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SITE INVESTIGATION PROJECT REPORT FOR FIRE TRAINING PITS AT FORT RICHARDSON AND FORT GREELY, ALASKA

Contract No. DACA85-88-D-0014
Delivery Order No. 14

September 1993

Prepared for:

UNITED STATES ARMY CORPS OF ENGINEERS
ALASKA DISTRICT
David Williams, P.E.
Engineering Project Management
U.S. Army Engineer District
P. O. Box 898
Anchorage, Alaska 99506

TABLE OF CONTENTS

Table of Contents (Cont.)

Table of Contents (Cont.)

Table of Contents (Cont.)

Appendices

LIST OF TABLES

List of Tables (Cont.)

List of Tables (Cont.)

List of Tables (Cont.)

LIST OF ILLUSTRATIONS

List of Illustrations (Cont.)

EXECUTIVE SUMMARY

The United States Army Corps of Engineers, Alaska District, (COE) tasked Ecology and Environment, Inc., (E & E) to conduct a site investigation at one fire training pit (FTP) at Fort Richardson and three FTPs at Fort Greely. This project was funded by the United States Department of Defense under the Installation Restoration Program.

The scope of work for Contract No. DACA85-88-D-0014, Delivery Order No. 14, originally tasked E & E to perform site investigations at two FTPs at Fort Richardson, one FTP at Fort Wainwright, and one FTP at Fort Greely. Modification No. 1, dated September 6, 1990, deleted one of the FTPs at Fort Richardson from the scope because of its location on a landfill. During the course of the project, additional FTPs were discovered at Fort Wainwright and Fort Greely during review of aerial photographs and subsequently confirmed in the field. Modification No. 3, dated April 2, 1992, deleted all Fort Wainwright FTPs from the scope and added two FTPs at Fort Greely.

The objectives of this investigation were to determine the extent and concentration of hazardous contaminants, analyze the risks those contaminants pose to human health and the surrounding environment, and present possible cleanup alternatives.

To accomplish these objectives, E & E installed 50 soil borings and collected 299 surface and subsurface soil samples. Samples were analyzed by project and quality assurance laboratories contracted by the COE North Pacific Division Laboratory.

Since groundwater was not encountered during subsurface exploration at any of the FTPs, groundwater samples were not collected. Additionally, surface water samples were not collected.

FORT RICHARDSON

Analytical results at the Fort Richardson FTP (RFTP-2) document petroleum contamination in soils exceeding the Alaska Department of Environmental Conservation (ADEC) cleanup levels outlined for nonunderground storage tank contaminated soils. The following table summarizes the range of concentrations for contaminants requiring remediation and compares them to the applicable action levels:

Contaminant	Ranges Detected (mg/kg)	Action Level (mg/kg)
Benzene	1.3	0.5
Benzene, toluene, ethylbenzene, and total xylenes (BTEX)	15.6 — 94.5	15
Diesel-range organics (DRO)	220 — 20,000	200
Total recoverable petroleum hydrocarbons (TRPH)	2,300 — 4,700	2,000

Contaminants were detected as deep as 35.7 feet below ground surface (BGS) but likely extend deeper. The estimated areal extent of contamination is 25,000 square feet, and the estimated volume of contaminated soil is 35,000 cubic yards.

Based on depth of contamination compared to the estimated depth of groundwater (140 feet), off-site migration of contaminants through groundwater is unlikely. Similarly, since no established surface drainage crosses this site, off-site migration of contaminants through surface water is unlikely.

Compounds that potentially could result in significant adverse health effects, if the area were to be used for residential purposes, were detected at RFTP-2. The presence of compounds at concentrations above their risk-based screening levels does not necessarily mean that the site poses an actual risk; it simply indicates that the site may not be suitable for the most sensitive potential use.

The following nine remedial alternatives were evaluated as methods to achieve state and federal cleanup levels for soils:

- No action;
- Vacuum extraction/bioventing;
- Land farming;
- Soil flushing;

- Soil washing;
- Low-temperature thermal desorption;
- *Ex situ* incineration;
- Off-site land disposal; and
- Capping.

Based on effectiveness, ability to implement, and cost, E & E recommends vacuum extraction/bioventing for soil from the Fort Richardson FTP.

FORT GREELY

Analytical results at the Fort Greely FTPs document petroleum and pesticide contamination in soils exceeding ADEC and United States Environmental Protection Agency standards. The following tables summarize the range of concentrations for contaminants requiring remediation and compare them to the applicable action levels:

GFTP-4A		
Contaminant	**Ranges Detected (mg/kg)**	**Action Level (mg/kg)**
Benzene	175 — 1,312	15
Diesel-range organics	200 — 8,000	200
Total recoverable petroleum hydrocarbons	2,000 — 9,900	2,000

At GFTP-4A, contaminants were detected as deep as 11.5 feet BGS. The estimated areal extent of contamination is 8,750 square feet, and the estimated volume of contaminated soil is 5,500 cubic yards.

GFTP-4B		
Contaminant	**Ranges Detected (mg/kg)**	**Action Level (mg/kg)**
Benzene	0.55	0.5
Gasoline-range organics	1,900	100
Diesel-range organics	200 — 10,200	200
Total recoverable petroleum hydrocarbons	2,700 — 26,000	2,000
Total DDT	233 — 271	200

At GFTP-4B, contaminants are estimated to extend to 20 feet BGS. The estimated areal extent of contamination is 4,000 square feet, and the estimated volume of contaminated soil is 2,500 cubic yards.

GFTP-4D EAST		
Contaminant	**Ranges Detected (mg/kg)**	**Action Level (mg/kg)**
Diesel-range organics	660	200

At GFTP-4D East, DRO contamination extends to approximately 3 feet BGS. The estimated areal extent of contamination is 100 square feet, and the estimated volume of contaminated soil is 10 cubic yards.

GFTP-4D WEST		
Contaminant	**Ranges Detected (mg/kg)**	**Action Level (mg/kg)**
Diesel-range organics	560 — 21,000	200
Total recoverable petroleum hydrocarbons	2,000 — 55,000	2,000

At GFTP-4D West, contaminants are estimated to extend to 13 feet BGS. The estimated areal extent of contamination is 1,250 square feet, and the estimated volume of contaminated soil is 600 cubic yards.

Based on depth of contamination compared to the estimated depth of groundwater (170 feet), off-site migration of contaminants through groundwater is unlikely. Similarly, since the FTPs are covered largely by vegetation, surface water transport of contaminants to nearby creeks is unlikely.

Compounds that potentially could result in significant adverse health effects, if the area were to be used for residential purposes, were detected at the Fort Greely FTPs. The presence of compounds at concentrations above the risk-based screening levels does not necessarily mean that the site poses an actual risk; it simply indicates the site may not be suitable for the most sensitive potential use.

The following nine remedial alternatives were evaluated as methods to achieve state and federal cleanup levels for soils:

- No action;
- Vacuum extraction/bioventing;
- Land farming;
- Soil flushing;
- Soil washing;
- Low-temperature thermal desorption;
- *Ex situ* incineration;
- Off-site land disposal; and
- Capping.

Based on effectiveness, ability to implement, and cost, E & E recommends soil washing, low-temperature thermal desorption, and off-site land disposal for soils from the Fort Greely FTPs.

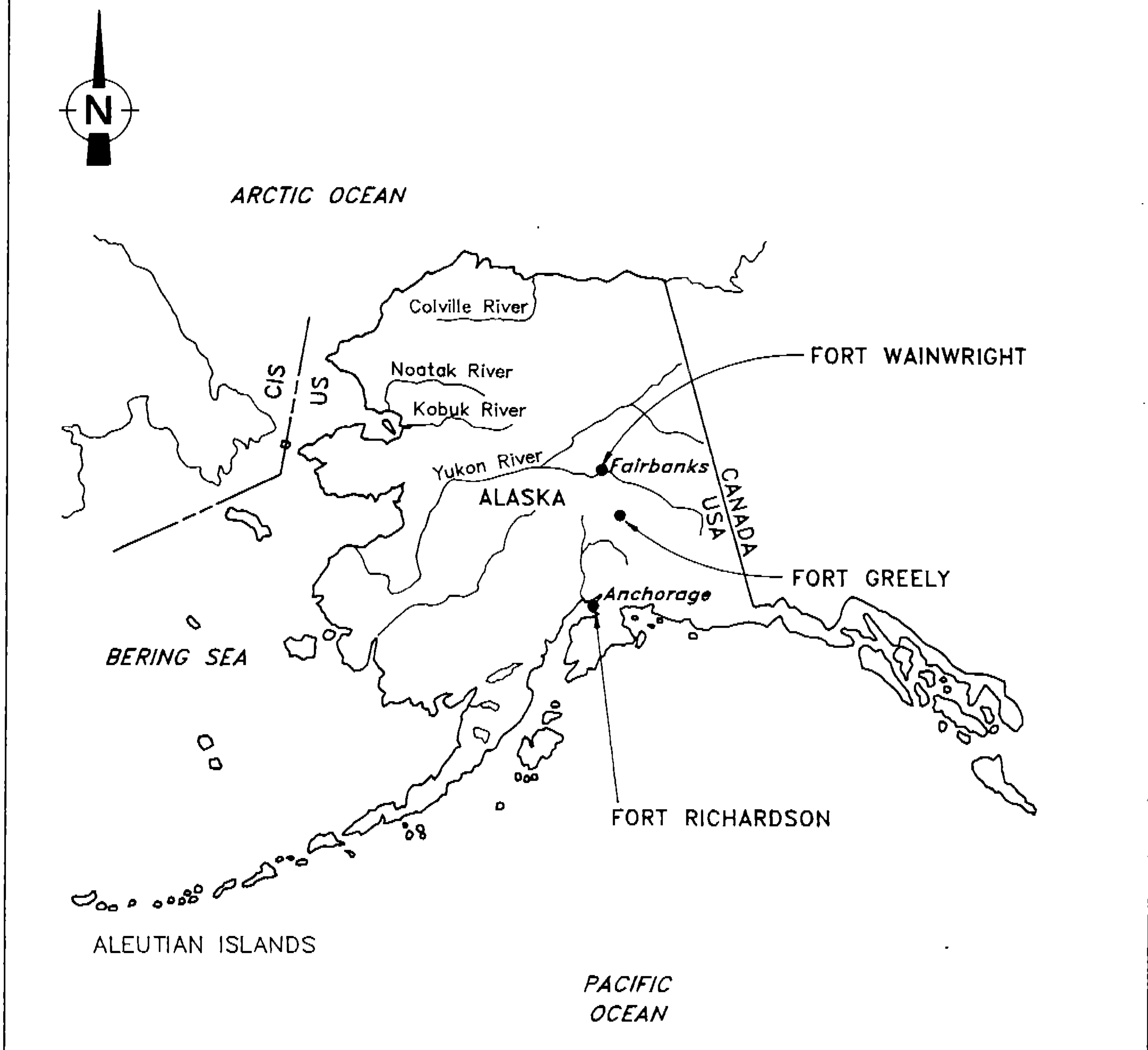
1. INTRODUCTION

The United States Army (Army), Sixth Infantry Division (Light), Directorate of Engineering and Housing (DEH) tasked the United States Army Corps of Engineers (USACE), Alaska District (COE) to perform site investigations at two fire training pits (FTPs) located at Fort Richardson, one FTP located at Fort Wainwright, and one FTP located at Fort Greely, Alaska (see Figure 1-1). The FTP investigation project was authorized for funding under the United States Department of Defense (DoD) Installation Restoration Program (IRP). The IRP program acts as the basis for response actions included under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as clarified by Executive Order No. 1.2316 for DoD facilities; it is designed to identify, evaluate, and clean up hazardous contamination and groundwater pollution at active DoD-operated installations.

1.1 SCOPE OF WORK

COE assigned the FTP site investigation to Ecology and Environment, Inc. (E & E) in 1989 for implementation under the terms of Indefinite Architect-Engineer Services Contract No. DACA85-88-D-0014, Delivery No. 14, and it has been modified several times since its initiation:

- One FTP associated with Fort Richardson is located on the Fort Richardson landfill. This FTP was eliminated from the project scope of work and included in a separate IRP project associated with the landfill; therefore, only one FTP associated with Fort Richardson is included in this delivery order;
- E & E identified two additional FTPs associated with Fort Greely and one additional FTP associated with Fort Wainwright while



FIRE TRAINING PIT SITES Ft. Richardson, Ft. Greely, Ft. Wainwright CONTRACT DACA85-88-D-0014	
TITLE: FORT LOCATION MAP Project No. KM5130	
ecology & environment, inc. ANCHORAGE, ALASKA	FIG. 1-1
Date: 05/93 Drawn by: EGM Scale:	

reviewing aerial photographs during preliminary stages of the investigation. These FTPs could not be confirmed during a site visit, however, due to vegetation and snow cover. As a result, COE issued a modification in 1990 to conduct a preliminary site investigation of the unconfirmed FTP at Fort Wainwright and two FTPs at Fort Greely; and

- Fort Wainwright was placed on the United States Environmental Protection Agency's (EPA's) National Priorities List (NPL) in 1990. As a result, the Fort Wainwright FTPs were removed from this contract delivery order. (Please note that borehole data associated with Fort Wainwright during the initial stages of the investigation are included in Appendix A.)

As a result of the modifications described above, the following *Site Investigation Project Report* includes one FTP located at Fort Richardson (RFTP-2) and three FTPs located at Fort Greely (GFTP-4A, GFTP-4B, and GFTP-4D).

1.2 OBJECTIVES

The primary goal of this site investigation was to determine the type and extent of contamination present at the four FTPs described in Section 1.1. Specific goals of the investigation included the following:

- Develop a work plan for field investigations at Fort Richardson and Fort Greely. This work plan was presented by E & E in *Field Investigation Plan, Fire Training Pits, Fort Richardson and Fort Greely, Alaska* (E & E 1991);
- Collect surface and subsurface soil samples from each FTP;
- Evaluate sample analytical results to determine the nature and extent of contamination;
- Develop a Potential Health Hazard Evaluation (PHHE) for each FTP; and
- Develop three remedial alternatives for each FTP.

This report presents background information associated with Fort Richardson and Fort Greely (Section 2), examines environmental settings (Section 3), summarizes field investigation activities (Section 4), presents sample analytical results (Section 5), discusses potential risks associated with contamination at each FTP (Section 6), and presents cleanup alternatives (Section 7). References used to prepare this document are presented in Section 8. Supporting documentation is presented in appendices A through F.

2. SITE BACKGROUND

The Fort Richardson and Fort Greely FTPs were locations of test fires used for the training of fire department and rescue crews. Fluids were stored at each site until they were burned for training purposes, and the exact nature of all substances that were placed in the FTPs has not been documented. The pits were soaked with water; filled with fuels, brake fluid, and solvents; and ignited. Fuels included diesel, JP-4, and waste oil. Solvents might have been present as contaminants in the waste oil.

It is estimated that 1,500 to 2,300 gallons of waste fuel were burned per year at each FTP (USACE 1989). The FTPs were never lined.

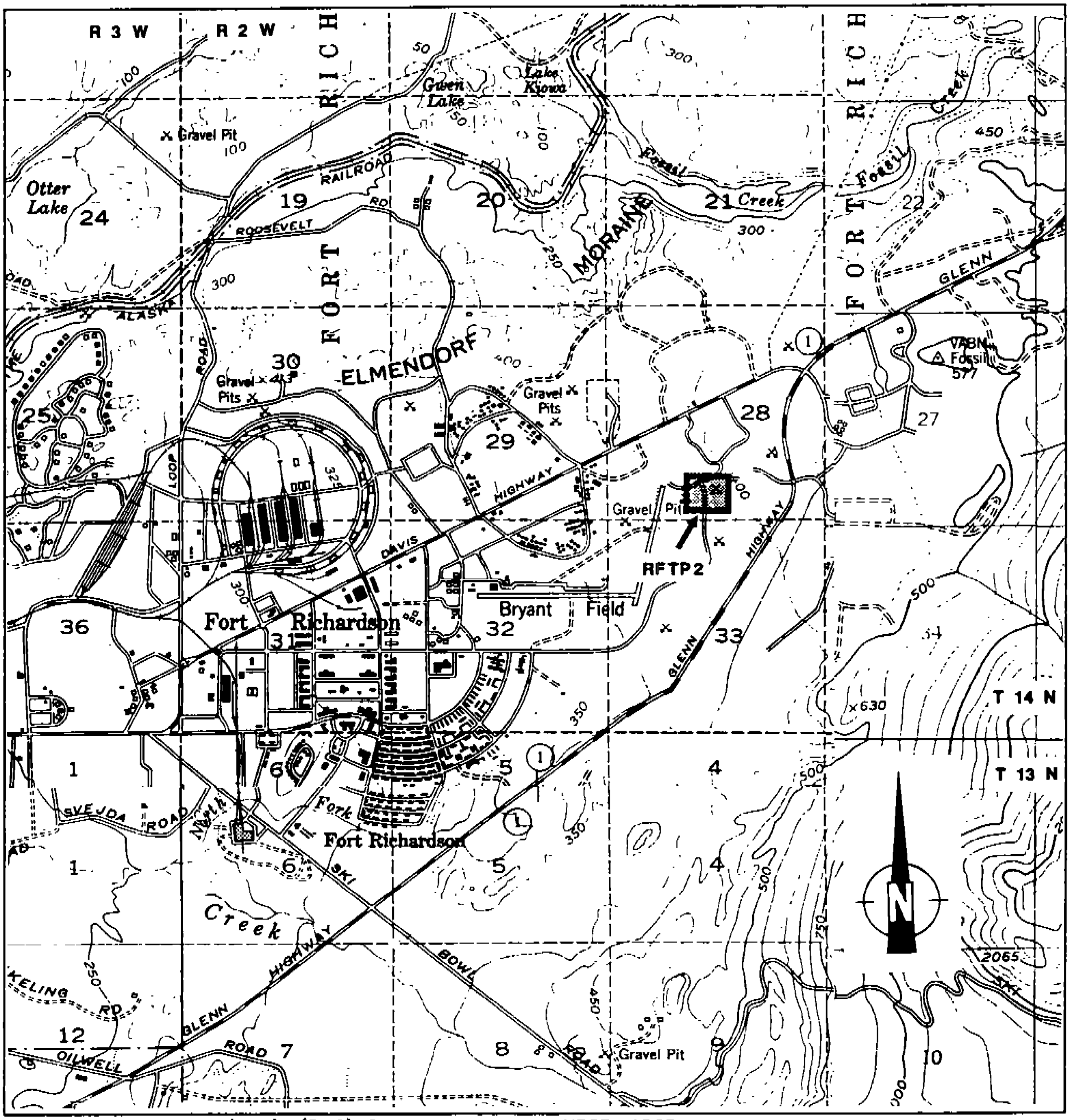
2.1 FORT RICHARDSON

2.1.1 Site Location

Fort Richardson is an Army installation located near Anchorage, Alaska. The site is bounded by the municipality of Anchorage and Elmendorf Air Force Base (EAFB) to the west; Eagle Bay and Knik Arm to the north; and the Chugach Mountains and Chugach State Park along the southern and eastern boundaries. The Glenn Highway bisects Fort Richardson. RFTP-2 is located in the southwest quarter of Section 28, Township 14 North, Range 2 West of the Seward Meridian, at an elevation of approximately 328 feet above mean sea level (MSL). RFTP-2 is located within the installation boundaries of Fort Richardson (see Figure 2-1).

2.1.2 Site Description

RFTP-2 was identified on aerial photographs taken in 1977. It is located among gravel pits east of Bryant Airfield, south of the Davis Highway, and west of the Glenn



Source: Anchorage (A-8), (B-8) Quadrangle, Alaska. USGS, 1965

0 1/2 1 2 MILES

LOCATION MAP

LEGEND

- Site location
- FTP Fire training pit

FIRE TRAINING PIT SITES
Fort Richardson, Anchorage, Alaska
CONTRACT DACA85-88-D-0014

TITLE:
FORT RICHARDSON
SITE LOCATION MAP

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 2-1

Date: 05/92 Drawn by: RSM Scale:

Highway. RFTP-2 is an approximately 50-foot-diameter circular area composed of petroleum-stained soil (see Figure 2-2). The soil is very hard, and a moderate petroleum odor was noted during 1992 fieldwork.

In 1991, E & E inspected the area surrounding RFTP-2 to determine the total acreage, including drum storage and debris locations, that were affected by fire training activities. During the May 1991 site reconnaissance, a charred drum, cable, metal cans, and wood were observed in RFTP-2. At the time fieldwork began in June 1991, the charred debris had been removed, the road bordering the west side of RFTP-2 no longer existed, and a new road had been graded 400 feet east of RFTP-2.

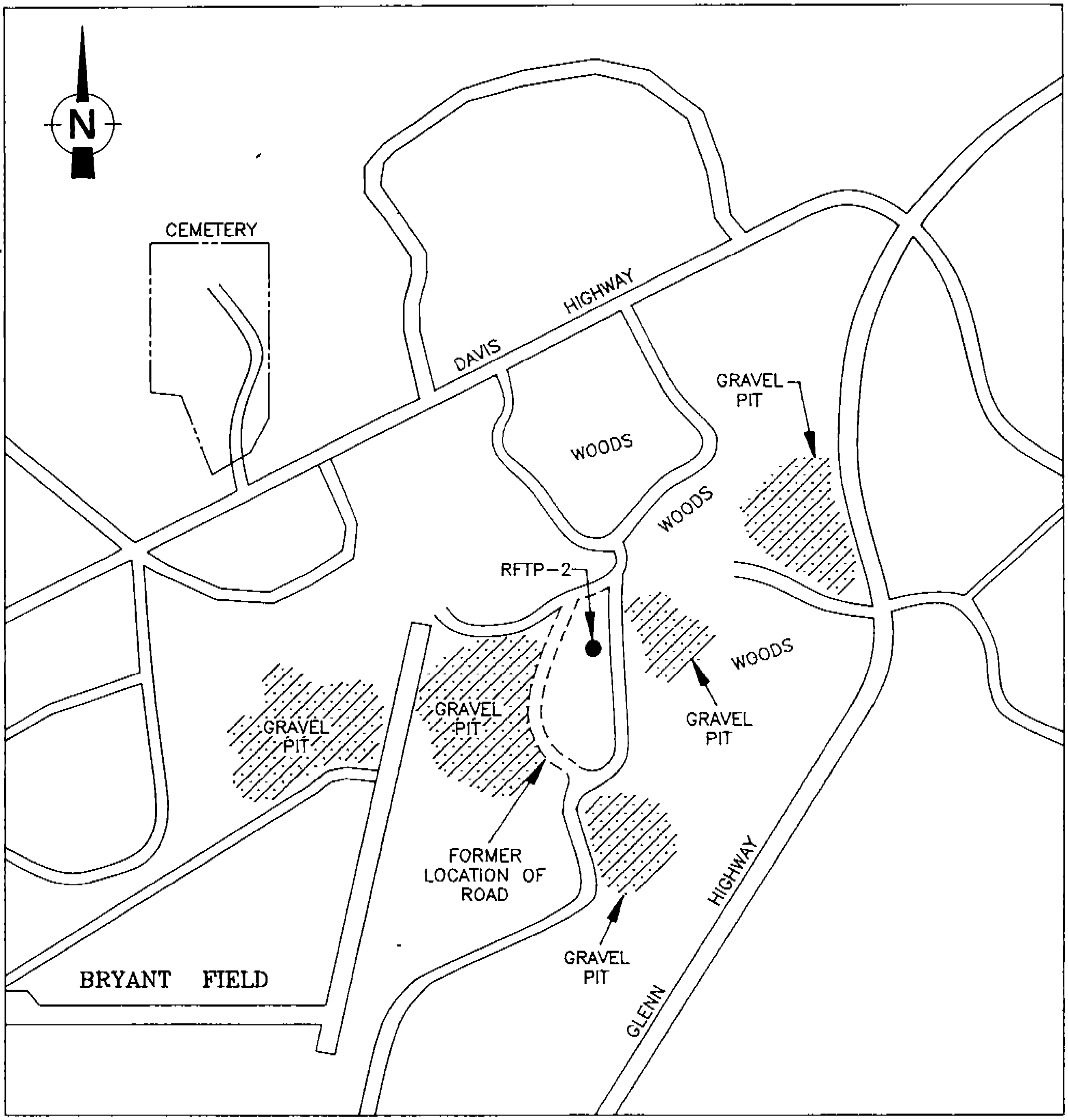
2.1.3 Previous Environmental Investigations

RFTP-2 was identified and documented in the Stage 1 IRP report of 1988 prepared by a consultant to USACE (WCC 1990a). No data were presented in this report concerning the historical use of RFTP-2 or the possible existence of other FTPs.

In 1986, the United States Army Environmental Hygiene Agency (AEHA) conducted an investigation of RFTP-2. Three soil borings were drilled and 20 subsurface soil samples were collected. Two soil borings met refusal at 20 feet below ground surface (BGS) and one met refusal at 26 feet BGS. Eight samples were analyzed for volatile organic compounds (VOCs), but no VOCs were detected above the detection limits; the remaining 12 samples were not analyzed for VOCs because holding times were exceeded (AEHA 1986).

In 1989, as part of the IRP program, 15 soil-gas probes were driven to a maximum depth of 9 feet (WCC 1990a). The soil-gas recovery system employed hollow probes placed into surficial soil to recover vapors. The vapor samples collected were tested for VOCs (E & E 1990). Benzene, toluene, and xylenes were identified in the soil-gas samples with maximum concentrations of 250 parts per million (ppm); 2,500 ppm; and 1,200 ppm, respectively. In addition, other identified hydrocarbons were detected. The RFTP-2 area was surveyed geographically by COE at this time (E & E 1990).

In 1991, E & E conducted a field investigation of RFTP-2 that included two soil borings. One soil boring was located south of the perimeter of RFTP-2 for use as a background sample, and the second soil boring was located near the center of the FTP. One composite surface soil sample was collected from stained soil near the center of the FTP (see Section 4).



LEGEND

RFTP = RICHARDSON FIRE TRAINING PIT

SCALE IN FEET

0 1000 2000 3000 4000

FIRE TRAINING PIT SITES Fort Richardson, Anchorage, Alaska CONTRACT DACA85-88-D-0014	
TITLE: FORT RICHARDSON SITE MAP Project No. KM5080	
ecology & environment, inc. ANCHORAGE, ALASKA	FIG. 2-2
Date: 05/93 Drawn by: EGM Scale:	

Analytical results of the composite surface soil sample from RFTP-2 revealed a lead concentration of 543 milligrams per kilogram (mg/kg), which exceeds the toxicity characteristic leaching procedure (TCLP) concentration of lead. In addition, diesel-range organics (DROs) were detected at 10,000 to 20,000 mg/kg, exceeding Alaska Department of Environmental Conservation (ADEC) cleanup levels (ADEC 1991a). This soil sample also contained tetrachloroethene (PCE; 485 micrograms per kilogram [μg/kg]), toluene (462 μg/kg), xylenes (1,116 μg/kg), bis(2-ethylhexyl)phthalate (4,100 μg/kg), copper (146 mg/kg), zinc (1,740 mg/kg), and dioxins (0.0022 μg/kg toxicity equivalent factor [TEF]).

RFTP-2 subsurface soil samples were collected at 5-foot intervals from 5 to 20 feet BGS. These subsurface samples contained acetone (283 μg/kg), trichloroethene (TCE; 46 μg/kg), toluene (56 μg/kg), and xylenes (42 μg/kg).

