is presented in Table 7.1. All materials (except wastewater treatment items) are stored in a garage space near the HAZMAT Office on Flightline Avenue at Eielson AFB. The wastewater treatment system and associated equipment/supplies are stored near the Battelle field trailer.

Table 7.1
Materials Inventory
1993 Elson AFB OU-1 Field Investigation

Quantity	Item Description
Health and Safety Related Items	
1 box	misc gloves, booties, MSA cartridges
1 box	misc. safety glasses
1 each	Blaze orange traffic vest
3 boxes	boot covers
2 pair	boot insulators
1 each	3-piece rainsuit
3 boxes	polycoated tyvek (XL)
1 box	polycoated tyvek (L)
1 box	perforated tyvek (XL)
1/2 box	 tyvek
8 boxes	6-pack of MSA respirator cartridges (GMCH)
2 boxes	MSA cleaner-sanitizer II
-	draeger tubes
-	ear plugs
Decontamination Supplies	
7 each	10-gal tubs
3 each	18-gal tubs
5 each	3-gal tubs
8 each	3-gal tub lids
12 each	10-gal and 18-gal tub lids
2 each	5-gal buckets
3 each	5-gal bucket lids
1 each	5-gal water container
1/2 roll	10-ft x 100-ft poly
11 each	spray jugs
3 each	spray bottles
Sampling Equipment	
4 cases	1/2-inch ID tubing
4 boxes	100-ft length of 3/16-inch tubing
4 boxes	C-flex tubing (size 15)
--	misc tubing
--	misc. tube fittings
1-1/2 boxes	disposable bailers
2 boxes	flow reducers for disposable bailers
--	fishing line
2 boxes	Water filters (0.45 um #12178, 12179, 12180)
1 can	PVC cement
-	finger cots
6 each	stainless steel bowls
5 each	large sample hand shovels
4 each	small sample hand shovels
6 each	stainless steel spoons
4 each	stainless steel sample knives
9 each	trowels
3 each	large spoons
	misc. spatulas/small spoons/apple corer

Table 7.1
Materials Inventory
1993 Elson AFB OU-1 Field Investigation

Quantity	Item Description
Chemicals and Standards	
1 gal	Methanol (pesticide grade)
1/4 gal	Methanol (anhydrous)
2 qt	Conductivity calibrator (YSI 3161)
2 gal	High purity water
2 pints	isopropyl alcohol
2 each	2.34-liter 10% HNO ₃ rinse
Treatment System and Associated Equipment	
4 each	500-gallon tanks
1 each	1/2 hp electric motor
2 each	Sediment filters
12 each	Blue barrels - carbon filled (2 spent)
1 each	Flow meter
2 each	30-ft length of 2-inch hose with fittings
1 each	50-ft length of 2-inch hose without fittings
1 each	step
2 each	garden hoses
5 each	sock filters for treatment plant
1/2 bag	sorbent pads
2 each	25-ft length garden hoses
1 each	25-ft length reinforced clear hose
1 each	steel link chain
General Supplies	
1-1/2 packs	copy paper
1 each	map holder
1 each	electric strip
--	computer paper
2 rolls	duct tape
1 each	24-inch x 18-inch black board
3 each	file trays
1 roll	Bubble pack (sticky back - 14-inch radius)
3 each	freezer thermometers
1 box	misc. baggies and garbage bags
2 each	scale
1 each	Tape gun
--	baggies
--	vermiculin
--	blue custody tape
2 cans	spray paint
1 each	black spray paint
--	red flagging
2 each	1-liter thermos

8.0 CHANGES FROM THE MANAGEMENT PLAN

The 1993 field investigation was conducted according to the Final Operable Unit 1 Management Plan and the procedures found in the Site Management Plan FSP, QAPP, and HSP (revision 5). In some instances, changes were made to the field investigation activities or procedures due to circumstances encountered in the field. These changes were discussed with the ESO representative on site and documented in the field change notebook maintained by Battelle. Copies of the notebook are attached. Also during the course of field work, errors or inconsistencies were discovered in the Management Plan, field instructions or work plan. These were resolved and also documented in Battelle's field change notebook.

In the first section of the field change notebook, errors in the Management Plan which did not result in changes in the field work are noted. These changes were minor and are not discussed in this section.

Deviations from the OU-1 Management Plan included:

- Well 48M02 was not sampled because it is buried beneath the coal pile.
- Temperature measurements were not made on the soil borings at ST48 because a soil temperature probe was not available.
- Well 20M01 was not sampled for metals because this well did not contain floating product as expected. The metals analysis was meant to be taken in a location where floating product was present. It was agreed that there would be a sufficient number of locations with floating product where metals analysis were being measured.
- Base Supply Well 8 was sampled using dedicated peristaltic pump tubing, instead of a dedicated bailer, due to an obstruction encountered at a depth of approximately 15 feet.
- Well 50M09 was not sampled because it no longer exists.
- Procedures described in the OU-1 Management Plan FSP for collection of groundwater samples from wells containing free product were modified slightly in the project instructions for groundwater sampling. The modified procedure used in the field involved use of a plug at the end of the PVC pipe through which sampling tubing could be inserted, rather than the retrievable plug described in the FSP.
- Background test pits at Blair Lakes were hand dug rather than excavated with a backhoe because the ground was too soft for the backhoe. Therefore, test pits were not as deep as proposed in the OU-1 Management Plan. The pits were dug to the depth at which water entered the hole, generally this was between 3.5 and 4 feet bgs.
- Sand cone density measurements were not made. The ground at Blair Lakes was too wet, therefore the one test that was attempted resulted in an erroneously high density.
- Vertical samples at well 50M01 were collected at two depths, rather than three as prescribed in the OU-1 Management Plan. This was because there were only 2 feet of water in the well.

**Appendix A
OU-1 Management Plan
Change Documentation**

CVOR348/008.51-2

5/17/93 Field Changes from Field Sampling Plan - Appendix D of the
OU-1 Management Plan

Page D.1 No telephone hook was available at the Base
and no FAX machine was obtained due to no
telephone lines

Page D.2 Sanitary facilities are supplied by CH2M Hill

Page D.4 "will be filtered through 0.45 micron
flow-through filter cells."

Section 3.1 page D.5

Delete entire section. Battelle has prelabelled
all samples. All other samples will be labelled consistent
with Battelle's labelling scheme (ie. for TOC - CH2M Hill lab and
TPH - for the ENSCO lab).

Page D.9 No sheeting is placed around wells
that are not drilled through asphalt. The
cuttings are scraped

Page D-10 1st full paragraph

PID measurements may also be taken from the
end of the split spoon before opening the spoon.

Page D-10 Decommissioning of Boreholes

Boring numbers are not etched into the top of
the soil borings. The concrete is too coarse to
read the number and the concrete typically
does not last more than a year. Also, the
soil borings do not have names.

Page D-11 - Soil samples for lithologic logging may
be logged from split-spoons for chemical sampling.
Lithologic samples will be collected every 5
feet where chemical samples are not being
collected.

D-13 Sampling instructions do not include a health ^{flashes} & safety plan. These are in the Management Plan and each team member has a copy.

Groundwater Field Data Sheets are not being used -
Buttel's Field Sample Record is being used instead. (which ^{has a copy} _{is similar})

Metals analyzed for filtered metals may be sampled using a peristaltic pump and ^{HH starts vinyl} tubing. Wells with floating product will also be sampled using the peristaltic pump and vinyl tubing.

1/2-inch I.D. PVC pipe will be used during sampling floating product wells. A finger cot will be placed over the bottom of the PVC pipe. The pipe will be lowered 2' below the floating product. A vinyl tubing w/ an exacto knife will be lowered through the inside of the PVC pipe. The exacto knife will be decontaminated with alcohol prior to use. A peristaltic pump will be used to purge and sample the well. Water level measurements will be taken during purging to ensure that product is not pulled into the tubing.

Deviations

(1) Well 98MW2 was not sampled. The well is buried in the coal piles.

(2) ^{soil} Temperature measurements were not taken from soil samples in soil boring near 53MW3 at ^{HH starts} 98MW3 because the probe had not arrived.

~~Heidi Hoffman~~ ^{str 12/13}

5/19/93 Field work deviations

- (1) Well 20M01 did not contain floating product, therefore metals were not sampled at this well since we were looking for metals at floating product areas. Tyler Gilmore approved this change.

Hildi Hoffmann 5/19/93

5/26/93 Well 50M09 does not exist - destroyed + was not sampled. Hildi Hoffmann 5/26/93

Test pits were hand dug at Blair Lakes because the ground was too soft for the backhoe. Therefore, the depths of the 2nd sample were not as deep as described in the management plan. The samples were collected ~~where~~^{at} just above ~~where~~^{the} water entered the test pit.

Vertical Samples at well 50M01 were only collected at 2 elevations because there was only ~2' of water in the well.

Sand cone density method did not work at the Blair Lakes test pits because the water content in the soil was high^{er} and the soil rebounded as it was removed from the hole reducing the volume of the hole in relation to the amount of soil removed.

**Appendix B
Soil Boring Logs and
Well Construction Information**

CVOR348/008.51-3

LOGGING

MONITORING WELL DRILLING & GEOLOGIC LOG

AP

PROJECT Eickson AFB PROJECT NO CV 2205FW
 WELL NO 20 MW 27 (ST 20 E-7) HYDROGEOLOGIST P. Patch / A. Stark
 ELEVATION (NOV. TOP OF WELL CASING) 546.45 SURFACE ELEVATION (NOV.) 547.84 (est.)
 WATER LEVEL ELEV./DATE (NOV.) 517.51 5/19/93 START DATE 5/19/93
 DRILLING CONTRACTOR Shannon & Wilson FINISH DATE 5/19/93
 DRILLING METHOD Hollow Stem Auger 8" ID, 6" ID SAMPLING METHOD Split Spoon (3")

ELEVATION (FEET)	DEPTH (FEET)	SAMPLE NO.	RECOVERY (INCHES)	UNIT/DVA (ppm)	GEOLOGIC LOG & USCS DESIGNATION (Soil name, color, grain size, moisture content, relative density, structure)	USCS DESIGNATION	FLUSH MUD PRACTICE COVER WELL CONSTRUCTION SKETCH
546.45	0				Auger, topsoil.		
546.45	1				1.0-2.0 Silty Sand, fine to med. grad, light brown to gray (10YR 6/2), damp.	SM	
546.45	2				2.0-3.0 Sand, fine to med. grad, gray to brown (10YR 5/2) damp to moist.	SW	
546.45	3				SANDIES E725 (VOA, AK101, AK102, SWA, ICP A2, Pb, TOL, Hg) (PCB, PEST)		
546.45	4				ETISM		
546.45	5				5.0-5.5 Gravelly Sand, med. to coarse grad, 20% rounded gravel to 1", moist. Sampled 5' from bottom (grain size, moisture)	SW	
546.45	6				5.5-6.0		
546.45	7				As Above GRAVELLY SAND, 50% gravel 6.0-7.0 - 1517 SW E725 - (VOA) (AK101) (AK102) (SWA) DA-8 - (VOA) (AK101) (AK102)		
546.45	8				8.0-9.0 SAND, med. grad. to coarse grad, 10% gravel (5%), gray (10YR 5/1), wet. E725 - (ICP A2, Pb) (DA-8) (TOL) (SWA) (ICP A2, Pb) (TOL) (Hg)	SW	
546.45	9						
546.45	10				As Above, sand, wet.	SW-SP	
546.45	11				E725 (PCB, PEST) DA-8 (PCB, PEST)		
546.45	12				SAND, as above, med. grad, minor gravel (10%)	SP	
546.45	13				E725M - GRAIN SIZE, MOISTURE DABSV - GRAIN SIZE, MOISTURE		
546.45	14				As above 14.0-14.5 SP	SW	
546.45	15				14.5-15.5 Gravelly Sand, wet, gray, (10YR 5/1) wet, 30-40% rounded gravel		

SS-07 Cont'd on next page

[illegible]

MONITORING WELL RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME Eielson AFB PROJECT NO. CV70205.FW
WELL NO. 20MW27 FIELD OBSERVERS A. Stark / P. Patchin
ELEV, NGVD (top of well casing) 546.84' SURFACE ELEV, NGVD 547.24' (est)
WATER LEVEL ELEV/DATE, NGVD stabilized 5.5 ft @ 5/19/93 START DATE 5/19/93
DRILLING CONTRACTOR Shannon & Wilson FINISH DATE 5/19/93
DRILLING METHOD Hollow Stem Auger

See Surface Detail (Bottom of Page)

DEPTHS ABOVE/BELOW GROUND SURFACE

WELLINST.DWG

WELL CONSTRUCTION MATERIALS

BOREHOLE DIA(S) 8 1/4 INCHES TO 14.5' BGS
3 INCHES TO 16.0' BGS
— INCHES TO — FT BGS
PROTECTIVE CASING TYPE Flush Mount w/ traffic l.d.
PROTECTIVE CASING DIAMETER 14"
WELL CASING TYPE Sch. 40 PVC DIAMETER 4"
COUPLING TYPE Flush-threaded joints
SCREEN TYPE Sch 40 PVC DIAMETER 4"
SLOT SIZE .010, mesh SCREEN LENGTH 10.0'
TOP CAP TYPE Locking collar
END CAP/PLUG TYPE Flush-threaded
CENTRALIZER TYPE none
CENTRALIZER LOCATION(S) none
FILTER PACK TYPE Chlo. Silica GRADATION 10/20
FILTER PACK VOLUME 3.0' cu ft.

SEAL(S)

SURFACE Concrete grout VOLUME 2.0 cu ft
ANNUAL see side note VOLUME none
BENTONITE chipped bentonite VOLUME 6 cu ft
BACKFILL none VOLUME none

Continuous bentonite chips from sand pack to surf. son 1

WELL DEVELOPMENT

DATE _____
METHOD _____
COMMENTS _____

Surface Detail

LOG1.DWG

MONITORING WELL DRILLING & GEOLOGIC LOG

PROJECT Fielson AFB PROJECT NO CV70205FW
 WELL NO 20MW26 (ST 20 E-9) HYDROGEOLOGIST P. Patchine / A. Stack
 ELEVATION, NGVD (Top of Well Casing) 546.84' SURFACE ELEVATION (NGVD) 547.34' (est)
 WATER LEVEL ELEV./DATE (NGVD) 6.85' @ 1053 m 5/19/93 START DATE 5/19/93
 DRILLING CONTRACTOR Shannon & Wilson FINISH DATE 5/19/93
 DRILLING METHOD Hollow Stem Auger 9 1/2" OD, 6 1/2" ID SAMPLING METHOD 3" Split Spoon

DEPTH (ft)	SAMPLE BLVD COUNTS RECOVERY (INCHES) TIME/TOVA (PPM)	GEOLOGIC LOG & USCS DESIGNATION (Soil name, color, grain size, moisture content, relative density, structure)	USCS DESIGNATION	WELL CONSTRUCTION SKETCH
0				
1				
SS 01	2-5.1 (13) 14	Gravelly sand, med to coarse grnd, yellow tan (10YR 4/2), grading to fine grnd sand last 6", damp. Sampled EQ-18 (VOR, AK101, AK102 T.C.P. As Pb, Tox)	SW	
3				
SS 02	2-7-9-9 (12) 1.8'	As above, very fine fine grnd, silty no gravel, damp to slightly moist, grayish brown (10YR 5/2). Sampled EQ-15 (VORs, AK102, Hg, PCB Pest) Sampled EQ-15M (grain size, moist)	SW- SM	
5				
SS 03	6-4-8 (12) 1.9'	As above, SAND, fine grnd, silty, minor gravel, moist, Sampled EQ-25 (VOR, AK101, AK102, Tox, Hg, SVORs, T.C.P. As Pb, PCB/Pest)	SM	
7				
SS 04	8-10-7-7 (6) 1.4'	7.5-8.1 - SAND, fine grnd, to fine grnd, gray, (10YR 5/1) wet, gray, (10YR 5/1) wet, last 6" coarse to very coarse grnd, up to 1". Sampled EQ-25M (grain size, moisture)	SM	
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LOG1.DWG

MONITORING WELL DRILLING & GEOLOGIC LOG

PROJECT Elkton PROJECT NO CU7020FW
WELL NO 20MW26 (ST20E-9) HYDROGEOLOGIST P. Pathari / A. Stone
ELEVATION NGVD (Top of Well Casing) 546.84' SURFACE ELEVATION (NGVD) 547.34' (est.)
WATER LEVEL ELEVATION (NGVD) 6.05 @ 1053 on 8/17/93 START DATE 5/19/93
DRILLING CONTRACTOR Shannon & Wilson FINISH DATE 5/18/93
DRILLING METHOD Hollow Stem Auger 9 1/2" OD, 6 1/2" ID SAMPLING METHOD 3" Split Spoon

[illegible]

MONITORING WELL RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME Eielson AFB PROJECT NO. CV 70205.FW
 WELL NO. 20MW26 FIELD OBSERVERS A. Stark / P. Pakhira
 ELEV. NGVD (TOP OF WELL CASING) 546.84' SURFACE ELEV. NGVD 547.34' (est.)
 WATER LEVEL ELEV./DATE, NGVD 546.84' @ 5/19/93 START DATE 5/19/93
 DRILLING CONTRACTOR Shannon & Wilson FINISH DATE 5/19/93
 DRILLING METHOD Hollow Stem Auger

See Surface Detail @ bottom of page

WELL CONSTRUCTION MATERIALS

BOREHOLE DIAM(S) 8 1/4 INCHES TO 15.5 FT BGS
3 INCHES TO 17.0 FT BGS
— INCHES TO — FT BGS
 PROTECTIVE CASING TYPE Flash Mount w/ traffic lid
 PROTECTIVE CASING DIAMETER 14"
 WELL CASING TYPE PVC (sch. 40) DIAMETER 4"
 COUPLING TYPE Flush-threaded joints
 SCREEN TYPE Sch. 40 PVC DIAMETER 4"
 SLOT SIZE .010 inch SCREEN LENGTH 10.0 ft
 TOP CAP TYPE Locking collar
 END CAP/PLUG TYPE Flush-threaded
 CENTRALIZER TYPE NONE
 CENTRALIZER LOCATION(S) Nine
 FILTER PACK TYPE Colorado silica GRADATION 10/20
 FILTER PACK VOLUME 3.0 cu ft.

SEAL(S)

SURFACE Concrete grout VOLUME 2 cu ft.
 ANNULAR see side note VOLUME —
 BENTONITE chipped bent. VOLUME 3.0 cu ft.
 BACKFILL none VOLUME none

Continuous bentonite chips to per spec. Sec. 1 5/17/93

WELL DEVELOPMENT

DATE —
 METHOD —
 COMMENTS —

• DEPTHS ABOVE/BELOW GROUND SURFACE
 WELLINST.DWG

LOG1.DWG

MONITORING WELL DRILLING & GEOLOGIC LOG

PROJECT Eiclon AFB PROJECT NO. CV7020FW
 WELL NO. 4B MW08 HYDROGEOLOGIST P. Pathin / A. Stark
 ELEVATION, NGVD (TOP OF WELL CASING) 538.87' SURFACE ELEVATION (NGVD) 539.37' (est)
 WATER LEVEL ELEV/DATE (NGVD) 11.78' @ 10:05 5/18/93 START DATE 5/18/93 8:58
 DRILLING CONTRACTOR Shannon Wilson FINISH DATE 5/18/93 12:13
 DRILLING METHOD Hollow Stem Auger SAMPLING METHOD Split spoon

ELEVATION (ft)	DEPTH (ft)	SAMPLE			GEOLOGIC LOG & USCS DESIGNATION (Soil name, color, grain size, moisture content, relative density, structure)	USCS DESIGNATION	WELL CONSTRUCTION SKETCH
		BLDG CINNIS	RECOVERY (INCHES)	WAT/DVA (ppm)			
	0						
SS 01	1				Gravelly Sand, grayish brn. (2.5YR 5/2) well graded, dry to damp, gravel to 1.5" - ST4845, (Von) (ICP, As, Pb) (AK101)	SW	
SS 02	2	3.2.8 (15)	10	0.1			
SS 02	3	7.10 (25)	8	0.1	As above, more fines, siltier. - ST4845 (SVon) (AK102)	SW	
SS 03	4	5.16 (21)	13	0.6	Sand, fine gravel. From approx 4.0', silty, clayey, mottled yellowish brn. (10YR 5/4) to gray (10YR 5/1) minor coarse sand, organic material (dk brn) at last 4" of sample, damp to moist	SM	
SS 04	5	4.10.14.21 (35)	15	2.3	Sand, med grad, grading to coarse with gravel, dk grayish brown (10YR 4/2) damp to moist. ST48-45M (grain size)	SW	
SS 05	8	4.10.17.10 (32)	16	2.7	Gravelly Sand, as above, gravel to 2", coarse to very coarse grad, minor silt & moist, ST48-55 (H ₂) (ICP, As, Pb) (SVon) (Von) (AK101) (AK102)	SW	
SS 06	11	9.7.10.11 (21)	16	38	Gravelly Sand, as above gravel to 2", vry. coarse to coarse grad, very minor fines, very moist. --- Water level 11.78' in auger --- ST48-55 (PCB, H ₂) (TOL) ST48-55M (grain size)	SW	
	12						
	13						
	14						
	15						

DUM Background = 0.1

ELEVATION (ft)	DEPTH (ft)	SAMP. F.		GEOLOGIC LOG & USCS DESIGNATION (Soil name, color, grain size, moisture content, relative density, structure)	USCS DESIGNATION	WELL CONSTRUCTION SKETCH
		BLOW COUNTS	RECOVERY (INCHES)			
55 07	15 16	7.8 2.0		Gravelly Sand, as above, gray (1042 S/1), wet, rounded gravel to 1", igneous	SW	
↑ Auger ↓	17					
	18					
	19					
55 08	20 21			No recovery (large cobble in split spoon in shoe)		20.0 20.6 by Sluffed in 2' Run Native Material
	22			T.D. 21.5' @ 10:15 Installed 4" Monitoring well see well construction diagram for details		

MONITORING WELL RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME Eldson PROJECT NO. CVD 70205 FW
 WELL NO. 49 MW08 FIELD OBSERVERS A. Stark / P. Patchin
 ELEV, NGVD (top of well casing) 538.87' SURFACE ELEV, NGVD 539.37'
 WATER LEVEL ELEV/DATE, NGVD 527.09' 5/18/93 START DATE 5/18/93
 DRILLING CONTRACTOR Shannon & Wilson FINISH DATE 5/18/93
 DRILLING METHOD Hollow Stem Auger 8 1/4" OD, 4" ID

• DEPTHS ABOVE/BELOW GROUND SURFACE
 WELL INST DWG

WELL CONSTRUCTION MATERIALS

BOREHOLE DIAM(S) 8 1/4" INCHES TO 20.6 FT BGS
3" INCHES TO 21.5 FT BGS
 _____ INCHES TO _____ FT BGS
 PROTECTIVE CASING TYPE Flush Mount 14" Traffic Cover
 PROTECTIVE CASING DIAMETER 14"
 WELL CASING TYPE PVC DIAMETER 4"
 COUPLING TYPE Flush joint threaded
 SCREEN TYPE PVC DIAMETER 4"
 SLOT SIZE 10 slot SCREEN LENGTH 10 ft.
 TOP CAP TYPE locking dollar cap.
 END CAP/PLUG TYPE 6" threaded
 CENTRALIZER TYPE NONE
 CENTRALIZER LOCATION(S) NONE
 FILTER PACK TYPE Colorado Silica GRADATION 10/20
 FILTER PACK VOLUME 3.5 cu ft.

SEAL(S)

SURFACE see side note - concrete VOLUME _____
 ANNULAR see side note - bent. chips. VOLUME _____
 BENTONITE bent. chips VOLUME 1.7 cu ft
 BACKFILL _____ VOLUME _____

Continued: Chipped bentonite Seal to surf

WELL DEVELOPMENT

DATE _____
 METHOD _____
 COMMENTS _____

REV 11/89 FORM D1586

(18.30)

DEPTH BELOW SURFACE (FT)	INTERVAL	SAMPLE NUMBER AND TYPE	RECOVERY (FT)	STANDARD TEST RESULTS		SOIL DESCRIPTION	COMMENTS
				PENETRATION	RESULTS		
1.0		SS-1	1.2			1.0-2.1: SAND with silt; 5% clay; 3/3; dark; slightly damp	4.5
2.5							OVN: 84 collected at 1600 5/10/93
5.0		SS-2	1.3			4.5-5.8: as follows: top 5" as above; rest of interval SAND; SP; 10% 3/10; little fines well sorted, slightly moist	OVN: 62 ppm - split spoon
7.5		SS-3	1.1			6.0-7.1: as follows: 6.0-6.8: SAND with silt; 6.8-7.1: silt (7) 10% 2/1; siltier (orange-brown); organic	OVN: 2.7 ppm oil; odor in spoon (SS-3 was centrifuged; split spoon to show oil were in water)
10.0						with bentonite chips to n/1.0' hydrating with water; concrete n/1.0' to ground surface	

PROJECT	ECLIPSE DA-1
ELEVATION	NM
DRILLING METHOD AND EQUIPMENT	MSA 34" O.D. 4 1/2" I.D. MOH. B-61
DRILLING CONTRACTOR	SHANNON + WILSON - GREG BROWN
LOCATION	DA-1 ST20 E-3 camp
LOGGERS	A. Stark
FINISH	1632
DATE	5/10/93
WELL	near S3M04
PROJECT NUMBER	CVE 70206 FW
BORING NUMBER	ST20E75B
SHEET	1 OF 1
SOIL BORING LOG

CVO 70205.FW

BORING NUMBER

ST20 EBSB

SHEET

1 OF 1

5/18/13

ST20 E-B SB

SOIL BORING LOG

Near well 20M14

PROJECT OU-1 EIELSON

DATE 5/18/13

LOCATION: near well 20M14 (3 PL ~~cont~~)

LOCATION NM

DRILLER: SHANNON WILSON 6264 BEACH - Driller 5/13/13

EQUIPMENT HSA 7 1/4" o.d. 4 1/2" I.D. MOBIL D-61

DEPTH 4.85' at well 20M14

1420

1459

LOGGER A. Stark / CH2M HILL

DEPTH BELOW SURFACE (FT.)	SAMPLE			STANDARD PENETRATION TEST RESULTS 6" 6" 6" (IN)	DESCRIPTION SOIL NAME USCS GROUP SYMBOL COLOR MOISTURE CONTENT RELATIVE DENSITY OR CONSISTENCY SOIL STRUCTURE MINERALOGY	COMMENTS DEPTH OF CASING DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT.)			
1.0	X	SS-1	1.1	15-18-19	1.0'-2.1': Silty sand w/ gravel (SW) (10% 3/2), dry, well graded, fine sand (35-40%) few % cobbles (to 1"); 7-10% gravel (20-35%), 15-20% fines	-25 s/10K3 ST20 EB 45" SVOAS sample collected: 1438 OVM: Bq (0.0 ppm) hard drilling
2.5	X	SS-2	1.1	8-11-11	3.0'-4.1' silty sand w/ gravel (SW), 10% 3/2, slightly damp (as above), except coarsening with depth	
5.0	X	SS-3	0.8	6-8-8	5.0'-5.8' sand w/ gravel (SW) 10% 3/3, moist, coarse sand and gravel (medium)	4.85' by S --- Water level 20M14 --- ST20 E-B-SS SVOAS (sample) 1500 (time) OVM: Bq (0.0 ppm)
7.5					T.D. 6.5' (augered to 5.0') Abandoned borehole to with bentonite chips to ~1.0' hydrated with potable water; concrete ~1.0' to surface	
10.0						
12.5						
15.0						

REV 11/01/01

REV 11/01/01

New well 53403

PROJECT NUMBER

CVO-70205.FW ST48SB

BORING NUMBER

SHEET

OF

SOIL BORING LOG

PROJECT **Eickson AFB** **OU-1** LOCATION **5 ft 2" SW of 53M03**
ELEVATION **511.11 (well 53403)** DRILLING CONTRACTOR **Shannon & W. 1501 - Grey Beach** (Driver)
DRILLING METHOD AND EQUIPMENT **Auger 7 1/4" OD, 4 1/4" ID - Mobil 8-61**
WATER LEVELS **N/A** START **14:30** FINISH **15:40** S/M/KZ **P. Patchin** (MK)

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)			
0				6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1.5	01	SS	15"	9.5-16 (31)	Gravelly Sand, SW, med. gray, damp, slightly silty. gravel to 2"	1.2 ppm/OVA 14:48 ST48-1S (SVDA, PCB)
6.0	02	SS	12"	3.4-4 (3)	Sand, U. fine gravel, silty. SM, damp to moist, clayey. No. cohesive, FCBX str. grayish brn (10YR 5/2) to yellowish brn. 10YR 5/8.	1.3/OVA 15:12 ST48-6S (SVDA, PCB)
11.0	03	SS	11"	12.16-17 (35)	Gravelly Sand, SW, 30% fine grad., stronger. coarse grad, gry (10YR 5/1) moist to very moist.	185 ppm down-hole Breathing zone < 6kg. Water level 13.3' in (BGS) 53M03 @ 15:10 126.9 ppm @ 12.6' in SS (split spoon end) 15:40 ST48-7S (SVDA, PCB)
Auger depth: 11.0' T.D 12.5' @ 15:40						
Abandoned Borehole: with bentonite chips to -1.0' hydrating @ 5.0' & 1.0' with potable water. Concrete -1.0' to surface. (5 bags bentonite chips, 1 bag concrete).						

(8.30)

bkgs = 1 ppm.

REV 11/89 FORM D1586

PROJECT NUMBER
CV070205.FWBORING NUMBER
ST49SB

SHEET 1 OF 1

SOIL BORING LOG

PROJECT Fielson AFBELEVATION: NM

DRILLING METHOD AND EQUIPMENT

WATER LEVELS NOT taken

DRILLING CONTRACTOR

LOCATION ST49 between 53M05 and Sump(?)
SHANNON (Wilson)
Hollow Stem Auger 7 1/4" OD, 4 1/4" ID continuous flight auger
START 5/20/93 9:00 FINISH 5/20/93 11:47 LOGGER P. Patcha

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS 6" 6" 6" (IN)	SOIL DESCRIPTION SOIL NAME USCS GROUP SYMBOL COLOR MOISTURE CONTENT RELATIVE DENSITY OR CONSISTENCY SOIL STRUCTURE MINERALOGY	COMMENTS DEPTH OF CASING DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)			
0						
1	1.0	SS 01	1.3'	6.7.10. (17)	1.0'-1.6' Silty Sand, w/ gravel Dark greyish brown (10YR 4/2), damp 1.6'-2.3' Sand, fine grained dark greyish brown (10YR 4/2) damp to dry, minor gravel SP	OVM: 0 ppm Sampled ST49SS: (VOR, SVOR, PCB/PST, AK101, AK102).
2	2.5					
3	2.5	SS 02	1.1	7.7.10 (17)	Silty Sand, as before at 1.0'-1.6', very fine grained, w/ occas. gravel to 1.5" brown (10YR 5/3) changing to dark grey (10YR 4/1) SM.	OVM: 0 ppm
4	4.0					
5	5.0	SS 03	1.0	3.4.5. (9)	Silty Sand - Sandy silt very fine grained, dark gray (10YR 4/1), damp P. occasional gravel. SM-ML	OVM: 0 ppm
6	6.5					
7	6.5	SS 04	1.1	1.3.5 (8)	Silty Sand - Sandy silt as above, approx 5% rounded gravel poorly graded, organic material wet at bottom SM-ML	OVM: 0.7 ppm Sampled VOR, AK101, AK102 (Sample # ST4965)
8	8.0					
9	8.0	SS 05	1.2'	5.22 (4)	Silty Sand, - Sandy silt. as above, very dark dark gray (2.5YR 2/1) wet with occasional gravel to 2" wet. SM-ML	Sampled: (SVOR, PCB/PST) (Sample # ST4965)
10	9.5					
					A TOTAL DEPTH 9.5' 10:00 Abandoned borehole. w/ 4.5' bugs chipped bottom	(extend to 8' approximate)

REV 11-89 FORM D1586

**Appendix C
Summary of Survey, Water Levels, and
Product Thickness Data**

CVOR348/008.51-4

Table C.1
Summary of Survey, Water Level and Product Thickness Data
1993 Eielson AFB OU-1 Field Investigation

Well/ Probe	Northing	Easting	ToC Elev. (ft)	Depth to Water (ft)	Depth to Product (ft)	Product Thickness (ft)	Water Level Elev. (ft)	Comment
ST20/E-7								
20M02	220478.5	390684.5	549.59	8.57		NP	541.02	New monitoring well
20M03			545.93	5.03		NP	540.90	
20M04			546.57				546.57	
20M05			546.36	5.18		NP	541.18	
20M09			547.23	6.40		NP	540.83	
20M10			547.54	7.10		NP	540.44	
20M11			546.56	5.46		NP	541.10	
20M12			547.63	7.64		NP	539.99	
20A-2			546.58	NM			ND	
20A-3			NM	6.80		NP	ND	
20M27			546.45	5.20		NP	541.25	
53M04			547.50	6.39		6.39	541.11	
54M01			550.71	NM	NM	ND	ND	
54M02			550.51	NM	NM	ND	ND	
54M03			550.45	NM	NM	ND	ND	
54M04			550.22	NM	NM	ND	ND	
20PP12			548.05	7.30	6.90	0.40	540.75	
20PP17	547.59	6.49	NP	NP	541.10			
20PP35	547.44	NM	NM	ND	ND			
ST20/E-8								
20M06			549.57	7.86		NP	541.71	No water present in probe
20M13			550.71	9.11		NP	541.60	
20M14			547.34	5.50		NP	541.84	
20M15			548.73	7.09		NP	541.64	
20M16			548.98	7.26		NP	541.72	
20M17			NM	6.00				
20M18			546.23	4.57		NP	541.66	
20M19			545.79	4.26		NP	541.53	
20PP48			550.40	8.76		NP	541.64	
20PP49			547.17	5.48		NP	541.69	
20PP50			547.55	5.83		NP	541.72	
20PP51			551.67	9.84		NP	541.83	
20PP52			551.20	9.52		NP	541.68	
20PP54			NM	9.51		NP	ND	
20PP55			550.59	8.83		NP	541.76	
20PP56			550.91	9.13		NP	541.78	
20PP77			549.13	7.45		NP	541.68	
20PP78			549.27	7.64		NP	541.63	
20PP79			549.39	7.71		NP	541.68	
20PP80			550.12			ND	ND	

Table C.1 Summary of Survey, Water Level and Product Thickness Data 1993 Elson AFB OU-1 Field Investigation								
Well/ Probe	Northing	Easting	ToC Elev. (ft)	Depth to Water (ft)	Depth to Product (ft)	Product Thickness (ft)	Water Level Elev. (ft)	Comment
ST20/E-9								
20M01	221752.1	391849.0	549.04	8.55		NP	540.49	New monitoring well Bottom of probe: 8 ft
20M07			550.69	10.15		NP	540.54	
20M08			550.06	9.71		NP	540.35	
20M20			547.67	7.27		NP	540.40	
20M21			548.64	7.70		NP	540.94	
20M22			546.87	6.96		NP	539.91	
20M23			546.74	6.53		NP	540.21	
20M24			NM	5.74		NP	ND	
20MW26			546.84	6.00		NP	540.84	
20PP58			546.26	5.90		NP	540.36	
20PP61			546.25	5.77	5.76	0.01	540.48	
20PP71			546.64	6.55	6.07	0.48	540.09	
20PP72			546.14	5.78	5.60	0.18	540.36	
20PP73			548.56		7.94	0.06	ND	
20PP74			546.18	6.33	5.51	0.82	539.85	
20PP101			549.64	9.37	9.36	0.01	540.27	
20PP102			551.95	11.80	11.64	0.16	540.15	
20PP103			550.08	9.84		NP	540.24	
20PP104			551.99	12.24	11.71	0.53	539.75	
20PP105			549.81	9.64		NP	540.17	
20PP106			549.96	9.87	9.75	0.12	540.09	
20PP107			550.09	9.97		NP	540.12	
20PP108			549.92	9.96	9.61	0.35	539.96	
20PP110			549.87	10.00	9.52	0.48	539.87	
20PP111			550.59	10.38	10.35	0.03	540.21	
20PP112			546.19	6.58	5.86	0.72	539.61	
20PP113			547.18	7.57	6.78	0.79	539.61	
20PP114			552.21	12.04	11.96	0.08	540.17	
20PP115			551.92	11.80		NP	540.12	
20PP116			552.00	11.81	11.74	0.07	540.19	
20PP117			552.06	11.69		NP	540.37	
20PP118			551.89	11.80	11.47	0.33	540.09	
20PP119			551.65	13.79	10.57	3.22	537.86	

<p align="center">Table C.1 Summary of Survey, Water Level and Product Thickness Data 1993 Eielson AFB OU-1 Field Investigation</p>								
Well/ Probe	Northing	Easting	ToC Elev. (ft)	Depth to Water (ft)	Depth to Product (ft)	Product Thickness (ft)	Water Level Elev. (ft)	Comment
ST48								
18-6			538.13	8.86		NP	529.27	
48M01			538.88			0.00	538.88	
48M03			544.51	15.36		NP	529.15	
48M04			545.39	16.22		NP	529.17	
48M05			544.69	15.63		NP	529.06	
48M06			545.54	17.01		NP	528.53	
48M07			540.60	10.84		NP	529.76	
48MW08	229869.6	388574.8	538.87	9.53		NP	529.34	New monitoring well
48PP09			538.47	9.98	9.57	0.41	528.49	
48PP13			539.67	10.87		NP	528.80	
48PP27			542.44	13.89		NP	528.55	
48PP28			543.28	15.89	14.46	1.43	527.39	
48PP67			538.98	NM	NM	ND	ND	Bent. obstruction at 8.25 ft
53M03			541.11	12.74	12.56	0.18	528.37	
ST49								
49M01			NM	8.72		NP	ND	
49M02			549.15	8.86		NP	540.29	
49M03			548.27	7.97		NP	540.30	
49M04			547.22	7.03		NP	540.19	
49M05			545.92	5.92		NP	540.00	
49M06			550.77	10.58		NP	540.19	
53M05			549.25	9.16		NP	540.09	
49GMW			551.42	11.08		NP	540.34	
49PP26			547.89	7.84		NP	540.05	
49PP40			548.84	8.81		NP	540.03	
49PP41			549.74	9.58		NP	540.16	
49PP42			550.31	10.17		NP	540.14	
49PP43			549.99	8.94		NP	541.05	
49PP44			547.52	7.03		NP	540.49	
49PP45			549.40	9.29		NP	540.11	
49PP46			546.99	6.79		NP	540.20	
49PP104			548.35	NM	NM	ND	ND	
49PP105			548.91	NM	NM	ND	ND	
49PP106			549.43	NM	NM	ND	ND	
49PP107			549.44	NM	NM	ND	ND	
49PP118			549.09	NM	NM	ND	ND	

Table C.1
Summary of Survey, Water Level and Product Thickness Data
1993 Elselon AFB OU-1 Field Investigation

Well/ Probe	Northing	Eastng	ToC Elev. (ft)	Depth to Water (ft)	Depth to Product (ft)	Product Thickness (ft)	Water Level Elev. (ft)	Comment
BLAIR LAKES								
50M01	99587.1	99803.0	737.34	13.33	11.79	1.54	724.01	New elev. = 736.75
50M02	99588.4	100046.8	735.24	8.10		NP	727.14	New elev = 734.9
50M04	99296.7	99660.5	737.54	9.52		NP	728.02	New elev = 736.93
50M05	99376.4	99958.4	737.10	4.81		NP	732.29	
50M06	99848.8	99650.9	734.30	10.69		NP	723.61	New elev. =733.02
50M07	99522.2	99979.1	736.50	8.98		NP	727.52	
50M08	99257.2	99792.4	732.73	4.18		NP	728.55	New elev =736.68
50M10	99920.4	99614.9	731.60	8.52		NP	723.08	New elev = 731.1
50PP01	99607.3	99828.5	733.95	NM	NM	ND	ND	Obstructed at 8.5'
50PP02	99596.6	99784.5	736.54	11.62	11.20	0.42	724.92	
50PP03	99618.6	99754.4	737.22	13.55	11.72	1.83	723.67	
50PP04	99644.6	99743.5	738.69	16.48		NP	722.21	
50PP05	99645.8	99812.5	733.24		7.56	0.02	ND	bottom of probe: 7.58'

NOTES: All depth and thickness field measured in feet. NP = no product; ND = not determined; NM = not measured

On base surveying conducted May 20-21, 1993

Water levels for base wells measured May 28, 1993 unless otherwise noted.

Product thicknesses for base probes measured May 28 and June 1, 1993.

Blair Lakes surveying conducted May 24-25, 1993; based on an assumed coordinate system.

Blair Lakes water levels collected May 24, 1993, prior to measurement of new well elevations.

Blair Lakes product thickness measurements conducted May 24, 1993.

Table C.2 Blair Lakes Bench Marks and Assumed Coordinates 1993 Eielson AFB OU-1 Field Investigation				
Bench Mark	Northing (assumed)	Easting (assumed)	Latitude	Longitude
BLAIR LAKES CONTROL				
BL-1	100000.00	100000.00	64-23-12.5854	147-41-42.2851
BL-2	98575.12	101262.73	64-22-57.3500	147-41-17.0789
2-7	100994.40	101047.88	64-23-21.2533	147-41-16.2435
BL-3	99306.23	99899.77	64-23-05.8953	147-41-46.1833
NOTES: Blair Lakes surveying conducted May 24-25, 1993 Northing/easting based on an assumed coordinate system and latitude/longitude based on Global Positioning System				

EIELSON AFB
Horizontal Control Listing of Features at Blair Lakes
Date of Listing: May 28 1993

Pt.#	Northing	Easting	Description
310	99560.2761(N)	100056.3516(E)	TEST PIT H2 (TYP.)
311	99469.9511(N)	100383.4564(E)	SOIL PIT 1 (TYP.)
312	99273.9153(N)	100282.7884(E)	SP 2
313	99351.1185(N)	100588.6162(E)	SP 4
314	99144.0722(N)	100430.9600(E)	SP 5
315	99498.4985(N)	100033.2120(E)	TP H1
316	99773.3609(N)	99606.8818(E)	NE COR RADIO TOWER
317	99767.3743(N)	99602.6343(E)	NW COR " "
318	99763.1348(N)	99607.7612(E)	SW COR " "
319	99768.7050(N)	99612.5116(E)	SE COR " "
320	99730.6247(N)	99659.6654(E)	N COR MAIN TOWER
321	99735.4512(N)	99683.9987(E)	E COR " "
322	99711.0789(N)	99688.6118(E)	S COR " "
323	99756.3111(N)	99736.1735(E)	N COR DECK, BY THE KITCHEN
324	99742.9398(N)	99756.1938(E)	S COR "
325	99828.7254(N)	99671.4994(E)	WIND SOCK
326	99936.5024(N)	100039.3275(E)	NW COR HELIPAD, LANDING LIGHTS
327	100015.6745(N)	100106.1692(E)	NE COR "
328	99947.5423(N)	100178.7412(E)	SE COR "
329	99870.9274(N)	100113.6849(E)	SW COR "
330	99710.2663(N)	99773.3387(E)	SE COR LIVING QUARTERS
331	99695.8229(N)	99812.7734(E)	N COR CONC PAD, INCINERATOR
332	99685.0686(N)	99826.9167(E)	E COR " " , ALSO TBM 21
333	99666.1522(N)	99812.4340(E)	S COR " "
334	99676.9192(N)	99798.2865(E)	W COR " "

335	99645.5258(N)	99787.6157(E)	NE COR GENERATOR BUILD
336	99628.8193(N)	99776.2413(E)	NW COR " "
337	99625.7560(N)	99816.8597(E)	SE COR " "
338	99624.7707(N)	99818.5240(E)	NE COR CONC BERM, ALSO TBM 20
339	99617.2807(N)	99829.4756(E)	SE COR " "
340	99623.4822(N)	99739.4810(E)	N COR SHOP BUILD
341	99755.3161(N)	99739.9034(E)	N COR LIVING QUARTERS W OF DECK
342	99880.3073(N)	99582.4767(E)	E COR SEWAGE POND
343	99995.3037(N)	99428.8192(E)	N COR " "
344	99903.5416(N)	99353.1221(E)	W COR " "
345	99801.6440(N)	99493.6453(E)	S COR " "
346	99728.1123(N)	99551.9281(E)	N COR RADAR TRAILIER
347	99707.8518(N)	99581.7988(E)	E COR " "
348	99699.4014(N)	99575.9333(E)	W COR " "
349	99625.1396(N)	99728.4298(E)	SW COR LIVING QUARTERS
350	99484.7248(N)	99962.4719(E)	N COR OUTSIDE COR TANK FARM
351	99425.4579(N)	99919.4578(E)	W COR " " " "
352	99442.8648(N)	100025.7513(E)	N COR INSIDE " " "
353	99507.7297(N)	100073.7898(E)	NE COR TANK FARM
354	99466.8537(N)	100134.0077(E)	E COR " "
355	99090.8792(N)	100113.6730(E)	SP 3
356	98930.0272(N)	100280.9752(E)	SP 6
357	99327.8780(N)	100048.5783(E)	S COR TANK FARM
358	99480.8462(N)	99924.9528(E)	E'LY SIDE OF GAS PUMP ISLAND
359	99469.0686(N)	99914.4914(E)	W'LY " " " "
360	99538.1145(N)	99758.6875(E)	S COR SHOP BUILD
361	99588.4596(N)	99791.7323(E)	E COR " "
362	99608.5374(N)	99806.3878(E)	SW COR GENERATOR BUILD
363	99602.5535(N)	99694.9322(E)	NE COR OF STORAGE SHED AREA

364	99565.7668(N)	99671.5539(E)	NW COR " " " "
365	99518.4069(N)	99744.4860(E)	SW COR " " " "
366	99382.4352(N)	99589.8997(E)	N COR HAZ ACCUMULATION POND
367	99353.2514(N)	99549.7261(E)	W COR " " " "
368	99333.6315(N)	99582.7241(E)	S COR " " " "
369	99361.3084(N)	99599.8270(E)	E COR " " " "
370	99142.9128(N)	99919.0206(E)	E COR NEW WELL PUMP HOUSE
371	99151.5485(N)	99913.0168(E)	N COR " " " "
372	99146.4550(N)	99906.2805(E)	W COR " " " "
373	99061.9469(N)	99885.8854(E)	E COR CARGO HELIPAD
374	99011.6790(N)	99843.3434(E)	S COR " " " "
375	99147.2200(N)	99787.9405(E)	N COR " " " "
376	99099.7013(N)	99738.2044(E)	W COR " " " "
5002	99588.3608(N)	100046.7911(E)	MONITORING WELL 2 (TYP.)
5007	99522.1554(N)	99979.1322(E)	MW 7
5001	99587.0940(N)	99802.9851(E)	MW 1
5103	99616.5540(N)	99754.3710(E)	PRODUCT PROBE 3 (TYP.)
5104	99644.6277(N)	99743.5192(E)	PP 4
5102	99596.5803(N)	99784.5009(E)	PP 2
5006	99843.8137(N)	99650.8798(E)	MW 6
5010	99920.3568(N)	99614.9095(E)	MW 10
5005	99376.3849(N)	99958.4388(E)	MW 5
5008	99257.2243(N)	99792.3759(E)	MW 8
5004	99296.6829(N)	99660.4729(E)	MW 4
5101	99607.2886(N)	99828.5334(E)	PP 1
5105	99645.7638(N)	99812.4922(E)	PP 5

BLAIR LAKES CONTROL

BL-1 100000.00(N) 100000.00(E) 64-23-12.5854(LAT) 147-41-42.2851(LONG)

BL-2 98575.12(N) 101262.73(E) 64-22-57.3500(LAT) 147-41-17.0789(LONG)

2-7 100994.40(N) 101047.88(E) 64-23-21.2533(LAT) 147-41-16.2435(LONG)

BL-3 99306.23(N) 99899.77(E) 64-23-05.8953(LAT) 147-41-46.1833(LONG)

**Appendixes D and E of the Field Summary Report
by CH2M Hill are not included.**

APPENDIX II - GROUNDWATER VELOCITY

1.0 PURPOSE

The purpose of this analysis was to approximate the mean annual groundwater velocity at each source area for use as input into the fate and transport modeling. The mean annual groundwater velocity beneath a source area will be used to calculate contaminant transport. Although seasonal fluctuations were observed in groundwater velocity (speed and direction) at each of the source areas, the mean average velocity was used for model input.

2.0 METHOD AND ASSUMPTIONS

Available hydraulic head data were analyzed to determine groundwater velocity at each source area. This analysis was performed on a computer using commercially available software (WATER-VEL, Version 2.21 by In-Situ Inc., 1991). This program determines the hydraulic gradient with a least-squares fit to a set of three or more hydraulic head measurements, and then uses Darcy's law and effective porosity to calculate the groundwater velocity (In-Situ Inc., 1991). The result is the average linear velocity as defined by Freeze and Cherry (1979), and herein referred to as the groundwater velocity. A set of hydraulic head measurements including x and y Cartesian coordinates for each measurement, hydraulic conductivity, and effective porosity were used as input to the program. The program assumes the aquifer is homogenous and there is no net pumping or injection in the study area (In-Situ Inc., 1991). The output is 1) a list of the input data, 2) the results of the least-squares match including the fitted equation used to calculate heads, and 3) the groundwater velocity (In-Situ Inc., 1991).

Hydrologic tests have been performed at several of the OU-1 source areas, and the results are summarized in Appendixes III and IV. Preliminary results from the analysis of these tests indicated that hydraulic conductivity on the base ranged from 60 m/d to 370 m/d. Because of time constraints, these preliminary values were used in the groundwater velocity analysis. The final results from the hydrologic tests show the hydraulic conductivity on the base to range from 73 m/d to 460 m/d (Appendix III). The reported hydraulic conductivities at Blair Lakes range from 2.9 m/d to 48.2 m/d (Appendix IV, Table IV.2). The uncertainty in the hydraulic conductivity values causes uncertainty in the groundwater velocities. Hydraulic conductivities of 61 m/d (200 ft/d) and 366 m/d (1200 ft/d) were both used as input to WATER-VEL for source areas on the base itself (i.e., ST20, ST48, and ST49). Hydraulic conductivities of 3.05 m/d (10 ft/d) and 48.8 m/d (160 ft/d) were used as input to the program for Blair Lakes. Therefore, the results presented here consist of a lower and upper bound on groundwater velocities. Using the final hydraulic conductivity values for source areas on the base would increase the lower velocity bound by about 20%, and increase the upper bound by about 25%. The effective porosity was assumed to be 30% at all source areas, and horizontal survey coordinates were used for the x and y Cartesian coordinates. Hydraulic conductivity was assumed to be isotropic at all source areas.

3.0 LIMITATIONS

The results of this analysis are affected by several factors. Hydraulic head measurements can be inaccurate because of errors in measurement device calibration, measurement taking, and well casing surveys, as well as inherent imprecision of the measurement method and heaving of well casings to a new elevation because of freezing and thawing of soil. Problems in the hydraulic head data set were identified by 1) comparing the water-level history of a well to the suspected inaccurate measurement, 2) comparing a given measurement to those taken at the same time in nearby wells, and 3) examining

the variance between the measured heads and the heads calculated by WATER-VEL. Based on these comparisons, some measurements were found to be suspect and were not used in this analysis. The number of hydraulic head measurements used in a velocity calculation also affects the results. Velocity values are more consistent when a large number of measurements are used in the calculations. However, many of the velocities presented here are based on only three measurements. In these instances, if the calculated velocity was distinctly different than the regional groundwater flow or differed from other velocity calculations at the same source area, and the difference could not be explained, the measurements were assumed to be inaccurate and the result was not used in computing the mean velocity. Measured hydraulic heads define the water table or potentiometric surface only at the point in time when the measurements were made. During the time in between measurements, the head configuration and hence groundwater velocity is unknown. Thus, the degree to which the average of several groundwater velocities approximates the mean annual velocity depends on the frequency and regularity of the head measurements. At many of the OU-1 source areas, head measurements are available for the summer and fall months, but winter and spring data are scarce and at some sites nonexistent.

As mentioned previously, the computer program used for this analysis assumes the aquifer is homogenous and there is no net pumping or injection in the study area (i.e., the flow system is at steady state). The varied hydrologic testing results show that the aquifer is not homogenous. If the scale of the heterogeneity is small, accurate velocity results could be obtained by using an average value for hydraulic conductivity. Because the scale of the heterogeneity is unknown, upper and lower hydraulic conductivity limits were used in this analysis to place bounds on the calculated velocities. There is a water supply well at ST48, but because it is pumping nearly constantly, the flow system is assumed to be at steady state.

4.0 RESULTS

The results of this analysis are shown in Figures 3.3, 3.16, 3.19, 3.25, and Table 3.3. In each site figure, the two velocity vectors show the extremes in the calculated flow directions for that site, as well as the mean velocity vector for all the measurements in the data set. The direction of the mean velocity vector is weighted by the magnitude of each of the component vectors, while the magnitude of the mean vector is a straight average. The two arrowheads on each vector represent the range of magnitude for that vector caused by the uncertainty in hydraulic conductivity. The output files from WATER-VEL are shown in Figure II.1.

5.0 REFERENCES

Freeze, R. A., and J. A. Cherry, 1979. Groundwater. Prentice Hall, Englewood Cliffs, New Jersey, 604 pp.

In-Situ Inc., 1991. WATER-VEL Version 2.3, User's Guide, prepared by the Hydrologic Modeling Division, In-Situ Inc., Laramie, Wyoming.

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-7) 28-Aug-91

Output file is : c:\eielson\watervel\output\78281.out
Input file is : c:\eielson\watervel\output\78281.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	390874.40	221004.50	540.10	540.12
2	390862.80	220743.30	540.29	540.21
3	390529.40	221203.70	539.94	539.95
4	390274.30	221118.00	539.97	539.91
5	390573.10	220841.10	539.98	540.09

Calc. Head (ft) = $2.916E-04 \cdot X - 3.359E-04 \cdot Y + 5.004E+02$

Natural groundwater flow = $2.97E-01$ ft/day ($1.08E+02$ ft/yr)
at 130.96 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-7) 28-Aug-91

Output file is : c:\eielson\watervel\output\78281b.out
Input file is : c:\eielson\watervel\output\78281.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	390874.40	221004.50	540.10	540.12
2	390862.80	220743.30	540.29	540.21
3	390529.40	221203.70	539.94	539.95
4	390274.30	221118.00	539.97	539.91
5	390573.10	220841.10	539.98	540.09

Calc. Head (ft) = $2.916E-04 \cdot X - 3.359E-04 \cdot Y + 5.004E+02$

Natural groundwater flow = $1.78E+00$ ft/day ($6.49E+02$ ft/yr)
at 130.96 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-7) September 27, 1991

Output file is : c:\eielson\ou-1\flowvel\79271.out
Input file is : c:\eielson\ou-1\flowvel\79271.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	390874.40	221004.50	540.06	540.07
2	390690.00	221105.10	540.00	539.98
3	390862.80	220743.30	540.24	540.24
4	390529.40	221203.70	539.89	539.90

Calc. Head (ft) = $1.042E-04 \cdot X - 6.646E-04 \cdot Y + 6.462E+02$

Natural groundwater flow = $4.49E-01$ ft/day ($1.64E+02$ ft/yr)
at 98.91 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-7) September 27, 1991

Output file is : c:\eielson\ou-1\flowvel\79271b.out
Input file is : c:\eielson\ou-1\flowvel\79271.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	390874.40	221004.50	540.06	540.07
2	390690.00	221105.10	540.00	539.98
3	390862.80	220743.30	540.24	540.24
4	390529.40	221203.70	539.89	539.90

Calc. Head (ft) = $1.042E-04 \cdot X - 6.646E-04 \cdot Y + 6.462E+02$

Natural groundwater flow = $2.69E+00$ ft/day ($9.82E+02$ ft/yr)
at 98.91 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

ST20 (E-7) 28-MAY-1993

Output file is : c:\temp\75283.out
Input file is : c:\temp\75283.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	390874.40	221004.50	541.02	541.23
2	390690.00	221105.10	540.90	540.98
3	390862.80	220743.30	541.18	541.27
4	390529.50	221203.70	540.83	540.76
5	390274.30	221118.00	540.44	540.46
6	390585.00	221657.20	541.10	540.73
7	390212.20	221864.50	539.99	540.22
8	390684.50	220478.50	541.25	541.11
9	390573.10	220841.10	541.11	540.89
10	390631.00	220800.50	540.75	540.97
11	390689.10	220775.20	541.10	541.05

Calc. Head (ft) = $1.237E-03 \cdot X - 2.214E-04 \cdot Y + 1.066E+02$

Natural groundwater flow = $8.38E-01$ ft/day ($3.06E+02$ ft/yr)
at 169.85 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

ST20 (E-7) 28-MAY-1993

Output file is : c:\temp\75283b.out
Input file is : c:\temp\75283.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	390874.40	221004.50	541.02	541.23
2	390690.00	221105.10	540.90	540.98
3	390862.80	220743.30	541.18	541.27
4	390529.50	221203.70	540.83	540.76
5	390274.30	221118.00	540.44	540.46
6	390585.00	221657.20	541.10	540.73
7	390212.20	221864.50	539.99	540.22
8	390684.50	220478.50	541.25	541.11
9	390573.10	220841.10	541.11	540.89
10	390631.00	220800.50	540.75	540.97
11	390689.10	220775.20	541.10	541.05

Calc. Head (ft) = $1.237E-03 \cdot X - 2.214E-04 \cdot Y + 1.066E+02$

Natural groundwater flow = $5.03E+00$ ft/day ($1.83E+03$ ft/yr)
at 169.85 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-8) 22-Jan-92

Output file is : c:\eielson\watervel\output\81222.out
Input file is : c:\eielson\watervel\output\81222.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391649.70	220419.20	540.35	540.37
2	391390.30	220466.50	540.28	540.27
3	391763.20	220567.50	540.34	540.33
4	391709.80	220921.80	540.12	540.11
5	391707.00	221609.70	539.72	539.73

Calc. Head (ft) = $2.918E-04 \cdot X - 5.593E-04 \cdot Y + 5.494E+02$

Natural groundwater flow = $4.21E-01$ ft/day ($1.54E+02$ ft/yr)
at 117.55 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-8) 22-Jan-92

Output file is : c:\eielson\watervel\output\81222b.out
Input file is : c:\eielson\watervel\output\81222.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391649.70	220419.20	540.35	540.37
2	391390.30	220466.50	540.28	540.27
3	391763.20	220567.50	540.34	540.33
4	391709.80	220921.80	540.12	540.11
5	391707.00	221609.70	539.72	539.73

Calc. Head (ft) = $2.918E-04 \cdot X - 5.593E-04 \cdot Y + 5.494E+02$

Natural groundwater flow = $2.52E+00$ ft/day ($9.21E+02$ ft/yr)
at 117.55 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-8) 21-May-92

Output file is : c:\eielson\watervel\output\e85212.out
Input file is : c:\eielson\watervel\output\e85212.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391649.70	220419.20	542.91	542.91
2	391985.80	220793.10	542.98	542.98
3	391707.00	221609.70	542.10	542.10

Calc. Head (ft) = $1.020E-03 \cdot X - 7.295E-04 \cdot Y + 3.043E+02$

Natural groundwater flow = 8.36E-01 ft/day (3.05E+02 ft/yr)
at 144.43 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-8) 21-May-92

Output file is : c:\eielson\watervel\output\e85212b.out
Input file is : c:\eielson\watervel\output\e85212.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391649.70	220419.20	542.91	542.91
2	391985.80	220793.10	542.98	542.98
3	391707.00	221609.70	542.10	542.10

Calc. Head (ft) = $1.020E-03 \cdot X - 7.295E-04 \cdot Y + 3.043E+02$

Natural groundwater flow = 5.02E+00 ft/day (1.83E+03 ft/yr)
at 144.43 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-8) 14-Jul-92

Output file is : c:\eielson\watervel\output\e87142.out
Input file is : c:\eielson\watervel\output\e87142.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391649.70	220419.20	540.92	540.92
2	391985.80	220793.10	540.83	540.83
3	391707.00	221609.70	540.20	540.20

Calc. Head (ft) = $4.280E-04 \cdot X - 6.253E-04 \cdot Y + 5.111E+02$

Natural groundwater flow = 5.05E-01 ft/day (1.84E+02 ft/yr)
at 124.39 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-8) 14-Jul-92

Output file is : c:\eielson\watervel\output\e87142b.out
Input file is : c:\eielson\watervel\output\e87142.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391649.70	220419.20	540.92	540.92
2	391985.80	220793.10	540.83	540.83
3	391707.00	221609.70	540.20	540.20

Calc. Head (ft) = $4.280E-04 \cdot X - 6.253E-04 \cdot Y + 5.111E+02$

Natural groundwater flow = 3.03E+00 ft/day (1.11E+03 ft/yr)
at 124.39 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-8) 20-Aug-92

Output file is : c:\eielson\watervel\output\es8202.out
Input file is : c:\eielson\watervel\output\es8202.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391649.70	220419.20	540.78	540.78
2	391985.80	220793.10	540.71	540.71
3	391707.00	221609.70	540.12	540.12

Calc. Head (ft) = $4.316E-04 \cdot X - 5.752E-04 \cdot Y + 4.985E+02$

Natural groundwater flow = $4.79E-01$ ft/day ($1.75E+02$ ft/yr)
at 126.88 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-8) 20-Aug-92

Output file is : c:\eielson\watervel\output\es8202b.out
Input file is : c:\eielson\watervel\output\es8202.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391649.70	220419.20	540.78	540.78
2	391985.80	220793.10	540.71	540.71
3	391707.00	221609.70	540.12	540.12

Calc. Head (ft) = $4.316E-04 \cdot X - 5.752E-04 \cdot Y + 4.985E+02$

Natural groundwater flow = $2.88E+00$ ft/day ($1.05E+03$ ft/yr)
at 126.88 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

ST20 (E-8) 28-MAY-93

Output file is : c:\temp\es5283.out
Input file is : c:\temp\es5283.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391649.70	220419.20	541.71	541.70
2	391390.30	220466.50	541.60	541.55
3	391693.90	220184.10	541.84	541.84
4	391610.80	220628.90	541.64	541.56
5	391763.20	220567.50	541.72	541.67
6	391726.30	221228.10	541.20	541.29
7	391985.80	220793.10	541.66	541.65
8	391709.80	220921.80	541.53	541.45
9	391631.60	220392.20	541.64	541.70
10	391661.10	220428.50	541.69	541.70
11	391682.80	220376.90	541.72	541.73
12	391641.90	220335.20	541.83	541.74
13	391603.80	220369.50	541.68	541.70
14	391554.60	220331.50	541.65	541.70
15	391594.00	220225.90	541.76	541.77
16	391682.40	220293.70	541.78	541.78
17	391652.00	220375.80	541.68	541.72
18	391644.80	220410.50	541.63	541.70
19	391645.10	220429.30	541.68	541.69

Calc. Head (ft) = $4.512E-04 \cdot X - 5.393E-04 \cdot Y + 4.839E+02$

Natural groundwater flow = $4.69E-01$ ft/day ($1.71E+02$ ft/yr)
at 129.92 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