2.2 FORT GREELY

2.2.1 Site Location

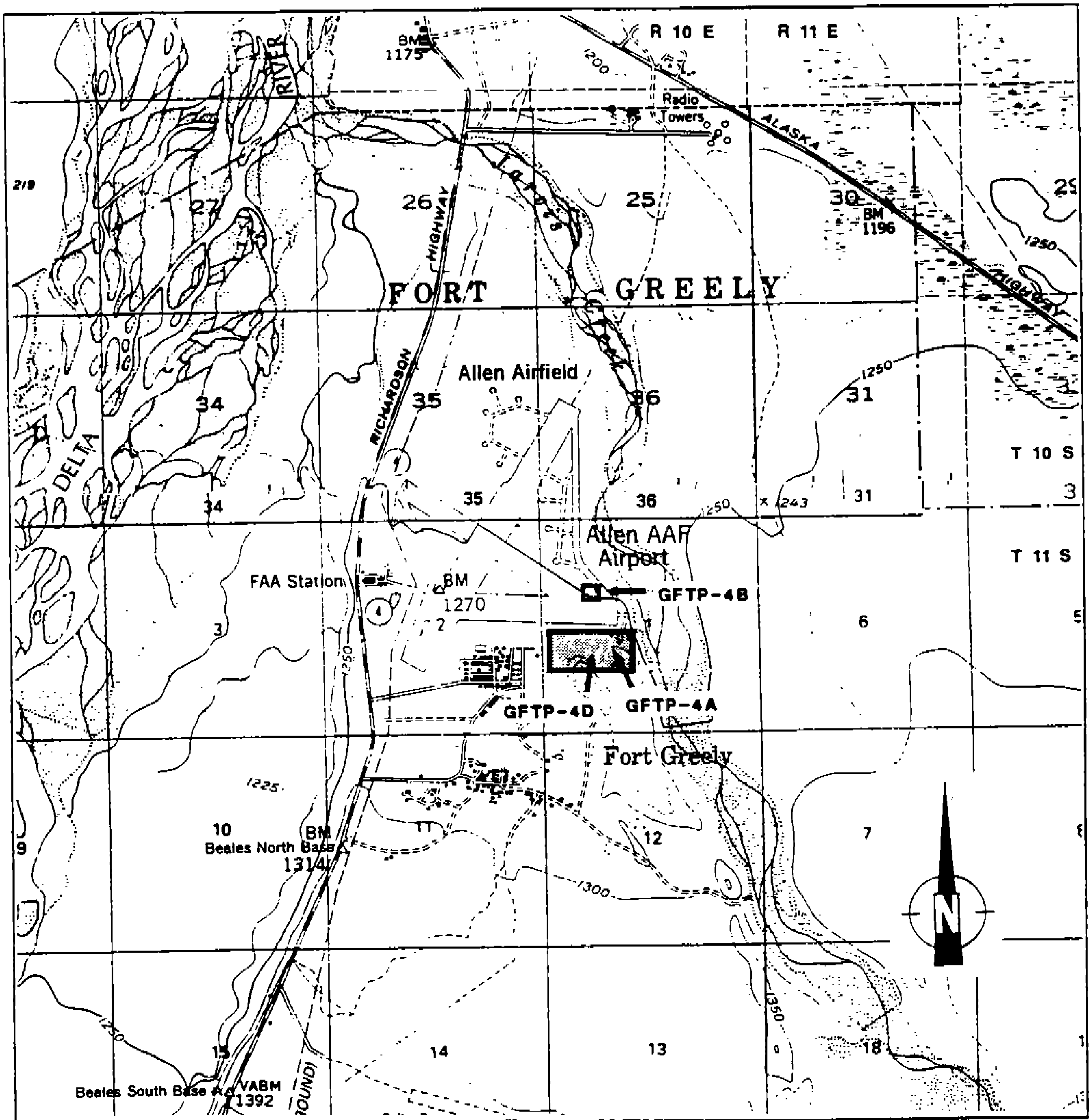
Fort Greely is located approximately 1 mile south of Delta Junction on the Richardson Highway. The northwestern section of Fort Greely is located at the confluence of the Delta River and Jarvis Creek.

The Delta River, Jarvis Creek, and the Richardson Highway all bisect the installation from north to south. The Fort Greely FTPs (GFTPs) are located in the northern portion of the installation in the southwest quarter of Section 1, Township 11 South of the Fairbanks Baseline, and Range 10 East of the Fairbanks Meridian (see Figure 2-3).

2.2.2 Site Description

This project included the investigation of three FTPs at Fort Greely: GFTP-4A, GFTP-4B, and GFTP-4D. GFTP-4A is located south of Sixth Avenue on Fort Greely, adjacent to the Fort Greely airfield. It includes approximately 4.5 acres covered with gravel and is encircled by trees (see Figure 2-4). According to aerial photographs, a rectangular pit was located at the center of GFTP-4A. Drums were stored on the western edge of the FTP. These features were no longer present during E & E's 1991 fieldwork.

GFTP-4B is located north of GFTP-4A and within the confines of the airfield boundaries north of a taxiway (see Figure 2-4). The FTP is a depression that is heavily vegetated with grasses. A small, vegetated access road south of the depression provides



Source: Big Delta (A-4), Mt Hayes (D-4) Quadrangles, Alaska. USGS, Photorevised 1975

0 1/2 1 MILE

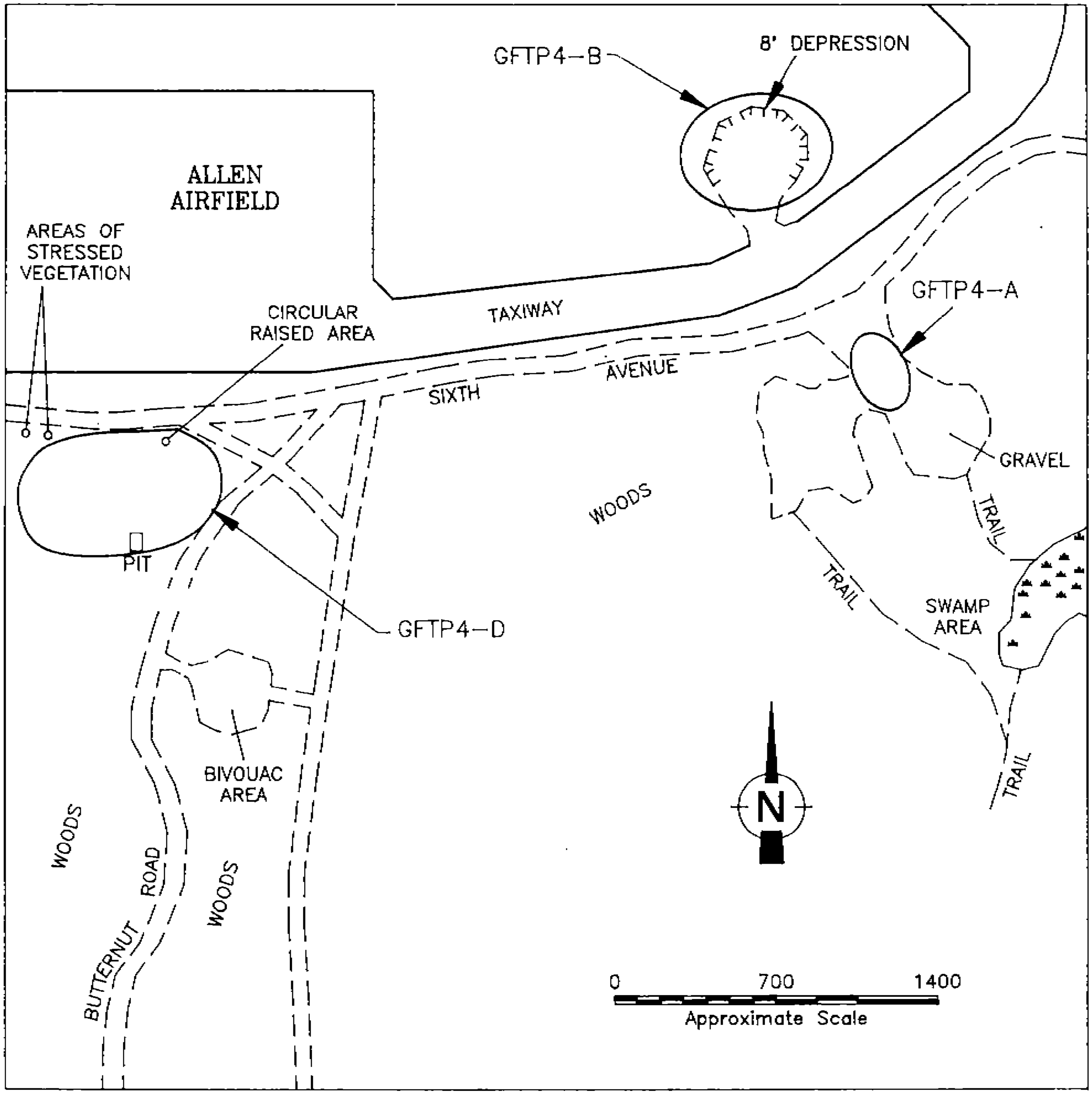
LOCATION MAP

ALASKA
Delta Junction

LEGEND

Site location
FTP Fire training pit

FIRE TRAINING PIT SITES Fort Greely, Delta Junction, Alaska CONTRACT DACA85-88-D-0014
TITLE: FORT GREELY SITE VICINITY MAP
Project No. KM5080
ecology & environment, inc. ANCHORAGE, ALASKA — FIG. 2-3
Date: 05/92 Drawn by: RSM Scale:



LEGEND

- - - Access road

FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85–88–D–0014

TITLE:

FORT GREELY SITE MAP

Project No. KM5000

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 2–4

Date: 04/93 Drawn by: EGM Scale: ____

entrance to the GFTP-4B from the taxiway. According to 1968 and 1969 aerial photographs, a rectangular pit was present in the center of the depression, and drums were stored on the southwest side of the pit. These features were no longer present during E & E's 1991 fieldwork.

GFTP-4D is located west of Butternut Road and west of GFTP-4A and GFTP-4B (see Figure 2-4). GFTP-4D consists of several distinct sections. The general GFTP-4D area includes a grassy field, an area containing concrete fill, and a forested area. Other sections include a raised circular area, which is approximately 6 inches high and 5 feet in diameter, and a 6-foot-deep pit, which is approximately 20 feet by 30 feet. These features are clearly visible on historical aerial photographs and were recognizable during fieldwork. Based on the contaminants detected during the 1991 investigation of GFTP-4D, 1992 fieldwork was concentrated in two areas: one area around 1991 boring 4D-3 and an area located approximately 500 feet west around 1991 boring 4D-2.

2.2.3 Previous Environmental Investigations

GFTP-4A was closed in 1985. No information is available regarding the operational period of the FTP. The area is now level, and no visible evidence of its prior use is present. In 1986, AEHA investigated GFTP-4A, drilled three borings, and collected 16 subsurface soil samples. Two of the three soil borings were 30 feet deep, and the other met refusal at 14 feet. Only one sample was analyzed for VOCs, but none of the target VOCs was detected. All the samples collected were analyzed for metals, explosives, pesticides, and base/neutral and acid extractable organic compounds (BNAs). The only target compounds detected were nine polynuclear aromatic hydrocarbons (PAHs) detected during BNA analyses of two soil samples collected from this FTP: fluoranthene (30 mg/kg and 40 mg/kg); pyrene (70 mg/kg and 30 mg/kg); benzo(a)anthracene (60 mg/kg and 30 mg/kg); chrysene (both 40 mg/kg); benzo(b)fluoranthene (20 mg/kg and 100 mg/kg); benzo(k)fluoranthene (50 mg/kg and 10 mg/kg); benzo(a)pyrene (50 mg/kg and 40 mg/kg); indeno(1,2,3-cd)pyrene (40 mg/kg and 20 mg/kg); and benzo(g,h,i)perylene (40 mg/kg and 240 mg/kg). All these PAHs are suspected carcinogens or equivocal tumorigenic agents and are listed as priority pollutants. None of these compounds was reported at any other FTPs at Fort Greely.

In 1989, 13 soil-gas probes were driven to a maximum depth of 10 feet. Analytical results of the soil-gas samples revealed benzene, toluene, and xylenes at maximum concentrations of 1,200; 1,100; and 1,000 ppm, respectively. Other hydrocarbons also were detected (WCC 1990s).

In 1991, E & E conducted a field investigation of the GFTPs. The investigation included nine soil borings and one shallow soil sample collected at 1 foot BGS (E & E 1991). Twenty-four subsurface soil samples were collected from the nine soil borings at 5-foot intervals. The depths of the borings ranged from 11 to 16.5 feet BGS.

DROs were detected in soil samples from GFTP-4B at concentrations exceeding ADEC regulations (ADEC 1991a). GFTP-4B soil samples collected from 4.5 to 11 feet BGS contained DROs at a maximum concentration of 2,734 mg/kg. In addition, GFTP-4B soil samples contained 4,4′-DDD (81,000 μg/kg); 4,4′-DDT (150,000 μg/kg); and 4,4′-DDE (2,900 μg/kg). GFTP-4D soil samples collected from 5 to 10 feet BGS contained 4,4′-DDD (330.0 μg/kg) and 4,4′-DDE (55.2 μg/kg).

Soil samples collected from 1 to 5 feet BGS from GFTP-4B and GFTP-4D also contained TCE (13 μg/kg and 15 μg/kg, respectively) and PCE (177 μg/kg and 182 μg/kg, respectively) at concentrations above background concentrations.

GFTP-4A soil samples from 5 to 6 feet BGS contained dioxin at a concentration of 0.0033 μg/kg TEF relative to 2,3,7,8-TCDD. Results are viewed with caution since dioxins were not detected in replicate samples analyzed at a second laboratory.

Previously identified PAH contamination was not encountered during this sampling event. This discrepancy with prior analytical results is probably because the 1991 sampling locations were in a different portion of the FTP from the 1986 sampling locations.

3. ENVIRONMENTAL SETTING

3.1 FORT RICHARDSON

3.1.1 Geographical Setting

Fort Richardson is located primarily within the Cook Inlet-Susitna lowland section of the Coastal Trough physiographic province of Alaska. The physiographic features of this glaciated province include ground moraines, drumlin fields, eskers, and outwash plains. Most of Fort Richardson lies less than 500 feet above MSL and has a local relief of 50 to 250 feet. However, the east-central and southeast sections of Fort Richardson lie within the Kenai-Chugach Mountains section of the Pacific Border Range physiographic province. Within the confines of Fort Richardson, the physiography in the Chugach Mountains section consists of discrete mountains that attain elevations of approximately 3,300 feet above MSL and are separated by formerly glaciated valleys. The northern portion of the installation, which includes RFTP-2, is flat to gently rolling, wooded terrain, with ponds and numerous streams within 2 to 4 miles of the site (WCC 1990b).

3.1.2 Climate

Fort Richardson is located in a climatic transition zone between the maritime climate of the coast and the continental climate of Interior Alaska. The mean monthly temperature ranges from a low of 11.8° Fahrenheit (F) in January to 57.9°F in July. The mean annual total precipitation is 14.7 inches, with almost half of the precipitation occurring July through September. The total precipitation includes a mean annual snowfall of 70 inches. The driest period occurs between January and May. Prevailing airflow originates from the south. However, from April through September, northerly winds blow at lower elevations. Mean wind speeds range from 5.8 to 8.3 miles per hour (ES&E 1983a).

3.1.3 Vegetation and Wildlife

The Fort Richardson area has a diverse wildlife population. Wildlife found at the fort include moose, bear, Dall Sheep, swans, and waterfowl. No threatened or endangered species are known to reside on the Fort Richardson installation (ES&E 1983a).

3.1.4 Geology

Surficial geology of the Fort Richardson area is characterized by sediments and landforms that are the effect of Pleistocene and Holocene glaciations. Remnants of the most recent glaciation include the massive Elmendorf Moraine, alluvial fans, and a large proglacial outwash deposit (Schmoll and Dobrovolny 1972). The Elmendorf Moraine, a northeast-southwest trending terminal moraine representing the Naptowne glaciation, consists of poorly sorted, unconsolidated till with boulders, gravel, sand, and silt. The southern boundary of the Elmendorf Moraine is located approximately 0.9 mile northwest of RFTP-2 (see Figure 2-1).

RFTP-2 is located on a large outwash plain along the margin of the Elmendorf Moraine. The outwash plain alluvium consists of gravel in the eastern portion of Fort Richardson, where RFTP-2 is located, and grades to sand in the western portion. The outwash plain has been a major source of sand and gravel for Fort Richardson (Schmoll and Dobrovolny 1972).

Lithologic logs of wells (FRA-1 through FRA-3) at the Fort Richardson landfill, located 1.5 miles northwest of RFTP-2, indicate that unconsolidated sediments are greater than 160 feet thick. A thick, coarse-grained, generally well-bedded and well-sorted, unconsolidated deposit of gravel and sand, with only 10% clay or silt by volume, underlies the vicinity of RFTP-2 (AEHA 1983).

3.1.5 Hydrology

Groundwater

Hydrogeology of the Fort Richardson area consists of a system of unconfined and confined aquifers that dip westward from the Chugach Mountains across the Anchorage basin (Cederstrom *et al.* 1964). Groundwater recharge originates in the Chugach Mountains and probably migrates throughout the alluvium of the glacial outwash plain, which underlies RFTP-2 and significant portions of Fort Richardson, south of the Elmendorf Moraine.

Specifically, these aquifers are recharged by infiltration of surface water runoff, direct infiltration of precipitation, and percolation from surface water bodies (Zenone and Anderson 1978). Fort Richardson is believed to overlie a major portion of the recharge area for a confined aquifer that serves Anchorage. Ship Creek replenishes the aquifer utilized by Anchorage, but the aquifer also is replenished by runoff from the Chugach Mountains (Cederstrom *et al.* 1964).

Several aquifers likely exist in the vicinity of RFTP-2. Lithologic logs of wells from the Fort Richardson fish hatchery (1.5 miles south of RFTP-2) and the Fort Richardson landfill (1.5 miles northwest of RFTP-2) indicate the depth to groundwater ranges from 38 to 140 feet BGS; however, the shallowest occurrence of groundwater likely represents perched aquifers. Given its proximity to Ship Creek, the existence of a shallow aquifer at the location of the Fort Richardson fish hatchery may indicate that the shallow aquifer could be hydraulically connected to the creek. The extent of this aquifer is unknown. The direction of groundwater flow was inferred to be west-northwest at the Fort Richardson fish hatchery (Zenone and Anderson 1978).

Surface Water

The principal surface water drainages of Fort Richardson and the distances of these from the RFTP-2 are as follows: Eagle River is located more than 3 miles to the north; Fossil Creek is located 1.3 miles to the north; and Ship Creek is located 2 miles to the south. Eagle River is fed by turbid glacial meltwater, snowmelt, and runoff; Ship Creek and Fossil Creek are sustained only by snowmelt and runoff. The tributary stream flow south of Elmendorf Moraine, where RFTP-2 is located, flows southwest into Ship Creek; however, no significant tributaries of Ship Creek are located near RFTP-2. Another water body, Otter Lake, is located 4.5 miles northwest of RFTP-2 (WCC 1990b). RFTP-2 is not located near any major tributaries of Eagle River or Ship Creek.

3.2 FORT GREELY

3.2.1 Geographical Setting

Fort Greely is located on the Richardson Highway, approximately 1 mile south of Delta Junction, Alaska. Fort Greely is located in the Tanana-Kuskokwim lowlands, which are characterized by bottomland forests and wetlands and braided, glacial meltwater streams that flow north toward the Tanana River (ES&E 1983b). The confluence of the Delta River and Jarvis Creek exists at the northwest corner of the Fort Greely property.

3.2.2 Climate

Fort Greely has a continental climate with warm summers and cold winters. The temperature ranges from 85°F to -65°F. The average temperature is 49.1°F in the summer and 5.8°F in the winter. High winds can make the winter particularly severe. Precipitation is light, averaging 11.51 inches including 41.3 inches of snow (Leslie 1989). Throughout the winter, the prevailing wind direction is from the southeast at approximately 9.1 miles per hour. During June and July, the wind is from the southwest at approximately 7.2 miles per hour (NOAA undated).

3.2.3 Vegetation and Wildlife

The Delta caribou herd regularly winters in the Fort Greely area (ADFG 1985). Moose are abundant, and brown bear also are found in the area of the fort (ADFG 1985). Bison, introduced to the area in the 1920s, have fall and winter ranges in the Fort Greely area. Ducks and geese migrate along the Delta and Tanana rivers (ADFG 1985). Sandhill cranes migrate through the Fort Greely area from late April to mid-May and in September. Thousands of migrating waterfowl are observed in the area each year (ADFG 1985). Lake trout and Arctic grayling are found in the Delta River (ADFG 1990).

3.2.4 Geology

Surficial geology of the Fort Greely area mainly includes glacial moraine and alluvial outwash deposits. Glaciers originated in the Alaska Range and moved north toward the Tanana-Kuskokwim lowlands. Glacially derived sediments form three moraines, the Darling Creek, Delta, and Donnelly moraines, which record the three most recent Pleistocene-age glacial advances in the Fort Greely area. Alluvial outwash deposits are located along the northern borders of their associated moraines. Fort Greely is located on the alluvial outwash deposits associated with the Donnelly Moraine. The alluvial outwash deposits consist of fine- to coarse-grained sand and gravel, with lenses of sand and silt. The alluvial outwash deposits are underlain by glacial till deposited during the Delta glaciation. The till of the Delta glaciation is underlain by gravel. Bedrock in the vicinity of Fort Greely occurs at depths greater than 400 feet BGS (COE 1991).

Soils beneath the FTPs mainly include stratified, well-drained gravel and sandy, silty soils with wet, silty, sandy permafrost soils in depressions (ES&E 1983b). Discontinuous permafrost is present in the Fort Greely area to a depth of 120 feet BGS. The permafrost lacks discrete ice because of the high porosity and low moisture content of the outwash deposits (COE 1991).

3.2.5 Hydrology

Groundwater

The water table of the shallowest aquifer in the Fort Greely area is encountered at a depth of 170 to 220 feet BGS. Consequently, alluvial outwash deposits associated with the Donnelly Moraine are unsaturated. The Delta till beneath the alluvial outwash deposits is thought to be a confining layer to the underlying gravel deposit, so the gravel deposit is thought to represent a confined aquifer. The direction of groundwater flow in the Fort Greely area is to the north (COE 1991).

Groundwater recharge to the confined gravel aquifer occurs in the late spring and early summer by percolation from the glacier-fed streams. Direct infiltration of precipitation and overland surface water run off contributes minimally to the aquifer supply.

Surface Water

The Delta River is located 1 mile west of the GFTPs, and Jarvis Creek is located 2,000 feet east of the GFTPs. Maximum stream discharge occurs in late summer when snow and ice melt reaches its maximum and is augmented by rainfall (ES&E 1983b). Surface water in the vicinity of the GFTPs flows to the north.

4. FIELD INVESTIGATION

4.1 OBJECTIVES

The primary objective of the field investigation was to determine the type and extent of contamination associated with the FTPs at Fort Richardson and Fort Greely. The lateral and vertical extents of contamination are necessary to calculate the volume of contaminated soil present. Once the volume and type of contamination is known, remedial alternatives to clean up the FTPs can be recommended.

Fieldwork conducted by E & E in 1991 was used to identify and characterize the need for further site investigation. Information obtained from 1991 field data was used to design and implement the more extensive surface and subsurface soil sampling effort performed in 1992. The 1992 soil sampling effort included samples collected at various depths and distances from each FTP until contamination was no longer detected using a photoionization detector (PID).

4.2 IMPLEMENTATION OF THE WORK PLAN

In 1991, E & E conducted a field investigation of RFTP-2 that included one composite surface soil sample and two soil borings. Five subsurface soil samples were collected from the boreholes associated with RFTP-2. E & E also conducted a field investigation at the GFTPs which included nine soil borings (E & E 1991). Twenty-five subsurface soil samples were collected from the nine soil borings, which ranged in total depth from 11 to 16.5 feet BGS (see Table 4-1). In addition, one subsurface soil sample was collected from 1 foot BGS at GFTP-4D.

Additional fieldwork was conducted at Fort Richardson and Fort Greely in September and October 1992. The Fort Richardson fieldwork included the collection of 25 surface soil samples and one surface soil background sample. Fifteen boreholes were drilled at RFTP-2. Five to 10 soil samples were collected from each borehole, depending on borehole depth, which ranged from 24.5 to 66.5 feet BGS. Sample locations at Fort Richardson are shown in figures 4-1 through 4-3.

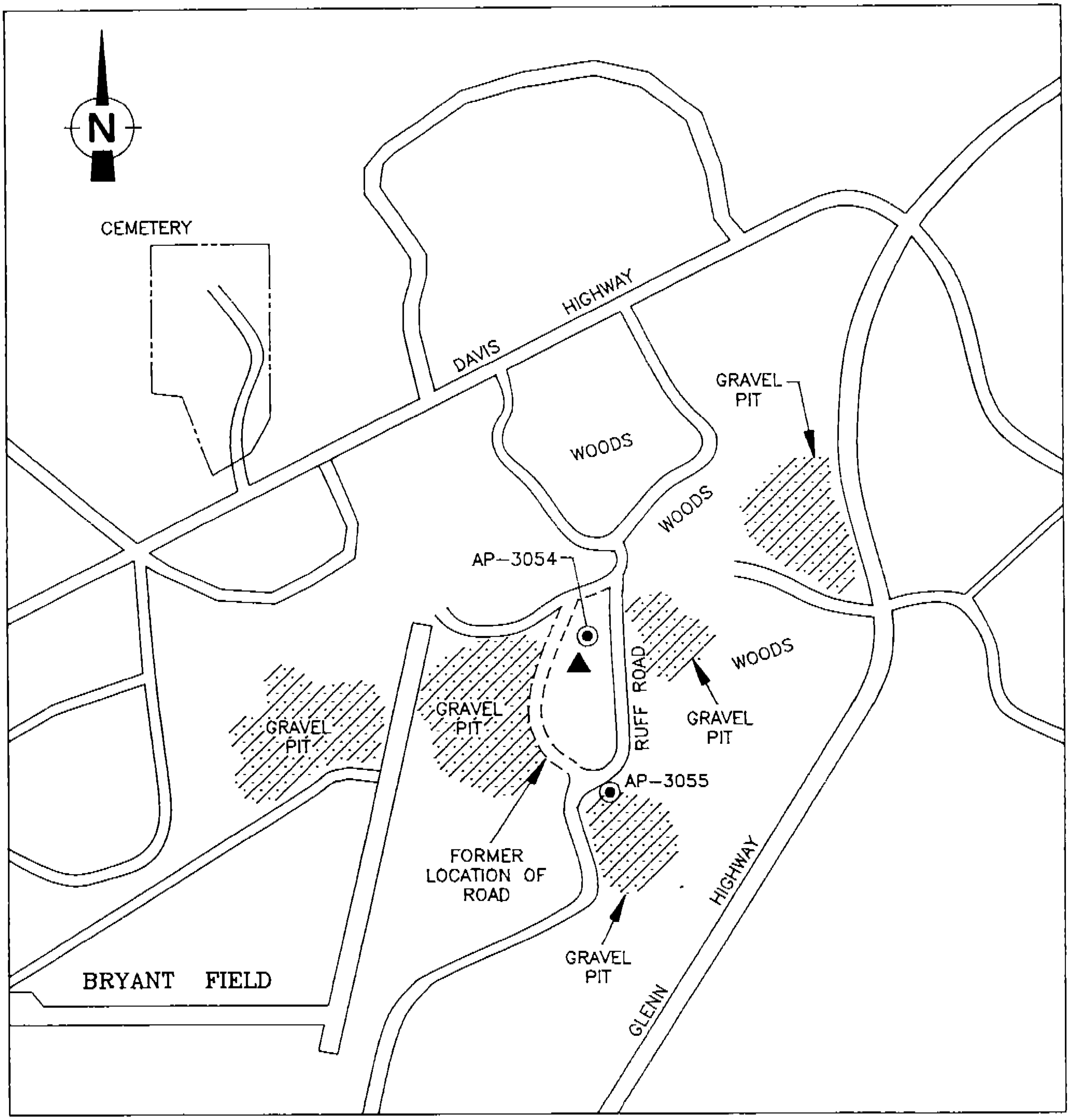
The 1992 sampling effort at Fort Greely included the collection of 34 surface soil samples, including one background surface soil sample, and soil samples from 24 boreholes. Two to nine soil samples were collected from each borehole depending on borehole depth, which ranged from 11.3 to 46.5 feet BGS. Sample locations at Fort Greely are shown in figures 4-4 through 4-8.