ST20 (E-8) 28-MAY-93

Output file is : c:\temp\es5283b.out
Input file is : c:\temp\es5283.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391649.70	220419.20	541.71	541.70
2	391390.30	220466.50	541.60	541.55
3	391693.90	220184.10	541.84	541.84
4	391610.80	220628.90	541.64	541.56
5	391763.20	220567.50	541.72	541.67
6	391726.30	221228.10	541.20	541.29
7	391985.80	220793.10	541.66	541.65
8	391709.80	220921.80	541.53	541.45
9	391631.60	220392.20	541.64	541.70
10	391661.10	220428.50	541.69	541.70
11	391682.80	220376.90	541.72	541.73
12	391641.90	220335.20	541.83	541.74
13	391603.80	220369.50	541.68	541.70
14	391554.60	220331.50	541.65	541.70
15	391594.00	220225.90	541.76	541.77
16	391682.40	220293.70	541.78	541.78
17	391652.00	220375.80	541.68	541.72
18	391644.80	220410.50	541.63	541.70
19	391645.10	220429.30	541.68	541.69

Calc. Head (ft) = $4.512E-04 \cdot X - 5.393E-04 \cdot Y + 4.839E+02$

Natural groundwater flow = $2.81E+00$ ft/day ($1.03E+03$ ft/yr)
at 129.92 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Elelson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 28-Aug-91

Output file is : c:\eielson\watervel\output\e98281c.out
Input file is : c:\eielson\watervel\output\e98281.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.57	539.57
2	391843.40	222072.70	538.88	538.88
3	391648.70	222205.30	539.43	539.43

Calc. Head (ft) = $-3.440E-03 \cdot X - 9.034E-04 \cdot Y + 2.088E+03$

Natural groundwater flow = 2.37E+00 ft/day (8.66E+02 ft/yr)
at 14.71 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 28-Aug-91

Output file is : c:\eielson\watervel\output\e98281b.out
Input file is : c:\eielson\watervel\output\e98281.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.57	539.57
2	391843.40	222072.70	538.88	538.88
3	391648.70	222205.30	539.43	539.43

Calc. Head (ft) = $-3.440E-03 \cdot X - 9.034E-04 \cdot Y + 2.088E+03$

Natural groundwater flow = 1.42E+01 ft/day (5.19E+03 ft/yr)
at 14.71 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 27-Sep-91

Output file is : c:\eielson\watervel\output\e99271c.out
Input file is : c:\eielson\watervel\output\e99271.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.56	539.56
2	391843.40	222072.70	537.90	537.90
3	391648.70	222205.30	539.41	539.41

Calc. Head (ft) = $-8.525E-03 \cdot X - 1.127E-03 \cdot Y + 4.129E+03$

Natural groundwater flow = 5.73E+00 ft/day (2.09E+03 ft/yr)
at 7.53 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 27-Sep-91

Output file is : c:\eielson\watervel\output\e99271b.out
Input file is : c:\eielson\watervel\output\e99271.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.56	539.56
2	391843.40	222072.70	537.90	537.90
3	391648.70	222205.30	539.41	539.41

Calc. Head (ft) = $-8.525E-03 \cdot X - 1.127E-03 \cdot Y + 4.129E+03$

Natural groundwater flow = 3.44E+01 ft/day (1.26E+04 ft/yr)
at 7.53 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Elelson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 22-Jan-92

Output file is : c:\eielson\watervel\output\e91222c.out
Input file is : c:\eielson\watervel\output\e91222.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.34	539.34
2	391448.30	221999.30	539.27	539.27
3	391707.00	221609.70	539.72	539.72

Calc. Head (ft) = $4.576E-04X - 8.509E-04Y + 5.490E+02$

Natural groundwater flow = $6.44E-01$ ft/day ($2.35E+02$ ft/yr)
at 118.27 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 22-Jan-92

Output file is : c:\eielson\watervel\output\e91222b.out
Input file is : c:\eielson\watervel\output\e91222.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.34	539.34
2	391448.30	221999.30	539.27	539.27
3	391707.00	221609.70	539.72	539.72

Calc. Head (ft) = $4.576E-04X - 8.509E-04Y + 5.490E+02$

Natural groundwater flow = $3.86E+00$ ft/day ($1.41E+03$ ft/yr)
at 118.27 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 19-Aug-92

Output file is : c:\eielson\watervel\output\e98192c.out
Input file is : c:\eielson\watervel\output\e98192.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.73	539.70
2	391843.40	222072.70	539.77	539.78
3	391648.70	222205.30	539.59	539.59
4	391448.30	221999.30	539.59	539.60
5	391803.10	222063.10	539.76	539.76

Calc. Head (ft) = $5.656E-04X - 6.236E-04Y + 4.566E+02$

Natural groundwater flow = $5.61E-01$ ft/day ($2.05E+02$ ft/yr)
at 132.21 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 19-Aug-92

Output file is : c:\eielson\watervel\output\e98192b.out
Input file is : c:\eielson\watervel\output\e98192.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.73	539.70
2	391843.40	222072.70	539.77	539.78
3	391648.70	222205.30	539.59	539.59
4	391448.30	221999.30	539.59	539.60
5	391803.10	222063.10	539.76	539.76

Calc. Head (ft) = $5.656E-04X - 6.236E-04Y + 4.566E+02$

Natural groundwater flow = $3.37E+00$ ft/day ($1.23E+03$ ft/yr)
at 132.21 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Eleison Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 21-Aug-92

Output file is : c:\eielson\watervel\output\e98212c.out
Input file is : c:\eielson\watervel\output\e98212.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.69	539.67
2	391843.40	222072.70	539.70	539.73
3	391648.70	222205.30	539.52	539.49
4	391448.30	221999.30	539.57	539.58
5	391464.30	222508.70	539.08	539.10
6	391742.40	222403.60	539.39	539.36
7	391968.90	222469.30	539.41	539.42
8	391803.10	222063.10	539.70	539.71

Calc. Head (ft) = $5.466E-04X - 9.501E-04Y + 5.365E+02$

Natural groundwater flow = $7.31E-01$ ft/day ($2.67E+02$ ft/yr)
at 119.91 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 21-Aug-92

Output file is : c:\eielson\watervel\output\e98212b.out
Input file is : c:\eielson\watervel\output\e98212.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.69	539.67
2	391843.40	222072.70	539.70	539.73
3	391648.70	222205.30	539.52	539.49
4	391448.30	221999.30	539.57	539.58
5	391464.30	222508.70	539.08	539.10
6	391742.40	222403.60	539.39	539.36
7	391968.90	222469.30	539.41	539.42
8	391803.10	222063.10	539.70	539.71

Calc. Head (ft) = $5.466E-04X - 9.501E-04Y + 5.365E+02$

Natural groundwater flow = $4.38E+00$ ft/day ($1.60E+03$ ft/yr)
at 119.91 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 22-Aug-92

Output file is : c:\eielson\watervel\output\e98222c.out
Input file is : c:\eielson\watervel\output\e98222.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.64	539.64
2	391843.40	222072.70	539.67	539.66
3	391648.70	222205.30	539.47	539.47
4	391803.10	222063.10	539.65	539.66

Calc. Head (ft) = $3.560E-04X - 9.377E-04Y + 6.084E+02$

Natural groundwater flow = $6.69E-01$ ft/day ($2.44E+02$ ft/yr)
at 110.79 deg to the positive X-axis

WATER-VEL COMPLETED

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 22-Aug-92

Output file is : c:\eielson\watervel\output\e98222b.out
Input file is : c:\eielson\watervel\output\e98222.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.64	539.64
2	391843.40	222072.70	539.67	539.66
3	391648.70	222205.30	539.47	539.47
4	391803.10	222063.10	539.65	539.66

Calc. Head (ft) = $3.560E-04X - 9.377E-04Y + 6.084E+02$

Natural groundwater flow = $4.01E+00$ ft/day ($1.46E+03$ ft/yr)
at 110.79 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 28-Aug-92

Output file is : c:\eielson\watervel\output\e98262c.out
Input file is : c:\eielson\watervel\output\e98262.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.45	539.45
2	391843.40	222072.70	539.80	539.49
3	391648.70	222205.30	539.28	539.28
4	391803.10	222063.10	539.47	539.48

Calc. Head (ft) = $4.497E-04 \cdot X - 9.301E-04 \cdot Y + 5.698E+02$

Natural groundwater flow = $6.89E-01$ ft/day ($2.51E+02$ ft/yr)
at 115.80 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 28-Aug-92

Output file is : c:\eielson\watervel\output\e98262b.out
Input file is : c:\eielson\watervel\output\e98262.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.45	539.45
2	391843.40	222072.70	539.80	539.49
3	391648.70	222205.30	539.28	539.28
4	391803.10	222063.10	539.47	539.48

Calc. Head (ft) = $4.497E-04 \cdot X - 9.301E-04 \cdot Y + 5.698E+02$

Natural groundwater flow = $4.13E+00$ ft/day ($1.31E+03$ ft/yr)
at 115.80 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 17-Sep-92

Output file is : c:\eielson\watervel\output\e99172c.out
Input file is : c:\eielson\watervel\output\e99172.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.49	539.49
2	391843.40	222072.70	539.55	539.56
3	391707.00	221609.70	539.89	539.89
4	391803.10	222063.10	539.55	539.54

Calc. Head (ft) = $5.503E-04 \cdot X - 8.834E-04 \cdot Y + 5.201E+02$

Natural groundwater flow = $6.94E-01$ ft/day ($2.53E+02$ ft/yr)
at 121.92 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 17-Sep-92

Output file is : c:\eielson\watervel\output\e99172b.out
Input file is : c:\eielson\watervel\output\e99172.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.49	539.49
2	391843.40	222072.70	539.55	539.56
3	391707.00	221609.70	539.89	539.89
4	391803.10	222063.10	539.55	539.54

Calc. Head (ft) = $5.503E-04 \cdot X - 8.834E-04 \cdot Y + 5.201E+02$

Natural groundwater flow = $4.16E+00$ ft/day ($1.52E+03$ ft/yr)
at 121.92 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 27-Oct-92

Output file is : c:\eielson\watervel\output\e9c10272.out
Input file is : c:\eielson\watervel\output\e910272.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.18	539.18
2	391843.40	222072.70	539.22	539.22
3	391648.70	222205.30	539.03	539.03
4	391707.00	221609.70	539.57	539.57

$$\text{Calc. Head (ft)} = 3.990\text{E-04} \cdot X - 8.705\text{E-04} \cdot Y + 5.762\text{E+02}$$

Natural groundwater flow = 6.38E-01 ft/day (2.33E+02 ft/yr)
at 114.63 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 20 (E-9) 27-Oct-92

Output file is : c:\eielson\watervel\output\e9b10272.out
Input file is : c:\eielson\watervel\output\e910272.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	539.18	539.18
2	391843.40	222072.70	539.22	539.22
3	391648.70	222205.30	539.03	539.03
4	391707.00	221609.70	539.57	539.57

$$\text{Calc. Head (ft)} = 3.990\text{E-04} \cdot X - 8.705\text{E-04} \cdot Y + 5.762\text{E+02}$$

Natural groundwater flow = 3.83E+00 ft/day (1.40E+03 ft/yr)
at 114.63 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

ST20 (E-9) 28-MAY-93

Output file is : c:\temp\e95283b.out
Input file is : c:\temp\e95283.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	540.49	540.49
2	391843.40	222072.70	540.54	540.56
3	391648.70	222205.30	540.35	540.32
4	391448.30	221999.30	540.40	540.40
5	391707.00	221609.70	540.94	540.92
6	391464.30	222508.70	539.91	539.93
7	391742.40	222403.60	540.21	540.20
8	391968.90	222469.30	540.28	540.27
9	391849.00	221752.00	540.84	540.87
10	391608.60	222134.70	540.36	540.37
11	391675.70	222059.00	540.48	540.48
12	391670.50	222015.70	540.48	540.51
13	391665.90	222045.40	540.51	540.48
14	391692.10	222049.50	540.51	540.50

$$\text{Calc. Head (ft)} = 5.964\text{E-04} \cdot X - 9.324\text{E-04} \cdot Y + 5.139\text{E+02}$$

Natural groundwater flow = 7.38E-01 ft/day (2.69E+02 ft/yr)
at 122.61 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

ST20 (E-9) 28-MAY-93

Output file is : c:\temp\e95283c.out
Input file is : c:\temp\e95283.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	391654.60	222028.00	540.49	540.49
2	391843.40	222072.70	540.54	540.56
3	391648.70	222205.30	540.35	540.32
4	391448.30	221999.30	540.40	540.40
5	391707.00	221609.70	540.94	540.92
6	391464.30	222508.70	539.91	539.93
7	391742.40	222403.60	540.21	540.20
8	391968.90	222469.30	540.28	540.27
9	391849.00	221752.00	540.84	540.87
10	391608.60	222134.70	540.36	540.37
11	391675.70	222059.00	540.48	540.48
12	391670.50	222015.70	540.48	540.51
13	391665.90	222045.40	540.51	540.48
14	391692.10	222049.50	540.51	540.50

$$\text{Calc. Head (ft)} = 5.964\text{E-04} \cdot X - 9.324\text{E-04} \cdot Y + 5.139\text{E+02}$$

Natural groundwater flow = 4.43E+00 ft/day (1.62E+03 ft/yr)
at 122.61 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 28-Aug-91

Output file is : c:\eielson\watervel\output\488281.out
Input file is : c:\eielson\watervel\output\488281.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388947.50	229976.70	528.55	528.59
2	388611.20	230310.00	528.53	528.40
3	388635.90	229630.50	529.18	529.06
4	388476.60	229692.10	529.11	529.07
5	388392.80	229902.10	528.77	528.90
6	388711.50	229976.00	528.58	528.69

Calc. Head (ft) = $-4.185E-04X - 9.861E-04Y + 9.182E+02$

Natural groundwater flow = 7.14E-01 ft/day (2.61E+02 ft/yr)
at 67.00 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 28-Aug-91

Output file is : c:\eielson\watervel\output\488281b.out
Input file is : c:\eielson\watervel\output\488281.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388947.50	229976.70	528.55	528.59
2	388611.20	230310.00	528.53	528.40
3	388635.90	229630.50	529.18	529.06
4	388476.60	229692.10	529.11	529.07
5	388392.80	229902.10	528.77	528.90
6	388711.50	229976.00	528.58	528.69

Calc. Head (ft) = $-4.185E-04X - 9.861E-04Y + 9.182E+02$

Natural groundwater flow = 4.29E+00 ft/day (1.56E+03 ft/yr)
at 67.00 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 27-Sep-91

Output file is : c:\eielson\watervel\output\489271.out
Input file is : c:\eielson\watervel\output\489271.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388947.50	229976.70	528.52	528.57
2	388611.20	230310.00	528.50	528.42
3	388732.00	230226.00	528.49	528.44
4	388635.90	229630.50	529.11	529.01
5	388476.60	229692.10	529.08	529.03
6	388392.80	229902.10	528.76	528.88
7	388711.50	229976.00	528.57	528.67

Calc. Head (ft) = $-4.371E-04X - 8.905E-04Y + 9.034E+02$

Natural groundwater flow = 6.61E-01 ft/day (2.41E+02 ft/yr)
at 63.86 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 27-Sep-91

Output file is : c:\eielson\watervel\output\489271b.out
Input file is : c:\eielson\watervel\output\489271.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388947.50	229976.70	528.52	528.57
2	388611.20	230310.00	528.50	528.42
3	388732.00	230226.00	528.49	528.44
4	388635.90	229630.50	529.11	529.01
5	388476.60	229692.10	529.08	529.03
6	388392.80	229902.10	528.76	528.88
7	388711.50	229976.00	528.57	528.67

Calc. Head (ft) = $-4.371E-04X - 8.905E-04Y + 9.034E+02$

Natural groundwater flow = 3.97E+00 ft/day (1.45E+03 ft/yr)
at 63.86 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 11-Oct-91

Output file is : c:\eielson\watervel\output\4810111.out
Input file is : c:\eielson\watervel\output\4810111.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388635.90	229630.50	529.29	529.22
2	388476.60	229692.10	529.15	529.25
3	388392.80	229902.10	528.83	528.77
4	388711.50	229976.00	528.15	528.18

Calc. Head (ft) = $-1.236E-03 \cdot X - 2.753E-03 \cdot Y + 1.642E+03$

Natural groundwater flow = $2.01E+00$ ft/day ($7.34E+02$ ft/yr)
at 65.83 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 11-Oct-91

Output file is : c:\eielson\watervel\output\48b10111.out
Input file is : c:\eielson\watervel\output\4810111.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388635.90	229630.50	529.29	529.22
2	388476.60	229692.10	529.15	529.25
3	388392.80	229902.10	528.83	528.77
4	388711.50	229976.00	528.15	528.18

Calc. Head (ft) = $-1.236E-03 \cdot X - 2.753E-03 \cdot Y + 1.642E+03$

Natural groundwater flow = $1.21E+01$ ft/day ($4.41E+03$ ft/yr)
at 65.83 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 22-Jan-92

Output file is : c:\eielson\watervel\output\481222.out
Input file is : c:\eielson\watervel\output\481222.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388738.70	229768.00	528.54	528.54
2	388635.90	229630.50	529.60	529.60
3	388392.80	229902.10	529.48	529.48

Calc. Head (ft) = $-4.424E-03 \cdot X - 4.402E-03 \cdot Y + 3.260E+03$

Natural groundwater flow = $4.16E+00$ ft/day ($1.52E+03$ ft/yr)
at 44.86 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 22-Jan-92

Output file is : c:\eielson\watervel\output\481222b.out
Input file is : c:\eielson\watervel\output\481222.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388738.70	229768.00	528.54	528.54
2	388635.90	229630.50	529.60	529.60
3	388392.80	229902.10	529.48	529.48

Calc. Head (ft) = $-4.424E-03 \cdot X - 4.402E-03 \cdot Y + 3.260E+03$

Natural groundwater flow = $2.50E+01$ ft/day ($9.11E+03$ ft/yr)
at 44.86 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 11-Feb-92

Output file is : c:\eielson\watervel\output\482112.out
Input file is : c:\eielson\watervel\output\482112.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388611.20	230310.00	528.83	528.83
2	388732.00	230226.00	528.88	528.88
3	388476.60	229692.10	529.41	529.41

Calc. Head (ft) = $-2.077E-04 \cdot X - 8.933E-04 \cdot Y + 8.153E+02$

Natural groundwater flow = 6.11E-01 ft/day (2.23E+02 ft/yr)
at 76.91 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 11-Feb-92

Output file is : c:\eielson\watervel\output\482112b.out
Input file is : c:\eielson\watervel\output\482112.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388611.20	230310.00	528.83	528.83
2	388732.00	230226.00	528.88	528.88
3	388476.60	229692.10	529.41	529.41

Calc. Head (ft) = $-2.077E-04 \cdot X - 8.933E-04 \cdot Y + 8.153E+02$

Natural groundwater flow = 3.67E+00 ft/day (1.34E+03 ft/yr)
at 76.91 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 15-Apr-92

Output file is : c:\eielson\watervel\output\484152.out
Input file is : c:\eielson\watervel\output\484152.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388738.70	229768.00	529.10	529.10
2	388732.00	230226.00	529.11	529.11
3	388392.80	229902.10	529.13	529.13

Calc. Head (ft) = $-7.877E-05 \cdot X + 2.070E-05 \cdot Y + 5.550E+02$

Natural groundwater flow = 5.43E-02 ft/day (1.98E+01 ft/yr)
at -14.72 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 15-Apr-92

Output file is : c:\eielson\watervel\output\484152b.out
Input file is : c:\eielson\watervel\output\484152.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388738.70	229768.00	529.10	529.10
2	388732.00	230226.00	529.11	529.11
3	388392.80	229902.10	529.13	529.13

Calc. Head (ft) = $-7.877E-05 \cdot X + 2.070E-05 \cdot Y + 5.550E+02$

Natural groundwater flow = 3.26E-01 ft/day (1.19E+02 ft/yr)
at -14.72 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Elelson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 14-Jul-92

Output file is : c:\eielson\watervel\output\487142.out
Input file is : c:\eielson\watervel\output\487142.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388738.70	229768.00	529.73	529.73
2	388732.00	230226.00	528.52	528.52
3	388392.80	229902.10	528.78	528.78

Calc. Head (ft) = $1.731E-03 \cdot X - 2.616E-03 \cdot Y + 4.579E+02$

Natural groundwater flow = $2.09E+00$ ft/day ($7.63E+02$ ft/yr)
at 123.49 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 14-Jul-92

Output file is : c:\eielson\watervel\output\487142b.out
Input file is : c:\eielson\watervel\output\487142.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388738.70	229768.00	529.73	529.73
2	388732.00	230226.00	528.52	528.52
3	388392.80	229902.10	528.78	528.78

Calc. Head (ft) = $1.731E-03 \cdot X - 2.616E-03 \cdot Y + 4.579E+02$

Natural groundwater flow = $1.25E+01$ ft/day ($4.58E+03$ ft/yr)
at 123.49 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 28-May-93

Output file is : a:\data\site48\output\485283.out
Input file is : a:\data\site48\input\485283.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388507.60	229995.70	529.27	529.48
2	388611.20	230310.00	529.15	529.05
3	388732.00	230226.00	529.17	528.71
4	388635.90	229630.60	529.76	529.22
5	388574.80	229869.60	529.34	529.32
6	388717.90	229712.60	528.82	528.94
7	388732.40	229677.60	528.80	528.91
8	388694.80	230018.00	528.55	528.90
9	388711.50	229976.00	528.52	528.86

Calc. Head (ft) = $-3.037E-03 \cdot X - 3.519E-04 \cdot Y + 1.790E+03$

Natural groundwater flow = $2.04E+00$ ft/day ($7.44E+02$ ft/yr)
at 6.61 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 48 28-May-93

Output file is : a:\data\site48\output\485283b.out
Input file is : a:\data\site48\input\485283.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388507.60	229995.70	529.27	529.48
2	388611.20	230310.00	529.15	529.05
3	388732.00	230226.00	529.17	528.71
4	388635.90	229630.60	529.76	529.22
5	388574.80	229869.60	529.34	529.32
6	388717.90	229712.60	528.82	528.94
7	388732.40	229677.60	528.80	528.91
8	388694.80	230018.00	528.55	528.90
9	388711.50	229976.00	528.52	528.86

Calc. Head (ft) = $-3.037E-03 \cdot X - 3.519E-04 \cdot Y + 1.790E+03$

Natural groundwater flow = $1.22E+01$ ft/day ($4.46E+03$ ft/yr)
at 6.61 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 49 21-Aug-92

Output file is : c:\eielson\watervel\output\498212.out
Input file is : c:\eielson\watervel\output\498212.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388864.60	220573.60	539.92	539.92
2	389029.30	221003.90	539.70	539.66
3	388856.10	221070.40	539.49	539.56
4	388707.40	221063.30	539.55	539.51
5	389015.10	221074.50	539.60	539.61
6	388964.00	221180.40	539.52	539.51

Calc. Head (ft) = $3.366E-04 \cdot X - 7.317E-04 \cdot Y + 5.704E+02$

Natural groundwater flow = $5.37E-01$ ft/day ($1.96E+02$ ft/yr)
at 114.70 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 49 21-Aug-92

Output file is : c:\eielson\watervel\output\498212b.out
Input file is : c:\eielson\watervel\output\498212.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388864.60	220573.60	539.92	539.92
2	389029.30	221003.90	539.70	539.66
3	388856.10	221070.40	539.49	539.56
4	388707.40	221063.30	539.55	539.51
5	389015.10	221074.50	539.60	539.61
6	388964.00	221180.40	539.52	539.51

Calc. Head (ft) = $3.366E-04 \cdot X - 7.317E-04 \cdot Y + 5.704E+02$

Natural groundwater flow = $3.22E+00$ ft/day ($1.18E+03$ ft/yr)
at 114.70 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 49 27-Oct-92

Output file is : c:\eielson\watervel\output\4910272.out
Input file is : c:\eielson\watervel\output\4910272.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388864.60	220573.60	539.45	539.45
2	389029.30	221003.90	539.21	539.21
3	388964.00	221180.40	539.06	539.06

Calc. Head (ft) = $3.883E-04 \cdot X - 7.064E-04 \cdot Y + 5.443E+02$

Natural groundwater flow = $5.37E-01$ ft/day ($1.96E+02$ ft/yr)
at 118.79 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 49 27-Oct-92

Output file is : c:\eielson\watervel\output\49b10272.out
Input file is : c:\eielson\watervel\output\4910272.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388864.60	220573.60	539.45	539.45
2	389029.30	221003.90	539.21	539.21
3	388964.00	221180.40	539.06	539.06

Calc. Head (ft) = $3.883E-04 \cdot X - 7.064E-04 \cdot Y + 5.443E+02$

Natural groundwater flow = $3.22E+00$ ft/day ($1.18E+03$ ft/yr)
at 118.79 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 49 28-May-93

Output file is : a:\data\site49\output\495283.out
Input file is : a:\data\site49\input\495283.csv

Isotropic hydraulic cond. = 200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388864.60	220573.60	540.49	540.53
2	389029.30	221003.90	540.29	540.24
3	388856.10	221070.40	540.30	540.20
4	388707.40	221063.30	540.19	540.21
5	388908.30	221333.40	540.00	540.03
6	389015.10	221074.50	540.19	540.20
7	388964.00	221180.40	540.09	540.13
8	389002.10	220879.00	540.34	540.32
9	389014.40	221113.20	540.16	540.17
10	389036.50	221092.70	540.14	540.18
11	389004.50	221164.60	540.11	540.14
12	388970.20	221156.80	540.20	540.14

Calc. Head (ft) = $-3.294E-05 \cdot X - 6.495E-04 \cdot Y + 6.966E+02$

Natural groundwater flow = 4.34E-01 ft/day (1.58E+02 ft/yr)
at 87.10 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 49 28-May-93

Output file is : a:\data\site49\output\495283b.out
Input file is : a:\data\site49\input\495283.csv

Isotropic hydraulic cond. = 1200.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	388864.60	220573.60	540.49	540.53
2	389029.30	221003.90	540.29	540.24
3	388856.10	221070.40	540.30	540.20
4	388707.40	221063.30	540.19	540.21
5	388908.30	221333.40	540.00	540.03
6	389015.10	221074.50	540.19	540.20
7	388964.00	221180.40	540.09	540.13
8	389002.10	220879.00	540.34	540.32
9	389014.40	221113.20	540.16	540.17
10	389036.50	221092.70	540.14	540.18
11	389004.50	221164.60	540.11	540.14
12	388970.20	221156.80	540.20	540.14

Calc. Head (ft) = $-3.294E-05 \cdot X - 6.495E-04 \cdot Y + 6.966E+02$

Natural groundwater flow = 2.60E+00 ft/day (9.50E+02 ft/yr)
at 87.10 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 22-Oct-89

Output file is : a:\data\site50\output\5010229.out
Input file is : a:\data\site50\input\5010229.csv

Isotropic hydraulic cond. = 10.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	100046.80	99588.40	725.56	725.38
2	99660.50	99296.70	727.16	727.37
3	99958.40	99376.40	726.85	727.16
4	99650.90	99848.80	722.14	722.33
5	99979.10	99522.20	725.78	725.87
6	99792.40	99257.20	728.40	727.96
7	99614.90	99920.40	721.80	721.62

Calc. Head (ft) = $1.718E-03 \cdot X - 9.106E-03 \cdot Y + 1.460E+03$

Natural groundwater flow = 3.09E-01 ft/day (1.13E+02 ft/yr)
at 100.68 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 22-Oct-89

Output file is : a:\data\site50\output\50b10229.out
Input file is : a:\data\site50\input\5010229.csv

Isotropic hydraulic cond. = 160.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	100046.80	99588.40	725.56	725.38
2	99660.50	99296.70	727.16	727.37
3	99958.40	99376.40	726.85	727.16
4	99650.90	99848.80	722.14	722.33
5	99979.10	99522.20	725.78	725.87
6	99792.40	99257.20	728.40	727.96
7	99614.90	99920.40	721.80	721.62

Calc. Head (ft) = $1.718E-03 \cdot X - 9.106E-03 \cdot Y + 1.460E+03$

Natural groundwater flow = 4.94E+00 ft/day (1.80E+03 ft/yr)
at 100.68 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 25-Feb-92

Output file is : a:\data\site50\output\502252.out
Input file is : a:\data\site50\input\502252.csv

Isotropic hydraulic cond. = 10.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	723.92	724.55
2	100046.80	99588.40	725.36	725.12
3	99660.50	99296.70	726.59	726.20
4	99650.90	99848.80	722.17	722.39
5	99979.10	99522.20	725.54	725.42
6	99792.40	99257.20	726.57	726.79
7	99614.90	99920.40	722.14	721.82

Calc. Head (ft) = $2.384E-03 \cdot X - 6.855E-03 \cdot Y + 1.169E+03$

Natural groundwater flow = $2.42E-01$ ft/day ($8.83E+01$ ft/yr)
at 109.18 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 25-Feb-92

Output file is : a:\data\site50\output\502252b.out
Input file is : a:\data\site50\input\502252.csv

Isotropic hydraulic cond. = 160.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	723.92	724.55
2	100046.80	99588.40	725.36	725.12
3	99660.50	99296.70	726.59	726.20
4	99650.90	99848.80	722.17	722.39
5	99979.10	99522.20	725.54	725.42
6	99792.40	99257.20	726.57	726.79
7	99614.90	99920.40	722.14	721.82

Calc. Head (ft) = $2.384E-03 \cdot X - 6.855E-03 \cdot Y + 1.169E+03$

Natural groundwater flow = $3.87E+00$ ft/day ($1.41E+03$ ft/yr)
at 109.18 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 18-Jun-92

Output file is : a:\data\site50\output\506182.out
Input file is : a:\data\site50\input\506182.csv

Isotropic hydraulic cond. = 10.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	725.55	726.45
2	99660.50	99296.70	728.66	728.46
3	99979.10	99522.20	727.76	727.32
4	99614.90	99920.40	723.67	723.41

Calc. Head (ft) = $2.051E-03 \cdot X - 7.946E-03 \cdot Y + 1.313E+03$

Natural groundwater flow = $2.74E-01$ ft/day ($9.98E+01$ ft/yr)
at 104.47 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 18-Jun-92

Output file is : a:\data\site50\output\506182b.out
Input file is : a:\data\site50\input\506182.csv

Isotropic hydraulic cond. = 160.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	725.55	726.45
2	99660.50	99296.70	728.66	728.46
3	99979.10	99522.20	727.76	727.32
4	99614.90	99920.40	723.67	723.41

Calc. Head (ft) = $2.051E-03 \cdot X - 7.946E-03 \cdot Y + 1.313E+03$

Natural groundwater flow = $4.38E+00$ ft/day ($1.60E+03$ ft/yr)
at 104.47 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE 1.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Elelean Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 01-Sep-92

Output file is : a:\data\site50\output\509012.out
Input file is : a:\data\site50\input\509012.csv

Isotropic hydraulic cond. = 10.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	724.19	725.09
2	99958.40	99376.40	727.88	727.25
3	99979.10	99522.20	726.05	726.19
4	99792.40	99257.20	727.64	727.62
5	99614.90	99920.40	722.27	721.88

Calc. Head (ft) = $3.342E-03 \cdot X - 7.763E-03 \cdot Y + 1.165E+03$

Natural groundwater flow = $2.82E-01$ ft/day ($1.03E+02$ ft/yr)
at 113.29 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 01-Sep-92

Output file is : a:\data\site50\output\509012b.out
Input file is : a:\data\site50\input\509012.csv

Isotropic hydraulic cond. = 160.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	724.19	725.09
2	99958.40	99376.40	727.88	727.25
3	99979.10	99522.20	726.05	726.19
4	99792.40	99257.20	727.64	727.62
5	99614.90	99920.40	722.27	721.88

Calc. Head (ft) = $3.342E-03 \cdot X - 7.763E-03 \cdot Y + 1.165E+03$

Natural groundwater flow = $4.51E+00$ ft/day ($1.65E+03$ ft/yr)
at 113.29 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 28-Dec-92

Output file is : a:\data\site50\output\5012282.out
Input file is : a:\data\site50\input\5012282.csv

Isotropic hydraulic cond. = 10.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	724.17	724.67
2	100046.80	99588.40	725.56	725.51
3	99660.50	99296.70	726.62	726.14
4	99958.40	99376.40	727.15	726.64
5	99650.90	99848.80	721.96	722.37
6	99979.10	99522.20	725.72	725.73
7	99792.40	99257.20	726.27	726.86
8	99614.90	99920.40	722.24	721.76

Calc. Head (ft) = $3.491E-03 \cdot X - 6.759E-03 \cdot Y + 1.049E+03$

Natural groundwater flow = $2.54E-01$ ft/day ($9.26E+01$ ft/yr)
at 117.32 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 28-Dec-92

Output file is : a:\data\site50\output\50b12282.out
Input file is : a:\data\site50\input\5012282.csv

Isotropic hydraulic cond. = 160.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	724.17	724.67
2	100046.80	99588.40	725.56	725.51
3	99660.50	99296.70	726.62	726.14
4	99958.40	99376.40	727.15	726.64
5	99650.90	99848.80	721.96	722.37
6	99979.10	99522.20	725.72	725.73
7	99792.40	99257.20	726.27	726.86
8	99614.90	99920.40	722.24	721.76

Calc. Head (ft) = $3.491E-03 \cdot X - 6.759E-03 \cdot Y + 1.049E+03$

Natural groundwater flow = $4.06E+00$ ft/day ($1.48E+03$ ft/yr)
at 117.32 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Elelen Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 11-Feb-93

Output file is : a:\data\site50\output\502113.out
Input file is : a:\data\site50\input\502113.csv

Isotropic hydraulic cond. = 10.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	723.96	724.37
2	99660.50	99296.70	726.17	725.74
3	99958.40	99376.40	726.94	726.32
4	99650.90	99848.80	721.63	722.10
5	99979.10	99522.20	725.36	725.44
6	99792.40	99257.20	725.87	726.48
7	99614.90	99920.40	722.02	721.50

Calc. Head (ft) = $3.702E-03 \cdot X - 6.519E-03 \cdot Y + 1.004E+03$

Natural groundwater flow = 2.50E-01 ft/day (9.12E+01 ft/yr)
at 119.59 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 11-Feb-93

Output file is : a:\data\site50\output\502113b.out
Input file is : a:\data\site50\input\502113.csv

Isotropic hydraulic cond. = 160.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	723.96	724.37
2	99660.50	99296.70	726.17	725.74
3	99958.40	99376.40	726.94	726.32
4	99650.90	99848.80	721.63	722.10
5	99979.10	99522.20	725.36	725.44
6	99792.40	99257.20	725.87	726.48
7	99614.90	99920.40	722.02	721.50

Calc. Head (ft) = $3.702E-03 \cdot X - 6.519E-03 \cdot Y + 1.004E+03$

Natural groundwater flow = 4.00E+00 ft/day (1.46E+03 ft/yr)
at 119.59 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 18-Feb-93

Output file is : a:\data\site50\output\502183.out
Input file is : a:\data\site50\input\502183.csv

Isotropic hydraulic cond. = 10.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	724.07	724.69
2	99660.50	99296.70	726.55	726.53
3	99958.40	99376.40	727.00	726.61
4	99979.10	99522.20	725.52	725.57
5	99614.90	99920.40	722.05	721.79

Calc. Head (ft) = $2.259E-03 \cdot X - 7.427E-03 \cdot Y + 1.239E+03$

Natural groundwater flow = 2.59E-01 ft/day (9.44E+01 ft/yr)
at 106.92 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 18-Feb-93

Output file is : a:\data\site50\output\502183b.out
Input file is : a:\data\site50\input\502183.csv

Isotropic hydraulic cond. = 160.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	724.07	724.69
2	99660.50	99296.70	726.55	726.53
3	99958.40	99376.40	727.00	726.61
4	99979.10	99522.20	725.52	725.57
5	99614.90	99920.40	722.05	721.79

Calc. Head (ft) = $2.259E-03 \cdot X - 7.427E-03 \cdot Y + 1.239E+03$

Natural groundwater flow = 4.14E+00 ft/day (1.51E+03 ft/yr)
at 106.92 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

**Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base**

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 24-May-93

Output file is : a:\data\site50\output\505243.out
Input file is : a:\data\site50\input\505243.csv

Isotropic hydraulic cond. = 10.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	725.26	725.97
2	100046.80	99588.40	727.14	726.89
3	99660.50	99296.70	728.02	727.65
4	99650.90	99848.80	723.61	723.39
5	99979.10	99522.20	727.52	727.14
6	99792.40	99257.20	728.55	728.45
7	99614.90	99920.40	723.08	722.71
8	99784.50	99596.60	725.26	725.83
9	99754.40	99618.60	725.15	725.55

Calc. Head (ft) = $3.813E-03 \cdot X - 7.645E-03 \cdot Y + 1.107E+03$

Natural groundwater flow = $2.85E-01$ ft/day ($1.04E+02$ ft/yr)
at 116.51 deg to the positive X-axis

WATER-VEL COMPLETED.

In-Situ Inc. Groundwater Velocity Program (V2.21)

Site 50 24-May-93

Output file is : a:\data\site50\output\505243b.out
Input file is : a:\data\site50\input\505243.csv

Isotropic hydraulic cond. = 160.00 ft/d
Effective porosity = 30.00 %

Least squares match to groundwater table:

N	X(ft)	Y(ft)	Meas. head (ft)	Calc. head (ft)
1	99803.00	99587.10	725.26	725.97
2	100046.80	99588.40	727.14	726.89
3	99660.50	99296.70	728.02	727.65
4	99650.90	99848.80	723.61	723.39
5	99979.10	99522.20	727.52	727.14
6	99792.40	99257.20	728.55	728.45
7	99614.90	99920.40	723.08	722.71
8	99784.50	99596.60	725.26	725.83
9	99754.40	99618.60	725.15	725.55

Calc. Head (ft) = $3.813E-03 \cdot X - 7.645E-03 \cdot Y + 1.107E+03$

Natural groundwater flow = $4.56E+00$ ft/day ($1.66E+03$ ft/yr)
at 116.51 deg to the positive X-axis

WATER-VEL COMPLETED.

FIGURE II.1. Output Files from WATER-VEL (continued)

APPENDIX III - SUMMARY AND EVALUATION OF HYDRAULIC PROPERTY DATA AVAILABLE FOR EIELSON AIR FORCE BASE, ALASKA

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APPENDIX III - SUMMARY AND EVALUATION OF HYDRAULIC PROPERTY DATA AVAILABLE FOR EIELSON AIR FORCE BASE, ALASKA

SUMMARY

Most of the contaminant source areas at Eielson Air Force Base are located above an unconfined alluvial aquifer with relatively high hydraulic conductivity. Hydraulic tests that have been conducted on wells at the base were evaluated, and in some cases reanalyzed, to determine hydraulic conductivity and specific yield for the aquifer. The reviewed tests included 2 multiple-well pumping tests and 30 slug tests. One slug test was conducted on a well in the bedrock aquifer at Site 38. All the other tests were conducted on the alluvial aquifer. Two slug tests performed on deeper wells in the alluvial aquifer showed an oscillatory response and had not been previously analyzed. Reanalysis of the pumping tests and analysis of the two oscillating slug tests resulted in estimates of hydraulic conductivity ranging from 240 to 1,500 ft/d for the alluvial aquifer underlying the developed portion of the base. Specific yield estimates ranging from 0.07 to 0.23 were determined from the pumping tests. The single slug test conducted in the bedrock aquifer resulted in an estimated hydraulic conductivity of 1.2 ft/d. Results of the other slug tests were not considered valid.

Review of the previous pumping tests indicated that the original analyses were not correct because type curves for an elastic unconfined aquifer response were used, while the data indicate nonelastic unconfined aquifer behavior. Reanalysis of the pumping test data, using the appropriate type curves, produced results for hydraulic conductivity that were within a factor of two of the original results. However, closer agreement between the results at different monitoring wells was obtained for both tests. Also, estimates of specific yield were obtained from reanalysis of the tests.

Review of the slug tests indicated that only the test conducted on the bedrock aquifer and the two oscillating slug tests gave reliable indications of hydraulic conductivity. Results of the other slug tests are not considered valid because of limitations of the slug test method for characterizing highly permeable aquifers and, in some cases, because of shortcomings in the data collection and analysis procedures. At best, the remaining slug tests may be used to indicate a minimum value for hydraulic conductivity. The actual hydraulic conductivity is thought to be significantly higher.

1.0 INTRODUCTION

Aquifer hydraulic properties, particularly hydraulic conductivity and effective porosity, are important in determining travel times of contaminants in ground water and are also important in designing remedial actions for clean-up of contaminated ground water. Hydraulic properties are usually determined by conducting well hydraulic tests such as pumping tests or slug tests. At Eielson Air Force Base (AFB), 2 pumping tests and 30 slug tests have been performed to determine aquifer hydraulic properties. These previous tests were reviewed to determine whether correct analysis methods were applied. This report provides the results of the review of previous hydraulic tests and a summary of available information on hydraulic properties at the base.

2.0 SITE DESCRIPTION

Eielson AFB is located in central Alaska, approximately 25 miles southeast of Fairbanks. Figure III.1 shows the locations of contaminant source areas and the locations of previous aquifer hydraulic tests. General information on the site and descriptions of identified contaminant source areas can be found in the Site Management Plan (USAF, 1993).

The developed portion of Eielson AFB and the vast majority of the contaminant source areas are located on fluvial and glaciofluvial deposits in the lowland area of the base. These sediments are approximately 400 to 600 ft thick (Pewe, 1975). The sediments are composed primarily of sand and gravel with cobbles up to 8 in. in diameter. Silt and clay content is variable, but is generally less than 10%. These sediments are expected to possess relatively high hydraulic conductivities. A few source areas, e.g., LF04 and WP38, are located in an upland area to the northeast of the developed portion of the base. Sediments in this area are thinner and contain a higher proportion of silt. A fractured bedrock aquifer underlies the sediments and is tapped by a few wells in the upland area. One slug test was conducted on the fractured bedrock and all the other tests were in the alluvial aquifer.

3.0 REVIEW OF PUMPING TESTS

This section presents the results of a review of two multiple-well pumping tests. Pumping tests are generally more accurate than slug tests because a greater hydraulic stress is applied to a larger part of the aquifer. The two pumping tests were originally reported by Harding Lawson Associates (HLA, 1989). One pumping test was conducted at well 54M01 and observation well data were collected at wells 54M02, 54M03, and 54M04. The other test was conducted at well 54M05 and wells 54M06, 54M07, and 54M08 were used for observation wells. Results of both tests were reanalyzed using improved analysis techniques. The following subsections contain a discussion of the theoretical basis for analyzing pumping tests in unconfined aquifers, a summary of the test reanalyses, and specific comments on deficiencies in the original HLA (1989) analyses. Details concerning the pumping test reanalyses are presented in Appendices III.A and III.B.

3.1 Theoretical Background For Unconfined Aquifer Pumping Tests

Technical criticism of the original pumping test analysis is based mainly on incorrect application of unconfined aquifer type curves. Therefore, it is beneficial to briefly examine the characteristic behavior of an unconfined aquifer during a constant-rate pumping test. The following discussion was taken primarily from Spane (1993).

For unconfined aquifers, ground water is produced during a pumping test from both elastic storage (including expansion of water and compression of the aquifer matrix) and by gravity drainage from the lowering water-table surface. At the beginning of the pumping period, water is produced mainly from

elastic storage, quantified by aquifer storativity (S). As test time increases, the elastic storage response becomes less important and ground-water production is controlled largely by the aquifer specific yield (S_y).

The fact that unconfined aquifers produce ground water from two sources of storage and that the water table is not fixed during testing causes the drawdown response during unconfined aquifer pumping tests to depart from that predicted by the Theis equation, which assumes confined aquifer conditions. Walton (1960) states that unconfined aquifer constant-rate discharge tests conducted within fully penetrating wells are characterized by the presence of three distinct segments on a time-drawdown curve. In the first segment, the aquifer reacts as would a confined aquifer, with ground water produced through the expansion of water and compression of the aquifer matrix. Drawdowns during this segment follow that predicted using the Theis equation, with aquifer storage equal to its elastic storativity component (S). During the second segment of the drawdown curve, the rate of drawdown decreases as gravity drainage, which induces a vertical ground-water flow component, becomes important. Gravity drainage (also referred to as delayed yield) within the unconfined aquifer causes the time-drawdown curve to deviate significantly from that predicted by the Theis equation because the gravity drainage/vertical ground-water flow components "reflect the presence of recharge in the vicinity of the pumped well" (Walton, 1960). During the third segment, the vertical flow component becomes insignificant and radial flow conditions are once again predominant within the aquifer. Drawdowns during the third segment once again follow that predicted using the Theis equation, with aquifer storage equal to its combined elastic storativity component (S) and specific yield (S_y).

Figure III.2 shows typical unconfined aquifer responses for various beta (β) values and a ratio of $S/S_y = 0.001$:

where
$$\beta = (K_v/K_h)(r/b)^2 \quad (1)$$

and where K_v = vertical hydraulic conductivity

K_h = horizontal hydraulic conductivity

r = distance from the pumped well

b = aquifer thickness.

A universal set of type curves for drawdown in an unconfined aquifer cannot be developed, because the relative degree of separation between the first and third segments of flow is dependent on the ratio of the aquifer's storativity and specific yield (i.e., $\sigma = S/S_y$).

Neuman (1975) developed type curves, however, that can be used to describe the first two segments of unconfined aquifer flow (Neuman Type A, shown in Figure III.3) and the last two unconfined aquifer response segments (Neuman Type B, shown in Figure III.4). Notice that the Neuman Type A curves are expressed with respect to the dimensionless time parameter (t_e), while Neuman Type B curves are reflective of the dimensionless time parameter (t_y); where, t_e and t_y are defined as:

$$t_e = (Tt)/(r^2 S) \quad (2)$$

$$t_y = (Tt)/(r^2 S_y) \quad (3)$$

It should be noted at this point that the original pumping test analyses used Neuman Type A curves for matching the test data, while either Neuman Type B curves or a complete unconfined aquifer analysis approach combining Neuman Type A and Type B curves was used in the reanalyses.

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Tests Conducted in Wells at Eielson Air Force Base

FIGURE III.2. Dimensionless Time-Drawdown Type Curves For Constant-Rate Discharge Tests in Unconfined Aquifers For $\sigma = 10^{-3}$

FIGURE III.3. Dimensionless Pressure Type Curves For Constant-Rate Discharge Tests - Unconfined Aquifer
 Delayed-Yield (Neuman) Type A Curves

FIGURE III.4. Dimensionless Pressure Type Curves For Constant-Rate Discharge Tests - Unconfined Aquifer Delayed-Yield (Neuman) Type B Curves

3.2 Summary of Pumping Test Reanalyses

The standard analysis procedure for unconfined aquifer tests is to match the drawdown response to a family of either Neuman Type A (elastic) or Neuman Type B (non-elastic) curves. Based on the type-curve beta value (β) selected in the curve-match analysis, the vertical anisotropy ($K_D = K_v/K_h$) can also be determined from Equation (1), provided that the observation well distance, r , and aquifer thickness, b , are known. However, because of the limited available time/drawdown data and predominance of "delayed-yield" response effects, observation well data were analyzed using beta values that were calculated based on an assumed K_D value (0.1), an aquifer thickness ($b = 20$ ft), and the given observation well distance (r) from the pumping well.

For alluvial-porous media aquifers, the vertical anisotropy value can be expected to range between 0.5 to 0.01, with the lower ratio values ascribed to aquifers having greater stratification. The use of an anisotropy ratio value of 0.1 is a common assumption that is used in aquifer test analysis of alluvial aquifers, and is consistent with the Harding Lawson Associates cited value of $K_D = 0.1$ (HLA, 1990) for other similar Eielson sites. In addition, effects on parameter estimates caused by the uncertainty in assuming a K_D value are reduced somewhat by the similarity in the beta curves over the range calculated for the given test site conditions. For example, for well 54M07 ($r = 10$ ft, $b = 20$ ft) assuming a K_D value of 0.1 yields a β value of 0.025. If in fact the K_D value is equal to 0.01, then β is equal to 0.0025. The difference between the type-curve shapes, however, is small, with the curves being displaced vertically by a factor of less than two. This vertical displacement indicates that the hydraulic conductivity estimate should be within a factor of two, even if the assumed vertical anisotropy is in error by this significant amount. This error would be propagated in the specific yield estimate as well, because the calculation of S_y is directly related to hydraulic conductivity, as indicated in Equation (3).

Both Eielson pumping tests were conducted in wells that partially penetrate the aquifer. However, an analysis method based on solutions for partially penetrating wells was not possible because the actual aquifer thickness and the vertical anisotropy are not known. Both the original analysis and the reanalysis, therefore, assumed that the wells fully penetrated a 20-ft thick aquifer, which is equivalent to the length of the well screen. This assumption results in uncertainty in the aquifer hydraulic conductivity values, which were calculated by dividing transmissivity obtained from the test analysis by 20 ft rather than by the actual aquifer thickness. Assuming a 20-ft aquifer thickness will result in a small error in hydraulic conductivity if $K_v \ll K_h$, as assumed. However, the estimated hydraulic conductivity may be higher than the actual hydraulic conductivity of the aquifer, especially if the vertical permeability (K_v) is larger than assumed. More detailed review comments concerning the original analyses are presented below.

Table III.1 shows a comparison of the hydraulic property results from the original test analyses and from the reanalyses. Details of the reanalyses are presented in Appendices III.A and III.B. Reanalysis of the 54M01 test yielded estimates of $K \approx 1,480$ ft/d and $S_y \approx 0.07$. Reanalysis of the 54M05 test yielded estimates of $K \approx 500$ ft/d and $S_y \approx 0.23$. A vertical anisotropy ratio (K_v/K_h or K_D) ≈ 0.1 was assumed in the analysis. Because of the lack of early-time test data, no estimate for aquifer storativity (S) was possible. The value of S , however, is likely to be ≤ 0.001 . Hydraulic property estimates from the test at well 54M05 should be used with caution, because they were obtained from analyzing only early-time test data (i.e., the first 40 min of the test data set). Test data after this time could not be used in the analysis, because the increase in water levels at both the pumping well and observation well indicates that the discharge rate at the pumping well (i.e., well 54M05) decreased significantly during this period. Only the average flow rate for each test was available.

Review of the pumping tests indicates that the original analysis procedures were not strictly correct and that no useful estimates of either aquifer storativity or specific yield were obtained. However, the hydraulic conductivity estimates obtained from the original analyses agreed with the reanalysis results within a factor of 1.7 or less.

TABLE III.1. Comparison of Analysis and Re-Analysis Results for Pumping Tests				
Original Analysis Result			Re-Analysis Result	
Observation Well	Hydraulic Conductivity (ft/d)	Storativity (-)	Hydraulic Conductivity (ft/d)	Storativity (-)
Pumping Well 54M01				
54M02	873	-	1,430	0.156
54M03	1,150	-	1,490	0.141
54M04	1,260	-	1,480	0.072
Best Estimate			1,480	0.07
Pumping Well 54M05				
54M06	464	-	523	0.21
54M07	583	-	486	0.27
54M08	884	-	490	0.22
Best Estimate			500	0.23

3.3 Technical Review Comments on the Original (HLA, 1989) Analysis

The following discussion pertains solely to the HLA (1989) analysis. The original analyses of both pumping tests, performed by matching type curves to the test data, was incorrect in that type curves for a confined aquifer (i.e., Neuman Type A curves) were used, while the data clearly display non-elastic unconfined aquifer behavior (i.e., Neuman Type B curves). The non-elastic nature of the response can be demonstrated through use of pressure derivatives (as discussed in Appendix III.A). Also, given the high transmissivity of the aquifer, the unconfined aquifer elastic response should be completely dissipated within the first few seconds of the test. This would have been evident if more frequent measurements had been made at the observation wells during the early part of the test. Specific comments on the original analyses are provided below.

3.3.1 Use of a Constant β Type-Curve Value

A constant and unrealistically low value of beta (β) was used by HLA (1989) in the analysis of observation well responses for each pumping test regardless of the radial distance to the observation well. $\beta = 0.001$ was used in the analysis of the 54M01 test responses and a value of 0.004 was used in the analysis of the 54M05 test. The use of a low β value essentially forces the analysis to use a near Theisian (confined aquifer) type curve for all observation well test data. In fact, as indicated in Equation (1): $\beta = (K_v/K_h)(r^2/b^2)$. Therefore, β values for type curves used in the HLA (1989) test analysis should have varied directly by the square of the observation well radial distance (i.e., by a factor of 16 for $r = 5$ to 20 ft). If it is assumed that the aquifer thickness, b , is 20 ft and the K_v/K_h ratio (i.e., K_p) is 0.1, as suggested in HLA (1990), then beta values would range between 0.1 (for wells 54M04 and 54M06) to 0.006 (for wells 54M02 and 54M06).

To demonstrate the difference in unconfined aquifer responses for different distances from the pumping well (i.e., for different β values), predicted drawdowns at radial distances of 5 ft ($\beta = 0.006$)

and 20 ft ($\beta = 0.1$) are shown in Figures III.5 and III.6 for the pumping tests at well 54M01 and 54M05, respectively. Predicted responses shown in Figures III.5 and III.6 were generated with the DELAY2 program described by Neuman (1975). The parameters used in calculating the predicted responses were largely obtained from the detailed test analysis presented in Appendices III.A and III.B.

A number of features are evident from the predicted drawdown patterns shown in Figures III.5 and III.6, including:

- the distinct difference in drawdown behavior for the two observation well distances
- the complete dissipation of elastic aquifer response prior to 1 min of pumping
- the good match between observed and predicted responses.

It should be noted that Figure III.6 does not include two time/drawdown data points for well 54M06 prior to 1 min, because of apparent effects of pumping rate variation that likely occurred during the early stages of the test prior to pumping-rate stabilization.

3.3.2 Use of Elastic Response Type Curves

The Harding Lawson analysis used an elastic unconfined aquifer approach (Neuman Type A curves - shown in Figure III.3) for matching the constant-rate pumping test data. As can be seen in Figures III.5 and III.6, Neuman Type B curves should have been used for matching the test data. The use of an elastic type-curve solution caused the "force-fit" of an incorrect type curve to the observation well time/drawdown data plot. The net result was that a wide range of hydraulic conductivity values (i.e., 464 to 884 ft/d) were obtained from the analysis of different observation well responses. The arbitrary use of an elastic type-curve solution also caused the analysis to provide unrealistically high estimates of storativity (0.05 to 0.28) for the various observation well responses. This, in fact, is in the range expected for aquifer specific yield and the storativity is expected to be 100 to 1,000 times lower.

Re-examination of Figures III.5 and III.6 indicates that the elastic unconfined aquifer response was largely dissipated during the first seconds of the test, before any drawdown data were collected. Additionally, the non-elastic nature of the observation well responses can be shown through use of pressure derivative analysis, which is discussed in Appendix III.A.

3.3.3 Use of a Full Penetration Well Solution

The HLA (1989) analysis assumes that the aquifer thickness equals the well screen length of 20 ft. However, HLA (1989) also acknowledges that the aquifer may in fact be 150 to 250 ft thick.

To illustrate the difference between test responses for fully penetrating and partially penetrating pumping wells, test responses were simulated using the DELAY2 program described by Neuman (1975). Figure III.7 shows the predicted drawdown responses coinciding with observation well distances of 5 ft and 20 ft for both full aquifer penetration ($b = 20$ ft) and partial penetration conditions ($b = 120$ ft). The aquifer thickness of 120 ft used in the partial penetration model corresponds with the approximate depth of a 20-ft thick silt layer that was reported to occur at the site by HLA (1990).

As indicated in Figure III.7, there is an overall similarity in the shape of drawdown responses for the full and partial penetration models. There is, however, a significant vertical shift in the drawdown curves. This indicates that for aquifers with equal transmissivity, substantially more drawdown is expected for the partial penetration case than the full penetration case. The net result of erroneously assuming a fully penetrating well in the test analysis when a partial penetration situation exists is to underestimate the transmissivity of the aquifer. For this example, transmissivity would be underestimated by a factor of 4. The degree of underestimation would increase as the actual aquifer thickness increases. For example, the factor of underestimation would increase to approximately 10 if

FIGURE III.5. Predicted Unconfined Aquifer Response At Observation Wells 54M02 and 54M04 Given: T = 30,000 ft²/d; S = 0.001; S_y = 0.07; Q = 36 gpm; b = 20 ft; and, K_v/K_h = 0.1

FIGURE III.6. Predicted Unconfined Aquifer Response At Observation Wells 54M06 and 54M08 Given:
 $T = 9,990 \text{ ft}^2/\text{d}$; $S = 0.001$; $S_y = 0.23$; $Q = 40 \text{ gpm}$; $b = 20 \text{ ft}$; and, $K_v/K_h = 0.1$

FIGURE III.7. Comparison of Full and Partially Penetrating Pumping Well Responses
 For Radial Distances of 5 and 20 ft

the aquifer thickness was actually 250 ft. Aquifer transmissivity determined by HLA (1989) from the pumping tests was probably affected by the assumption of a fully penetrating well. Values of hydraulic conductivity would also be underestimated if they were determined by dividing by the actual aquifer thickness. However, because hydraulic conductivity was calculated from the transmissivity result by dividing by the screen length (20 ft) rather than the actual aquifer thickness (assumed to be 120 to 250 ft), the underestimation is offset and the calculated hydraulic conductivity is expected to be only slightly overestimated.

It should also be noted that the overall similarity in the shape of type curves for partially and fully penetrating wells precludes their use in identifying which of the two models is actually operative.

3.3.4 Total Drawdown Data Analysis

For the pumping test at well 54M05, the HLA (1989) analysis used the entire time/drawdown data available for each observation well. However, an apparent decline in pumping rate at well 54M05 adversely affected drawdown at the observation wells for test times greater than 40 min. The decline in pumping rate caused drawdown patterns to "flatten" or to decrease during the remainder of the test. As indicated in Figure III.6, however, later-time drawdown response is expected to deflect upward with time, which is typical of a non-elastic or Neuman Type B response. It should also be noted that the predicted non-elastic drawdown behavior would have been exhibited even earlier in the test (i.e., as predicted in Figure III.6) if the higher transmissivity values calculated by HLA (1989) were used in the drawdown calculation.

4.0 REVIEW OF SLUG TEST ANALYSES

This section presents the results of a review of slug test results for Eielson AFB. A total of 30 wells were characterized using the slug test method. Two wells (03M07 and 48M06), which exhibited oscillatory behavior, were not analyzed by HLA (1989). These two tests have subsequently been analyzed (see Appendix III.C) and indicated hydraulic conductivities of 415 ft/d at well 48M06 and 243 ft/d at well 03M07. These two results are considered representative of the aquifer.

The remaining 28 (non-oscillatory) slug test analysis results reported in HLA (1989) are evaluated below. Based on this evaluation, it is recommended that hydraulic properties determined from 27 of these analyses not be used quantitatively in support of hydraulic characterization or remediation activities. The reasons for this conclusion are discussed below and include limitations of the single-well slug test method, deficiencies in data collection, and application of an inappropriate analysis method. The aquifer hydraulic conductivity at these wells is likely to be significantly higher than the results reported by HLA (1989). The single remaining slug test was conducted at Well 38M03 and is the only test conducted in the confined bedrock aquifer (HLA 1990). The hydraulic conductivity of 1.2 ft/d reported by HLA (1989) for this test is considered representative of the aquifer. A summary of the slug test results is shown in Table III.2.

An attempt was made to reanalyze some of the remaining slug tests using the method of Bouwer and Rice (1976), which is more appropriate for a well completed at the water table in an unconfined aquifer. However, because of the high transmissivity of the aquifer and limitations of the Bouwer and Rice method discussed below, the results were not considered valid.

TABLE III.2. Summary of Slug Test Hydraulic Conductivity (K) Results

Well Number	HLA (1989) Calculated K (ft/d)	Best Estimate K (ft/d)	Comments
03M01	45	-	not valid, probably higher
03M02	96	-	not valid, probably higher
03M04	-	-	not analyzed, high K
03M07	-	243	oscillatory, Appendix III.C
06M02	-	-	not analyzed, high K
09M02	-	-	not analyzed, high K
20M02	4	-	not valid, probably higher
20M03	4	-	not valid, probably higher
20M04	97	-	not valid, probably higher
20M05	201	-	not valid, probably higher
20M06	-	-	not analyzed, high K
20M07	44	-	not valid, probably higher
20M08	149	-	not valid, probably higher
20M09	-	-	not analyzed, high K
25M01	33	-	not valid, probably higher
25M05	42	-	not valid, probably higher
29M03	13	-	not valid, probably higher
32M01	82	-	not valid, probably higher
32M02	116	-	not valid, probably higher
35M02	58	-	not valid, probably higher
38M03	1.2	1.2	confined aquifer
41M01	103	-	not valid, probably higher
44M01	-	-	not analyzed, high K
45M03	84	-	not valid, probably higher
46M02	156	-	not valid, probably higher
47M01	140	-	not valid, probably higher
48M03	193	-	not valid, probably higher
48M06	-	415	Oscillatory, Appendix III.C
54M02	-	-	not analyzed, high K
54M06	-	-	not analyzed, high K

4.1 Theoretical Background for Slug Test Analysis

Slug tests are conducted by instantaneously changing the water level in a well and monitoring the recovery to static conditions. Two of the commonly recognized methods used for analyzing slug tests are the Cooper et al. (1967) method for confined aquifers (fully penetrating wells), and the Bouwer and Rice (1976) method for unconfined aquifers (for fully or partially penetrating wells). Bouwer (1989) states that the Bouwer and Rice (1976) method can also be used to provide "...reasonable values of K (hydraulic conductivity) in confined...aquifers." The analysis method presented in Cooper et al. (1976) is theoretically restricted to fully penetrating wells in confined aquifers, but in certain situations can be extended and used for the analysis of slug tests conducted under partially penetrating and unconfined aquifer conditions (Walter and Thompson, 1982; Spane, 1992).

Although the preceding suggests a similarity, there are significant differences between the two analysis methods. Briefly stated, the Cooper et al. (1967) method is derived from the Theis equation, and uses a semi-log, type-curve matching technique in which the entire test data record is matched to established type curves that represent different formation storativity and well geometry relationships. In contrast, the Bouwer and Rice (1976) method is based on the Thiem equation, and relies on a semi-log, straight-line analysis technique that focuses on analysis of early test-time data. For a more complete description of the analysis procedures for each method, the reader is instructed to consult the identified references.

4.2 Limitations on Applicability of Slug Tests

The slug test provides a rapid and economical hydraulic characterization method for acquiring site-specific estimates of hydraulic conductivity. Although these characteristics make slug testing a popular test method, slug tests have a number of disadvantages that limit their application. Some of these disadvantages include:

- limited use in moderate to high permeability aquifers
- limited radius of investigation
- susceptibility to near-field heterogeneities.

4.2.1 Permeability Limitations

Cooper et al. (1967) noted that slug tests conducted in confined aquifers are limited to test zones possessing transmissivities of less than 7,000 ft²/d. However, the well casing radius also has a significant effect on the transmissivity range to which slug tests are applicable because the square of the well casing radius is directly proportional to the time required for slug recovery. Spane (1992), in examining the well geometry characteristic of RCRA site installations, indicated that single-well slug tests were likely to be limited to characterizing test intervals with transmissivities less than about 1,000 ft²/d. To illustrate the transmissivity limitation, Figure III.8 shows predicted slug test responses in a 2-in. diameter well for test intervals with transmissivities of 1,000 and 10,000 ft²/d. As shown, for a slug test conducted in an interval having a transmissivity of 10,000 ft²/d, the imposed slug pressure difference is 98% dissipated within 1 sec. For a transmissivity of 1,000 ft²/d, about 60% recovery is indicated after 1 sec and 94% recovery after 5 sec. Results of the two pumping tests at Eielson AFB indicated hydraulic conductivities of 500 and 1,480 ft/d, which corresponds to transmissivities of 5,000 and 15,000 ft²/d for a 10 ft long test interval typical of the slug tests.