Table 4-1 compares the work proposed in the Field Investigation Plan prepared for the 1991 FTP investigation to work actually completed in the field. Table 4-2 compares the work proposed in the *1992 Fire Training Pits Work Plan* (E & E 1992) to the work completed in the field. E & E deviated from the original 1992 work plan by increasing the number of soil samples collected at each FTP because the volume and depth of contamination was much greater than expected. Borings were drilled deeper than expected to determine the vertical extent of contamination. In summary, the work performed in the field for both 1991 and 1992 differs only slightly from the work proposed.

4.3 SAMPLING PROGRAM

The primary objective of the 1991 sampling program was to identify and characterize in sufficient detail contaminated areas of suspected FTPs. This activity was used to provide data for further decisions pertaining to the direction for further investigation. The 1991 sampling plan was prepared based on past sampling activities, United States Department of Transportation (DOT) regulations (49 CFR 1972), and EPA Hazardous and Toxic Waste regulations (40 CFR 261-264). The 1991 sampling plan was designed to meet the following objectives:

- Characterize wastes potentially present at each suspected FTP;
- Determine the vertical extent of soil contamination at each suspected FTP;
- Fill data gaps at "confirmed" FTPs by collecting samples from one soil boring at the center of each confirmed FTP; and



LEGEND

RFTP = Richardson Fire Training Pit

◉ 1991 Boring locations

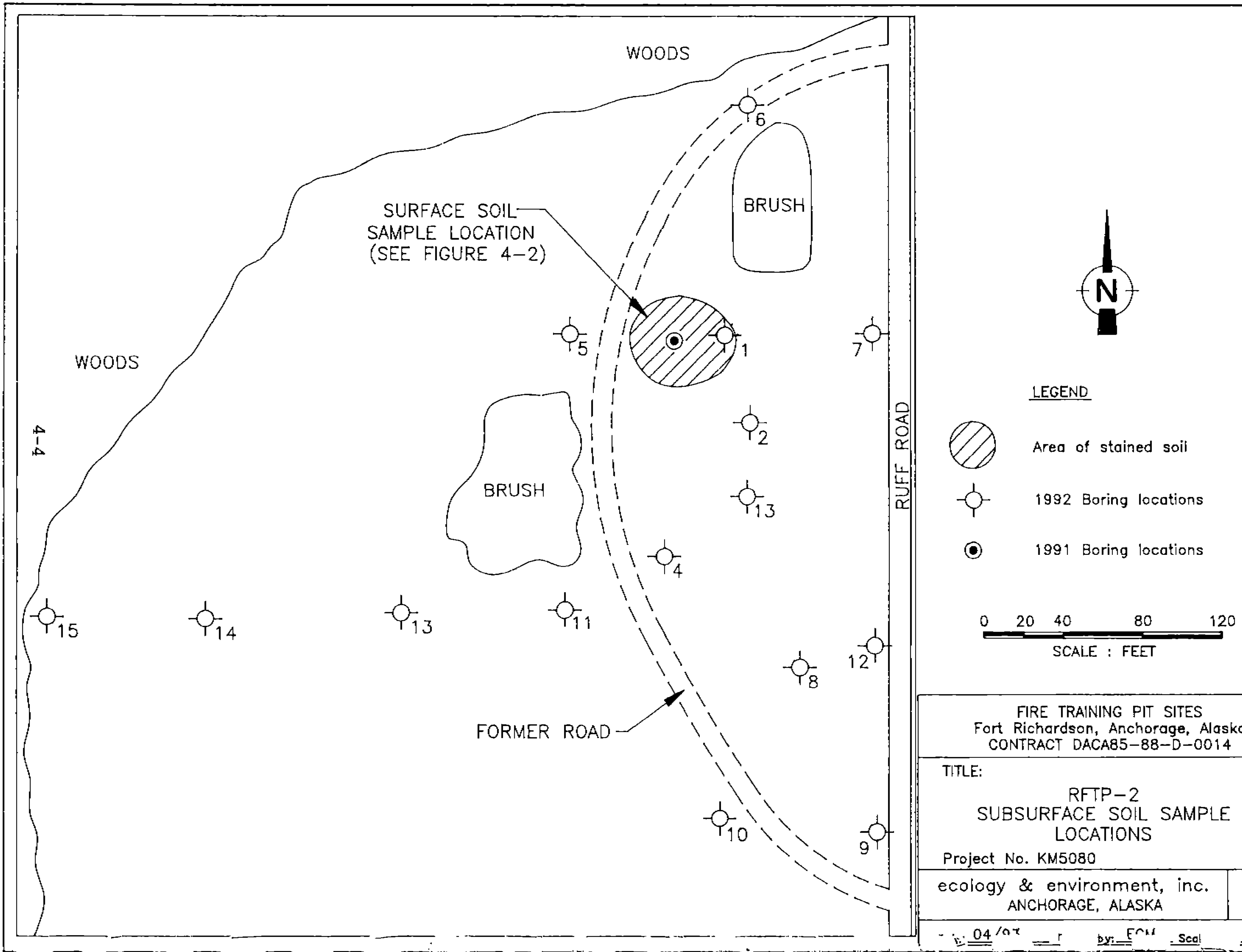
▲ Composite surface soil sample location

SCALE IN FEET

0 1000 2000 3000 4000

FIRE TRAINING PIT SITES Fort Richardson, Anchorage, Alaska CONTRACT DACA85-88-D-0014	
TITLE: FORT RICHARDSON 1991 SAMPLE LOCATION MAP Project No. KM5080	
ecology & environment, inc. ANCHORAGE, ALASKA	FIG. 4-1
Date: 05/93 Drawn by: EGM Scale:	

C:\CORP\KM5080\KMF4-1A.DWG MAY 5, 1993



FIRE TRAINING PIT SITES
Fort Richardson, Anchorage, Alaska
CONTRACT DACA85-88-D-0014

TITLE:

RFTP-2
SUBSURFACE SOIL SAMPLE LOCATIONS

Project No. KM5080

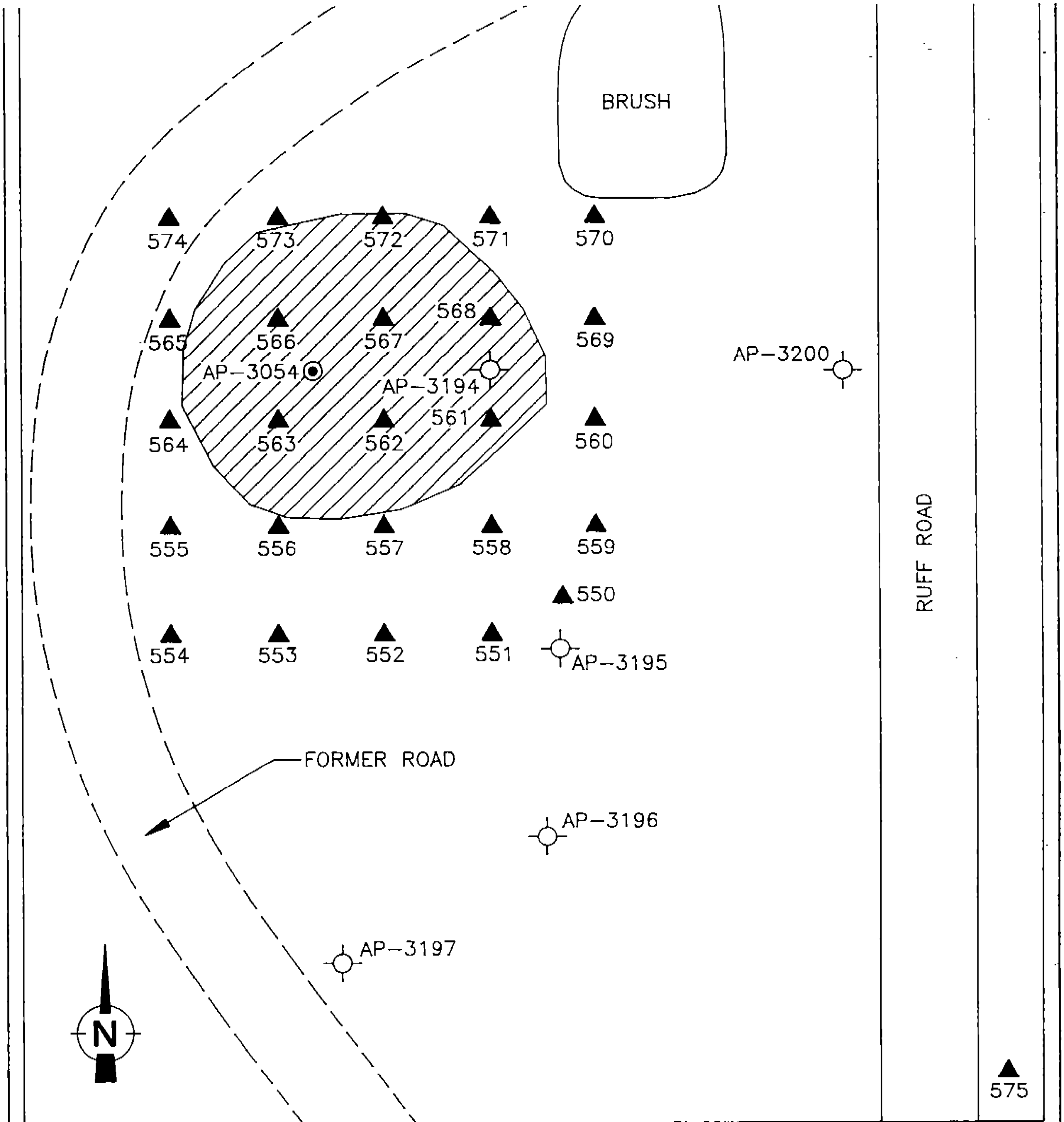
ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 4-2

04/93 by: ECM Scal

4-4

OUA 0001153



LEGEND

Area of stained soil

▲ Surface soil sample locations (1992)

1992 Boring locations

1991 Boring locations

0 10 20 30 40

SCALE : FEET

FIRE TRAINING PIT SITES
Fort Richardson, Anchorage, Alaska
CONTRACT DACA85-88-D-0014

TITLE:

RFTP-2 SURFACE SOIL SAMPLE LOCATION MAP
Delivery Order No. 14

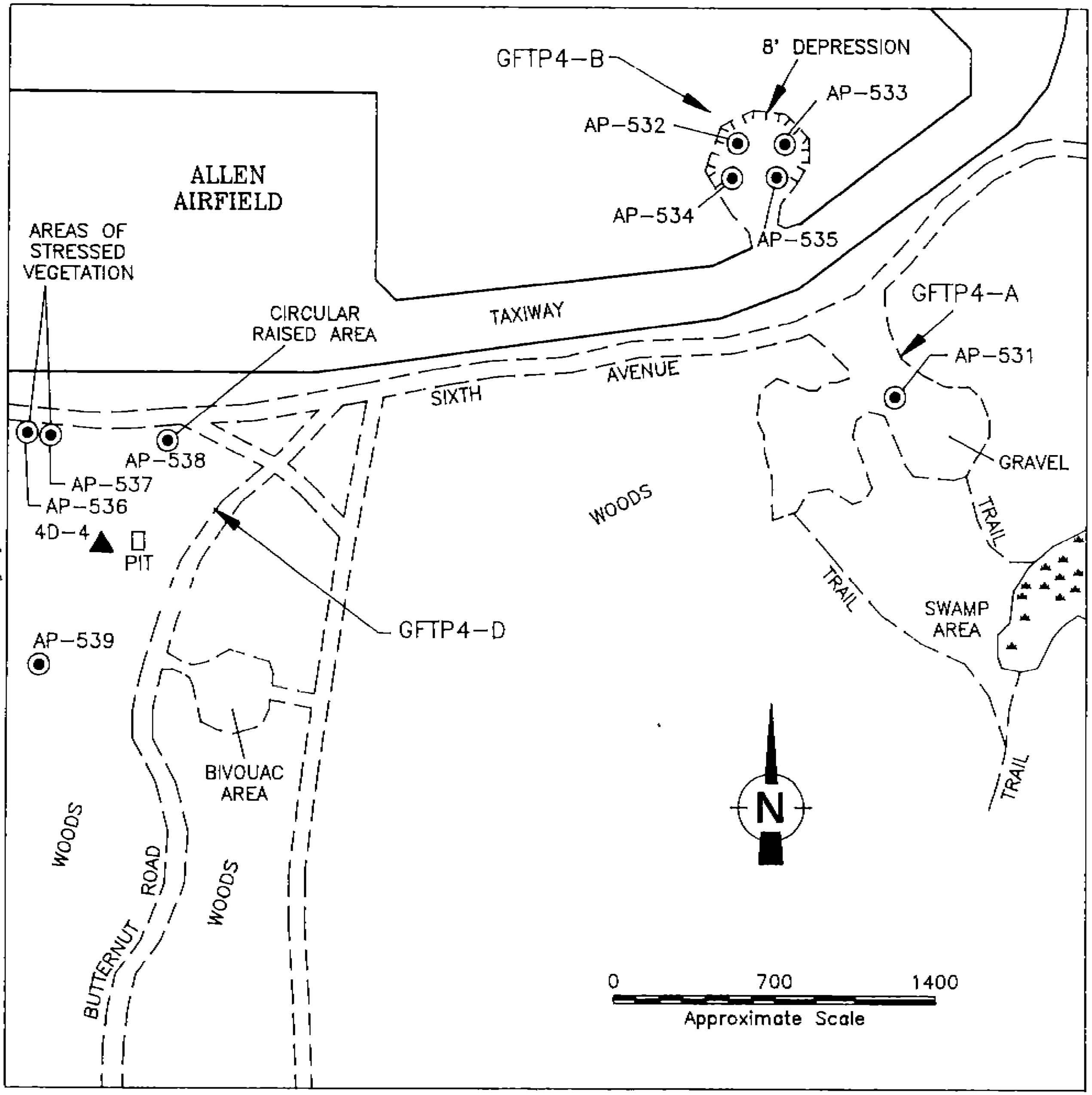
Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 4-3

Date: 05/93 Drawn by: EGM Scale: 1"=20'

C:\CORP\KM5080\KMF4-3A.DWG\ MAY 22, 1993



LEGEND

- Access road
- ▲ Surface soil sample location
- ◉ 1991 Boring locations

FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85-88-D-0014

TITLE:

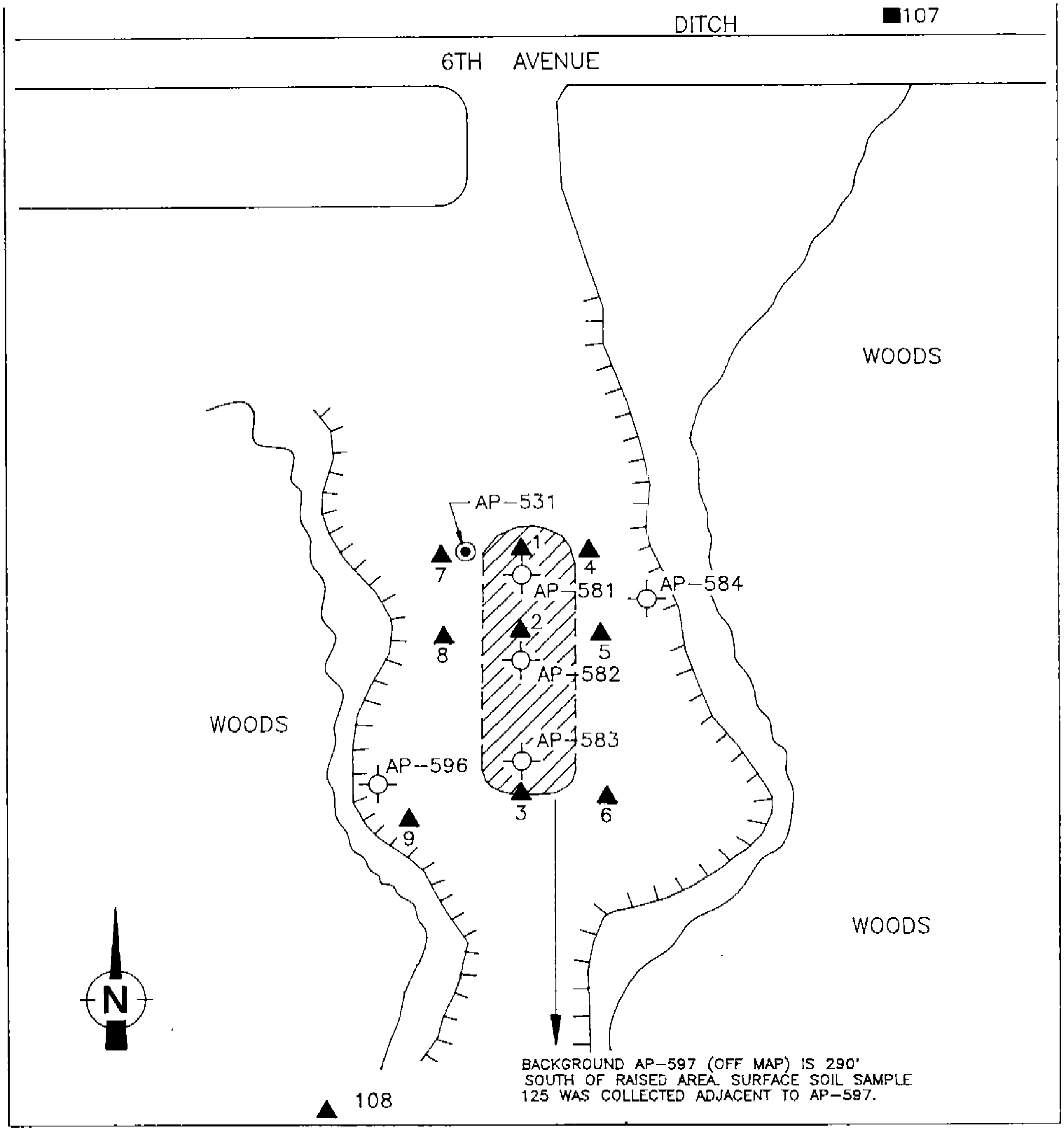
1991 SAMPLE LOCATION MAP
Delivery Order No. 14

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 4-4

Date: 04/93 Dr. EGM Scale:



LEGEND

- Area of soil raised 2" above surrounding soil
- Sediment sample location (1992)
- Surface soil sample locations (1992)
- 1992 Boring locations
- 1991 Boring locations
- Depression

0 20 40 80 120

SCALE : FEET

FIRE TRAINING PIT SITES Fort Greely, Delta Junction, Alaska CONTRACT DACA85-88-D-0014	
TITLE: GFTP-4A SURFACE AND SUBSURFACE SOIL SAMPLE LOCATIONS Project No. KM5080	
ecology & environment, inc. ANCHORAGE, ALASKA	FIG. 4-5
Date: 05/93 Drawn by: EGM Scale:	

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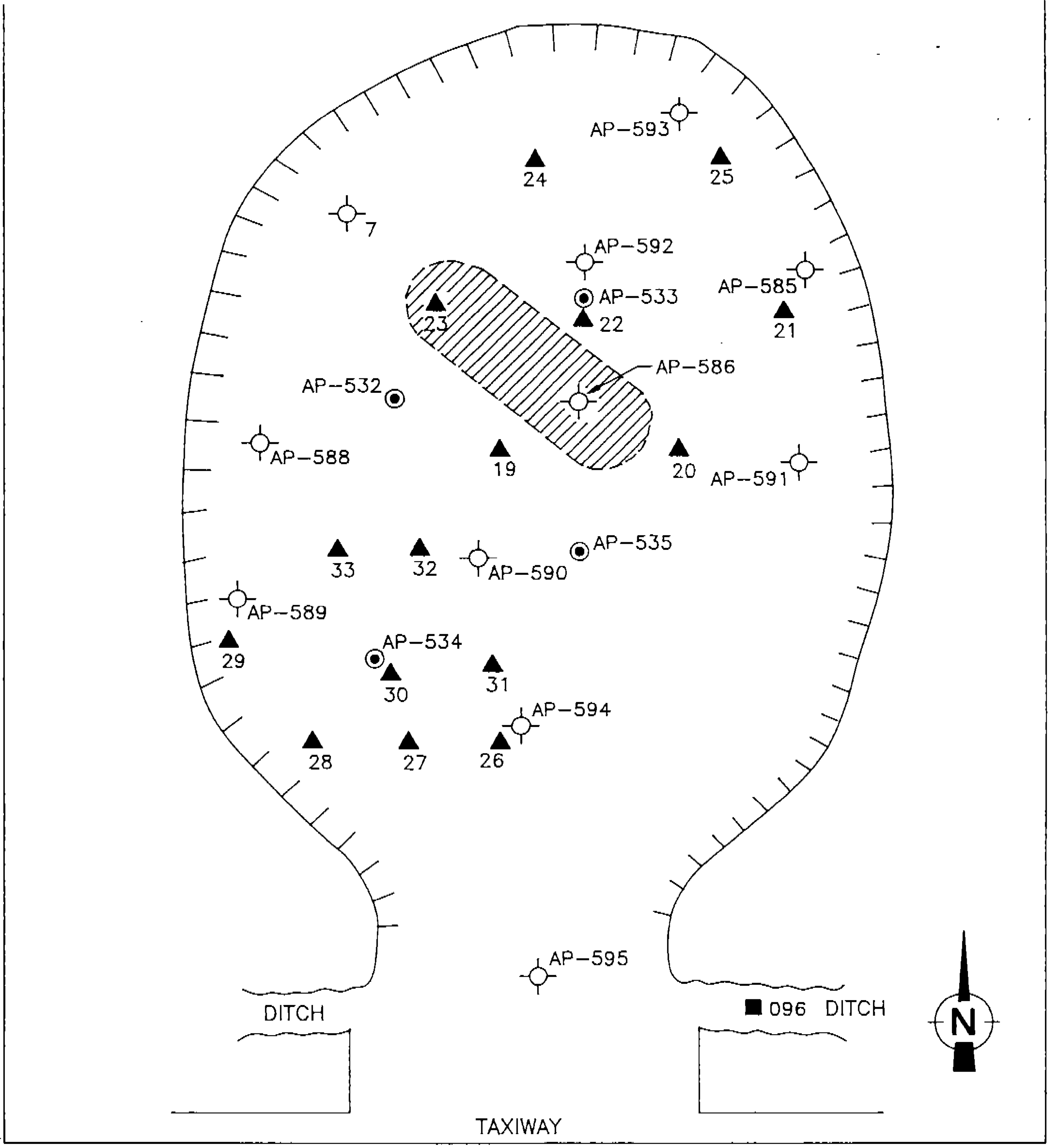
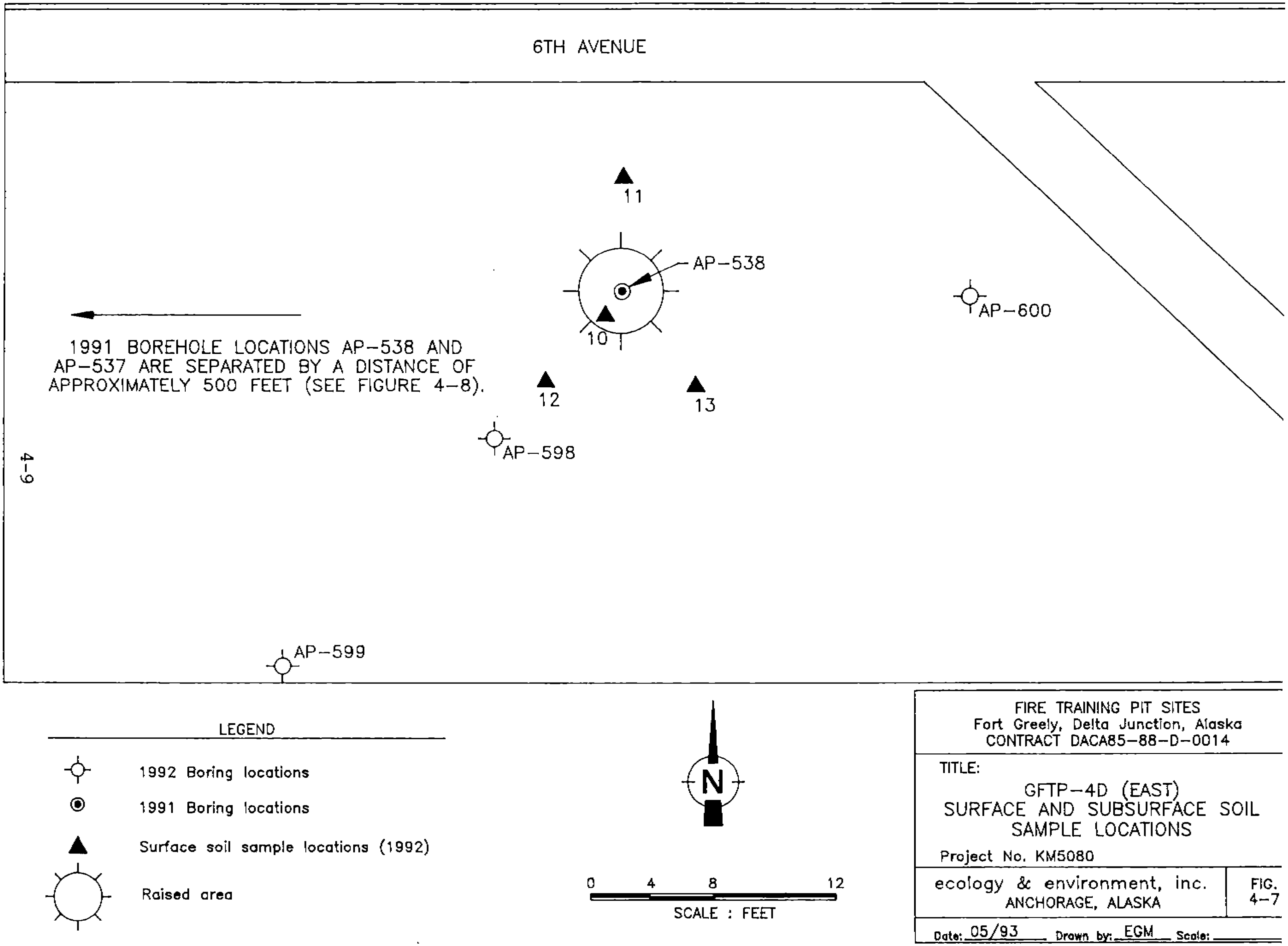