In addition to the practical difficulties involved in collecting adequate data within such a short time interval, turbulent flow conditions and friction loss in the well casing caused by high velocity flow in the early part of the test may invalidate the test results. Analytical methods for slug tests (e.g., Cooper et al., 1967; Bouwer and Rice, 1976) assume laminar flow conditions. The presence of turbulent flow can be determined by calculating the Reynolds number, R_e , for each time/data point from:

FIGURE III.8. Predicted Slug Test Response at the Stress Well for Transmissivities of 1,000 and 10,000 ft^2/d , and Storativity of 10^{-3} (adapted from Spane 1992)

$$R_e = (2 V r_o) / \mu \quad (4)$$

where V = fluid velocity

μ = kinematic viscosity of water within the water column.

Reynolds numbers $\geq 2,000$ are commonly regarded as indicative of turbulent flow conditions. For a well casing diameter of 2 in., turbulent flow is expected at flow rates higher than about 1.7 gpm. The combination of small diameter casing, high flow rates, and turbulent flow conditions results in friction losses independent of the aquifer that slow the water-level recovery during the slug test. Analysis of tests that are significantly affected by friction in the well casing, therefore, will give results for hydraulic conductivity that are lower than the actual hydraulic conductivity of the test interval.

4.2.2 Radius of Investigation

The distance from the well that the aquifer is perturbed by the slug test depends on the ratio of the formation's storativity to the wellbore storage (Karasaki et al., 1988). The lower the storativity within a confined aquifer or the lower the elastic storage characteristics possessed by an unconfined aquifer, the greater the distance investigated by a slug test. Figure III.9 shows dimensionless head responses versus dimensionless distances from the stress well predicted for selected storativity values. The selected storativity values reflect the expected range for transmissive confined and unconfined (elastic response) aquifers. The dimensionless parameters are defined as:

$$H_D = H/H_o \quad (5)$$

$$r_D = r_o/r_w \quad (6)$$

where H = observed head at time t , minus pre-test static head in well; [L]

H_o = instantaneous head change applied to well; [L]

r_o = radial distance away from the stress well that the response is observed; [L]

r_w = effective well radius within the test interval; [L].

As indicated in Figure III.9, the radius of investigation for a slug test (as designated by a dimensionless head, H_D , response of 0.001), can extend a distance of 100 to 1,000 wellbore radii (i.e., dimensionless radial distance, r_D) into the surrounding formation for storativities lower than 0.01. However, for wells completed at the water table in unconfined aquifers, the specific yield component of aquifer storage may limit the radius of investigation to less than 30 wellbore radii.

4.2.3 Near-Field Heterogeneity Effects

Because of the instantaneous slug implementation and radius of investigation limitations, slug tests are more susceptible to near-field heterogeneities than pumping tests. Natural and construction-related test interval heterogeneities (e.g., facies change, presence of well gravel-pack) can severely limit the analysis of slug tests.

To illustrate the effects of near-field heterogeneities, Figure III.10 shows the predicted response for a slug test conducted in a confined aquifer. The hypothetical well is surrounded by a zone (gravel pack) to a distance of 3 ft that possesses transmissivity equal to 10 times that of the test formation with both zones having a storativity of 10^{-3} . As indicated in Figure III.10, the initial slug test response (i.e., $t \leq 1$ sec) is dominated by near-field conditions, followed by the slug response reflecting a

FIGURE III.9. Dimensionless Head Versus Dimensionless Radial Distance Relationships for Slug Tests (modified from Spane 1992)

"transitional" or composite pattern that is a combination of the hydraulic properties of the two zones. Of particular note is the fact that the slug test response never reflects only the hydraulic properties of the test formation, which attests to the influence exerted by the near-field heterogeneity.

4.3 Evaluation of Harding Lawson Analyses

Harding Lawson Associates (HLA, 1989) applied the Cooper et al. (1967) method for the analysis of all slug test data. Calculated hydraulic conductivity values ranging from 1.2 to 202 ft/d were reported for 20 of the 30 tests. Eight tests were not analyzed because of the rapid recovery that occurred following slug initiation, indicating a high test interval hydraulic conductivity. Two of the tests exhibited oscillatory well response and were not analyzed by HLA (1989).

In addition to the general limitations on slug tests discussed above, a number of deficiencies and potential errors were noted in reviewing the HLA (1989) slug test analyses. A listing of the major deficiencies and a more detailed discussion of each is provided below:

- The Cooper et al. (1967) method is improperly applied to unconfined aquifer slug tests in wells screened at the water table
- Initial stress level, H_0 , is not calculated correctly for each test
- The actual time of test initiation is not known.

FIGURE III.10. Effect of a Near-Field Heterogeneity for Varying Property Values and a Radial Distance of 1 Meter

4.3.1 Inappropriate Analytical Method

The Cooper et al. (1967) method is strictly valid for the analysis of slug tests conducted in wells that fully penetrate confined aquifers. However, under certain conditions, this analytical method can be applied to slug tests conducted in partially penetrating wells within unconfined aquifers. These "favorable" conditions normally require that the test interval is anisotropic (i.e., $K_v/K_h \ll 1$) to minimize vertical flow components, that there not be a significant change in saturated thickness during testing, and that the screened interval not encompass the water-table surface if significant water-table changes occur during testing.

The HLA (1989) report does not address the applicability of using the Cooper et al. (1967) method. Because nearly all the slug tests were conducted for shallow wells with screened intervals that encompass the water table, hydraulic conductivity estimates based on this method are not considered valid.

4.3.2 Slug Test Stress Level

The initial slug stress level, H_0 , was determined for each test by HLA (1989) as the maximum recorded water-level displacement that was observed at the beginning of the test. Reported H_0 values that were "observed" for the slug tests ranged between 0.273 ft and 2.55 ft. Implicit in the H_0 determination is the assumption that the recording equipment "captured" the maximum displacement at the beginning of the test—a highly unlikely event given the expected high transmissivities and rapid recoveries. It should also be noted that determining H_0 based on observations within small diameter wells can provide unreliable results, because of movement of the submerged pressure sensor during slugging rod removal, water-column transients induced by slugging rod insertion or removal, etc.

It should be possible, however, to calculate the H_0 based on the slugging rod volume and cross-section area of the well casing or screen. Because the slugging rod used appears to have been the same for all slug tests (reported slug volume = 0.037 ft³) and the well casing/screen dimensions are the same for the test wells (i.e., except for well 38M03), the H_0 value would be expected to be identical for all tests. The actual H_0 value can be calculated by dividing the known slugging rod volume, V_{sr} , by π and the square of the radius of the well casing/screen. Given a reported well screen diameter of 2.067 in. (HLA, 1989), then, provides a calculated H_0 value of 1.59 ft for most of the Eielson slug tests.

For those cases where the aquifer hydraulic conductivity is significantly lower than the sand pack, H_0 should be calculated based on an equivalent well radius, r_{ew} . The r_{ew} is representative of the "total free-water surface area" in the well screen and sand-packed interval. This calculation can be obtained using the following relationship provided in Bouwer (1989):

$$r_{ew} = [(1 - n)r_c^2 + n r_w^2]^{1/2} \quad (7)$$

where n = sand-pack porosity

r_w = wellbore radius.

Based on results of the pumping tests and oscillatory slug tests, it would appear that the test formation permeability is similar to that of the emplaced sand pack.

The use of an erroneous H_0 value causes the slug test, semi-log data recovery plot to be oversteepened for cases where the H_0 is underestimated, and to be too gradual for situations where H_0 is overestimated. The distortion in the data plot causes an incorrect type-curve selection for matching the test data. Match points obtained from the test data/type-curve matching process are then used

for calculation of test interval transmissivity and storativity. If an erroneous type curve is used in the test data match, errors in transmissivity and storativity would be expected.

If the well casing size and effective well radius are known and if the storativity/specific yield conditions for the test interval can be estimated, suitable type curves (i.e., alpha) for slug test analysis can be independently determined from $\alpha = (r_w^2 S)/r_c^2$. For the Eielson slug tests, alpha type curves of 10^{-3} or greater would be expected. The fact that most (i.e., > 75%) of the slug tests were matched with type curves significantly lower (i.e., 10^{-6} to 10^{-10}) suggests that the test data were over-steepened because of the use of an underestimated H_0 value. Significant errors, therefore, would be expected in the transmissivity and storativity estimates that are based on inappropriate type-curve analysis.

4.3.3 Test Initiation

Like the initial slug stress level, H_0 , the start of each slug test was determined by HLA (1989) as occurring when the maximum recorded water-level displacement was observed at the beginning of the test. Implicit in this determination is the assumption that the recording equipment "captured" the maximum displacement at the beginning of the test, which is highly unlikely. An error in determining the start of the test tends to distort the early-time portion of the data plot, with a late estimate causing an over-steepened curve. Some of the ambiguity in selecting the actual start time can be eliminated by projecting back to when the "expected" or calculated H_0 occurred or by placing more emphasis on later-time data in the type-curve matching analysis.

4.3.4 Bouwer and Rice Analysis Evaluation

In evaluating the slug test results provided in HLA (1989), an attempt was made to reanalyze three of the tests (i.e., wells 03M01, 25M01, and 45M03) using the Bouwer and Rice (1976) method. However, like the Cooper et al. (1967) method, the Bouwer and Rice (1976) method may have characterization limitations and not be applicable for test intervals having transmissivities greater than 1,000 ft²/d (i.e., $K >$ than 100 ft/d for a 10-ft screened interval). Therefore, the results of the analyses were not considered valid. The Bouwer and Rice (1976) analytical limitations are discussed briefly below.

Because of the semi-empirical nature of the Bouwer and Rice (1976) analysis method, a number of analytical limitations exist. Most of these have been previously discussed in Bouwer and Rice (1976) and Bouwer (1989). Unlike the Cooper et al. (1976) method, Bouwer and Rice (1976) do not provide any upper transmissivity limit for this analysis method. However, because of its dependence on early-time data, it is probably more restrictive than the Cooper et al. (1976) method, which uses the entire data response. The Bouwer and Rice (1976) method requires that a straight-line be fit to the early-time portion of the water-level recovery response. For higher permeability test intervals (i.e., $K \geq 100$ ft/d) the early-time data portion that is analyzable with the Bouwer and Rice (1976) method is over within the first 1 to 2 sec of the test. Fitting a straight-line to recovery data recorded after this time will provide hydraulic property estimates that are erroneous. To illustrate the extent of the early-time, analyzable straight-line segment, Figure III.11 shows a simulated slug test response and the straight-line analysis slope for a fully penetrating well within a test interval that has a hydraulic conductivity of 100 ft/d. As indicated, the early-time, straight-line segment of the recovery lasts for only approximately 2 sec at the beginning of the test. This suggests that, conservatively, test intervals possessing transmissivities $\geq 1,000$ ft²/d (i.e., $K \geq 100$ ft/d) are not analyzable with this test or analysis method (see Figures III.8 and III.11). In addition, the problems of turbulence and friction loss in the well casing discussed for the Cooper et al. (1976) method are expected to be even more significant during the earlier part of the slug test used in the Bouwer and Rice analysis.

FIGURE III.11. Delineation of the Early-Time, Straight-Line Segment During a Slug Test, Which is Valid For Use in the Bouwer and Rice (1976) Method:
 $T = 1,000 \text{ ft}^2/\text{d}; S = 0.001$

5.0 CONCLUSIONS AND RECOMMENDATIONS

Pumping tests and oscillatory slug tests in the unconfined alluvial aquifer at Eielson AFB demonstrate that the hydraulic conductivity is relatively high, with test results ranging from 240 to 1,500 ft/d. Specific yield estimates from reanalysis of the multiple well pumping tests ranged from 0.07 to 0.23. A single slug test conducted in the confined bedrock aquifer at well 38M03 indicated a hydraulic conductivity of 1.2 ft/d.

Other slug test results reported in HLA (1989) are not considered reliable because of limitations of the slug test method for characterizing high permeability aquifers and, in some cases, because of shortcomings in the data collection and analysis procedures. At best, these tests may provide estimates of the minimum hydraulic conductivity for the tested interval. The actual hydraulic conductivity is thought to be significantly higher.

In general, single well slug tests in small-diameter wells are not appropriate for characterizing test intervals with transmissivity greater than 1,000 ft²/d (hydraulic conductivity > 100 ft/d for a 10 ft test interval). Single well slug tests using wells with larger casing ($\geq$ 6 in.) could provide reliable results. Multiple-well slug-interference tests are a possible alternative method. These tests require a minimum of two wells in close proximity (< 50 ft) and one of the wells (the stress well) should have a diameter of at least 6 in. Slug interference tests have advantages over pumping tests in that they are quickly completed, minimize perturbation of the ground-water flow system, and do not produce large amounts of possibly contaminated water. Based on the assumed range of hydraulic properties, a slug-interference test would be expected to be completed within a 30-min period. A description of the design, performance, and analysis of slug interference tests is provided in Spane (1992).

If additional constant-rate pumping tests are conducted in the unconfined alluvial aquifer at the site, the following test design recommendations are suggested:

- The test should be conducted for a minimum of 2 days.
- A long-term, pre-test equilibration monitoring period should be initiated for the purpose of removing extraneous hydrologic trends (e.g., recharge event) or stresses (e.g., barometric pressure fluctuation) from the pumping test record.
- A higher pumping rate should be considered to maximize the observed interference response at the observation well locations.
- Water-level measurements should be made as frequently as every second during the early stages of the test to help establish the early-time, unconfined aquifer (i.e., elastic) response characteristics.
- Because of the shallow water table and high T of the aquifer, efforts should be made not to discharge the ground water withdrawn during pumping to land surface within 2,000 ft of the observation wells.

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APPENDIX III.A

Hydraulic Test Analysis For Constant-Rate Pumping Test At Well 54M01

Hydraulic test analyses were performed on available observation well drawdown data that were obtained during a constant-rate pumping test at well 54M01 on October 7, 1988. The constant-rate test was conducted for a total test period of 1,043 min, at an average discharge rate of 36 gpm. Observation well distances (r) from the pumping well (54M01) are listed as:

54M02- r = 5 ft

54M03- r = 10 ft

54M04- r = 20 ft.

Hydraulic test analysis methods for the unconfined aquifer test included both confined aquifer analysis (Cooper and Jacob, 1946) for test data sections that displayed radial flow conditions, and unconfined aquifer type-curve analysis using Neuman Type B curves (Neuman, 1975) and associated derivative plots (Spane, 1993). The results obtained from the two analysis methods provided corroborative estimates for hydraulic conductivity and specific yield that ranged between 1,410 and 1,505 ft/d, and between 0.070 and 0.162, respectively.

It should be noted that the drawdown analyses presented in this appendix are based on the assumption of a fully penetrating well and an aquifer thickness of 20 ft. Hydraulic conductivity was, therefore, calculated from the estimated transmissivity value by dividing by 20 ft. The actual aquifer thickness is thought to be 120 to 250 ft. As noted in the text, the effects of partial penetration cause the transmissivity determined from the type-curve match to significantly underestimate the transmissivity of the entire aquifer thickness (i.e. by a factor of 4 to 10). However, in calculating hydraulic conductivity, this error is offset by dividing the transmissivity result by the screen length (20 ft) rather than by the actual aquifer thickness.

The best estimates for aquifer hydraulic properties are 1,480 ft/d for hydraulic conductivity, and 0.07 for storativity. The best estimates are based on analyses performed on drawdown data obtained from observation well 54M04; which is the most distant of the observation wells monitored during the test. The greater observation well distance results in a larger beta type-curve value (i.e., 0.1 versus 0.006 for well 54M02), which provides a higher degree of certainty in the unconfined aquifer, type-curve analysis. Analysis of the drawdown responses for observation wells 54M02 and 54M03 also provided comparable estimates.

Hydraulic property estimates obtained from analysis of each observation well response are presented in Table III.A.1. A brief description of the analysis process and selected analysis figures are presented below. A detailed description of the use of confined aquifer solutions and the unconfined aquifer type-curve method for analyzing unconfined aquifer responses is presented in Neuman (1975) and Spane (1993).

Confined Aquifer Analysis

The analysis procedure includes the use of a log-log diagnostic plot of the drawdown and drawdown derivative (for a discussion on the use of pressure derivatives in hydrologic test analysis see Spane and Wurster, 1992 and Spane, 1993) to identify the existence of radial flow conditions within the drawdown data, which can then be analyzed using the semi-log, straight-line method of Cooper and Jacob (1946). The straight-line analysis method is valid generally (i.e., within 2%) for test times exceeding a "u criteria value" of 0.05 (Chapuis, 1992). The Jacob correction for unconfined aquifer

TABLE III.A.1. Summary of Hydraulic Test Analysis Results For Constant-Rate Pumping Test At Well 54MO1			
Well	Analysis Method	Hydraulic Property Estimate	
		Hydraulic Conductivity (ft/d)	Specific Yield
54MO2	Confined Aquifer: Semi-Log, Straight-Line Analysis	1,411	0.162
54MO3	Confined Aquifer: Semi-Log, Straight-Line Analysis	1,488	0.137
54MO4	Confined Aquifer: Semi-Log, Straight-Line Analysis	1,505	0.073
54MO2	Unconfined Aquifer: Neuman Type B Curve Analysis	1,451	0.149
54MO3	Unconfined Aquifer: Neuman Type B Curve Analysis	1,491	0.145
54MO4	Unconfined Aquifer: Neuman Type B Curve Analysis	1,451	0.070
Best Estimate		1,480	0.07
* Best estimate values based on average analysis results obtained for well 54MO4.			

dewatering should also be applied for the observed drawdown data following the suggestion provided in Neuman (1975).

Figure III.A.1 shows a log-log diagnostic plot of the drawdown data and data derivative for well 54M02. The relatively high "noise" level in the data necessitated the use of a derivative L-spacing of 0.4. The diagnostic plot indicates that radial flow conditions were established after approximately 17 min and lasted until approximately 683 min into the test. Figure III.A.2 shows the semi-log, straight-line analysis for drawdown data during this period. As indicated in the figure, a transmissivity of 28,210 ft²/d and a specific yield of 0.162 were obtained from the straight-line analysis. A hydraulic conductivity estimate of 1411 ft/d was calculated by dividing by the assumed aquifer thickness of 20 ft. Figures III.A.3 through III.A.6 show the diagnostic and straight-line analysis plots for observation wells 54M03 and 54M04. The diagnostic plot for well 54M03 indicates radial flow conditions between 20 and 683 min after the test began. Semi-log straight-line analysis of the data resulted in a transmissivity of 29,750 ft²/d and a specific yield of 0.137. A hydraulic conductivity of 1,488 ft/d was calculated by dividing by the assumed aquifer thickness of 20 ft. The diagnostic plot for well 54M04 indicates radial flow conditions were established after 30 min and lasted until the end of the test at 1043 min. Semi-log straight-line analysis of these data resulted in a transmissivity of 30,100 ft²/d and a specific yield of 0.073. A hydraulic conductivity estimate of 1,505 ft/d was calculated by dividing by the assumed aquifer thickness of 20 ft.

FIGURE III.A.1. Diagnostic Log-Log Analysis Plot of Drawdown Data and Data Derivative For Well 54M02

FIGURE III.A.2 Semi-Log, Straight-Line Analysis For Well 54M02 Drawdown Data

FIGURE III.A.3. Diagnostic Log-Log Analysis Plot of Drawdown Data and Data Derivative For Well 54M03

FIGURE III.A.4. Semi-Log, Straight-Line Analysis For Well 54M03 Drawdown Data

FIGURE III.A.5. Diagnostic Log-Log Analysis Plot of Drawdown Data and Data Derivative For Well 54M04

FIGURE III.A.6. Semi-Log, Straight-Line Analysis For Well 54M04 Drawdown Data

Unconfined Aquifer Type B Curve Analysis

The unconfined aquifer type-curve analysis procedure includes the log-log matching of the drawdown data and data derivative to established type curves (Neuman 1975) and type-curve derivatives (Spane 1993). Figure III.A.7 shows an example of the combined type curve and derivative responses for a selected beta curve range of 0.001 to 0.1. As indicated, the ambiguity in selecting the best type-curve match is significantly reduced by the convergence of the derivative curves with a horizontal line at a dimensionless drawdown value of 0.5. This effectively fixes the vertical scale for type-curve matching purposes.

Figures III.A.8 through III.A.10 show combined drawdown and derivative type curves matched to data from each of the three observation wells. Drawdown type curves (Neuman Type B) and corresponding derivative curves were generated and fitted to the data using computer software programs. The best-fit of the drawdown data and data derivative for well 54M02 was obtained using a type-curve beta value of 0.006. This type-curve match (Figure A.8) provided estimates for transmissivity and specific yield of 29,020 ft²/d and 0.149, respectively. A hydraulic conductivity estimate of 1,451 ft/d was calculated by dividing by the assumed aquifer thickness of 20 ft. The best-fit of the drawdown data and data derivative for well 54M03 was obtained using a type-curve beta value of 0.025. This type-curve match (Figure III.A.9) resulted in transmissivity and specific yield estimates of 29,810 ft²/d and 0.145, respectively. A hydraulic conductivity estimate of 1491 ft/d was calculated by dividing by the assumed aquifer thickness of 20 ft. The best-fit of the drawdown data and data derivative for well 54M04 was obtained using a type-curve beta value of 0.1. This type-curve match (Figure III.A.10) resulted in transmissivity and specific yield estimates of 29,025 ft²/d and 0.070, respectively. A hydraulic conductivity estimate of 1,451 ft/d was calculated by dividing by the assumed aquifer thickness of 20 ft. Results of the unconfined aquifer type curve analysis method are in close agreement with results obtained from the confined aquifer analysis method.

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FIGURE III.A.7. Dimensionless Neuman Type B Curves and Type-Curve Derivatives for Selected Beta Values

FIGURE III.A.8. Diagnostic Log-Log Analysis Plot and Unconfined Aquifer Type-Curve Match For Well 54M02 Drawdown Data

FIGURE III.A.9. Diagnostic Log-Log Analysis Plot and Unconfined Aquifer Type-Curve Match For Well 54M03 Drawdown Data

FIGURE III.A.10 Diagnostic Log-Log Analysis Plot and Unconfined Aquifer Type-Curve Match For Well 54M04 Drawdown Data

APPENDIX III.B

Hydraulic Test Analysis For Constant-Rate Pumping Test At Well 54M05

Hydraulic test analyses were performed on available observation well drawdown data that were obtained during a constant-rate pumping test at well 54M05 on October 8, 1988. The constant-rate test was conducted for a total test period of 545 min, at a reported average discharge rate of 40 gpm. Observation well distances (r) from the pumping well (54M05) are listed as:

54M06- $r = 5$ ft

54M07- $r = 10$ ft

54M08- $r = 20$ ft.

The discharge rate at well 54M05 is reported by HLA (1989) as 40 gpm. No information is provided in the test data sheets that would indicate if the discharge rate varied or was maintained at a constant rate during the pumping period. The standard analysis methods used for the interpretation of unconfined aquifer pumping tests (e.g., Neuman, 1975) all require that the discharge rate be uniform during the test.

Figure III.B.1 shows the time/drawdown record at the pumping well (well 54M05). As shown, drawdown does not exhibit a steady decline pattern, and in fact shows an increasing pattern (i.e., water-level rise) after approximately 40 min. There are a number of factors that can cause an increasing water-level during a pumping test; the most plausible for these test site conditions being a decrease in the pumping rate and/or well development at the pumping well site. Because decreasing drawdown patterns were evident at all observation wells after this point in the test, a decline in pumping rate is believed to be the most plausible explanation.

Because of the apparent decrease in pumping rate, only observation well data for the test period prior to 40 min were subjected to analysis. It was also assumed that the pumping rate during this period was constant and averaged 40 gpm. Any errors in the assumed discharge rate will be directly manifested in the hydraulic properties estimated from the test analysis.

The unconfined aquifer type-curve analysis method described in Neuman (1975) and Spaine (1993) was used. Results obtained from the analysis provided corroborative estimates for the aquifer transmissivity and specific yield that ranged between 486 and 523 ft/d, and between 0.21 and 0.27, respectively.

It should be noted that the drawdown analyses presented in this appendix are based on the assumption of a fully penetrating well and an aquifer thickness of 20 ft. Hydraulic conductivity was, therefore, calculated from the estimated transmissivity value by dividing by 20 ft. The actual aquifer thickness is thought to be 120 to 250 ft. As noted in the text, the effects of partial penetration cause the transmissivity determined from the type-curve match to significantly underestimate the transmissivity of the entire aquifer thickness (i.e., by a factor of 4 to 10). However, in calculating hydraulic conductivity, this error is offset by dividing the transmissivity result by the screen length (20 ft) rather than by the actual aquifer thickness.

The best estimates for the aquifer hydraulic properties are 500 ft/d for hydraulic conductivity, and 0.23 for storativity. The best estimate values are based on the average of estimates obtained from the three observation well test results. It should be noted that pressure derivative analysis, which proved to be useful in analyzing the previous pumping test (54M01), could not be effectively applied to this

pumping test data set, because of the shortness of the data length, the inherent "noise" level within the data, and the predominance of "delay-yield" effects within the data record.

Hydraulic property estimates obtained from individual well analyses are presented in Table III.B.1. A brief description of the analysis process, and selected analysis figures are presented below.

Unconfined Aquifer Type B Curve Analysis

The unconfined aquifer type-curve analysis procedure, which includes the log-log matching of the drawdown data to established Neuman Type B (non-elastic) curves (Neuman, 1975), was used to analyze the available (representative) observation well data. As noted previously, because of the limited observation well data available, pre-selected beta curves were used in the type-curve analysis based on an aquifer thickness, b , of 20 ft, the reported observation well distance, r , and an assumed vertical anisotropy ratio, K_D , of 0.1. The Type B curves were calculated using the DELAY2 program, which is described in Neuman (1975). It should be noted that the type-curve derivative method used in analyzing the first pumping test data set (Well 54M01) was not used for this pumping test reanalysis, because of the limited observation well data available.

Figures III.B.1 through III.B.3 show the results and hydraulic property estimates obtained from the type-curve analysis for observation wells 54M06 through well 54M08, respectively. As indicated, a close correspondence in hydraulic properties was obtained.

Figure III.B.4 shows a combined drawdown plot analysis for all observation well locations, together with the predicted drawdown response based on the best estimate derived values for transmissivity ($9,990 \text{ ft}^2/\text{d}$) and specific yield (0.23), and assumed values for storativity (0.001), vertical anisotropy (0.1), and aquifer thickness (20 ft). The close correspondence between the predicted and observed drawdown response indicates that the test interval is relatively homogeneous within the immediate surrounding area. The close correspondence also suggests that the assumed K_D value of 0.1 must be close to the actual value. No inference concerning assumed aquifer thickness, however, can be made because the relative separation between beta curves is approximately the same, whether the wells are fully or partially penetrating.

Figure III.B.4 also shows that during the first 40 min of the test, drawdown responses at the observation wells were significantly influenced by "delayed-yield" effects. The third segment or late-stage of unconfined aquifer flow behavior (which follows the Theis curve with respect to the specific yield) is not exhibited at any of the observation wells. Confined aquifer analyses (which are based on the Theis solution), therefore, cannot be used in analyzing the drawdown data.

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TABLE III.B.1. Summary of Hydraulic Test Analysis Results For Constant-Rate Pumping Test At Well 54MO5

Well	Analysis Method	Hydraulic Property Estimate	
		Hydraulic Conductivity (ft/d)	Specific Yield
54MO6	Unconfined Aquifer: Neuman Type B Curve Analysis	523	0.21
54MO7	Unconfined Aquifer: Neuman Type B Curve Analysis	486	0.27
54MO8	Unconfined Aquifer: Neuman Type B Curve Analysis	490	0.22
Best Estimate		500	0.23
* Best estimate values based on analysis results obtained for observation wells 54MO6, 54MO7, and 54MO8.

FIGURE III.B.1. Time/Drawdown Data Plot for Pumping Well 54M05

FIGURE III.B.2. Log-Log Type-Curve Analysis Results of Drawdown Data From Observation Well 54M06

FIGURE III.B.3. Log-Log Type-Curve Analysis Results of Drawdown Data From Observation Well 54M07

FIGURE III.B.4. Log-Log Type-Curve Analysis Results of Drawdown Data From Observation Well 54M08

FIGURE III.B.5. Combined Drawdown Plot for Observation Wells 54M06, 54M07, and 54M08, and Predicted Responses Based on: $T = 9,990 \text{ ft}^2/\text{d}$; $S_y = 0.23$, $S = 0.001$, $K_D = 0.1$, and $b = 20 \text{ ft}$

APPENDIX III.C

Analysis of Oscillating Slug Tests

This appendix presents results of analyses performed on 2 slug tests that displayed oscillatory patterns following slug test initiation. The tests were part of a series of slug tests conducted on 30 wells by Harding Lawson Associates (HLA, 1989). Of these 30 wells, only two (wells 03M07 and 48M06) exhibited oscillatory behavior. Because of the oscillatory response, the slug tests for these two wells were not analyzed by HLA (1989).

Slug tests that display oscillatory behavior (i.e., under-damped response) commonly occur in wells that intersect a highly transmissive confined aquifer and/or possess a significant water volume (i.e., mass) within the well casing. It is interesting to note that of the 30 wells slug tested as part of the Eielson AFB characterization program, only the two deepest wells (i.e., greater than 50 ft in depth and not completed at the water table) exhibited an oscillatory response. Standard analytical methods (e.g., Cooper et al., 1967; Bouwer and Rice, 1976) that are valid for the analysis of slug tests that exhibit an exponential decay pattern (i.e., over-damped response) cannot be used for analyzing slug tests that display oscillatory behavior.

Theoretical Background

As discussed in Cooper et al. (1965) and Van der Kamp (1976), a well-aquifer system response to slug testing can be represented by the performance of a mass suspended on a spring in a viscous medium. In this analogy, the mass is represented by the water in the well bore and in the affected area of the surrounding aquifer, and the spring by characteristics of the aquifer. Depending on the various properties of the well-aquifer system, three types of free water well response cases are possible: over-damped, under-damped, and critically damped.

In an over-damped well response situation, water levels recover to the static, pre-test level in an exponential manner. Slug tests that exhibit an over-damped response indicate that frictional forces within the well-aquifer system are dominant over inertial forces (i.e., represented primarily by the mass of water within the well column). Because of this force relationship, over-damped well response is associated with aquifers possessing low to moderate transmissivity, for wells of shallow to intermediate test depths. Analytical solutions for this test response have been developed and presented by Cooper et al. (1967), Bouwer and Rice (1976), etc.

For the under-damped well response case, recovery water levels oscillate about the static water level with amplitudes that decrease with time. The oscillatory behavior exhibited indicates that inertial forces within the well-aquifer system are significant and must be accounted for in the test analysis. This type of well response is commonly exhibited for highly transmissive aquifers and/or well test systems possessing large volumes (i.e., mass) of water. The occurrence of oscillatory inertial behavior within wells was first identified and described in Cooper et al. (1965) and Bredehoeft et al. (1966). Analytical solutions for under-damped slug test response are presented in Van der Kamp (1976), Krauss (1977), Shinohara and Ramey (1979), Kipp (1985), and Kabala et al. (1985). Because of the relative ease of application, the analytical method developed by Van der Kamp (1976) was used in the analysis of the Eielson AFB oscillatory slug test responses and is, therefore, the method discussed in this report section.

Critically damped well responses represent a transitional response between the over- and under-damped cases. The type-curve matching method presented in Kipp (1985) is the only known analytical technique for analyzing slug tests exhibiting this type of composite well response behavior.

Van der Kamp Analysis Procedure

The Van der Kamp (1976) analysis method is predicated on describing the damped, oscillatory slug test response, H_t , based on the following approximate solution:

$$H_t = H_o e^{-\tau t} \cos (wt) \quad (1)$$

where H_o = initial slug stress applied; [L]

τ = damping constant; [T^{-1}]

t = test time; [T]

w = angular frequency; [radians/T].

The analysis procedure begins by determining the damped angular frequency, w , and damping constant, τ . The angular frequency is determined by:

$$w = 2\pi/p \quad (2)$$

where p = period of oscillation

The damping constant, τ , is determined by:

$$\tau = -\ln [H_t/H_o (\cos wt)]/t \quad (3)$$

Next the effective water-column length, L_e , within the well is calculated by:

$$L_e = g/(w^2 + \tau^2) \quad (4)$$

Knowing τ and L_e , calculate the damping factor, d , by:

$$d = \tau/(g/L_e)^{1/2} \quad (5)$$

Once the damping factor has been determined, the transmissivity for the test interval can be determined by:

$$T = b + a \ln(T) \quad (6)$$

where a = analysis parameter; equal to $r_c^2 (g/L_e)^{1/2} / 8d$

b = analysis parameter; equal to $-a \ln [0.79 r_{ew}^2 S(g/L_e)^{1/2}]$.

As discussed in Van der Kamp (1976), the b analysis parameter requires that the effective well radius, r_{ew} , and storativity, S , of the aquifer be known. However, because the natural logarithm is taken of their product, the calculation of b is rather insensitive to large variations or uncertainties in either r_{ew}^2 or S .

For the Eielson AFB slug tests analyses, r_{ew} was calculated as the equivalent radius representative of the "total free-water surface area" in the well screen and sand-packed interval. This calculation can be obtained using the following relationship provided in Bouwer (1989):

$$r_{ew} = [(1 - n)r_c^2 + n r_w^2]^{1/2} \quad (7)$$

where n = sand-pack porosity

r_w = wellbore radius.

Krauss (1977) and Kabala et al. (1985) state if S is not known independently, then a value of $S = 10^{-4}$ is recommended. As mentioned previously, the relative insensitivity of the analysis parameter b to S , suggests that estimates of transmissivity should not vary by more than a factor of about two over the range for storativity commonly ascribed to confined aquifers (i.e., 10^{-3} to 10^{-5}).

Once analysis parameters a and b have been calculated, the transmissivity can be calculated from Equation (6) through an iterative procedure beginning with a first approximation of $T_0 = b$, and continuing to:

$$T_n = b + a \ln T_{n-1} \quad (8)$$

where $n \geq 1$.

Convergence to a final transmissivity value generally occurs within three or four iterations.

Various assumptions of the approximate analysis solution are discussed in detail in Van der Kamp (1976). Implicit in the analysis (as with most hydrologic test analyses) is that laminar flow conditions exist within the test system during testing. It is important, therefore, that the under-damped analysis be applied to test data displaying laminar flow behavior. Because of the nature of the test, turbulent flow conditions may occur during the early stages of the test response, immediately following initiation of the slug test. The presence of turbulent flow conditions can be assessed by calculating the Reynolds number, R_e , for each time/data point. The well-known Reynolds number is given in fluid mechanics textbooks as:

$$R_e = (2 V r_c) / \mu \quad (9)$$

where V = fluid velocity

μ = kinematic viscosity of water within the water column.

Reynolds numbers $\geq$ to 2,000 are commonly regarded as indicative of turbulent flow conditions.

Analysis of Well 48M06 Slug Test

Test data and as-built construction details for this well test are contained in HLA (1989). The test was conducted on October 4, 1988. The manner of slug initiation is unknown, but is believed to have been implemented by removing a submerged slugging rod of known volume (0.037 ft^3) from the well column. The well screen and wellbore radii are reported in HLA (1989) as 0.083 ft and 0.229 ft, respectively. The well is screened over the depth interval 89.0 to 99.0 ft bls. The depth to water at the time of testing is not known, but is estimated to be 13.6 ft bls, based on a static water-level measurement obtained several weeks prior to (i.e., 9/23/88, 13.7 ft bls) and following the test (10/31/88, 13.2 ft bls).

Figure III.C.1 shows the oscillatory pattern exhibited at the well following initiation of the slug test. As indicated, a well defined under-damped response is indicated with an oscillation period of 10.5 sec. The under-damped response was analyzed using the approximate solution method reported in Van der Kamp (1976). Pertinent input parameters required for the analysis included the effective water-column length, $L_e = 88.39 \text{ ft}$; effective well radius, $r_{ew} = 0.135 \text{ ft}$; well casing radius, $r_c = 0.086$ (note: the HLA value of 0.083 is incorrect); angular frequency, $w = 0.5984 \text{ rad/sec}$ (from the oscillation

FIGURE III.C.1. Under-Damped (Oscillatory) Slug Test Response and Analysis For Well 48M06

period analysis); damping constant, $\tau = 0.0768 \text{ s}^{-1}$ (from the oscillation amplitude analysis); storativity = 0.0001 (assumed); initial slug stress, $H_0 = 1.59 \text{ ft}$ (calculated from slug volume displacement and casing cross-sectional area).

Based on these given input parameters, a transmissivity of $4,150 \text{ ft}^2/\text{d}$ was calculated. The approximate solution is rather insensitive to storativity. For this example, varying storativity from 10^{-3} to 10^{-5} causes the transmissivity estimate to range between 3,150 and $5,100 \text{ ft}^2/\text{d}$. As suggested in Krauss (1977) and Kabala et al. (1985) for transmissive test intervals exhibiting an under-damped response, a value of 10^{-4} is recommended when the storativity is not already known. Like all single-well slug tests, the transmissivity is reflective of the screened interval; therefore, an equivalent hydraulic conductivity of 415 ft/d is indicated for the 10-ft test interval length.

It should also be noted that the slug test analysis is dependent on laminar flow conditions occurring within the test system. To assess whether turbulent flow conditions existed during the test, Reynolds numbers (Re) were calculated for each time/data point. This assessment indicated that turbulent flow conditions (i.e., $Re \geq 2,000$) did exist during the early stages of the test, but had largely dissipated by a test time of approximately 14 s. For this reason, only test data after 14 s were used in the under-damped slug test analysis. As shown in Figure III.C.1, a good match between the observed and predicted response is indicated, even for the early test period (i.e., $t < 14 \text{ s}$).

Analysis of Well 03M07 Slug Test

Test data and as-built construction details for this well test are contained in HLA (1989). The test was conducted on October 2, 1988. The manner of slug initiation is unknown, but is believed to have been implemented by removing a submerged slugging rod of known volume (0.037 ft^3) from the well column. The well screen and wellbore radii are reported in HLA (1989) as 0.083 ft and 0.229 ft, respectively. The well is screened over the depth interval 89.5 to 99.5 ft bls. The depth to water at the time of testing is not known, but is estimated to be 11.3 ft bls, based on a static water-level measurement obtained on October 5, 1988.

Figure III.C.2 shows the oscillatory pattern exhibited at the well following initiation of the slug test. As indicated, only one and one-half oscillations are exhibited for the 15 sec of test data recorded at the site. As with well 48M06, the slug test response was assessed for turbulent flow conditions. The analysis indicates that turbulent flow conditions were dissipated after 9 sec into the test. This indicates that only the last 6 sec of test data can be "rigorously" analyzed. The under-damped response was analyzed using the approximate solution method as described for well 48M07. Pertinent input parameters required for the analysis included the effective water-column length, $L_w = 85.92 \text{ ft}$; effective well radius, $r_{ew} = 0.135 \text{ ft}$; well casing radius, $r_c = 0.086$ (note: the HLA value of 0.083 is incorrect); angular frequency, $w = 0.5984 \text{ rad/sec}$ (from the oscillation period analysis); damping constant, $\tau = 0.1280 \text{ s}^{-1}$ (calculated oscillation amplitude analysis); storativity = 0.0001 (assumed); initial slug stress, $H_0 = 1.59 \text{ ft}$ (calculated from slug volume displacement and casing cross-sectional area).

Based on these given input parameters, a transmissivity of $2,425 \text{ ft}^2/\text{d}$ is indicated. As discussed previously, the approximate solution is rather insensitive to storativity. For this example, varying storativity from 10^{-3} to 10^{-5} causes the transmissivity estimate to range between 1825 and $3000 \text{ ft}^2/\text{d}$. As suggested in Krauss (1977) and Kabala et al. (1985) for transmissive test intervals exhibiting an under-damped response, a value of 10^{-4} is recommended when the storativity is not already known. Like all single-well slug tests, the transmissivity is reflective of the screened interval; therefore, an equivalent hydraulic conductivity of 243 ft/d is indicated for the 10 ft-test interval length. Because of the limited amount of test data available for this test, however, discretion should be exercised in the use of the hydraulic property estimates obtained from this test.

FIGURE III.C.2. Under-Damped (Oscillatory) Slug Test Response and Analysis For Well 03M07

It should be noted that similar periods of oscillation (i.e., 10.5 sec) were indicated for both wells 48M06 and 03M07. As indicated in Van der Kamp (1976), the oscillation period is largely controlled by the effective length of the well water column (L_w). Because the wells have nearly identical well dimensions (i.e., depth, casing and effective well radii) and depth to water conditions, a close similarity in oscillation period would be expected.

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APPENDIX IV - ANALYSIS OF HYDRAULIC CHARACTERIZATION TESTS—BLAIR LAKES TARGET FACILITY

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APPENDIX IV - ANALYSIS OF HYDRAULIC CHARACTERIZATION TESTS—BLAIR LAKES TARGET FACILITY

This appendix presents analysis results of the hydraulic characterization tests conducted during May 1993 at the Blair Lakes Target Facility. The objective of the hydraulic characterization tests was to obtain preliminary estimates for hydraulic properties (i.e., transmissivity, hydraulic conductivity) for the shallow alluvial aquifer underlying the target range.

The hydraulic characterization consisted of a series of slug tests conducted in shallow monitoring wells completed within the alluvial unconfined aquifer, above the permafrost, and a constant-rate pumping test performed at the old water supply well completed in the alluvial confined aquifer beneath the permafrost. Before and during the hydraulic characterization, a baseline hydraulic head monitoring investigation was conducted within selected monitoring wells at the target range. The objective for the baseline hydraulic head monitoring investigation was to provide information concerning the shallow and deep alluvial aquifer system flow dynamics (i.e., response to natural phenomena, aquifer interaction) and obtain time-dependent/areal head information for determining lateral groundwater flow patterns beneath the target range. Results of the baseline monitoring investigation are presented in Appendix IV.A.

A brief description of the hydrologic tests used during the hydraulic characterization and a discussion of the application and limitations of analytical methods used in the test analyses are included below. Results of the characterization tests are summarized and followed by individual test analysis figures.

1.0 HYDRAULIC CHARACTERIZATION

The hydraulic characterization consisted of a series of single-well slug tests conducted at the shallow monitoring wells and a constant-rate pumping test conducted at the old water supply well. The shallow wells are completed in the alluvial unconfined aquifer above the permafrost; the old water supply well is completed in the deeper alluvial confined aquifer underlying the permafrost. The permafrost discontinuously underlies the target range. Water-level responses were monitored within the wells during characterization testing using sensitive strain gauge pressure transducers and automated data loggers.

In all, six monitoring wells were characterized using the slug test method. Two other monitoring wells were originally planned for testing, however, permafrost and frozen well water conditions (well 50M05) and well decommissioning (well 50M09 was destroyed) precluded characterization testing in these wells. Table IV.1 lists pertinent hydraulic characterization information for the slug test wells.

The slug tests were initiated by "instantaneously" removing a submerged slugging rod of known displacement volume from the well water column. The slugging rod was removed from the well water column (thereby simulating a slug withdrawal test condition) after sufficient equilibration time had elapsed following slugging rod emersion. As indicated in Table IV.1, three different slugging rods were used for the characterization tests to maximize the stress displacement, given the individual monitoring well's diameter and saturated screen length.

The pumping test was conducted at the old water supply well at a constant discharge rate of 10.7 gpm, which continued for a total test period of 480 min. Ground water produced during the test was discharged to land surface at a distance greater than 300 ft from the pumping well to minimize effects on water-level responses in the pumped well during testing. Possible drawdown interference responses were also monitored at a nearby observation well 50M01 at a distance of 18 ft from the

TABLE IV.1. Pertinent Hydraulic Characterization Slug Test Information					
Well	Slug Tests	Slug Displace. Volume (ft ³)	Well Screen Diameter (in)	Well Depth (ft bls)	Sat. Well Screen Length (ft)
50M02	1 Slug Withdrawal	0.034	2	7.0-17.0	6.76
50M04	2 Slug Withdrawal	0.034	2	4.5-14.5	5.94
50M06	2 Slug Withdrawal	0.034	2	4.5-14.5	5.96
50M07	3 Slug Withdrawal	0.255	4	5.7-11.8	4.48
50M08	2 Slug Withdrawal	0.034	2	3.5-13.5	5.63
50M10	2 Slug Withdrawal	0.062	2	4.5-14.5	7.82

pumped well. Well 50M01 is a shallow monitoring well completed in the unconfined aquifer above the permafrost. No discernable interference responses were observed at this well during or following termination of the constant-rate pumping test.

2.0 SLUG TEST ANALYSES

This section discusses the theoretical background of slug test analysis methods, factors affecting slug test response, and summarizes the analytical results of slug tests conducted as part of the hydraulic characterization. The theoretical background discussion of slug tests and factors affecting slug test response is taken largely from Spane (1993a). Selected analyses for individual slug tests are presented in Appendix IV.A.

2.1 Standard Analytical Methods

Two of the commonly recognized methods used for analyzing slug tests are the Cooper et al. (1967) method for confined aquifers (fully penetrating wells), and the Bouwer and Rice (1976) method for unconfined aquifers (for fully or partially penetrating wells). Bouwer (1989) states that the Bouwer and Rice (1976) method can also be used to provide "...reasonable values of K (hydraulic conductivity) in confined...aquifers". The analysis method presented in Cooper et al. (1976) is more restrictive in application, but in certain situations (i.e., low stress levels, thick aquifer conditions, no significant vertical flow component) it can be extended and used for the analysis of slug tests conducted under partially penetrating and unconfined aquifer conditions (Walter and Thompson, 1982; Dax, 1987; Spane, 1992).

Although the preceding suggests an analytical similarity, there are significant differences between each method. Briefly stated, the Cooper et al. (1967) method is derived from the Theis equation, and uses a semi-log, type-curve matching technique in which the entire test data record is matched to

established type curves that represent different formation storativity and well geometry relationships. In contrast, the Bouwer and Rice (1976) method is based on the Thiem equation, and relies on a semi-log, straight-line analysis technique that focuses on analysis of early test-time data.

2.2 Factors Affecting Slug Test Response

The slug test provides a rapid and economical hydraulic characterization method for the purpose of acquiring site specific estimates of transmissivity. Although these characteristics make slug testing a popular test method in site characterization studies, slug tests have a number of disadvantages that limit their universal application. Some of these limitations include:

- restricted use in moderate to high permeability aquifers,
- limited radius of investigation, and
- susceptibility to near-field heterogeneities (e.g., facies change, presence of well sand-pack) and wellbore conditions (e.g., turbulent flow).

A brief discussion concerning these limitations is provided below.

2.2.1 Permeability Limitations

Because of the manner of test initiation (i.e., an instantaneous application of stress), well responses to slug tests are quickly dissipated at the stress well. Cooper et al. (1967) noted that slug tests conducted in confined aquifers were limited to test zones possessing transmissivities of less than 7,000 ft²/d. It should be noted, however, that slug test dissipation is also directly proportional to the square of the well casing radius. Spane (1992), in examining the dissipation characteristics for well geometry relationships characteristic of RCRA site installations, indicated that single-well slug tests were likely to be limited for characterizing test intervals possessing transmissivities less than about 1,000 ft²/d. To illustrate the transmissivity limitation, Figure IV.1 shows predicted slug test responses for test intervals with transmissivities ranging between 10³ to 10⁵ ft²/d, and having well casing and well screen radii of 2- and 4-in., respectively. As shown, a slug test conducted within an aquifer having a transmissivity of 10⁵ ft²/d is completely dissipated by 1 sec, while for a transmissivity of 10³ ft²/d, about 30% recovery is indicated during the first second of the test.

As a note of interest, even though single-well slug tests exhibit this transmissivity limitation, Spane (1992) indicated that slug interference tests (i.e., slug tests using nearby observation well data) could provide extended hydraulic characterization for test intervals possessing transmissivities up to 10⁵ ft²/d.

2.2.2 Radius of Investigation

A common perception of slug tests is that because of their short duration, they only investigate a small distance into the surrounding formation. However, as indicated by Karasaki et al. (1988), this "perception" is not quite correct, because it can be shown that slug test duration (i.e., the time required to dissipate the slug response) is proportional to the wellbore storage and inversely proportional to the test zone's transmissivity. The formational distance from the well that is perturbed by the slug response does not depend on the duration of the slug test, but instead depends on the ratio of the formation's storativity to the wellbore storage (Karasaki et al., 1988). The lower the storativity within a confined aquifer or the lower the elastic storage characteristics possessed by an unconfined aquifer, the greater the distance investigated by a slug test.

FIGURE IV.1. Predicted Slug Test Response at the Stress Well for a Transmissivity Range 10^3 to 10^5 ft^2/d , and a Storativity of 10^{-3} (adapted from Spaine, 1992)

Figure IV.2 shows dimensionless head responses versus dimensionless distances from the stress well that are predicted for selected storativity values that are reflective of the range common for transmissive confined and unconfined (elastic response) aquifers. The dimensionless parameters are defined as:

$$H_D = H/H_o \quad (1)$$

$$r_D = r_o/r_w \quad (2)$$

where H = observed head at time t , minus pre-test static head level in well; [L]

H_o = instantaneous head change applied to well; [L]

r_o = radial distance from the stress well that the response is observed; [L]

r_w = effective well radius within the test interval; [L].

As indicated, the radius of investigation for a slug test (as designated by a dimensionless head, H_D , response of 0.001), can extend a distance of 100 to 1,000 wellbore radii (i.e., dimensionless radial distance, r_D) into the surrounding formation. However, for wells completed at the water table within unconfined aquifers, delayed-yield affects may significantly reduce the elastic storage component of the aquifer storage. For these test situations, the radius of investigation is primarily dependent on the aquifer specific yield component, which may limit the radius of investigation to less than 30 wellbore radii (Figure IV.2, $S = 0.1$).

FIGURE IV.2. Dimensionless Head Versus Dimensionless Radial Distance Relationships for Slug Tests (modified from Spane, 1992)

2.2.3 Near-Field Heterogeneity/Wellbore Condition Effects

Because of their inherent characteristics (e.g., instantaneous slug implementation, radius of investigation limitations), slug tests are more susceptible to near-field heterogeneities and wellbore conditions. Natural and man-related test interval heterogeneities (e.g., facies change, presence of well gravel-pack) and adverse wellbore flow conditions (e.g., turbulent flow regime) can severely limit the analysis of slug test response.

To illustrate the effects of near-field heterogeneities, Figure IV.3 shows the predicted response for a slug test conducted in a confined aquifer. The well is surrounded by a zone to a distance of 1 m that possesses a transmissivity 10 times the value of the test formation ($T = 5.3 \times 10^{-5} \text{ m}^2/\text{s}$), with both zones having a storativity of 10^{-3} . As indicated in Figure IV.3, the initial slug test response (i.e., $t \leq 1$ sec) is totally reflective of the near-field hydrogeologic conditions, following which the slug response reflects a "transitional" or composite pattern that is a combination of the hydraulic properties of the two zones. Of particular note is the fact that, for this example, the slug test response does not ever reflect only the hydraulic properties of the test formation, which attests to the influence exerted by the near-field heterogeneity.

Analytical methods used for the interpretation of slug tests (e.g., Cooper et al., 1967; Bouwer and Rice, 1976) are also dependent on analyzing test data that reflect laminar flow conditions. Because of the nature of slug test initiation, however, turbulent flow conditions commonly occur during the early stages of the test, which would preclude their use in test analysis (i.e., the test data representative of non-laminar flow conditions). The presence of turbulent flow conditions can be assessed by

FIGURE IV.3. Effect of a Near-Field Heterogeneity for Varying Property Values and a Radial Distance of 1 Meter
 (adapted from Spang, 1993a)

calculating the Reynolds number, R_e , for each time/data point. The well-known Reynolds number is given in fluid mechanics text books as:

$$R_e = (2 V r_o) / \mu \quad (3)$$

where V = fluid velocity

μ = kinematic viscosity of water within the water column

Reynolds numbers $\geq$ to 2,000 are commonly regarded as indicative of turbulent flow conditions.

2.3 Slug Test Analysis Results

Table IV.2 presents the results and pertinent analytical parameters used in the analysis of slug tests conducted as part of the hydraulic characterization at the Blair Lakes Target Facility. For most monitoring wells, multiple slug withdrawal tests were conducted. However, only one representative slug test at each monitoring site was selected and subjected to quantitative analysis. In most cases, the slug tests at individual well sites exhibited very similar slug test dissipation responses; and therefore, would provide essentially the same hydraulic property estimates. Slug tests selected for detailed analysis generally exhibited fewer test response complexities (e.g., unstable pre-test trends), and "captured" higher slug stress responses immediately following initiation of the test. Slug tests with recorded higher initial stress levels were usually afforded more credence because of recording limitations of the data acquisition system used (i.e., 2 sec = highest recording frequency), and the dependence of the Bouwer and Rice method (1976) on early-time test data.

Because of the inherent test site conditions (i.e., thin unconfined aquifer, high stress level to aquifer thickness conditions, etc.), the Bouwer and Rice method (1976) was used as the primary analysis method. Although the Cooper et al. (1967) method was not used for quantitative slug test analysis, the method was used qualitatively to predict slug test responses as a means of general comparison with the Bouwer and Rice (1976) analysis results. Figure IV.4 shows an example of Cooper et al. (1967) predicted slug test responses for the given well dimensions and an assumed specific yield of 0.1. As indicated, a transmissivity range of 25 to 500 ft^2/d encompasses the majority of the slug test responses observed at the four monitoring wells having identical well casing diameters (i.e., 2 in.) and slug stress levels (i.e., 1.57 ft).

2.4 Bouwer and Rice Analysis Results

Table IV.2 summarizes the results of analyzing the slug tests using the Bouwer and Rice (1976) analysis method. For this method, equivalent hydraulic conductivity for screened interval tested is equal to:

$$K_e = \frac{r_c^2 \ln(R_e/r_w) \ln(y_o/y_i)}{2L_e t} \quad (4)$$

where r_c = radius of the well casing (L)

r_w = radius of the well screen (L)

R_e = effective test radius (L)

y_o = water-level stress applied at initiation of test (L)

TABLE IV.2. Slug Test Information Summary for Bouwer and Rice Analyses						
Well	Slug With. Test Analyzed	Stress Level (ft)	Cal. Well Screen Radius (ft)	Cal. Well Casing Radius (ft)	Sat. Well Screen Length (ft)	Equiv. K_o (ft/d)
50M02	1	1.57	0.167	0.115	6.76	30.5
50M04	2	1.57	0.167	0.115	5.94	9.6
50M06	2	1.57	0.167	0.115	5.96	158.0
50M07	3	2.92	0.250	0.196	4.48	13.3
50M08	1	1.57	0.167	0.115	5.63	32.4
50M10	1	2.86	0.167	0.115	7.82	65.5

y_t = water-level difference from static level, at time t (L)

L_o = well screen test interval length (L)

t = test time at y_t (T).

Note: Equivalent hydraulic conductivity, K_o , is the assigned average value for the test interval based on the saturated well screen length. Individual zones within the test interval may possess a higher and/or lower hydraulic conductivity than the calculated (i.e., equivalent) average value.

For the Blair Lakes Target Facility hydraulic characterization, it was assumed that the well screened sections fully penetrated the unconfined aquifer above the permafrost. This seems to be a reasonable assumption based on the shallow depths to permafrost noted in earlier characterization investigations.

For fully penetrating test conditions, Bouwer and Rice (1976) state that the effective test radius to well screen radius, R_o/r_w , can be determined from the following relationship:

$$\ln(R_o/r_w) = [(1.1/\ln(L_w/r_w)) + C/(L_o/r_w)]^{-1} \quad (5)$$

where C = dimensionless parameter that is a function of L_o/r_w ;
see Bouwer and Rice (1976) for relationship

L_w = distance from water table to bottom of the well screen (L).

Because the water table was within the well screened section (see Table IV.1), $L_o = L_w = H$ (i.e., the aquifer thickness). For test situations where the water table is within the well screen and the well has a sand/gravel pack installation, Bouwer (1989) reports that the existing r_o and r_w dimensions have to be amended to account for the presence of the sand/gravel pack. For this situation, the modified r_{ox} can be calculated using the following relationship:

$$r_{ox} = [(1 - n)r_o^2 + nr_{wx}^2]^{1/2} \quad (6)$$

where r_{wx} = radial distance from the well center to outer sand/gravel pack installation (L)

n = sand/gravel pack porosity; assumed to be 30%

FIGURE IV.4. Comparison of Slug Test Response At Four Monitor Well Sites Having Identical Well Diameters and Slug Stress Levels, and Bounding Cooper et al. (1967) Slug Test Responses
For $T = 25$ and $500 \text{ ft}^2/\text{d}$; $S = S_y = 0.1$

For these test site situations, the calculated values of r_{ox} and r_{wx} should be substituted for r_o and r_w , respectively, in Equations (4) and (5) for the calculation of the equivalent hydraulic conductivity.

Like the Cooper et al. (1967) technique, the Bouwer and Rice method also has an upper permeability limitation for the analysis of test interval response. The Bouwer and Rice (1976) method requires that a straight-line be fit to the early-time portion of the slug water-level recovery response. For higher permeability test intervals (i.e., $K \geq 100$ ft/d) the early-time data portion that is analyzable with the Bouwer and Rice (1976) method is over after the first 2 sec of the test. Fitting a straight-line to recovery data after this time, then, will provide hydraulic property estimates that are erroneous. To illustrate the extent of the early-time, straight-line segment during slug test recovery [that is analyzable with the Bouwer and Rice (1976) method], Figure IV.5 shows the slug test response and the straight-line analysis slope for a fully penetrating well within a test interval that has a hydraulic conductivity of 100 ft/d. As indicated, the early-time, straight-line segment of the recovery lasts for only approximately 2 sec at the beginning of the test.

As indicated in Table IV.2, equivalent hydraulic conductivity values ranged between 9.6 and 158 ft/d for the six monitoring wells tested. As a whole, the tests indicate a moderate to high hydraulic conductivity for the shallow alluvial aquifer situated above the permafrost. Diagnostic test analysis (not shown here) also indicates that the slug tests displayed unconfined aquifer behavior and some of the tests exhibited sand/gravel pack effects for slug test responses immediately following test initiation. A brief discussion of the slug test analysis and an analysis support figure for each individual monitoring well tested is presented in Appendix IV.A.

3.0 CONSTANT-RATE PUMPING TEST

A constant-rate pumping test was conducted at the old water supply well completed in the alluvial aquifer beneath the permafrost (completion depth = 165 to 185 ft bls). The pumping test was conducted at a constant discharge rate of 10.7 gpm and continued for a total test period of 480 min. Ground water produced during the test was discharged to land surface at a distance greater than 300 ft from the pumping well to minimize effects on water-level responses in the pumped well during testing. Possible drawdown interference responses were also monitored at a nearby observation well 50M01 at a distance of 18 ft from the pumped well. Well 50M01 is a shallow monitor well completed in the unconfined aquifer above the permafrost. No discernable interference responses were observed at this well during or following termination of the constant-rate pumping test. Water-level responses within the wells during the pumping test were monitored using sensitive strain gauge pressure transducers and automated data loggers. Figure IV.6 shows the water-level response at the old water supply well for the time period immediately before, during, and after termination of the constant-rate test. As indicated, a linear hydrologic trend occurred during the period of testing (i.e., 5.4×10^{-5} ft/min). The effects of this trend were removed from the observed water-level record to accommodate test analysis of the hydrologic response at the old water supply well.

3.1 Analysis Method

The analysis method used for analyzing constant-rate tests is dependant on the test aquifer conditions that exist at the site. Available hydrogeologic information suggests that the deep alluvial aquifer intersected by the old water supply well would be expected to be under confined aquifer conditions. The recent development of pressure derivative analysis can also be employed diagnostically to identify the operative hydrogeologic model during testing. As will be shown, the diagnostic derivative plots during pumping drawdown and recovery phases indicate a nonleaky confined aquifer response. The reader is referred to Spane (1993b) for a detailed discussion of the uses of pressure derivatives for the analysis of constant-rate tests under a variety of test site/aquifer conditions.

FIGURE IV.5. Delineation of the Early-Time, Straight-Line Segment During a Slug Test, Which is Valid For Use in the Bouwer and Rice (1976) Method: $T = 1,000 \text{ ft}^2/\text{d}$; $S = 0.001$ (adapted from Spaine, 1993a)

FIGURE IV.6. Water-Level Response For the Old Water Supply Well Immediately Prior To, During, and Following Termination of the Constant-Rate Pumping Test

The general analysis procedure used for pumping test drawdown data included the following steps:

1. Develop a log-log plot of the drawdown data and drawdown derivative versus time.
2. Evaluate the drawdown data and data derivative pattern (i.e., diagnostic analysis) to ascertain the operative test interval response model (i.e., unconfined versus confined aquifer, presence of boundaries, etc.) and to ascertain the presence of radial flow conditions within the test data record.
3. Calculate the transmissivity for the confined aquifer based on analysis of the indicated infinite acting, radial flow section of the test data using the Cooper and Jacob (1946) semi-log straight-line method.

The general analysis procedure for pumping test recovery data is identical with that outlined for the drawdown data, except that the recovery buildup data (i.e., the observed water level during recovery minus the observed water level at the termination of testing) are plotted versus the equivalent time function described in Agarwal (1980). The Agarwal equivalent time function accounts for the duration of the discharge time period, thereby permitting the use of drawdown type curves and analysis methods for the analysis of recovery data. The equivalent time function, t_e , is defined in Agarwal (1980) as:

$$t_e = (t \times t') / (t + t') \quad (7)$$

where t = duration of the discharge test [T]

t' = time since discharge test terminated [T].

3.1.1 Recovery Analysis

The pumping test recovery phase generally provides better data (i.e., less "noise") for test analysis than does the drawdown phase. This is attributed largely to the effects of flow variation that commonly occur during the early stages of the "constant-rate" pumping test. Examination of Figure IV.6 indicates that, indeed, more data variation was exhibited during the drawdown phase. For this reason, more emphasis was placed on the recovery data analysis.

Figure IV.7 shows the diagnostic log-log plot of the recovery and recovery data derivative. The effects of the pre-test trend were removed from the observed recovery data prior to test analysis. The derivative plot was calculated using the DERIV program described in Spane and Wurster (1992). An L-spacing of 0.3 was used in the derivative calculation. Recognizable features in the diagnostic plot include:

- presence of wellbore storage effects during the first minute of recovery
- establishment of infinite-acting radial flow conditions after three minutes of recovery (i.e., Agarwal equivalent time)
- a diagnostic plot pattern consistent with a nonleaky confined aquifer flow model, with no boundaries or significant leakage effects evident.

Based on the diagnostic log-log assessment, recovery data reflective of infinite-acting radial flow conditions were analyzed with the Cooper and Jacob semi-log straight-line method for calculation of the test interval transmissivity, using the equation:

FIGURE IV.7. Diagnostic Log-Log Analysis of Recovery and Recovery Data Derivative Plot For the Old Water Supply Well Following Termination of the Constant-Rate Pumping Test

$$T = (2.3 Q)/(4\pi \Delta h) \quad (8)$$

where Q = constant pumping discharge rate

Δh = change in water level during the straight-line period over one t_e log cycle.

Figure IV.8 shows the results of the semi-log straight-line analysis. As indicated, a transmissivity of 2,825 ft²/d was calculated from the recovery analysis. As a means of total response comparison, a recovery type curve and derivative plot was generated that accounts for wellbore storage effects, using the TYPCURV program described in Novakowski (1990).

Note: Storativity cannot be quantitatively calculated based on semi-log straight-line analysis for test data from the pumping well; however, a qualitative estimate of 1.3×10^{-3} was obtained from this analysis and used in the type curve generation. This number was determined by estimating the drawdown at a straight-line projection time of 0 and by using equation relationships for observation well drawdown test analysis in Cooper and Jacob (1946).

The comparison of the calculated recovery and derivative curves and the recovery and recovery data derivatives are shown superimposed in Figure IV.7. As indicated, close correspondence between calculated and observed response data is indicated.

3.1.2 Drawdown Analysis

Figure IV.9 shows the diagnostic log-log plot of the drawdown and drawdown data derivative. The effects of the pre-test trend were removed from the observed drawdown data prior to test analysis. The derivative plot was calculated using the DERIV program described in Spane and Wurstner (1992). An L-spacing of 0.3 was used in the derivative calculation. Although it displays more derivative "noise", the diagnostic drawdown log-log plot exhibits the same recognizable features as previously indicated for the diagnostic recovery plot, including:

- presence of wellbore storage effects during the first minute of drawdown
- establishment of infinite-acting radial flow conditions after three minutes of drawdown
- a diagnostic plot pattern consistent with a nonleaky confined aquifer flow model, with no boundaries or significant leakage effects evident.

Based on the diagnostic log-log assessment, drawdown data reflective of infinite-acting radial flow conditions were analyzed with the Cooper and Jacob semi-log straight-line method for calculation of the test interval transmissivity, using Equation (8) (with t substituted for t_e). Figure IV.10 shows the results of the semi-log straight-line analysis. As indicated, a transmissivity of 2,870 ft²/d was calculated from the drawdown analysis. As a means of total response comparison, a drawdown type curve and derivative plot was generated that accounts for wellbore storage effects, using the TYPCURV program described in Novakowski (1990).

Note: A qualitative estimate of 1.8×10^{-3} was obtained from the semi-log analysis and used in the type curve generation. This number was determined by estimating the drawdown at a straight-line projection time of 0 and by using equation relationships for observation well drawdown test analysis in Cooper and Jacob (1946).

The comparison of the calculated drawdown and derivative curves and the drawdown and drawdown data derivatives are shown superimposed in Figure IV.9. As indicated, close correspondence between calculated and observed response data is indicated.

FIGURE IV.8. Semi-Log Straight-Line Analysis of Recovery Data Following Termination of Constant-Rate Pumping Test For the Old Water Supply Well

FIGURE IV.9. Diagnostic Log-Log Analysis of Drawdown and Drawdown Data Derivative Plot for the Old Water Supply Well Constant-Rate Pumping Test

FIGURE IV.10. Semi-Log Straight-Line Analysis of Constant-Rate Pumping Test Drawdown Data
 For the Old Water Supply Well

3.1.3 Summary

Drawdown and recovery analysis of constant-rate test data for the old water supply well provided very similar estimates for the confined aquifer beneath the permafrost (i.e., 2,825 to 2,870 ft²/d). Detailed hydrogeologic information is not available for this deeper aquifer at the Blair Lakes Target Facility. If it is assumed that the well fully penetrates the aquifer (i.e., the aquifer thickness is 20 ft), then an equivalent hydraulic conductivity value of approximately 142 ft/d is indicated for this deeper aquifer system. As a point of comparison, this falls within the upper range previously established for the shallow unconfined alluvial aquifer, based on slug test characterization.

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APPENDIX IV.A

Figures IV.A.1 through IV.A.6 provide pertinent analysis information used in analyzing the slug withdrawal tests conducted at the six Blair Lakes Target Facility monitoring wells. As a whole, the tests indicate a moderate to high hydraulic conductivity for the shallow alluvial aquifer situated above the permafrost. Diagnostic test analysis (not shown) also indicates that the slug tests displayed unconfined aquifer behavior and some of the tests exhibited sand/gravel pack effects for slug test responses immediately following test initiation. A brief test analysis description for each well is provided below.

WELL 50M02

One slug withdrawal test was conducted at this test site on May 21, 1993. The slug stress imposed within the 2-in. diameter well screen was calculated to be 1.57 ft. Analysis of the slug test response using the Bouwer and Rice (1976) method (shown in Figure IV.A.1) provided an equivalent hydraulic conductivity estimate of 30.5 ft/d. No test heterogeneities or complexities were noted in the test response.

WELL 50M04

Two slug withdrawal tests were conducted at this test site on May 21, 1993. The slug stress imposed within the 2-in. diameter well screen was calculated to be 1.57 ft. Nearly identical slug test responses were exhibited for both slug withdrawal tests. Analysis of slug withdrawal test #2 using the Bouwer and Rice (1976) method (shown in Figure IV.A.2) provided an equivalent hydraulic conductivity estimate of 9.6 ft/d. Sand/gravel pack effects were exhibited immediately following slug test initiation, and lasted until approximately 0.067 min. The second established straight-line was then analyzed, as indicated in Bouwer (1989), for representative analysis of test interval characteristics.

WELL 50M06

Two slug withdrawal tests were conducted at this test site on May 21, 1993. The slug stress imposed within the 2-in. diameter well screen was calculated to be 1.57 ft. Nearly identical slug test responses were exhibited for both slug withdrawal tests. Analysis of slug withdrawal test #2 using the Bouwer and Rice (1976) method (shown in Figure IV.A.3) provided an equivalent hydraulic conductivity estimate of 158 ft/d. Because of the test interval's inherent high hydraulic conductivity, the slug test response recovered rapidly (i.e., greater than 90% recovery by 0.05 min). This is near the approximate upper limit for hydraulic conductivity determination using single-well slug test analysis, for the given well diameter/construction conditions. No test heterogeneities or complexities were noted in the test response.

WELL 50M07

Two slug withdrawal tests were conducted at this test site on May 21, 1993, and a third test on May 22, 1993. The slug stress imposed within the 4-in. diameter well screen was calculated to be 2.92 ft, although total slugging rod submergence may not have occurred during the first two tests. A review of the slug test responses exhibited for all slug withdrawal tests indicates the presence of pre-test trends imposed on the slug withdrawal recovery by a lack of equilibration for the earlier slugging rod submergence. Analysis of slug withdrawal test #3 using the Bouwer and Rice (1976) method (shown in Figure IV.A.4) provided an equivalent hydraulic conductivity estimate of 13.3 ft/d. Slug withdrawal test #3 was selected for analysis based on the higher stress level observed immediately following test

initiation, and greater linearity for the pre-test trend. No other test heterogeneities or complexities were noted within the test responses.

WELL 50M08

Two slug withdrawal tests were conducted at this test site on May 21, 1993. The slug stress imposed within the 2-in. diameter well screen was calculated to be 1.57 ft. Nearly identical slug test responses were exhibited for both slug withdrawal tests; however, the test responses displayed an off-set/shift of approximately 0.1 ft in comparison to each other. Analysis of slug withdrawal test #1 using the Bouwer and Rice (1976) method (shown in Figure IV.A.5) provided an equivalent hydraulic conductivity estimate of 32.4 ft/d. No other significant test heterogeneities or complexities were noted within the test responses.

WELL 50M10

Two slug withdrawal tests were conducted at this test site on May 21, 1993. The slug stress imposed within the 2-in. diameter well screen was calculated to be 2.86 ft. Nearly identical slug test responses were exhibited for both slug withdrawal tests; however, the test responses displayed a small off-set/shift of less than 0.05 ft. Analysis of slug withdrawal test #1 using the Bouwer and Rice (1976) method (shown in Figure IV.A.6) provided an equivalent hydraulic conductivity estimate of 65.5 ft/d. The recovery pattern indicates that a zone of lower permeability or possibly a boundary exists in the vicinity of the well that affected the test interval's test response. The early-time data analyzed, however, were only marginally affected by this test heterogeneity.

FIGURE IV.A.1. Bower and Rice Analysis For Slug Withdrawal Test #1 - Well 50M02

FIGURE IVA.2 Bouwer and Rice Analysis For Slug Withdrawal Test #2 - Well 50M04

FIGURE IV.A.3. Bouwer and Rice Analysis For Slug Withdrawal Test #2 - Well 50M06

FIGURE IV.A.4. Bouwer and Rice Analysis For Slug Withdrawal Test #3 - Well 50M07

FIGURE IV.A.5. Bouwer and Rice Analysis For Slug Withdrawal Test #1 - Well 50M08

FIGURE IV.A.6. Bouwer and Rice Analysis For Slug Withdrawal Test #1 - Well 50M10

APPENDIX V - PERMAFROST STUDY—BLAIR LAKES TARGET FACILITY

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APPENDIX V - PERMAFROST STUDY—BLAIR LAKES TARGET FACILITY

1.0 PURPOSE

A direct current (DC) resistivity sounding and shallow frequency-domain electromagnetics (FDEM) survey were performed at the Blair Lakes Target Facility to find the depth to the top of the permafrost in the vicinity of the building complex. The final objective was to produce a top of permafrost surface contour map for the site that could be used to better define the hydrologic environment.

2.0 INSTRUMENT OPERATING PRINCIPLES

Two subsurface resistivity measuring methods were tried to measure the unfrozen/frozen soil resistivity contrast: DC resistivity using a Wenner array and shallow FDEM using a constant frequency, fixed coil spacing system. The DC resistivity method measures resistivity to different depths of investigation by varying the electrode spacing. The shallow FDEM method that was used, on the other hand, measures resistivity to only one depth of investigation (~ 3 m) because the coil spacing is fixed. However, the FDEM method has a high horizontal resolution so it was hoped it would be useful in detecting lateral changes in permafrost depth.

2.1 DC Resistivity

The DC resistivity method employs a DC generator (terrameter), which also doubles as a voltage meter, and four electrodes, two for current and two for voltage, which are connected to the terrameter by electrical leads. The terrameter used in this study was an Abem SAS 300 that has seven current settings from 0.2 to 20 mA, noise rejection circuitry, and the ability to cycle through and average a number of readings at each measurement. The leads were single core insulated wires and the electrodes were large steel nails that could be hammered into the gravelly alluvium.

A Wenner electrode array was used for the Blair Lakes survey. In the Wenner array, the four electrodes are arranged along a line such that there is equal spacing between all electrodes. The current electrodes are placed on the outside and the voltage ones on the inside. The midpoint of the array represents the measure point. The advantages of this symmetric array as compared to other types of arrays are greatly simplified computations, increased separation between electrodes enabling greater depth of investigation for a particular line length, and less influence from near-surface variations in conductivity (which is often considered noise). The physics of the DC resistivity measurement is very straight forward. The DC is emitted into the ground through one of the outer electrodes, travels through the subsurface, and returns to the terrameter through the electrode on the opposite side of the array. The voltage field set up by the current flow in the subsurface is measured by the two inner electrodes. The apparent resistivity is directly proportional to the measured voltage according to Ohm's Law, generalized to include resistivity instead of resistance. Resistivity is independent of geometry, unlike resistance. The measured resistivity is referred to as 'apparent' because the value does not represent the true resistivity of the subsurface at a particular depth but the weighted average of the subsurface resistivities down to that depth. The array spacing starts out small and is increased in increments to provide a range of depths of investigations.

2.2 Shallow FDEM

The FDEM instrument used, a Geonics, Ltd. EM-31, consists of a 3.7-m tube with a transmitter coil on one end and a receiver coil on the other. An electronics box at the center of the tube provides the

power and controls for the tool. The system is operated by standing over the point on the ground to be measured with the tool horizontal and stationary. A sinusoidal current of constant frequency is driven through the transmitter coil, which produces a magnetic field. This primary magnetic field causes eddy currents to flow in the ground which in turn create a time-varying secondary magnetic field. The secondary magnetic field is measured as a voltage in the receiver coil. Because the intensity of the eddy currents is a function of subsurface conductivity (the inverse of resistivity), the strength of the secondary magnetic field and the receiver coil voltage are also functions of conductivity. The instrument electronics converts the measured voltage to a digital conductivity reading. Again, like DC resistivity, the conductivity reading is actually a weighted average measurement down to a certain depth, not a focused measurement of a small depth interval. The system takes essentially continuous readings although it sometimes needs half a minute or so to stabilize. The EM-31 internal electronics need to be calibrated before each use.

3.0 SURVEY PROCEDURES

3.1 Acquisition

3.1.1 DC Resistivity

Upon arrival on site a preliminary test array was performed to evaluate how effective DC resistivity would be for detecting the resistivity contrast caused by permafrost and to determine the best spacings between electrodes ('a' spacing) for the specific environment at hand. The data from this test showed a uniform, sharp increase in resistivity with greater 'a' spacing, suggesting the measurements were detecting permafrost. From this preliminary test, it was decided that a maximum 'a' spacing of 30.5 m would suffice to penetrate deep enough into the permafrost.

Measurement points, from which recording arrays were centered, were chosen so as to obtain data for all sides of the building complex, concentrating on the back-filled, developed area. The terrameter was placed at the measurement midpoint and two tape measures were extended in opposite directions along a line away from the midpoint. The electrodes were staked in the ground along the tape measures to be symmetric around the midpoint with equal distance between each other. Several readings were taken at each spacing, checked for consistency, and then averaged internally in the terrameter to arrive at the final value for that spacing. If the readings were inconsistent, the electrical connections were checked or a different current was tried. The array was expanded around the midpoint to the spacings determined from the test array. If sharp aberrations in the readings occurred between different spacings, the electrical connections were checked, and fixed if necessary, and the measurements were retaken. This procedure was repeated at all the measurement points. The data was entered onto the field computer at the end of the day and a quick analysis was performed to check for erroneous readings.

3.1.2 Shallow FDEM

A preliminary walk-around survey was performed with the FDEM system to determine how well it would detect lateral resistivity contrasts because of changes in the permafrost depth. Unfortunately, very little change in conductivity around the site was measured by the tool. The readings clustered around 10 mmho conductivity (or 100 ohm-m in resistivity units). There are several possible reasons why the FDEM system didn't detect any significant resistivity contrasts. The system measures conductivity and, thus, performs best in high conductivity (low resistivity) environments. However, the Blair Lakes site turned out to be a very high resistivity environment because of the presence of alluvial gravels and very fresh water. Also, the permafrost depth in many areas around the site was found to be deeper than the maximum depth of investigation of the shallow FDEM. As a result of these two

environmental conditions, the tool could not generate enough signal in the permafrost zone to affect the measurement. In response to the findings of the preliminary survey, a production survey was not carried out with the shallow FDEM system.

3.2 Data Reduction

Fifteen DC resistivity soundings were measured resulting in 15 apparent resistivity versus 'a' spacing profiles. The profiles were analyzed on a PC computer using the DC resistivity interpretation software RESIX Plus, by Interpex Limited of Golden, Colorado. RESIX Plus is a forward and inverse modeling program for interpreting resistivity sounding data in terms of a layered earth (1-D) model. Data points that were scattered from the curve profile caused by excessive noise were masked to leave a smooth curve. A first guess geoelectric section model (depth versus resistivity) was created from which the software generated a synthetic resistivity sounding curve using linear filters. The model was manually refined to get a fairly close fit between the synthetic and the actual sounding curves. This model was entered into the inversion routine, which uses ridge regression to iteratively adjust the model by varying depth and resistivity, to obtain the best fit between the synthetic and actual sounding curves.

Once a satisfactory best-fit model was developed, an equivalence analysis was performed to show alternative models that fit the data nearly as well as the best-fit model, but differ from it in terms of depths and/or resistivities. The software accomplishes this by setting an error threshold, 1.2 times the best fit error, and then varying the model to find the variation that produces a fit equal to this error threshold. This is done twice for each model parameter (layer thickness and resistivity), once to find the upper bound and once to find the lower bound. Models with different numbers of layers were also tried and compared with each other. The final model chosen for each sounding was determined on the basis of best-fit, minimal variance in equivalence models, and geologic accuracy. The top of permafrost was picked from the final models by locating the top depth of the first substantial layer from the surface with a resistivity greater than 1,000 ohm-m.

4.0 RESULTS

The interpreted top of permafrost varies between 1.6 and 6.7 m. The results indicate that the permafrost depth varies significantly across the site and is closest to the surface on the east side of the building complex. From the 15 soundings recorded, 13 were used to construct the top of permafrost surface contour map. The two soundings rejected, soundings 7 and 15 located just southeast of the building complex, had very abnormal apparent resistivity-'a' spacing profiles that could not be modeled accurately or realistically. Sounding 15 was recorded adjacent to sounding 7 to verify the readings from sounding 7. These profiles are characterized by a sharp increase in apparent resistivity from an 'a' spacing of 1.5 to 10 m followed by a sudden sharp decrease. The profile for sounding 7 shows another sharp increase starting from 25 m. The erroneous, but continuous, nature of these results suggest that the readings were affected by coherent noise, most likely the buried power line running between the main complex and the fuel island.

The sounding profile and model figures as well as the results in text form are included following the descriptions for each of the sounding results. The dotted lines in the model figures represent the alternative models derived from equivalence analysis.

Sounding 1

The interpretation of results for the first sounding, the test survey, was fairly straight forward. The best-fit model, with a fitting error of 1.6%, is a geoelectric section with three layers: a very thin, low resistivity surface layer; a 6-m thick, 333 ohm-m resistivity layer; and a high resistivity (2,744 ohm-m)

bottom layer starting at 6.1 m. The bottom layer was picked as permafrost. The parameter bounds from equivalence analysis were well confined with the depth to the permafrost layer ranging from between 5.7 and 6.6 m.

Sounding 2

The second sounding was interpreted similar to the first (three layers with about the same resistivities), but the depth to the top of the permafrost layer is shallower (4.1 m) and not as well bounded in the equivalence analysis (3.4 to 4.9 m). The fitting error is also a little higher (2.8%) but still very good.

Sounding 3

The apparent resistivity versus 'a' spacing profile for sounding 3 was more complicated than the first two soundings but a well-confined model was still obtainable. The best-fit geoelectric section (fitting error = 3.1%) contains five layers with a thin (0.5 m), very high resistivity (~20,000 ohm-m) layer at 2.1 m depth and another very high resistivity bottom layer at 6.7 m depth. Both these layers are well confined by equivalence analysis. The bottom high resistivity layer was picked as permafrost. The shallow, thin high resistivity layer could be interpreted as a lens of ice. The sounding was located on the heli-pad, which was made of gravelly fill overlying the natural muskeg. The fill could be acting as a thermal insulator keeping the temperature cold enough to support ice.

Sounding 4

A well-confined model for sounding 4 could not be designed. The best-fit model (fitting error = 3.5%) contains six layers with the highest resistivity layer (4,700 ohm-m) starting at 2.3 m. The equivalence bounds of the depth to the high resistivity layer range from 1.6 to 4.1 m. There are also two other thin, very shallow high resistivity layers, separated by low resistivity layers, in the model. The deepest, thickest, high resistivity layer was picked as permafrost. The data from this sounding may be noisy because of the proximity of standing water and a possible dump site identified by Harding Lawson Associates.

Sounding 5

The interpretation for sounding 5 produced a well-confined model with a very low fitting error (1.3%). However, the results were very different from the previous soundings. A 4.5-m thick high resistivity (2,000 ohm-m) layer starts at 1.6 m depth, underlain by a 500 ohm-m layer, which in turn is underlain by a high resistivity layer starting at 30 m. The top of permafrost was picked at 1.6 m, the top of the first high resistivity layer, because that layer is the first substantial high resistivity layer from the surface. Because of the objective of the entire survey, to locate the top of permafrost, the electrode array width was not extended beyond 130 m. Therefore, it would not be valid to make any specific interpretations deeper than 20 m. It appears likely, though, by the shape of the apparent resistivity profile and the final model that there is a melted zone within the permafrost starting before the 10 m depth. The gravelly fill used to support the building complex may be providing insulation for ice to exist, identical to the situation in sounding 3.

Sounding 6

The interpreted geoelectric section chosen for sounding 6 was not the absolute best-fitting model possible, but was the most simple, realistic, and well-confined one (and still had a fitting error of only 2.7%). The model consists of only two layers: a 100 ohm-m resistivity surface layer and a 2,300 ohm-m resistivity layer, interpreted as permafrost, starting at 2.9 m depth. The equivalence bounds for the depth to the top of the permafrost are from 2.6 to 3.1 m. The location of this sounding was off the

backfilled area. The shape of the apparent resistivity profile matches the profiles of the two previous soundings that were entirely off the backfilled area (soundings 1 and 2).

Sounding 8

The results for sounding 8 contained three spurious data points that were masked for the interpretation. The most simple, realistic, best-fit model for this sounding (fitting error = 3.9%) incorporates three layers, the middle of which is the high resistivity (2,770 ohm-m) layer. This layer begins at 2.4 m (equivalence bounds of 2.1 to 2.7 m), where the top of permafrost was picked, and is 8.6 m thick. As with previous soundings, there likely exists a melted zone within the permafrost below the 10 m depth.

Sounding 9

The ninth sounding was modeled using three layers, the most appropriate number of layers for the apparent resistivity profile shape. The model fitting error is 3.4%. The high resistivity (1,285 ohm-m) bottom layer, which starts at 6.2 m depth, was interpreted as permafrost. The equivalence bounds for the permafrost depth are from 5.4 to 7.4 m.

Sounding 10

The final model chosen for sounding 10 consists of four layers and has a very low fitting error of 1.5%. The model contains a thin high resistivity layer near the surface and a substantial high resistivity (1,846 ohm-m) bottom layer, which was interpreted as permafrost. The depth to the top of the bottom layer is 8.9 m and has equivalence bounds of 7.7 to 10.6 m.

Sounding 11

The results from sounding 11 presented many difficulties in interpretation. The apparent resistivity profile has many inflection points. At first all the data points were included in the interpretation and a complicated five layer model was incorporated. This model gave an acceptable fitting error of 3.4% but was poorly confined. Because the data points for the first two 'a' spacings seemed to be giving the interpretation routine a lot of difficulty, they were masked. This did not cause much concern because the surface of the sounding location was very disturbed and, thus, very apt to cause noise in the shallow readings. When the first two data points were masked, a simple two layer model produced accurate (fitting error = 2.3%) and well-confined results. This model was used for the final geoelectric section giving a permafrost depth of 6 m with 5.3 to 6.8 m equivalence bounds.

Sounding 12

Sounding 12, taken adjacent to the sewage pond, was interpreted using a six layer best-fit (fitting error = 3.4%) model. The apparent resistivity profile was complicated but very consistent, which was the impetus for a many layered model. The top of the permafrost was picked as the top of the first high resistivity (3,700 ohm-m) layer at the 2.9 m depth. The bounds for this value from equivalence analysis is 2.2 to 3.9 m. Once again, from the shape of the profile and the final interpreted geoelectric section there appears to be a melted zone starting above 10 m depth. This seems quite plausible considering the proximity of the sewage pond.

Sounding 13

The results from sounding 13 contain a sharp discontinuity in the apparent resistivity profile between an 'a' spacing of 2 and 5 m. Three data points were masked to eliminate this discontinuity leaving a more rounded profile. A four layer model was used in the interpretation resulting in a 2.3% fitting error

and a high resistivity (1,577 ohm-m) bottom layer starting at 3.2 m, interpreted as the permafrost top. The depth parameter bounds from equivalence analysis were not real well confined, 2.8 to 4.2 m for the bottom layer top, but represented the best that could be accomplished.

Sounding 14

Sounding 14 was performed next to the new water supply well so the results could be compared with the borehole log constructed when the well was drilled. The most simple, realistic model to fit the nondistinct apparent resistivity profile is a three-layer geoelectric model with an extremely high resistivity (constrained to 50,000 ohm-m) bottom layer beginning at 4.0 m, where the permafrost top was picked. The equivalence bounds on that depth are 3.3 to 4.4 m. The borehole log starts mentioning "frozen" material at 8.5 m, significantly deeper than was predicted by the DC resistivity sounding. The log is quite vague and somewhat questionable, though. The next closest sounding, about 75 m to the northwest, did yield a permafrost top of 8.8 m, much closer to the well log value.

FIGURE V.1. Site 50 Eielson Air Force Base, 5/20/93, Data Set: BLK TEST, Azimuth: 45° NE, Sounding: 1

FIGURE V.1. (Contd)

DATA SET: BLK-TEST

CLIENT: US Air Force
LOCATION: Site 50 Eielson AFB
COUNTY: Blair Lakes Air Force Range
PROJECT: Permafrost Study
ELEVATION: 750.00
SOUNDING COORDINATES: X: 127.4100 Y: -50.2900

DATE: 5/20/93
SOUNDING: 1
AZIMUTH: 45 NE
EQUIPMENT: Abax SAS 300

Wenner Configuration

FITTING ERROR: 1.556 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (ohm-m ²)
			750.0		
1	67.13	0.121	749.8	0.00181	8.17
2	333.7	6.00	743.8	0.0179	2002.8
3	2744.5				

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER	MINIMUM	BEST	MAXIMUM
RHO			
1	47.926	67.133	80.134
2	320.716	333.743	347.493
3	2561.980	2744.507	2981.436
THICK			
1	0.079	0.122	0.154
2	5.622	6.001	6.429
DEPTH			
1	0.079	0.122	0.154
2	5.734	6.123	6.562

No.	SPACING (m)	RHO-A (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.152	97.50	97.43	0.0718
2	0.304	148.0	148.3	-0.211
3	0.609	213.0	213.5	-0.226
4	1.21	274.3	273.2	0.380
5	2.43	323.3	319.5	1.19
6	3.04	335.2	335.3	-0.0268
7	6.09	417.6	430.6	-3.12
8	9.14	557.4	554.5	0.530
9	12.19	697.3	682.6	2.09
10	15.24	814.1	804.0	1.24
11	18.28	908.0	915.8	-0.865
12	21.33	1045.9	1018.3	2.63
13	24.38	1072.7	1112.3	-3.68
14	30.48	1264.3	1278.2	-1.09
15	36.57	1402.2	1419.7	-1.24
16	42.67	1555.5	1541.6	0.888
17	45.72	1609.1	1596.4	0.788
18	48.76	1655.1	1647.6	0.454

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	1.00				
P 2	0.00	1.00			
P 3	0.00	0.00	1.00		
T 1	0.00	0.00	0.00	0.99	
T 2	0.00	0.00	0.00	0.00	1.00
	P 1	P 2	P 3	T 1	T 2

FIGURE V.2. Site 50 Eielson Air Force Base, 5/21/93, Data Set: BLK.NE1, Azimuth: 135° SE, Sounding: 2

FIGURE V.2. (Contd)

DATA SET: BLK.NE1

CLIENT: US Air Force
LOCATION: Site 50 Eielson AFB
COUNTY: Blair Lakes Air Force Range
PROJECT: Permafrost Study
ELEVATION: 750.00
SOUNDING COORDINATES: X: 101.8000 Y: 99.6700

DATE: 5/21/93
SOUNDING: 2
AZIMUTH: 135 SE
EQUIPMENT: Abem SAS 300

Wenner Configuration

FITTING ERROR: 2.758 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m ²)
			750.0		
1	49.64	0.207	749.7	0.00418	10.30
2	199.6	3.84	745.9	0.0192	767.5
3	1796.5				

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER	MINIMUM	BEST	MAXIMUM
RHO			
1	28.374	49.647	68.300
2	175.982	199.603	225.343
3	1578.438	1796.551	2090.225
THICK			
1	0.098	0.207	0.326
2	3.255	3.845	4.567
DEPTH			
1	0.098	0.207	0.326
2	3.401	4.053	4.865

No.	SPACING (m)	RHO-A (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.304	75.26	75.62	-0.468
2	0.609	113.7	110.8	-2.51
3	1.21	147.0	150.8	-2.53
4	2.43	183.8	193.2	-5.12
5	3.04	212.5	211.8	0.328
6	3.65	239.0	231.4	3.17
7	4.26	257.4	252.1	2.03
8	4.87	281.9	273.9	2.83
9	5.48	303.3	296.3	2.30
10	6.09	325.5	319.2	1.94
11	9.14	413.6	432.4	-4.54
12	12.19	513.2	536.1	-4.46
13	15.24	603.2	628.5	-4.19
14	18.28	712.4	710.9	0.211
15	21.33	804.3	784.6	2.45
16	24.38	873.3	850.9	2.55
17	30.48	976.7	965.3	1.17
18	36.57	1057.1	1060.0	-0.274
19	39.62	1095.4	1101.5	-0.553

CURRENT RESOLUTION MATRIX NOT AVAILABLE

FIGURE V.3. Site 50 Elelson Air Force Base, 5/21/93, Data Set: BLKNE2, Azimuth: 135° SE, Sounding: 3

Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base

FIGURE V.3. (Contd)

DATA SET: BLN.NE2

CLIENT: US Air Force
LOCATION: Site 50 Eielson AFB
COUNTY: Blair Lakes Air Force Range
PROJECT: Permafrost Study
ELEVATION: 750.00
SOUNDING COORDINATES: X: 68.5800 Y: 50.9000

DATE: 5/21/93
SOUNDING: 3
AZIMUTH: 135 SE
EQUIPMENT: Aben SAS 300

Wenner Configuration

FITTING ERROR: 3.100 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (ohm-m ²)
			750.0		
1	959.4	0.246	749.7	2.565E-04	236.0
2	285.3	1.88	747.8	0.00660	537.3
3	19789.8	0.504	747.3	2.550E-05	9984.9
4	100.0	4.02	743.3	0.0402	402.3
5	20000.0				

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER	MINIMUM	BEST	MAXIMUM
RHO			
1	744.441	959.495	1231.605
2	273.388	285.322	297.974
3	18686.904	19789.814	21478.225
4	95.132	100.035	106.161
5	10205.463	20000.000	320000.000
THICK			
1	0.216	0.246	0.276
2	1.777	1.883	2.005
3	0.471	0.505	0.555
4	3.778	4.022	4.246
DEPTH			
1	0.216	0.246	0.276
2	2.023	2.129	2.251
3	2.526	2.634	2.757
4	6.412	6.656	6.880

No.	SPACING (m)	RHO-A (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.609	436.2	436.0	0.0504
2	1.21	346.2	348.2	-0.576
3	2.43	459.6	456.6	0.646
4	3.04	522.8	526.3	-0.673
5	3.65	581.4	591.5	-1.73
6	4.26	640.8	649.1	-1.29
7	4.87	686.4	698.3	-1.73
8	5.48	741.1	739.4	0.228
9	6.09	773.7	773.2	0.0640
10	9.14	896.3	859.4	4.11
11	12.19	926.9	869.6	6.17
12	15.24	880.9	857.6	2.65
13	18.28	827.3	849.0	-2.62
14	21.33	790.9	854.0	-7.96
15	24.38	873.3	874.4	-0.130
16	30.48	995.9	955.4	4.06
17	36.57	1103.1	1072.7	2.75
18	39.62	1120.3	1139.5	-1.70

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.01								
P 2	0.02	0.25							
P 3	0.00	0.01	0.00						
P 4	0.00	0.00	0.00	0.00					
P 5	0.00	0.00	0.00	0.00	0.00				
T 1	0.02	0.02	0.00	0.00	0.00	0.04			
T 2	0.00	-0.17	-0.01	0.00	0.00	0.01	0.16		
T 3	0.00	0.05	0.01	0.01	0.00	0.00	-0.05	0.08	
T 4	0.00	-0.01	-0.01	-0.01	0.00	0.00	0.01	-0.06	0.14
P 1	P 2	P 3	P 4	P 5	T 1	T 2	T 3	T 4

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5 of 6

FIGURE V.4. Site 50 Eielson Air Force Base, 5/21/93, Data Set: BLK.NE3, Azimuth: 135° SE, Sounding: 4

FIGURE V.4. (Contd)

DATA SET: BLK.NE3

CLIENT: US Air Force DATE: 5/21/93
LOCATION: Site 50 Eielson AFB SOUNDING: 4
COUNTY: Blair Lakes Air Force Range AZIMUTH: 135 SE
PROJECT: Permafrost Study EQUIPMENT: Abaco SAS 300
ELEVATION: 750.00
SOUNDING COORDINATES: X: 5.4900 Y: 20.4200

Wenner Configuration

FITTING ERROR: 1.455 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m ²)
			750.0		
1	3907.3	0.185	749.8	4.742E-05	724.0
2	81.23	0.337	749.4	0.00415	27.41
3	1571.5	0.795	748.6	5.064E-04	1250.8
4	51.37	0.958	747.7	0.0186	49.25
5	4688.2	8.18	739.5	0.00175	38369.6
6	731.8				

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	1287.847	3907.325	13923.519
	2	32.206	81.235	148.023
	3	847.653	1571.581	4252.059
	4	14.620	51.371	149.111
	5	2240.859	4688.277	16552.729
	6	415.000	731.819	1269.588
THICK	1	0.141	0.185	0.240
	2	0.135	0.337	0.627
	3	0.294	0.796	1.524
	4	0.273	0.959	2.784
	5	2.084	8.184	27.293
DEPTH	1	0.141	0.185	0.240
	2	0.329	0.523	0.807
	3	0.831	1.319	2.042
	4	2.632	2.277	4.062
	5	4.318	10.461	29.609

No.	SPACING ($\text{\AA}$)	RHO-A (one-m)		DIFFERENCE (percent)
		DATA	SYNTHETIC	
1	0.609	340.1	335.8	0.0770
2	0.21	277.5	290.1	-4.63
3	2.42	392.2	383.2	2.28
4	3.04	422.3	396.6	5.84
5	3.65	415.9	401.8	3.38
6	4.26	396.6	404.5	-1.95
7	4.87	395.2	407.9	-3.20
8	5.48	405.5	413.5	-2.54
9	6.09	413.6	421.9	-1.98
10	6.14	488.3	497.0	-1.78
11	12.19	601.3	595.1	1.03
12	15.24	704.7	689.0	2.23
13	18.28	826.2	770.5	6.74
14	21.33	848.6	838.5	1.19
15	24.38	842.6	893.9	-6.08
16	30.48	940.3	975.6	-3.53
17	36.57	1038.6	1021.0	1.71
18	39.62	1040.7	1035.6	0.486

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

INDICATES FIXED PARAMETER												
P 1	0.05											
P 2	0.00	0.50										
P 3	0.00	0.01	0.51									
P 4	0.00	-0.01	0.03	0.49								
P 5	0.00	0.00	-0.01	0.02	0.40							
P 6	-0.01	0.00	0.01	-0.03	0.27	0.37						
T 1	0.21	0.03	0.00	0.00	0.00	0.00	0.95					
T 2	0.00	-0.49	-0.03	0.00	-0.01	0.01	0.02	0.49				
T 3	0.00	-0.03	0.49	0.01	-0.02	0.02	0.00	0.01	0.46			
T 4	0.00	0.00	0.00	-0.49	-0.05	0.02	0.00	0.00	0.02	0.51		
T 5	0.00	0.00	-0.01	-0.01	0.36	0.27	0.00	-0.01	-0.01	-0.01	0.33	
	P 1	P 2	P 3	P 4	P 5	P 6	T 1	T 2	T 3	T 4	T 5

FIGURE V.5. Site 50 Eielson Air Force Base, 5/21/93, Data Set: BLK.NE4, Azimuth: 135° SE, Sounding: 5

Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base

FIGURE V.5. (Contd)

DATA SET: BLK.NE4

CLIENT: US Air Force
LOCATION: Site 50 Eielson AFB
COUNTY: Blair Lakes Air Force Range
PROJECT: Permafrost Study
ELEVATION: 750.00
SOUNDING COORDINATES: X: 30.4800 Y: 8.8400

DATE: 5/21/93
SOUNDING: 5
AZIMUTH: 135 SE
EQUIPMENT: Abem SAS 300

Wenner Configuration

FITTING ERROR: 1.330 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (ohm-m ²)
			750.0		
1	514.6	0.577	749.4	0.00112	297.2
2	130.7	1.05	748.3	0.00809	138.1
3	2021.6	4.53	743.8	0.00224	9173.1
4	493.9	23.86	719.9	0.0483	11787.3
5	2063.1				

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER	MINIMUM	BEST	MAXIMUM
RHO			
1	497.176	514.672	536.995
2	110.022	130.720	160.230
3	1599.923	2021.666	2827.945
4	429.549	493.998	622.720
5	1253.087	2063.101	2975.371
THICK			
1	0.517	0.578	0.633
2	0.852	1.057	1.322
3	2.824	4.537	6.348
4	17.438	23.861	40.382
DEPTH			
1	0.517	0.578	0.633
2	1.475	1.635	1.849
3	4.487	6.172	7.961
4	24.018	30.033	45.850

No.	SPACING (m)	RHO-A (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.609	408.3	408.8	-0.127
2	1.21	286.5	286.4	0.0122
3	2.43	318.6	322.8	-1.31
4	3.04	380.7	376.1	1.20
5	3.65	441.7	428.5	2.97
6	4.26	473.7	476.9	-0.664
7	4.87	508.6	520.4	-2.31
8	5.48	556.0	559.2	-0.566
9	6.09	591.7	593.5	-0.289
10	9.14	719.9	710.2	1.34
11	12.19	763.0	763.9	-0.123
12	15.24	779.4	783.3	-0.500
13	18.28	785.9	786.4	-0.0510
14	21.33	790.9	783.3	0.959
15	24.38	792.1	780.0	1.53
16	30.48	764.1	781.8	-2.31
17	36.57	795.1	798.6	-0.433
18	39.62	824.1	811.9	1.47

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99								
P 2	-0.06	0.48							
P 3	-0.01	-0.14	0.53						
P 4	0.00	0.03	-0.07	0.80					
P 5	0.00	-0.01	0.02	0.00	0.22				
T 1	0.03	0.24	0.05	-0.01	0.00	0.88			
T 2	-0.03	-0.31	-0.13	0.02	-0.01	0.14	0.81		
T 3	-0.01	-0.02	0.39	0.18	-0.04	0.02	0.02	0.58	
T 4	0.00	0.03	0.01	-0.21	-0.33	-0.01	0.02	0.11	0.61
P 1	P 2	P 3	P 4	P 5	T 1	T 2	T 3	T 4

FIGURE V.6. Site 50 Eielson Air Force Base, 5/21/93, Data Set: BLK.SE2B, Azimuth: 45° NE, Sounding: 6

FIGURE V.6. (Contd)

DATA SET: BLK.SE2B

CLIENT: US Air Force
LOCATION: Site 50 Eielson AFB
COUNTY: Blair Lakes Air Force Range
PROJECT: Permafrost Study
ELEVATION: 750.00
SOUNDING COORDINATES: X: 76.5100 Y: -76.2000

DATE: 5/21/93
SOUNDING: 6
AZIMUTH: 45 NE
EQUIPMENT: Abem SAS 300

Wenner Configuration

FITTING ERROR: 2.747 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m ²)
1	100.6	2.86	750.0		
2	2278.5		747.1	0.0285	288.6

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER	MINIMUM	BEST	MAXIMUM
RHO 1	94.710	100.606	106.445
2	2006.707	2278.565	2635.566

THICK	1	2.634	2.869	3.112
DEPTH 1	2.634	2.869	3.112	

SPACING (m)	RHO-A (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)	
1	0.609	102.6	101.3	1.29
2	1.21	99.43	105.9	-6.58
3	2.43	138.5	131.7	4.85
4	3.04	159.1	151.0	5.08
5	3.65	176.2	172.6	2.05
6	4.26	197.8	195.5	1.19
7	4.87	216.0	218.9	-1.33
8	5.48	240.6	242.4	-0.743
9	6.09	262.3	265.7	-1.29
10	9.14	363.6	377.4	-3.78
11	12.19	468.8	479.4	-2.26
12	15.24	566.9	572.7	-1.03
13	18.28	651.5	658.4	-1.06
14	21.33	727.9	737.4	-1.30
15	24.38	818.1	810.5	0.927
16	30.48	955.6	941.4	1.48
17	36.57	1070.9	1055.1	1.47
18	39.62	1110.4	1106.5	0.348

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER
P 1 1.00
P 2 0.00 1.00
T 1 0.00 0.00 1.00
P 1 P 2 T 1

FIGURE V.7. Site 50 Eielson Air Force Base, 5/22/93, Data Set: BLK.SE1, Azimuth: 45° NE, Sounding: 7

FIGURE V.8. Site 50 Eielson Air Force Base, 5/22/93, Data Set: BLK-SE3B, Azimuth: 45° NE, Sounding: 8

FIGURE V.8. (Contd)

DATA SET: BLK.SE3B

CLIENT: US Air Force
LOCATION: Site 50 Eielson AFB
COUNTY: Blair Lakes Air Force Range
PROJECT: Permafrost Study
ELEVATION: 750.00
SOUNDING COORDINATES: X: 31.7000 Y: -43.2800

DATE: 5/22/93
SOUNDING: 6
AZIMUTH: 45 NE
EQUIPMENT: Aben SAS 300

Wenner Configuration

FITTING ERROR: 3.888 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m ²)
			750.0		
1	144.0	2.38	747.6	0.0165	342.9
2	2768.9	8.64	738.9	0.00312	23945.3
3	127.2				

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER	MINIMUM	BEST	MAXIMUM
RHO			
1	132.653	144.081	154.707
2	1675.323	2768.995	6251.673
3	34.667	127.232	393.687
THICK			
1	2.073	2.380	2.678
2	3.631	8.648	15.008
DEPTH			
1	2.073	2.380	2.678
2	6.182	11.028	17.286

No.	SPACING (m)	RHO-A (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.609	138.6	145.8	-5.18
2	1.21	163.9	156.4	4.57
3	2.43	252.8	208.3	17.57
4	3.04	260.4	243.2	6.60
5	3.65	283.6	280.0	1.26
6	4.26	364.3	316.9	13.03
7	4.87	341.3	352.9	-3.38
8	5.48	372.6	387.5	-4.00
9	6.09	400.6	420.6	-4.98
10	9.14	558.4	559.4	-0.173
11	12.19	683.3	656.3	3.94
12	15.24	742.1	717.6	3.30
13	18.28	744.6	750.1	-0.738
14	21.33	772.2	760.4	1.52
15	24.38	727.7	754.2	-3.63
16	30.48	503.6	709.5	-40.86

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1 0.99
P 2 0.00 0.57
P 3 0.00 0.03 0.07
T 1 -0.01 -0.04 0.01 0.99
T 2 0.00 0.45 0.11 0.04 0.50
P 1 P 2 P 3 T 1 T 2

FIGURE V.9. Site 50 Eielson Air Force Base, 5/22/93, Data Set: BLK.SW1, Azimuth: 135° SE, Sounding: 9

FIGURE V.9. (Contd)

DATA SET: BLK.SW1

CLIENT: US Air Force
LOCATION: Site 50 Eielson AFB
COUNTY: Blair Lakes Air Force Range
PROJECT: Permafrost Study
ELEVATION: 750.00
SOUNDING COORDINATES: X: -14.0200 Y: -45.7200
DATE: 5/22/93
SOUNDING: 9
AZIMUTH: 135 SE
EQUIPMENT: Abem SAS 300

Wenner Configuration

FITTING ERROR: 3.402 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m ²)
1	255.6	0.524	750.0	0.00205	134.1
2	144.7	5.70	749.4	0.0394	825.0
3	1284.8		743.7		

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	216.732	255.634	327.016
	2	130.503	144.710	156.754
	3	999.560	1284.870	1858.574
THICK	1	0.302	0.525	0.846
	2	4.530	5.701	6.989
DEPTH	1	0.302	0.525	0.846
	2	5.363	6.226	7.419

No.	SPACING (m)	RHO-A (ohm-m) DATA	RHO-A (ohm-m) SYNTHETIC	DIFFERENCE (percent)
1	0.609	222.1	222.7	-0.255
2	1.21	182.3	180.3	1.06
3	2.43	154.5	159.4	-3.15
4	3.04	158.9	160.7	-1.14
5	3.65	171.6	165.3	3.71
6	4.26	175.0	172.0	1.73
7	4.87	177.1	180.4	-1.87
8	5.48	184.0	190.1	-3.27
9	6.09	204.9	200.7	2.03
10	9.14	280.9	261.1	7.05
11	12.19	314.8	323.0	-2.58
12	15.24	375.3	380.9	-1.47
13	18.28	409.0	433.9	-6.08
14	24.38	520.9	526.7	-1.12
15	30.48	633.9	604.9	4.57

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	1.00				
P 2	0.00	1.00			
P 3	0.00	0.00	1.00		
T 1	0.00	0.00	0.00	0.99	
T 2	0.00	0.00	0.00	0.00	1.00
	P 1	P 2	P 3	T 1	T 2

FIGURE V.10. Site 50 Eielson Air Force Base, 5/22/93, Data Set: BLK.SW2, Azimuth: 135° SE, Sounding: 10

FIGURE V.10. (Contd)

DATA SET: BLK.SW2

CLIENT: US Air Force
LOCATION: Site 50 Eielson AFB
COUNTY: Blair Lakes Air Force Range
PROJECT: Permafrost Study
ELEVATION: 750.00
SOUNDING COORDINATES: X: -44.5000 Y: -87.7800

DATE: 5/22/93
SOUNDING: 10
AZIMUTH: 135 SE
EQUIPMENT: Abem SAS 300

Wenner Configuration

FITTING ERROR: 1.492 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m ²)
			750.0		
1	182.2	0.475	749.5	0.00261	86.59
2	937.5	0.792	748.7	8.449E-04	742.7
3	296.2	7.61	741.1	0.0256	2254.6
4	1845.8				

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER	MINIMUM	BEST	MAXIMUM
RHO			
1	129.398	182.282	217.956
2	698.430	937.573	1380.883
3	264.460	296.277	333.885
4	1541.922	1845.803	2411.156
THICK			
1	0.291	0.475	0.632
2	0.469	0.792	1.235
3	6.257	7.610	9.505
DEPTH			
1	0.291	0.475	0.632
2	0.974	1.267	1.686
3	7.684	8.877	10.643

No.	SPACING (m)	RHO-A (ohm-m) DATA	RHO-A (ohm-m) SYNTHETIC	DIFFERENCE (percent)
1	0.609	262.3	262.0	0.118
2	1.21	364.6	368.7	-1.12
3	2.43	436.6	427.3	2.14
4	3.04	427.0	423.9	0.743
5	3.65	408.8	415.4	-1.60
6	4.26	408.8	406.6	0.501
7	4.87	393.4	400.3	-1.74
8	5.48	396.8	396.6	0.560
9	6.09	392.2	395.9	-0.939
10	9.14	432.0	427.4	1.07
11	12.19	505.6	490.1	3.06
12	15.24	551.5	561.4	-1.79
13	18.28	619.3	632.2	-2.07
14	21.33	691.7	699.2	-1.07
15	24.38	772.2	761.4	1.38
16	30.48	877.1	872.2	0.562

PARAMETER RESOLUTION MATRIX:

"F" INDICATES FIXED PARAMETER

P 1 0.85
P 2 -0.05 0.62
P 3 0.03 0.02 0.94
P 4 0.01 0.03 -0.05 0.84
T 1 -0.21 -0.16 0.06 0.03 0.66
T 2 0.00 0.42 0.07 0.04 0.08 0.36
T 3 0.05 0.02 -0.10 -0.13 0.09 0.12 0.82
P 1 P 2 P 3 P 4 T 1 T 2 T 3

FIGURE V.11. Site 50 Elselon Air Force Base, 5/22/93, Data Set: BLK.SW3C, Azimuth: 135° SE, Sounding: 11

FIGURE V.11. (Contd)

DATA SET: BLK.SW3C

CLIENT: US Air Force
LOCATION: Site 50 Eielson AFB
COUNTY: Blair Lakes Air Force Range
PROJECT: Permafrost Study
ELEVATION: 750.00
SOUNDING COORDINATES: X: -48.4600 Y: -6.4000

DATE: 5/22/93
SOUNDING: 11
AZIMUTH: 135 SE
EQUIPMENT: Abem SAS 300

Wenner Configuration

FITTING ERROR: 2.277 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m ²)
1	253.3	6.04	750.0		
2	1038.7		743.9	0.0238	1530.6

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER	MINIMUM	BEST	MAXIMUM
RHO 1	241.576	253.360	264.664
2	939.508	1038.778	1178.484

THICK	1	5.305	6.041	6.832
DEPTH	1	5.305	6.041	6.832

No.	SPACING (m)	RHO-A (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)
1	1.21	149.6	254.3	-69.89
2	2.43	255.1	260.5	-2.15
3	3.04	273.2	266.5	2.45
4	3.65	273.7	274.5	-0.297
5	4.26	275.9	284.2	-3.02
6	4.87	292.0	295.4	-1.18
7	5.48	310.9	307.9	0.964
8	6.09	324.0	321.3	0.838
9	9.14	390.7	393.8	-0.817
10	12.19	451.9	463.7	-2.59
11	15.24	536.2	525.0	2.08
12	18.28	576.8	577.7	-0.157
13	21.33	652.8	622.9	4.57
14	24.38	664.9	662.0	0.441
15	30.48	699.0	725.5	-3.78

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER
P 1 1.00
P 2 0.00 1.00
T 1 0.00 0.00 1.00
P 1 P 2 T 1

FIGURE V.12. Site 50 Elselon Air Force Base, 5/22/93, Data Set: BLK.NW1, Azimuth: 45° NE, Sounding: 12

FIGURE V.12. (Contd)

DATA SET: BLK.NW1

CLIENT: US Air Force
LOCATION: Site 50 Eielson AFB
COUNTY: Blair Lakes Air Force Range
PROJECT: Permafrost Study
ELEVATION: 750.00
SOUNDING COORDINATES: X: -40.8400 Y: 80.1600
DATE: 5/22/93
SOUNDING: 12
AZIMUTH: 45 NE
EQUIPMENT: Abem SAS 300

Wenner Configuration

FITTING ERROR: 3.380 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m ²)
1	153.6	0.912	750.0	0.00594	140.1
2	537.8	1.11	749.0	0.00207	597.3
3	78.60	0.805	747.1	0.0102	63.28
4	3701.0	2.89	744.2	7.825E-04	10718.3
5	88.63	3.41	740.8	0.0385	303.0
6	7549.7				

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER	MINIMUM	BEST	MAXIMUM
RHO			
1	122.984	153.621	170.283
2	368.447	537.839	817.199
3	14.617	78.608	200.625
4	1568.507	3701.053	20006.967
5	10.954	88.635	389.286
6	2369.519	7549.740	54117.082
THICK			
1	0.502	0.912	1.231
2	0.622	1.111	1.657
3	0.138	0.805	1.945
4	0.365	2.896	6.923
5	0.533	3.419	16.901
DEPTH			
1	0.502	0.912	1.231
2	1.485	2.023	2.541
3	2.212	2.828	3.941
4	2.950	5.724	9.861
5	6.263	9.144	22.789

No.	SPACING (m)	RHO-A (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.609	166.2	166.9	-0.424
2	1.21	206.0	206.7	-0.321
3	2.43	274.5	271.2	1.22
4	3.04	302.6	293.4	3.02
5	3.65	314.6	313.7	0.278
6	4.26	319.0	333.8	-4.63
7	4.87	340.1	354.2	-4.16
8	5.48	371.2	375.0	-1.00
9	6.09	403.7	395.7	1.97
10	9.14	515.3	490.9	4.73
11	12.19	587.5	563.6	4.08
12	15.24	622.4	617.1	0.851
13	18.28	620.5	659.2	-6.24
14	21.33	671.6	695.9	-3.61
15	24.38	717.0	731.0	-1.95
16	30.48	848.4	804.2	5.20

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99																	
P 2	-0.01	0.58																
P 3	0.00	0.09	0.47															
P 4	0.00	-0.03	0.02	0.46														
P 5	0.00	0.01	-0.01	0.05	0.47													
P 6	0.00	0.00	0.00	-0.02	0.07	0.01												
T 1	-0.03	-0.14	0.02	-0.03	0.01	0.00	0.86											
T 2	-0.01	0.42	-0.03	-0.04	0.02	0.00	0.05	0.36										
T 3	0.00	-0.04	-0.48	-0.04	0.01	0.00	0.00	0.08	0.50									
T 4	0.00	-0.02	0.00	0.45	0.03	-0.02	-0.03	-0.03	-0.01	0.44								
T 5	0.00	-0.01	0.01	-0.02	-0.48	-0.07	-0.01	-0.01	-0.01	-0.01	0.49							
P 1	P 2	P 3	P 4	P 5	P 6	T 1	T 2	T 3	T 4	T 5

FIGURE V.13. Site 50 Eielson Air Force Base, 5/22/93, Data Set: BLK.NW2B, Azimuth: 45° NE, Sounding: 13

FIGURE V.13. (Contd)

DATA SET: BLK.NW2B

CLIENT: US Air Force
LOCATION: Site 50 Eielson AFB
COUNTY: Blair Lakes Air Force Range
PROJECT: Permafrost Study
ELEVATION: 750.00
SOUNDING COORDINATES: X: -15.2400 Y: 20.4200

DATE: 5/22/93
SOUNDING: 13
AZIMUTH: 45 NE
EQUIPMENT: Abem SAS 300

Wenner Configuration

FITTING ERROR: 2.315 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m ²)
			750.0		
1	197.1	0.724	749.2	0.00368	142.8
2	733.8	0.740	748.5	0.00101	543.6
3	70.82	1.74	746.7	0.0247	123.9
4	1576.6				

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	166.553	197.104	210.830
	2	420.629	733.806	876.016
	3	55.737	70.830	104.344
	4	1414.794	1576.664	1908.680
THICK	1	0.465	0.725	0.865
	2	0.559	0.741	1.370
	3	1.331	1.750	2.639
DEPTH	1	0.465	0.725	0.865
	2	1.320	1.466	1.961
	3	2.751	3.215	4.233

No.	SPACING (m)	RHO-A (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.609	224.8	223.1	0.772
2	1.21	268.1	270.8	-0.999
3	2.43	287.5	281.3	2.15
4	3.04	293.7	270.3	7.97
5	3.65	300.8	261.7	13.00
6	4.26	276.4	258.2	6.59
7	4.87	263.2	260.0	1.18
8	5.48	261.3	266.5	-2.02
9	6.09	265.4	276.6	-4.22
10	9.14	355.0	352.7	0.653
11	12.19	438.9	436.2	0.613
12	15.24	532.4	513.3	3.56
13	18.28	595.2	582.9	2.07
14	21.33	636.8	645.6	-1.39
15	24.38	674.1	702.5	-4.21
16	30.48	812.0	801.5	1.29

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99						
P 2	-0.02	0.34					
P 3	0.01	-0.05	0.25				
P 4	0.00	0.02	-0.04	0.98			
T 1	-0.03	-0.24	0.03	0.00	0.86		
T 2	0.00	0.35	0.16	-0.01	0.10	0.79	
T 3	0.01	0.11	-0.36	-0.03	0.06	0.00	0.79
	P 1	P 2	P 3	P 4	T 1	T 2	T 3

FIGURE V.14. Site 50 Eielson Air Force Base, 5/23/93, Data Set: BLKWS1C, Azimuth: 135° SE, Sounding: 14

FIGURE V.14. (Contd)

DATA SET: BLK.WS1C

CLIENT: US Air Force
LOCATION: Site 50 Eielson AFB
COUNTY: Blair Lakes Air Force Range
PROJECT: Permafrost Study
ELEVATION: 750.00
SOUNDING COORDINATES: X: -25.0000 Y: -486.0000

DATE: 5/23/93
SOUNDING: 14
AZIMUTH: 135 SE
EQUIPMENT: Abem SAS 300

Wenner Configuration

FITTING ERROR: 5.024 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m ²)
			750.0		
1	14.69	0.261	749.7	0.0178	3.84
2	156.2	3.75	745.9	0.0240	585.9
3	50000.0				

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	1.330	14.693	29.212
	2	121.759	156.214	173.011
	3	14413.109	50000.000	57268.996
THICK	1	0.021	0.262	0.545
	2	3.212	3.751	3.811
DEPTH	1	0.021	0.262	0.545
	2	3.250	4.013	4.356

No.	SPACING (m)	RHO-A (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.609	37.80	37.79	0.0174
2	1.21	61.82	63.26	-2.34
3	2.43	101.7	101.1	0.603
4	3.04	124.2	118.0	5.06
5	3.65	145.0	134.8	7.01
6	4.26	147.2	152.0	-3.26
7	4.87	169.1	169.6	-0.271
8	5.48	182.0	187.6	-3.10
9	6.09	179.6	206.1	-14.75
10	9.14	287.2	302.3	-5.22
11	12.19	406.0	401.0	1.23
12	15.24	519.9	500.0	3.83
13	18.28	625.1	598.7	4.21
14	21.33	736.0	697.1	5.28
15	24.38	839.6	795.1	5.29
16	30.48	1007.3	990.0	1.72
17	36.57	1176.7	1183.3	-0.564
18	39.62	1232.4	1279.4	-3.81

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1 0.67
P 2 -0.03 1.00
P 3 -0.01 0.00 0.02
T 1 -0.34 -0.03 -0.02 0.64
T 2 -0.03 0.00 -0.01 -0.03 1.00
P 1 P 2 P 3 T 1 T 2

FIGURE V.15. Site 50 Eielson Air Force Base, 5/23/93, Data Set: BLK,SE4B, Azimuth: 45° NE, Sounding: 15

APPENDIX VI - SOIL GAS RESULTS

TABLES		Page
VI.1	SE20 E-9 Soil Gas Results	VI.1
VI.2	ST48 Soil Gas Results	VI.6
VI.3	ST49 Soil Gas Results	VI.9

TABLE VI.1. ST20 E-9 Soil Gas Results

Sample Location	Depth (feet)	Vacuum (in. Hg)	Vacuum Release (minutes)	Peaks Prior to Benzene ^a	Benzene	Toluene	Ethylbenzene	Total Xylenes	Unidentified Peaks After Benzene ^b	Total Volatile Hydrocarbons ^c
V1A	2	1	<0.1	<1	<1	<1	<1	<1	<1	<1
V1B	5	6	<0.1	<200	<2	<1	<1	<1	<2	<200*
V1C	5.5	9	<0.1	<1	<1	<1	<1	<1	<1	<1
V2	2	5	<0.1	<1	<1	<1	<1	<1	<1	<1
V3A	2	11	>1	<1	<1	<1	<1	<1	<1	<1
V3B	5	10	<0.1	<400	<4	<2	<1	<1	<4	<400*
V3C	7	10	<0.1	<10	<2	<1	<1	<1	<2	<17*
V4A	5	8	<0.1	<1	<1	<1	<1	<1	<1	<1
V4B	7	8	<0.1	<1	<1	<1	<1	<1	<1	<1
V4C	10	8	<0.1	<1	<1	<1	<1	<1	<1	<1
V5A	3	1	<0.1	<1	<1	<1	<1	<1	<1	<1
V5B	4.5	9	<0.1	<1	<1	<1	<1	<1	<1	<1
V6	5	15	<0.1	<400	<5	<1	<1	<1	<400	<800*
V7	NO SAMPLE TAKEN									
V8	NO SAMPLE TAKEN									

- a. Quantification based on V-sec:ppm ratio for pentane. Early peaks from blank data subtracted from sample values.
b. Quantification based on standard mean V-sec:ppm ratio.
c. Summation of all detected constituents.
-- Indicates not quantifiable; masked by coeluting compounds.

* Matrix interferences, probably because of water introduced during sample collection, result in higher detection limits for these samples. No distinct fuel pattern could be identified in chromatograms.

TABLE VI.1. (Cont'd)

Sample Location	Depth (feet)	Vacuum (in. Hg)	Vacuum Release (minutes)	Peaks Prior to Benzene*	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Unidentified Peaks After Benzene*	Total Volatile Hydrocarbons*
V9	5	5	<0.1	<1	<1	<1	<1	<1	<1	<1
V10	5	5	<0.1	150	<1	<5	<5	<5	370	530
V11	5	7	<0.1	<20	<1	<1	<1	<1	<1	<20*
V12	5	2	<0.1	<1	<1	<1	<1	<1	<1	<1
V13	5	2	<0.1	80	<50	<50	100	15	750	950
V14	5	1	<0.1	4	<1	16	<1	11	35	74
V15	5	4	<0.1	7700	<400	3000	150	200	15000	26000
V16	5	6	<0.1	1	<1	4	<1	<1	12	17
V17	5	2	<0.1	<1	<1	<1	<1	<1	<1	<1
V18	5	10	0.2	<1	<1	<1	<1	<1	<1	<1
V19	5	1	<0.1	<1	<1	<1	<1	<1	<1	<1
V20	5	2	<0.1	<1	<1	<1	<1	<1	<1	<1
V21	5	1	<0.1	<1	<1	<1	<1	<1	<1	<1
V22	5	1	<0.1	19	<1	5	5	<1	57	86
V23	5	1	<0.1	2	<1	<10	<10	<100	3200	6300
V24	5	1	<0.1	3100	<1	<1	<1	<1	<1	<1
V25	5	10	0.2	<1	<1	<1	<1	<1	<1	<1
V26	5	1	<0.1	6	<1	<1	<1	<1	6	12
V27	5	1	<0.1	<3	<1	<1	<1	<1	<1	<3*
V28	5	2	<0.1	<1	<1	<1	<1	<1	<1	<1
V29	5	2	<0.1	4100	<100	<100	<100	<100	3400	7500
V30	5	6	0.3	<1	<1	<1	<1	<1	<1	<1
V31	5	5	0.3	2300	<100	40	40	40	2400	4800
V32	5	4	<0.1	1300	<100	40	<40	<40	1100	2400
V33	5	1	<0.1	2900	<200	40	40	<40	3800	6800

TABLE VI.1. (Contd)

Sample Location	Depth (feet)	Vacuum (in. Hg)	Vacuum Release (min)	Peaks Prior to Benzene*	Benzene	Toluene	Ethylbenzene	Total Xylenes	Unidentified Peaks After Benzene*	Total Volatile Hydrocarbons*
V35	5	1	<0.1	4400	<200	100	<100	<100	5000	9500
V36	5	2	<0.1	1800	<40	<40	<40	<40	330	2100
V37	5	2	<0.1	48	<1	<2	3	<1	26	77
V38	3.5	2	<0.1	<1	<1	<1	<1	<1	<1	<1
V39	5	2	<0.1	1	<1	<1	<1	<1	1	2
V40	5	10	0.3	150	<10	230	<10	<10	470	850
V41	5	2	<0.1	3	<1	<1	<1	<1	5	8
V42	2.5	1	<0.1	3	<1	<1	<1	<1	5	8
V43	3.5	1	<0.1	<1	<1	<1	<1	<1	<1	<1
V44	5	9	0.3	<1	<1	<1	<1	<1	<1	<1
V45	5	2	<0.1	11000	<400	<400	<400	<400	13000	24000
V46	5	2	<0.1	23000	<400	<400	<400	<400	26000	49000
V47	5	10	0.3	160	<5	<5	<5	<5	60	220
V48	5	10	0.3	55	<1	<1	<1	<1	46	100
V49	3	1	<0.1	<1	<1	<1	<1	<1	<1	<1
V50	5	10	0.3	180	<5	5	10	30	240	460
V51	5	<1	<0.1	3400	<100	<500	300	700	12000	16000
V52	5	<1	<0.1	660	<40	<200	120	<40	4400	5200
V53	5	2	0.1	150	<5	230	<5	<5	580	960
V54	5	0.1	0.1	4100	<100	<500	300	600	1800	23000
V55	5	<1	<0.1	25	<5	530	25	25	600	1200
V56	5	4	0.1	140	<5	<25	<10	<10	310	450
V57	5	10	>2	3	<1	2	<1	<1	10	15

TABLE VI.1. (Contd)

BLANK DATA

Date	Test Time	Peaks Prior to Benzene ^a	Benzene	Toluene	Ethyl- benzene	m,p-Xylene	o-Xylene	Unidentified Peaks After Benzene ^b	Total Volatile Hydro- carbons ^c
5/13/93	1030	<1	<1	<1	<1	<1	<1	<1	<1
6/05/93	0930	<1	<1	<1	<1	<1	<1	<1	<1
6/06/93	0903	<1	<1	<1	<1	<1	<1	<1	<1
6/10/93	1702	<1	<1	<1	<1	<1	<1	<1	<1
6/11/93	1242	<1	<1	<1	<1	<1	<1	<1	<1
6/12/93	1230	<1	<1	<1	<1	<1	<1	<1	<1

TABLE VI.1. (Contd)

PERCENTAGE OF STANDARD RECOVERED

Date	Test Time	Benzene	Toluene	Ethyl- benzene	m,p-Xylene	o-Xylene	n-Pentane	n-Hexane	iso-Octane
5/13/93	1020**	100	100	100	100	100	100	100	100
	1326	74	66	140	140	160	110	110	110
6/05/93	1005**	100	100	100	100	100	100	100	100
	1326	74	66	100	100	130	72	73	85
	1724	95	100	170	170	400	92	100	160
6/06/93	0925**	100	100	100	100	100	100	100	100
	1245	110	95	110	130	120	93	110	110
	1548**	100	100	100	100	100	100	100	100
	1957	73	78	81	81	78	75	100	57
6/10/93	1648**	100	100	100	100	100	100	100	100
	1827	100	120	100	100	100	110	130	120
	2050	90	80	98	98	98	83	86	86
6/11/93	1348**	100	100	100	100	100	100	100	100
	2129	110	78	170	170	160	100	100	150
6/12/93	1328**	100	100	100	100	100	100	100	100
	1745	110	110	110	110	110	110	110	110
	2144	90	100	130	130	130	110	110	96

** Calibration standard.

TABLE VI.2 ST48 Soil Gas Results

Sample Location	Depth (feet)	Vacuum (in. Hg)	Vacuum Release (minutes)	Peaks Prior to Benzene ^a	Benzene	Toluene	Ethylbenzene	Total Xylenes	Unidentified Peaks After Benzene ^a	Total Volatile Hydrocarbons ^b
V1A	8	6	<0.1	2	<1	<1	<1	1	1	4
V1B	10.5	3	<0.1	2	<1	1	<1	<1	2	5
V1C	12.5	11	<0.1	2	<1	1	<1	<1	2	5
V2	9	1	<0.1	1100	<100	100	<100	<100	440	1700
V3	9	11	0.1	100	<40	80	<40	<40	150	330
V4	9	8	<0.1	5	<5	50	<5	<5	68	120
V5	8	1	<0.1	95	<5	<5	<5	<5	16	110
V6	8	9	<0.1	78	<5	5	20	40	120	260
V7	8	<1	<0.1	69	<5	5	15	30	95	220
V8	8	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V9	8	<1	<0.1	210	<5	<5	5	5	280	500
V10	8	2	<0.1	1600	<40	<40	<40	<40	360	2000
V11	9	2	<0.1	850	<5	<5	<5	<5	36	890
V12	9	<1	<0.1	1	<1	<1	<1	<1	2	3
V13	9	<1	<0.1	10	<1	<1	<1	<1	<1	10

a. Quantification based on V-sec:ppm ratio for pentane. Early peaks from blank data subtracted from sample values.
 b. Quantification based on standard mean V-sec:ppm ratio.
 c. Summation of all detected constituents.
 Indicates not quantifiable; masked by coeluting compounds.