LEGEND

0 10 20 40 60
SCALE : FEET

- Black stained soil at 2" bgs
- ■ Sediment sample location (1992)
- ▲ Surface soil sample locations (1992)
- 1992 Boring locations
- 1991 Boring locations
- Depression
- Drainage ditch

FIRE TRAINING PIT SITES Fort Greely, Delta Junction, Alaska CONTRACT DACA85-88-D-0014	
TITLE: GFTP-4B SURFACE AND SUBSURFACE SOIL SAMPLE LOCATIONS Project No. KM5080	
ecology & environment, inc. ANCHORAGE, ALASKA	FIG. 4-6
Date: 05/93 Drawn by: EGM Scale:	



FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85-88-D-0014

TITLE:
GFTP-4D (EAST)
SURFACE AND SUBSURFACE SOIL SAMPLE LOCATIONS

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 4-7

Date: 05/93 Drawn by: EGM Scale:

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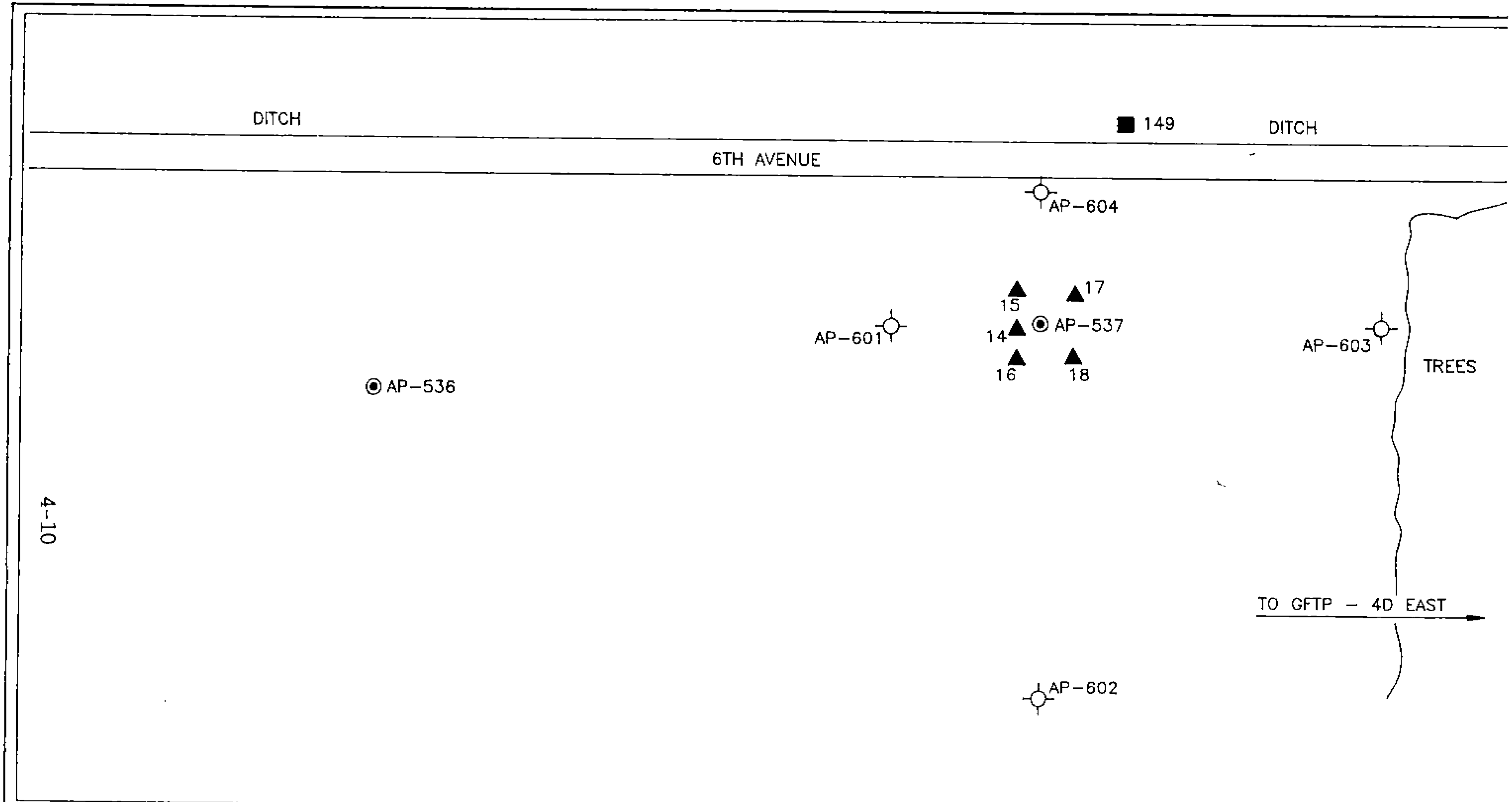


LEGEND

⌖	1992 Boring locations
◉	1991 Boring locations
▲	Surface soil sample locations (1992)
■	Sediment sample location (1992)

N

0 5 10 20

SCALE : FEET

FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85-88-D-0014

TITLE:

GFTP-4D (WEST)
SURFACE AND SUBSURFACE
SOIL SAMPLE LOCATIONS

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 4-8

- Evaluate waste quantities, current use, and distance to groundwater and surface water users.

The focus of the 1992 sampling program for each FTP was to delineate the vertical and lateral extent of soil contamination in sufficient detail to select the optimal remedial alternatives. The sampling plan for each FTP was prepared based on the results of previous sampling activities and the requirements of the DOT (49 CFR 1972) ADEC (1991a, 1991b), and EPA Hazardous and Toxic Waste regulations (40 CFR 261-264; see Table 4-3). The 1992 sampling program was designed to meet the following objectives:

- Determine the concentrations of contaminants in soil at each FTP;
- Determine the lateral and vertical extents of soil contamination at each FTP;
- Determine the quantity of soil contaminated in excess of ADEC- and EPA-approved guidelines; and
- Fill data gaps concerning the concentration of dioxin/furans; and
- Provide a data base of the chemical contaminants in soil from which PHHEs and remedial alternative measures will be developed.

4.3.1 Sample Location Rationale

The 1991 sampling locations were chosen on the basis of aerial photograph interpretation and a detailed site reconnaissance. Surface soil samples were collected to determine whether the topsoil is contaminated. Since stained soil was not observed at Fort Greely, surface samples were not collected in 1991. Figures 4-1 through 4-8 present borehole, sediment, and surface soil sampling locations for the 1991 and 1992 field investigations at Fort Richardson and Fort Greely.

The 1992 sample locations were selected to further delineate the areas of soil contamination detected during the 1991 investigation and to estimate the volume of soil requiring remediation. The depth of contamination at each site was assumed to be no deeper than 15 feet BGS. However, PID/FID monitoring of samples collected at this depth and deeper indicated the presence of organic vapors above background concentrations. Therefore, borehole depth increased until volatile organics were no longer detected in soils collected from the boreholes.

Surface soil samples were collected at Fort Greely from inside the perimeters of the FTPs and beyond the perimeter to determine whether the surrounding soil had been impacted by FTP operations. Three sediment samples were collected from surface water drainages to assess whether impacted soils within the GFTPs had been transported beyond the perimeters of the FTPs by surface water runoff.

4.3.2 Fort Richardson

Borehole Sampling

Seventeen boreholes were drilled at RFTP-2; two were drilled in 1991 and 15 were drilled in 1992. Figure 4-1 shows the location of the 1991 boreholes. During the 1992 field investigation boreholes were numbered consecutively from 1 to 15. Subsequently the COE has redesignated the 1992 field assigned borehole numbers BH-1 through BH-15 to consecutive AP-3194 through AP-3208 (see Figure 4-2). Borehole logs are presented in Appendix A.

The 1991 borehole was located near the center of the FTP. It was drilled to a depth of 21 feet BGS using an Acker Soil Max hollow stem auger rig. The background borehole was drilled to a depth of 6 feet BGS.

Four subsurface soil samples were collected from the 1991 borehole drilled near the center of the FTP. Samples were collected at the approximate depths of 5, 10, 15, and 20 feet BGS. These samples were analyzed for VOCs, BNAs, Fuel ID, Organochlorine Pesticides/Polychlorinated biphenyls (PCBs), dioxin/furan, and metals.

The 1992 boreholes were also drilled using hollow-stem augers. Although the 1992 boreholes were intended to be drilled to a maximum depth of 25 feet BGS, the depth was increased due to the detection of volatile organics by a PID/FID in soils collected from the boreholes. Borehole depths at Fort Richardson ranged from 24.5 to 66.5 feet BGS.

The 1992 subsurface soil samples were collected at the approximate depths of 2.5, 5, 10, 15, and 25 feet BGS. Once 25 feet BGS was reached, samples were collected at approximate 5-foot intervals. The subsurface soils collected from the 1992 boreholes at Fort Richardson were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX), DRO, Fuel ID, lead, Pest/PCB, dioxin, and/or VOCs. Not all samples were analyzed for all seven the analyses mentioned above. The type of analysis performed was based on the type of contamination expected based on 1991 investigation results.

Surface Soil Sampling

Surface soil sampling at Fort Richardson during 1991 consisted of the collection of one composite soil sample. This sample was analyzed for VOCs, BNA, Fuel ID, Pest/PCBs, dioxin/furan, and metals.

Twenty-six surface soil samples were collected at RFTP-2 in 1992 (see Figure 4-3). The 1992 soil samples were collected in a grid pattern within RFTP-2 and from soil immediately beyond the perimeter of the FTP. All 1992 surface soil samples collected were analyzed for BTEX, Fuel ID, DRO, and lead. Five samples were also analyzed for dioxin/furan.

4.3.3 Fort Greely

Borehole Sampling

Thirty-three boreholes were drilled at GFTP-4; nine were drilled in 1991 and 24 were drilled in 1992 (see figures 4-4 through 4-8).

The nine 1991 boreholes were drilled using a Mobile B-50 hollow stem auger rig, with the exception of AP-588 which was excavated with a hand auger. Borehole depth was proposed at approximately 15 feet BGS, or deep enough to collect two or three soil samples at 5-foot intervals depending on the extent of contamination and depth to groundwater. The actual borehole depths range from 12 to 16.5 feet BGS.

Seventeen soil samples were collected from the nine 1991 boreholes drilled at Fort Greely. These samples were analyzed for VOCs, BNA, Fuel ID, Pest/PCBs, dioxin/furan, and metals.

The 1992 boreholes were also drilled using hollow-stem augers. Boreholes depths ranged from 11.3 to 46.5 feet BGS. Borehole depth increased slightly from the proposed depth stated in the 1992 work plan due to the continued detection of volatile organics in soils collected from the boreholes.

The 1992 soil samples were collected at the approximate depths of 2.5, 5, 10, 15, and 25 feet BGS. Once 25 feet BGS was reached, samples were collected at approximate

5-foot intervals. The soils collected from 1992 boreholes at Fort Greely were analyzed for BTEX, DRO, Fuel ID, lead, Pest/PCBs, dioxin, and/or VOCs. Not all samples were analyzed for all seven of the analyses mentioned above. The type of analysis chosen was dependent on the type of contamination expected based on 1991 investigation results.

Surface Soil Sampling

Surface soil samples were not collected at Fort Greely during the 1991 field investigation. Thirty-four surface soil samples were collected during the 1992 field investigation (see figures 4-5 through 4-8). Most samples were analyzed for BTEX, DRO, Fuel ID, Pest/PCB, and lead. Some samples were also analyzed for dioxin and BNA.

Sediment Sampling

Sediment samples were not collected from Fort Richardson or Fort Greely in 1991. Three sediment samples were collected from Fort Greely in 1992. One sediment sample was collected at each FTP: Sample number 107 was collected near GFTP-A; sample number 096 was collected near GFTP-B; sample number 149 was collected near GFTP-4D. All sediment samples were analyzed for Pest/PCBs.

4.3.4 Quality Control and Quality Assurance Samples

Quality control/quality assurance (QA/QC) samples were collected to detect potential errors introduced during sample collection, handling, and analysis, and to permit COE North Pacific Division Laboratory (CENPD-PE-GT-L) to evaluate data reproducibility. External QA/QC samples consisted of project samples collected in triplicate, laboratory matrix spike and matrix spike duplicate samples (MS/MSD), and equipment rinsate blank samples. All samples were collected and handled in accordance with the procedures outlined in the 1992 Fire Training Pits Work Plan (E & E 1992).

Replicate samples were collected in triplicate to verify the reproducibility of the analytical data. Two of the replicate samples were analyzed as blind duplicates by the CENPD-PE-GT-L contracted project laboratory and the third replicate sample was a QA duplicate analyzed by the CENPD-PE-GT-L contracted QA laboratory.

A minimum of 12% of all samples collected at Fort Richardson and Fort Greely FTPs were collected in triplicate. Specifically, a total of 141 subsurface and surface samples were collected at RFTP-2. Thirty-four of these samples were QA or QC duplicate samples yielding approximately 12.1% QC frequency. For Fort Greely, the analogous numbers were 158 total samples with 40 QA or QC duplicates yielding approximately 12.7% QC frequency. Discussion of the QA and QC duplicate sample results is found in Section 5.3.

Two equipment rinsate samples were collected from the soil sampling apparatus used at Fort Richardson and an additional two rinsate samples were collected at Fort Greely. The intended use for theses samples was to determine whether sample cross contamination may have occurred through incomplete or improper decontamination procedures. Discussion of rinsate sample results is found in Section 5.3.

4.4 LABORATORY PROGRAM

Samples collected were analyzed at CENPD-PE-GT-L contracted laboratories. Data was produced by following published EPA and CENPD-PE-GT-L approved methods.

4.4.1 Data Quality Objectives

High quality data sufficient for site characterization, regulatory decision making, and preparation of remedial alternative analyses were the primary objectives of the sampling program. Project samples collected in triplicate, laboratory MS/MSD, and equipment rinsate blank samples were all intended to ensure that the analytical results were acceptable and of sufficient quality to be representative of media and conditions encountered at the FTPs.

Samples were handled in accordance with USACE Regulation No. ER-1110-1-263 (USACE 1990). Sample containers complied with the applicable guidelines outlined by EPA (EPA 1989a). Decontamination procedures described in the work plan were followed rigorously. All data were reviewed by CENPD-PE-GT-L chemists (see Appendix D). Control limits employed were defined using acceptable criteria established in *Test Methods for Evaluating Solid Wastes* (EPA 1986c) and CENPD-PE-GT-L.

4.4.2 Laboratories Used

The project laboratory for this investigation was National Environmental Testing (NET) Pacific, Inc. of Santa Rosa, California, and ARDL, Inc. of Mount Vernon, Illinois, was the QA laboratory. The Chemical Quality Assurance Report (CQAR) was compiled by CENPD-PE-GT-L (see Appendix D).

4.4.3 Analytical Methods and Procedures

Sample preparation and analyses were conducted using analytical methods described in *Test Methods for Evaluating Solid Wastes* (EPA 1986c) and COE's modification of EPA Method 8015 entitled *Fuel Identification and Quantitation*. Analytical methods used are summarized in Table 4-3.

Table 4-1

DEVIATIONS FROM THE 1991 WORK PLAN
FORT RICHARDSON AND FORT GREELY, ALASKA

Location	Proposed Number of Boreholes	Actual Number of Boreholes	Proposed Subsurface Soil Samples	Actual Subsurface Soil Samples	Proposed Surface Soil Samples	Actual Surface Soil Samples	Reason for Deviation
RFTP-2	1	1	2-3	4	0	1	Composite surface soil collected from areas of stained soil.
RFTP-2 (Background)	1	1	1	1	0	0	No deviation.
GFTP-4A	1	1	2-3	3	0	0	No deviation.
GFTP-4B	4	4	8-12	11	0	0	No deviation.
GFTP-4D	4	3	8-12	9	0	0	Decrease in number of boreholes.
GFTP-4 (Background)	1	1	1	2	1	4	PID/FID detected VOCs in the shallow sample.

Key:

FID = Flame ionization detector.
PID = Photoionization detector.
VOCs = Volatile organic compounds.

Source: Ecology and Environment, Inc. 1993.

Table 4-2

DEVIATIONS FROM THE 1992 WORK PLAN
FORT RICHARDSON AND FORT GREELY, ALASKA

Location	Proposed Number of Boreholes	Actual Number of Boreholes	Proposed Subsurface Soil Samples	Actual Subsurface Soil Samples	Proposed Surface Soil Samples	Actual Surface Soil Samples	Proposed Sediment Samples	Actual Sediment Samples	Reason for Deviation
RFTP-2	6	15	30	105	25	25	0	0	More boreholes.
RFTP-2 (Background)	NA	NA	0	0	0	1	0	0	Background sample needed.
GFTP-4A	4	5	24	23	10	9	0	0	More boreholes.
GFTP-4B	6	11	36	65	14	15	0	0	More boreholes.
GFTP-4D West	5	4	22	19	5	5	0	0	Fewer boreholes.
GFTP-4D East	2	3	6	9	4	4	0	0	More boreholes.
GFTP-4A, 4B, 4D	NA	NA	NA	NA	NA	NA	5	3	Only three surface water pathways were found.
GFTP (Background)	1	1	3	3	1	1	0	0	NA

Key:

NA = Not applicable.

Source: Ecology and Environment, Inc. 1993.

19:KM5900_A199_T42-09/23/93-F1

Table 4-3

SAMPLE ANALYTICAL METHODS
FORT RICHARDSON AND FORT GREELEY
FIRE TRAINING PITS

Analysis	Preparation Method/Analytical Method	Description of Method
Aromatic volatile organic compounds (BTEX)	EPA 5030/8020	Purge and trap, GC/PID
Base neutral and acid extractable organic compounds (BNA)	EPA 3550/8270	Sonic extraction, GC/MS
Diesel-range organics (DRO)	COE modified EPA 8100	Extraction, GC/FID
Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (dioxin/furan)	EPA 3550/8280/8290	Sonic extraction, high resolution GC/MS
Fuel Identification and Quantitation (FIQ)	COE modified EPA 8015	Extraction, GC/FID
Lead	EPA 3050/7421	Acid digestion, GFAA
Organochlorine pesticides/polychlorinated biphenyls (Pest/PCB)	EPA 3550/8080	Sonic extraction, GC/ECD
Toxicity Characteristic Leaching Procedure (TCLP) Lead	EPA 1311/7421	TCLP extraction, acid digestion, GFAA

Key:

BTEX = Benzene, toluene, ethylbenzene, and total xylenes.
COE = U.S. Army Corps of Engineers.
ECD = Electron capture detector.
EPA = United States Environmental Protection Agency.
FID = Flame ionization detector.
GC = Gas chromatography.
GFAA = Graphite furnace atomic adsorption.
MS = Mass spectrometry.
PID = Photoionization detector.

Source: Ecology and Environment, Inc. 1993.

5. RESULTS AND SIGNIFICANCE OF FINDINGS

5.1 SITE GEOLOGY

5.1.1 Fort Richardson

RFTP-2 is located on a large outwash plain along the margin of the Elmendorf Moraine. The outwash plain alluvium consists of gravel in the eastern portion of Fort Richardson where RFTP-2 is located and grades to sand in the western portion. Borehole well logs in the vicinity of RFTP-2 indicate that sediment consists of dry, massive, very dense well-graded gravel (1-7 cm) and sand with minor silt and cobbles. Gravel and sand grains are angular to subangular. Grain size analysis conducted on subsurface soil samples indicates that these sediments contain approximately 59% gravel, 33% sand, and 8% silt and clay (see Appendix A). The total thickness of the sediments is unknown, but they extend at least to 66.5 feet BGS.

Discontinuous stratigraphic horizons encountered during drilling include a 2 inch silt layer and wood. A poorly stratified 2-inch-thick silt bed interbedded with unconsolidated sand and gravel was encountered in borehole AP-3194 at 45 feet. This silt bed is apparently a minor lateral feature as it was not encountered in adjacent boreholes. Wood was encountered in AP-3200 at 10 to 11 feet and again at 15 feet BGS. Borehole logs of wells from the Fort Richardson fish hatchery (1.5 miles south of RFTP-2) and the Fort Richardson landfill (1.5 miles northwest of RFTP-2) indicate the depth to groundwater ranges from 38 to 140 feet BGS. Groundwater was encountered in AP-3196 at 34.8 feet BGS in course-grained sand. It is believed that this is a perched water table of minor lateral extent. Groundwater was not encountered in any other borehole. Detailed descriptions for each soil boring are presented in the soil boring logs (see Appendix A).

5.1.2 Fort Greely

Fort Greely is located on the alluvial outwash deposits associated with the Donnelly Moraine. The alluvial outwash deposit consists of fine to coarse-grained sand and gravel with lenses of sand and silt. Borehole well logs of GFTP indicate that sediments consist of unconsolidated, generally poorly sorted, subangular to subrounded gravel (1-7 cm); fine to course-grained sand; and minor amounts of silt. Grain size analyses conducted on subsurface soil samples indicate that the majority of sediments are well-graded gravel or gravel-sand mixtures, with little or no fines. Grain-size analysis and moisture content analysis conducted on samples taken 1.5 to 3.5 feet BGS indicate that sediments consist of sandy silts and have water contents of 21.6% and 12.9% (see Appendix A). The total thickness of the sediments is unknown, but based on borehole well logs, they extend to 46.5 feet BGS. The water table of the shallowest aquifer in the Fort Greely area is encountered at a depth of 170 to 200 feet BGS, although groundwater was not encountered during drilling due to shallow depth of drilling. Permafrost was not encountered during drilling. Detailed descriptions for each soil boring are presented in the soil boring logs (see Appendix A).

5.2 REGULATORY ACTION LEVELS

Chemical analyses were performed on soil samples collected from numerous locations at Fort Richardson and Fort Greely FTPs. Results from these analyses were used to define areas potentially requiring cleanup or remediation based upon applicable or relevant and appropriate regulations or guidance. ADEC requirements mandated in 18 Alaska Administrative Code 75.140 (18 AAC 75.140) were used to identify areas of non-underground storage tank (UST) derived contamination that may require remediation due to the presence of non-crude oil or refined petroleum products. In addition, areas that may present a potential human health hazard have been identified using EPA Region 10 *Supplemental Risk Assessment Guidance for Superfund* (EPA 1991) and *Revised Cheat Sheets* (EPA 1992) as guidelines.

5.2.1 Petroleum, Oil, and Lubricants

Guidance for non-UST contaminated soil cleanup levels (ADEC 1991) provides a matrix score sheet for calculating ADEC site-specific cleanup levels (A, B, C, or D) for petroleum-contaminated soils. The matrix addresses maximum permissible petroleum, oil, and lubricants (POL) soil contaminant levels after evaluating the depth to groundwater, mean annual precipitation, soil type, distance to potential groundwater pathway receptors, and volume of contaminated soil.

ADEC matrix cleanup level A is the most restrictive and matrix cleanup level D is the least restrictive. POL contaminants of concern are diesel-range petroleum hydrocarbons as determined by analytical methods, DROs, and fuel identification and quantitation (FIQ); gasoline-range petroleum hydrocarbons as determined by analytical method FIQ; residual-range petroleum hydrocarbons as determined by analytical method FIQ; and benzene and total BTEX as determined by analytical methods aromatic volatile organics (AVO) and VOCs. Results identified as jet fuel or kerosene were considered diesel-range petroleum hydrocarbons for the matrix evaluation.

Matrix Level A action limits have been used as a guideline to define POL contaminated areas that may require remediation. Since the depth of subsurface contamination is not known and matrix level A cleanup limits are the most stringent, they are used solely to present a worst-case scenario. This use of Matrix Level A in no way signifies that it is the appropriate or correct cleanup level for the FTPs. Section 6 of this report presents the human health hazard evaluation on which Section 7 premises the remedial cleanup levels.

5.2.2 Other Regulated Contaminants

The regulatory cleanup levels and risk-based criteria presented in Table 5-1 were prepared using action levels numerically described in EPA Region 10 *Supplemental Risk Assessment Guidance for Superfund* (EPA 1991), *Revised Cheat Sheets* (EPA 1992), 18 AAC 78.315 (matrix score sheet Level A), and 40 Code of Federal Regulations 261.24 (40 CFR 261.24) toxicity characteristic action levels. Table 5-1 presents the regulatory action levels and risk-based evaluation criteria applied to FTP data during this investigation. Samples were evaluated to determine FTP contaminant levels of VOCs, fuels, total and TCLP lead, organochlorine pesticides and PCBs, BNAs, and polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (dioxin/furan).

5.3 ANALYTICAL RESULTS

Throughout Section 5, discussions of analytical results associated with Fort Richardson are presented first, followed by discussions of analytical results associated with Fort Greely. Analytical results obtained in 1992 for subsurface samples are presented first, followed by results for surface samples. Analytical results from 1992 sampling activities conducted at the Fort Richardson FTP are presented in tables 5-2 through 5-5, and analytical results from 1992 sampling activities conducted at the Fort Greely FTPs are presented in tables 5-6 through 5-13.

Sample results from 1991 follow the 1992 results; however, the 1991 results were organized differently. The 1991 data tables are organized by the analytes examined, and data tables for Fort Greely are not FTP specific. Analytical results from 1991 sampling activities conducted at the Fort Richardson FTP are presented in tables 5-14 through 5-18. Analytical results from 1991 sampling activities conducted at the Fort Greely FTPs are compiled in tables 5-19 through 5-23. Analytical results from 1991 Fort Greely FTPs QA samples are compiled in tables 5-24 through 5-28. No QA rinsate samples specific to Fort Richardson were collected during the 1991 sampling activities.

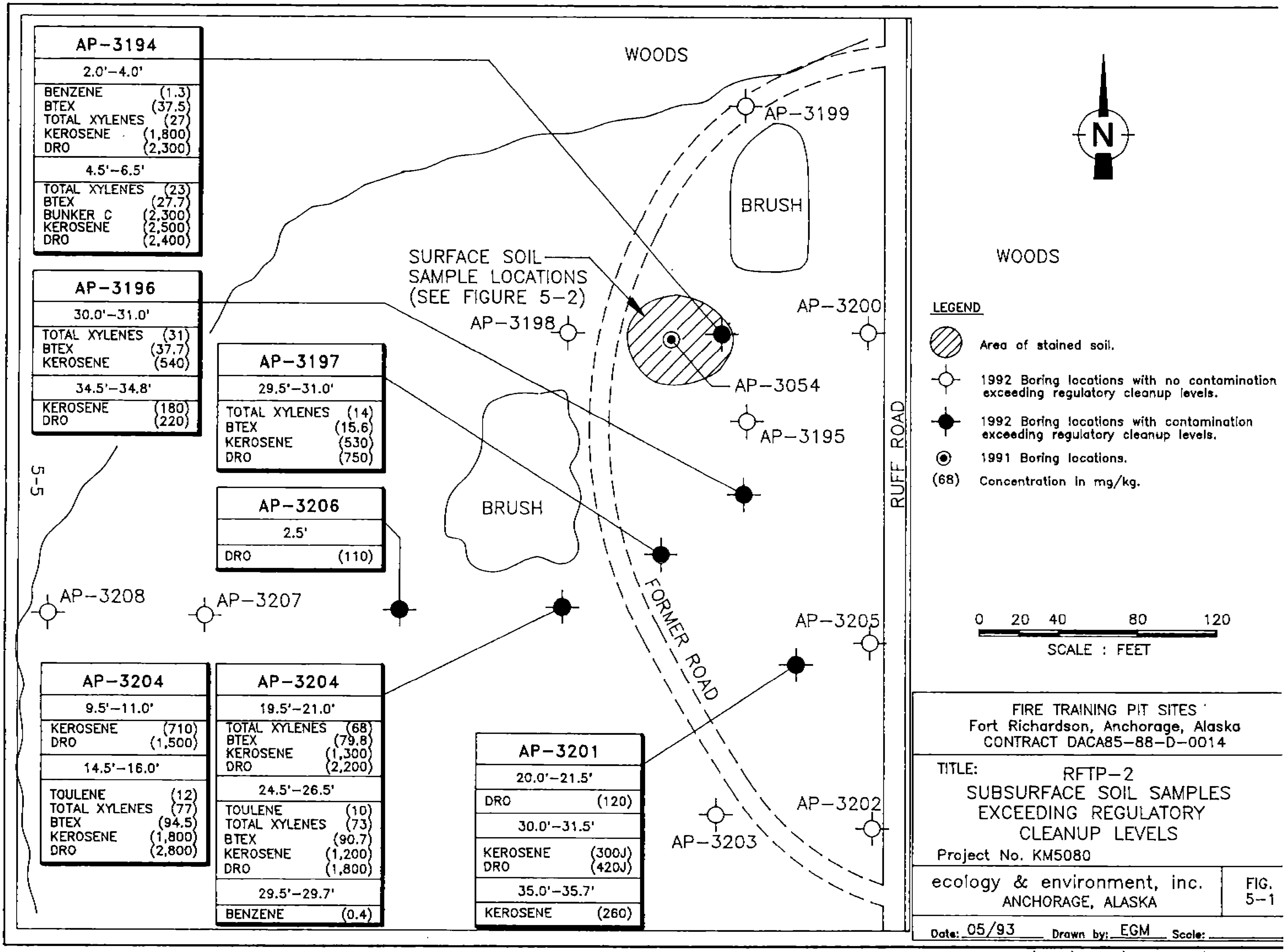
Sample locations associated with Fort Richardson FTP are presented in figures 5-1 and 5-2, and sample locations associated with the Fort Greely are presented in figures 5-3 through 5-8.