TABLE VI.2. (Contd)

Sample Location	Depth (feet)	Vacuum (in. Hg)	Vacuum Release (minutes)	Peaks Prior to Benzene ^a	Benzene	Toluene	Ethylbenzene	Total Xylenes	Unidentified Peaks After Benzene ^b	Total Volatile Hydrocarbons ^c
V14	9	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V15	8	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V16	8	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V17	8	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V18	8	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V19	8	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V20	8.5	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V21	9.5	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V22	9.5	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V23	8.5	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V24	9.5	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V25	9.5	<1	<0.1	<1	<1	<1	<1	<1	<1	<1
V26	9.5	<1	<0.1	<1	<1	<1	<1	<1	<1	<1

TABLE VI.2. (Contd)

BLANK DATA

<u>Date</u>	<u>Test Time</u>	<u>Peaks Prior to Benzene^a</u>	<u>Benzene</u>	<u>Toluene</u>	<u>Ethyl-benzene</u>	<u>m,p-Xylene</u>	<u>o-Xylene</u>	<u>Unidentified Peaks After Benzene^b</u>	<u>Total Volatile Hydrocarbons^c</u>
6/18/93	1208	<1	<1	<1	<1	<1	<1	<1	<1
6/19/93	1145	<1	<1	<1	<1	<1	<1	<1	<1
6/21/93	1049	<1	<1	<1	<1	<1	<1	<1	<1

PERCENTAGE OF STANDARD RECOVERED

<u>Date</u>	<u>Test Time</u>	<u>Benzene</u>	<u>Toluene</u>	<u>Ethyl-benzene</u>	<u>m,p-Xylene</u>	<u>o-Xylene</u>	<u>n-Pentane</u>	<u>n-Hexane</u>	<u>iso-Octane</u>
6/18/93	1233**	100	100	100	100	100	100	100	100
	1610	73	100	110	110	90	83	75	84
	1724	74	77	99	99	77	66	59	59
6/19/93	1215**	100	100	100	100	100	100	100	100
	1501	89	88	100	100	92	77	77	65
6/21/93	1116**	100	100	100	100	100	100	100	100
	1616	92	87	93	93	83	84	86	71

** Calibration standard.

TABLE VI.3. ST49 Soil Gas Results

Sample Location	Depth (feet)	Vacuum (in. Hg)	Vacuum Release (minutes)	Peaks Prior to Benzene ^a	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Unidentified Peaks After Benzene ^b	Total Volatile Hydrocarbons ^c
V1	7	<1	<0.1	<1	<1	<1	<1	<1	1	1
V2	7	6	0.1	35	<1	<1	<1	<1	3	38*
V3	5.5	2	<0.1	<1	<1	<1	<1	<1	<1	<1
V4	5.5	7	0.1	<1	<1	<1	<1	<1	<1	<1
V5	5.5	3	<0.1	280	<1	<1	<1	<1	5	290*
V6	5.5	8	0.1	<1	<1	<1	<1	<1	<1	<1
V7	5.5	10	1	270	<1	<1	<1	<1	<1	270*
V8	5.5	2	<0.1	37	<1	<1	<1	<1	<1	37*
V9	5.5	10	>2	60	<1	<1	<1	<1	<1	60*
V10	5.5	10	0.1	27	<1	<1	<1	<1	1	28*
V11	7	1	<0.1	5	<1	<5	20	20	120	170

- a. Quantification based on V-sec:ppm ratio for pentane. Early peaks from blank data subtracted from sample values.
 b. Quantification based on standard mean V-sec:ppm ratio.
 c. Summation of all detected constituents.
 -- Indicates not quantifiable; masked by coeluting compounds.

* Chromatogram is dominated by an early eluting peak, disproportionally large when compared with the fuel patterns observed in the chromatograms.

TABLE VI.3. (Contd)

BLANK DATA									
<u>Date</u>	<u>Test Time</u>	<u>Peaks Prior to Benzene^a</u>	<u>Benzene</u>	<u>Toluene</u>	<u>Ethyl-benzene</u>	<u>m,p-Xylene</u>	<u>o-Xylene</u>	<u>Unidentified Peaks After Benzene^b</u>	<u>Total Volatile Hydrocarbons^c</u>
6/24/93	1219	<1	<1	<1	<1	<1	<1	<1	<1

PERCENTAGE OF STANDARD RECOVERED

<u>Date</u>	<u>Test Time</u>	<u>Benzene</u>	<u>Toluene</u>	<u>Ethyl-benzene</u>	<u>m,p-Xylene</u>	<u>o-Xylene</u>	<u>n-Pentane</u>	<u>n-Hexane</u>	<u>iso-Octane</u>
6/24/93	1232**	100	100	100	100	100	100	100	100
	1743	99	110	140	140	150	97	98	110

** Calibration standard.

APPENDIX VII - T-Tests

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APPENDIX VII - T-Tests

Elevated concentrations of metals have been measured in soil and groundwater at Eielson Air Force Base (AFB). Many of these metals including antimony, arsenic, barium, beryllium, cadmium, chromium, lead, and manganese have been detected at or above the risk-based screening levels. Many of these metals, however, may be naturally occurring at the site. For this reason, the metals that exceed the risk-based screening levels (screening levels are listed in Table 4.2 of the text) were then statistically compared to background to determine if they are elevated above background. Background concentrations in sediment and groundwater have been established for the main base (U.S. Air Force, 1993a; 1993b). Background sediment concentrations were established for Blair Lakes in this report (Table VII.1).

The results of the statistical comparisons indicate that all except for manganese in ST48 passed the t-test evaluations. The results of some of the more significant t-tests, those with high variances and borderline cases, are presented in Table VII.2.

Note, because of high variances in some of the tests, the null hypotheses cannot be rejected. This may allow some very high values to pass the test. To supplement the t-tests, a list of all metal analytes that exceeded the 95% confidence level are listed in Table VII.3. Of particular note, arsenic, barium, calcium, manganese, magnesium, lead, potassium, and zinc spiked repeatedly at all sites. These metals passed the t-test, but the distribution contains some "spikes" that exceed the confidence level. These spikes in general are not considered a concern based on the spacial distributions of the spikes. The wide-spread occurrence of the spikes indicate they are not the result a point contaminant source and are not likely the result of pollution.

Additionally, there are two metals, antimony and beryllium, that do not have established backgrounds on the main base for either groundwater or sediment. The statistical distribution of these metals are shown in Table VII.4. The variance of the concentrations for both antimony and beryllium were generally low. In addition, the wide-spread occurrence of these metals in sediment and groundwater on loose indicate these metals may be from a naturally occurring source.

Statistical T-Test Method

At each site, the mean for each set of values for an individual metal analyte was compared to the established background mean through a one-tailed t-test (Equation 1). This equation assumes unequal variances. The null hypothesis tested was that the mean of the site metal concentrations was less than or equal to the mean of the background metal concentrations. If the calculated t-value is less than the t-value calculated for a one-tailed test with $(N + N_b - 2)$ degrees of freedom with 5% level of significance (α) (e.g., the null hypotheses cannot be rejected), there is not significant evidence to suggest that the sample and background came from populations having different means. For metals that satisfy the null hypotheses suggesting that there are significant differences or if the variance of the site-specific population was very large, then those metals will be carried through the feasibility study as contaminants of concern. Table VII.5 lists the metals that are significantly different from background and will be carried through the Feasibility Study.

$$t = \frac{(\bar{x} - \bar{x}_b)}{\sqrt{\frac{(N - 1) \times S^2 + ((N_b - 1) \times S_b^2)}{N + N_b - 2}} \times \frac{N + N_b}{N \times N_b}} \quad (1)$$

where $\bar{x}$ = sample mean
 $\bar{x}_b$ = background mean
 S = sample standard deviation
 N = number of site measurement
 N_b = number of background measurement.

Establishing Background Concentrations at Blair Lakes Target Facility

Backgrounds for the sediment at the remotely located Blair Lakes Target Facility were established by sampling six sediment test pits at the surface and approximately 1.6 m below land surface. The results of these samples were used as the background population for comparisons (Table VII.1). These test pits were located hydraulically upgradient from the facility (Figure 7, Appendix I).

It was logistically not feasible to establish background groundwater concentrations at the Blair Lakes Target Facility. Inferences based on comparative metal concentrations in the sediment as well as variances from the mean and areal distribution were used to determine if the groundwater concentrations are elevated as a result of pollution.

TABLE VII.1. Background Soil Concentrations at Blair Lakes Target Facility

ALUMINUM	μG/KG	ANTIMONY	μG/KG	ARSENIC	μG/KG	BARIUM	μG/KG	BERYLLIUM	μG/KG
BL1-2S	1.1E+07	BL1-1S	2135	BL2-2S	19000	BL2-1S	280000	BL3-2S	700
BL2-1S	1.1E+07	BL1-2S	2135	BL1-2S	16000	BL1-1S	270000	BL6-2S	700
BL2-2S	1.1E+07	BL2-1S	2135	BL5-2S	13000	BL5-1S	250000	BL3-1S	800
BL5-2S	1.1E+07	BL2-2S	2135	BL2-1S	11000	BL2-2S	240000	BL4-1S	800
BL1-1S	1E+07	BL5-1S	2135	BL5-1S	10000	BL5-2S	240000	BL6-1S	800
BL5-1S	1E+07	BL5-2S	2135	BL3-2S	8800	BL3-2S	240000	BL1-2S	400
BL3-2S	1E+07	BL3-1S	2135	BL1-1S	8700	BL1-2S	210000	BL2-1S	400
BL6-2S	8600000	BL3-2S	2135	BL3-1S	8100	BL6-2S	210000	BL2-2S	400
BL6-1S	8400000	BL4-1S	2135	BL4-2S	7100	BL6-1S	160000	BL5-1S	400
BL3-1S	7300000	BL4-2S	2135	BL6-2S	6400	BL4-1S	150000	BL5-2S	400
BL4-1S	6400000	BL6-1S	2135	BL4-1S	5000	BL3-1S	110000	BL1-1S	300
BL4-2S	5200000	BL6-2S	2135	BL6-1S	1400	BL4-2S	79000	BL4-2S	48.35
	9241667		2135		9541.67		203250		482.3625
CADMIUM	μG/KG	CALCIUM	μG/KG	CHROMIUM	μG/KG	COBALT	μG/KG	COPPER	μG/KG
BL3-2S	1000	BL4-1S	4400000	BL2-2S	23000	BL2-2S	13000	BL2-2S	31000
BL6-2S	1000	BL5-1S	3100000	BL1-2S	22000	BL1-2S	12000	BL5-2S	31000
BL1-2S	600	BL1-2S	2900000	BL2-1S	22000	BL3-2S	11000	BL3-2S	30000
BL2-2S	330	BL1-1S	2700000	BL5-2S	22000	BL1-1S	10000	BL6-2S	30000
BL1-1S	165	BL2-1S	2700000	BL5-1S	20000	BL5-2S	10000	BL1-2S	28000
BL2-1S	165	BL5-2S	2600000	BL1-1S	18000	BL6-2S	10000	BL2-1S	27000
BL5-1S	165	BL2-2S	2500000	BL3-2S	18000	BL2-1S	8000	BL1-1S	24000
BL5-2S	165	BL3-2S	2500000	BL6-2S	18000	BL5-1S	8000	BL5-1S	20000
BL3-1S	165	BL6-2S	2500000	BL6-1S	14000	BL3-1S	7000	BL3-1S	18000
BL4-1S	165	BL3-1S	2300000	BL3-1S	13000	BL4-1S	5000	BL4-1S	14000
BL4-2S	165	BL6-1S	2200000	BL4-1S	11000	BL4-2S	4000	BL4-2S	8000
BL6-1S	165	BL4-2S	1800000	BL4-2S	8000	BL6-1S	4000	BL6-1S	3000
	354.167		2678000		17750		8583.3		22000
IRON	μG/KG	LEAD	μG/KG	MAGNESIUM	μG/KG	MANGANESE	μG/KG	MERCURY	μG/KG
BL2-2S	2.7E+07	BL5-2S	20000	BL2-2S	5100000	BL1-2S	640000	BL3-1S	300
BL1-2S	2.4E+07	BL3-2S	19000	BL5-2S	5000000	BL2-2S	630000	BL3-2S	200
BL5-2S	2.4E+07	BL2-1S	18000	BL3-2S	5000000	BL3-2S	410000	BL4-1S	100
BL3-2S	2.4E+07	BL2-2S	18000	BL6-2S	4700000	BL5-1S	350000	BL6-2S	100
BL6-2S	2.3E+07	BL6-2S	18000	BL1-2S	4600000	BL2-1S	290000	BL1-2S	90
BL2-1S	2.2E+07	BL1-2S	17000	BL2-1S	4600000	BL6-2S	290000	BL6-1S	90
BL1-1S	2.1E+07	BL1-1S	14000	BL1-1S	4300000	BL5-2S	280000	BL1-1S	40
BL5-1S	2E+07	BL5-1S	13000	BL5-1S	4000000	BL4-1S	240000	BL2-1S	40
BL3-1S	1.8E+07	BL3-1S	8500	BL6-1S	3800000	BL1-1S	220000	BL2-2S	40
BL4-1S	1.4E+07	BL4-2S	7400	BL3-1S	3500000	BL3-1S	220000	BL5-1S	40
BL6-1S	1.3E+07	BL4-1S	6600	BL4-1S	2500000	BL6-1S	150000	BL5-2S	40
BL4-2S	1.2E+07	BL6-1S	5800	BL4-2S	2400000	BL4-2S	130000	BL4-2S	40
	2E+07		13775		4125000		320833		93.33333
NICKEL	μG/KG	POTASSIUM	μG/KG	SILVER	μG/KG	SODIUM	μG/KG	TIN	μG/KG
BL2-2S	31000	BL2-2S	1800000	BL2-2S	4000	BL1-2S	100000	BL1-1S	2560
BL6-2S	29000	BL5-2S	1700000	BL1-1S	3000	BL5-1S	100000	BL1-2S	2560
BL5-2S	28000	BL1-2S	1600000	BL1-2S	3000	BL4-1S	100000	BL2-1S	2560
BL1-2S	27000	BL2-1S	1500000	BL2-1S	3000	BL1-1S	80000	BL2-2S	2560
BL3-2S	27000	BL5-1S	1300000	BL5-1S	3000	BL2-1S	80000	BL5-1S	2560
BL2-1S	25000	BL1-1S	1200000	BL5-2S	3000	BL2-2S	80000	BL5-2S	2560
BL1-1S	24000	BL3-2S	1000000	BL3-1S	163	BL5-2S	80000	BL3-1S	2560
BL5-1S	20000	BL6-1S	820000	BL3-2S	163	BL4-2S	80000	BL3-2S	2560
BL3-1S	17000	BL6-2S	870000	BL4-1S	163	BL6-1S	70000	BL4-1S	2560
BL4-1S	13000	BL3-1S	590000	BL4-2S	163	BL3-2S	60000	BL4-2S	2560
BL6-1S	12000	BL4-2S	570000	BL6-1S	163	BL6-2S	60000	BL6-1S	2560
BL4-2S	9000	BL4-1S	560000	BL6-2S	163	BL3-1S	50000	BL6-2S	2560
	21633.3		1134167		1664.83		78333		0
VANADIUM	μG/KG	ZINC	μG/KG						
BL2-1S	27000	BL5-2S	100000						
BL1-2S	26000	BL2-2S	99000						
BL5-2S	26000	BL3-2S	98000						
BL1-1S	25000	BL1-2S	90000						
BL2-2S	25000	BL6-2S	89000						
BL5-1S	25000	BL2-1S	83000						
BL6-2S	23000	BL1-1S	80000						
BL3-2S	22000	BL5-1S	65000						
BL3-1S	18000	BL6-1S	60000						
BL4-1S	18000	BL3-1S	59000						
BL6-1S	18000	BL4-1S	39000						
BL4-2S	14000	BL4-2S	36000						
	22250		74833.33						

TABLE VII.2. T-Test Results with High Variances and Borderline Cases

ARSENIC		Figure 1			
BACKGROUND	Sample ID	Concentration	Comments		
ALLUVIUM	ID	μG/L			
58	20M12F	22	Filtered *	SITE 20 - GROUND WATER	
19	20M07F	13	Filtered	t-Test: Two-Sample Assuming Unequal Variances	
10	20C_2F	12	Filtered	Filtered	Alluvium
9.1	20M08F	9.5	Filtered *	Mean	7.115385 8.435714
2.5	20MW26F	8.8	Filtered	Variance	39.08308 209.9117
2.5	53M04F	8.4	Filtered	Observations	13 14
2.5	20M23F	6.9	Filtered	Pearson Correlation	#N/A
2.5	20M06F	5.9	Filtered	Pooled Variance	3.5
2.5	20M15F	2	Filtered	df	17.95395
2.5	POND	2	Filtered	t	-0.3112
2.5	20MW27F	1	Filtered	P(T < = t) one-tail	0.379715
2.5	20M14F	0.5	Filtered	t Critical one-tail	1.739908
2.5	20M21F	0.5	Filtered	P(T < = t) two-tail	0.759429
2.5				t Critical two-tail	2.109819
				t-Test: Two-Sample Assuming Unequal Variances	
	20M12	71	*	Unfiltered	Alluvium
	20M08	33	*	Mean	15.74615 8.435714
	20M23	20		Variance	352.336 209.9117
	20M07	15		Observations	13 14
	20C_2	14		Pearson Correlation	#N/A
	53M04	14	Site 20	Pooled Variance	3.5
	20M21	12		df	22.57281
	20M08	8.1		t	1.128732
	20MW26	7.1		P(T < = t) one-tail	0.135998
	20M15	6		t Critical one-tail	1.717144
	20MW27	2		P(T < = t) two-tail	0.271998
	POND	2		t Critical two-tail	2.073875
	20M14	0.5			

CHROMIUM		Figure 2			
BACKGROUND	Sample ID	Concentration	Comments		
ALLUVIUM	ID	μG/L			
10	53M04	17	*	SITE 20 - GROUND WATER	
10	20M08	14	*	t-Test: Two-Sample Assuming Unequal Variances	
10	20C_2	12	*	Unfiltered	Alluvium
10	20M07	12	*	Mean	6.328231 10
10	20M14	5.6		Variance	28.52864 0
10	20M08	2.71		Observations	13 14
10	20M12	2.71		Pearson Correlation	#N/A
10	20M15	2.71		Pooled Variance	3.5
10	20M21	2.71		df	12
10	20M23	2.71		t	-2.47783
10	20MW26	2.71		P(T < = t) one-tail	0.014534
10	20MW27	2.71		t Critical one-tail	1.782287
10	POND	2.71		P(T < = t) two-tail	0.029068
10				t Critical two-tail	2.178813
				t-Test: Two-Sample Assuming Unequal Variances	
	20M07F	14	Filtered *	Filtered	Alluvium
	53M04F	12	Filtered *	Mean	5.621538 10
	20C_2F	10	Filtered *	Variance	17.8359 0
	20M06F	9.3	Filtered *	Observations	13 14
	20M14F	6.1	Filtered	Pearson Correlation	#N/A
	20M08F	2.71	Filtered	Pooled Variance	3.5
	20M12F	2.71	Filtered	df	12
	20M15F	2.71	Filtered	t	-3.75919
	20M21F	2.71	Filtered	P(T < = t) one-tail	0.001362
	20M23F	2.71	Filtered	t Critical one-tail	1.782287
	20MW26F	2.71	Filtered	P(T < = t) two-tail	0.002725
	20MW27F	2.71	Filtered	t Critical two-tail	2.178813
	POND	2.71	Filtered		

TABLE VII.2. (Contd)

MANGANESE			Figure 3	
BACKGROUND	Sample ID	Concentration		
ALLUVIUM		$\mu\text{G/L}$		
3300	20M15	3700		
2900	20M06	2700		
2800	20M07	2400		
2400	20MW26	1900		
2200	20M12	1800		
2100	20C_2	1800		
1500	20M08	1200		
1200	20M21	1200		
1100	20M23	1200		
980	20MW27	1100		
770	53M04	950		
420	POND	30		
190	20M14	20		
120				
	20M12F	2900	Filtered	
	20M07F	2800	Filtered	
	20M06F	2300	Filtered	
	20MW26F	2000	Filtered	
	20C_2F	1800	Filtered	
	20M21F	1100	Filtered	
	20M23F	1000	Filtered	
	20MW27F	980	Filtered	
	20M15F	950	Filtered	
	53M04F	930	Filtered	
	20M08F	870	Filtered	
	PONDF	20	Filtered	
	20M14F	6.5	Filtered	
SITE 20 - GROUND WATER				
t-Test: Two-Sample Assuming Unequal Variances				
			Unfiltered	Alluvium
Mean			1523.077	1555.714
Variance			1035573	1066673
Observations			13	14
Pearson Correlation			#N/A	
Pooled Variance			3.5	
df			24.90333	
t			-0.08267	
P(T < = t) one-tail			0.467389	
t Critical one-tail			1.710862	
P(T < = t) two-tail			0.934788	
t Critical two-tail			2.063898	
t-Test: Two-Sample Assuming Unequal Variances				
			Filtered	Alluvium
Mean			1342.808	1555.714
Variance			862888.3	1066673
Observations			13	14
Pearson Correlation			#N/A	
Pooled Variance			3.5	
df			24.97917	
t			-0.56367	
P(T < = t) one-tail			0.289038	
t Critical one-tail			1.710862	
P(T < = t) two-tail			0.578071	
t Critical two-tail			2.063898	

ARSENIC			Figure 4	
BACKGROUND	Sample ID	Concentration		
ALLUVIUM		$\mu\text{G/L}$		
56	53M03	38		
19	48MW8	24		
10	48M07	20		
8.1	48M01	10		
2.5	48M03	4		
2.5				
2.5	48MW8F	25	Filtered	
2.5	53M03F	17	Filtered	
2.5	48M07F	14	Filtered	
2.5	48M01F	6.5	Filtered	
2.5	48M03F	0.5	Filtered	
2.5				
2.5				
2.5				
2.5				
SITE 48 - GROUND WATER				
t-Test: Two-Sample Assuming Unequal Variances				
			Unfiltered	Alluvium
Mean			19.2	8.435714
Variance			173.2	209.9117
Observations			5	14
Pooled Variance			3.5	
df			7.764555	
t			1.527907	
P(T < = t) one-tail			0.085189	
t Critical one-tail			1.894578	
P(T < = t) two-tail			0.170378	
t Critical two-tail			2.364623	
t-Test: Two-Sample Assuming Unequal Variances				
			Filtered	Alluvium
Mean			12.8	8.435714
Variance			89.675	209.9117
Observations			5	14
Pooled Variance			3.5	
df			11.0972	
t			0.725684	
P(T < = t) one-tail			0.24159	
t Critical one-tail			1.795884	
P(T < = t) two-tail			0.483181	
t Critical two-tail			2.200986	

TABLE VII.2. (Contd)

MANGANESE		Figure 5			
BACKGROUND	Sample	Concentration			
ALLUVIUM	ID	µG/L			
3300	48M03	4500			
2900	48MW8	3800			
2600	48M01	3400			
2400	53M03	3100			
2200	48M07	2000			
2100					
1500	48MW8F	3900	Filtered		
1200	48M01F	3500	Filtered		
1100	53M03F	3100	Filtered		
980	48M07F	1900	Filtered		
770	48M03F	1500	Filtered		
420					
190					
120					

SITE 48 - GROUND WATER			
t-Test: Two-Sample Assuming Unequal Variances			
	Unfiltered	Alluvium	
Mean	3360	1555.714	
Variance	853000	1066673	
Observations	5	14	
Pearson Correlation	#N/A		
Pooled Variance	3.5		
df	7.886656		
t	3.631967		
P(T < = t) one-tail	0.004188		
t Critical one-tail	1.894578		
P(T < = t) two-tail	0.008376		
t Critical two-tail	2.364623		

t-Test: Two-Sample Assuming Unequal Variances			
	Filtered	Alluvium	
Mean	2780	1555.714	
Variance	1072000	1066673	
Observations	5	14	
Pearson Correlation	#N/A		
Pooled Variance	3.5		
df	7.073242		
t	2.271129		
P(T < = t) one-tail	0.028691		
t Critical one-tail	1.894578		
P(T < = t) two-tail	0.057382		
t Critical two-tail	2.364623		

TABLE VII.2. (Contd)

Figure 6			
SITE 49	Sample Concentration		
ARSENIC	ID	μG/KG	Comments
BACKGROUND			
ALLUVIUM			
47300	49M018A	9340	
31100	49M018B	9320	
30300			
27600			
24700			
23100			
21500			
20500			
20100			
20000			
19400			
19100			
18900			
18300			
17800			
16500			
16100			
15700			
15700			
15100			
15000			
13900			
13800			
13500			
13300			
13200			
13100			
13000			
12900			
12400			
12400			
12100			
11500			
11400			
11400			
11200			
11000			
10500			
10400			
10300			
10300			
10200			
9900			
9700			
9400			
9300			
8600			
8400			
8100			
8000			
7900			
7700			
7500			
7300			
5600			
5300			
5000			
4300			
3500			
1200			

SITE 49 - SOIL		
t-Test: Two-Sample Assuming Unequal Variances		
	AS Soils	Alluvium
Mean	9330	13668.33
Variance	200	58226607
Observations	2	60
Pearson Correlation	#N/A	
Pooled Variance	3.5	
df	59.01212	
t	-4.80688	
P(T < = t) one-tail	1.12E-05	
t Critical one-tail	1.671092	
P(T < = t) two-tail	2.23E-05	
t Critical two-tail	2.000997	

TABLE VII.2. (Contd)

ARSENIC			Figure 7		SITE 49 - GROUND WATER		
BACKGROUND	Sample ID	Concentration			t-Test: Two-Sample Assuming Unequal Variances		
ALLUVIUM	ID	µG/L			Unfiltered	Aluvium	
56	49M01	19			Mean	7.5	8.435714
19	49M05	16			Variance	61.5	209.9117
10	49M02	3			Observations	6	14
8.1	53M05	3			Pearson Correlation	#N/A	
2.5	SL_2	3			Pooled Variance	3.5	
2.5	SL_1	1			df	16.63578	
2.5	49M05F	10	Filtered		t	-0.19624	
2.5	49M01F	6.2	Filtered		P(T < = t) one-tail	0.4273	
2.5	49M02F	3	Filtered		t Critical one-tail	1.745884	
2.5	53M05F	2	Filtered		P(T < = t) two-tail	0.854599	
2.5	SL_1F	1	Filtered		t Critical two-tail	2.119905	
2.5	SL_2F	0.5	Filtered				
					t-Test: Two-Sample Assuming Unequal Variances		
					Filtered	Aluvium	
					Mean	3.783333	8.435714
					Variance	13.36167	209.9117
					Observations	6	14
					Pearson Correlation	#N/A	
					Pooled Variance	3.5	
					df	16.21823	
					t	-1.12112	
					P(T < = t) one-tail	0.139392	
					t Critical one-tail	1.745884	
					P(T < = t) two-tail	0.278784	
					t Critical two-tail	2.119905	

TABLE VII.2. (Contd)

CHROMIUM		Figure 8			
BACKGROUND	Sample	Concentration		SITE 49 - SOIL	
ALLUVIUM	ID	µG/KG	Soil	t-Test: Two-Sample Assuming Unequal Variances	
61000	ST49_7S	19000	Soil		
47200	49M016B	18900	Soil		
46900	49M018A	18700	Soil		
45700	ST49_8S	18000	Soil		
44200					
43700					
43300					
41100					
39900					
39200					
38500					
35900					
35300					
35200					
34300					
32700					
31200					
30800					
30200					
28700					
28200					
28000					
27100					
26300					
25800					
24900					
24500					
23500					
23300					
22300					
20700					
20800					
20400					
19900					
19800					
19800					
19100					
18900					
18800					
18800					
18500					
18400					
18200					
18200					
18200					
18100					
18100					
17400					
17100					
16900					
16500					
16400					
15100					
15000					
14900					
14800					
14500					
13800					
13400					
13200					

TABLE VII.2. (Contd)

MANGANESE		Figure 9				SITE 49 - GROUND WATER	
BACKGROUND	Sample Concentration	ID	μG/L			t-Test: Two-Sample Assuming Unequal Variances	
ALLUVIUM						Unfiltered	Alluvium
3300	49M01		4000			Mean	2138.333 1555.714
2900	49M05		3700			Variance	2807617 1086673
2600	53M05		2700			Observations	6 14
2400	49M02		1800			Pearson Correlation	#N/A
2200	SL_2		480			Pooled Variance	3.5
2100	SL_1		150			df	6.826096
1500						t	0.818196
1200	49M01F	3800	Filtered			P(T < = t) one-tail	0.223052
1100	49M05F	3800	Filtered			t Critical one-tail	1.943181
980	53M05F	2400	Filtered			P(T < = t) two-tail	0.448105
770	49M02F	1800	Filtered			t Critical two-tail	2.448914
420	SL_2F	670	Filtered				
190	SL_1F	50	Filtered				
120							
						t-Test: Two-Sample Assuming Unequal Variances	
						Filtered	Alluvium
						Mean	2053.333 1555.714
						Variance	2470867 1086673
						Observations	6 14
						Pearson Correlation	#N/A
						Pooled Variance	3.5
						df	6.930056
						t	0.712338
						P(T < = t) one-tail	0.251501
						t Critical one-tail	1.943181
						P(T < = t) two-tail	0.503001
						t Critical two-tail	2.448914

ARSENIC		Figure 10				SITE 50 - SOIL	
BACKGROUND	Sample Concentration	ID	μG/KG	Comments		t-Test: Two-Sample Assuming Unequal Variances	
						All Soils	Test Soils
18000	50M02SB	18200	Soil			Mean	6805 8541.667
16000	50M04SA	8650	Soil			Variance	37027690 21195379
13000	50M02SA	3195	Soil			Observations	6 12
11000	50M04SB	3195	Soil			Pearson Correlation	#N/A
10000	50M06SA	3195	Soil			Pooled Variance	3.5
9800	50M06SB	3195	Soil			df	7.974743
8700						t	-1.04234
8100						P(T < = t) one-tail	0.165954
7100						t Critical one-tail	1.894578
6400						P(T < = t) two-tail	0.331908
5000						t Critical two-tail	2.364623
1400							

BERYLLIUM		Figure 11				SITE 50 - SOILS	
BACKGROUND	Sample Concentration	ID	μG/KG			t-Test: Two-Sample Assuming Unequal Variances	
μG/KG						All Soils	Test Soils
700	50M02SB	623				Mean	237.1667 462.3625
700	50M02SA	160				Variance	35728.17 35180.8
600	50M04SA	160				Observations	6 12
600	50M04SB	160				Pearson Correlation	#N/A
600	50M06SA	160				Pooled Variance	3.5
400	50M06SB	160				df	10.03025
400						t	-2.38889
400						P(T < = t) one-tail	0.019015
400						t Critical one-tail	1.812462
300						P(T < = t) two-tail	0.03803
48.35						t Critical two-tail	2.228139

TABLE VII.3. Statistical Distribution of Beryllium and Antimony at Eielson Air Force Base

Distribution of Beryllium at Eielson AFB

MCL = 1 HQ = 20 CC = 0.02

	$\mu\text{G/L}$	Beryllium	
20C_2	0.86		
20M21	0.91		
48M07	1.9	Mean	1.887142857
50M06	4	Standard Error	0.429087174
50M08	2.4	Median	1.9
50M10	2.2	Mode	#N/A
53M05	0.94	Standard Deviation	1.135205037
		Variance	1.288690476
		Kurtosis	1.0172491
		Skewness	1.073634344
		Range	3.14
		Minimum	0.86
		Maximum	4
		Sum	13.21
		Count	7

	$\mu\text{G/L}$	Beryllium (Filtered)	
50M08F	0.82		
50M05F	0.9		
48M03F	1.9	Mean	2.245714286
20C_2F	2	Standard Error	0.658276455
48M07F	2	Median	2
20M21F	2.1	Mode	2
53M04F	6	Standard Deviation	1.741635794
		Variance	3.033295238
		Kurtosis	5.052879783
		Skewness	2.098243476
		Range	5.18
		Minimum	0.82
		Maximum	6
		Sum	15.72
		Count	7

TABLE VII.3. (Contd)

Distribution of Antimony at Eielson AFB
MCL = 5 HQ = 10

	$\mu\text{G/L}$	Antimony Column 1	
20M06	71		
48MW8	72		
20M07	82	Mean	109.2666667
48M07	86	Standard Error	6.141557633
20M21	88	Median	110
48M01FT	100	Mode	110
48M03	100	Standard Deviation	23.78815043
20M23	110	Variance	565.7809524
20MW26	110	Kurtosis	-0.297684408
53M04	110	Skewness	0.220084183
48M01	120	Range	79
20M08	130	Minimum	71
53M03	130	Maximum	150
20M12	150	Sum	1639
20MW27	150	Count	15

	$\mu\text{G/L}$	Antimony (Filtered) Column 1	
48M01F	170		
20M23F	150		
20MW27F	140	Mean	116.7692308
20M06F	140	Standard Error	7.398157988
20M07F	120	Median	110
48M07F	110	Mode	110
20MW26F	110	Standard Deviation	26.67443797
20M12F	110	Variance	711.525641
20M08F	110	Kurtosis	-0.189203735
20C_2F	100	Skewness	0.523384732
53M04F	97	Range	93
48M03F	84	Minimum	77
20M21F	77	Maximum	170
		Sum	1518
		Count	13

TABLE VII.4. Metal Values Above 95% Confidence Limit at Eielson Air Force Base
(Wells followed by an F are filtered samples.)

Site 20

95% CL = 15		Arsenic μG/L	95% CL = 119	Barium	95% CL = 59373	Calcium μG/L
20M12	71		20M08	270	20MW26	98000
20M08	33		20MW26	270	20MW26F	95000
20M12F	22		20M07F	260	20M08	83000
20M23	20		20MW26F	260	20MW27F	81000
20M07	15		20M07	240	20MW27	80000
			20M08F	210	20M08F	72000
			53M04	200	20M12	71000
			20M12	180	20M12F	68000
			20M12F	180	20M23	65000
			53M04F	170	20M23F	62000
			20C_2	160		
			20M23	160		
			20M15	150		
			20M21	130		
			20MW27	130		
			20M23F	130		
			20C_2F	120		
			20MW27F	120		
5% CL > = 20		Copper μG/L	95% CL = 2545	Iron μG/L	95% CL = 12731	Magnesium μG/L
53M04	50		20M08	18000	20MW26	21000
			20M07F	18000	20MW26F	20000
			20C_2	17000	20M08	18000
			20M07	17000	20M08F	18000
			20MW26F	16000	20M12	15000
			20M12	15000	53M04	14000
53M04	12		20MW26	15000	20M12F	14000
20M14	8.6		53M04	11000	53M04F	14000
			20C_2F	9800	20M23	13000
			53M04F	9200	20MW27	13000
			20M12F	9100	20M23F	13000
			20M08F	8700	20MW27F	13000
			20M23	8400		
			20M06	5300		
			20M21	4200		
			20M23F	4100		
			20M06F	3700		
			20M21F	2700		
			20M15	2600		
5% CL = 2045		Manganese μG/L	95% CL = 3252	Potassium	95% CL > = 10	Zinc μG/L
20M15	3700		20M07	10000	53M04	60
20M12F	2900		20M07F	10000	20M08F	40
20M07F	2800		POND	9000	20M23F	40
20M08	2700		PONDF	9000	20M21F	30
20M07	2400		20MW26	4000	POND	20
20M08F	2300		20MW26F	4000	20M06	20
					20M15	20
					PONDF	20
					20C_2F	20

TABLE VII.4. (Contd)

Site 48					
Arsenic		Barium		Calcium	
95% CL = 15	µG/L	95% CL = 119	µG/L	95% CL = 59373	µG/L
53M03	38	48M01F	590	48M01	130000
48MW8F	25	48M01	580	48M01F	130000
48MW8	24	53M03	320	53M03	80000
48M07	20	48MW8F	300	53M03F	80000
53M03F	17	53M03F	300	48M03	76000
		48MW8	290	48M03F	75000
		48M03	230	48M07F	62000
		48M07	180	48M07	60000
		48M03F	180		
		48M07F	180		
Chromium		Iron		Magnesium	
5% CL > = 20	µG/L	95% CL = 2545	µG/L	95% CL = 12731	µG/L
48M03	20	48M01F	71000	48M01F	26000
		48M01	70000	48M01	25000
		53M03	23000	53M03	21000
Lead					
95% CL > = 5	µG/L	53M03F	23000	53M03F	21000
		48MW8F	17000	48M03	15000
53M03	14	48MW8	16000	48M03F	15000
		48M07	13000	48M07	13000
		48M07F	8200	48MW8	13000
				48M07F	13000
				48MW8F	13000
Manganese		Potassium		Sodium	
5% CL = 2045	µG/L	95% CL = 3252	µG/L		µG/L
48M03	4500	48M01	8000	48M01	11000
48MW8F	3900	48M01F	8000	48M01F	11000
48MW8	3800	48M03	4000	48M03	9700
48M01F	3500	48M07	4000	48M03F	9600
48M01	3400	48MW8	4000	53M03F	9100
53M03	3100	48M03F	4000	53M03	8900
53M03F	3100	48MW8F	4000	48M07F	6300
				48M07	6200
Zinc		Soil 95% CLs			
5% CL > = 10	µG/L				
48MW8	20	ST48_4S	µG/KG	95% CLs	
48MW8F	20	Barium	350000	153200	
48M07	10	Lead	21000	11600	
		Zinc	130000	75200

TABLE VII.4. (Contd)

Site 49		Barium		Calcium	
Arsenic		$\mu\text{G/L}$		$\mu\text{G/L}$	
95% CL = 15		95% CL = 119		95% CL = 59373	
49M01	19	53M05	280	49M02F	70000
49M05	16	49M01	250	49M02	63000
		49M05	250	49M05	63000
		49M05F	240	49M05F	63000
Copper		53M05F	210		
5% CL > = 20	$\mu\text{G/L}$	49M01F	160		
49M01	20	49M02	120		
53M05	20				
Iron		Magnesium		Manganese	
5% CL = 2545	$\mu\text{G/L}$	$\mu\text{G/L}$		$\mu\text{G/L}$	
49M01	19000	49M02F	14000	49M01	4000
53M05	14000	49M02	13000	49M01F	3800
49M05	13000	49M05	13000	49M05F	3800
49M05F	12000	53M05	13000	49M05	3700
53M05F	6800	49M05F	13000	53M05	2700
49M01F	5800			53M05F	2400
Lead		Potassium		Sodium	
95% CL > = 5	$\mu\text{G/L}$	95% CL = 3252	$\mu\text{G/L}$	95% CL = 5769	$\mu\text{G/L}$
SL_2	11	49M02	4000	49M01F	7500
53M05	6.3	49M05	4000	49M01	6900
		53M05	4000	49M05F	5800
		49M02F	4000		
Zinc		Soil 95% CLs		95% CLs	
5% CL > = 10	$\mu\text{G/L}$				
SL_2	210	ST49_8S	$\mu\text{G/KG}$		
SL_2F	150	Lead	22000		11600
49M01	50	Zinc	120000		75200
53M05	40				
49M02	20				

TABLE VII.4. (Contd)

Site 80 (Using Eielson 95% Confidence Limit Values for Groundwater Samples)

Arsenic cl = 15 µG/L		Barium cl = 119 µG/L		Calcium cl = 59373 µG/L	
SOM08	31	SOM08	1000	SOM05	150000
SOM02	21	SOM08	900	SOM05F	140000
SOM05	19	SOM10	890	SOM02	81000
SOM05F	17	SOM08	480	SOM10	74000
		SOM08F	420	SOM08	74000
		SOM07	400	SOM08	74000
		SOM02	400	SOM02F	64000
		SOM10F	140	SOM07	63000
		SOM01	120	OWF	60000
		SOM01F	120		
Cobalt cl > = 20 µG/L		Copper cl > = 20 µG/L		Iron µG/L	
SOM08	50				
SOM06	30				
SOM10	20				
Chromium cl > = 20 µG/L		Copper cl > = 20 µG/L		Iron µG/L	
SOM08	100	SOM10	140	SOM08	100000
SOM06	70	SOM08	140	SOM08	93000
SOM10	50	SOM08	130	SOM10	57000
SOM07	50	SOM07	90	SOM07	54000
SOM02	30	SOM02	50	SOM02	47000
				SOM05	30000
				SOM05F	25000
Lead cl > = 5 µG/L		Magnesium cl = 12731 µG/L		Manganese cl = 2045 µG/L	
SOM08	96	SOM08	31000	SOM05	15000
SOM06	80	SOM08	28000	SOM05F	15000
SOM10	71	SOM10	26000	SOM08	12000
SOM07	70	SOM08	25000	SOM06	9200
SOM02	43	SOM05F	24000	SOM06F	4500
SOM10F	8.5	SOM02	21000	SOM10	3300
		SOM07	19000	SOM02	3100
		SOM04F	15000		
		SOM04	13000		
		SOM10F	13000		
Nickel cl > = 30 µG/L		Potassium cl = 3252 µG/L		Sodium cl = 5769 µG/L	
SOM08	110	SOM08	8000	SOM02	13000
SOM10	90	SOM10	7000	SOM05	10000
SOM06	90	SOM08	7000	SOM05F	9700
SOM07	50	SOM08	6000	SOM02F	7800
SOM02	40	SOM05F	6000	SOM08	7700
		SOM07	5000	SOM10	6100
		SOM02	4000		
Vanadium cl > = 30 µG/L		Zinc cl > = 10 µG/L			
SOM08	90	SOM10	3700		
SOM06	90	SOM10F	970		
SOM10	70	SOM08	390		
SOM07	50	SOM08	380		
SOM02	30	SOM07	230		
		SOM02	200		
		OW	70		
		NW	70		
		NWF	30		
		SOM05	20		
		SOM07F	20		

TABLE VII.4. (Contd)

Site 50 (Blair Lakes) Soils

Peaks in comparison to maximum local background values at the Blair Lakes soil test pits.

LM - local maximum value

Chromium		Copper		Iron	
LM = 23000	µG/KG	LM = 31000	µG/KG	LM = 27000000	µG/KG
50M02SB	25800	50M02SB	42700	50M06SB	34300000
		50M06SB	36800	50M02SB	29200000
Lead		Manganese		Zinc	
LM = 20000	µG/KG	LM = 640000	µG/KG	LM = 100000	µG/KG
50M02SB	31900	50M02SB	661000.00	50M02SB	157.000 mg/kg
50M06SA	26200			50M06SB	136.000 mg/kg
50M06SB	26100		Nickel	50M04SA	103.000 mg/kg
50M04SA	24500	LM = 31000	µG/KG		
50M06SB	24500				
50M02SB	22300	50M02SB	38600		
		50M06SB	33400		

APPENDIX VIII - ANALYTICAL DATA

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Operable Unit 1

Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Media Area	Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Soil	Stage 3	2-Methylnaphthalene	30	ug/kg	14	2	3000	42000	48TP04
			Benzene	44	ug/kg	14	1	112	112	48TP04
			Bis(2-ethylhexyl) phthalate	100	ug/kg	14	1	1200	1200	48M04
			Chlorobenzene	20	ug/kg	14	1	80	80	48TP04
			Di-n-octylphthalate	150	ug/kg	14	1	700	700	53M03
			Ethylbenzene	80	ug/kg	14	1	3700	3700	48TP04
			Fluorene	30	ug/kg	14	1	210	210	53M03
			Lead	4560	ug/kg	13	9	5420	23500	48M02
			Moisture	.	Percent	14	14	1.9	37.1	48TP02
			Naphthalene	9	ug/kg	14	2	1400	21000	48TP04
			Phenanthrene	20	ug/kg	14	1	110	110	53M03
			TPH	10000	ug/kg	14	8	38600	13000000	48TP04
			Toluene	160	ug/kg	14	1	410	410	48TP04
			Xylenes (total)	80	ug/kg	14	2	0.42	18.2	48TP04

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Operable Unit 1

Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Media Area	Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Soil	Stage 4	Moisture	.	Percent	24	24	1.7	27.9	48SB09
			TPH	10000	ug/kg	100	40	13000	32000000	48SB02

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Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Soil	1993	0,0,0-Triethyl phosphorothioate	660	ug/kg	6	.	.	.	.
			0,0-Diethyl 0-2-pyrazinyl phosphorothio	660	ug/kg	6	.	.	.	.
			1,2,4,5-Tetrachlorobenzene	660	ug/kg	6	.	.	.	.
			1,2,4-Trichlorobenzene	660	ug/kg	6	.	.	.	.
			1,2-Dichlorobenzene	660	ug/kg	6	.	.	.	.
			1,3-Dichlorobenzene	660	ug/kg	6	.	.	.	.
			1,4-Dichlorobenzene	660	ug/kg	6	.	.	.	.
			1,4-Napthoquinone	660	ug/kg	6	.	.	.	.
			1-Naphthylamine	660	ug/kg	6	.	.	.	.
			2,3,4,6-Tetrachlorophenol	660	ug/kg	6	.	.	.	.
			2,4,5-Trichlorophenol	660	ug/kg	6	.	.	.	.
			2,4,6-Trichlorophenol	660	ug/kg	6	.	.	.	.
			2,4-Dichlorophenol	660	ug/kg	6	.	.	.	.
			2,4-Dimethylphenol	660	ug/kg	6	.	.	.	.
			2,4-Dinitrophenol	3300	ug/kg	6	.	.	.	.
			2,4-Dinitrotoluene	660	ug/kg	6	.	.	.	.
			2,6-Dichlorophenol	660	ug/kg	6	.	.	.	.
			2,6-Dinitrotoluene	660	ug/kg	6	.	.	.	.
			2-Acetylaminofluorene	660	ug/kg	6	.	.	.	.
			2-Chloronaphthalene	660	ug/kg	6	.	.	.	.
			2-Chlorophenol	660	ug/kg	6	.	.	.	.
			2-Methylnaphthalene	660	ug/kg	6	1	46000	46000	53M03
			2-Methylphenol	660	ug/kg	6	.	.	.	.
			2-Naphthylamine	660	ug/kg	6	.	.	.	.
			2-Nitroaniline	3300	ug/kg	6	.	.	.	.
			2-Nitrophenol	660	ug/kg	6	.	.	.	.
			2-Picoline	660	ug/kg	6	.	.	.	.
			3,3'-Dichlorobenzidine	1300	ug/kg	6	.	.	.	.
			3,3'-Dimethylbenzidine	660	ug/kg	6	.	.	.	.
			3-Methylcholanthrene	660	ug/kg	6	.	.	.	.
			3-Nitroaniline	3300	ug/kg	6	.	.	.	.
			4,4'-DDD	20	ug/kg	3	2	4.4	63	COMPOSITE
			4,4'-DDE	10	ug/kg	3	1	47	47	COMPOSITE
			4,4'-DDT	20	ug/kg	3	1	180	180	COMPOSITE
			4,6-Dinitro-o-cresol	3300	ug/kg	6	.	.	.	.
			4-Aminobiphenyl	660	ug/kg	6	.	.	.	.
			4-Bromophenylphenyl ether	660	ug/kg	6	.	.	.	.
			4-Chloro-3-methylphenol	1300	ug/kg	6	.	.	.	.
			4-Chloroaniline	1300	ug/kg	6	.	.	.	.
			4-Chlorophenylphenyl ether	660	ug/kg	6	.	.	.	.
			4-Methylphenol	660	ug/kg	6	.	.	.	.
			4-Nitroaniline	3300	ug/kg	6	.	.	.	.
			4-Nitrophenol	3300	ug/kg	6	.	.	.	.
			4-Nitroquinoline-1-oxide	660	ug/kg	6	.	.	.	.
			5-Nitro-o-toluidine	660	ug/kg	6	.	.	.	.
			7,12-Dimethylbenz[a]anthracene	660	ug/kg	6	.	.	.	.
			Acenaphthene	660	ug/kg	6	.	.	.	.
			Acenaphthylene	660	ug/kg	6	.	.	.	.
			Acetophenone	660	ug/kg	6	.	.	.	.
			Aldrin	10	ug/kg	3	.	.	.	.
			Alpha-BHC	10	ug/kg	3	.	.	.	.
			Aluminum	20000	ug/kg	2	2	11000000	11000000	NEW WELL
			Aniline	660	ug/kg	6	.	.	.	.
			Anthracene	660	ug/kg	6	1	400	400	NEW WELL
			Antimony	20000	ug/kg	2	.	.	.	.
			Aramite	660	ug/kg	6	.	.	.	.
			Aroclor-1016	100	ug/kg	6	.	.	.	.
			Aroclor-1221	200	ug/kg	6	.	.	.	.

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Eielson Air Force Base, Alaska
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 Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Soil	1993	Aroclor-1232	200	ug/kg	6	.	.	.	.
			Aroclor-1242	100	ug/kg	6	.	.	.	.
			Aroclor-1248	100	ug/kg	6	.	.	.	.
			Aroclor-1254	100	ug/kg	6	.	.	.	.
			Aroclor-1260	100	ug/kg	6	.	.	.	.
			Arsenic	500	ug/kg	2	2	4800	7400	NEW WELL
			Barium	2000	ug/kg	2	2	130000	350000	NEW WELL
			Benzo(a)anthracene	660	ug/kg	6	1	970	970	NEW WELL
			Benzo(a)pyrene	660	ug/kg	6	1	980	980	NEW WELL
			Benzo(b)fluoranthene	660	ug/kg	6	1	950	950	NEW WELL
			Benzo(ghi)perylene	660	ug/kg	6	1	540	540	NEW WELL
			Benzo(k)fluoranthene	660	ug/kg	6	1	870	870	NEW WELL
			Benzothiazole	660	ug/kg	6	.	.	.	.
			Benzyl alcohol	1300	ug/kg	6	.	.	.	.
			Beryllium	300	ug/kg	2	2	400	400	NEW WELL
			Beta-BHC	10	ug/kg	3	.	.	.	.
			Bis(2-Chloroethoxy)methane	660	ug/kg	6	.	.	.	.
			Bis(2-Chloroisopropyl) ether	660	ug/kg	6	.	.	.	.
			Bis(2-chloroethyl) ether	660	ug/kg	6	.	.	.	.
			Bis(2-ethylhexyl) phthalate	660	ug/kg	6	2	150	660	NEW WELL
			Butylbenzylphthalate	660	ug/kg	6	.	.	.	.
			Cadmium	1000	ug/kg	2	1	430	430	NEW WELL
			Calcium	10000	ug/kg	2	2	6000000	11000000	NEW WELL
			Chlordane	50	ug/kg	3	1	15	15	COMPOSITE
			Chlorobenzilate	660	ug/kg	6	.	.	.	.
			Chromium	2000	ug/kg	2	2	19000	24000	NEW WELL
			Chrysene	660	ug/kg	6	1	1100	1100	NEW WELL
			Cobalt	2000	ug/kg	2	2	7000	9000	NEW WELL
			Copper	2000	ug/kg	2	2	18000	24000	NEW WELL
			Delta-BHC	20	ug/kg	3	.	.	.	.
			Di-n-butylphthalate	660	ug/kg	6	.	.	.	.
			Di-n-octylphthalate	660	ug/kg	6	.	.	.	.
			Diallate	660	ug/kg	6	.	.	.	.
			Dibenz[a,h]anthracene	660	ug/kg	6	.	.	.	.
			Dibenzofuran	660	ug/kg	6	.	.	.	.
			Dieldrin	10	ug/kg	3	.	.	.	.
			Diethylphthalate	660	ug/kg	6	.	.	.	.
			Dimethoate	660	ug/kg	6	.	.	.	.
			Dimethyl phthalate	660	ug/kg	6	.	.	.	.
			Diphenylamine	660	ug/kg	6	.	.	.	.
			Endosulfan I	10	ug/kg	3	.	.	.	.
			Endosulfan II	10	ug/kg	3	.	.	.	.
			Endosulfan sulfate	20	ug/kg	3	.	.	.	.
			Endrin	10	ug/kg	3	.	.	.	.
			Endrin Aldehyde	50	ug/kg	3	.	.	.	.
			Ethyl methanesulfonate	660	ug/kg	6	.	.	.	.
			Famphur	660	ug/kg	6	.	.	.	.
			Fluoranthene	660	ug/kg	6	1	2200	2200	NEW WELL
			Fluorene	660	ug/kg	6	.	.	.	.
			Gamma-BHC (Lindane)	10	ug/kg	3	.	.	.	.
			Heptachlor	10	ug/kg	3	1	1	1	COMPOSITE
			Heptachlor epoxide	60	ug/kg	3	.	.	.	.
			Hexachlorobenzene	660	ug/kg	6	.	.	.	.
			Hexachlorobutadiene	660	ug/kg	6	.	.	.	.
			Hexachlorocyclopentadiene	660	ug/kg	6	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Soil	1993	Hexachloroethane	660	ug/kg	6	.	.	.	.
			Hexachlorophene	660	ug/kg	6	.	.	.	.
			Hexachloropropene	660	ug/kg	6	.	.	.	.
			Indeno (1,2,3-cd) pyrene	660	ug/kg	6	1	510	510	NEW WELL
			Iron	2000	ug/kg	2	2	12000000	19000000	NEW WELL
			Isodrin	660	ug/kg	6	.	.	.	.
			Isophorone	660	ug/kg	6	.	.	.	.
			Isosafrole	660	ug/kg	6	.	.	.	.
			Kepone	660	ug/kg	6	1	370000	370000	53M03
			Kerosene	660	ug/kg	6	2	7000	21000	NEW WELL
			Lead	500	ug/kg	2	2	3800000	4900000	NEW WELL
			Magnesium	10000	ug/kg	2	2	260000	380000	NEW WELL
			Manganese	1000	ug/kg	2	1	100	100	NEW WELL
			Mercury	400	ug/kg	2	.	.	.	.
			Methapyrilene	660	ug/kg	6	.	.	.	.
			Methoxychlor	100	ug/kg	3	.	.	.	.
			Methyl methanesulfonate	660	ug/kg	6	.	.	.	.
			N-Nitroso-di-n-dipropylamine	660	ug/kg	6	.	.	.	.
			N-Nitrosodi-n-butylamine	660	ug/kg	6	.	.	.	.
			N-Nitrosodiethylamine	660	ug/kg	6	.	.	.	.
			N-Nitrosodimethylamine	660	ug/kg	6	.	.	.	.
			N-Nitrosodiphenylamine	660	ug/kg	6	.	.	.	.
			N-Nitrosomethylethylamine	660	ug/kg	6	.	.	.	.
			N-Nitrosomorpholine	660	ug/kg	6	.	.	.	.
			N-Nitrosopiperidine	660	ug/kg	6	1	16000	16000	53M03
			Naphthalene	660	ug/kg	6	2	17000	22000	NEW WELL
			Nickel	3000	ug/kg	2	.	.	.	.
			Nitrobenzene	660	ug/kg	6	.	.	.	.
			Nitrosopyrrolidine	660	ug/kg	6	.	.	.	.
			Parathion	660	ug/kg	6	.	.	.	.
			Pentachlorobenzene	660	ug/kg	6	.	.	.	.
			Pentachloronitrobenzene (PCNB)	660	ug/kg	6	.	.	.	.
			Pentachlorophenol	3300	ug/kg	6	.	.	.	.
			Phenacetin	660	ug/kg	6	1	1500	1500	NEW WELL
			Phenanthrene	660	ug/kg	6	.	.	.	.
			Phenol	660	ug/kg	6	2	900000	1100000	NEW WELL
			Potassium	30000	ug/kg	2	2	.	.	.
			Pronamide	660	ug/kg	6	.	.	.	.
			Pyrene	660	ug/kg	6	1	2000	2000	NEW WELL
			Pyridine	660	ug/kg	6	.	.	.	.
			Safrol	660	ug/kg	6	.	.	.	.
			Silver	2000	ug/kg	2	.	.	.	.
			Sodium	30000	ug/kg	2	2	340000	690000	NEW WELL
			TPH-diesel	4300	ug/kg	1	1	4900	11000	COALPILE
			TPH-diesel	4300	ug/kg	2	1	4900	11000	COALPILE
			TPH-gasoline	5100	ug/kg	1	.	.	.	.
			TPH-gasoline	5400	ug/kg	2	.	.	.	.
			Tetraethyl dithiopyrophosphate	660	ug/kg	6	.	.	.	.
			Tin	10000	ug/kg	2	.	.	.	.
			Toxaphene	400	ug/kg	3	.	.	.	.
			Tributyl phosphate	660	ug/kg	6	.	.	.	.
			Tris-2-chloroethyl phosphate	660	ug/kg	6	.	.	.	.
			Vanadium	3000	ug/kg	2	2	33000	44000	NEW WELL
			Zinc	10	ug/kg	2	2	34000	130000	NEW WELL
			alpha, alpha-Dimethylphenethylamine	660	ug/kg	6	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Soil	1993	m-Cresol	660	ug/kg	6	.	.	.	.
			m-Dinitrobenzene	660	ug/kg	6	.	.	.	.
			o-Toluidine	660	ug/kg	6	.	.	.	.
			p-Dimethylaminoazobenzene	660	ug/kg	6	.	.	.	.
			p-Phenylenediamine	660	ug/kg	6	.	.	.	.
			sym-Trinitrobenzene	660	ug/kg	6	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Soil Gas	Stage 3	1,3-Dimethylbenzene	10	ug/L	45	12	10	2610	48SV32
			BTEX	10	ug/L	45	24	10	43400	48SV20
			Benzene	10	ug/L	45	14	10	390	48SV01
			Ethylbenzene	10	ug/L	45	15	10	11800	48SV32
			Toluene	10	ug/L	45	17	10	39600	48SV20

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Water	Stage 3	2,4-Dimethylphenol	0.28	ug/L	9	1	5.1	5.1	48M01
			2-Methylnaphthalene	0.9	ug/L	9	2	130	261	53M03
			Aluminum (Unfiltered)	30	ug/L	1	1	11900	11900	53M03
			Arsenic (Filtered)	40	ug/L	1	1	20	20	53M03
			Arsenic (Unfiltered)	40	ug/L	1	1	26.8	26.8	53M03
			Barium (Filtered)	1	ug/L	1	1	50	50	53M03
			Barium (Unfiltered)	1	ug/L	1	1	722	722	53M03
			Benzene	0.15	ug/L	9	5	0.34	1330	48M01
			Bis(2-ethylhexyl) phthalate	2	ug/L	9	1	700	700	48P01
			Butylbenzylphthalate	1.5	ug/L	9	1	520	520	48P01
			Calcium (Filtered)	13	ug/L	1	1	174000	174000	53M03
			Calcium (Unfiltered)	13	ug/L	1	1	136000	136000	53M03
			Chloride	200	ug/L	1	1	11250	11250	53M03
			Chloroform	0.2	ug/L	9	.	.	.	.
			Chromium (Unfiltered)	10	ug/L	1	1	12.3	12.3	53M03
			Cobalt (Unfiltered)	10	ug/L	1	1	18	18	53M03
			Copper (Unfiltered)	3	ug/L	1	1	118	118	53M03
			Ethylbenzene	0.46	ug/L	9	2	89.2	160	48M01
			Iron (Filtered)	20	ug/L	1	1	24700	24700	53M03
			Iron (Unfiltered)	20	ug/L	1	1	42400	42400	53M03
			Lead (Filtered)	1.4	ug/L	9	1	3	3	48M03
			Lead (Unfiltered)	1.4	ug/L	9	7	2.7	152	48M05
			Magnesium (Filtered)	44	ug/L	1	1	36900	36900	53M03
			Magnesium (Unfiltered)	44	ug/L	1	1	43700	43700	53M03
			Manganese (Filtered)	1.4	ug/L	1	1	5200	5200	53M03
			Manganese (Unfiltered)	1.4	ug/L	1	1	5670	5670	53M03
			Mercury (Filtered)	0.2	ug/L	1	1	0.7	0.7	53M03
			Mercury (Unfiltered)	0.2	ug/L	1	1	0.3	0.3	53M03
			Naphthalene	0.26	ug/L	9	2	230	440	53M03
			Nitrite/Nitrate	10	ug/L	8	4	15	185	48M04
			Potassium (Filtered)	408	ug/L	1	1	4980	4980	53M03
			Potassium (Unfiltered)	408	ug/L	1	1	7200	7200	53M03
			Residue, DISS	1000	ug/L	9	9	200000	704000	53M03
			Sodium (Filtered)	82	ug/L	1	1	11000	11000	53M03
			Sodium (Unfiltered)	82	ug/L	1	1	13200	13200	53M03
			Sulfate	500	ug/L	1	1	130700	130700	53M03
			TPH	100	ug/L	9	2	3400	44000	48M01
			Toluene	0.25	ug/L	9	2	53.2	88	48M01
			Vanadium (Unfiltered)	10	ug/L	1	1	37	37	53M03
			Xylenes (total)	0.85	ug/L	9	3	1.62	929	48M01
			Zinc (Filtered)	2	ug/L	1	1	30	30	53M03
			Zinc (Unfiltered)	2	ug/L	1	1	72.4	72.4	53M03