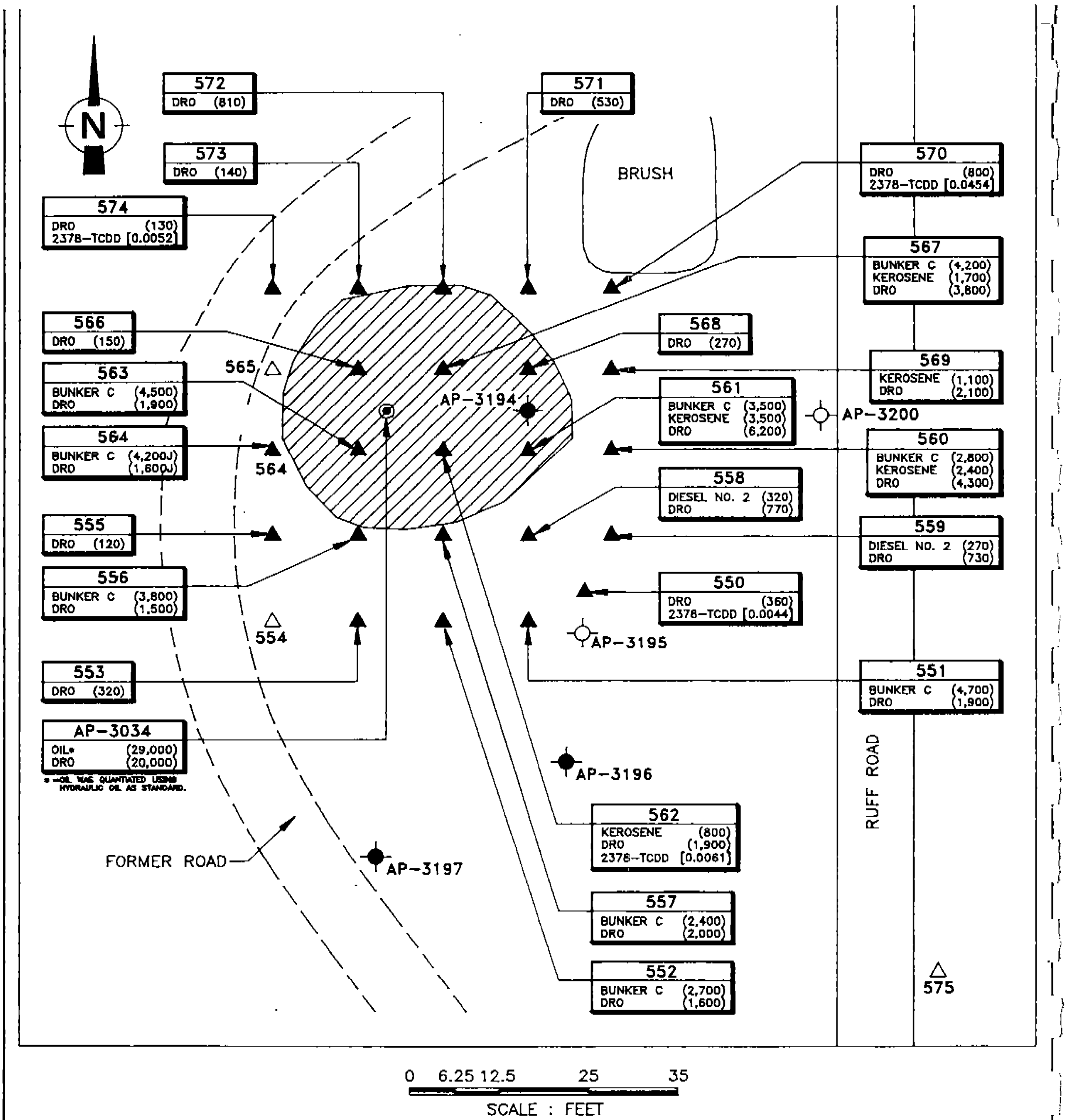
For the purposes of discussing analytical data, the term "significant" indicates that a reported result exceeds the action level. Analytical results considered significant by exceeding either the State of Alaska Matrix Level A or the EPA Region 10 risked-based action levels are shaded in 1992 data tables. Lead results that required TCLP extraction and were determined to contain TCLP lead content are also shaded.

A comprehensive examination of analytical results is presented in Section 5.2. A discussion of data validation is presented in Section 5.3. Data flags associated with data usability were included in data tables as appropriate. These data flags, their definitions, and rationale are also discussed in Section 5.3. Significant analytical results are presented in Section 5.4.

5.3.1 Fort Richardson Analytical Results

RFTP-2 was examined during the 1992 field investigation. Borehole locations from which subsurface samples were collected are shown in Figure 5-1, while analytical results from subsurface samples are presented in Table 5-2. Similarly, locations of the surface samples are shown in Figure 5-2, with analytical results presented in Table 5-3. Figures 5-1 and 5-2 also identify sample locations where concentrations exceeded action levels.


AP-3194
2.0'-4.0'
BENZENE (1.3)
BTEX (37.5)
TOTAL XYLENES (27)
KEROSENE (1,800)
DRO (2,300)
4.5'-6.5'
TOTAL XYLENES (23)
BTEX (27.7)
BUNKER C (2,300)
KEROSENE (2,500)
DRO (2,400)
AP-3196
30.0'-31.0'
TOTAL XYLENES (31)
BTEX (37.7)
KEROSENE (540)
34.5'-34.8'
KEROSENE (180)
DRO (220)
AP-3197
29.5'-31.0'
TOTAL XYLENES (14)
BTEX (15.6)
KEROSENE (530)
DRO (750)
AP-3206
2.5'
DRO (110)
AP-3204
9.5'-11.0'
KEROSENE (710)
DRO (1,500)
14.5'-16.0'
TOULENE (12)
TOTAL XYLENES (77)
BTEX (94.5)
KEROSENE (1,800)
DRO (2,800)
AP-3204
19.5'-21.0'
TOTAL XYLENES (68)
BTEX (79.8)
KEROSENE (1,300)
DRO (2,200)
24.5'-26.5'
TOULENE (10)
TOTAL XYLENES (73)
BTEX (90.7)
KEROSENE (1,200)
DRO (1,800)
29.5'-29.7'
BENZENE (0.4)
AP-3201
20.0'-21.5'
DRO (120)
30.0'-31.5'
KEROSENE (300J)
DRO (420J)
35.0'-35.7'
KEROSENE (260)
WOODS
AP-3199
BRUSH
SURFACE SOIL
SAMPLE LOCATIONS
(SEE FIGURE 5-2)
AP-3198
AP-3200
AP-3054
AP-3195
BRUSH
RUFF ROAD
FORMER ROAD
AP-3208
AP-3207
AP-3205
AP-3202
AP-3203
N
WOODS
LEGEND
Area of stained soil.
1992 Boring locations with no contamination exceeding regulatory cleanup levels.
1992 Boring locations with contamination exceeding regulatory cleanup levels.
1991 Boring locations.
(68) Concentration in mg/kg.
0 20 40 80 120
SCALE : FEET
FIRE TRAINING PIT SITES
Fort Richardson, Anchorage, Alaska
CONTRACT DACA85-88-D-0014
TITLE:
RFTP-2
SUBSURFACE SOIL SAMPLES
EXCEEDING REGULATORY
CLEANUP LEVELS
Project No. KM5080
ecology & environment, inc.
ANCHORAGE, ALASKA
FIG.
5-1
Date: 05/93 Drawn by: EGM Scale:



LEGEND

- Area of stained soil.
- △ 1992 Surface soil samples with no contamination exceeding regulatory cleanup levels.
- ▲ 1992 Surface soil sample locations with contamination exceeding cleanup regulatory levels.
- 1992 Boring locations with no contamination exceeding regulatory cleanup levels.
- 1992 Boring locations with contamination exceeding regulatory cleanup levels (See Figure 5–1).
- 1991 Boring locations.
- (215) Concentration in mg/kg.
- [0.045] Concentration in µg/kg.

FIRE TRAINING PIT SITES
Fort Richardson, Anchorage, Alaska
CONTRACT DACA85–88–D–0014

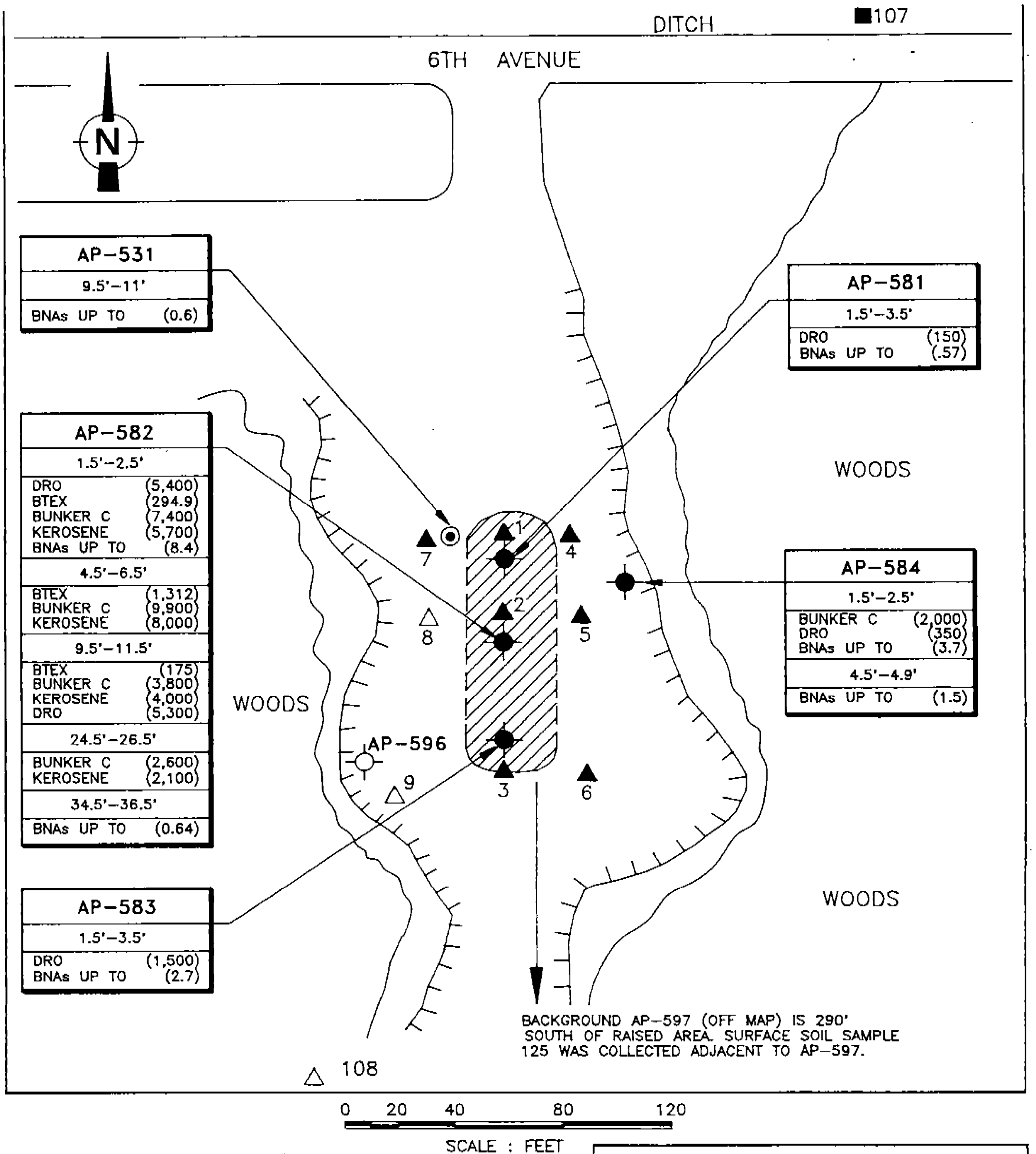
TITLE: RFTP–2
SURFACE SOIL SAMPLES EXCEEDING REGULATORY CLEANUP LEVELS

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 5–2

Date: 05/93 Drawn by: EGM Scale: 1"=25'



LEGEND

- Area of soil raised 2" above surrounding soil.
- 1992 Sediment sample location with contamination exceeding regulatory cleanup levels.
- △ 1992 Surface soil sample location with no contamination exceeding regulatory cleanup levels.
- ▲ 1992 Surface soil sample locations with contamination exceeding regulatory cleanup levels. (See Figure 5-3).
- 1992 Boring locations with no contamination exceeding regulatory cleanup levels.
- 1992 Boring locations with contamination exceeding regulatory cleanup levels.
- (10) Concentration in mg/kg.
- 1991 Boring locations.
- Depression

FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85-88-D-0014

TITLE: GFTP-4A
SUBSURFACE SOIL SAMPLES EXCEEDING REGULATORY CLEANUP LEVELS

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 5-3

Date: 05/93 Drawn by: EGM Scale: ______

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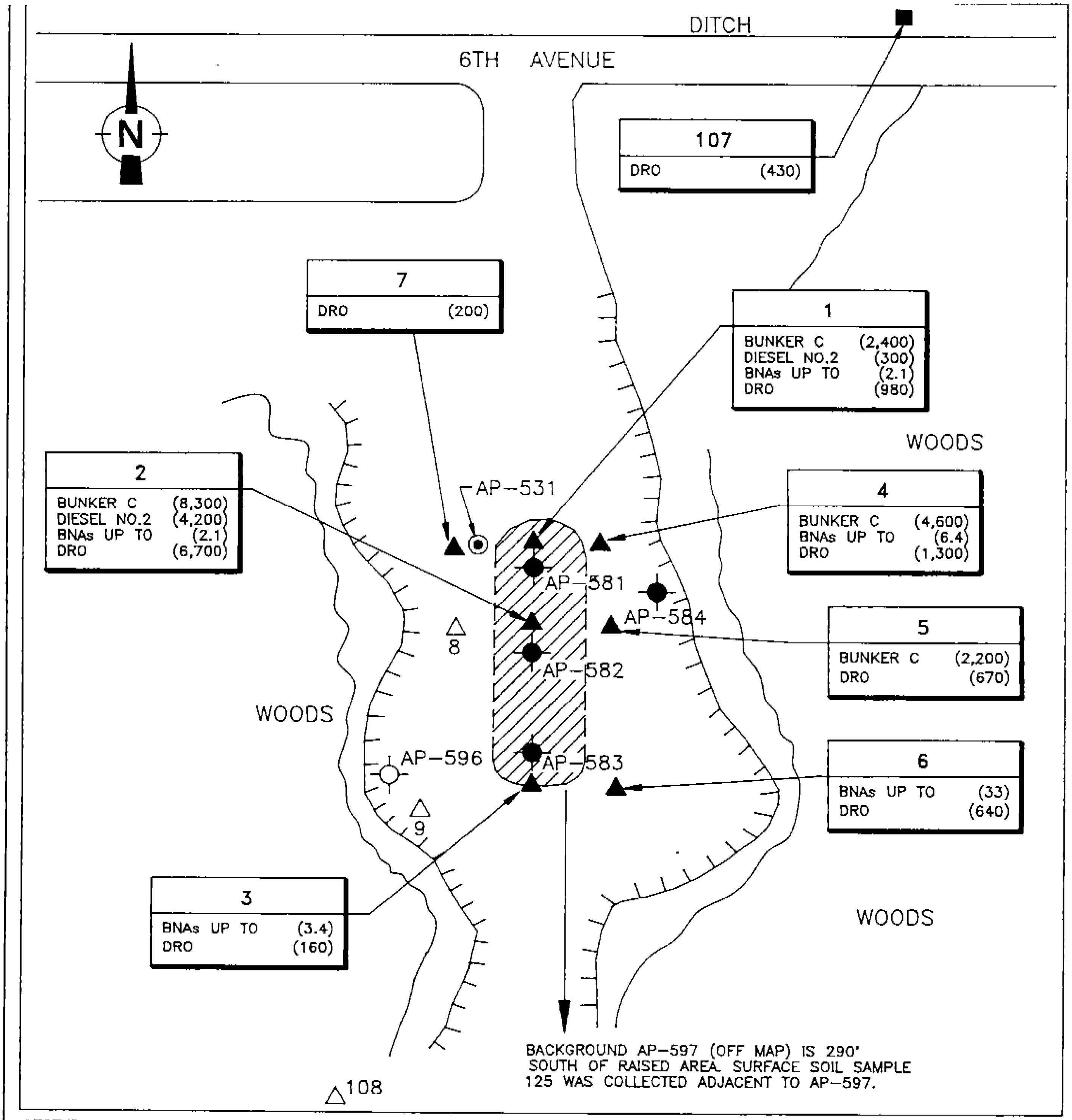


LEGEND

- Area of soil raised 2" above surrounding soil.
- 1992 Sediment sample location with contamination exceeding regulatory cleanup levels.
- 1992 Surface soil sample locations with no contamination exceeding regulatory cleanup levels.
- 1992 Surface soil sample locations with contamination exceeding regulatory cleanup levels.
- 1992 Boring locations with no contamination exceeding regulatory cleanup levels.
- 1992 Boring locations with contamination exceeding regulatory cleanup levels (See Figure 5-4).
- 1991 Boring locations.
- (300) Concentration in mg/kg.
- Depression.

0 20 40 80 120

SCALE : FEET

FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85-88-D-0014

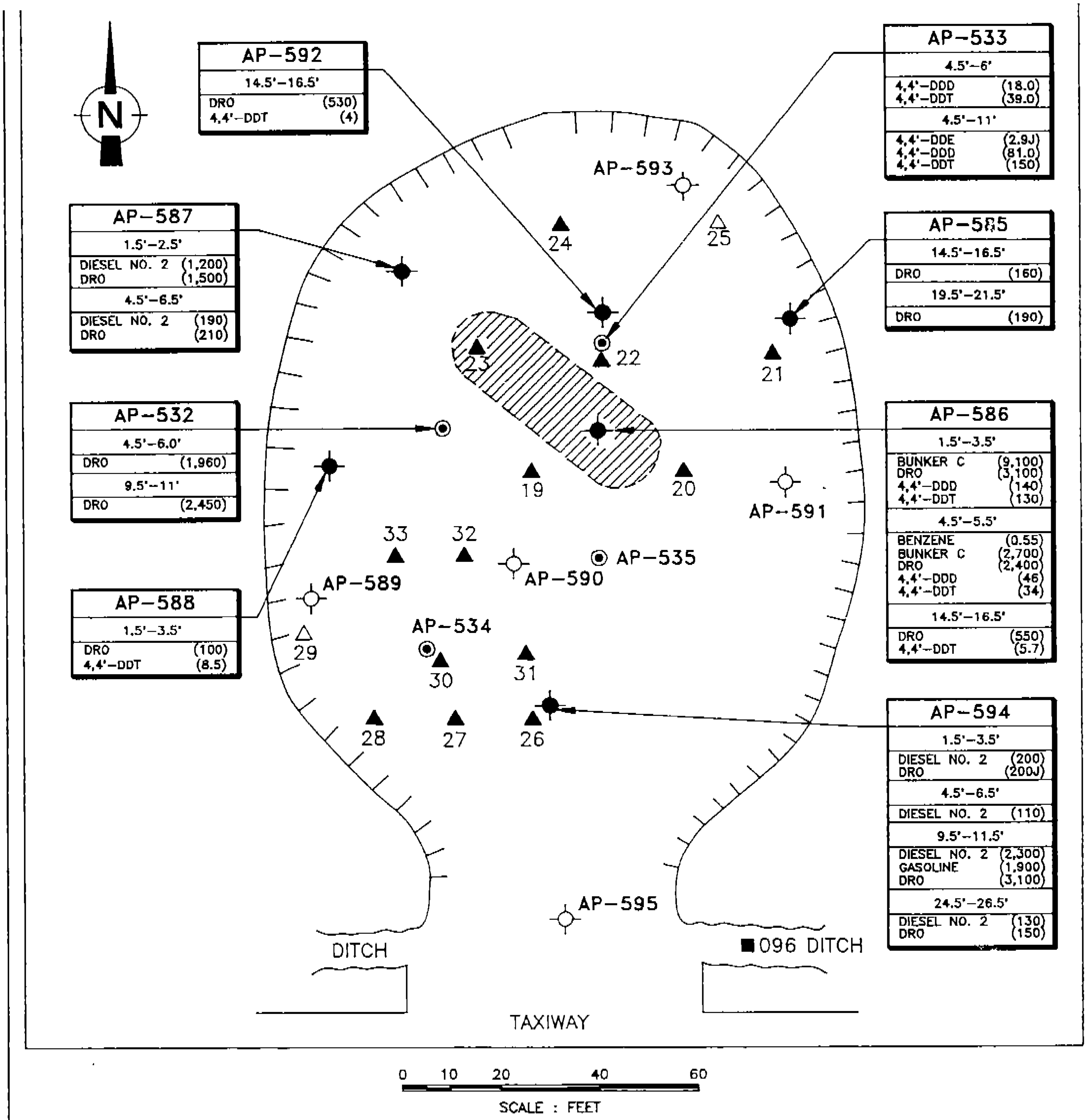
TITLE: GFTP-4A
SURFACE SOIL AND SEDIMENT SAMPLES EXCEEDING REGULATORY CLEANUP LEVELS

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 5-4

Date: 05/93 Drawn by: EGM Scale:



LEGEND

- Black stained soil at 2" below ground surface
- 1992 Sediment sample location with contamination exceeding regulatory cleanup levels.
- △ 1992 Surface soil sample location with no contamination exceeding regulatory cleanup levels. (See Figure 5-5).
- ▲ 1992 Surface soil sample locations with contamination exceeding regulatory cleanup levels.
- 1992 Boring locations with no contamination exceeding regulatory cleanup levels.
- 1992 Boring locations with contamination exceeding regulatory cleanup levels.
- (10) Concentration in mg/kg.
- ◉ 1991 Boring locations.
- Depression
- Drainage ditch

FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85-88-D-0014

TITLE: GFTP-4B
SUBSURFACE SOIL SAMPLES EXCEEDING REGULATORY CLEANUP LEVELS

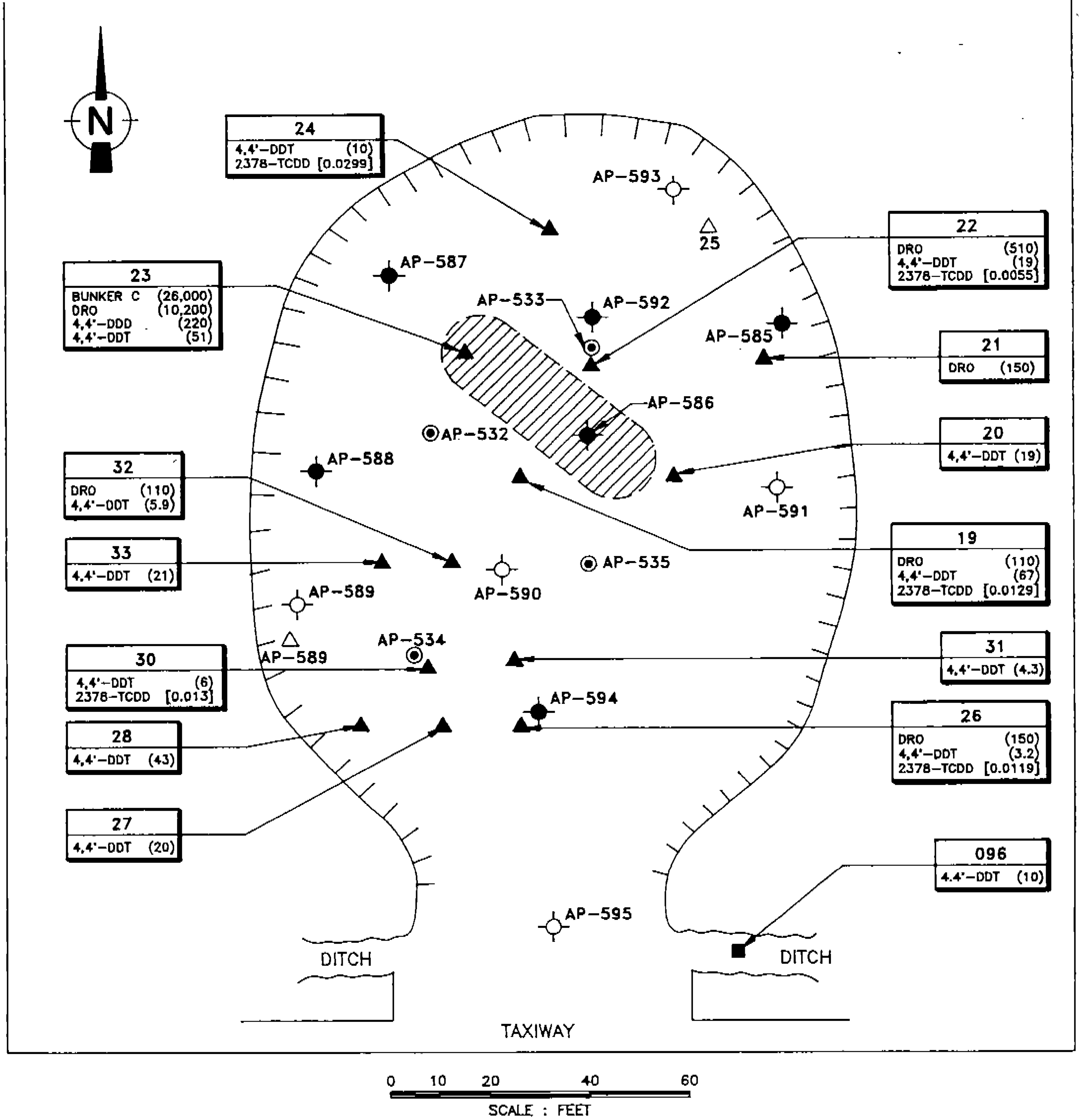
Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 5-5

Date: 05/93 Drawn by: EGM Scale:

OUA 0001178



LEGEND

- Black stained soil at 2" below ground surface
- 1992 Sediment sample location with contamination exceeding regulatory cleanup levels.
- 1992 Surface soil sample location with no contamination exceeding regulatory cleanup levels.
- 1992 Surface soil sample locations with contamination exceeding regulatory cleanup levels.
- 1992 Boring locations with no contamination exceeding regulatory cleanup levels.
- 1992 Boring locations with con- tamination exceeding regulatory cleanup levels. (See Figure 5-6).
- (10) Concentration in mg/kg.
- [0.013] Concentration in µg/Kg.
- 1991 Boring locations.
- Depression
- Drainage ditch

FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85-88-D-0014

TITLE: GFTP-4B
SURFACE SOIL SAMPLES
EXCEEDING REGULATORY
CLEANUP LEVELS

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 5-6

Date: 05/93 Drawn by: EGM Scale:

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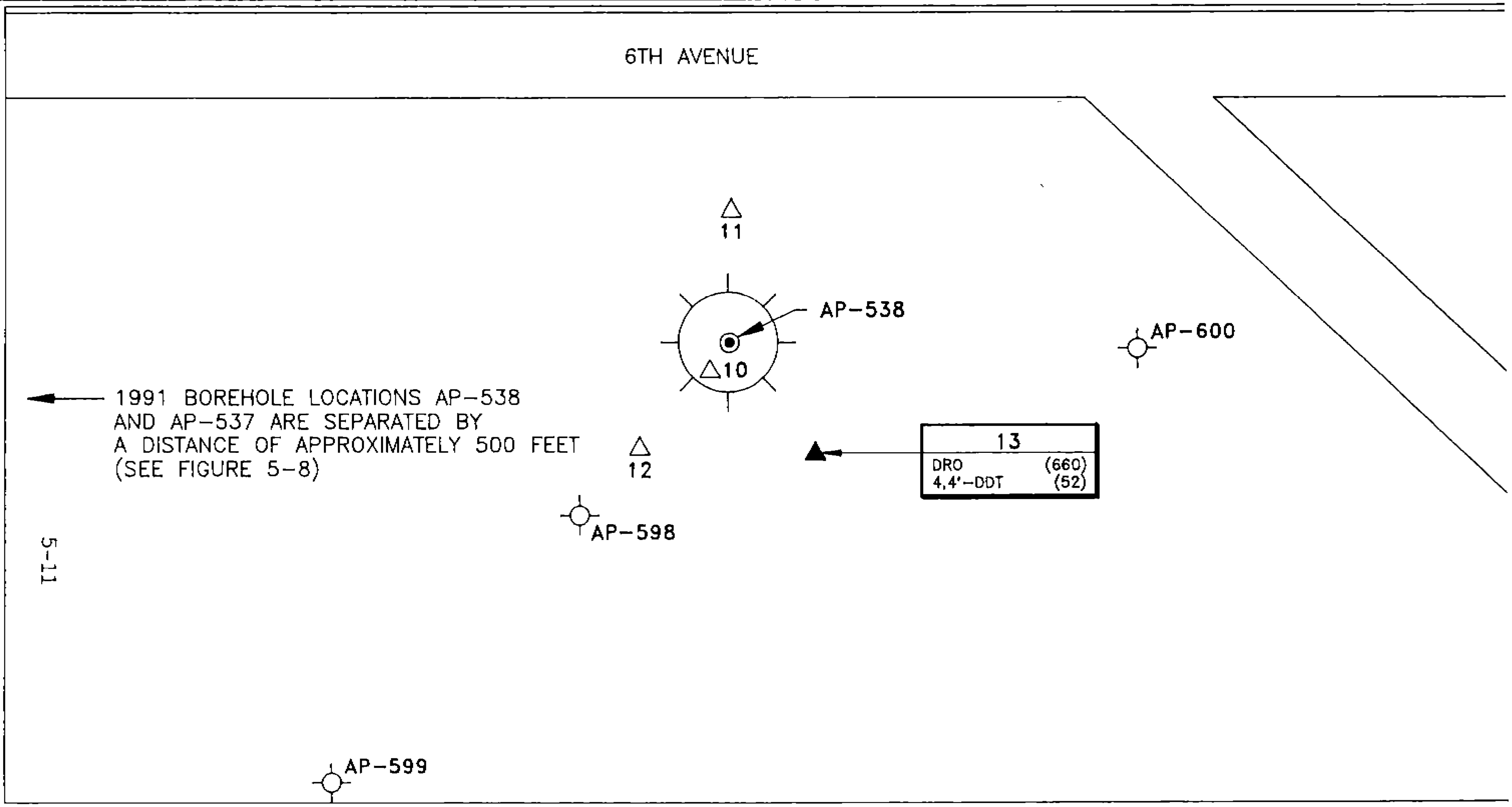

LEGEND

- Raised area.
- 1992 Surface soil sample locations with no contamination exceeding regulatory cleanup levels.
- 1992 Surface soil sample locations with contamination exceeding regulatory cleanup levels.
- 1992 Boring locations with no contamination exceeding regulatory cleanup levels.
- 1991 Boring locations.
- (660) Concentration in mg/kg.

FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85-88-D-0014

TITLE: GFTP-4D (EAST) SURFACE AND SUBSURFACE SOIL SAMPLES EXCEEDING REGULATORY CLEANUP LEVELS

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 5-7

Date: 05/93 Drawn by: EGM Scale:

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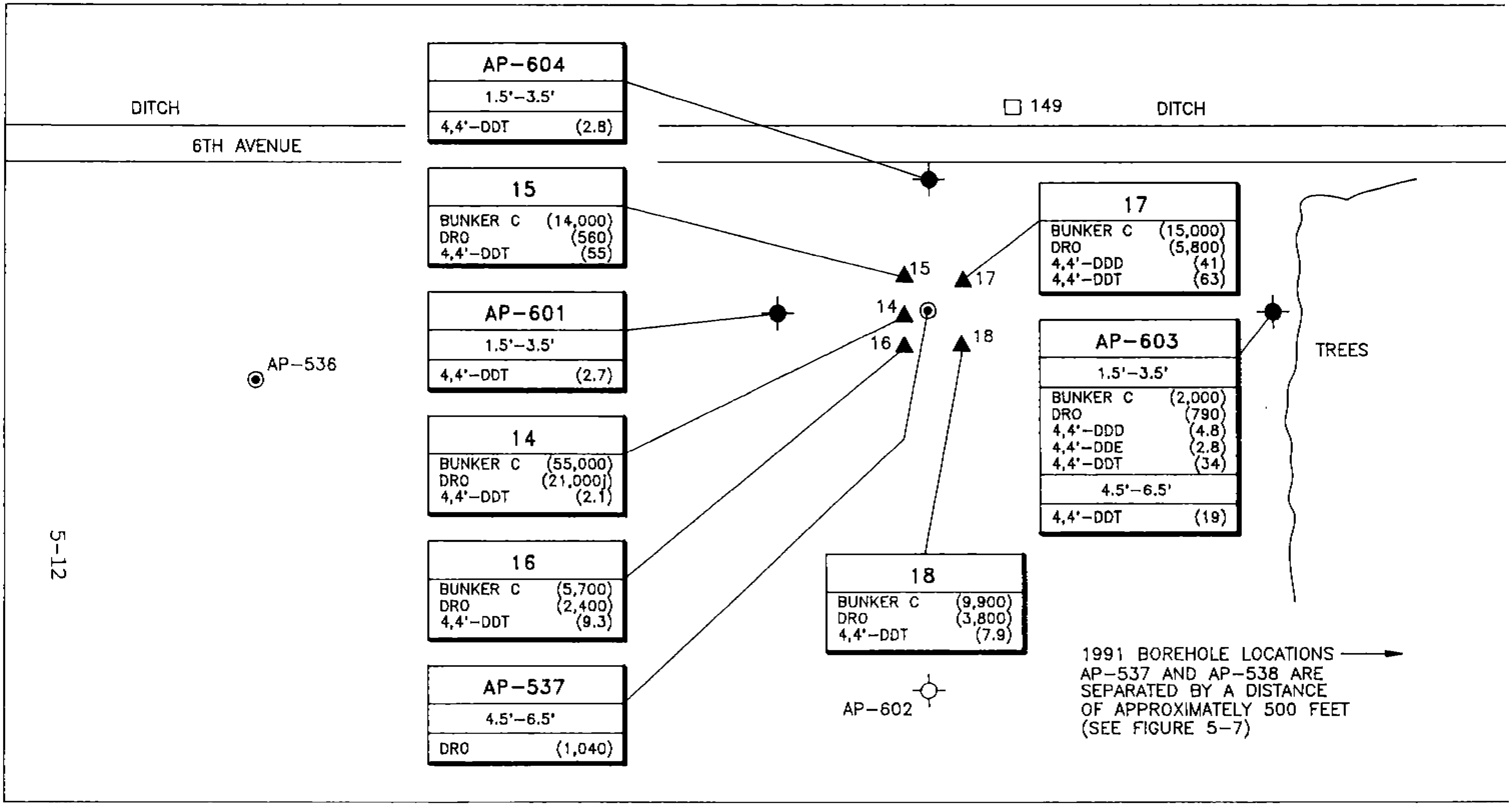
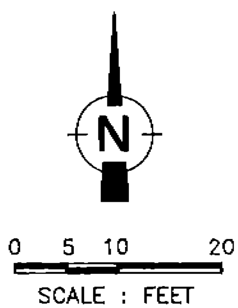


LEGEND

- △ 1992 Surface soil sample location with no contamination exceeding regulatory cleanup levels.
- ▲ 1992 Surface soil sample locations with contamination exceeding regulatory cleanup levels.
- 1992 Boring locations with no contamination exceeding regulatory cleanup levels.
- 1992 Boring locations with contamination exceeding regulatory cleanup levels.
- ◉ 1991 Boring locations.
- □ 1992 Sediment sample location with no contamination exceeding regulatory cleanup levels.
- (200) Concentration in mg/kg.



FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85-88-D-0014

TITLE: GFTP-4D (WEST) SURFACE AND SUBSURFACE SOIL SAMPLES EXCEEDING REGULATORY CLEAN UP LEVELS

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 5-8

05/93 ECM Scale

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Background sample results are presented in Table 5-4 with rinsate sample results presented in Table 5-5. Discrepancies between 1991 and 1992 surface contamination may be attributed to road construction activities. This resulted in clean soils covering contaminated surface soils.

Aromatic Volatile Organic Compounds

The surface and subsurface soil samples collected were submitted to the CENPD-PE-GT-L designated laboratories for aromatic volatile organic (BTEX) analyses using EPA Method 8020. Subsurface sample 92RFTP302SL was collected from borehole AP-3194 at 2.0 to 4.0 feet BGS and contained 1.3 mg/kg benzene, the greatest subsurface concentration of benzene encountered at RFTP-2 (see Table 5-2). Subsurface sample 92RFTP381SL was collected from borehole AP-3204 at 29.5 to 29.7 feet BGS and contained a significant benzene concentration (0.430 mg/kg). Concentrations of benzene that were detected and were not considered to be significant ranged from 0.0030 to 0.011 mg/kg. Sample results reported as not detected (ND) were determined using detection limits that ranged from 0.0020 to 0.0060 mg/kg.

Subsurface samples collected from borehole AP-3204 at depths ranging from 14.5 to 26.0 feet BGS contained the greatest concentrations of total BTEX at RFTP-2. The maximum concentrations were detected in samples 92RFTP378SL (94.5 mg/kg), 92RFTP379SL (79.8 mg/kg), and 92RFTP380SL (90.7 mg/kg). Other significant concentrations of total BTEX were found in the following samples:

- 92RFTP302SL (37.5 mg/kg) and 92RFTP303SL (27.7 mg/kg) collected from AP-3194 at 2.0 to 4.0 and 4.5 to 6.5 feet BGS;
- 92RFTP327SL (37.7 mg/kg) collected from AP-3196 at 30.0 to 31.0 feet BGS; and
- 92RFTP334SL (15.6 mg/kg) collected from AP-3197 at 29.5 to 31.0 feet BGS.

Concentrations of total BTEX that were not considered to be significant ranged from 0.0022 to 5.86 mg/kg. Sample results reported as ND were analyzed at detection limits that ranged from 0.0080 to 0.0228 mg/kg.

Analytical results for the surface samples collected at RFTP-2 contained neither significant amounts of benzene nor total BTEX (see Table 5-3). Benzene was not detected in any surface sample analyzed. Total BTEX concentrations ranged from 0.0049 to 3.4 mg/kg. Sample results reported as ND were analyzed at detection limits that ranged from 0.0096 to 0.920 mg/kg. No significant BTEX compound contamination was determined in the 1991 investigation (see Table 5-14).

Petroleum, Oil, and Lubricants

Surface and subsurface soil samples were submitted to the laboratories for POL analyses using COE's modification of EPA Method 8015 (FIQ) and the State of Alaska's DRO method. Subsurface sample 92RFTP378SL collected from AP-3204 at 14.5 to 16.0 feet BGS contained DRO at 2,800 mg/kg, the highest subsurface DRO concentration encountered at RFTP-2. Other significant concentrations of DRO were found in the following subsurface samples:

- 92RFTP302SL (2,300 mg/kg) and 92RFTP303SL (2,400 mg/kg) collected from AP-3194 at 2.0 to 4.0 feet and at 4.5 to 6.5 feet BGS;
- 92RFTP328SL (220 mg/kg) collected from AP-3196 at 34.5 to 34.8 feet BGS;
- 92RFTP334SL (750 mg/kg) collected from AP-3197 at 29.5 to 31.0 feet BGS;
- 92RFTP360SL (120 mg/kg) and 92RFTP361SL (420 J mg/kg) collected from AP-3201 at 20.0 to 21.5 feet and at 30.0 to 31.5 feet BGS;
- 92RFTP377SL (1,500 mg/kg), 92RFTP379SL (2,000 mg/kg), and 92RFTP380SL (1,800 mg/kg) collected from AP-3204 at 9.5 to 11.0 feet, at 19.5 to 21.0 feet, and at 24.5 to 26.0 feet BGS; and
- 92RFTP386SL (110 mg/kg) collected from AP-3206 at 2.5 feet BGS.

DRO concentrations that were not considered to be significant ranged from 4.2 to 66 mg/kg. Sample results reported as ND were analyzed at detection limits that ranged from 0.10 to 5.2 to mg/kg.

Surface sample 92RFTP561SL contained DRO at a concentration of 6,200 mg/kg, the greatest DRO concentration detected at RFTP-2. Other surface samples with DRO concentrations that exceeded cleanup levels were:

- 92RFTP550SL (360 J mg/kg), 92RFTP551SL (1,900 mg/kg), 92RFTP552SL (1,600 mg/kg), 92RFTP553SL (320 mg/kg), 92RFTP555SL (120 mg/kg), 92RFTP556SL (1,500 mg/kg), 92RFTP557SL (2,000 mg/kg), 92RFTP558SL (770 mg/kg), 92RFTP559SL (730 mg/kg), 92RFTP560SL (4,300 mg/kg), 92RFTP563SL (1,900 mg/kg), 92RFTP564SL (1,600 J mg/kg), 92RFTP567SL (3,800 mg/kg), 92RFTP568SL (270 mg/kg), 92RFTP569SL (2,100 mg/kg), 92RFTP571SL (530 mg/kg), 92RFTP572SL (810 mg/kg), 92RFTP573SL (140 mg/kg), and 92RFTP574SL (130 mg/kg);

- 92RFTP562SL (1,900 mg/kg) and duplicate sample 92RFTP453SL (1,400 mg/kg);

- 92RFTP566SL and duplicate sample 92RFTP454SL (150 mg/kg);

- 92RFTP570SL and duplicate sample 92RFTP456SL (800 mg/kg).

DRO concentrations that were detected but were not considered to be significant ranged from 6.8 to 83 mg/kg. Only sample 92RFTP450SL, the QA duplicate for sample 92RFTP554SL, reported DRO results as ND. The stated DRO detection limit was 0.12 mg/kg. The CQAR considered the QA data unacceptable due to poor laboratory performance.

The State of Alaska requires that diesel-like petroleum product concentrations be presented as diesel-range petroleum hydrocarbons, while FIQ analysis identifies individual petroleum components. Positive DRO results were confirmed when FIQ analyses identified kerosene as the principal DRO contaminant. Significant kerosene concentrations detected in subsurface samples ranged from 180 to 2,500 mg/kg. Significant kerosene concentrations were found in the following subsurface samples:

- 92RFTP302SL (1,800 mg/kg) and 92RFTP303SL (2,500 mg/kg) collected from AP-3194 at 2.0 to 4.0 feet and at 4.5 to 6.5 feet BGS;

- 92RFTP327SL (540 mg/kg) and 92RFTP328SL (180 mg/kg) collected from AP-3196 at 30.0 to 31.0 feet and at 34.5 and 34.8 feet BGS;

- 92RFTP334SL (530 mg/kg) collected from AP-3197 at 29.5 to 31.0 feet BGS;

- 92RFTP361SL (300 J mg/kg) and 92RFTP362SL (260 mg/kg) collected from AP-3201 at 30.0 to 31.5 feet and 31.5 to 35.7 feet;

- 92RFTP377SL (710 mg/kg), 92RFTP378SL (1,800 mg/kg), 92RFTP379SL (1,300 mg/kg), and 92RFTP380SL (1,200 mg/kg) collected from AP-3204 at 9.5 to 11.0, 14.5 to 16.0, 19.5 to 21.0, and 24.5 to 26.0 feet BGS.

Concentrations of kerosene that were detected but not considered to be significant ranged from 37 to 71 mg/kg. Sample results reported as ND were analyzed at detection limits that ranged from 1.7 to 22 mg/kg.

Significant kerosene concentrations were detected in surface samples 92RFTP560SL (2,400 mg/kg), 92RFTP561SL (3,500 mg/kg), 92RFTP562SL (800 mg/kg) and blind duplicate 92RFTP453SL (730 mg/kg), and 92RFTP567SL (1,700 mg/kg). Overall samples with significant kerosene concentrations exhibited larger significant DRO results. Samples reported as ND were analyzed using detection limits that ranges from 2 to 190 mg/kg.

Gasoline was not detected in any subsurface sample analyzed. Samples analyzed for FIQ exhibited results for gasoline that were reported as ND at detection limits that ranged from 1.7 to 22 mg/kg.

Gasoline was not detected in any surface sample analyzed. Samples analyzed for FIQ exhibited results for gasoline that were reported as ND at detection limits that ranged from 2.0 to 190 mg/kg.

FIQ analytical results identified as Bunker C were classified as residual-range petroleum hydrocarbons. Subsurface sample 92RFTP303SL collected from AP-3194 at 4.5 to 6.5 feet BGS exhibited 2,300 mg/kg Bunker C. This was the only subsurface sample that exceeded the State of Alaska cleanup level. Non-significant Bunker C concentrations in subsurface samples ranged from 1,700 to 12 mg/kg. Sample results reported as ND were analyzed at detection limits that ranged from 8.7 to 12 mg/kg.

Surface sample 92RFTP551SL contained Bunker C at a concentration of 4,700 mg/kg, the largest surface concentration measured at RFTP-2. Other surface samples that contained significant concentrations by exceeding the State of Alaska cleanup level were the following:

- 92RFTP552SL (2,700 mg/kg), 92RFTP556SL (3,800 mg/kg), 92RFTP557SL (2,900 mg/kg), 92RFTP560SL (2,800 mg/kg), 92RFTP561SL (3,500 mg/kg), 92RFTP563SL (4,500 mg/kg), 92RFTP564SL (4,200 J mg/kg), and 92RFTP567SL (4,200 mg/kg).

Bunker C concentrations that were detected but were not considered to be significant ranged from 21 to 1,700 mg/kg. Sample results reported as ND were analyzed at detection limits that ranged from 10 to 970 mg/kg.

Significant diesel-range petroleum hydrocarbon contamination was detected in the 1991 investigation. Surface samples 9126RFTP029SL, 9126RFTP029SL, and 9126RFTP029SL each exhibited over 10,000 mg/kg diesel-range petroleum hydrocarbon contamination (see Table 5-15). No subsurface contamination was detected in the 1991 sample analyses, however.

Lead

Every 1992 subsurface sample analyzed for total lead contained total lead above detection limits, with concentrations ranging from 3.6 J to 300 mg/kg. EPA Method 3050 (digestion) was used followed by Method 7421 (analytical). Samples that produced total lead results greater than 100 mg/kg were subjected to TCLP analysis using EPA Method 1311, and the TCLP extract lead content was determined using Method 7421 (analytical). No samples produced TCLP lead results above the toxicity characteristic limit that would require treatment as a 40 CFR 261.24 characteristic waste. Subsurface sample 92RFTP502SL, which was collected from AP-3208 at 5.0 feet BGS, exhibited total lead at a concentration of 300 mg/kg. The sample was subjected to TCLP analysis. TCLP results were measured at 0.120 mg/L, which is less than the 5.0 mg/L action limit.

Every surface sample analyzed for total lead contained total lead at concentrations above detection limits, and concentrations ranged from 5.3 to 400 mg/kg. Surface sample 92RFTP456SL, the QA duplicate of sample 92RFTP570SL, contained the greatest concentration of total lead at 400 mg/kg. Other surface samples with total lead concentrations requiring TCLP lead analysis were the following:

- 92RFTP551SL (160 mg/kg), 92RFTP567SL (120 mg/kg), and 92RFTP572SL (180 mg/kg);
- Duplicate samples 92RFTP570SL (280 mg/kg) and 92RFTP457SL (400 mg/kg).

TCLP lead results were measured at concentrations ranging from 0.003 to 0.710 mg/L, all of which were less than the 5.0 mg/L action limit. Again, no samples produced

TCLP lead results above the toxicity characteristic limit that would require treatment as a 40 CFR 261.24 listed waste. Based on the 1992 TCLP analysis data, lead was not presumed to be a contaminant of concern at RFTP-2.

Total lead content was determined in selected surface and subsurface samples collected in 1991 (see Table 5-18). The highest detected concentrations of lead were in surface samples 9126 RFTP029SL (543 mg/kg) and 9126 RFTP040SL (330 mg/kg). No TCLP extractions were performed on the samples collected during 1991 field activities.

Organochlorine Pesticides and Polychlorinated Biphenyls

All compounds included in EPA Method 8080 were included in Pest/PCB analyses of selected 1992 subsurface samples. None of the Pest/PCB target compounds was detected in any analyzed sample. Detection limits ranged from 0.0031 to 0.0032 mg/kg.

No 1992 surface samples were examined for Pest/PCB. Because 4,4'-DDT and metabolites 4,4'-DDD and 4,4'-DDE were detected at the Fort Greely FTPs, these compounds appear on the Fort Richardson data tables even though they were not detected.

No organochlorine pesticides or polychlorinated biphenyls were detected in the 1991 RFTP-2 samples (see Table 5-16).

Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans

Polychlorinated dioxin/furans were detected in subsurface and surface soil samples through analyses using EPA Method 8290 or Method 8280. Homologues and congeners determined to be present were reported as a calculated total concentration of 2,3,7,8-Tetrachlorodibenzo-p-dioxins (2,3,7,8-TCDD). I-TEFs/89 TEF found in *Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-P-Dioxins and -Dibenzofurans (CDDs and CDFs) and 1989 Update* (EPA 1989b) were used to calculate the total 2,3,7,8-TCDD equivalence value. A conservative approach was employed to calculate total 2,3,7,8-TCDD when only homologues and not specific congener concentrations were reported; in those instances, the 2,3,7,8-congener was used. No 2,3,7,8-TCDD was detected in any samples. None of the reported 1991 or 1992 sample results exceeds the generally accepted EPA cleanup action level of 1 μg/kg for soils.

None of the 1992 subsurface samples yielded a calculated 2,3,7,8-TCDD value above the EPA Region X 10^{-6} Risk Based Concentration (RBC) of 0.004 μg/kg (EPA 1992). Reported concentrations ranged from 0 to 0.0028 μg/kg TEF.

A conservative TEF calculation of heptachlorodibenzo dioxin may have caused all of the samples to exceed the RBC.

Surface soil samples collected in 1992 that exceeded the RBC included:

- 92RFTP550SL (.0044 μg/kg TEF), 92RFTP570SL (.0454 μg/kg TEF), 92RFTP574SL (.0052 μg/kg TEF);

- Replicate samples 92RFTP562SL (.0055 μg/kg TEF), 92RFTP452SL (0.0061 μg/kg TEF blank contaminated), 92RFTP453SL (.0059 μg/kg TEF).

Calculated total 2,3,7,8-TCDD concentrations for surface soil samples collected in 1991 that exceeded the RBC included:

- Replicate samples 91RFTP029SL (0.019 μg/kg TEF), 91RFTP039SL (0.046 μg/kg TEF) and 91RFTP040SL (0.038 μg/kg TEF).

The COE project laboratory conducted analyses utilizing EPA Method 8280, while its QA laboratory utilized Method 8290. These methods should provide similar though not identical results. The lack of congener data cannot be attributed to the use of either method. Replacement of congener concentrations by homologue concentrations and the use of the 2,3,7,8-congener TEF may lead to an overestimate in the calculated total 2,3,7,8-TCDD concentration.

5.3.2 Fort Greely Analytical Results

Three FTPs at Fort Greely were included within the scope of the 1992 field investigation, and they were designated as GFTP-4A, GFTP-4B, and GFTP-4D.

Analytical data from detected contaminants associated with subsurface samples collected at GFTP-4A are presented in Table 5-6, and analytical data from detected contaminants associated surface samples are presented in Table 5-7. Borehole locations from which subsurface samples were collected are presented in Figure 5-3, including sample results that exceed regulatory cleanup levels. Figure 5-4 presents surface sample locations and includes surface sample results that exceed regulatory cleanup levels.

Analytical data associated with subsurface samples collected at GFTP-4B are presented in Table 5-8, and analytical data from detected contaminants associated with surface samples are presented in Table 5-9. Borehole sample locations from which subsurface samples were collected are presented in Figure 5-5, including analytical parameters that exceed regulatory cleanup levels. Figure 5-6 presents surface sample locations and includes sample results that exceed regulatory cleanup levels.

Analytical data from detected contaminants associated with subsurface samples collected at GFTP-4D are presented in Table 5-10, and analytical data associated with surface samples are presented in Table 5-11. Figure 5-7 presents surface and subsurface soil sample locations and includes sample results that exceed regulatory cleanup levels for GFTP-4D East and Figure 5-8 presents GFTP-4D West.

GFTP's background sample results are presented in Table 5-12 and rinsate sample results are presented in Table 5-13. 1991 GFTP data tables are presented at the end of this section, and these analytical results are discussed only briefly. Subsurface sample results and background results are presented in tables 5-19 through 5-23. No surface sample results were reported in 1991 data tables. 1991 QA sample results presented in tables 5-24 through 5-28. (As previously mentioned, the 1991 data are organized according to parameter rather than locations, and the data are not separated according to each FTP at Fort Greely.)

Aromatic Volatile Organic Compounds

GFTP-4A. Subsurface sample 92GFTP038SL was collected from borehole AP-582 at 4.5 to 6.5 feet BGS and exhibited 12 mg/kg benzene, the greatest subsurface concentration detected at GFTP-4A. The only other subsurface sample with significant benzene concentration (6.9 mg/kg) was detected in subsurface sample 92GFTP037SL from AP-582 at 1.5 to 2.5 feet BGS. Concentrations of benzene that were not considered to be significant ranged from 0.0022 J to 0.024 mg/kg. Sample reported as ND used detection limits that ranged from 0.0028 to 0.0025 mg/kg.