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Water	Stage 4	1,2-Dimethylbenzene	1	ug/L	21	8	5	1300	48FW12
			1,3-Dimethylbenzene	1	ug/L	21	9	5	3300	48FW12
			2,4-Dimethylphenol	2	ug/L	9	.	.	.	.
			2-Methylnaphthalene	1	ug/L	9	3	24	140	48M01
			Benzene	1	ug/L	30	9	3.01	7100	48FW11
			Bis(2-ethylhexyl) phthalate	2	ug/L	9	1	52	52	48M07
			Butylbenzylphthalate	1.5	ug/L	9	.	.	.	.
			Chlorobenzene	0.4	ug/L	9	.	.	.	.
			Di-n-octylphthalate	2.4	ug/L	9	.	.	.	.
			Ethylbenzene	1	ug/L	30	10	3	950	48FW12
			Fluorene	1	ug/L	9	.	.	.	.
			Naphthalene	1	ug/L	9	3	24	270	48M01
			Phenanthrene	1	ug/L	9	.	.	.	.
			TPH	200	ug/L	9	4	300	400000	48M02
			Toluene	1	ug/L	30	10	1	6600	48FW11
			Xylenes (total)	0.4	ug/L	9	2	1550	1990	53M03
			trans-1,2-Dichloroethylene	1	ug/L	21	2	17	490	48FW12

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Water	1993	0,0,0-Triethyl phosphorothioate	10	ug/L	7	.	.	.	.
			0,0-Diethyl 0-2-pyrazinyl phosphorothio	10	ug/L	7	.	.	.	.
			1,1,1-Trichloroethane	0.5	ug/L	14	.	.	.	.
			1,1,2-Trichloroethane	0.5	ug/L	14	1	0.067	0.067	48MW8
			1,1-Dichloroethane	1	ug/L	14	.	.	.	.
			1,2,4,5-Tetrachlorobenzene	10	ug/L	7	.	.	.	.
			1,2,4-Trichlorobenzene	10	ug/L	7	.	.	.	.
			1,2-Dichlorobenzene	10	ug/L	7	.	.	.	.
			1,2-Dichloroethane	0.5	ug/L	14	2	2.2	2.4	53M03
			1,3-Dichlorobenzene	10	ug/L	7	.	.	.	.
			1,4-Dichlorobenzene	2	ug/L	14	1	0.41	0.41	48MW8
			1,4-Dichlorobenzene	10	ug/L	7	.	0.41	0.41	48MW8
			1,4-Naphthoquinone	10	ug/L	7	.	.	.	.
			1-Naphthylamine	10	ug/L	7	.	.	.	.
			2,3,4,6-Tetrachlorophenol	10	ug/L	7	.	.	.	.
			2,4,5-Trichlorophenol	10	ug/L	7	.	.	.	.
			2,4,6-Trichlorophenol	10	ug/L	7	.	.	.	.
			2,4-Dichlorophenol	10	ug/L	7	.	.	.	.
			2,4-Dimethylphenol	10	ug/L	7	.	.	.	.
			2,4-Dinitrophenol	50	ug/L	7	.	.	.	.
			2,4-Dinitrotoluene	10	ug/L	7	.	.	.	.
			2,6-Dichlorophenol	10	ug/L	7	.	.	.	.
			2,6-Dinitrotoluene	10	ug/L	7	.	.	.	.
			2-Acetylaminofluorene	10	ug/L	7	.	.	.	.
			2-Chloronaphthalene	10	ug/L	7	.	.	.	.
			2-Chlorophenol	10	ug/L	7	.	.	.	.
			2-Methylnaphthalene	10	ug/L	7	3	80	130	48M01
			2-Methylphenol	10	ug/L	7	.	.	.	.
			2-Naphthylamine	10	ug/L	7	.	.	.	.
			2-Nitroaniline	50	ug/L	7	.	.	.	.
			2-Nitrophenol	10	ug/L	7	.	.	.	.
			2-Picoline	10	ug/L	7	.	.	.	.
			3,3'-Dichlorobenzidine	20	ug/L	7	.	.	.	.
			3,3'-Dimethylbenzidine	10	ug/L	7	.	.	.	.
			3-Methylcholanthrene	10	ug/L	7	.	.	.	.
			3-Nitroaniline	50	ug/L	7	.	.	.	.
			4,6-Dinitro-o-cresol	50	ug/L	7	.	.	.	.
			4-Aminobiphenyl	10	ug/L	7	.	.	.	.
			4-Bromophenylphenyl ether	10	ug/L	7	.	.	.	.
			4-Chloro-3-methylphenol	20	ug/L	7	.	.	.	.
			4-Chloroaniline	20	ug/L	7	.	.	.	.
			4-Chlorophenylphenyl ether	10	ug/L	7	.	.	.	.
			4-Methylphenol	10	ug/L	7	2	6.6	7	53M03
			4-Nitroaniline	50	ug/L	7	.	.	.	.
			4-Nitrophenol	50	ug/L	7	.	.	.	.
			4-Nitroquinoline-1-oxide	10	ug/L	7	.	.	.	.
			5-Nitro-o-toluidine	10	ug/L	7	.	.	.	.
			7,12-Dimethylbenz[a]anthracene	10	ug/L	7	.	.	.	.
			Acenaphthene	10	ug/L	7	.	.	.	.
			Acenaphthylene	10	ug/L	7	.	.	.	.
			Acetophenone	10	ug/L	7	.	.	.	.
			Aluminum (Filtered)	200	ug/L	7	.	.	.	.
			Aluminum (Unfiltered)	200	ug/L	7	3	54	1600	48M07
			Aniline	10	ug/L	7	.	.	.	.
			Anthracene	10	ug/L	7	.	.	.	.
			Antimony (Filtered)	200	ug/L	7	4	84	170	48M01
			Antimony (Unfiltered)	200	ug/L	7	7	72	130	53M03
			Aramite	10	ug/L	7	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Water	1993	Arsenic (Filtered)	5	ug/L	7	5	6.5	45	53M03
			Arsenic (Unfiltered)	5	ug/L	6	5	4	38	53M03
			Barium (Filtered)	20	ug/L	7	7	0.52	590	48M01
			Barium (Unfiltered)	20	ug/L	7	6	180	580	48M01
			Benzene	2	ug/L	14	9	0.12	910	48M01
			Benzo(a)anthracene	10	ug/L	7	.	.	.	.
			Benzo(a)pyrene	10	ug/L	7	.	.	.	.
			Benzo(b)fluoranthene	10	ug/L	7	.	.	.	.
			Benzo(ghi)perylene	10	ug/L	7	.	.	.	.
			Benzo(k)fluoranthene	10	ug/L	7	.	.	.	.
			Benzothiazole	10	ug/L	7	.	.	.	.
			Benzyl alcohol	20	ug/L	7	.	.	.	.
			Beryllium (Filtered)	3	ug/L	7	3	1.9	2.3	48M01FT
			Beryllium (Unfiltered)	3	ug/L	7	2	1.9	2.3	48M01FT
			Bis(2-Chloroethoxy)methane	10	ug/L	7	.	.	.	.
			Bis(2-Chloroisopropyl) ether	10	ug/L	7	.	.	.	.
			Bis(2-chloroethyl) ether	10	ug/L	7	.	.	.	.
			Bis(2-ethylhexyl) phthalate	10	ug/L	7	.	.	.	.
			Butylbenzylphthalate	10	ug/L	7	.	.	.	.
			Cadmium (Filtered)	10	ug/L	7	2	5	5.8	48M03
			Cadmium (Unfiltered)	10	ug/L	7	1	6.2	6.2	46M07
			Calcium (Filtered)	100	ug/L	7	7	100	130000	48M01
			Calcium (Unfiltered)	100	ug/L	7	7	59	130000	48M01
			Carbon tetrachloride	1	ug/L	14	.	.	.	.
			Chlorobenzilate	10	ug/L	7	.	.	.	.
			Chloroform	0.5	ug/L	14	.	.	.	.
			Chromium (Filtered)	20	ug/L	7	3	6.8	14	48M03
			Chromium (Unfiltered)	20	ug/L	7	3	6.4	20	48M03
			Chrysene	10	ug/L	7	.	.	.	.
			Cobalt (Filtered)	20	ug/L	7	3	4.4	6.6	48M01FT
			Cobalt (Unfiltered)	20	ug/L	7	3	4.4	8.6	48M03
			Copper (Filtered)	20	ug/L	7	1	7	7	48M03
			Copper (Unfiltered)	20	ug/L	7	5	3.5	14	53M03
			Di-n-butylphthalate	10	ug/L	7	.	.	.	.
			Di-n-octylphthalate	10	ug/L	7	.	.	.	.
			Diallate	10	ug/L	7	.	.	.	.
			Dibenz[a,h]anthracene	10	ug/L	7	.	.	.	.
			Dibenzofuran	10	ug/L	7	.	.	.	.
			Diethylphthalate	10	ug/L	7	.	.	.	.
			Dimethoate	10	ug/L	7	.	.	.	.
			Dimethyl phthalate	10	ug/L	7	.	.	.	.
			Diphenylamine	10	ug/L	7	.	.	.	.
			Ethyl methanesulfonate	10	ug/L	7	.	.	.	.
			Ethylbenzene	2	ug/L	14	7	0.12	150	48MW8
			Famphur	10	ug/L	7	.	.	.	.
			Fluoranthene	10	ug/L	7	.	.	.	.
			Fluorene	10	ug/L	7	.	.	.	.
			Hexachlorobenzene	10	ug/L	7	.	.	.	.
			Hexachlorobutadiene	10	ug/L	7	.	.	.	.
			Hexachlorocyclopentadiene	10	ug/L	7	.	.	.	.
			Hexachloroethane	10	ug/L	7	.	.	.	.
			Hexachlorophene	10	ug/L	7	.	.	.	.
			Hexachloropropene	10	ug/L	7	.	.	.	.
			Indeno(1,2,3-cd)pyrene	10	ug/L	7	.	.	.	.
			Iron (Filtered)	20	ug/L	7	7	20	71000	48M01

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Water	1993	Iron (Unfiltered)	20	ug/L	7	7	20	70000	48M01
			Isodrin	10	ug/L	7	.	.	.	.
			Isophorone	10	ug/L	7	.	.	.	.
			Isosafrole	10	ug/L	7	.	.	.	.
			Kepon	10	ug/L	7	.	.	.	.
			Kerosene	10000	ug/L	7	.	.	.	.
			Lead (Filtered)	5	ug/L	7	2	3	4	48M01
			Lead (Unfiltered)	5	ug/L	6	4	2	14	53M03
			Magnesium (Filtered)	100	ug/L	7	7	38	26000	48M01
			Magnesium (Unfiltered)	100	ug/L	7	7	26	25000	48M01
			Manganese (Filtered)	10	ug/L	7	6	1500	3900	48MW8
			Manganese (Unfiltered)	10	ug/L	7	6	2000	4500	48M03
			Mercury (Filtered)	0.2	ug/L	7	1	0.3	0.3	48MW8
			Mercury (Unfiltered)	0.2	ug/L	7	2	0.2	0.4	48MW8
			Methapyrilene	10	ug/L	7	.	.	.	.
			Methyl methanesulfonate	10	ug/L	7	.	.	.	.
			Methylenechloride	5	ug/L	14	4	0.069	0.25	48M03
			N-Nitroso-di-n-dipropylamine	10	ug/L	7	.	.	.	.
			N-Nitrosodi-n-butylamine	10	ug/L	7	.	.	.	.
			N-Nitrosodiethylamine	10	ug/L	7	.	.	.	.
			N-Nitrosodimethylamine	10	ug/L	7	.	.	.	.
			N-Nitrosodiphenylamine	10	ug/L	7	.	.	.	.
			N-Nitrosomethylethylamine	10	ug/L	7	.	.	.	.
			N-Nitrosomorpholine	10	ug/L	7	.	.	.	.
			N-Nitrosopiperidine	10	ug/L	7	.	.	.	.
			Naphthalene	10	ug/L	7	4	74	250	48M01
			Nickel (Filtered)	30	ug/L	7	.	.	.	.
			Nickel (Unfiltered)	30	ug/L	7	1	25	25	48M03
			Nitrobenzene	10	ug/L	7	.	.	.	.
			Nitrosopyrrolidine	10	ug/L	7	.	.	.	.
			Parathion	10	ug/L	7	.	.	.	.
			Pentachlorobenzene	10	ug/L	7	.	.	.	.
			Pentachloronitrobenzene (PCNB)	10	ug/L	7	.	.	.	.
			Pentachlorophenol	50	ug/L	7	.	.	.	.
			Phenacetin	10	ug/L	7	.	.	.	.
			Phenanthrene	10	ug/L	7	.	.	.	.
			Phenol	10	ug/L	7	1	51	51	48M01
			Potassium (Filtered)	300	ug/L	7	6	3000	6000	48M01
			Potassium (Unfiltered)	300	ug/L	7	6	3000	6000	48M01
			Pronamide	10	ug/L	7	.	.	.	.
			Pyrene	10	ug/L	7	.	.	.	.
			Pyridine	10	ug/L	7	.	.	.	.
			Safrol	10	ug/L	7	.	.	.	.
			Silver (Filtered)	20	ug/L	7	4	3.9	4.6	48MW8
			Silver (Unfiltered)	20	ug/L	7	4	2.9	5.4	48M07
			Sodium (Filtered)	300	ug/L	7	7	55	11000	48M01
			Sodium (Unfiltered)	300	ug/L	7	7	110	11000	48M01
			Tetrachloroethene	0.5	ug/L	14	6	0.14	3.7	53M03
			Tetraethyl dithiopyrophosphate	10	ug/L	7	.	.	.	.
			Tin (Filtered)	100	ug/L	7	.	.	.	.
			Tin (Unfiltered)	100	ug/L	7	2	52	60	53M03
			Toluene	2	ug/L	14	8	0.13	820	48MW8
			Tributyl phosphate	10	ug/L	7	.	.	.	.
			Trichloroethene	1	ug/L	14	10	0.18	2.1	48M07
			Tris-2-chloroethyl phosphate	10	ug/L	7	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
48	Water	1993	Vanadium (Filtered)	30	ug/L	7	3	7.6	12	53M03
			Vanadium (Unfiltered)	30	ug/L	7	4	7.7	13	53M03
			Vinyl chloride	2	ug/L	14	.	.	.	.
			Xylenes (total)	5	ug/L	14	7	0.34	570	48MW8
			Zinc (Filtered)	10	ug/L	7	4	4.4	20	48MW8
			Zinc (Unfiltered)	10	ug/L	7	4	7.6	20	48MW8
			alpha, alpha-Dimethylphenethylamine	10	ug/L	7	.	.	.	.
			cis-1,2-Dichloroethylene	1	ug/L	14	9	0.42	1.4	48M04
			m-Cresol	10	ug/L	7	.	.	.	.
			m-Dinitrobenzene	10	ug/L	7	.	.	.	.
			o-Toluidine	10	ug/L	7	.	.	.	.
			p-Dimethylaminoazobenzene	10	ug/L	7	.	.	.	.
			p-Phenylenediamine	10	ug/L	7	.	.	.	.
			sym-Trinitrobenzene	10	ug/L	7	.	.	.	.
			trans-1,2-Dichloroethylene	1	ug/L	14	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Media Area Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Soil	Stage 3	4,4'-DDD	1 ug/kg	2	1	356	356	53M05
		Aluminum	14700	ug/kg	2	2	9900000	10300000	49M01
		Arsenic	6390	ug/kg	2	2	9320	9340	49M01
		Barium	330	ug/kg	2	2	92100	108000	49M01
		Benzo(a)anthracene	10	ug/kg	10	3	120	390	49M04
		Benzo(a)pyrene	9	ug/kg	10	2	140	400	49M03
		Benzo(b)fluoranthene	30	ug/kg	10	1	160	160	49M01
		Benzo(ghi)perylene	40	ug/kg	10	1	40	40	49M03
		Beryllium	320	ug/kg	2	2	925	1180	49M01
		Bis(2-ethylhexyl) phthalate	100	ug/kg	10	2	130	160	49M01
		Butylbenzylphthalate	70	ug/kg	10	1	390	390	49M04
		Calcium	5400	ug/kg	2	2	6060	5190000	49M01
		Chromium	720	ug/kg	2	2	18700	18900	49M01
		Chrysene	70	ug/kg	10	2	190	490	49M03
		Cobalt	770	ug/kg	4	4	11500	18900	49M01
		Copper	210	ug/kg	2	2	27000	34600	49M01
		DOT, PP'	1	ug/kg	2	1	76	76	53M0P
		Endosulfan I	1	ug/kg	2	.	.	.	.
		Endosulfan II	1	ug/kg	2	.	.	.	.
		Endosulfan sulfate	1	ug/kg	2	.	.	.	.
		Fluoranthene	50	ug/kg	10	3	300	630	49M04
		Indeno(1,2,3-cd)pyrene	50	ug/kg	10	2	90	290	49M03
		Iron	8100	ug/kg	2	2	18700000	19800000	49M01
		Lead	4560	ug/kg	2	2	7390	8530	49M01
		Magnesium	4400	ug/kg	2	2	5860000	6320000	49M01
		Manganese	250	ug/kg	2	2	355000	437000	49M01
		Methylenechloride	150	ug/kg	10	5	220	1500	49M01
		Moisture	.	Percent	10	10	1.6	21.7	49M03
		Nickel	2000	ug/kg	2	2	23.6	25.6	49M01
		Phenanthrene	20	ug/kg	10	3	230	520	49M04
		Potassium	77600	ug/kg	2	2	889000	890000	49M01
		Pyrene	60	ug/kg	10	3	300	650	49M04
		Sodium	21900	ug/kg	2	2	419000	435000	49M01
		TPH	10000	ug/kg	10	4	172000	2530000	53M0P
		Vanadium	1700	ug/kg	2	2	36.6	38.7	49M01
		Zinc	610	ug/kg	2	2	59700	71600	49M01

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Soil	Stage 4	Moisture	.	Percent	9	9	6.9	33	49SB05
			TPH	10000	ug/kg	25	19	12000	860000	49SB03

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Soil	1993	0,0,0-Triethyl phosphorothioate	660	ug/kg	8	.	.	.	
			0,0-Diethyl 0-2-pyrazinyl phosphorothio	660	ug/kg	8	.	.	.	
			1,1,1-Trichloroethane	0.5	ug/kg	9	.	.	.	
			1,1,2-Trichloroethane	0.5	ug/kg	9	.	.	.	
			1,1-Dichloroethane	1	ug/kg	9	1	2	2	DIRECTED
			1,2,4,5-Tetrachlorobenzene	660	ug/kg	8	.	.	.	
			1,2,4-Trichlorobenzene	660	ug/kg	8	.	.	.	
			1,2-Dichlorobenzene	660	ug/kg	8	.	.	.	
			1,2-Dichloroethane	0.5	ug/kg	9	.	.	.	
			1,3-Dichlorobenzene	660	ug/kg	8	.	.	.	
			1,4-Dichlorobenzene	2	ug/kg	9	1	0.39	0.39	SUMP53M05
			1,4-Dichlorobenzene	660	ug/kg	8	.	0.39	0.39	SUMP53M05
			1,4-Napththoquinone	660	ug/kg	8	.	.	.	
			1-Napththylamine	660	ug/kg	8	.	.	.	
			2,3,4,6-Tetrachlorophenol	660	ug/kg	8	.	.	.	
			2,4,5-Trichlorophenol	660	ug/kg	8	.	.	.	
			2,4,6-Trichlorophenol	660	ug/kg	8	.	.	.	
			2,4-Dichlorophenol	660	ug/kg	8	.	.	.	
			2,4-Dimethylphenol	660	ug/kg	8	.	.	.	
			2,4-Dinitrophenol	3300	ug/kg	8	.	.	.	
			2,4-Dinitrotoluene	660	ug/kg	8	.	.	.	
			2,6-Dichlorophenol	660	ug/kg	8	.	.	.	
			2,6-Dinitrotoluene	660	ug/kg	8	.	.	.	
			2-Acetylaminofluorene	660	ug/kg	8	.	.	.	
			2-Chloronaphthalene	660	ug/kg	8	.	.	.	
			2-Chlorophenol	660	ug/kg	8	.	.	.	
			2-Methylnaphthalene	660	ug/kg	8	1	220	220	SLOUGH
			2-Methylphenol	660	ug/kg	8	.	.	.	
			2-Napththylamine	660	ug/kg	8	.	.	.	
			2-Nitroaniline	3300	ug/kg	8	.	.	.	
			2-Nitrophenol	660	ug/kg	8	.	.	.	
			2-Picoline	660	ug/kg	8	.	.	.	
			3,3'-Dichlorobenzidine	1300	ug/kg	8	.	.	.	
			3,3'-Dimethylbenzidine	660	ug/kg	8	.	.	.	
			3-Methylcholanthrene	660	ug/kg	8	.	.	.	
			3-Nitroaniline	3300	ug/kg	8	.	.	.	
			4,4'-DDD	20	ug/kg	6	6	22	1000	GARRISON S
			4,4'-DDE	10	ug/kg	6	4	40	240	COMPOSITE
			4,4'-DDT	20	ug/kg	6	4	60	2900	COMPOSITE
			4,6-Dinitro-o-cresol	3300	ug/kg	8	.	.	.	
			4-Aminobiphenyl	660	ug/kg	8	.	.	.	
			4-Bromophenylphenyl ether	660	ug/kg	8	.	.	.	
			4-Chloro-3-methylphenol	1300	ug/kg	8	.	.	.	
			4-Chloroaniline	1300	ug/kg	8	.	.	.	
			4-Chlorophenylphenyl ether	660	ug/kg	8	.	.	.	
			4-Methylphenol	660	ug/kg	8	.	.	.	
			4-Nitroaniline	3300	ug/kg	8	.	.	.	
			4-Nitrophenol	3300	ug/kg	8	.	.	.	
			4-Nitroquinoline-1-oxide	660	ug/kg	8	.	.	.	
			5-Nitro-o-toluidine	660	ug/kg	8	.	.	.	
			7,12-Dimethylbenz[a]anthracene	660	ug/kg	8	.	.	.	
			Acenaphthene	660	ug/kg	8	1	1000	1000	SLOUGH
			Acenaphthylene	660	ug/kg	8	.	.	.	
			Acetophenone	660	ug/kg	8	.	.	.	
			Aldrin	10	ug/kg	6	1	1.5	1.5	SUMP
			Alpha-BHC	10	ug/kg	6	2	0.34	0.35	GARRISON S
			Aluminum	20000	ug/kg	3	3	8300000	11000000	SLOUGH
			Aniline	660	ug/kg	8	.	.	.	

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Soil	1993	Anthracene	660	ug/kg	8	1	2300	2300	SLOUGH
			Antimony	20000	ug/kg	3	.	.	.	
			Aramite	660	ug/kg	8	.	.	.	
			Aroclor-1016	100	ug/kg	6	.	.	.	
			Aroclor-1221	200	ug/kg	6	.	.	.	
			Aroclor-1232	200	ug/kg	6	.	.	.	
			Aroclor-1242	100	ug/kg	6	.	.	.	
			Aroclor-1248	100	ug/kg	6	.	.	.	
			Aroclor-1254	100	ug/kg	6	.	.	.	
			Aroclor-1260	100	ug/kg	6	.	.	.	
			Arsenic	500	ug/kg	3	3	2500	5600	GARRISON S
			Barium	2000	ug/kg	3	3	86000	96000	SLOUGH
			Benzene	2	ug/kg	9	2	0.43	0.56	SUMP53M05
			Benzo(a)anthracene	660	ug/kg	8	2	470	4600	SLOUGH
			Benzo(a)pyrene	660	ug/kg	8	2	550	6200	SLOUGH
			Benzo(b)fluoranthene	660	ug/kg	8	2	500	6500	SLOUGH
			Benzo(ghi)perylene	660	ug/kg	8	2	300	4400	SLOUGH
			Benzo(k)fluoranthene	660	ug/kg	8	2	530	5300	SLOUGH
			Benzothiazole	660	ug/kg	8	.	.	.	
			Benzyl alcohol	1300	ug/kg	8	.	.	.	
			Beryllium	300	ug/kg	3	.	.	.	
			Beta-BHC	10	ug/kg	6	2	0.44	1.7	SUMP53M05
			Bis(2-Chloroethoxy)methane	660	ug/kg	8	.	.	.	
			Bis(2-Chloroisopropyl) ether	660	ug/kg	8	.	.	.	
			Bis(2-chloroethyl) ether	660	ug/kg	8	.	.	.	
			Bis(2-ethylhexyl) phthalate	660	ug/kg	8	3	120	860	DIRECTED
			Butylbenzylphthalate	660	ug/kg	8	.	.	.	
			Cadmium	1000	ug/kg	3	3	3400000	5100000	SLOUGH
			Calcium	10000	ug/kg	3	3	.	.	
			Carbon tetrachloride	1	ug/kg	9	.	.	.	
			Chlordane	50	ug/kg	6	4	170	2100	COMPOSITE
			Chlorobenzilate	660	ug/kg	8	.	.	.	
			Chloroform	0.5	ug/kg	9	.	.	.	
			Chromium	2000	ug/kg	3	3	18000	19000	GARRISON S
			Chrysene	660	ug/kg	8	2	620	6300	SLOUGH
			Cobalt	2000	ug/kg	3	3	5000	7000	SLOUGH
			Copper	2000	ug/kg	3	3	22000	27000	GARRISON S
			Delta-BHC	20	ug/kg	6	.	.	.	
			Di-n-butylphthalate	660	ug/kg	8	2	140	160	GARRISON S
			Di-n-octylphthalate	660	ug/kg	8	.	.	.	
			Diallate	660	ug/kg	8	.	.	.	
			Dibenz[a,h]anthracene	660	ug/kg	8	1	1500	1500	SLOUGH
			Dibenzofuran	660	ug/kg	8	1	770	770	SLOUGH
			Dieldrin	10	ug/kg	6	1	30	30	COMPOSITE
			Diethylphthalate	660	ug/kg	8	1	170	170	SLOUGH
			Dimethoate	660	ug/kg	8	.	.	.	
			Dimethyl phthalate	660	ug/kg	8	.	.	.	
			Diphenylamine	660	ug/kg	8	.	.	.	
			Endosulfan I	10	ug/kg	6	.	.	.	
			Endosulfan II	10	ug/kg	6	.	.	.	
			Endosulfan sulfate	20	ug/kg	6	.	.	.	
			Endrin	10	ug/kg	6	.	.	.	
			Endrin Aldehyde	50	ug/kg	6	.	.	.	
			Ethyl methanesulfonate	660	ug/kg	8	.	.	.	
			Ethylbenzene	2	ug/kg	9	2	1.1	2.9	SUMP53M05

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Soil	1993	Famphur	660	ug/kg	8	.	.	.	.
			Fluoranthene	660	ug/kg	8	2	970	14000	SLOUGH
			Fluorene	660	ug/kg	8	1	1400	1400	SLOUGH
			Gamma-BHC (Lindane)	10	ug/kg	6	.	.	.	.
			Heptachlor	10	ug/kg	6	3	3	7.1	COMPOSITE
			Heptachlor epoxide	60	ug/kg	6	1	14	14	COMPOSITE
			Hexachlorobenzene	660	ug/kg	8	.	.	.	.
			Hexachlorobutadiene	660	ug/kg	8	.	.	.	.
			Hexachlorocyclopentadiene	660	ug/kg	8	.	.	.	.
			Hexachloroethane	660	ug/kg	8	.	.	.	.
			Hexachlorophene	660	ug/kg	8	.	.	.	.
			Hexachloropropene	660	ug/kg	8	.	.	.	.
			Indeno (1,2,3-cd)pyrene	660	ug/kg	8	2	300	4300	SLOUGH
			Iron	2000	ug/kg	3	3	12000000	16000000	SLOUGH
			Isodrin	660	ug/kg	8	.	.	.	.
			Isophorone	660	ug/kg	8	.	.	.	.
			Isosafrole	660	ug/kg	8	.	.	.	.
			Kepone	660	ug/kg	8	.	.	.	.
			Kerosene	660	ug/kg	8	1	63	63	SLOUGH
			Lead	500	ug/kg	3	3	11000	22000	SLOUGH
			Magnesium	10000	ug/kg	3	3	3000000	4800000	SLOUGH
			Manganese	1000	ug/kg	3	3	170000	230000	GARRISON S
			Mercury	400	ug/kg	3	.	.	.	.
			Methapyrilene	660	ug/kg	8	.	.	.	.
			Methoxychlor	100	ug/kg	6	1	13	13	SLOUGH
			Methyl methanesulfonate	660	ug/kg	8	.	.	.	.
			Methylenechloride	5	ug/kg	9	.	.	.	.
			N-Nitroso-di-n-dipropylamine	660	ug/kg	8	.	.	.	.
			N-Nitrosodi-n-butylamine	660	ug/kg	8	.	.	.	.
			N-Nitrosodiethylamine	660	ug/kg	8	.	.	.	.
			N-Nitrosodimethylamine	660	ug/kg	8	.	.	.	.
			N-Nitrosodiphenylamine	660	ug/kg	8	.	.	.	.
			N-Nitrosomethylethylamine	660	ug/kg	8	.	.	.	.
			N-Nitrosomorpholine	660	ug/kg	8	.	.	.	.
			N-Nitrosopiperidine	660	ug/kg	8	.	.	.	.
			Naphthalene	660	ug/kg	8	.	.	.	.
			Nickel	3000	ug/kg	3	3	13000	18000	SLOUGH
			Nitrobenzene	660	ug/kg	8	.	.	.	.
			Nitrosopyrrolidine	660	ug/kg	8	.	.	.	.
			Parathion	660	ug/kg	8	.	.	.	.
			Pentachlorobenzene	660	ug/kg	8	.	.	.	.
			Pentachloronitrobenzene (PCNB)	660	ug/kg	8	.	.	.	.
			Pentachlorophenol	3300	ug/kg	8	.	.	.	.
			Phenacetin	660	ug/kg	8	.	.	.	.
			Phenanthrene	660	ug/kg	8	2	550	12000	SLOUGH
			Phenol	660	ug/kg	8	.	.	.	.
			Potassium	30000	ug/kg	3	3	720000	1500000	GARRISON S
			Pronamide	660	ug/kg	8	.	.	.	.
			Pyrene	660	ug/kg	8	2	970	10000	SLOUGH
			Pyridine	660	ug/kg	8	3	250	610	GARRISON S
			Safrol	660	ug/kg	8	.	.	.	.
			Silver	2000	ug/kg	3	3	1600	2000	SLOUGH
			Sodium	30000	ug/kg	3	3	360000	660000	SLOUGH
			TPH-diesel	4200	ug/kg	1	1	7600	7900	SUMP (53M05)
			TPH-diesel	5500	ug/kg	1	1	7600	7900	SUMP (53M05)

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Soil	1993	TPH-gasoline	9700	ug/kg	1	.	1100	1100	SUMP
			TPH-gasoline	9700	ug/kg	1	1	1100	1100	SUMP
			Tetrachloroethene	0.5	ug/kg	9	.	.	.	.
			Tetraethyl dithiopyrophosphate	660	ug/kg	8	.	.	.	.
			Tin	10000	ug/kg	3	.	.	.	.
			Toluene	2	ug/kg	9	8	0.23	7.5	DIRECTED
			Toxaphene	400	ug/kg	6	.	.	.	.
			Tributyl phosphate	660	ug/kg	8	.	.	.	.
			Trichloroethene	1	ug/kg	9	.	.	.	.
			Tris-2-chloroethyl phosphate	660	ug/kg	8	.	.	.	.
			Vanadium	3000	ug/kg	3	3	30000	37000	SLOUGH
			Vinyl chloride	2	ug/kg	9	.	.	.	.
			Xylenes (total)	5	ug/kg	9	4	0.87	30	SUMP53M05
			Zinc	10	ug/kg	3	3	40000	120000	SLOUGH
			alpha,alpha-Dimethylphenethylamine	660	ug/kg	8	.	.	.	.
			cis-1,2-Dichloroethylene	1	ug/kg	9	6	1	1	DIRECTED
			m-Cresol	660	ug/kg	8	.	.	.	.
			m-Dinitrobenzene	660	ug/kg	8	.	.	.	.
			o-Toluidine	660	ug/kg	8	.	.	.	.
			p-Dimethylaminoazobenzene	660	ug/kg	8	.	.	.	.
			p-Phenylenediamine	660	ug/kg	8	.	.	.	.
			sym-Trinitrobenzene	660	ug/kg	8	.	.	.	.
			trans-1,2-Dichloroethylene	1	ug/kg	9	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Soil Gas	Stage 3	1,3-Dimethylbenzene	10	ug/L	17	4	30	760	49SV01
			BTEX	10	ug/L	17	5	60	5860	49SV17
			Benzene	10	ug/L	17	5	10	40	49SV17
			Ethylbenzene	10	ug/L	17	3	20	5440	49SV17
			Toluene	10	ug/L	17	5	10	2080	49SV01

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Water	Stage 3	1,1,1-Trichloroethane	0.2	ug/L	7	2	0.447	4.77	53M05
			1,1-Dichloroethane	0.46	ug/L	7	1	1.57	1.57	53M05
			1,2-Dichlorobenzene	0.2	ug/L	7	1	0.21	0.21	49M03
			1,3-Dichlorobenzene	0.2	ug/L	7	.	.	.	.
			2-Methylnaphthalene	0.9	ug/L	7	1	117	117	49M02
			Aluminum (Unfiltered)	30	ug/L	1	1	13200	13200	53M05
			Arsenic (Filtered)	40	ug/L	1	1	10	10	53M05
			Arsenic (Unfiltered)	40	ug/L	1	1	22.4	22.4	53M05
			Barium (Filtered)	1	ug/L	1	1	300	300	53M05
			Barium (Unfiltered)	1	ug/L	1	1	418	418	53M05
			Benzene	0.15	ug/L	7	3	0.57	4.71	49M03
			Calcium (Filtered)	13	ug/L	1	1	56900	56900	53M05
			Calcium (Unfiltered)	13	ug/L	1	1	67000	67000	53M05
			Chloride	200	ug/L	1	1	2027	2027	53M05
			Chlorobenzene	0.34	ug/L	7	1	0.432	0.432	49M02
			Chloroform	0.2	ug/L	7	.	.	.	.
			Chromium (Unfiltered)	10	ug/L	1	1	18.1	18.1	53M05
			Cobalt (Unfiltered)	10	ug/L	1	1	16.4	16.4	53M05
			Copper (Unfiltered)	3	ug/L	1	1	62.2	62.2	53M05
			Dibenzofuran	0.34	ug/L	7	1	0.62	0.62	49M02
			Ethylbenzene	0.46	ug/L	7	3	0.55	5.37	49M02
			Iron (Filtered)	20	ug/L	1	1	700	700	53M05
			Iron (Unfiltered)	20	ug/L	1	1	18600	18600	53M05
			Lead (Unfiltered)	1.4	ug/L	1	1	20.8	20.8	53M05
			Magnesium (Filtered)	44	ug/L	1	1	12400	12400	53M05
			Magnesium (Unfiltered)	44	ug/L	1	1	18100	18100	53M05
			Manganese (Filtered)	1.4	ug/L	1	1	2400	2400	53M05
			Manganese (Unfiltered)	1.4	ug/L	1	1	2960	2960	53M05
			Methylenechloride	1.31	ug/L	7	7	1310	1310	49M01
			Naphthalene	0.26	ug/L	7	2	6.2	62	49M02
			Nickel (Unfiltered)	20	ug/L	1	1	26.2	26.2	53M05
			Potassium (Filtered)	408	ug/L	1	1	2940	2940	53M05
			Potassium (Unfiltered)	408	ug/L	1	1	5760	5760	53M05
			Residue, DISS	1000	ug/L	7	7	30400	322000	49M03
			Sodium (Filtered)	82	ug/L	1	1	5010	5010	53M05
			Sodium (Unfiltered)	82	ug/L	1	1	6840	6840	53M05
			Sulfate	500	ug/L	1	1	63810	63810	53M05
			TPH	100	ug/L	7	1	28400	28400	49M02
			Toluene	0.25	ug/L	7	2	0.31	0.49	49M02
			Trichloromonofluoromethane	0.32	ug/L	7	1	0.788	0.788	49M01
			Vanadium (Unfiltered)	10	ug/L	1	1	28.2	28.2	53M05
			Xylenes (total)	0.85	ug/L	7	2	3.99	18.1	49M02
			Zinc (Filtered)	2	ug/L	1	1	60	60	53M05
			Zinc (Unfiltered)	2	ug/L	1	1	79.9	79.9	53M05
			trans-1,2-Dichloroethylene	0.38	ug/L	7	1	0.4	0.4	53M05

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Water	Stage 4	1,1,1-Trichloroethane	0.2	ug/L	7	4	0.333	1.16	53M05
			1,1-Dichloroethane	0.4	ug/L	7	2	0.457	1.01	49M05
			1,2-Dichlorobenzene	0.5	ug/L	6	.	.	.	.
			1,2-Dimethylbenzene	1	ug/L	20	3	2	24	49FW03
			1,3-Dichlorobenzene	1	ug/L	6	.	.	.	.
			1,3-Dimethylbenzene	1	ug/L	20	5	3	37	49FW03
			1,4-Dichlorobenzene	1	ug/L	7	1	4.53	4.53	49M03
			Acenaphthene	1	ug/L	7	4	1	6.43	49M02
			Anthracene	1	ug/L	7	2	0.031	0.034	49M04
			Benzene	1	ug/L	27	16	0.33	6	49FW08
			Benzo(a)anthracene	1	ug/L	7	7	0.0006	0.026	49M02
			Benzo(a)pyrene	2	ug/L	7	6	0.0006	0.015	49M02
			Benzo(b)fluoranthene	1.5	ug/L	7	7	0.0003	0.012	49M02
			Benzo(ghi)perylene	2.5	ug/L	7	4	0.001	0.023	49M03
			Benzo(k)fluoranthene	1.5	ug/L	7	6	0.0004	0.008	49M02
			Chlorobenzene	0.4	ug/L	6	.	.	.	.
			Chloroform	0.2	ug/L	7	.	.	.	.
			Chrysene	1	ug/L	7	4	0.01	0.03	49M04
			Dibenz[a,h]anthracene	2.5	ug/L	7	5	0.0009	0.005	49M02
			Ethylbenzene	1	ug/L	27	8	0.63	8	49FW03
			Fluoranthene	1	ug/L	7	7	0.003	0.356	49M02
			Fluorene	1	ug/L	7	5	0.142	10.8	49M02
			Indeno(1,2,3-cd)pyrene	2.5	ug/L	7	4	0.001	0.009	49M02
			Methylenechloride	1.4	ug/L	6	.	.	.	.
			Naphthalene	1	ug/L	7	6	0.878	49.9	49M02
			Phenanthrene	1	ug/L	7	6	0.02	21	49M02
			Pyrene	1	ug/L	7	6	0.015	0.85	49M02
			TPH	200	ug/L	7	2	1700	32300	49M05
			Toluene	1	ug/L	27	2	0.72	0.83	49M02
			Trichloroethene	1	ug/L	27	12	0.963	6.93	49M05
			Trichloromonofluoromethane	0.4	ug/L	6	.	.	.	.
			Xylenes (total)	0.4	ug/L	7	2	0.94	5.95	49M02
			trans-1,2-Dichloroethylene	1	ug/L	26	1	2	2	49FW12

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Water	1993	0,0,0-Triethyl phosphorothioate	10	ug/L	8	.	.	.	.
			0,0-Diethyl 0-2-pyrazinyl phosphorothio	10	ug/L	8	.	.	.	.
			1,1,1-Trichloroethane	0.5	ug/L	20	8	0.34	0.63	49M05
			1,1,2-Trichloroethane	0.5	ug/L	20	.	.	.	.
			1,1-Dichloroethane	1	ug/L	20	4	0.59	0.73	49M05
			1,2,4,5-Tetrachlorobenzene	10	ug/L	8	.	.	.	.
			1,2,4-Trichlorobenzene	10	ug/L	8	.	.	.	.
			1,2-Dichlorobenzene	10	ug/L	8	.	.	.	.
			1,2-Dichloroethane	0.5	ug/L	20	.	.	.	.
			1,3-Dichlorobenzene	10	ug/L	8	.	.	.	.
			1,4-Dichlorobenzene	2	ug/L	20	1	0.18	0.18	49M05
			1,4-Dichlorobenzene	10	ug/L	8	.	0.18	0.18	49M05
			1,4-Naphthoquinone	10	ug/L	8	.	.	.	.
			1-Naphthylamine	10	ug/L	8	.	.	.	.
			2,3,4,6-Tetrachlorophenol	10	ug/L	8	.	.	.	.
			2,4,5-Trichlorophenol	10	ug/L	8	.	.	.	.
			2,4,6-Trichlorophenol	10	ug/L	8	.	.	.	.
			2,4-Dichlorophenol	10	ug/L	8	.	.	.	.
			2,4-Dimethylphenol	10	ug/L	8	.	.	.	.
			2,4-Dinitrophenol	50	ug/L	8	.	.	.	.
			2,4-Dinitrotoluene	10	ug/L	8	.	.	.	.
			2,6-Dichlorophenol	10	ug/L	8	.	.	.	.
			2,6-Dinitrotoluene	10	ug/L	8	.	.	.	.
			2-Acetylaminofluorene	10	ug/L	8	.	.	.	.
			2-Chloronaphthalene	10	ug/L	8	.	.	.	.
			2-Chlorophenol	10	ug/L	8	.	.	.	.
			2-Methylnaphthalene	10	ug/L	8	2	45	140	49M02
			2-Methylphenol	10	ug/L	8	.	.	.	.
			2-Naphthylamine	10	ug/L	8	.	.	.	.
			2-Nitroaniline	50	ug/L	8	.	.	.	.
			2-Nitrophenol	10	ug/L	8	.	.	.	.
			2-Picoline	10	ug/L	8	.	.	.	.
			3,3'-Dichlorobenzidine	20	ug/L	8	.	.	.	.
			3,3'-Dimethylbenzidine	10	ug/L	8	.	.	.	.
			3-Methylcholanthrene	10	ug/L	8	.	.	.	.
			3-Nitroaniline	50	ug/L	8	.	.	.	.
			4,6-Dinitro-o-cresol	50	ug/L	8	.	.	.	.
			4-Aminobiphenyl	10	ug/L	8	.	.	.	.
			4-Bromophenylphenyl ether	10	ug/L	8	.	.	.	.
			4-Chloro-3-methylphenol	20	ug/L	8	.	.	.	.
			4-Chloroaniline	20	ug/L	8	.	.	.	.
			4-Chlorophenylphenyl ether	10	ug/L	8	.	.	.	.
			4-Methylphenol	10	ug/L	8	.	.	.	.
			4-Nitroaniline	50	ug/L	8	.	.	.	.
			4-Nitrophenol	50	ug/L	8	.	.	.	.
			4-Nitroquinoline-1-oxide	10	ug/L	8	.	.	.	.
			5-Nitro-o-toluidine	10	ug/L	8	.	.	.	.
			7,12-Dimethylbenz[a]anthracene	10	ug/L	8	.	.	.	.
			Acenaphthene	10	ug/L	8	.	.	.	.
			Acenaphthylene	10	ug/L	8	.	.	.	.
			Acetophenone	10	ug/L	8	1	57	57	49M02
			Aluminum (Filtered)	200	ug/L	8	3	46	70	49M02
			Aluminum (Unfiltered)	200	ug/L	8	8	61	2200	53M05
			Aniline	10	ug/L	8	.	.	.	.
			Anthracene	10	ug/L	8	.	.	.	.
			Antimony (Filtered)	200	ug/L	8	.	.	.	.
			Antimony (Unfiltered)	200	ug/L	8	.	.	.	.
			Aramite	10	ug/L	8	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Water	1993	Arsenic (Filtered)	5	ug/L	8	6	1	10	49M05
			Arsenic (Unfiltered)	5	ug/L	6	6	1	19	49M01
			Barium (Filtered)	20	ug/L	8	8	20	240	49M05
			Barium (Unfiltered)	20	ug/L	8	8	30	280	53M05
			Benzene	2	ug/L	20	13	0.31	8.4	49M05
			Benzo(a)anthracene	10	ug/L	8	.	.	.	.
			Benzo(a)pyrene	10	ug/L	8	.	.	.	.
			Benzo(b)fluoranthene	10	ug/L	8	.	.	.	.
			Benzo(ghi)perylene	10	ug/L	8	.	.	.	.
			Benzo(k)fluoranthene	10	ug/L	8	.	.	.	.
			Benzothiazole	10	ug/L	8	.	.	.	.
			Benzyl alcohol	20	ug/L	8	.	.	.	.
			Beryllium (Filtered)	3	ug/L	8	.	.	.	.
			Beryllium (Unfiltered)	3	ug/L	8	1	0.94	0.94	53M05
			Bis(2-Chloroethoxy)methane	10	ug/L	8	.	.	.	.
			Bis(2-Chloroisopropyl) ether	10	ug/L	8	.	.	.	.
			Bis(2-chloroethyl) ether	10	ug/L	8	2	520	720	49M02
			Bis(2-ethylhexyl) phthalate	10	ug/L	8	.	.	.	.
			Butylbenzylphthalate	10	ug/L	8	.	.	.	.
			Cadmium (Filtered)	10	ug/L	8	.	.	.	.
			Cadmium (Unfiltered)	100	ug/L	8	8	17000	70000	49M02
			Calcium (Filtered)	100	ug/L	8	8	19000	67000	49M02
			Calcium (Unfiltered)	1	ug/L	20	.	.	.	.
			Carbon tetrachloride	10	ug/L	8	.	.	.	.
			Chlorobenzilate	0.5	ug/L	20	2	0.058	8.4	49M02
			Chloroform	20	ug/L	8	1	6	6	49M02
			Chromium (Filtered)	20	ug/L	8	4	5.5	8.1	53M05
			Chromium (Unfiltered)	10	ug/L	8	.	.	.	.
			Chrysene	20	ug/L	8	1	10	10	49M02
			Cobalt (Filtered)	20	ug/L	8	2	4.7	5	49M02
			Cobalt (Unfiltered)	20	ug/L	8	3	6.5	11	SLOUGH
			Copper (Filtered)	20	ug/L	8	6	4.3	20	49M01
			Copper (Unfiltered)	10	ug/L	8	.	.	.	.
			Di-n-butylphthalate	10	ug/L	8	.	.	.	.
			Di-n-octylphthalate	10	ug/L	8	.	.	.	.
			Diallate	10	ug/L	8	.	.	.	.
			Dibenz[a,h]anthracene	10	ug/L	8	.	.	.	.
			Dibenzofuran	10	ug/L	8	.	.	.	.
			Diethylphthalate	10	ug/L	8	.	.	.	.
			Dimethoate	10	ug/L	8	.	.	.	.
			Dimethyl phthalate	10	ug/L	8	.	.	.	.
			Diphenylamine	10	ug/L	8	.	.	.	.
			Ethyl methanesulfonate	2	ug/L	20	14	0.3	21	49M02
			Ethylbenzene	10	ug/L	8	.	.	.	.
			Famphur	10	ug/L	8	.	.	.	.
			Fluoranthene	10	ug/L	8	1	11	11	49M02
			Fluorene	10	ug/L	8	.	.	.	.
			Hexachlorobenzene	10	ug/L	8	.	.	.	.
			Hexachlorobutadiene	10	ug/L	8	.	.	.	.
			Hexachlorocyclopentadiene	10	ug/L	8	.	.	.	.
			Hexachloroethane	10	ug/L	8	.	.	.	.
			Hexachlorophene	10	ug/L	8	.	.	.	.
			Hexachloropropene	10	ug/L	8	.	.	.	.
			Indeno(1,2,3-cd)pyrene	20	ug/L	8	8	140	12000	49M05
			Iron (Filtered)							

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Water	1993	Iron (Unfiltered)	20	ug/L	8	8	670	19000	49M01
			Isodrin	10	ug/L	8	.	.	.	.
			Isophorone	10	ug/L	8	.	.	.	.
			Isosafrole	10	ug/L	8	.	.	.	.
			Kepone	10	ug/L	8	.	.	.	.
			Kerosene	10000	ug/L	8	3	4.2	2800	49M02
			Lead (Filtered)	5	ug/L	8	5	1	2	53M05
			Lead (Unfiltered)	5	ug/L	6	6	1	11	SLOUGH2
			Magnesium (Filtered)	100	ug/L	8	8	3700	14000	49M02
			Magnesium (Unfiltered)	100	ug/L	8	8	4000	14000	49M02
			Manganese (Filtered)	10	ug/L	8	8	50	3800	49M01
			Manganese (Unfiltered)	10	ug/L	8	8	150	4000	49M01
			Mercury (Filtered)	0.2	ug/L	8	1	0.3	0.3	49M05
			Mercury (Unfiltered)	0.2	ug/L	8	3	0.3	0.4	49M01
			Methapyrilene	10	ug/L	8	.	.	.	.
			Methyl methanesulfonate	10	ug/L	8	.	.	.	.
			Methylenechloride	5	ug/L	20	3	0.06	99	49M02
			N-Nitroso-di-n-dipropylamine	10	ug/L	8	.	.	.	.
			N-Nitrosodi-n-butylamine	10	ug/L	8	.	.	.	.
			N-Nitrosodiethylamine	10	ug/L	8	.	.	.	.
			N-Nitrosodimethylamine	10	ug/L	8	.	.	.	.
			N-Nitrosodiphenylamine	10	ug/L	8	.	.	.	.
			N-Nitrosomethylethylamine	10	ug/L	8	.	.	.	.
			N-Nitrosomorpholine	10	ug/L	8	.	.	.	.
			N-Nitrosopiperidine	10	ug/L	8	.	.	.	.
			Naphthalene	30	ug/L	8	1	19	19	49M02
			Nickel (Filtered)	30	ug/L	8	.	.	.	.
			Nickel (Unfiltered)	10	ug/L	8	.	.	.	.
			Nitrobenzene	10	ug/L	8	.	.	.	.
			Nitrosopyrrolidine	10	ug/L	8	.	.	.	.
			Parathion	10	ug/L	8	.	.	.	.
			Pentachlorobenzene	10	ug/L	8	.	.	.	.
			Pentachloronitrobenzene (PCNB)	50	ug/L	8	.	.	.	.
			Pentachlorophenol	10	ug/L	8	.	.	.	.
			Phenacetin	10	ug/L	8	.	.	.	.
			Phenanthrene	10	ug/L	8	.	.	.	.
			Phenol	300	ug/L	8	8	1000	4000	49M02
			Potassium (Filtered)	300	ug/L	8	8	2000	4000	49M02
			Potassium (Unfiltered)	10	ug/L	8	.	.	.	.
			Pronamide	10	ug/L	8	.	.	.	.
			Pyrene	10	ug/L	8	.	.	.	.
			Pyridine	10	ug/L	8	.	.	.	.
			Safrol	20	ug/L	8	1	6.5	6.5	49M01
			Silver (Filtered)	20	ug/L	8	3	3.2	3.8	53M05
			Silver (Unfiltered)	300	ug/L	8	8	1300	7500	49M01
			Sodium (Filtered)	300	ug/L	8	8	1200	6900	49M01
			Sodium (Unfiltered)	0.5	ug/L	20	1	0.058	0.058	49M05
			Tetrachloroethene	10	ug/L	8	.	.	.	.
			Tetraethyl dithiopyrophosphate	100	ug/L	8	.	.	.	.
			Tin (Filtered)	100	ug/L	8	.	.	.	.
			Tin (Unfiltered)	2	ug/L	20	13	0.084	0.49	49M06
			Toluene	10	ug/L	8	.	.	.	.
			Tributyl phosphate	1	ug/L	20	15	0.18	23	49M02
			Trichloroethene	10	ug/L	8	.	.	.	.
			Tris-2-chloroethyl phosphate							

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
49	Water	1993	Vanadium (Filtered)	30	ug/L	8	1	9.7	9.7	49M01
			Vanadium (Unfiltered)	30	ug/L	8	2	5.4	12	53M05
			Vinyl chloride	2	ug/L	20	7	2	2	49M01
			Xylenes (total)	5	ug/L	20	18	0.24	37	49M02
			Zinc (Filtered)	10	ug/L	8	5	5.7	150	SLOUGH2
			Zinc (Unfiltered)	10	ug/L	8	8	4.9	230	SLOUGH
			alpha,alpha-Dimethylphenethylamine	10	ug/L	8	.	.	.	.
			cis-1,2-Dichloroethylene	1	ug/L	20	12	0.45	3.2	49M05
			m-Cresol	10	ug/L	8	.	.	.	.
			m-Dinitrobenzene	10	ug/L	8	.	.	.	.
			o-Toluidine	10	ug/L	8	.	.	.	.
			p-Dimethylaminoazobenzene	10	ug/L	8	.	.	.	.
			p-Phenylenediamine	10	ug/L	8	.	.	.	.
			sym-Trinitrobenzene	10	ug/L	8	.	.	.	.
			trans-1,2-Dichloroethylene	1	ug/L	20	2	0.19	0.27	53M05

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
50	Soil	Stage 3	2-Chlorophenol	9	ug/kg	12	1	110	110	50M02
			2-Methylnaphthalene	30	ug/kg	12	9	290	320000	50M01
			Acenaphthene	10	ug/kg	12	1	50	50	50M02
			Aluminum	14700	ug/kg	12	12	3660000	13900000	50M06
			Arsenic	6390	ug/kg	12	2	8650	18200	50M02
			Barium	330	ug/kg	12	12	80000	366000	50M03
			Benzene	44	ug/kg	12	3	680	3790	50M03
			Beryllium	320	ug/kg	12	1	620	620	50M02
			Bis(2-ethylhexyl) phthalate	100	ug/kg	12	.	.	.	.
			Cadmium	455	ug/kg	12	12	660	1990	50M02
			Calcium	5400	ug/kg	12	12	1690000	5690000	50M02
			Chromium	720	ug/kg	12	12	6200	25800	50M02
			Cobalt	770	ug/kg	12	12	3890	15300	50M02
			Copper	210	ug/kg	12	12	6790	42700	50M02
			Dibenzofuran	10	ug/kg	12	4	380	11000	50M01
			Ethylbenzene	80	ug/kg	12	6	1800	170000	50M01
			Fluorene	30	ug/kg	12	3	150	12000	50M01
			Iron	8100	ug/kg	12	12	7510000	34300000	50M06
			Lead	4560	ug/kg	24	24	5050	31900	50M02
			Magnesium	4400	ug/kg	12	12	1710000	7440000	50M02
			Manganese	250	ug/kg	12	12	218000	661000	50M02
			Moisture	.	Percent	12	12	0.8	36.7	50M02
			Naphthalene	9	ug/kg	12	9	150	160000	50M01
			Nickel	2000	ug/kg	12	12	8790	38600	50M02
			Phenol	30	ug/kg	12	1	170	170	50M02
			Potassium	77600	ug/kg	12	12	496000	1720000	50M06
			Sodium	21900	ug/kg	12	12	73100	216000	50M01
			TPH	10000	ug/kg	27	16	12000	91800000	50M01
			Toluene	160	ug/kg	12	5	310	150000	50M01
			Vanadium	1700	ug/kg	12	12	7990	29000	50M02
			Xylenes (total)	80	ug/kg	12	7	200	1470000	50M01
			Zinc	610	ug/kg	12	12	38100	157000	50M02

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
50	Soil	Stage 4	2,4-Dimethylphenol	80	ug/kg	14	.	.	.	.
			2-Chlorophenol	80	ug/kg	14	.	.	.	.
			2-Methylnaphthalene	30	ug/kg	14	6	120	150000	50SB06
			4-Methylphenol	30	ug/kg	14	.	.	.	.
			Acenaphthene	30	ug/kg	14	.	.	.	.
			Acetophenone	30	ug/kg	14	1	75000	75000	50SB06
			Benzene	80	ug/kg	4	.	.	.	.
			Bis(2-ethylhexyl) phthalate	50	ug/kg	14	2	80	90	50SB03
			Butylbenzylphthalate	40	ug/kg	14	.	.	.	.
			Chlorobenzene	170	ug/kg	4	.	.	.	.
			Chloroform	120	ug/kg	4	.	.	.	.
			Chloromethane	80	ug/kg	4	.	.	.	.
			Dibenzofuran	30	ug/kg	14	1	750	750	50SB05
			Diethylphthalate	40	ug/kg	14	.	.	.	.
			Ethylbenzene	250	ug/kg	4	.	.	.	.
			Fluorene	30	ug/kg	14	.	.	.	.
			Methylenechloride	760	ug/kg	4	.	.	.	.
			Moisture	.	Percent	20	20	4.7	26.2	50SB02
			N-Nitrosopiperidine	30	ug/kg	14	2	190	320	50SB09
			Naphthalene	30	ug/kg	14	4	1100	82000	50SB06
			Phenol	80	ug/kg	14	.	.	.	.
			TPH	10000	ug/kg	55	35	20400	49000000	50SB06
			Toluene	170	ug/kg	4	.	.	.	.
			Xylenes (total)	770	ug/kg	4	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
50	Soil	1993	Aluminum	20000	ug/kg	1	1	10000000	10000000	SOIL PIT 1
			Antimony	20000	ug/kg	1	.	.	.	.
			Aroclor-1016	100	ug/kg	1	.	.	.	.
			Aroclor-1221	200	ug/kg	1	.	.	.	.
			Aroclor-1232	200	ug/kg	1	.	.	.	.
			Aroclor-1242	100	ug/kg	1	.	.	.	.
			Aroclor-1248	100	ug/kg	1	.	.	.	.
			Aroclor-1254	100	ug/kg	1	.	.	.	.
			Aroclor-1260	100	ug/kg	1	.	.	.	.
			Arsenic	500	ug/kg	1	1	11000	11000	SOIL PIT 1
			Barium	2000	ug/kg	1	1	230000	230000	SOIL PIT 1
			Beryllium	300	ug/kg	1	1	400	400	SOIL PIT 1
			Cadmium	1000	ug/kg	1	.	.	.	.
			Calcium	10000	ug/kg	1	1	2800000	2800000	SOIL PIT 1
			Chromium	2000	ug/kg	1	1	21000	21000	SOIL PIT 1
			Cobalt	2000	ug/kg	1	1	10000	10000	SOIL PIT 1
			Copper	2000	ug/kg	1	1	21000	21000	SOIL PIT 1
			Iron	2000	ug/kg	1	1	22000000	22000000	SOIL PIT 1
			Lead	500	ug/kg	1	1	14000	14000	SOIL PIT 1
			Magnesium	10000	ug/kg	1	1	4100000	4100000	SOIL PIT 1
			Manganese	1000	ug/kg	1	1	230000	230000	SOIL PIT 1
			Mercury	400	ug/kg	1	.	.	.	.
			Nickel	3000	ug/kg	1	1	22000	22000	SOIL PIT 1
			Potassium	30000	ug/kg	1	1	1600000	1600000	SOIL PIT 1
			Silver	2000	ug/kg	1	1	3000	3000	SOIL PIT 1
			Sodium	30000	ug/kg	1	1	110000	110000	SOIL PIT 1
			TPH-diesel	4500	ug/kg	1	1	5800	200000	TANKFARM-PIT-1
			TPH-diesel	4800	ug/kg	1	1	5800	200000	TANKFARM-PIT-1
			TPH-diesel	4900	ug/kg	1	1	5800	200000	TANKFARM-PIT-1
			TPH-diesel	5800	ug/kg	1	.	5800	200000	TANKFARM-PIT-1
			TPH-gasoline	5600	ug/kg	1	1	77000	100000	TANKFARM-PIT-1
			TPH-gasoline	6000	ug/kg	1	1	77000	100000	TANKFARM-PIT-1
			TPH-gasoline	6100	ug/kg	1	.	77000	100000	TANKFARM-PIT-1
			TPH-gasoline	7200	ug/kg	1	.	77000	100000	TANKFARM-PIT-1
			Tin	10000	ug/kg	1	.	.	.	.
			Vanadium	3000	ug/kg	1	1	26000	26000	SOIL PIT 1
			Zinc	10	ug/kg	1	1	72000	72000	SOIL PIT 1

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
50	Soil Gas	Stage 3	1,3-Dimethylbenzene	10	ug/L	15	4	40	3400	50SV06
			Benzene	10	ug/L	15	3	50	170	50SV05
			Ethylbenzene	10	ug/L	15	4	30	26800	50SV06
			Toluene	10	ug/L	15	5	60	1130	50SV05
			Total BTEX	10	ug/L	15	5	280	30400	50SV06

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
50	Water	Stage 3	2,4-Dimethylphenol	0.28	ug/L	6	1	4.7	4.7	50M05
			2-Methylnaphthalene	0.9	ug/L	6	1	454	454	50M01
			Aluminum (Filtered)	30	ug/L	5	4	30	40	50M02
			Aluminum (Unfiltered)	30	ug/L	5	5	80	90600	50M06
			Arsenic (Unfiltered)	40	ug/L	5	2	50	100	50M06
			Barium (Filtered)	1	ug/L	5	5	100	700	50M04
			Barium (Unfiltered)	1	ug/L	5	5	50	4180	50M06
			Benzene	0.15	ug/L	6	3	3	65.2	50M01
			Butylbenzylphthalate	1.5	ug/L	6	3	3.7	12	50M05
			Cadmium (Unfiltered)	3	ug/L	5	3	10	20	50M06
			Calcium (Filtered)	13	ug/L	5	5	5230	59700	50M02
			Calcium (Unfiltered)	13	ug/L	5	5	51100	84200	50M06
			Chloride	200	ug/L	5	5	448	5877	50M06
			Chlorobenzene	0.34	ug/L	6	1	1.73	1.73	50M05
			Chloromethane	0.4	ug/L	6	4	0.08	1.32	50M03
			Chromium (Unfiltered)	10	ug/L	5	4	20	820	50M04
			Cobalt (Unfiltered)	10	ug/L	5	4	20	150	50M06
			Copper (Filtered)	3	ug/L	5	1	4	4	50M03
			Copper (Unfiltered)	3	ug/L	5	5	6.5	511	50M06
			Diethylphthalate	1	ug/L	6	1	6.6	6.6	50M05
			Ethylbenzene	0.46	ug/L	6	2	136	332	50M01
			Iron (Filtered)	20	ug/L	5	5	50	1000	50M01
			Iron (Unfiltered)	20	ug/L	5	5	230	309000	50M06
			Lead (Filtered)	1.4	ug/L	5	3	2	2	50M03
			Lead (Unfiltered)	1.4	ug/L	10	8	50.4	400	50M06
			Magnesium (Filtered)	44	ug/L	5	5	8390	9350	50M02
			Magnesium (Unfiltered)	44	ug/L	5	5	8580	51900	50M06
			Manganese (Filtered)	1.4	ug/L	5	5	80	5000	50M06
			Manganese (Unfiltered)	1.4	ug/L	5	5	77.6	34600	50M06
			Methylenechloride	1.31	ug/L	6	.	.	.	.
			Molybdenum (Unfiltered)	10	ug/L	5	2	19.8	51.8	50M06
			Naphthalene	0.26	ug/L	6	1	540	540	50M01
			Nickel (Unfiltered)	20	ug/L	5	4	21.3	344	50M06
			Nitrite/Nitrate	10	ug/L	5	1	102	102	50M02
			Phenol	1	ug/L	6	1	6.8	6.8	50M05
			Potassium (Filtered)	408	ug/L	5	5	1100	2000	50M06
			Potassium (Unfiltered)	408	ug/L	5	5	1420	13000	50M06
			Residue, DISS	1000	ug/L	5	5	226000	316000	50M06
			Sodium (Filtered)	82	ug/L	10	10	2240	7470	50M06
			Sulfate	500	ug/L	5	5	32130	64060	50M02
			TPH	100	ug/L	6	1	119000	119000	50M01
			Toluene	0.25	ug/L	6	2	52.5	261	50M01
			Vanadium (Unfiltered)	10	ug/L	5	4	25.6	254	50M06
			Xylenes (total)	0.85	ug/L	6	2	602	1860	50M01
			Zinc (Filtered)	2	ug/L	5	4	30	60	50M03
			Zinc (Unfiltered)	2	ug/L	5	5	46.4	1180	50M06

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
50	Water	Stage 4	2,4-Dimethylphenol	2	ug/L	9	1	12	12	50M05
			2-Chlorophenol	2	ug/L	9	.	.	.	.
			2-Methylnaphthalene	1	ug/L	9	3	1.3	12000	50M01
			4-Methylphenol	2	ug/L	9	.	.	.	.
			Acenaphthene	1	ug/L	9	.	.	.	.
			Acetophenone	1	ug/L	9	.	.	.	.
			Benzene	1	ug/L	9	4	3.8	335	50M01
			Bis(2-ethylhexyl) phthalate	2	ug/L	9	1	4.1	4.1	50M02
			Butylbenzylphthalate	1.5	ug/L	9	.	.	.	.
			Chlorobenzene	0.4	ug/L	9	.	.	.	.
			Chloroform	0.2	ug/L	9	1	1.01	1.01	50M08
			Chloromethane	0.4	ug/L	9	.	.	.	.
			Dibenzofuran	1	ug/L	9	.	.	.	.
			Diethylphthalate	1	ug/L	9	.	.	.	.
			Ethylbenzene	1	ug/L	9	3	0.99	2210	50M01
			Fluorene	1	ug/L	9	.	.	.	.
			Methylenechloride	1.4	ug/L	9	.	.	.	.
			N-Nitrosopiperidine	1	ug/L	9	.	.	.	.
			Naphthalene	1	ug/L	9	2	32	5700	50M01
			Phenol	2	ug/L	9	.	.	.	.
			TPH	200	ug/L	9	2	300	1980000	50M01
			Toluene	1	ug/L	29	6	2.69	2080	50M01
			Xylenes (total)	0.4	ug/L	9	3	11.3	6940	50M01

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
50	Water	1993	0,0,0-Triethyl phosphorothioate	10	ug/L	10	.	.	.	.
			0,0-Diethyl 0-2-pyrazinyl phosphorothio	10	ug/L	10	.	.	.	.
			1,1,1-Trichloroethane	0.5	ug/L	17	.	.	.	.
			1,1,2-Trichloroethane	0.5	ug/L	17	.	.	.	.
			1,1-Dichloroethane	1	ug/L	17	.	.	.	.
			1,2,4,5-Tetrachlorobenzene	10	ug/L	10	.	.	.	.
			1,2,4-Trichlorobenzene	10	ug/L	10	.	.	.	.
			1,2-Dichlorobenzene	10	ug/L	10	.	.	.	.
			1,2-Dichloroethane	0.5	ug/L	17	1	0.43	0.43	50M05
			1,3-Dichlorobenzene	10	ug/L	10	.	.	.	.
			1,4-Dichlorobenzene	2	ug/L	17	.	.	.	.
			1,4-Dichlorobenzene	10	ug/L	10	.	.	.	.
			1,4-Naphthoquinone	10	ug/L	10	.	.	.	.
			1-Naphthylamine	10	ug/L	10	.	.	.	.
			2,3,4,6-Tetrachlorophenol	10	ug/L	10	.	.	.	.
			2,4,5-Trichlorophenol	10	ug/L	10	.	.	.	.
			2,4,6-Trichlorophenol	10	ug/L	10	.	.	.	.
			2,4-Dichlorophenol	10	ug/L	10	.	.	.	.
			2,4-Dimethylphenol	10	ug/L	10	.	.	.	.
			2,4-Dinitrophenol	50	ug/L	10	.	.	.	.
			2,4-Dinitrotoluene	10	ug/L	10	.	.	.	.
			2,6-Dichlorophenol	10	ug/L	10	.	.	.	.
			2,6-Dinitrotoluene	10	ug/L	10	.	.	.	.
			2-Acetylaminofluorene	10	ug/L	10	.	.	.	.
			2-Chloronaphthalene	10	ug/L	10	.	.	.	.
			2-Chlorophenol	10	ug/L	10	.	.	.	.
			2-Methylnaphthalene	10	ug/L	10	3	14	55	50M05
			2-Methylphenol	10	ug/L	10	.	.	.	.
			2-Naphthylamine	10	ug/L	10	.	.	.	.
			2-Nitroaniline	50	ug/L	10	.	.	.	.
			2-Nitrophenol	10	ug/L	10	.	.	.	.
			2-Picoline	10	ug/L	10	.	.	.	.
			3,3'-Dichlorobenzidine	20	ug/L	10	.	.	.	.
			3,3'-Dimethylbenzidine	10	ug/L	10	.	.	.	.
			3-Methylcholanthrene	10	ug/L	10	.	.	.	.
			3-Nitroaniline	50	ug/L	10	.	.	.	.
			4,6-Dinitro-o-cresol	50	ug/L	10	.	.	.	.
			4-Aminobiphenyl	10	ug/L	10	.	.	.	.
			4-Bromophenylphenyl ether	10	ug/L	10	.	.	.	.
			4-Chloro-3-methylphenol	20	ug/L	10	.	.	.	.
			4-Chloroaniline	20	ug/L	10	.	.	.	.
			4-Chlorophenylphenyl ether	10	ug/L	10	.	.	.	.
			4-Methylphenol	10	ug/L	10	.	.	.	.
			4-Nitroaniline	50	ug/L	10	.	.	.	.
			4-Nitrophenol	50	ug/L	10	.	.	.	.
			4-Nitroquinoline-1-oxide	10	ug/L	10	.	.	.	.
			5-Nitro-o-toluidine	10	ug/L	10	.	.	.	.
			7,12-Dimethylbenz[a]anthracene	10	ug/L	10	.	.	.	.
			Acenaphthene	10	ug/L	10	.	.	.	.
			Acenaphthylene	10	ug/L	10	.	.	.	.
			Acetophenone	10	ug/L	10	.	.	.	.
			Alkalinity	50	mg/L	1	.	170	170	50M08
			Aluminum (Filtered)	200	ug/L	13	5	47	100	50M05
			Aluminum (Unfiltered)	200	ug/L	13	11	35	77000	50M08
			Aniline	10	ug/L	10	.	.	.	.
			Anthracene	10	ug/L	10	.	.	.	.
			Antimony (Filtered)	200	ug/L	13	.	.	.	.
			Antimony (Unfiltered)	200	ug/L	13	.	.	.	.