Subsurface sample 92GFTP038SL contained total BTEX at a concentration of 1,312 mg/kg, the greatest subsurface total BTEX concentration detected at GFTP-4A. All other significant total BTEX results from GFTP-4A were also from AP-582:

- 92GFTP037SL (294.9 mg/kg) collected at 1.5 to 2.5 feet BGS; and

- 92GFTP039SL (175 mg/kg) collected at 9.5 to 11.5 feet BGS.

Concentrations of total BTEX that were detected but were not considered to be significant ranged from 0.0022 J to 6.664 mg/kg. Sample results reported as ND used detection limits that ranged from 0.0114 to 0.0122 mg/kg.

Benzene was not detected in any surface samples using detection limits that ranged from 0.0027 to 0.0029 mg/kg. Total BTEX was detected in one surface sample at a concentration of 0.833 mg/kg, which is not considered to be significant. Detection limits for total BTEX ranged from 0.0118 to 0.0128 mg/kg.

Benzene was not detected in samples collected during 1991 field activities, and no significant concentrations of BTEX were detected.

GFTP-4B. Subsurface sample 92GFTP063SL was collected from borehole AP-586 at 4.5 to 5.5 feet BGS and contained benzene at a concentration of 0.550 mg/kg, the only significant concentration detected at GFTP-4B (see Table 5-8). Concentrations of benzene that were not considered to be significant ranged from 0.0022 J to 0.091 to mg/kg. Samples reported as ND used detection limits that ranged from 0.0025 to 0.0028 mg/kg.

Subsurface samples did not contain significant concentrations of total BTEX. Concentrations of total BTEX that were not considered to be significant were detected from 0.0024 to 3.73 mg/kg. Sample results reported as ND used total BTEX detection limits that ranged from 0.0110 to 0.0124 mg/kg.

Benzene was detected in surface sample 92GFTP024SL at a concentration of 0.17 mg/kg, which is not considered to be significant (see Table 5-9). Detection limits for sample results reported as ND ranged from 0.0021 to 0.0033 mg/kg.

Total BTEX was detected in some GFTP-4B surface samples, but at concentrations which were not significant. Concentrations were detected from 0.0023 to 0.030 mg/kg. Detection limits for sample results reported as ND ranged from 0.0066 to 0.0144 mg/kg.

Benzene was not detected in samples collected during 1991 field activities, and no significant concentrations of BTEX were detected in any of the 1991 samples (see Table 5-14).

GFTP-4D. Benzene was not detected in subsurface samples using detection limits that ranged from 0.0025 to 0.005 mg/kg (see Table 5-10). Total BTEX was detected in subsurface samples at concentrations ranging from 0.0042 to 0.040, but these concentrations were not considered to be significant. Sample results reported as ND used limits that ranged from 0.0110 to 0.020 mg/kg.

Neither benzene nor total BTEX was detected in any GFTP-4D surface sample (see Table 5-11). Detection limits for benzene results reported as ND ranged from 0.0027 to 0.0034 mg/kg. Detection limits for total BTEX ranged from 0.0118 to 0.0150 mg/kg.

No benzene was detected and no significant concentrations of BTEX were detected in samples collected during 1991 field activities.

Petroleum, Oil, and Lubricants

Surface and subsurface soil samples collected were submitted to CENPD-PE-GT-L contracted laboratories for POL analyses using COE's modification of EPA Method 8015 (FIQ) and the State of Alaska's DRO method.

GFTP-4A. Subsurface sample 92GFTP037SL was collected from AP-582 at 1.5 to 2.5 feet BGS and contained DRO at a concentration of 5,400 mg/kg, the highest subsurface DRO concentration detected at GFTP-4A (see Table 5-6). Other significant concentrations of DRO were detected in the following subsurface sample:

- 92GFTP039SL (5,300 mg/kg) collected from AP-582 at 9.5 to 11.5 feet BGS;
- 92GFTP034SL (150 mg/kg) collected from AP-581 at 1.5 to 2.5 feet BGS; and
- 92GFTP050SL (350 mg/kg) collected from AP-584 at 1.5 to 2.5 feet BGS.

Concentrations detected that were not considered to be significant ranged from 6.4 to 91 mg/kg. Sample results reported as ND were analyzed at detection limits that ranged from 4.1 to 4.5 mg/kg.

Surface sample 92GFTP002SL contained DRO at a concentration of 6,700 mg/kg, the largest greatest concentration detected at GFTP-4A (see Table 5-7). Other surface samples with DRO concentrations that exceeded cleanup levels were the following:

- 92GFTP001SL (980 mg/kg), 92GFTP003SL (160 mg/kg), 92GFTP004SL (1,300 mg/kg), 92GFTP005SL (670 mg/kg), 92GFTP006SL (640 mg/kg), and 92GFTP007SL (200 mg/kg).

DRO concentrations were measured in all surface samples analyzed and ranged from 27 to 6,700 mg/kg.

Kerosene results were substituted for DRO results for subsurface sample 92GFTP038SL collected from AP-582 at 4.5 to 6.5 feet BGS, and subsurface sample 92GFTP040SL collected from AP-582 at 24.5 to 26.5 feet BGS. No DRO analysis were performed on these samples, but significant concentrations of kerosene were detected at 8,000 and 2,100 mg/kg, respectively. Significant concentrations of kerosene were also found in samples collected from borehole AP-582 at depths ranging from 1.5 to 26.5 feet BGS. Kerosene concentrations ranged from 24 J to 8,000 mg/kg. Sample results reported as ND used detection limits that ranged from 10 to 11 mg/kg.

Significant concentrations of kerosene were not detected in any GFTP-4A surface samples (see Table 5-7). Only sample 92GFTP009SL contained kerosene at a concentration of 100 mg/kg. Detection limits ranged from 11 to 12 mg/kg.

Gasoline was not detected in any 1992 subsurface samples. Samples analyzed for FIQ exhibited results for gasoline that were reported as ND at detection limits that ranged from 10 to 11 mg/kg.

Gasoline was not detected in surface samples. Samples analyzed for FIQ exhibited results for gasoline that were reported as ND used detection limits that ranged from 10 to 11 mg/kg.

FIQ analytical results identified as Bunker C were classified as residual-range petroleum hydrocarbons. Subsurface sample 92GFTP038SL was collected from AP-582 at 4.5 to 6.5 feet BGS and contained Bunker C at a concentration of 9,900 mg/kg, the greatest subsurface concentration detected at GFTP-4A (see Table 5-6). Other subsurface samples collected from AP-582 that exceeded the State of Alaska cleanup levels included:

- 92GFTP037SL (7,400 mg/kg) at 1.5 to 2.5 feet BGS;

- 92GFTP039SL (3,800 mg/kg) at 9.5 to 11.5 feet BGS; and
- 92GFTP040SL (2,600 mg/kg) at 24.5 to 26.5 feet BGS.

Significant Bunker C concentrations were also detected in sample 92GFT050SL (2,000 mg/kg) from AP-584. Concentrations of Bunker C that were not considered to be significant ranged from 10 to 450 mg/kg. Sample results reported as ND were analyzed at detection limits that ranged from 10 to 11 mg/kg.

Surface sample 92GFTP002SL contained Bunker C at a concentration of 8,300 mg/kg, the largest surface Bunker C concentration detected at GFTP-4A. Samples containing concentrations of Bunker C exceeding cleanup levels included the following:

- 92GFTP001SL (2400 J mg/kg), 92GFTP004SL (4,600 mg/kg), and 92GFTP005SL (2,200 mg/kg).

Bunker C concentrations detected in surface samples ranged from 43 to 8,300 mg/kg. No fuel contamination was detected in GFTP-4A samples collected during 1991 field activities (see Table 5-20).

GFTP-4B. Subsurface sample 92GFTP062SL was collected from AP-586 at 1.5 to 3.5 feet BGS and subsurface sample 92GFTP115SL collected from AP-594 at 9.5 to 11.5 feet BGS each contained DRO at a concentration of 3,100 mg/kg. These samples contained the highest subsurface DRO concentration encountered at GFTP-4B (see Table 5-8). Other significant concentrations of DRO were found in the following samples:

- 92GFTP057SL (160 mg/kg) and 92GFTP058SL (190 mg/kg) collected from AP-585 at depths from 14.5 to 16.5 and 19.5 to 21.5 feet BGS, respectively;
- 92GFTP063SL (2,400 mg/kg) and 92GFTP065SL (550 mg/kg) collected from AP-586 at depths from 4.5 to 5.5 and 14.5 to 16.5 feet BGS, respectively;
- 92GFTP072SL (1,500 mg/kg) and 92GFTP073SL (210 mg/kg) collected from AP-587 at depths from 1.5 to 2.5 and 4.5 to 6.5 feet BGS, respectively;
- 92GFTP079SL (100 mg/kg) collected from AP-588 at 1.5 to 3.5 feet BGS;

- 92GFTP104SL (530 mg/kg) collected from AP-592 at 14.5 to 16.5 feet BGS;

- 92GFTP113SL (200 J mg/kg) and 92GFTP117SL (150 mg/kg) collected from AP-594 at depths ranging from 1.5 to 3.5 and 24.5 to 26.5 feet BGS, respectively.

Concentrations of DRO detected in subsurface soil samples that were not considered to be significant ranged from 5.7 to 61 to mg/kg. Sample results reported as ND were analyzed using detection limits that ranged from 4.1 to 4.5 mg/kg.

Surface sample 92GFTP023SL contained DRO at 10,200 mg/kg, the largest surface DRO concentration measured at GFTP-4B (see Table 5-9). Samples containing DRO concentrations that exceeded cleanup levels included the following:

- Duplicate samples 92GFTP019SL (110 mg/kg) and 92GFTP252SL (110 mg/kg);

- 92GFTP021SL (150 mg/kg);

- Duplicate samples 92GFTP022SL (510 mg/kg) and duplicate sample 92GFTP250SL (600 mg/kg);

- 92GFTP258SL (10,000 mg/kg), 92GFTP259SL (200 J mg/kg), 92GFTP026SL (150 mg/kg), and 92GFTP032SL (110 mg/kg).

Concentrations of DRO that were detected but were not considered to be significant ranged from 9.7 J to 83 J mg/kg. Sample results reported as ND were analyzed at detection limits that ranged from 4.4 to 0.110 mg/kg.

Gasoline was detected at a significant concentration of 1,900 mg/kg in subsurface sample 92GFTP115SL from borehole AP-594 at 9.5 to 11.5 feet BGS. Sample 92GFTP088-SL contained gasoline at a concentration of 24 mg/kg, but this concentration was not considered to be significant. Sample results reported as ND were analyzed using detection limits that ranged from 10 to 11 mg/kg.

Significant concentrations of Bunker C were detected in two samples collected from AP-586: Subsurface sample 92GFTP062SL was collected at 1.5 to 3.5 BGS and contained Bunker C at a concentration of 9,100 mg/kg, the largest subsurface concentration measure at GFTP-4B; and sample 92GFTP036SL was collected at 4.5 to 5.5 BGS and contained 2,700 mg/kg. Concentrations of Bunker C that were not considered to be significant ranged from

21 to 1,400 mg/kg. Sample results reported as ND were analyzed using detection limits that ranged from 10 to 11 mg/kg.

Significant subsurface diesel-range petroleum hydrocarbon contamination was detected in two of the 1991 samples collected at AP-533 at depths ranging from 4.5 to 11 feet BGS (see Table 5-20). The amounts of diesel-range petroleum hydrocarbons quantified were 2,004 and 2,734 mg/kg.

GFTP-4D. Subsurface sample 92GFTP151SL was collected from AP-603 at 1.5 to 3.5 feet BGS and contained DRO at a concentration of 790 mg/kg (see Figure 5-8). This significant concentration was the largest subsurface DRO concentration detected at GFTP-4D. The only other sample exceeding the DRO cleanup level was duplicate sample 92GFTP248SL which contained DRO at a concentration of 760 mg/kg. DRO concentrations that were detected but were not considered to be significant ranged from 11 to 92 mg/kg. Sample results reported as ND were analyzed at detection limits that ranged from 4.1 to 5.1 mg/kg.

DRO was found in every GFTP-4D surface sample. Surface sample 92GFTP014SL contained DRO at a significant concentration of 21,000 mg/kg, the largest surface DRO concentration measured at GFTP-4D. Other samples with DRO concentrations that exceeded cleanup level were the following:

- 92GFTP013SL (660 mg/kg), 92GFTP015SL (560 mg/kg), 92GFTP016SL (2,400 mg/kg), 92GFTP017SL (5,800 mg/kg), and 92GFTP018SL (3,800 mg/kg).

DRO concentrations that were detected but were not considered significant ranged from 5.3 to 31 mg/kg.

Neither gasoline nor kerosene was detected in any subsurface sample analyzed. Samples analyzed for FIQ gasoline and kerosene that were reported as ND used detection limits that ranged from 10 to 13 mg/kg.

Subsurface sample 92GFTP248SL from the west area contained Bunker C at a concentration of 2,000 mg/kg, the largest subsurface concentration measured at GFTP-4D. This was the only subsurface sample that exceeded the State of Alaska cleanup level. Bunker C concentrations ranged from 14 to 2,000 mg/kg. Sample results reported as ND were analyzed at detection limits that ranged from 10 to 12 mg/kg.

Surface sample 92GFTP014SL from the west area contained Bunker C at a significant concentration of 55,000 J mg/kg, the largest concentration detected at GFTP-4D. Other surface samples that exceeded the State of Alaska cleanup level were the following:

- 92GFTP015SL (14,000 mg/kg), 92GFTP016SL (5,700 mg/kg), 92GFTP017SL (15,000 mg/kg), and 92GFTP018SL (9,900 mg/kg).

Concentrations of Bunker C that were detected but were not considered to be significant ranged from 48 to 660 mg/kg. Only one samples was reported as ND using a detection limit of 11 mg/kg.

Significant subsurface diesel-range petroleum hydrocarbon contamination was detected in 1991 duplicate samples collected at GFTP-4D location AP-537 from 4.5 to 6.5 feet BGS (see Table 5-20). The amounts of diesel-range petroleum hydrocarbons quantified were 294 and 1,040 mg/kg. Significant diesel-range petroleum hydrocarbon contamination was also detected in the 1991 sludge sample identified as 9130GFTP084SL. The amount of diesel-range petroleum hydrocarbons quantified was 808 mg/kg. However, the exact location from which sample 9130GFTP084SL was collected is unknown. The documentation regarding this sample is incomplete and the field team leader/sampler responsible for this sampling cannot be reached. Thus, sample 9130GFTP084SL will not be used for Human Health Hazard Evaluation (Section 6) or Remedial Options (Section 7) purposes. The exclusion of this data fortunately does not affect the conclusions of Section 6 or Section 7.

Lead

GFTP-4A. Total lead was determined in many subsurface samples and all surface samples. EPA Method 3050 (digestion) was used, followed by Method 7421 (analytical). Samples that contained concentrations of total lead greater than 100 mg/kg were subjected to TCLP analysis using EPA Method 1311, and TCLP extract lead content was determined using Method 7421. No samples produced TCLP lead results that would require treatment as a 40 CFR 261.24 defined waste.

Every subsurface sample analyzed for lead produced results above detection limits (see Table 5-6). Subsurface sample 92GFTP037SL was collected from AP-582 at 4.5 to 6.5 feet BGS and contained lead at 120 mg/kg; therefore, the sample was subjected to TCLP analyses. TCLP lead results were measured at 0.220 mg/L, which is below the 5.0 mg/L action limit. Total lead concentrations ranged from 4.2 to 120 mg/kg.

Every surface sample analyzed for lead produced results above detection limits (see Table 5-7). Surface sample 92GFTP003SL contained the greatest concentration of total lead at 130 mg/kg. One other surface sample, 92GFTP006SL, contained a total lead concentration that required analysis to determine TCLP lead. Again, no samples produced TCLP lead results above the toxicity characteristic limit that would require treatment as a 40 CFR 261.24 defined waste. TCLP lead results ranged from concentrations of 0.31 to 2.3 mg/L, which were less than the 5.0 mg/L action limit. Concentrations of total lead concentrations ranged from 13 to 130 mg/kg.

Lead was detected in every 1991 GFTP-4A sample analyzed for metals and ranged from 8.8 mg/kg to 12.6 mg/kg (see Table 5-23). None of the lead quantified was detected in significant concentrations, however.

GFTP-4B. Total lead was determined in many subsurface and all surface samples collected at GFTP-4B. EPA Method 3050 (digestion) was used followed by analytical method 7421.

Every subsurface sample analyzed for lead produced results above detection limits None of the samples analyzed produced total lead results greater than 100 mg/kg; therefore, none was subjected to TCLP analysis. Total lead concentrations in subsurface samples ranged from 3.4 to 66 mg/kg.

Every surface sample analyzed for lead produced results above detection limits. Total lead concentrations in surface samples ranged from 8.6 to 746 mg/kg. Surface sample 92GFTP259SL, the duplicate of surface sample 92GFTP023SL, contained 746 mg/kg, the greatest concentration of total lead at GFTP-4B. Other GFTP-4B surface samples which contained total lead concentrations requiring the determination of TCLP lead were the following:

- Duplicate samples 92GFTP023SL and 92GFTP258SL (110 mg/kg);
- 92GFTP025SL (210 mg/kg), and 92GFTP266SL (120 mg/kg).

Once again, no samples produced TCLP lead results above the toxicity characteristic limit that would require treatment as a 40 CFR 261.24 defined waste. TCLP lead results were measured at concentrations that ranged from 0.003 to 0.79 mg/L, which is below the 5.0 mg/L action limit.

Lead was detected in every 1991 GFTP-4B sample analyzed for metals and ranged from 3.5 mg/kg to 29.0 mg/kg. None of the lead quantified was significant (see Table 5-23).

GFTP-4D. Total lead was determined in many subsurface and all surface samples collected from GFTP-4D. EPA Method 3050 (digestion) was used followed by Method 7421 (analytical).

Every subsurface sample analyzed for lead produced results above detection limits (see Table 5-10). Total lead concentrations ranged from 4.1 to 33 to mg/kg. None of the samples produced total lead results greater than 100 mg/kg; therefore, none was subjected to TCLP.

Every surface sample analyzed for lead produced results above detection limits (see Table 5-11). Total lead concentrations ranged from 4.6 to 330 mg/kg. Surface sample 92GFTP014SL exhibited the greatest concentration of total lead determined at GFTP-4D (330 mg/kg). This was the only GFTP-4D surface sample which had a total lead concentration requiring TCLP analysis. As with all other GFTP samples analyzed, TCLP lead results were below the toxicity characteristic limit that would require treatment as a 40 CFR 261.24 defined waste. TCLP lead results were detected at a concentrations of 0.41 mg/L, which is less than the 5.0 mg/L action limit.

Lead was detected in every 1991 GFTP-4D sample analyzed for metals and ranged from 5.2 mg/kg to 20 mg/kg. None of the lead quantified was significant (see Table 5-23).

Organochlorine Pesticides and Polychlorinated Biphenyls

GFTP-4A. All target compounds listed in EPA Method 8080 were included in organochlorine Pest/PCB analyses of selected GFTP subsurface and all surface samples.

Pest/PCB target compounds 4,4'-DDD and 4,4'-DDT were detected in some of the subsurface samples analyzed (see Table 5-6). However, none of the 4,4'-DDD or 4,4'-DDT detected was measured at levels above the EPA Region 10 risk-based guidance levels. Concentrations of 4,4'-DDD ranged from 0.0050 to 0.100 mg/kg. Concentrations of 4,4'-DDT ranged from 0.0040 to 0.230 B mg/kg. Sample results reported as ND for each analyte used detection limits that ranged from 0.0034 to 0.0030 mg/kg.

Pest/PCB target compounds 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were detected in some of the surface samples analyzed from GFTP-4A (see Table 5-7). However, none of these concentrations was detected at above the risk-based guidance levels. Concentrations of 4,4'-DDD ranged from 0.012 to 0.190 mg/kg. The only concentration of 4,4'-DDE detected was 0.033 mg/kg. Concentrations of 4,4'-DDT ranged from 0.012 B to 0.390 mg/kg. Sample results reported as ND were analyzed at detection limits that ranged from 0.0032 to 0.0035 mg/kg.

No Pest/PCB target compound was detected in any 1991 GFTP-4A samples (see Table 5-21).

GFTP-4B. Pest/PCB target compounds 4,4'-DDD and 4,4'-DDT were detected in some subsurface samples. Concentrations of 4,4'-DDD and 4,4'-DDT were measured at levels above risk-based guidance levels. Subsurface samples 92GFTP062SL was collected from AP-586 at 1.5 to 3.5 feet BGS and contained a significant concentration 4,4'-DDD at 140 mg/kg. Subsurface sample 92GFTP063SL was collected from AP-586 at 4.5 to 5.5 feet BGS and contained a significant concentration of 4,4'-DDD at 46.0 mg/kg. Concentrations of 4,4'-DDD that were detected at concentrations that were not considered to be significant ranged from 0.0032 to 0.160 mg/kg.

Significant concentrations of 4,4'-DDT were detected in three subsurface samples from AP-586:

- 92GFTP062SL (130 mg/kg) was collected at 1.5 to 3.5 feet BGS;
- 92GFTP063SL (34.0 mg/kg) was collected at 4.5 to feet 5.5 BGS;
- 92GFTP065SL (5.7 mg/kg) was collected at 14.5 to 16.5 feet BGS.

Other significant 4,4'-DDT concentrations were detected in subsurface samples collected from AP-588 and AP-592: Sample 92GFTP079SL (8.5 mg/kg) was collected from AP-588 at 1.5 to 3.5 feet BGS; and 92GFTP104SL (4.0 mg/kg) was collected from AP-592 at 14.5 to 16.5 feet BGS contained 4.0 mg/kg. Concentrations of 4,4'-DDT that were detected but were not considered to be significant ranged from 0.0039 B to 0.590 mg/kg. Sample results for 4,4'-DDT and metabolites reported as ND were analyzed at detection limits that ranged from 0.0030 to 0.0041 mg/kg.

Pest/PCB target compounds 4,4'-DDD, 4,4'-DDE, and/or 4,4'-DDT were detected in every surface sample analyzed from GFTP-B. Significant concentrations of 4,4'-DDD were detected in five samples:

- 92GFTP273SL (9.4 J mg/kg) and 92GFTP276SL (2.1 mg/kg).
- Duplicate samples 92GFTP253SL (3.9 mg/kg), and 92GFTP019SL;
- Duplicate samples 92GFTP023SL (220.0 mg/kg) and duplicate sample 92GFTP258SL (170.0 mg/kg);

Concentrations that were detected but were not considered significant ranged from 0.015 J to 0.94 J mg/kg.

Significant concentrations of 4,4'-DDE were measured in samples 92GFTP253SL (2.3 mg/kg), the QA duplicate of sample 92GFTP019SL, and in sample 92GFTP259SL (6.2 mg/kg), the QA duplicate of sample 92GFTP023SL. Other concentrations of 4,4'-DDE that were detected in surface samples but were not considered to be significant ranged from 0.019 to 1.9 J mg/kg.

Significant concentrations of 4,4'-DDT were detected in 29 of 43 surface samples at concentrations up to 67 mg/kg. Concentrations of 4,4'-DDT that were detected but were not considered significant ranged from were measured at concentrations that ranged from 0.054 to 1.5 mg/kg. Only one surface sample analyzed for 4,4'-DDT produced ND results.

For 4,4'-DDT and metabolites 4,4'-DDD and 4,4'-DDE, surface sample results reported as ND in surface samples were analyzed using detection limits that ranged from 0.0032 to 1.9 mg/kg.

Pest/PCB target compound 4,4'-DDT and metabolites 4,4'-DDD and 4,4'-DDE were quantified at significant level in the 1991 samples collected from GFTP-B (see Table 5-21). Location AP-533 exhibited 4,4'-DDT at concentrations up to 150 mg/kg in samples collected at depths ranging from 4.5 to 11 feet BGS. 4,4'-DDD and 4,4'-DDE were also detected in these AP-533 samples at concentrations up to 2.9 J and 81 mg/kg, respectively.

GFTP-4D. Pest/PCB target compounds 4,4'-DDD, 4,4'-DDE and 4,4'-DDT were detected in some subsurface samples analyzed from GFTP-4D. Concentrations of 4,4'-DDD, 4,4'-DDE and 4,4'-DDT were measured at concentrations exceeding risk-based guidance levels.

Sample 92GFTP285SL was collected from AP-603 at 1.5 to 3.5 feet BGS and contained 4,4'DDD at a concentration of 4.8 J mg/kg. Concentrations of 4,4'-DDD that were detected but were not considered to be significant ranged from 0.0073 J to 0.021 mg/kg.

Sample 92GFTP285SLA was also collected from AP-603 at 1.5 to 3.5 feet BGS and contained significant 4,4'-DDE concentration of 2.8 J mg/kg. Sample 92GFTP133SL contained a concentration of 0.0098 mg/kg, but this concentration was not considered to be significant.

Significant concentrations of 4,4'-DDT were detected at GFTP-4D in boreholes AP-601, AP-603, and AP-604. Concentrations of 4,4'-DDT collected from AP-603 were detected at 1.5 to 3.5 feet BGS in replicate subsurface samples 92GFTP151SL (18.0 mg/kg), 92GFTP284SL (33.0 mg/kg), and 92GFTP285SL (34.0 mg/kg), and at 4.5 to 6.5 feet BGS in sample 92GFTP152SL (19.0 mg/kg). Other significant 4,4'-DDT concentrations were detected in the following subsurface samples:

- 92GFTP138SL (2.7 mg/kg) collected from AP-601 at 1.5 to 3.5 feet BGS;

- 92GFTP155SL (2.8 mg/kg) and 92GFTP288SL (3.2 mg/kg) collected from AP-604 at 1.5 to 3.5 BGS.

Concentrations of 4,4'-DDT that were detected but were not considered to be significant ranged from 0.0029 to 1.7 JB mg/kg. For 4,4'-DDT and metabolites 4,4'-DDD and 4,4'-DDE, subsurface sample results reported as ND were analyzed at detection limits that ranged from 0.0030 to 0.022 mg/kg.

Pest/PCB target compounds 4,4'-DDD, 4,4'-DDE, and/or 4,4'-DDT were detected in every surface samples analyzed. However, the only significant concentration of 4,4'-DDD was detected in west area sample 92GFTP017SL at 41.0 mg/kg. Concentrations of 4,4'-DDD that were detected but were not considered to be significant ranged from 0.067 to 0.860 mg/kg.

Significant concentrations of 4,4'-DDE were not detected any GFTP-4D surface samples. Concentrations that were detected but were not considered to be significant were detected in sample 92GFTP011SL (0.037 mg/kg), and 92GFTP012SL (0.094 mg/kg).

4,4'-DDT was detected in all GFTP-4D surface samples in which it was a target analyte. Significant concentrations of 4,4'-DDT were measured in the following surface samples:

- 92GFTP013SL (52.0 mg/kg), 92GFTP014SL (2.1 mg/kg), 92GFTP015SL (55.0 mg/kg), 92GFTP016SL (9.3 mg/kg), 92GFTP017SL (63.0 mg/kg), and 92GFTP018SL (7.9 mg/kg) (see Figure 5-8).