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Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
50	Water	1993	Aramite	10	ug/L	10	.	.	.	
			Arsenic (Filtered)	5	ug/L	13	5	1	17	50M05
			Arsenic (Unfiltered)	5	ug/L	11	8	1	31	50M08
			Barium (Filtered)	20	ug/L	13	13	0.22	420	50M05
			Barium (Unfiltered)	20	ug/L	13	13	0.22	1700	50M08
			Benzene	2	ug/L	17	9	0.18	290	50M05
			Benzo(a)anthracene	10	ug/L	10	.	.	.	
			Benzo(a)pyrene	10	ug/L	10	.	.	.	
			Benzo(b)fluoranthene	10	ug/L	10	.	.	.	
			Benzo(ghi)perylene	10	ug/L	10	.	.	.	
			Benzo(k)fluoranthene	10	ug/L	10	.	.	.	
			Benzothiazole	20	ug/L	10	.	.	.	
			Benzyl alcohol	3	ug/L	13	2	0.82	0.9	50M05
			Beryllium (Filtered)	3	ug/L	13	4	2.2	4	50M06
			Beryllium (Unfiltered)	10	ug/L	10	.	.	.	
			Bis(2-Chloroethoxy)methane	10	ug/L	10	.	.	.	
			Bis(2-Chloroisopropyl) ether	10	ug/L	10	.	.	.	
			Bis(2-chloroethyl) ether	10	ug/L	10	1	5.2	5.2	50M01
			Bis(2-ethylhexyl) phthalate	500	ug/L	3	.	.	.	
			Bromide	10	ug/L	10	.	.	.	
			Butylbenzylphthalate	10	ug/L	13	.	.	.	
			Cadmium (Filtered)	10	ug/L	13	1	9.3	9.3	50M06
			Cadmium (Unfiltered)	100	ug/L	13	13	36	140000	50M05
			Calcium (Filtered)	100	ug/L	13	13	33	150000	50M05
			Calcium (Unfiltered)	1	ug/L	17	.	.	.	
			Carbon tetrachloride	200	ug/L	3	3	500	2900	50M08
			Chloride	10	ug/L	10	.	.	.	
			Chlorobenzilate	0.5	ug/L	17	2	4.9	6.7	50M01
			Chloroform	20	ug/L	13	1	6.8	6.8	50M07
			Chromium (Filtered)	20	ug/L	13	7	11	200	50M08
			Chromium (Unfiltered)	10	ug/L	10	.	.	.	
			Chrysene	20	ug/L	13	1	16	16	50M05
			Cobalt (Filtered)	20	ug/L	13	8	6.8	100	50M08
			Cobalt (Unfiltered)	20	ug/L	13	3	3.5	6.9	50M10
			Copper (Filtered)	20	ug/L	13	8	3.7	280	50M08
			Copper (Unfiltered)	10	ug/L	10	.	.	.	
			Di-n-butylphthalate	10	ug/L	10	.	.	.	
			Di-n-octylphthalate	10	ug/L	10	.	.	.	
			Diallate	10	ug/L	10	.	.	.	
			Dibenz[a,h]anthracene	10	ug/L	10	.	.	.	
			Dibenzofuran	10	ug/L	10	.	.	.	
			Diethylphthalate	10	ug/L	10	.	.	.	
			Dimethoate	10	ug/L	10	.	.	.	
			Dimethyl phthalate	10	ug/L	10	.	.	.	
			Diphenylamine	10	ug/L	10	.	.	.	
			Ethyl methanesulfonate	2	ug/L	17	8	0.35	370	50M05
			Ethylbenzene	10	ug/L	10	.	.	.	
			Famphur	10	ug/L	10	.	.	.	
			Fluoranthene	10	ug/L	10	.	.	.	
			Fluorene	100	ug/L	3	3	400	600	50M08
			Fluoride	10	ug/L	10	.	.	.	
			Hexachlorobenzene	10	ug/L	10	.	.	.	
			Hexachlorobutadiene	10	ug/L	10	.	.	.	
			Hexachlorocyclopentadiene	10	ug/L	10	.	.	.	
			Hexachloroethane	10	ug/L	10	.	.	.	

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Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
50	Water	1993	Hexachlorophene	10	ug/L	10	.	.	.	.
			Hexachloropropene	10	ug/L	10	.	.	.	.
			Indeno(1,2,3-cd)pyrene	10	ug/L	10	.	.	.	.
			Iron (Filtered)	20	ug/L	13	10	30	25000	50M05
			Iron (Unfiltered)	20	ug/L	13	12	1200	200000	50M08
			Isodrin	10	ug/L	10	.	.	.	.
			Isophorone	10	ug/L	10	.	.	.	.
			Isosafrole	10	ug/L	10	.	.	.	.
			Kepone	10	ug/L	10	.	.	.	.
			Kerosene	10000	ug/L	10	1	8.1	8.1	50M01
			Lead (Filtered)	5	ug/L	13	4	2	8.5	50M10
			Lead (Unfiltered)	5	ug/L	11	7	2	96	50M08
			Magnesium (Filtered)	100	ug/L	13	12	8200	24000	50M05
			Magnesium (Unfiltered)	100	ug/L	13	12	8400	48000	50M08
			Manganese (Filtered)	10	ug/L	13	12	80	15000	50M05
			Manganese (Unfiltered)	10	ug/L	13	12	80	17000	50M08
			Mercury (Filtered)	0.2	ug/L	13	1	0.3	0.3	50M05
			Mercury (Unfiltered)	0.2	ug/L	13	7	0.2	1.5	50M08
			Methapyrilene	10	ug/L	10	.	.	.	.
			Methyl methanesulfonate	10	ug/L	10	.	.	.	.
			Methylenechloride	5	ug/L	17	4	0.12	47	50M01
			N-Nitroso-di-n-dipropylamine	10	ug/L	10	.	.	.	.
			N-Nitrosodi-n-butylamine	10	ug/L	10	.	.	.	.
			N-Nitrosodiethylamine	10	ug/L	10	.	.	.	.
			N-Nitrosodimethylamine	10	ug/L	10	.	.	.	.
			N-Nitrosodiphenylamine	10	ug/L	10	.	.	.	.
			N-Nitrosomethylethylamine	10	ug/L	10	.	.	.	.
			N-Nitrosomorpholine	10	ug/L	10	.	.	.	.
			N-Nitrosopiperidine	10	ug/L	10	.	.	.	.
			Naphthalene	10	ug/L	10	3	26	190	50M05
			Nickel (Filtered)	30	ug/L	13	1	23	23	50M05
			Nickel (Unfiltered)	30	ug/L	13	6	40	230	50M08
			Nitrate	200	ug/L	3	2	50	1100	50M08
			Nitrite	200	ug/L	3	.	.	.	.
			Nitrobenzene	10	ug/L	10	.	.	.	.
			Nitrosopyrrolidine	10	ug/L	10	.	.	.	.
			Parathion	10	ug/L	10	.	.	.	.
			Pentachlorobenzene	10	ug/L	10	.	.	.	.
			Pentachloronitrobenzene (PCNB)	10	ug/L	10	.	.	.	.
			Pentachlorophenol	50	ug/L	10	.	.	.	.
			Phenacetin	10	ug/L	10	.	.	.	.
			Phenanthrene	10	ug/L	10	.	.	.	.
			Phenol	10	ug/L	10	1	4.3	4.3	OLD WELL
			Phosphate	400	ug/L	3	.	.	.	.
			Potassium (Filtered)	300	ug/L	13	13	740	6000	50M05
			Potassium (Unfiltered)	300	ug/L	13	12	810	10000	50M08
			Pronamide	10	ug/L	10	.	.	.	.
			Pyrene	10	ug/L	10	.	.	.	.
			Pyridine	10	ug/L	10	.	.	.	.
			Safrol	10	ug/L	10	.	.	.	.
			Silver (Filtered)	20	ug/L	13	3	3.4	5.1	50M10
			Silver (Unfiltered)	20	ug/L	13	5	4	10	50M06
			Sodium (Filtered)	300	ug/L	13	13	900	9700	50M05
			Sodium (Unfiltered)	300	ug/L	13	13	700	13000	50M02
			Sulfate	500	ug/L	3	3	36000	39000	50M08

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
50	Water	1993	Tetrachloroethene	0.5	ug/L	17	.	.	.	.
			Tetraethyl dithiopyrophosphate	10	ug/L	10	.	.	.	.
			Tin (Filtered)	100	ug/L	13	.	.	.	.
			Tin (Unfiltered)	100	ug/L	13	.	.	.	.
			Toluene	2	ug/L	17	10	0.11	140	50M01
			Total dissolved solids	10	mg/L	1	1	240	240	50M08
			Tributyl phosphate	10	ug/L	10	.	.	.	.
			Trichloroethene	1	ug/L	17	.	.	.	.
			Tris-2-chloroethyl phosphate	10	ug/L	10	.	.	.	.
			Vanadium (Filtered)	30	ug/L	13	1	4.3	4.3	50M10
			Vanadium (Unfiltered)	30	ug/L	13	6	30	180	50M08
			Vinyl chloride	2	ug/L	17	3	2	2	50M06
			Xylenes (total)	5	ug/L	17	10	0.22	1900	50M05
			Zinc (Filtered)	10	ug/L	13	5	7.7	970	50M10
			Zinc (Unfiltered)	10	ug/L	13	10	9.5	3700	50M10
			alpha, alpha-Dimethylphenethylamine	10	ug/L	10	.	.	.	.
			cis-1, 2-Dichloroethylene	1	ug/L	17	.	.	.	.
			m-Cresol	10	ug/L	10	.	.	.	.
			m-Dinitrobenzene	10	ug/L	10	.	.	.	.
			o-Toluidine	10	ug/L	10	.	.	.	.
			p-Dimethylaminoazobenzene	10	ug/L	10	.	.	.	.
			p-Phenylenediamine	10	ug/L	10	.	.	.	.
			sym-Trinitrobenzene	10	ug/L	10	.	.	.	.
			trans-1, 2-Dichloroethylene	1	ug/L	17	.	.	.	.

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Soil	1986	1,1,2,2-Tetrachloroethane	5	ug/kg	12	.	.	.	.
			1,1-Dichloroethene	5	ug/kg	12	.	.	.	.
			2-Butanone	5	ug/kg	12	.	.	.	.
			Benzene	5	ug/kg	12	.	.	.	.
			Chlorobenzene	5	ug/kg	12	.	.	.	.
			Chloroform	5	ug/kg	12	.	.	.	.
			Ethylbenzene	5	ug/kg	12	.	.	.	.
			Methylenechloride	5	ug/kg	12	.	.	.	.
			Tetrachloroethene	5	ug/kg	12	.	.	.	.
			Toluene	5	ug/kg	12	.	.	.	.
			Vinyl chloride	5	ug/kg	12	.	.	.	.
			Xylenes (total)	5	ug/kg	12	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Soil	Stage 3	2-Methylnaphthalene	30	ug/kg	1	1	40	40	53M04
			4,4'-DDE	1	ug/kg	1	.	.	.	.
			Aroclor-1254	1	ug/kg	1	1	70	70	53M04
			Benzene	44	ug/kg	9	1	263	263	20M04
			Chlordane	1	ug/kg	1	.	.	.	.
			Dieldrin	1	ug/kg	1	.	.	.	.
			Ethylbenzene	80	ug/kg	9	.	.	.	.
			Methylenechloride	150	ug/kg	9	3	510	1100	20M04
			Moisture	.	Percent	9	9	2.6	25.9	20M04
			TPH	10000	ug/kg	9	2	24800	39500	53M04
			Tetrachloroethene	90	ug/kg	9	.	.	.	.
			Toluene	160	ug/kg	9	1	380	380	20M04
			Vinyl chloride	290	ug/kg	9	.	.	.	.
			Xylenes (total)	80	ug/kg	9	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Soil	1993	0,0,0-Triethyl phosphorothioate	660	ug/kg	5	.	.	.	.
			0,0-Diethyl 0-2-pyrazinyl phosphorothio	660	ug/kg	5	.	.	.	.
			1,1,1-Trichloroethane	0.5	ug/kg	3	.	.	.	.
			1,1,2-Trichloroethane	0.5	ug/kg	3	.	.	.	.
			1,1-Dichloroethane	1	ug/kg	3	.	.	.	.
			1,2,4,5-Tetrachlorobenzene	660	ug/kg	5	.	.	.	.
			1,2,4-Trichlorobenzene	660	ug/kg	5	.	.	.	.
			1,2-Dichlorobenzene	660	ug/kg	5	.	.	.	.
			1,2-Dichloroethane	0.5	ug/kg	3	.	.	.	.
			1,3-Dichlorobenzene	660	ug/kg	5	.	.	.	.
			1,4-Dichlorobenzene	2	ug/kg	3	.	.	.	.
			1,4-Dichlorobenzene	660	ug/kg	5	.	.	.	.
			1,4-Naphthoquinone	660	ug/kg	5	.	.	.	.
			1-Naphthylamine	660	ug/kg	5	.	.	.	.
			2,3,4,6-Tetrachlorophenol	660	ug/kg	5	.	.	.	.
			2,4,5-Trichlorophenol	660	ug/kg	5	.	.	.	.
			2,4,6-Trichlorophenol	660	ug/kg	5	.	.	.	.
			2,4-Dichlorophenol	660	ug/kg	5	.	.	.	.
			2,4-Dimethylphenol	660	ug/kg	5	.	.	.	.
			2,4-Dinitrophenol	3300	ug/kg	5	.	.	.	.
			2,4-Dinitrotoluene	660	ug/kg	5	.	.	.	.
			2,6-Dichlorophenol	660	ug/kg	5	.	.	.	.
			2,6-Dinitrotoluene	660	ug/kg	5	.	.	.	.
			2-Acetylaminofluorene	660	ug/kg	5	.	.	.	.
			2-Chloronaphthalene	660	ug/kg	5	.	.	.	.
			2-Chlorophenol	660	ug/kg	5	.	.	.	.
			2-Methylnaphthalene	660	ug/kg	5	.	.	.	.
			2-Methylphenol	660	ug/kg	5	.	.	.	.
			2-Naphthylamine	660	ug/kg	5	.	.	.	.
			2-Nitroaniline	3300	ug/kg	5	.	.	.	.
			2-Nitrophenol	660	ug/kg	5	.	.	.	.
			2-Picoline	660	ug/kg	5	.	.	.	.
			3,3'-Dichlorobenzidine	1300	ug/kg	5	.	.	.	.
			3,3'-Dimethylbenzidine	660	ug/kg	5	.	.	.	.
			3-Methylcholanthrene	660	ug/kg	5	.	.	.	.
			3-Nitroaniline	3300	ug/kg	5	.	.	.	.
			4,4'-DDD	20	ug/kg	5	3	5.8	570	COMPOSITE
			4,4'-DDE	10	ug/kg	5	2	9	230	COMPOSITE
			4,4'-DDT	20	ug/kg	5	2	2	1500	COMPOSITE
			4,6-Dinitro-o-cresol	3300	ug/kg	5	.	.	.	.
			4-Aminobiphenyl	660	ug/kg	5	.	.	.	.
			4-Bromophenylphenyl ether	660	ug/kg	5	.	.	.	.
			4-Chloro-3-methylphenol	1300	ug/kg	5	.	.	.	.
			4-Chloroaniline	1300	ug/kg	5	.	.	.	.
			4-Chlorophenylphenyl ether	660	ug/kg	5	.	.	.	.
			4-Methylphenol	660	ug/kg	5	.	.	.	.
			4-Nitroaniline	3300	ug/kg	5	.	.	.	.
			4-Nitrophenol	3300	ug/kg	5	.	.	.	.
			4-Nitroquinoline-1-oxide	660	ug/kg	5	.	.	.	.
			5-Nitro-o-toluidine	660	ug/kg	5	.	.	.	.
			7,12-Dimethylbenz[a]anthracene	660	ug/kg	5	.	.	.	.
			Acenaphthene	660	ug/kg	5	.	.	.	.
			Acenaphthylene	660	ug/kg	5	.	.	.	.
			Acetophenone	660	ug/kg	5	.	.	.	.
			Aldrin	10	ug/kg	5	.	.	.	.
			Alpha-BHC	10	ug/kg	5	.	.	.	.
			Aluminum	20000	ug/kg	3	3	6400000	9100000	20MW13
			Aniline	660	ug/kg	5	.	.	.	.

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 Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Soil	1993	Anthracene	660	ug/kg	5	.	.	.	.
			Antimony	20000	ug/kg	3	.	.	.	.
			Aramite	660	ug/kg	5	.	.	.	.
			Aroclor-1016	100	ug/kg	4	.	.	.	.
			Aroclor-1221	200	ug/kg	4	.	.	.	.
			Aroclor-1232	200	ug/kg	4	.	.	.	.
			Aroclor-1242	100	ug/kg	4	.	.	.	.
			Aroclor-1248	100	ug/kg	4	.	.	.	.
			Aroclor-1254	100	ug/kg	4	.	.	.	.
			Aroclor-1260	100	ug/kg	4	.	.	.	.
			Arsenic	500	ug/kg	3	3	3200	6300	20MW13
			Barium	2000	ug/kg	3	3	67000	88000	20MW13
			Benzene	2	ug/kg	3	.	.	.	.
			Benzo(a)anthracene	660	ug/kg	5	.	.	.	.
			Benzo(a)pyrene	660	ug/kg	5	.	.	.	.
			Benzo(b)fluoranthene	660	ug/kg	5	.	.	.	.
			Benzo(ghi)perylene	660	ug/kg	5	.	.	.	.
			Benzo(k)fluoranthene	660	ug/kg	5	.	.	.	.
			Benzothiazole	660	ug/kg	5	.	.	.	.
			Benzyl alcohol	1300	ug/kg	5	.	.	.	.
			Beryllium	300	ug/kg	3	3	140	600	POND
			Beta-BHC	10	ug/kg	5	.	.	.	.
			Bis(2-Chloroethoxy)methane	660	ug/kg	5	.	.	.	.
			Bis(2-Chloroisopropyl) ether	660	ug/kg	5	.	.	.	.
			Bis(2-chloroethyl) ether	660	ug/kg	5	1	500	500	20MW27
			Bis(2-ethylhexyl) phthalate	660	ug/kg	5	.	.	.	.
			Butylbenzylphthalate	660	ug/kg	5	1	490	490	20MW13
			Cadmium	1000	ug/kg	3	3	4700000	8200000	20MW13
			Calcium	10000	ug/kg	3	.	.	.	.
			Carbon tetrachloride	1	ug/kg	3	1	2200	2200	COMPOSITE
			Chlordane	50	ug/kg	5	.	.	.	.
			Chlorobenzilate	660	ug/kg	5	.	.	.	.
			Chloroform	0.5	ug/kg	3	.	.	.	.
			Chromium	2000	ug/kg	3	3	16000	19000	20MW13
			Chrysene	660	ug/kg	5	1	210	210	POND
			Cobalt	660	ug/kg	5	3	6000	7000	20MW13
			Copper	2000	ug/kg	3	3	12000	22000	POND
			Delta-BHC	20	ug/kg	5	.	.	.	.
			Di-n-butylphthalate	660	ug/kg	5	.	.	.	.
			Di-n-octylphthalate	660	ug/kg	5	.	.	.	.
			Diallate	660	ug/kg	5	.	.	.	.
			Dibenz[a,h]anthracene	660	ug/kg	5	.	.	.	.
			Dibenzofuran	660	ug/kg	5	1	34	34	COMPOSITE
			Dieldrin	10	ug/kg	5	.	.	.	.
			Diethylphthalate	660	ug/kg	5	.	.	.	.
			Dimethoate	660	ug/kg	5	.	.	.	.
			Dimethyl phthalate	660	ug/kg	5	.	.	.	.
			Diphenylamine	660	ug/kg	5	.	.	.	.
			Endosulfan I	10	ug/kg	5	.	.	.	.
			Endosulfan II	10	ug/kg	5	.	.	.	.
			Endosulfan sulfate	20	ug/kg	5	.	.	.	.
			Endrin	10	ug/kg	5	.	.	.	.
			Endrin Aldehyde	50	ug/kg	5	.	.	.	.
			Ethyl methanesulfonate	660	ug/kg	5	.	.	.	.
			Ethylbenzene	2	ug/kg	3	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Soil	1993	Famphur	660	ug/kg	5	.	.	.	.
			Fluoranthene	660	ug/kg	5	2	220	470	POND
			Fluorene	660	ug/kg	5	.	.	.	.
			Gamma-BHC (Lindane)	10	ug/kg	5	.	.	.	.
			Heptachlor	10	ug/kg	5	1	5.7	5.7	COMPOSITE
			Heptachlor epoxide	60	ug/kg	5	1	13	13	COMPOSITE
			Hexachlorobenzene	660	ug/kg	5	.	.	.	.
			Hexachlorobutadiene	660	ug/kg	5	.	.	.	.
			Hexachlorocyclopentadiene	660	ug/kg	5	.	.	.	.
			Hexachloroethane	660	ug/kg	5	.	.	.	.
			Hexachlorophene	660	ug/kg	5	.	.	.	.
			Hexachloropropene	660	ug/kg	5	.	.	.	.
			Indeno (1,2,3-cd)pyrene	660	ug/kg	5	.	.	.	.
			Iron	2000	ug/kg	3	3	12000000	17000000	20MW13
			Isodrin	660	ug/kg	5	.	.	.	.
			Isophorone	660	ug/kg	5	.	.	.	.
			Isosafrole	660	ug/kg	5	.	.	.	.
			Kepone	660	ug/kg	5	.	.	.	.
			Kerosene	660	ug/kg	5	.	.	.	.
			Lead	500	ug/kg	3	3	3500	7700	POND
			Magnesium	10000	ug/kg	3	3	3500000	4900000	20MW13
			Manganese	1000	ug/kg	3	3	160000	310000	20MW13
			Mercury	400	ug/kg	3	1	100	100	POND
			Methapyrilene	660	ug/kg	5	.	.	.	.
			Methoxychlor	100	ug/kg	5	.	.	.	.
			Methyl methanesulfonate	660	ug/kg	5	.	.	.	.
			Methylenechloride	5	ug/kg	3	.	.	.	.
			N-Nitroso-di-n-dipropylamine	660	ug/kg	5	.	.	.	.
			N-Nitrosodi-n-butylamine	660	ug/kg	5	.	.	.	.
			N-Nitrosodiethylamine	660	ug/kg	5	.	.	.	.
			N-Nitrosodimethylamine	660	ug/kg	5	.	.	.	.
			N-Nitrosodiphenylamine	660	ug/kg	5	.	.	.	.
			N-Nitrosomethylethylamine	660	ug/kg	5	.	.	.	.
			N-Nitrosomorpholine	660	ug/kg	5	.	.	.	.
			N-Nitrosopiperidine	660	ug/kg	5	.	.	.	.
			Naphthalene	660	ug/kg	5	.	.	.	.
			Nickel	3000	ug/kg	3	3	14000	20000	20MW13
			Nitrobenzene	660	ug/kg	5	.	.	.	.
			Nitrosopyrrolidine	660	ug/kg	5	.	.	.	.
			Parathion	660	ug/kg	5	.	.	.	.
			Pentachlorobenzene	660	ug/kg	5	.	.	.	.
			Pentachloronitrobenzene (PCNB)	660	ug/kg	5	.	.	.	.
			Pentachlorophenol	3300	ug/kg	5	.	.	.	.
			Phenacetin	660	ug/kg	5	.	.	.	.
			Phenanthrene	660	ug/kg	5	.	.	.	.
			Phenol	660	ug/kg	5	.	.	.	.
			Potassium	30000	ug/kg	3	3	600000	800000	20MW13
			Pronamide	660	ug/kg	5	.	.	.	.
			Pyrene	660	ug/kg	5	2	190	380	POND
			Pyridine	660	ug/kg	5	.	.	.	.
			Safrol	660	ug/kg	5	.	.	.	.
			Silver	2000	ug/kg	3	.	.	.	.
			Sodium	30000	ug/kg	3	3	390000	580000	20MW13
			TPH-diesel	4400	ug/kg	1	.	.	.	.
			TPH-diesel	4700	ug/kg	1	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Soil	1993	TPH-gasoline	7700	ug/kg	1	.	.	.	.
			TPH-gasoline	8300	ug/kg	1	.	.	.	.
			TPH-gasoline	0.5	ug/kg	3	.	.	.	.
			Tetrachloroethene	660	ug/kg	5	.	.	.	.
			Tetraethyl dithiopyrophosphate	660	ug/kg	3	.	.	.	.
			Tin	10000	ug/kg	3	1	0.18	0.18	20MW27
			Toluene	2	ug/kg	3	.	.	.	.
			Toxaphene	400	ug/kg	5	.	.	.	.
			Tributyl phosphate	660	ug/kg	5	.	.	.	.
			Trichloroethene	1	ug/kg	3	.	.	.	.
			Tris-2-chloroethyl phosphate	660	ug/kg	5	.	.	.	.
			Vanadium	3000	ug/kg	3	3	29000	51000	20MW27
			Vinyl chloride	2	ug/kg	3	.	.	.	.
			Xylenes (total)	5	ug/kg	3	1	5.3	5.3	POND
			Zinc	10	ug/kg	3	3	31000	42000	20MW13
			alpha,alpha-Dimethylphenethylamine	660	ug/kg	5	.	.	.	.
			cis-1,2-Dichloroethylene	1	ug/kg	3	2	1	1	20MW13
			m-Cresol	660	ug/kg	5	.	.	.	.
			m-Dinitrobenzene	660	ug/kg	5	.	.	.	.
			o-Toluidine	660	ug/kg	5	.	.	.	.
			p-Dimethylaminoazobenzene	660	ug/kg	5	.	.	.	.
			p-Phenylenediamine	660	ug/kg	5	.	.	.	.
			sym-Trinitrobenzene	660	ug/kg	5	.	.	.	.
			trans-1,2-Dichloroethylene	1	ug/kg	3	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Soil Gas	Stage 3	1,3-Dimethylbenzene	10	ug/L	40	20	10	8800	20SV85
			Benzene	10	ug/L	40	18	20	272000	20SV86
			Ethylbenzene	10	ug/L	40	19	10	7640	20SV65
			Toluene	10	ug/L	40	26	10	158000	20SV61
			Total BTEX	10	ug/L	40	27	10	293000	20SV86

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Water	1986	1,1,2,2-Tetrachloroethane	1	ug/L	3	.	.	.	.
			1,1-Dichloroethene	1	ug/L	3	.	.	.	.
			2-Butanone	1	ug/L	3	.	.	.	.
			Benzene	1	ug/L	4	.	.	.	.
			Chlorobenzene	1	ug/L	3	.	.	.	.
			Chloroform	1	ug/L	3	.	.	.	.
			Ethylbenzene	1	ug/L	3	.	.	.	.
			Methylenechloride	1	ug/L	3	.	.	.	.
			Oil & Grease	100	ug/L	4	3	100	300	W-3
			Petroleum Oil & Grease	100	ug/L	4	3	100	300	W-3
			TOC	.	ug/L	4	4	8300	47000	W-3
			Tetrachloroethene	1	ug/L	3	.	.	.	.
			Toluene	1	ug/L	3	.	.	.	.
			Vinyl chloride	1	ug/L	3	.	.	.	.
			Xylenes (total)	1	ug/L	3	.	.	.	.

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 Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Water	Stage 3	2,4-Dimethylphenol	0.28	ug/L	7	1	13	13	20M04
			2-Methylnaphthalene	0.9	ug/L	7	3	2.8	88.9	53M04
			2-Methylphenol	0.84	ug/L	7	3	2.52	68.4	53M04
			4-Methylphenol	0.8	ug/L	7	2	5	12	53M04
			Acenaphthene	0.32	ug/L	7	.	.	.	.
			Aluminum (Unfiltered)	30	ug/L	1	1	25600	25600	53M04
			Anthracene	0.52	ug/L	7	.	.	.	.
			Arsenic (Filtered)	40	ug/L	2	2	10	50	53M04
			Arsenic (Unfiltered)	40	ug/L	1	1	27.5	27.5	53M04
			BIS (2-Ethylmexylphthalate)	2	ug/L	7	.	.	.	.
			Barium (Filtered)	1	ug/L	1	1	200	200	53M04
			Barium (Unfiltered)	1	ug/L	1	1	579	579	53M04
			Benzene	0.15	ug/L	7	6	4.72	12000	53M04
			Benzoic acid	.	ug/L	7	1	10.7	10.7	20M04
			Benzyl alcohol	0.07	ug/L	7	1	2.78	2.78	20M04
			Calcium (Filtered)	13	ug/L	1	1	53600	53600	53M04
			Calcium (Unfiltered)	13	ug/L	1	1	65200	65200	53M04
			Chloride	200	ug/L	6	1	755	755	53M04
			Chlorobenzene	0.34	ug/L	7	.	.	.	.
			Chromium (Unfiltered)	10	ug/L	1	1	40.7	40.7	53M04
			Cobalt (Unfiltered)	10	ug/L	1	1	32.8	32.8	53M04
			Copper (Unfiltered)	3	ug/L	1	1	218	218	53M04
			Dibenzofuran	0.34	ug/L	7	.	.	.	.
			Ethylbenzene	0.46	ug/L	7	4	24.6	1130	20M04
			Fluoranthene	1	ug/L	7	.	.	.	.
			Fluorene	0.88	ug/L	7	.	.	.	.
			Iron (Filtered)	20	ug/L	1	1	3700	3700	53M04
			Iron (Unfiltered)	20	ug/L	1	1	74400	74400	53M04
			Lead (Unfiltered)	1.4	ug/L	2	2	55.6	90	53M04
			Magnesium (Filtered)	44	ug/L	1	1	13200	13200	53M04
			Magnesium (Unfiltered)	44	ug/L	1	1	22400	22400	53M04
			Manganese (Filtered)	1.4	ug/L	1	1	800	800	53M04
			Manganese (Unfiltered)	1.4	ug/L	1	1	1190	1190	53M04
			Mercury (Filtered)	0.2	ug/L	1	1	0.7	0.7	53M04
			Mercury (Unfiltered)	0.2	ug/L	1	1	0.4	0.4	53M04
			Naphthalene	0.26	ug/L	7	3	8.6	130	53M04
			Nickel (Unfiltered)	20	ug/L	1	1	57.4	57.4	53M04
			Nitrite/Nitrate	10	ug/L	7	2	12	12	20M04
			Phenanthrene	0.46	ug/L	7	.	.	.	.
			Phenol	1	ug/L	7	4	2.6	140	53M04
			Potassium (Filtered)	408	ug/L	1	1	2530	2530	53M04
			Potassium (Unfiltered)	408	ug/L	1	1	7440	7440	53M04
			Pyrene	1	ug/L	7	.	.	.	.
			Residue, DISS	1000	ug/L	7	7	216000	312000	53M04
			Sodium (Filtered)	82	ug/L	1	1	4580	4580	53M04
			Sodium (Unfiltered)	82	ug/L	1	1	8720	8720	53M04
			Sulfate	500	ug/L	6	1	5930	5930	53M04
			TPH	100	ug/L	7	2	4300	7600	20M04
			Toluene	0.25	ug/L	7	3	348	19700	53M04
			Trichloromonofluoromethane	0.32	ug/L	1	.	.	.	.
			Vanadium (Unfiltered)	10	ug/L	1	1	72.5	72.5	53M04
			Xylenes (total)	0.85	ug/L	7	3	290	3830	53M04
			Zinc (Filtered)	2	ug/L	1	1	40	40	53M04
			Zinc (Unfiltered)	2	ug/L	1	1	191	191	53M04

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Water	Stage 4	1,1-Dichloroethene	5	ug/L	26	4	6	32	20FW56
			1,2-Dimethylbenzene	1	ug/L	30	2	1	2	20FW75
			1,3-Dimethylbenzene	1	ug/L	30	3	1	2	20FW74
			Benzene	1	ug/L	40	21	0.32	7170	20M04
			Chlorobenzene	0.4	ug/L	10	.	.	.	.
			Ethylbenzene	1	ug/L	40	6	1	1120	53M04
			Methylenechloride	1.4	ug/L	26	5	3	5	20FW55
			TPH	200	ug/L	10	2	500	4900	20M04
			Toluene	1	ug/L	40	14	0.6	15900	53M04
			Xylenes (total)	0.4	ug/L	10	4	1.21	3820	20M04

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Media Area Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Water	1993	0,0,0-Triethyl phosphorothioate	10	ug/L	4	.	.	.
			0,0-Diethyl 0-2-pyrazinyl phosphorothio	10	ug/L	4	.	.	.
			1,1,1-Trichloroethane	0.5	ug/L	13	.	.	.
			1,1,2-Trichloroethane	0.5	ug/L	13	.	.	.
			1,1-Dichloroethane	1	ug/L	13	.	.	.
			1,2,4,5-Tetrachlorobenzene	10	ug/L	4	.	.	.
			1,2,4-Trichlorobenzene	10	ug/L	4	.	.	.
			1,2-Dichlorobenzene	10	ug/L	4	.	.	.
			1,2-Dichloroethane	0.5	ug/L	13	.	.	.
			1,3-Dichlorobenzene	10	ug/L	4	.	.	.
			1,4-Dichlorobenzene	2	ug/L	13	.	.	.
			1,4-Dichlorobenzene	10	ug/L	4	.	.	.
			1,4-Dichlorobenzene	10	ug/L	4	.	.	.
			1,4-Naphthoquinone	10	ug/L	4	.	.	.
			1-Naphthylamine	10	ug/L	4	.	.	.
			2,3,4,6-Tetrachlorophenol	10	ug/L	4	.	.	.
			2,4,5-Trichlorophenol	10	ug/L	4	.	.	.
			2,4,6-Trichlorophenol	10	ug/L	4	.	.	.
			2,4-Dichlorophenol	10	ug/L	4	.	.	.
			2,4-Dimethylphenol	10	ug/L	4	2	22	30 20M04
			2,4-Dinitrophenol	50	ug/L	4	.	.	.
			2,4-Dinitrotoluene	10	ug/L	4	.	.	.
			2,6-Dichlorophenol	10	ug/L	4	.	.	.
			2,6-Dinitrotoluene	10	ug/L	4	.	.	.
			2-Acetylaminofluorene	10	ug/L	4	.	.	.
			2-Chloronaphthalene	10	ug/L	4	.	.	.
			2-Chlorophenol	10	ug/L	4	.	.	.
			2-Methylnaphthalene	10	ug/L	4	2	40	61 53M04
			2-Methylphenol	10	ug/L	4	2	300	460 20M04
			2-Naphthylamine	10	ug/L	4	.	.	.
			2-Nitroaniline	50	ug/L	4	.	.	.
			2-Nitrophenol	10	ug/L	4	.	.	.
			2-Picoline	10	ug/L	4	.	.	.
			3,3'-Dichlorobenzidine	20	ug/L	4	.	.	.
			3,3'-Dimethylbenzidine	10	ug/L	4	.	.	.
			3-Methylcholanthrene	10	ug/L	4	.	.	.
			3-Nitroaniline	50	ug/L	4	.	.	.
			4,6-Dinitro-o-cresol	50	ug/L	4	.	.	.
			4-Aminobiphenyl	10	ug/L	4	.	.	.
			4-Bromophenylphenyl ether	10	ug/L	4	.	.	.
			4-Chloro-3-methylphenol	20	ug/L	4	.	.	.
			4-Chloroaniline	20	ug/L	4	.	.	.
			4-Chlorophenylphenyl ether	10	ug/L	4	.	.	.
			4-Methylphenol	10	ug/L	4	2	62	180 20M04
			4-Nitroaniline	50	ug/L	4	.	.	.
			4-Nitrophenol	50	ug/L	4	.	.	.
			4-Nitroquinoline-1-oxide	10	ug/L	4	.	.	.
			5-Nitro-o-toluidine	10	ug/L	4	.	.	.
			7,12-Dimethylbenz[a]anthracene	10	ug/L	4	.	.	.
			Acenaphthene	10	ug/L	4	.	.	.
			Acenaphthylene	10	ug/L	4	.	.	.
			Acetophenone	10	ug/L	4	1	99	99 53M04
			Aluminum (Filtered)	200	ug/L	4	1	72	72 POND
			Aluminum (Unfiltered)	200	ug/L	4	3	81	1600 53M04
			Aniline	10	ug/L	4	.	.	.
			Anthracene	10	ug/L	4	.	.	.
			Antimony (Filtered)	200	ug/L	4	3	97	140 20M27
			Antimony (Unfiltered)	200	ug/L	4	3	110	150 20M12
			Aramite	10	ug/L	4	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Water	1993	Arsenic (Filtered)	5	ug/L	4	4	1	22	20M12
			Arsenic (Unfiltered)	5	ug/L	4	4	2	71	20M12
			Barium (Filtered)	20	ug/L	4	4	30	180	20M12
			Barium (Unfiltered)	20	ug/L	4	4	30	200	53M04
			Benzene	2	ug/L	13	8	1.4	200	53M04
			Benzo(a)anthracene	10	ug/L	4	.	.	.	.
			Benzo(a)pyrene	10	ug/L	4	.	.	.	.
			Benzo(b)fluoranthene	10	ug/L	4	.	.	.	.
			Benzo(ghi)perylene	10	ug/L	4	.	.	.	.
			Benzo(k)fluoranthene	10	ug/L	4	.	.	.	.
			Benzothiazole	10	ug/L	4	.	.	.	.
			Benzyl alcohol	20	ug/L	4	.	.	.	.
			Beryllium (Filtered)	3	ug/L	4	1	6	6	53M04
			Beryllium (Unfiltered)	3	ug/L	4	.	.	.	.
			Bis(2-Chloroethoxy)methane	10	ug/L	4	.	.	.	.
			Bis(2-Chloroisopropyl) ether	10	ug/L	4	.	.	.	.
			Bis(2-chloroethyl) ether	10	ug/L	4	.	.	.	.
			Bis(2-ethylhexyl) phthalate	10	ug/L	4	3	11	1000	53M04
			Butylbenzylphthalate	10	ug/L	4	.	.	.	.
			Cadmium (Filtered)	10	ug/L	4	1	8.7	8.7	53M04
			Cadmium (Unfiltered)	10	ug/L	4	.	.	.	.
			Calcium (Filtered)	100	ug/L	4	4	12000	81000	20MW27
			Calcium (Unfiltered)	100	ug/L	4	4	13000	80000	20MW27
			Carbon tetrachloride	1	ug/L	13	.	.	.	.
			Chlorobenzilate	10	ug/L	4	.	.	.	.
			Chloroform	0.5	ug/L	13	.	.	.	.
			Chromium (Filtered)	20	ug/L	4	1	12	12	53M04
			Chromium (Unfiltered)	20	ug/L	4	1	17	17	53M04
			Chrysene	10	ug/L	4	.	.	.	.
			Cobalt (Filtered)	20	ug/L	4	1	17	17	53M04
			Cobalt (Unfiltered)	20	ug/L	4	2	7.5	9	53M04
			Copper (Filtered)	20	ug/L	4	1	10	10	53M04
			Copper (Unfiltered)	20	ug/L	4	2	4.6	50	53M04
			Di-n-butylphthalate	10	ug/L	4	.	.	.	.
			Di-n-octylphthalate	10	ug/L	4	.	.	.	.
			Diallate	10	ug/L	4	.	.	.	.
			Dibenz[a,h]anthracene	10	ug/L	4	.	.	.	.
			Dibenzofuran	10	ug/L	4	.	.	.	.
			Diethylphthalate	10	ug/L	4	.	.	.	.
			Dimethoate	10	ug/L	4	.	.	.	.
			Dimethyl phthalate	10	ug/L	4	.	.	.	.
			Diphenylamine	10	ug/L	4	.	.	.	.
			Ethyl methanesulfonate	10	ug/L	4	.	.	.	.
			Ethylbenzene	2	ug/L	13	11	0.11	25	20M03
			Famphur	10	ug/L	4	.	.	.	.
			Fluoranthene	10	ug/L	4	.	.	.	.
			Fluorene	10	ug/L	4	.	.	.	.
			Hexachlorobenzene	10	ug/L	4	.	.	.	.
			Hexachlorobutadiene	10	ug/L	4	.	.	.	.
			Hexachlorocyclopentadiene	10	ug/L	4	.	.	.	.
			Hexachloroethane	10	ug/L	4	.	.	.	.
			Hexachlorophene	10	ug/L	4	.	.	.	.
			Hexachloropropene	10	ug/L	4	.	.	.	.
			Indeno(1,2,3-cd)pyrene	10	ug/L	4	.	.	.	.
			Iron (Filtered)	20	ug/L	4	4	120	9200	53M04

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Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base

Eielson Air Force Base, Alaska

Operable Unit 1

Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Water	1993	Iron (Unfiltered)	20	ug/L	4	4	180	15000	20M12
			Isodrin	10	ug/L	4	.	.	.	.
			Isophorone	10	ug/L	4	.	.	.	.
			Isosafrole	10	ug/L	4	.	.	.	.
			Kepone	10	ug/L	4	.	.	.	.
			Kerosene	10000	ug/L	4	1	390	390	53M04
			Lead (Filtered)	5	ug/L	4	.	.	.	.
			Lead (Unfiltered)	5	ug/L	4	2	3	12	53M04
			Magnesium (Filtered)	100	ug/L	4	4	5900	14000	20M12
			Magnesium (Unfiltered)	100	ug/L	4	4	5900	15000	20M12
			Manganese (Filtered)	10	ug/L	4	4	20	2900	20M12
			Manganese (Unfiltered)	10	ug/L	4	4	30	1800	20M12
			Mercury (Filtered)	0.2	ug/L	4	.	.	.	.
			Mercury (Unfiltered)	0.2	ug/L	4	1	0.3	0.3	53M04
			Methapyrilene	10	ug/L	4	.	.	.	.
			Methyl methanesulfonate	10	ug/L	4	.	.	.	.
			Methylenechloride	5	ug/L	13	12	0.067	0.29	20A-3
			N-Nitroso-di-n-dipropylamine	10	ug/L	4	.	.	.	.
			N-Nitrosodi-n-butylamine	10	ug/L	4	.	.	.	.
			N-Nitrosodiethylamine	10	ug/L	4	.	.	.	.
			N-Nitrosodimethylamine	10	ug/L	4	.	.	.	.
			N-Nitrosodiphenylamine	10	ug/L	4	.	.	.	.
			N-Nitrosomethylethylamine	10	ug/L	4	.	.	.	.
			N-Nitrosomorpholine	10	ug/L	4	.	.	.	.
			N-Nitrosopiperidine	10	ug/L	4	2	80	85	53M04
			Naphthalene	30	ug/L	4	.	.	.	.
			Nickel (Filtered)	30	ug/L	4	1	20	20	53M04
			Nickel (Unfiltered)	10	ug/L	4	.	.	.	.
			Nitrobenzene	10	ug/L	4	.	.	.	.
			Nitrosopyrrolidine	10	ug/L	4	.	.	.	.
			Parathion	10	ug/L	4	.	.	.	.
			Pentachlorobenzene	10	ug/L	4	.	.	.	.
			Pentachloronitrobenzene (PCNB)	50	ug/L	4	.	.	.	.
			Pentachlorophenol	10	ug/L	4	.	.	.	.
			Phenacetin	10	ug/L	4	.	.	.	.
			Phenanthrene	10	ug/L	4	2	79	170	20M04
			Phenol	300	ug/L	4	4	2000	9000	POND
			Potassium (Filtered)	300	ug/L	4	4	2000	9000	POND
			Potassium (Unfiltered)	10	ug/L	4	.	.	.	.
			Pronamide	10	ug/L	4	.	.	.	.
			Pyrene	10	ug/L	4	.	.	.	.
			Pyridine	10	ug/L	4	.	.	.	.
			Safrol	20	ug/L	4	2	4	4.8	20MM27
			Silver (Filtered)	20	ug/L	4	2	4.8	5.5	53M04
			Silver (Unfiltered)	300	ug/L	4	4	1100	4500	20M12
			Sodium (Filtered)	300	ug/L	4	4	1500	5200	20M12
			Sodium (Unfiltered)	0.5	ug/L	13	.	.	.	.
			Tetrachloroethene	10	ug/L	4	.	.	.	.
			Tetraethyl dithiopyrophosphate	100	ug/L	4	.	.	.	.
			Tin (Filtered)	100	ug/L	4	.	.	.	.
			Tin (Unfiltered)	2	ug/L	13	12	0.15	1000	53M04
			Toluene	10	ug/L	4	.	.	.	.
			Tributyl phosphate	1	ug/L	13	.	.	.	.
			Trichloroethene	10	ug/L	4	.	.	.	.
			Tris-2-chloroethyl phosphate							

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Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-7	Water	1993	Vanadium (Filtered)	30	ug/L	4	1	7.5	7.5	53M04
			Vanadium (Unfiltered)	30	ug/L	4	1	5.8	5.8	53M04
			Vinyl chloride	2	ug/L	13	12	2	2	20A-3
			Xylenes (total)	5	ug/L	13	12	1.1	89	20M03
			Zinc (Filtered)	10	ug/L	4	1	20	20	POND
			Zinc (Unfiltered)	10	ug/L	4	3	8.1	60	53M04
			alpha, alpha-Dimethylphenethylamine	10	ug/L	4	.	.	.	.
			cis-1,2-Dichloroethylene	1	ug/L	13	.	.	.	.
			m-Cresol	10	ug/L	4	.	.	.	.
			m-Dinitrobenzene	10	ug/L	4	.	.	.	.
			o-Toluidine	10	ug/L	4	.	.	.	.
			p-Dimethylaminoazobenzene	10	ug/L	4	.	.	.	.
			p-Phenylenediamine	10	ug/L	4	.	.	.	.
			sym-Trinitrobenzene	10	ug/L	4	.	.	.	.
			trans-1,2-Dichloroethylene	1	ug/L	13	.	.	.	.

Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Soil	1986	1,1,2,2-Tetrachloroethane	5	ug/kg	11	.	.	.	.
			1,1-Dichloroethene	5	ug/kg	11	.	.	.	.
			1,2-Dimethylbenzene	5000	ug/kg	11	.	.	.	.
			2-Butanone	5	ug/kg	11	.	.	.	.
			Benzene	5	ug/kg	11	.	.	.	.
			Chlorobenzene	5	ug/kg	11	.	.	.	.
			Chloroform	5	ug/kg	11	.	.	.	.
			Ethylbenzene	5	ug/kg	11	.	.	.	.
			Methylenechloride	5	ug/kg	11	.	.	.	.
			Tetrachloroethene	5	ug/kg	11	.	.	.	.
			Toluene	5	ug/kg	11	.	.	.	.
			Vinyl chloride	5	ug/kg	11	.	.	.	.

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Eielson Air Force Base, Alaska

Operable Unit 1

Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Soil	Stage 3	Benzene	44	ug/kg	2	1	3310	3310	20M06
			Ethylbenzene	80	ug/kg	2	2	390	8800	20M06
			Methylenechloride	150	ug/kg	2	1	290	290	20M06
			Moisture	.	Percent	2	2	19.6	22.5	20M06
			TPH	10000	ug/kg	2	2	283000	500000	20M06
			Tetrachloroethene	90	ug/kg	2	.	.	.	.
			Toluene	160	ug/kg	2	2	3300	240000	20M06
			Vinyl chloride	290	ug/kg	2	.	.	.	.
			Xylenes (total)	80	ug/kg	2	2	6830	12400	20M06

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Eielson Air Force Base, Alaska

Operable Unit 1

Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Soil	Stage 4	1,1,2,2-Tetrachloroethane	170	ug/kg	13	.	.	.	.
			2,4-Dimethylphenol	80	ug/kg	13	.	.	.	.
			2-Methylnaphthalene	30	ug/kg	13	.	.	.	.
			2-Methylphenol	30	ug/kg	13	.	.	.	.
			4-Methylphenol	30	ug/kg	13	.	.	.	.
			Acenaphthene	30	ug/kg	13	1	90	90	20M14
			Acenaphthylene	30	ug/kg	13	1	30	30	20M14
			Anthracene	30	ug/kg	13	1	1700	1700	20M14
			Benzo(a)anthracene	50	ug/kg	13	1	630	630	20M14
			Benzo(a)pyrene	70	ug/kg	13	1	700	700	20M14
			Benzo(b)fluoranthene	70	ug/kg	13	1	720	720	20M14
			Benzo(ghi)perylene	80	ug/kg	13	1	520	520	20M14
			Benzo(k)fluoranthene	70	ug/kg	13	1	510	510	20M14
			Benzoic acid	80	ug/kg	13	.	.	.	.
			Benzyl alcohol	80	ug/kg	13	.	.	.	.
			Bis(2-ethylhexyl) phthalate	50	ug/kg	13	4	90	320	20M14
			Chrysene	50	ug/kg	13	1	1100	1100	20M14
			Dikenz[a,h]anthracene	80	ug/kg	13	1	140	140	20M14
			Dibenzofuran	30	ug/kg	13	1	80	80	20M14
			Fluoranthene	30	ug/kg	13	1	1700	1700	20M14
			Fluorene	30	ug/kg	13	1	110	110	20M14
			Indeno(1,2,3-cd)pyrene	80	ug/kg	13	1	600	600	20M14
			Moisture	.	Percent	13	13	0.6	22.7	20SB05
			Naphthalene	30	ug/kg	13	.	.	.	.
			Phenanthrene	30	ug/kg	13	1	1700	1700	20M14
			Phenol	80	ug/kg	13	.	.	.	.
			Pyrene	30	ug/kg	13	1	1700	1700	20M14
			TPH	10000	ug/kg	51	27	10000	888000	20SB06
			Toluene	170	ug/kg	13	.	.	.	.
			Xylenes (total)	770	ug/kg	13	.	.	.	.

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Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Soil	1993	0,0,0-Triethyl phosphorothioate	660	ug/kg	2	.	.	.	.
			0,0-Diethyl 0-2-pyrazinyl phosphorothio	660	ug/kg	2	.	.	.	.
			1,2,4,5-Tetrachlorobenzene	660	ug/kg	2	.	.	.	.
			1,2,4-Trichlorobenzene	660	ug/kg	2	.	.	.	.
			1,2-Dichlorobenzene	660	ug/kg	2	.	.	.	.
			1,3-Dichlorobenzene	660	ug/kg	2	.	.	.	.
			1,4-Dichlorobenzene	660	ug/kg	2	.	.	.	.
			1,4-Naphthoquinone	660	ug/kg	2	.	.	.	.
			1-Naphthylamine	660	ug/kg	2	.	.	.	.
			2,3,4,6-Tetrachlorophenol	660	ug/kg	2	.	.	.	.
			2,4,5-Trichlorophenol	660	ug/kg	2	.	.	.	.
			2,4,6-Trichlorophenol	660	ug/kg	2	.	.	.	.
			2,4-Dichlorophenol	660	ug/kg	2	.	.	.	.
			2,4-Dimethylphenol	660	ug/kg	2	.	.	.	.
			2,4-Dinitrophenol	3300	ug/kg	2	.	.	.	.
			2,4-Dinitrotoluene	660	ug/kg	2	.	.	.	.
			2,6-Dichlorophenol	660	ug/kg	2	.	.	.	.
			2,6-Dinitrotoluene	660	ug/kg	2	.	.	.	.
			2-Acetylaminofluorene	660	ug/kg	2	.	.	.	.
			2-Chloronaphthalene	660	ug/kg	2	.	.	.	.
			2-Chlorophenol	660	ug/kg	2	.	.	.	.
			2-Methylnaphthalene	660	ug/kg	2	.	.	.	.
			2-Methylphenol	660	ug/kg	2	.	.	.	.
			2-Naphthylamine	660	ug/kg	2	.	.	.	.
			2-Nitroaniline	3300	ug/kg	2	.	.	.	.
			2-Nitrophenol	660	ug/kg	2	.	.	.	.
			2-Picoline	660	ug/kg	2	.	.	.	.
			3,3'-Dichlorobenzidine	1300	ug/kg	2	.	.	.	.
			3,3'-Dimethylbenzidine	660	ug/kg	2	.	.	.	.
			3-Methylcholanthrene	660	ug/kg	2	.	.	.	.
			3-Nitroaniline	3300	ug/kg	2	.	.	.	.
			4,4'-DDD	20	ug/kg	1	.	.	.	.
			4,4'-DDE	10	ug/kg	1	.	.	.	.
			4,4'-DDT	20	ug/kg	1	.	.	.	.
			4,6-Dinitro-o-cresol	3300	ug/kg	2	.	.	.	.
			4-Aminobiphenyl	660	ug/kg	2	.	.	.	.
			4-Bromophenylphenyl ether	660	ug/kg	2	.	.	.	.
			4-Chloro-3-methylphenol	1300	ug/kg	2	.	.	.	.
			4-Chloroaniline	1300	ug/kg	2	.	.	.	.
			4-Chlorophenylphenyl ether	660	ug/kg	2	.	.	.	.
			4-Methylphenol	660	ug/kg	2	.	.	.	.
			4-Nitroaniline	3300	ug/kg	2	.	.	.	.
			4-Nitrophenol	3300	ug/kg	2	.	.	.	.
			4-Nitroquinoline-1-oxide	660	ug/kg	2	.	.	.	.
			5-Nitro-o-toluidine	660	ug/kg	2	.	.	.	.
			7,12-Dimethylbenz[a]anthracene	660	ug/kg	2	.	.	.	.
			Acenaphthene	660	ug/kg	2	.	.	.	.
			Acenaphthylene	660	ug/kg	2	.	.	.	.
			Acetophenone	660	ug/kg	2	.	.	.	.
			Aldrin	10	ug/kg	1	.	.	.	.
			Alpha-BHC	10	ug/kg	1	.	.	.	.
			Aniline	660	ug/kg	2	.	.	.	.
			Anthracene	660	ug/kg	2	.	.	.	.
			Aramite	660	ug/kg	2	.	.	.	.
			Aroclor-1016	100	ug/kg	1	.	.	.	.
			Aroclor-1221	200	ug/kg	1	.	.	.	.
			Aroclor-1232	200	ug/kg	1	.	.	.	.
			Aroclor-1242	100	ug/kg	1	.	.	.	.

Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base

Eielson Air Force Base, Alaska

Operable Unit 1

Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Soil	1993	Aroclor-1248	100	ug/kg	1	.	.	.	.
			Aroclor-1254	100	ug/kg	1	.	.	.	.
			Aroclor-1260	100	ug/kg	1	.	.	.	.
			Benzo(a)anthracene	660	ug/kg	2	1	400	400	20M14
			Benzo(a)pyrene	660	ug/kg	2	1	410	410	20M14
			Benzo(b)fluoranthene	660	ug/kg	2	1	410	410	20M14
			Benzo(ghi)perylene	660	ug/kg	2	1	250	250	20M14
			Benzo(k)fluoranthene	660	ug/kg	2	1	390	390	20M14
			Benzothiazole	660	ug/kg	2	.	.	.	.
			Benzyl alcohol	1300	ug/kg	2	.	.	.	.
			Beta-BHC	10	ug/kg	1	.	.	.	.
			Bis(2-Chloroethoxy)methane	660	ug/kg	2	.	.	.	.
			Bis(2-Chloroisopropyl) ether	660	ug/kg	2	.	.	.	.
			Bis(2-chloroethyl) ether	660	ug/kg	2	.	.	.	.
			Bis(2-ethylhexyl) phthalate	660	ug/kg	2	.	.	.	.
			Butylbenzylphthalate	660	ug/kg	2	.	.	.	.
			Chlordane	50	ug/kg	1	.	.	.	.
			Chlorobenzilate	660	ug/kg	2	.	.	.	.
			Chrysene	660	ug/kg	2	1	610	610	20M14
			Delta-BHC	20	ug/kg	1	.	.	.	.
			Di-n-butylphthalate	660	ug/kg	2	.	.	.	.
			Di-n-octylphthalate	660	ug/kg	2	.	.	.	.
			Diallate	660	ug/kg	2	.	.	.	.
			Dibenz[a,h]anthracene	660	ug/kg	2	.	.	.	.
			Dibenzofuran	660	ug/kg	2	.	.	.	.
			Dieldrin	10	ug/kg	1	.	.	.	.
			Diethylphthalate	660	ug/kg	2	.	.	.	.
			Dimethoate	660	ug/kg	2	.	.	.	.
			Dimethyl phthalate	660	ug/kg	2	.	.	.	.
			Diphenylamine	660	ug/kg	2	.	.	.	.
			Endosulfan I	10	ug/kg	1	.	.	.	.
			Endosulfan II	10	ug/kg	1	.	.	.	.
			Endosulfan sulfate	20	ug/kg	1	.	.	.	.
			Endrin	10	ug/kg	1	.	.	.	.
			Endrin Aldehyde	50	ug/kg	1	.	.	.	.
			Ethyl methanesulfonate	660	ug/kg	2	.	.	.	.
			Famphur	660	ug/kg	2	.	.	.	.
			Fluoranthene	660	ug/kg	2	1	1300	1300	20M14
			Fluorene	660	ug/kg	2	.	.	.	.
			Gamma-BHC (Lindane)	10	ug/kg	1	.	.	.	.
			Heptachlor	10	ug/kg	1	.	.	.	.
			Heptachlor epoxide	60	ug/kg	1	.	.	.	.
			Hexachlorobenzene	660	ug/kg	2	.	.	.	.
			Hexachlorobutadiene	660	ug/kg	2	.	.	.	.
			Hexachlorocyclopentadiene	660	ug/kg	2	.	.	.	.
			Hexachloroethane	660	ug/kg	2	.	.	.	.
			Hexachlorophene	660	ug/kg	2	.	.	.	.
			Hexachloropropene	660	ug/kg	2	.	.	.	.
			Indeno(1,2,3-cd)pyrene	660	ug/kg	2	1	260	260	20M14
			Isodrin	660	ug/kg	2	.	.	.	.
			Isophorone	660	ug/kg	2	.	.	.	.
			Isosafrole	660	ug/kg	2	.	.	.	.
			Kepone	660	ug/kg	2	.	.	.	.
			Kerosene	660	ug/kg	2	.	.	.	.
			Methapyrilene	660	ug/kg	2	.	.	.	.

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Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base

Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Soil	1993	Methoxychlor	100	ug/kg	1	.	.	.	
			Methyl methanesulfonate	660	ug/kg	2	.	.	.	
			N-Nitroso-di-n-dipropylamine	660	ug/kg	2	.	.	.	
			N-Nitrosodi-n-butylamine	660	ug/kg	2	.	.	.	
			N-Nitrosodiethylamine	660	ug/kg	2	.	.	.	
			N-Nitrosodimethylamine	660	ug/kg	2	.	.	.	
			N-Nitrosodiphenylamine	660	ug/kg	2	.	.	.	
			N-Nitrosomethylethylamine	660	ug/kg	2	.	.	.	
			N-Nitrosomorpholine	660	ug/kg	2	.	.	.	
			N-Nitrosopiperidine	660	ug/kg	2	.	.	.	
			Naphthalene	660	ug/kg	2	.	.	.	
			Nitrobenzene	660	ug/kg	2	.	.	.	
			Nitrosopyrrolidine	660	ug/kg	2	.	.	.	
			Parathion	660	ug/kg	2	.	.	.	
			Pentachlorobenzene	660	ug/kg	2	.	.	.	
			Pentachloronitrobenzene (PCNB)	660	ug/kg	2	.	.	.	
			Pentachlorophenol	3300	ug/kg	2	.	.	.	
			Phenacetin	660	ug/kg	2	.	.	.	
			Phenanthrene	660	ug/kg	2	1	1100	1100	20M14
			Phenol	660	ug/kg	2	.	.	.	
			Pronamide	660	ug/kg	2	.	.	.	
			Pyrene	660	ug/kg	2	1	1100	1100	20M14
			Pyridine	660	ug/kg	2	.	.	.	
			Safrol	660	ug/kg	2	.	.	.	
			Tetraethyl dithiopyrophosphate	660	ug/kg	2	.	.	.	
			Toxaphene	400	ug/kg	1	.	.	.	
			Tributyl phosphate	660	ug/kg	2	.	.	.	
			Tris-2-chloroethyl phosphate	660	ug/kg	2	.	.	.	
			alpha,alpha-Dimethylphenethylamine	660	ug/kg	2	.	.	.	
			m-Cresol	660	ug/kg	2	.	.	.	
			m-Dinitrobenzene	660	ug/kg	2	.	.	.	
			o-Toluidine	660	ug/kg	2	.	.	.	
			p-Dimethylaminoazobenzene	660	ug/kg	2	.	.	.	
			p-Phenylenediamine	660	ug/kg	2	.	.	.	
			sym-Trinitrobenzene	660	ug/kg	2	.	.	.	

Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Soil Gas	Stage 3	1,3-Dimethylbenzene	10	ug/L	24	5	10	9970	20SV79
			Benzene	10	ug/L	24	5	10	9620	20SV46
			Ethylbenzene	10	ug/L	24	10	10	3550	20SV79
			Toluene	10	ug/L	24	15	10	12800	20SV79
			Total BTEX	10	ug/L	24	16	10	26500	20SV79

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Operable Unit 1

Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Water	1986	1,1,2,2-Tetrachloroethane	1	ug/L	4	.	.	.	
			1,1-Dichloroethene	1	ug/L	4	.	.	.	
			2-Butanone	1	ug/L	4	.	.	.	
			Benzene	1	ug/L	4	.	.	.	
			Chlorobenzene	1	ug/L	4	.	.	.	
			Chloroform	1	ug/L	4	.	.	.	
			Ethylbenzene	1	ug/L	4	.	.	.	
			Methylenechloride	1	ug/L	4	.	.	.	
			Oil & Grease	100	ug/L	4	2	100	200	20B-2
			Petroleum Oil & Grease	100	ug/L	4	2	100	200	20B-2
			TOC	.	ug/L	4	4	1300	13000	20B-2
			Tetrachloroethene	1	ug/L	4	.	.	.	
			Toluene	1	ug/L	4	.	.	.	
			Vinyl chloride	1	ug/L	4	.	.	.	
			Xylenes (total)	1	ug/L	4	.	.	.	

Eielson Air Force Base, Alaska

Operable Unit 1

Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Water	Stage 3	2,4-Dimethylphenol	0.28	ug/L	1	.	.	.	.
			2-Methylnaphthalene	0.9	ug/L	1	.	.	.	.
			2-Methylphenol	0.84	ug/L	1	.	.	.	.
			4-Methylphenol	0.8	ug/L	1	.	.	.	.
			Acenaphthene	0.32	ug/L	1	.	.	.	.
			Anthracene	0.52	ug/L	1	.	.	.	.
			BIS (2-Ethylmexylphthalate)	2	ug/L	1	.	.	.	.
			Benzene	0.15	ug/L	1	1	481	481	20M06
			Benzoic acid	.	ug/L	1	.	.	.	.
			Benzyl alcohol	0.07	ug/L	1	.	.	.	.
			Chloride	200	ug/L	1	.	.	.	.
			Chlorobenzene	0.34	ug/L	1	1	10.6	10.6	20M06
			Dibenzofuran	0.34	ug/L	1	.	.	.	.
			Ethylbenzene	0.46	ug/L	1	1	86.7	86.7	20M06
			Fluoranthene	1	ug/L	1	.	.	.	.
			Fluorene	0.88	ug/L	1	.	.	.	.
			Naphthalene	0.26	ug/L	1	.	.	.	.
			Nitrite/Nitrate	10	ug/L	1	.	.	.	.
			Phenanthrene	0.46	ug/L	1	.	.	.	.
			Phenol	1	ug/L	1	.	.	.	.
			Pyrene	1	ug/L	1	.	.	.	.
			Residue, DISS	1000	ug/L	1	1	254000	254000	20M06
			Sulfate	500	ug/L	1	.	.	.	.
			TPH	100	ug/L	1	.	.	.	.
			Toluene	0.25	ug/L	1	1	95	939	20M06
			Xylenes (total)	0.85	ug/L	1	1	236	236	20M06

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Eielson Air Force Base

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Operable Unit 1

Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Water	Stage 4	1,2-Dimethylbenzene	1	ug/L	44	12	1	380	20FW70
			1,3-Dimethylbenzene	1	ug/L	44	18	1	640	20FW02
			2,4-Dimethylphenol	2	ug/L	8	.	.	.	.
			2-Methylnaphthalene	1	ug/L	8	1	39	39	20M06
			2-Methylphenol	2	ug/L	8	.	.	.	.
			4-Methylphenol	2	ug/L	8	.	.	.	.
			Acenaphthene	1	ug/L	8	.	.	.	.
			Acenaphthylene	1	ug/L	8	.	.	.	.
			Anthracene	1	ug/L	52	10	0.45	830	20FW70
			Benzene	1	ug/L	8	.	.	.	.
			Benzo(a)anthracene	2	ug/L	8	.	.	.	.
			Benzo(a)pyrene	1.5	ug/L	8	.	.	.	.
			Benzo(b)fluoranthene	2.5	ug/L	8	.	.	.	.
			Benzo(ghi)perylene	1.5	ug/L	8	.	.	.	.
			Benzo(k)fluoranthene	25	ug/L	8	.	.	.	.
			Benzoic acid	2	ug/L	8	.	.	.	.
			Benzyl alcohol	2	ug/L	8	6	6.4	2900	20M06
			Bis(2-ethylhexyl) phthalate	0.4	ug/L	8	.	.	.	.
			Chlorobenzene	1	ug/L	8	.	.	.	.
			Chrysene	2.5	ug/L	8	.	.	.	.
			Dibenz[a,h]anthracene	1	ug/L	8	.	.	.	.
			Dibenzofuran	1	ug/L	52	4	3	470	20FW02
			Ethylbenzene	1	ug/L	8	.	.	.	.
			Fluoranthene	1	ug/L	8	.	.	.	.
			Fluorene	2.5	ug/L	8	.	.	.	.
			Indeno(1,2,3-cd)pyrene	1	ug/L	8	1	25	25	20M06
			Naphthalene	1	ug/L	8	.	.	.	.
			Phenanthrene	2	ug/L	8	.	.	.	.
			Phenol	1	ug/L	8	.	.	.	.
			Pyrene	200	ug/L	8	1	1400	1400	20M06
			TPH	1	ug/L	52	23	0.87	3040	20M06
			Toluene	0.4	ug/L	8	1	1550	1550	20M06
			Xylenes (total)							

Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Water	1993	0,0,0-Triethyl phosphorothioate	10	ug/L	4	.	.	.	.
			0,0-Diethyl 0-2-pyrazinyl phosphorothio	10	ug/L	4	.	.	.	.
			1,1,1-Trichloroethane	0.5	ug/L	11	.	.	.	.
			1,1,2-Trichloroethane	0.5	ug/L	11	.	.	.	.
			1,1-Dichloroethane	1	ug/L	11	.	.	.	.
			1,2,4,5-Tetrachlorobenzene	10	ug/L	4	.	.	.	.
			1,2,4-Trichlorobenzene	10	ug/L	4	.	.	.	.
			1,2-Dichlorobenzene	10	ug/L	4	.	.	.	.
			1,2-Dichloroethane	0.5	ug/L	11	.	.	.	.
			1,3-Dichlorobenzene	10	ug/L	4	.	.	.	.
			1,4-Dichlorobenzene	2	ug/L	11	.	.	.	.
			1,4-Dichlorobenzene	10	ug/L	4	.	.	.	.
			1,4-Naphthoquinone	10	ug/L	4	.	.	.	.
			1-Naphthylamine	10	ug/L	4	.	.	.	.
			2,3,4,6-Tetrachlorophenol	10	ug/L	4	.	.	.	.
			2,4,5-Trichlorophenol	10	ug/L	4	.	.	.	.
			2,4,6-Trichlorophenol	10	ug/L	4	.	.	.	.
			2,4-Dichlorophenol	10	ug/L	4	.	.	.	.
			2,4-Dimethylphenol	10	ug/L	4	.	.	.	.
			2,4-Dinitrophenol	50	ug/L	4	.	.	.	.
			2,4-Dinitrotoluene	10	ug/L	4	.	.	.	.
			2,6-Dichlorophenol	10	ug/L	4	.	.	.	.
			2,6-Dinitrotoluene	10	ug/L	4	.	.	.	.
			2-Acetylaminofluorene	10	ug/L	4	.	.	.	.
			2-Chloronaphthalene	10	ug/L	4	.	.	.	.
			2-Chlorophenol	10	ug/L	4	.	.	.	.
			2-Methylnaphthalene	10	ug/L	4	.	.	.	.
			2-Methylphenol	10	ug/L	4	.	.	.	.
			2-Naphthylamine	10	ug/L	4	.	.	.	.
			2-Nitroaniline	50	ug/L	4	.	.	.	.
			2-Nitrophenol	10	ug/L	4	.	.	.	.
			2-Picoline	10	ug/L	4	.	.	.	.
			3,3'-Dichlorobenzidine	20	ug/L	4	.	.	.	.
			3,3'-Dimethylbenzidine	10	ug/L	4	.	.	.	.
			3-Methylcholanthrene	10	ug/L	4	.	.	.	.
			3-Nitroaniline	50	ug/L	4	.	.	.	.
			4,6-Dinitro-o-cresol	50	ug/L	4	.	.	.	.
			4-Aminobiphenyl	10	ug/L	4	.	.	.	.
			4-Bromophenylphenyl ether	10	ug/L	4	.	.	.	.
			4-Chloro-3-methylphenol	20	ug/L	4	.	.	.	.
			4-Chloroaniline	20	ug/L	4	.	.	.	.
			4-Chlorophenylphenyl ether	10	ug/L	4	.	.	.	.
			4-Methylphenol	10	ug/L	4	1	4.7	4.7	20M06
			4-Nitroaniline	50	ug/L	4	.	.	.	.
			4-Nitrophenol	50	ug/L	4	.	.	.	.
			4-Nitroquinoline-1-oxide	10	ug/L	4	.	.	.	.
			5-Nitro-o-toluidine	10	ug/L	4	.	.	.	.
			7,12-Dimethylbenz[a]anthracene	10	ug/L	4	.	.	.	.
			Acenaphthene	10	ug/L	4	.	.	.	.
			Acenaphthylene	10	ug/L	4	.	.	.	.
			Acetophenone	10	ug/L	4	1	5.4	5.4	20M06
			Aluminum (Filtered)	200	ug/L	4	.	.	.	.
			Aluminum (Unfiltered)	200	ug/L	4	3	76	300	20M14
			Aniline	10	ug/L	4	.	.	.	.
			Anthracene	10	ug/L	4	.	.	.	.
			Antimony (Filtered)	200	ug/L	4	2	100	140	20M06
			Antimony (Unfiltered)	200	ug/L	4	2	71	110	20M06
			Aramite	10	ug/L	4	.	.	.	.

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Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base

Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Water	1993	Arsenic (Filtered)	5	ug/L	4	3	2	5.9	20M06
			Arsenic (Unfiltered)	5	ug/L	3	2	6	8.1	20M06
			Barium (Filtered)	20	ug/L	4	4	40	90	20M06
			Barium (Unfiltered)	20	ug/L	4	4	50	150	20M15
			Benzene	2	ug/L	11	8	260	570	20M06
			Benzo(a)anthracene	10	ug/L	4	.	.	.	.
			Benzo(a)pyrene	10	ug/L	4	.	.	.	.
			Benzo(b)fluoranthene	10	ug/L	4	.	.	.	.
			Benzo(ghi)perylene	10	ug/L	4	.	.	.	.
			Benzo(k)fluoranthene	10	ug/L	4	.	.	.	.
			Benzothiazole	10	ug/L	4	.	.	.	.
			Benzyl alcohol	20	ug/L	4	.	.	.	.
			Beryllium (Filtered)	3	ug/L	4	.	.	.	.
			Beryllium (Unfiltered)	3	ug/L	4	.	.	.	.
			Bis(2-Chloroethoxy)methane	10	ug/L	4	.	.	.	.
			Bis(2-Chloroisopropyl) ether	10	ug/L	4	.	.	.	.
			Bis(2-chloroethyl) ether	10	ug/L	4	.	.	.	.
			Bis(2-ethylhexyl) phthalate	10	ug/L	4	2	6.6	7.3	20M06
			Butylbenzylphthalate	10	ug/L	4	.	.	.	.
			Cadmium (Filtered)	10	ug/L	4	.	.	.	.
			Cadmium (Unfiltered)	10	ug/L	4	1	5.7	5.7	20M06
			Calcium (Filtered)	100	ug/L	4	4	40000	56000	20M06
			Calcium (Unfiltered)	100	ug/L	4	4	43000	60000	20M06
			Carbon tetrachloride	1	ug/L	11	.	.	.	.
			Chlorobenzilate	10	ug/L	4	.	.	.	.
			Chloroform	0.5	ug/L	11	.	.	.	.
			Chromium (Filtered)	20	ug/L	4	3	6.1	16	20M06
			Chromium (Unfiltered)	20	ug/L	4	3	5.6	14	20M06
			Chrysene	10	ug/L	4	.	.	.	.
			Cobalt (Filtered)	20	ug/L	4	2	5.2	5.2	20M06
			Cobalt (Unfiltered)	20	ug/L	4	2	5.1	7.3	20M06
			Copper (Filtered)	20	ug/L	4	2	2.9	4.6	20M06
			Copper (Unfiltered)	20	ug/L	4	2	15	20	20M06
			Di-n-butylphthalate	10	ug/L	4	.	.	.	.
			Di-n-octylphthalate	10	ug/L	4	.	.	.	.
			Diallate	10	ug/L	4	.	.	.	.
			Dibenz[a,h]anthracene	10	ug/L	4	.	.	.	.
			Dibenzofuran	10	ug/L	4	.	.	.	.
			Diethylphthalate	10	ug/L	4	.	.	.	.
			Dimethoate	10	ug/L	4	.	.	.	.
			Dimethyl phthalate	10	ug/L	4	.	.	.	.
			Diphenylamine	10	ug/L	4	.	.	.	.
			Ethyl methanesulfonate	10	ug/L	4	.	.	.	.
			Ethylbenzene	2	ug/L	11	9	0.049	120	20M06
			Famphur	10	ug/L	4	.	.	.	.
			Fluoranthene	10	ug/L	4	.	.	.	.
			Fluorene	10	ug/L	4	.	.	.	.
			Hexachlorobenzene	10	ug/L	4	.	.	.	.
			Hexachlorobutadiene	10	ug/L	4	.	.	.	.
			Hexachlorocyclopentadiene	10	ug/L	4	.	.	.	.
			Hexachloroethane	10	ug/L	4	.	.	.	.
			Hexachlorophene	10	ug/L	4	.	.	.	.
			Hexachloropropene	10	ug/L	4	.	.	.	.
			Indeno(1,2,3-cd)pyrene	10	ug/L	4	.	.	.	.
			Iron (Filtered)	20	ug/L	4	4	40	3900	20M06

Remedial Investigation Report: Operable Unit 1
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Eielson Air Force Base, Alaska
 Operable Unit 1
 Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Water	1993	Iron (Unfiltered)	20	ug/L	4	4	540	5300	20M06
			Isodrin	10	ug/L	4	.	.	.	.
			Isophorone	10	ug/L	4	.	.	.	.
			Isosafrole	10	ug/L	4	.	.	.	.
			Kepone	10	ug/L	4	.	.	.	.
			Kerosene	10000	ug/L	4	1	7.3	7.3	20M06
			Lead (Filtered)	5	ug/L	4	2	2	3	20M15
			Lead (Unfiltered)	5	ug/L	3	3	2	8.6	20M14
			Magnesium (Filtered)	100	ug/L	4	4	9100	11000	20M06
			Magnesium (Unfiltered)	100	ug/L	4	4	9800	12000	20M06
			Manganese (Filtered)	10	ug/L	4	4	6.5	2300	20M06
			Manganese (Unfiltered)	10	ug/L	4	4	20	3700	20M15
			Mercury (Filtered)	0.2	ug/L	4	.	.	.	.
			Mercury (Unfiltered)	0.2	ug/L	4	.	.	.	.
			Methapyrilene	10	ug/L	4	.	.	.	.
			Methyl methanesulfonate	10	ug/L	4	.	.	.	.
			Methylenechloride	5	ug/L	11	7	0.071	0.3	20M06
			N-Nitroso-di-n-dipropylamine	10	ug/L	4	.	.	.	.
			N-Nitrosodi-n-butylamine	10	ug/L	4	.	.	.	.
			N-Nitrosodiethylamine	10	ug/L	4	.	.	.	.
			N-Nitrosodimethylamine	10	ug/L	4	.	.	.	.
			N-Nitrosodiphenylamine	10	ug/L	4	.	.	.	.
			N-Nitrosomethylethylamine	10	ug/L	4	.	.	.	.
			N-Nitrosomorpholine	10	ug/L	4	.	.	.	.
			N-Nitrosopiperidine	10	ug/L	4	.	.	.	.
			Naphthalene	10	ug/L	4	.	.	.	.
			Nickel (Filtered)	30	ug/L	4	.	.	.	.
			Nickel (Unfiltered)	30	ug/L	4	.	.	.	.
			Nitrobenzene	10	ug/L	4	.	.	.	.
			Nitrosopyrrolidine	10	ug/L	4	.	.	.	.
			Parathion	10	ug/L	4	.	.	.	.
			Pentachlorobenzene	10	ug/L	4	.	.	.	.
			Pentachloronitrobenzene (PCNB)	10	ug/L	4	.	.	.	.
			Pentachlorophenol	50	ug/L	4	.	.	.	.
			Phenacetin	10	ug/L	4	.	.	.	.
			Phenanthrene	10	ug/L	4	.	.	.	.
			Phenol	10	ug/L	4	2	6.6	13	20M06
			Potassium (Filtered)	300	ug/L	4	4	2000	3000	20M06
			Potassium (Unfiltered)	300	ug/L	4	4	2000	3000	20M06
			Pronamide	10	ug/L	4	.	.	.	.
			Pyrene	10	ug/L	4	.	.	.	.
			Pyridine	10	ug/L	4	.	.	.	.
			Safrol	10	ug/L	4	.	.	.	.
			Silver (Filtered)	20	ug/L	4	1	3.4	3.4	20M06
			Silver (Unfiltered)	20	ug/L	4	1	4	4	20M06
			Sodium (Filtered)	300	ug/L	4	4	3000	3900	20M15
			Sodium (Unfiltered)	300	ug/L	4	4	3100	4500	20M15
			Tetrachloroethene	0.5	ug/L	11	.	.	.	.
			Tetraethyl dithiopyrophosphate	10	ug/L	4	.	.	.	.
			Tin (Filtered)	100	ug/L	4	.	.	.	.
			Tin (Unfiltered)	100	ug/L	4	.	.	.	.
			Toluene	2	ug/L	11	10	0.13	230	20M06
			Tributyl phosphate	10	ug/L	4	.	.	.	.
			Trichloroethene	1	ug/L	11	.	.	.	.
			Tris-2-chloroethyl phosphate	10	ug/L	4	.	.	.	.

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 Eielson Air Force Base

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Eielson Air Force Base, Alaska

Operable Unit 1

Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-8	Water	1993	Vanadium (Filtered)	30	ug/L	4	.	.	.	20M15
			Vanadium (Unfiltered)	30	ug/L	4	2	4.2	5	20M06
			Vinyl chloride	2	ug/L	11	11	2	2	20M06
			Xylenes (total)	5	ug/L	11	10	0.25	370	20M06
			Zinc (Filtered)	10	ug/L	4	1	4.1	4.1	20M15
			Zinc (Unfiltered)	10	ug/L	4	4	4.8	20	20M06
			alpha, alpha-Dimethylphenethylamine	10	ug/L	4	.	.	.	.
			cis-1,2-Dichloroethylene	1	ug/L	11	.	.	.	.
			m-Cresol	10	ug/L	4	2	3.8	11	20M06
			m-Dinitrobenzene	10	ug/L	4	.	.	.	.
			o-Toluidine	10	ug/L	4	.	.	.	.
			p-Dimethylaminoazobenzene	10	ug/L	4	.	.	.	.
			p-Phenylenediamine	10	ug/L	4	.	.	.	.
			sym-Trinitrobenzene	10	ug/L	4	.	.	.	.
			trans-1,2-Dichloroethylene	1	ug/L	11	.	.	.	.

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Eielson Air Force Base, Alaska

Operable Unit 1

Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Soil	1986	1,1,2,2-Tetrachloroethane	5	ug/kg	6	.	.	.	.
			1,1-Dichloroethene	5	ug/kg	6	.	.	.	.
			1,2-Dimethylbenzene	5000	ug/kg	6	.	.	.	.
			2-Butanone	5	ug/kg	6	.	.	.	.
			Benzene	5	ug/kg	6	.	.	.	.
			Chlorobenzene	5	ug/kg	6	.	.	.	.
			Chloroform	5	ug/kg	6	.	.	.	.
			Ethylbenzene	5	ug/kg	6	.	.	.	.
			Methylenechloride	5	ug/kg	6	.	.	.	.
			Tetrachloroethene	5	ug/kg	6	.	.	.	.
			Toluene	5	ug/kg	6	.	.	.	.
			Vinyl chloride	5	ug/kg	6	.	.	.	.

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Eielson Air Force Base, Alaska

Operable Unit 1

Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Soil	Stage 3	Benzene	44	ug/kg	2	.	.	.	.
			Ethylbenzene	80	ug/kg	2	1	8700	8700	20M01
			Methylenechloride	150	ug/kg	2	.	.	.	.
			Moisture	.	Percent	2	2	3.1	4	20M01
			TPH	10000	ug/kg	2	2	41000	157000	20M01
			Tetrachloroethene	90	ug/kg	2	1	8500	8500	20M01
			Toluene	160	ug/kg	2	.	.	.	.
			Vinyl chloride	290	ug/kg	2	1	13000	13000	20M01
			Xylenes (total)	80	ug/kg	2	1	12100	12100	20M01

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Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Media Area Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Soil	Stage 4	1,1,2,2-Tetrachloroethane	170	ug/kg	11	1	670	670 20SB14
			1,1-Dichloroethene	200	ug/kg	11	.	.	.
			2,4-Dimethylphenol	80	ug/kg	11	.	.	.
			2-Methylnaphthalene	30	ug/kg	11	2	780	2500 20SB14
			2-Methylphenol	30	ug/kg	11	.	.	.
			4-Methylphenol	30	ug/kg	11	.	.	.
			Acenaphthene	30	ug/kg	11	3	40	90 20SB07
			Acenaphthylene	30	ug/kg	11	1	70	70 20SB09
			Anthracene	30	ug/kg	11	4	60	190 20SB09
			Benzene	80	ug/kg	11	.	.	.
			Benzo(a)anthracene	50	ug/kg	11	4	280	1700 20M24
			Benzo(a)pyrene	70	ug/kg	11	4	260	1500 20M24
			Benzo(b)fluoranthene	70	ug/kg	11	4	240	1300 20M24
			Benzo(ghi)perylene	80	ug/kg	11	4	170	1000 20M24
			Benzo(k)fluoranthene	70	ug/kg	11	4	270	1000 20M24
			Benzoic acid	80	ug/kg	11	.	.	.
			Benzyl alcohol	80	ug/kg	11	.	.	.
			Bis(2-ethylhexyl) phthalate	50	ug/kg	11	4	60	310 20SB21
			Chlorobenzene	170	ug/kg	11	.	.	.
			Chloroform	120	ug/kg	11	.	.	.
			Chrysene	50	ug/kg	11	4	360	1900 20M24
			Dibenz[a,h]anthracene	80	ug/kg	11	1	100	100 20SB09
			Dibenzofuran	30	ug/kg	11	3	50	210 20M24
			Ethylbenzene	250	ug/kg	11	.	.	.
			Fluoranthene	30	ug/kg	11	4	910	4800 20M24
			Fluorene	30	ug/kg	11	4	50	340 20M24
			Indeno(1,2,3-cd)pyrene	80	ug/kg	11	4	190	1100 20M24
			Methylenechloride	760	ug/kg	11	.	.	.
			Moisture	.	Percent	11	11	3.3	19.2 20M22
			Naphthalene	30	ug/kg	11	2	280	840 20SB14
			Phenanthrene	30	ug/kg	11	4	820	3500 20M24
			Phenol	80	ug/kg	11	.	.	.
			Pyrene	30	ug/kg	11	4	660	1800 20M24
			TPH	10000	ug/kg	47	30	10000	28000000 20SB07
			Tetrachloroethene	130	ug/kg	11	.	.	.
			Toluene	170	ug/kg	11	1	10000	10000 20SB07
			Trichloromonofluoromethane	80	ug/kg	6	.	.	.
			Vinyl chloride	80	ug/kg	11	.	.	.
			Xylenes (total)	770	ug/kg	11	1	59600	59600 20SB07

Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Soil	1993	0,0,0-Triethyl phosphorothioate	660	ug/kg	19	.	.	.	
			0,0-Diethyl 0-2-pyrazinyl phosphorothio	660	ug/kg	19	.	.	.	
			1,1,1-Trichloroethane	0.5	ug/kg	2	.	.	.	
			1,1,2-Trichloroethane	0.5	ug/kg	2	.	.	.	
			1,1-Dichloroethane	1	ug/kg	2	.	.	.	
			1,2,4,5-Tetrachlorobenzene	660	ug/kg	19	.	.	.	
			1,2,4-Trichlorobenzene	660	ug/kg	19	.	.	.	
			1,2-Dichlorobenzene	660	ug/kg	19	.	.	.	
			1,2-Dichloroethane	0.5	ug/kg	2	.	.	.	
			1,3-Dichlorobenzene	660	ug/kg	19	.	.	.	
			1,4-Dichlorobenzene	2	ug/kg	2	.	.	.	
			1,4-Dichlorobenzene	660	ug/kg	19	.	.	.	
			1,4-Napthoquinone	660	ug/kg	19	.	.	.	
			1-Naphthylamine	660	ug/kg	19	.	.	.	
			2,3,4,6-Tetrachlorophenol	660	ug/kg	19	.	.	.	
			2,4,5-Trichlorophenol	660	ug/kg	19	.	.	.	
			2,4,6-Trichlorophenol	660	ug/kg	19	.	.	.	
			2,4-Dichlorophenol	660	ug/kg	19	.	.	.	
			2,4-Dimethylphenol	660	ug/kg	19	.	.	.	
			2,4-Dinitrophenol	3300	ug/kg	19	.	.	.	
			2,4-Dinitrotoluene	660	ug/kg	19	.	.	.	
			2,6-Dichlorophenol	660	ug/kg	19	.	.	.	
			2,6-Dinitrotoluene	660	ug/kg	19	.	.	.	
			2-Acetylaminofluorene	660	ug/kg	19	.	.	.	
			2-Chloronaphthalene	660	ug/kg	19	.	.	.	
			2-Chlorophenol	660	ug/kg	19	.	.	.	
			2-Methylnaphthalene	660	ug/kg	19	1	670	670	TAXI WAY
			2-Methylphenol	660	ug/kg	19	.	.	.	
			2-Naphthylamine	660	ug/kg	19	.	.	.	
			2-Nitroaniline	3300	ug/kg	19	.	.	.	
			2-Nitrophenol	660	ug/kg	19	.	.	.	
			2-Picoline	660	ug/kg	19	.	.	.	
			3,3'-Dichlorobenzidine	1300	ug/kg	19	.	.	.	
			3,3'-Dimethylbenzidine	660	ug/kg	19	.	.	.	
			3-Methylcholanthrene	660	ug/kg	19	.	.	.	
			3-Nitroaniline	3300	ug/kg	19	.	.	.	
			4,4'-DDD	20	ug/kg	3	2	5.2	25	COMPOSITE
			4,4'-DDE	10	ug/kg	3	1	9.6	9.6	COMPOSITE
			4,4'-DDT	20	ug/kg	3	1	50	50	COMPOSITE
			4,6-Dinitro-o-cresol	3300	ug/kg	19	.	.	.	
			4-Aminobiphenyl	660	ug/kg	19	.	.	.	
			4-Bromophenylphenyl ether	660	ug/kg	19	.	.	.	
			4-Chloro-3-methylphenol	1300	ug/kg	19	.	.	.	
			4-Chloroaniline	1300	ug/kg	19	.	.	.	
			4-Chlorophenylphenyl ether	660	ug/kg	19	.	.	.	
			4-Methylphenol	660	ug/kg	19	.	.	.	
			4-Nitroaniline	3300	ug/kg	19	.	.	.	
			4-Nitrophenol	3300	ug/kg	19	.	.	.	
			4-Nitroquinoline-1-oxide	660	ug/kg	19	.	.	.	
			5-Nitro-o-toluidine	660	ug/kg	19	.	.	.	
			7,12-Dimethylbenz[a]anthracene	660	ug/kg	19	.	.	.	
			Acenaphthene	660	ug/kg	19	7	170	7500	TAXI WAY
			Acenaphthylene	660	ug/kg	19	2	520	1300	TAXI WAY
			Acetophenone	660	ug/kg	19	.	.	.	
			Aldrin	10	ug/kg	3	.	.	.	
			Alpha-BHC	10	ug/kg	3	.	.	.	
			Aluminum	20000	ug/kg	2	2	9100000	9600000	20MW26
			Aniline	660	ug/kg	19	.	.	.	

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Eielson Air Force Base

Eielson Air Force Base, Alaska
 Operable Unit 1
 Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Soil	1993	Anthracene	660	ug/kg	19	7	420	13000	TAXI WAY
			Antimony	20000	ug/kg	2	1	11000	11000	20MW26
			Aramite	660	ug/kg	19	.	.	.	.
			Aroclor-1016	100	ug/kg	3	.	.	.	.
			Aroclor-1221	200	ug/kg	3	.	.	.	.
			Aroclor-1232	200	ug/kg	3	.	.	.	.
			Aroclor-1242	100	ug/kg	3	.	.	.	.
			Aroclor-1248	100	ug/kg	3	.	.	.	.
			Aroclor-1254	100	ug/kg	3	.	.	.	.
			Aroclor-1260	100	ug/kg	3	.	.	.	.
			Arsenic	500	ug/kg	2	2	4600	7200	20MW26
			Barium	2000	ug/kg	2	2	76000	100000	20MW26
			Benzene	2	ug/kg	2	.	.	.	.
			Benzo(a)anthracene	660	ug/kg	19	9	220	29000	TAXI WAY
			Benzo(a)pyrene	660	ug/kg	19	10	180	31000	TAXI WAY
			Benzo(b)fluoranthene	660	ug/kg	19	9	240	28000	TAXI WAY
			Benzo(ghi)perylene	660	ug/kg	19	8	270	17000	TAXI WAY
			Benzo(k)fluoranthene	660	ug/kg	19	8	500	30000	TAXI WAY
			Benzo(b)thiazole	660	ug/kg	19	.	.	.	.
			Benzyl alcohol	1300	ug/kg	19	.	.	.	.
			Beryllium	300	ug/kg	2	2	170	180	20MW26
			Beta-BHC	10	ug/kg	3	.	.	.	.
			Bis(2-Chloroethoxy)methane	660	ug/kg	19	.	.	.	.
			Bis(2-Chloroisopropyl) ether	660	ug/kg	19	.	.	.	.
			Bis(2-chloroethyl) ether	660	ug/kg	19	.	.	.	.
			Bis(2-ethylhexyl) phthalate	660	ug/kg	19	3	75	140	20MW26
			Butylbenzylphthalate	660	ug/kg	19	.	.	.	.
			Cadmium	1000	ug/kg	2	1	400	400	20MW26
			Calcium	10000	ug/kg	2	2	4800000	6800000	20MW26
			Carbon tetrachloride	1	ug/kg	2	.	.	.	.
			Chlordane	50	ug/kg	3	1	21	21	COMPOSITE
			Chlorobenzilate	660	ug/kg	19	.	.	.	.
			Chloroform	0.5	ug/kg	2	.	.	.	.
			Chromium	2000	ug/kg	2	2	18000	22000	20MW26
			Chrysene	660	ug/kg	19	9	240	39000	TAXI WAY
			Cobalt	2000	ug/kg	2	2	8000	10000	20MW26
			Copper	2000	ug/kg	2	2	19000	28000	20MW26
			Delta-BHC	20	ug/kg	3	.	.	.	.
			Di-n-butylphthalate	660	ug/kg	19	.	.	.	.
			Di-n-octylphthalate	660	ug/kg	19	.	.	.	.
			Diallate	660	ug/kg	19	.	.	.	.
			Dibenz[a,h]anthracene	660	ug/kg	19	.	.	.	.
			Dibenzofuran	660	ug/kg	19	7	140	5700	TAXI WAY
			Dieldrin	10	ug/kg	3	.	.	.	.
			Diethylphthalate	660	ug/kg	19	2	200	600	TAXI WAY 1
			Dimethoate	660	ug/kg	19	.	.	.	.
			Dimethyl phthalate	660	ug/kg	19	.	.	.	.
			Diphenylamine	660	ug/kg	19	.	.	.	.
			Endosulfan I	10	ug/kg	3	.	.	.	.
			Endosulfan II	10	ug/kg	3	.	.	.	.
			Endosulfan sulfate	20	ug/kg	3	.	.	.	.
			Endrin	10	ug/kg	3	.	.	.	.
			Endrin Aldehyde	50	ug/kg	3	.	.	.	.
			Ethyl methanesulfonate	660	ug/kg	19	.	.	.	.
			Ethylbenzene	2	ug/kg	2	.	.	.	.

Eielson Air Force Base, Alaska
 Operable Unit 1
 Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Soil	1993	Famphur	660	ug/kg	19	.	.	.	.
			Fluoranthene	660	ug/kg	19	12	280	90000	TAXI WAY
			Fluorene	660	ug/kg	19	6	260	9300	TAXI WAY
			Gamma-BHC (Lindane)	10	ug/kg	3	.	.	.	.
			Heptachlor	10	ug/kg	3	.	.	.	.
			Heptachlor epoxide	60	ug/kg	3	.	.	.	.
			Hexachlorobenzene	660	ug/kg	19	.	.	.	.
			Hexachlorobutadiene	660	ug/kg	19	.	.	.	.
			Hexachlorocyclopentadiene	660	ug/kg	19	.	.	.	.
			Hexachloroethane	660	ug/kg	19	.	.	.	.
			Hexachlorophene	660	ug/kg	19	.	.	.	.
			Hexachloropropene	660	ug/kg	19	.	.	.	.
			Indeno (1,2,3-cd)pyrene	660	ug/kg	19	8	280	17000	TAXI WAY
			Iron	2000	ug/kg	2	2	16000000	20000000	20MW26
			Isodrin	660	ug/kg	19	.	.	.	.
			Isophorone	660	ug/kg	19	.	.	.	.
			Isosafrole	660	ug/kg	19	.	.	.	.
			Kepone	660	ug/kg	19	.	.	.	.
			Kerosene	660	ug/kg	19	.	.	.	.
			Lead	500	ug/kg	2	2	4400	6800	20MW26
			Magnesium	10000	ug/kg	2	2	4600000	5000000	20MW26
			Manganese	1000	ug/kg	2	2	300000	350000	20MW26
			Mercury	400	ug/kg	2	.	.	.	.
			Methapyrilene	660	ug/kg	19	.	.	.	.
			Methoxychlor	100	ug/kg	3	.	.	.	.
			Methyl methanesulfonate	660	ug/kg	19	.	.	.	.
			Methylenechloride	5	ug/kg	2	.	.	.	.
			N-Nitroso-di-n-dipropylamine	660	ug/kg	19	.	.	.	.
			N-Nitrosodi-n-butylamine	660	ug/kg	19	.	.	.	.
			N-Nitrosodiethylamine	660	ug/kg	19	.	.	.	.
			N-Nitrosodimethylamine	660	ug/kg	19	.	.	.	.
			N-Nitrosodiphenylamine	660	ug/kg	19	.	.	.	.
			N-Nitrosomethylethylamine	660	ug/kg	19	.	.	.	.
			N-Nitrosomorpholine	660	ug/kg	19	.	.	.	.
			N-Nitrosopiperidine	660	ug/kg	19	.	.	.	.
			Naphthalene	660	ug/kg	19	1	790	790	TAXI WAY
			Nickel	3000	ug/kg	2	2	19000	23000	20MW26
			Nitrobenzene	660	ug/kg	19	.	.	.	.
			Nitrosopyrrolidine	660	ug/kg	19	.	.	.	.
			Parathion	660	ug/kg	19	.	.	.	.
			Pentachlorobenzene	660	ug/kg	19	.	.	.	.
			Pentachloronitrobenzene (PCNB)	660	ug/kg	19	.	.	.	.
			Pentachlorophenol	3300	ug/kg	19	.	.	.	.
			Phenacetin	660	ug/kg	19	.	.	.	.
			Phenanthrene	660	ug/kg	19	10	330	81000	TAXI WAY
			Phenol	660	ug/kg	19	.	.	.	.
			Potassium	30000	ug/kg	2	2	800000	900000	20MW26
			Pronamide	660	ug/kg	19	.	.	.	.
			Pyrene	660	ug/kg	19	12	260	71000	TAXI WAY
			Pyridine	660	ug/kg	19	5	210	39000	TAXI WAY
			Safrol	660	ug/kg	19	.	.	.	.
			Silver	2000	ug/kg	2	.	.	.	.
			Sodium	30000	ug/kg	2	2	440000	570000	20MW26
			TPH-diesel	5000	ug/kg	1	.	.	.	.
			TPH-diesel	5200	ug/kg	1	.	.	.	.

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 Eielson Air Force Base

Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Soil	1993	TPH-gasoline	8800	ug/kg	1	.	.	.	
			TPH-gasoline	9000	ug/kg	1	.	.	.	
			Tetrachloroethene	0.5	ug/kg	2	.	.	.	
			Tetraethyl dithiopyrophosphate	660	ug/kg	19	.	.	.	
			Tin	10000	ug/kg	2	.	.	.	
			Toluene	2	ug/kg	2	2	0.17	0.33	20MW26
			Toxaphene	400	ug/kg	3	.	.	.	
			Tributyl phosphate	660	ug/kg	19	.	.	.	
			Trichloroethene	1	ug/kg	2	.	.	.	
			Tris-2-chloroethyl phosphate	660	ug/kg	19	.	.	.	
			Vanadium	3000	ug/kg	2	2	36000	39000	20MW26
			Vinyl chloride	2	ug/kg	2	.	.	.	
			Xylenes (total)	5	ug/kg	2	.	.	.	
			Zinc	10	ug/kg	2	2	40000	47000	20MW26
			alpha, alpha-Dimethylphenethylamine	660	ug/kg	19	.	.	.	
			cis-1,2-Dichloroethylene	1	ug/kg	2	2	1	1	20MW26
			m-Cresol	660	ug/kg	19	.	.	.	
			m-Dinitrobenzene	660	ug/kg	19	.	.	.	
			o-Toluidine	660	ug/kg	19	.	.	.	
			p-Dimethylaminoazobenzene	660	ug/kg	19	.	.	.	
			p-Phenylenediamine	660	ug/kg	19	.	.	.	
			sym-Trinitrobenzene	660	ug/kg	19	.	.	.	
			trans-1,2-Dichloroethylene	1	ug/kg	2	.	.	.	

Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Soil Gas	Stage 3	1,3-Dimethylbenzene	10	ug/L	23	17	10	18200	20SV15
			Benzene	10	ug/L	23	7	290	69400	20SV15
			Ethylbenzene	10	ug/L	23	9	10	19800	20SV17
			Toluene	10	ug/L	23	13	10	129000	20SV15
			Total BTEX	10	ug/L	23	18	10	235000	20SV15

Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Water	1986	1,1,2,2-Tetrachloroethane	1	ug/L	2	.	.	.	.
			1,1-Dichloroethene	1	ug/L	2	.	.	.	.
			2-Butanone	1	ug/L	2	.	.	.	.
			Benzene	1	ug/L	2	.	.	.	.
			Chlorobenzene	1	ug/L	2	.	.	.	.
			Chloroform	1	ug/L	2	.	.	.	.
			Ethylbenzene	1	ug/L	2	.	.	.	.
			Methylenechloride	1	ug/L	2	.	.	.	.
			Oil & Grease	100	ug/L	2	2	100	100	20C-2
			Petroleum Oil & Grease	100	ug/L	2	2	100	100	20C-2
			TOC	.	ug/L	2	2	11000	13000	20C-3
			Tetrachloroethene	1	ug/L	2	.	.	.	.
			Toluene	1	ug/L	2	.	.	.	.
			Vinyl chloride	1	ug/L	2	.	.	.	.
			Xylenes (total)	1	ug/L	2	.	.	.	.

Eielson Air Force Base, Alaska
Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Water	Stage 3	2,4-Dimethylphenol	0.28	ug/L	3	.	.	.	.
			2-Methylnaphthalene	0.9	ug/L	3	1	191	191	20M01
			2-Methylphenol	0.84	ug/L	3	.	.	.	.
			4-Methylphenol	0.8	ug/L	3	.	.	.	.
			Acenaphthene	0.32	ug/L	2	.	.	.	.
			Anthracene	0.52	ug/L	3	1	5.2	5.2	20M01
			BIS (2-Ethylmethylphthalate)	2	ug/L	3	1	56	56	20M01
			Benzene	0.15	ug/L	3	3	0.47	120	20M01
			Benzoic acid	.	ug/L	3	.	.	.	.
			Benzyl alcohol	0.07	ug/L	3	.	.	.	.
			Chloride	200	ug/L	3	.	.	.	.
			Chlorobenzene	0.34	ug/L	3	1	48.1	48.1	20M01
			Dibenzofuran	0.34	ug/L	3	1	2.56	2.56	20M01
			Ethylbenzene	0.46	ug/L	3	1	380	380	20M01
			Fluoranthene	1	ug/L	3	1	20	20	20M01
			Fluorene	0.88	ug/L	3	1	6.4	6.4	20M01
			Naphthalene	0.26	ug/L	3	1	140	140	20M01
			Nitrite/Nitrate	10	ug/L	3	3	12	16	20M08
			Phenanthrene	0.46	ug/L	3	1	22	22	20M01
			Phenol	1	ug/L	3	.	.	.	.
			Pyrene	1	ug/L	3	1	15	15	20M01
			Residue, DISS	1000	ug/L	3	3	204000	322000	20M08
			Sulfate	500	ug/L	3	.	.	.	.
			TPH	100	ug/L	3	1	13100	13100	20M01
			Toluene	0.25	ug/L	3	3	0.28	2010	20M01
			Xylenes (total)	0.85	ug/L	3	2	2.33	2200	20M01

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Media Area	Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Water	Stage 4	1,2-Dimethylbenzene	1	ug/L	27	12	1	1400	20FW42
			1,3-Dimethylbenzene	1	ug/L	27	14	1	4700	20FW39
			2,4-Dimethylphenol	2	ug/L	8	.	.	.	.
			2-Methylnaphthalene	1	ug/L	8	2	42	260	20M07
			2-Methylphenol	2	ug/L	8	.	.	.	.
			4-Methylphenol	2	ug/L	8	.	.	.	.
			Acenaphthene	1	ug/L	8	.	.	.	.
			Acenaphthylene	1	ug/L	8	.	.	.	.
			Anthracene	1	ug/L	8	1	1.7	1.7	20M01
			Benzene	1	ug/L	35	15	2	25000	20FW42
			Benzo(a)anthracene	1	ug/L	7	.	.	.	.
			Benzo(a)pyrene	2	ug/L	8	.	.	.	.
			Benzo(b)fluoranthene	1.5	ug/L	8	.	.	.	.
			Benzo(ghi)perylene	2.5	ug/L	8	.	.	.	.
			Benzo(k)fluoranthene	1.5	ug/L	8	.	.	.	.
			Benzoic acid	25	ug/L	8	.	.	.	.
			Benzyl alcohol	2	ug/L	8	.	.	.	.
			Bis(2-ethylhexyl) phthalate	2	ug/L	8	3	7.1	21	20M22
			Chlorobenzene	0.4	ug/L	8	.	.	.	.
			Chrysene	1	ug/L	8	.	.	.	.
			Dibenz[a,h]anthracene	2.5	ug/L	8	.	.	.	.
			Dibenzofuran	1	ug/L	8	.	.	.	.
			Ethylbenzene	1	ug/L	35	12	1.21	1600	20FW46
			Fluoranthene	1	ug/L	8	1	6.3	6.3	20M01
			Fluorene	1	ug/L	8	.	.	.	.
			Indeno(1,2,3-cd)pyrene	2.5	ug/L	8	.	.	.	.
			Naphthalene	1	ug/L	8	2	12	160	20M07
			Phenanthrene	1	ug/L	8	1	6.6	6.6	20M01
			Phenol	2	ug/L	8	.	.	.	.
			Pyrene	1	ug/L	8	1	5.5	5.5	20M01
			TPH	200	ug/L	8	1	6300	6300	20M01
			Toluene	1	ug/L	35	18	0.56	21000	20FW42
			Xylenes (total)	0.4	ug/L	8	4	3.44	1590	20M07

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Water	1993	0,0,0-Triethyl phosphorothioate	10	ug/L	7	.	.	.	.
			0,0-Diethyl 0-2-pyrazinyl phosphorothio	10	ug/L	7	.	.	.	.
			1,1,1-Trichloroethane	0.5	ug/L	20	.	.	.	.
			1,1,2-Trichloroethane	0.5	ug/L	20	.	.	.	.
			1,1-Dichloroethane	1	ug/L	20	.	.	.	.
			1,2,4,5-Tetrachlorobenzene	10	ug/L	7	.	.	.	.
			1,2,4-Trichlorobenzene	10	ug/L	7	.	.	.	.
			1,2-Dichlorobenzene	10	ug/L	7	.	.	.	.
			1,2-Dichloroethane	0.5	ug/L	20	.	.	.	.
			1,3-Dichlorobenzene	10	ug/L	7	.	.	.	.
			1,4-Dichlorobenzene	2	ug/L	20	.	.	.	.
			1,4-Dichlorobenzene	10	ug/L	7	.	.	.	.
			1,4-Dichlorobenzene	10	ug/L	7	.	.	.	.
			1,4-Naphthoquinone	10	ug/L	7	.	.	.	.
			1-Naphthylamine	10	ug/L	7	.	.	.	.
			2,3,4,6-Tetrachlorophenol	10	ug/L	7	.	.	.	.
			2,4,5-Trichlorophenol	10	ug/L	7	.	.	.	.
			2,4,6-Trichlorophenol	10	ug/L	7	.	.	.	.
			2,4-Dichlorophenol	10	ug/L	7	.	.	.	.
			2,4-Dimethylphenol	10	ug/L	7	.	.	.	.
			2,4-Dinitrophenol	50	ug/L	7	.	.	.	.
			2,4-Dinitrotoluene	10	ug/L	7	.	.	.	.
			2,6-Dichlorophenol	10	ug/L	7	.	.	.	.
			2,6-Dinitrotoluene	10	ug/L	7	.	.	.	.
			2-Acetylaminofluorene	10	ug/L	7	.	.	.	.
			2-Chloronaphthalene	10	ug/L	7	.	.	.	.
			2-Chlorophenol	10	ug/L	7	.	.	.	.
			2-Methylnaphthalene	10	ug/L	7	1	58	58	20M07
			2-Methylphenol	10	ug/L	7	.	.	.	.
			2-Naphthylamine	10	ug/L	7	.	.	.	.
			2-Nitroaniline	50	ug/L	7	.	.	.	.
			2-Nitrophenol	10	ug/L	7	.	.	.	.
			2-Picoline	10	ug/L	7	.	.	.	.
			3,3'-Dichlorobenzidine	20	ug/L	7	.	.	.	.
			3,3'-Dimethylbenzidine	10	ug/L	7	.	.	.	.
			3-Methylcholanthrene	10	ug/L	7	.	.	.	.
			3-Nitroaniline	50	ug/L	7	.	.	.	.
			4,6-Dinitro-o-cresol	50	ug/L	7	.	.	.	.
			4-Aminobiphenyl	10	ug/L	7	.	.	.	.
			4-Bromophenylphenyl ether	10	ug/L	7	.	.	.	.
			4-Chloro-3-methylphenol	20	ug/L	7	.	.	.	.
			4-Chloroaniline	20	ug/L	7	.	.	.	.
			4-Chlorophenylphenyl ether	10	ug/L	7	.	.	.	.
			4-Methylphenol	10	ug/L	7	.	.	.	.
			4-Nitroaniline	50	ug/L	7	.	.	.	.
			4-Nitrophenol	50	ug/L	7	.	.	.	.
			4-Nitroquinoline-1-oxide	10	ug/L	7	.	.	.	.
			5-Nitro-o-toluidine	10	ug/L	7	.	.	.	.
			7,12-Dimethylbenz[a]anthracene	10	ug/L	7	.	.	.	.
			Acenaphthene	10	ug/L	7	.	.	.	.
			Acenaphthylene	10	ug/L	7	.	.	.	.
			Acetophenone	10	ug/L	7	.	.	.	.
			Aluminum (Filtered)	200	ug/L	8	2	43	150	20M07
			Aluminum (Unfiltered)	200	ug/L	8	4	73	700	20M08
			Aniline	10	ug/L	7	.	.	.	.
			Anthracene	10	ug/L	7	.	.	.	.
			Antimony (Filtered)	200	ug/L	8	6	77	150	20M23
			Antimony (Unfiltered)	200	ug/L	8	5	92	130	20M08
			Aramite	10	ug/L	7	.	.	.	.

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Water	1993	Arsenic (Filtered)	5	ug/L	8	6	6.9	13	20M07
			Arsenic (Unfiltered)	5	ug/L	8	7	7.1	33	20M08
			Barium (Filtered)	20	ug/L	8	7	110	260	20M07
			Barium (Unfiltered)	20	ug/L	8	8	0.52	270	20M08
			Benzene	2	ug/L	20	11	0.21	660	20M07
			Benzo(a)anthracene	10	ug/L	7	.	.	.	.
			Benzo(a)pyrene	10	ug/L	7	.	.	.	.
			Benzo(b)fluoranthene	10	ug/L	7	.	.	.	.
			Benzo(ghi)perylene	10	ug/L	7	.	.	.	.
			Benzo(k)fluoranthene	10	ug/L	7	.	.	.	.
			Benzothiazole	10	ug/L	7	.	.	.	.
			Benzyl alcohol	20	ug/L	7	.	.	.	.
			Beryllium (Filtered)	3	ug/L	8	2	2	2.1	20M21
			Beryllium (Unfiltered)	3	ug/L	8	2	0.86	0.91	20M21
			Bis(2-Chloroethoxy)methane	10	ug/L	7	.	.	.	.
			Bis(2-Chloroisopropyl) ether	10	ug/L	7	.	.	.	.
			Bis(2-chloroethyl) ether	10	ug/L	7	.	.	.	.
			Bis(2-ethylhexyl) phthalate	10	ug/L	7	3	5.8	160	20M07
			Butylbenzylphthalate	10	ug/L	7	.	.	.	.
			Cadmium (Filtered)	10	ug/L	8	1	5	5	20M08
			Cadmium (Unfiltered)	10	ug/L	8	3	6.7	7.2	20M08
			Calcium (Filtered)	100	ug/L	8	8	87	95000	20MW26
			Calcium (Unfiltered)	100	ug/L	8	8	97	98000	20MW26
			Carbon tetrachloride	1	ug/L	20	.	.	.	.
			Chlorobenzilate	10	ug/L	7	.	.	.	.
			Chloroform	0.5	ug/L	20	.	.	.	.
			Chromium (Filtered)	20	ug/L	8	2	10	14	20M07
			Chromium (Unfiltered)	20	ug/L	8	3	6.7	12	20C-2
			Chrysene	10	ug/L	7	.	.	.	.
			Cobalt (Filtered)	20	ug/L	8	7	4.1	8.6	20M07
			Cobalt (Unfiltered)	20	ug/L	8	5	4.9	9.9	20MW26
			Copper (Filtered)	20	ug/L	8	1	8.1	8.1	20M07
			Copper (Unfiltered)	20	ug/L	8	.	.	.	.
			Di-n-butylphthalate	10	ug/L	7	.	.	.	.
			Di-n-octylphthalate	10	ug/L	7	.	.	.	.
			Diallate	10	ug/L	7	.	.	.	.
			Dibenz[a,h]anthracene	10	ug/L	7	.	.	.	.
			Dibenzofuran	10	ug/L	7	.	.	.	.
			Diethylphthalate	10	ug/L	7	.	.	.	.
			Dimethoate	10	ug/L	7	.	.	.	.
			Dimethyl phthalate	10	ug/L	7	.	.	.	.
			Diphenylamine	10	ug/L	7	.	.	.	.
			Ethyl methanesulfonate	10	ug/L	7	.	.	.	.
			Ethylbenzene	2	ug/L	20	12	0.065	170	20M07
			Famphur	10	ug/L	7	.	.	.	.
			Fluoranthene	10	ug/L	7	.	.	.	.
			Fluorene	10	ug/L	7	.	.	.	.
			Hexachlorobenzene	10	ug/L	7	.	.	.	.
			Hexachlorobutadiene	10	ug/L	7	.	.	.	.
			Hexachlorocyclopentadiene	10	ug/L	7	.	.	.	.
			Hexachloroethane	10	ug/L	7	.	.	.	.
			Hexachlorophene	10	ug/L	7	.	.	.	.
			Hexachloropropene	10	ug/L	7	.	.	.	.
			Indeno(1,2,3-cd)pyrene	10	ug/L	7	.	.	.	.
			Iron (Filtered)	20	ug/L	8	8	15	18000	20M07

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Operable Unit 1
Summary of Sampling Effort and Results for Each Source Area, Media, Stage

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Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Water	1993	Iron (Unfiltered)	20	ug/L	8	8	20	18000	20M08
			Isodrin	10	ug/L	7	.	.	.	.
			Isophorone	10	ug/L	7	.	.	.	.
			Isosafrole	10	ug/L	7	.	.	.	.
			Kepone	10	ug/L	7	.	.	.	.
			Kerosene	10000	ug/L	7	2	14	170	20M07
			Lead (Filtered)	5	ug/L	8	1	4	4	20M07
			Lead (Unfiltered)	5	ug/L	8	3	1	2	20M08
			Magnesium (Filtered)	100	ug/L	8	8	29	20000	20MW26
			Magnesium (Unfiltered)	100	ug/L	8	7	9600	21000	20MW26
			Manganese (Filtered)	10	ug/L	8	7	870	2800	20M07
			Manganese (Unfiltered)	10	ug/L	8	7	1200	2400	20M07
			Mercury (Filtered)	0.2	ug/L	7	.	.	.	.
			Mercury (Unfiltered)	0.2	ug/L	7	.	.	.	.
			Methapyrilene	10	ug/L	7	.	.	.	.
			Methyl methanesulfonate	10	ug/L	7	.	.	.	.
			Methylenechloride	5	ug/L	20	7	0.056	0.18	20M23
			N-Nitroso-di-n-dipropylamine	10	ug/L	7	.	.	.	.
			N-Nitrosodi-n-butylamine	10	ug/L	7	.	.	.	.
			N-Nitrosodiethylamine	10	ug/L	7	.	.	.	.
			N-Nitrosodimethylamine	10	ug/L	7	.	.	.	.
			N-Nitrosodiphenylamine	10	ug/L	7	.	.	.	.
			N-Nitrosomethylethylamine	10	ug/L	7	.	.	.	.
			N-Nitrosomorpholine	10	ug/L	7	.	.	.	.
			N-Nitrosopiperidine	10	ug/L	7	.	.	.	.
			Naphthalene	10	ug/L	7	1	83	83	20M07
			Nickel (Filtered)	30	ug/L	8	1	23	23	20M07
			Nickel (Unfiltered)	30	ug/L	8	1	24	24	20M21
			Nitrobenzene	10	ug/L	7	.	.	.	.
			Nitrosopyrrolidine	10	ug/L	7	.	.	.	.
			Parathion	10	ug/L	7	.	.	.	.
			Pentachlorobenzene	10	ug/L	7	.	.	.	.
			Pentachloronitrobenzene (PCNB)	10	ug/L	7	.	.	.	.
			Pentachlorophenol	50	ug/L	7	.	.	.	.
			Phenacetin	10	ug/L	7	.	.	.	.
			Phenanthrene	10	ug/L	7	.	.	.	.
			Phenol	10	ug/L	7	.	.	.	.
			Potassium (Filtered)	300	ug/L	8	7	2000	10000	20M07
			Potassium (Unfiltered)	300	ug/L	8	7	2000	10000	20M07
			Pronamide	10	ug/L	7	.	.	.	.
			Pyrene	10	ug/L	7	.	.	.	.
			Pyridine	10	ug/L	7	.	.	.	.
			Safrol	10	ug/L	7	.	.	.	.
			Silver (Filtered)	20	ug/L	8	5	2.9	4.9	20M08FT
			Silver (Unfiltered)	20	ug/L	8	3	3.5	6.1	20M08FT
			Sodium (Filtered)	300	ug/L	8	8	84	4300	20M08
			Sodium (Unfiltered)	300	ug/L	8	8	63	4400	20MW26
			Tetrachloroethene	0.5	ug/L	20	.	.	.	.
			Tetraethyl dithiopyrophosphate	10	ug/L	7	.	.	.	.
			Tin (Filtered)	100	ug/L	8	1	65	65	20M07
			Tin (Unfiltered)	100	ug/L	8	1	53	53	20MW26
			Toluene	2	ug/L	20	16	0.12	300	20M07
			Tributyl phosphate	10	ug/L	7	.	.	.	.
			Trichloroethene	1	ug/L	20	.	.	.	.
			Tris-2-chloroethyl phosphate	10	ug/L	7	.	.	.	.

Remedial Investigation Report: Operable Unit 1
Eielson Air Force Base

February 1, 1994

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Eielson Air Force Base, Alaska
Operable Unit 1

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Summary of Sampling Effort and Results for Each Source Area, Media, Stage

Source Area	Media Sampled	Sampling Stage	Analyte	Detection Limit	Units	Samples	Detects	Minimum Detect	Maximum Detect	Maximum Location
E-9	Water	1993	Vanadium (Filtered)	30	ug/L	8	1	4.1	4.1	20M21
			Vanadium (Unfiltered)	30	ug/L	8	2	4	8.5	20M08
			Vinyl chloride	2	ug/L	20	16	2	2	20M07
			Xylenes (total)	5	ug/L	20	16	0.23	530	20M07
			Zinc (Filtered)	10	ug/L	8	5	8.1	40	20M08
			Zinc (Unfiltered)	10	ug/L	8	4	4.5	9.9	20M08FT
			alpha, alpha-Dimethylphenethylamine	10	ug/L	7	.	.	.	.
			cis-1,2-Dichloroethylene	1	ug/L	20	.	.	.	.
			m-Cresol	10	ug/L	7	.	.	.	.
			m-Dinitrobenzene	10	ug/L	7	.	.	.	.
			o-Toluidine	10	ug/L	7	.	.	.	.
			p-Dimethylaminoazobenzene	10	ug/L	7	.	.	.	.
			p-Phenylenediamine	10	ug/L	7	.	.	.	.
			sym-Trinitrobenzene	10	ug/L	7	.	.	.	.
			trans-1,2-Dichloroethylene	1	ug/L	20	.	.	.	.

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