Concentrations of 4,4'-DDT that were detected but were not considered to be significant ranged from 0.0088 B to 0.074 mg/kg. For 4,4'-DDT and metabolites 4,4'-DDD and 4,4'-DDE, sample results reported as ND were analyzed at detection limits that ranged from 0.0032 to 0.0041 mg/kg.

Soil samples collected from GFTP-4D during 1991 field activities contained concentrations of 4,4'-DDT and metabolites that were not considered to be significant (see Table 5-21). However, significant quantities of 4,4'-DDT and 4,4'-DDD were measured in 1991 sludge sample 9130GFTP084SL at concentrations of 6.2 and 4.8 mg/kg, respectively (see Table 5-21). The exact location of sample 9130GFTP084SL is unknown.

Base/Neutral and Acid Extractable Organic Compounds

BNA analyses were performed only on samples collected from GFTP-4A (see tables 5-6 and 5-7). Results were determined using the analytical procedures specified in EPA Method 8270. Selected subsurface and all surface samples were examined for these chemical contaminants. Target compounds belonging to a subset of BNA analytes, PAHs were identified as present in some samples above action levels. These PAH compounds are probably individual components derived from POL contamination. PAH samples were detected above action levels in the following surface samples:

- 92GTFP001SL; 92GTFP002SL; 92GTFP003SL; 92GTFP004SL and 92GTFP006SL.

Concentrations above action levels ranged from 0.77 mg/kg benzo(a)anthracene at 92GFTP001SL to 33.0 mg/kg benzo(b)fluoranthene at 92GFTP006SL. Sample results reported as ND were analyzed at detection limits that ranged from 0.35 to 0.37 mg/kg.

Subsurface samples containing PAHs above action levels were collected from boreholes AP-582, AP-583, and AP-584. Subsurface sample 92GFTP037SL was collected from AP-582 at 1.5 to 2.5 feet BGS and contained the greatest concentration of all PAHs detected. Other subsurface samples with PAHs above action levels were the following:

- 92GFTP041SL collected from AP-582 at 34.5 to 36.5 feet BGS;
- 92GFTP071SL and duplicate samples 92GFTP282SL and 92GFTP283SL collected from AP-583 at 1.5 to 3.5 feet BGS; and
- 92GFTP050SL and 92GFTP051SL collected from AP-584 at 1.5 to 2.5 feet BGS and 4.5 to 4.9 feet BGS.

Most PAH results detected were above the risk-based action levels. Concentrations above action levels ranged from 8.4 mg/kg benzo(a)pyrene at AP-582 to 0.200 J benzo(a)anthracene at AP-581. Concentration either below action levels or for which no EPA Region 10 risk-based action level guidance was provided ranged from 55.0 mg/kg 2-methylnaphthalene at AP-582 to 0.064 J mg/kg anthracene at AP-583. Sample results reported as ND were analyzed at detection limits that ranged from 0.340 to 0.370 mg/kg.

No significant quantities of BNA target compound were detected in any 1991 GFTP samples.

Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans

Polychlorinated dioxin/furans were detected in subsurface and surface soil samples through analyses using EPA Method 8290 or Method 8280. Homologues and congeners determined to be present were reported as a calculated total concentration of 2,3,7,8-Tetrachlorodibenzo-p-dioxins (2,3,7,8-TCDD). I-TEFs/89 TEF found in *Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-P-Dioxins and -Dibenzofurans (CDDs and CDFs) and 1989 Update* (EPA 1989b) were used to calculate the total 2,3,7,8-TCDD equivalence value. A conservative approach was employed to calculate total 2,3,7,8-TCDD when only homologues and not specific congener concentrations were reported; in those instances, the 2,3,7,8-congener was used.

No 2,3,7,8-TCDD was detected in any samples. None of the reported 1991 or 1992 sample results exceeds the generally accepted EPA cleanup action level of 1 μg/kg for soils.

GFTP-4A. No calculated total 2,3,7,8-TCDD concentrations for subsurface or surface soil samples collected at GFTP-4A 1992 exceeded the EPA Region X 10^{-6} RBC of 0.004 μg/kg.

GFTP-4B. None of the 1992 subsurface samples yielded a calculated 2,3,7,8-TCDD value above the EPA Region X 10^{-6} (RBC) of 0.004 μg/kg (EPA 1992). A conservative (health protective) approach was employed to evaluate the data when the specific congener was not known; in this case the TFF of the most toxic isomer was used. Hence, a conservative TEF calculation of heptachlorodibenzo dioxin may have caused some of the samples to exceed the RBC. Surface soil samples collected in 1992 that exceeded the RBC included:

- Replicate samples 92GFTP019SL (.0129 μg/kg TEF), 92GFTP252SL (.0063 μg/kg TEF);
- Replicate samples 92GFTP022SL (.0055 μg/kg), 92GFTP250SL (.0063 μg/kg TEF);
- Replicate samples 92GFTP024SL (.0299 μg/kg TEF), 92GFTP260SL (.017 μg/kg TEF); and
- 92GFTP026SL (.0119 μg/kg TEF) and 92GFTP030SL (.0123 μg/kg TEF).

Replacement of congener concentrations by homologue concentrations and the use of the 2,3,7,8-congener TEF may lead to an overestimate in the calculated total 2,3,7,8-TCDD concentration. All samples that exceeded the RBC and used a conservative calculation of heptachlorodibenzo dioxin included: 92GFTP019SL, 92GFTP022SL, 92GFTP024SL, 92GFTP026SL, 92GFTP030SL, 92GFTP250SL, 92GFTP252SL, and 92GFTP260SL.

GFTP-4D. No calculated total 2,3,7,8-TCDD concentrations for subsurface or surface soil samples collected at GFTP-4D 1992 exceeded the EPA Region X 10^{-6} RBC of 0.004 μg/kg.

No calculated total 2,3,7,8-TCDD concentrations for subsurface or surface soil samples collected in 1991 exceeded the EPA Region X 10^{-6} RBC of 0.004 μg/kg.

5.4 DATA VALIDATION

All analytical data collected during the 1992 Fort Richardson and Fort Greely FTP site investigation were evaluated for precision, accuracy, and completeness by COE chemists at the North Pacific Division Laboratory (CENPD-PE-GT-L) in Troutdale, Oregon. Based on the findings presented in CENPD-PE-GT-L's CQAR prepared for this project, CENPD-PE-GT-L concludes that data submitted by the project and QA laboratories generally met QA/QC requirements with the exceptions discussed below. The complete CQAR reports are found in Appendix D.

5.4.1 Fort Richardson Data

Generally, both the project and the QA laboratory 1992 Fort Richardson FTP data were deemed acceptable by CENPD-PE-GT-L. The CQAR states that exceptions to usable data were found in the QA laboratory's data for DRO, with many results considered unacceptable due to laboratory QC failures, and in the QA laboratory's dioxin/furan analysis data that were deemed unacceptable due to incomplete laboratory QC. Data flags were assigned based on CQAR direction. Sample values considered to be estimates are flagged as "J"; estimated detection limits are flagged "UJ"; results that may be associated with blank contamination are flagged "B"; and unacceptable results were not reported and numerical values were replaced with the qualifier "R". Unacceptable QA laboratory data did not affect overall project data usability.

Benzene, Toluene, Ethylbenzene, and Total Xylenes

The 1992 Fort Richardson FTP BTEX data for both the project and the QA laboratory were accepted by CENPD-PE-GT-L with one exception: The surrogate recovery for sample 92RFTP413SL was 30%; therefore, low levels of fuel may not have been detected. This sample's results were flagged J or UJ.

A comparison of the project and QA laboratory data for the Fort Richardson FTP revealed only one discrepancy between replicates: Ethylbenzene analytical results for sample 92RFTP562SL that were analyzed at the project laboratory did not agree with the project laboratory blind duplicate sample 92RFTP453SL or the QA replicate sample 92RFTP452SL. The project laboratory detected ethylbenzene in sample 92RFTP562SL, but it either failed to detect or could not detect ethylbenzene in sample 92RFTP453SL. This may be due to matrix interference. The QA laboratory did not detect ethylbenzene. The quantity of ethylbenzene measured was extremely low (0.069 mg/kg) and was not considered significant for the purposes of this project.

Fuel Identification and Quantitation

The Fort Richardson FTP project lab FIQ data achieved most CENPD-PE-GT-L required control limits; exceptions were the surrogate recoveries in several samples. Samples 92RFTP349SL, 92RFTP363SL, 92RFTP406SL, 92RFTP420SL, and 92RFTP502SL had that high surrogate recoveries that the CQAR attributed to matrix interface. Also, high concentration of fuels found in samples 92RFTP312SL, 92RFTP361SL, 92RFTP400SL, 92RFTP550SL, and 92RFTP564SL required analytical dilutions that decreased the surrogate compound concentration below detection limits. The FIQ results for the mentioned samples are considered estimated and flagged J.

Analytical precision for Bunker C results, as measured by relative percent difference (RPD) in subsurface samples 92RFTP329SL, 92RFTP331SL, 92RFTP332SL, 92RFTP333SL, 92RFTP334SL, 92RFTP335SL, 92RFTP343SL, 92RFTP348SL, 92RFTP395SL, 92RFTP396SL, 92RFTP404SL, 92RFTP424SL were above 28. CENPD-PE-GT-L considers these sample results estimated and E & E has flagged these samples J.

Sample 92RFTP386SL analyzed by the project laboratory showed a positive result for kerosene, unlike blind duplicate sample 92RFTP422SL and QA replicate sample 92RFTP423SL. Chromatograms indicate that samples 92RFTP422SL and 92RFTP423SL show greater similarity than sample 92RFTP386SL, suggesting that nonhomogenous samples were submitted. In another set of analyses, results for 92RFTP452SL, the QA replicate do not agree with the results for project lab duplicates 92RFTP562SL and 92RFTP453SL. CENPD-PE-GT-L has identified the QA laboratory's use of nonstandard methods in quantitation of fuels as the cause of the disparity. Additionally, sample 92RFTP457SL results are considered estimated by CENPD-PE-GT-L and flagged J.

Diesel-Range Organics

DRO results for Fort Richardson FTP samples achieved method advisory limits for most samples. Exceptions were related to surrogate recoveries and RPD value calculations. DRO results for samples 92RFTP311SL, 92RFTP361SL, 92RFTP550SL, and 92RFTP564SL had elevated surrogate recoveries due to matrix interference. High concentrations of fuels were present in the samples. DRO results for these samples have been flagged J or UJ as appropriate.

MS/MSD recoveries and RPD values calculated for samples analyzed at the QA laboratory were erratic. CENPD-PE-GT-L stated that due to erratic and inconsistent results, all QA laboratory DRO data are considered estimated and flagged J.

Total Lead and Toxicity Characteristic Leaching Procedure Lead

The 1992 Fort Richardson FTP project laboratory samples for lead were accepted by CENPD-PE-GT-L without qualification and met all method defined QC limits.

Several samples analyzed at the QA laboratory produced data that CENPD-PE-GT-L considered estimated due to MS recoveries being outside QC limits. Samples 92RFTP405SL and 92RFTP407SL were analyzed in a QC group that had MS recovery of 138%, exceeding the maximum acceptable QC limit of 125%. Affected results are flagged J. Similarly, samples 92RFTP423SL and 92RFTP425SL were analyzed in a QC group that had an MS recovery of 68%, below the minimum acceptable QC limit of 75%. Affected results are flagged J or UJ.

CENPD-PE-GT-L comparisons between replicates submitted to the project laboratory and the QA laboratory revealed some discrepancies in the sample data. Data for the project laboratory duplicates 92GFTP024SL and 92GFTP260SL do not agree with the QA replicate 92GFTP261SL. CENPD-PE-GT-L suggests this discrepancy is due to nonhomogeneous distribution of lead in soil samples analyzed.

Organochlorine Pesticides and Polychlorinated Biphenyls

All 1992 Fort Richardson FTP project and QA laboratory Pest/PCB analyses were validated as acceptable by CENPD-PE-GT-L. No data qualifiers were assigned.

Volatile Organic Compounds

Due to laboratory problems, some Fort Richardson FTP samples had VOC analyses conducted in place of the requested BTEX analyses. CENPD-PE-GT-L has considered all the VOC data to be completely acceptable as a replacement for the requested BTEX analyses and all VOC results were within the EPA method- defined QC limits.

Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans

The 1992 Fort Richardson FTPs project laboratory dioxin/furan data achieved all method specified QC requirements and was reported without qualification. The QA laboratory's data was considered questionable by CENPD-PE-GT-L. The QA laboratory instructed the subcontract laboratory analyzing the dioxin/furan samples not to perform MS/MSD analyses due to funding limitations. Precision and accuracy of the QA laboratory's samples could not be established. All the QA dioxin/furan results are considered estimated.

Method blanks for Fort Richardson FTP dioxin/furan data contained 36.9, 2.1, and 0.48 ng/kg of OCDD; 1,2,3,4,6,7,8 HpCDD; and 2,3,7,8-TCDF, respectively. Data for these analytes were considered estimated. The QA laboratory reported nine isomers of dioxin and furans in samples 92RFTP450SL and 92RFTP452SL, in part due to laboratory contamination. The results for these samples were considered estimated and not disregarded as blank contamination. Other samples taken in the same vicinity, RFTP-2, had positive results for the same congeners yet, no blank contamination. Data were reported in terms TEF as 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD).

5.4.2 Fort Greely Data

Overall, the 1992 Fort Greely FTP project laboratory samples were considered acceptable by CENPD-PE-GT-L. Exceptions were metabolites of 4,4'-DDT, specifically 4,4'-DDD, and 4,4'-DDE that may not have been detected due to masking caused by high concentrations of 4,4'-DDT. Low levels of 4,4'-DDT were found in some of the method blanks; thus, 4,4'-DDT results below 100 μg/kg were considered potentially laboratory-derived blank contamination and were flagged B. Samples flagged B were determined to contain the qualified analyte at less than 10 times the concentration found in the associated laboratory blanks.

The 1992 Fort Greely FTP QA laboratory sample analyses were generally accepted by CENPD-PE-GT-L except for BTEX, dioxin/furan, and some FIQ and DRO results. CENPD-PE-GT-L considered the BTEX results either estimated or unusable due to the QA laboratory's failure to recover the surrogate compound and the performance of incomplete laboratory QC. Affected samples have been flagged J or R. Numerical results for those analytes flagged R are not reported.

The CENPD-PE-GT-L contracted QA laboratory instructed its subcontract laboratory not to analyze MS/MSD samples during the dioxin/furan analyses. Therefore, precision and accuracy of dioxins and furan analyses could not be adequately determined. Results are flagged J or UJ.

Some QA laboratory analytical results for FIQ and DRO are rejected based on a combination of surrogate failure and MS/MSD recoveries that were either low or diluted out. Analytical results for these analytes in the specified samples are not reported and numerical results have been replaced with the qualifier R.

Benzene, Toluene, Ethylbenzene, and Total Xylenes

The 1992 Fort Greely FTPs BTEX sample results from the project laboratory were generally accepted by CENPD-PE-GT-L without qualification. However, the QA laboratory data for BTEX is considered suspect by CENPD-PE-GT-L. The surrogate recoveries for samples 92GFTP251SL, 92GFTP253SL, 92GFTP255SL, 92GFTP257SL, 92GFTP259SL, 92GFTP261SL, 92GFTP263SL, 92GFTP265SL, 92GFTP267SL, 92GFTP269SL, and 92GFTP275SL are all below the minimum control limit 60%. BTEX results are considered estimated by CENPD-PE-GT-L and were flagged J. The J flag was assigned because no MS/MSD analyses were performed for any of the BTEX analysis and no duplicate samples were submitted to this laboratory. The QA laboratory's analytical precision could not be determined from the results presented. Samples 92GFTP251SL and 92GFTP263SL had surrogate recoveries below the minimum statistical outer limit of 10%, therefore, the data for these two samples is considered unusable for any purposes and numerical results are replaced with the qualifier R.

Comparing the project laboratory and the QA laboratory replicate sample results for 1992 Fort Greely FTP samples suggests that some samples had either a nonhomogeneous distribution of analyte or were nonidentical. Xylene results for samples 92GFTP023SL and

92GFTP258SL analyzed by the project laboratory did not have comparable results with their QA replicate 92GFTP259SL. The QA laboratory's low results may also be attributed to laboratory problems illustrated by poor BTEX surrogate recovery. The project laboratory sample 92GFTP024SL results did not correlate with project laboratory blind duplicate sample 92GFTP260SL and QA replicate sample 92GFTP261SL. Samples 92GFTP260SL and 92GFTP261SL had similar percent solids; therefore, the data suggests nonhomogeneous samples were submitted as replicates.

Fuel Identification and Quantitation

Approximately 75% of the project laboratory's FIQ data for Fort Greely FTPs met all CENPD-PE-GT-L required control limits; approximately 25% of samples had surrogate recoveries that were either diluted out or not calculable due to matrix interference. The surrogate compound in samples 92GFTP001SL, 92GFTP014SL, 92GFTP067SL, 92GFTP071SL, 92GFTP072SL, 92GFTP075SL, and 92GFTP266SL were diluted out. Results for these samples are considered estimated and flagged J. Estimated data are usable for project requirements.

All of the QA laboratory's FIQ sample results for Fort Greely were considered unacceptable by CENPD-PE-GT-L. Specifically, these samples are 92GFTP251SL, 92GFTP253SL, 92GFTP257SL, 92GFTP259SL, 92GFTP261SL, 92GFTP263SL, 92GFTP267SL, 92GFTP269SL, 92GFTP271SL, 92GFTP273SL, 92GFTP275SL, 92GFTP285SL, and 92GFTP289SL. The surrogate recoveries and the MS/MSD results were below the minimum acceptable CENPD-PE-GT-L control limits. Also, the QA laboratory replicate sample analyses failed to identify fuels that were found by the project laboratory. The QA laboratory's data for these samples was considered unusable for any purposes and numerical results are replaced with the qualifier R.

Diesel-Range Organics

The project and the QA laboratory DRO results for 1992 Fort Greely FTP samples achieved ADEC method-defined advisory requirements except for the surrogate recoveries of the following samples: 92GFTP014SL, 92GFTP034SL, 92GFTP070SL, 92GFTP113SL, 92GFTP259SL, and 92GFTP266SL. All these samples had either high surrogate recoveries due to matrix interference or no surrogate recovery because it was diluted out. Analytical results for these samples are considered estimated and flagged J or UJ. Samples 92GFTP285SL and 92GFTP289SL were analyzed by the QA laboratory and produced surrogate recoveries below QC advisory limits. The QA laboratory's data for these samples were considered unusable for any purposes by CENPD-PE-GT-L, and numerical results were replaced with the qualifier R.

Total Lead and Toxicity Characteristic Leaching Procedure Lead

Both the project and QA laboratory 1992 Fort Greely FTP data achieved method specified QC limits for total lead and TCLP lead analyses. According to CENPD-PE-GT-L, the only discrepancy with the samples is due to either nonhomogeneous distribution of lead in the soil or nonhomogeneous aliquots of soil used for analysis. Analytical results from the project laboratory duplicate samples 92GFTP025SL, 92GFTP026SL, 92GFTP262SL, and 92GFTP266SL do not agree with their QA replicate samples 92GFTP263SL and 92GFTP267SL. CENPD-PE-GT-L has not assigned any data qualifiers to these results, but recommends using results from the project laboratory.

Organochlorine Pesticides and Polychlorinated Biphenyls

Most Pest/PCB project laboratory results for 1992 Fort Greely FTPs samples achieved method-defined QC limits and were accepted by CENPD-PE-GT-L without qualification. Exceptions to achieving QC limits were found in samples 92GFTP008SL, 92GFTP012SL, 92GFTP014SL, 92GFTP053SL, 92GFTP054SL, 92GFTP140SL, 92GFTP145SL, 92GFTP146SL, 92GFTP214SL, 92GFTP220SL, 92GFTP260SL, and 92GFTP262SL in which the surrogate recovery was zero. These samples contained very high analyte concentrations requiring many-fold dilutions that decreased the surrogate concentration below detection limits. No data qualifiers were assigned solely for this reason.

The project laboratory also had a method blank contaminated with 0.010 mg/L of 4,4'-DDT. CENPD-PE-GT-L recommends that samples with 4,4'-DDT results below 0.100 mg/kg be used "with caution"; affected samples are flagged B to indicate blank contamination.

The QA laboratory reported results for target compounds 4,4'-DDT, 4,4'-DDE, and 4,4'-DDT while the project laboratory detected only 4,4'-DDT. CENPD-PE-GT-L suggests that the project laboratory did not detect 4,4'-DDD or 4,4'-DDE in samples where high concentrations of 4,4'-DDT was found, probably due to many-fold dilution applied to the extracts.

The QA laboratory reported all pesticides with the qualifier J because analytes were found below the required practical quantitation limits. CENPD-PE-GT-L's CQAR states the QA laboratory's data for 4,4'-DDD and 4,4'-DDE can be substituted for the project data, if applicable.

Base/Neutral and Acid Extractable Organic Compounds

All 1992 Fort Greely FTP project and QA laboratory BNA analyses were validated as acceptable by CENPD-PE-GT-L. No data qualifiers were assigned.

Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans

The 1992 Fort Greely FTPs project laboratory dioxin/furan data achieved all method-specified QC requirements and was reported without qualification. The QA laboratory's data were considered questionable by CENPD-PE-GT-L. The QA laboratory instructed the subcontract laboratory analyzing the dioxin/furan samples not to perform MS/MSD analyses. Precision and accuracy of the QA laboratory's samples could not be established. All the QA dioxin/furan results are considered estimated and qualified J. Data were reported in terms of TEF as TCDD.

5.4.3 QA/QC Sample Discussion

Greater than 11% of all FTP samples analyzed at both Fort Greely and Fort Richardson were replicate samples collected in triplicate for QA/QC purposes. Thirty-four subsurface and surface samples were collected in triplicate at RFTP-2, and 40 subsurface and surface samples were collected in triplicate at the GFTPs. Triplicate results were generally comparable. Noncomparable triplicate results were discussed individually earlier in this report.

One rinsate sample from a stainless steel bowl and one rinsate sample from a split spoon were submitted to the project laboratory from both the 1992 Fort Richardson and 1992 Fort Greely FTPs soil sampling efforts. Analytical results for the rinsate samples are presented in Table 5-5 for Fort Richardson and Table 5-13 for Fort Greely samples.

The Fort Richardson rinsate samples were identified 92RFTP393WA and 92RFTP394WA, and were analyzed for all parameters of interest. Both of the rinsate samples exhibited positive results for total xylenes. According to CENPD-PE-GT-L, the presence of this aromatic volatile organic compound could be due to several factors including: laboratory-derived contamination; contamination encountered during rinsate preparation; or because contaminated deionized water was used to prepare the rinsate samples.

The Fort Greely rinsate samples identified 92GFTP601WA and 92GFTP602WA and were analyzed for all analytes of interest. Small amounts (0.25 mg/L) of DRO were found in sample 92GFTP601WA. Benzene and ethylbenzene at 0.0038 and 0.0076 mg/L, respectively, were found in sample 92GFTP602WA. CENPD-PE-GT-L advised caution as the volatiles could also have been introduced during rinsate blank sample preparation through the use of contaminated deionized water. No data qualifiers were assigned based solely on these results.

5.5 SUMMARY OF SIGNIFICANT FINDINGS

Analytical results above the action levels specified in section in this report were found at all FTPs examined. Samples collected from RFTP-2 contained analytes that are classified as POL contaminants. Analyzed samples exceeded the State of Alaska's, non-UST petroleum contaminant action levels and EPA Region 10 guidelines for risk-based action levels specific to chemical contaminants. POL contamination was encountered at both subsurface and surface locations. Significant levels of dioxin/furans were also encountered at surface locations.

Samples collected from Fort Greely FTPs exceeded both the State of Alaska's, non-UST petroleum contaminant action levels and EPA Region 10 guidelines for risk-based action levels specific to chemical contaminants. Significant contaminants at GFTP-4A can all be categorized as POL and related compounds and were encountered at both subsurface and surface locations. Significant contaminants at GFTP-4B and GFTP-4D can be categorized POL compounds and as organochlorine pesticides, specifically 4,4'-DDT and metabolites and also were encountered at both subsurface and surface locations. Significant levels of dioxin/furans were encountered at surface locations at GFTP-4B.

Table 5-1

REGULATORY CLEANUP LEVELS AND RISK-BASED EVALUATION CRITERIA FIRE TRAINING PITS FORT RICHARDSON AND FORT GREELY, ALASKA (mg/kg)

Parameter	Regulatory Level	Risk-Based Concentration[a] Based on Soil Ingestion, Residential		
		Risk = 10^{-6}	Risk = 10^{-4}	HQ = 1
VOAs				
Acetone	NA	NC	NC	NC
2-Butanone	NA	NC	NC	10,000
Chloroform	120[b]	100	10,000	3,000
1,2-Dichloroethane	10[b]	7	700	NC
cis-1,2-Dichloroethene	14[b]	NC	NC	3,000
trans-1,2-Dichloroethene	14[b]	NC	NC	6,000
Total 1,2-Dichloroethene	14[b]	NC	NC	6,000
Methylene Chloride	NA	NC	NC	NC
1,1,1-Trichloroethane	NA	NC	NC	20,000
Trichloroethene	10[b]	50	5,000	2,000
Tetrachloroethene	NA	10	1,000	3,000
Benzene	0.1[c]	20	2,000	NC
Chlorobenzene	NA	NC	NC	5,000
Ethylbenzene	10[c]	NC	NC	30,000
Toluene	10[c]	NC	NC	50,000
Total Xylenes	10[c]	NC	NC	500,000
Total BTEX	10[c]	NC	NC	500,000
BNAs				
Benzo(a)anthracene	NA	0.09	9	NC
Benzo(b)fluoranthene	NA	0.09	9	NC
Benzo(k)fluoranthene	NA	0.09	9	NC
Benzo(g,h,i)perylene	NA	NC	NC	NC
Benzo(a)pyrene	NA	0.09	9	NC
Bis(2-ethylhexyl)phthalate	NA	50	5,000	5,000
Chrysene	NA	0.09	9	NC
Di-n-butylphthalate	NA	NC	NC	30,000

Table 5-1

REGULATORY CLEANUP LEVELS AND
RISK-BASED EVALUATION CRITERIA
FIRE TRAINING PITS
FORT RICHARDSON AND FORT GREELY, ALASKA
(mg/kg)

Parameter	Regulatory Level	Risk-Based Concentration[a] Based on Soil Ingestion, Residential		
		Risk = 10^{-6}	Risk = 10^{-4}	HQ = 1
Fluoranthene	NA	NC	NC	10,000
Indeno(1,2,3-cd)pyrene	NA	0.09	9	NC
2-Methylnaphthalene	NA	NC	NC	NC
Naphthalene	NA	NC	NC	10,000
Pentachlorophenol	2,000[b]	5	500	8,000
Phenanthrene	NA	NC	NC	NC
Pyrene	NA	NC	NC	5,000
FUELS				
Diesel-Range Petroleum Hydrocarbons	100[c]	NC	NC	NC
Gasoline-Range Petroleum Hydrocarbons	50[c]	NC	NC	NC
Residual-Range Petroleum Hydrocarbons	2,000[c]	NC	NC	NC
PESTICIDES/PCBs				
α-BHC	2.6[b]	0.1	10	NC
β-BHC	2.6[b]	0.4	40	NC
γ-BHC (Lindane)	8[b]	0.5	50	80
δ-BHC	2.6[b]	NC	NC	NC
Heptachlor	0.16[b]	0.1	10	100
Aldrin	NA	0.04	4	8
Heptachlor epoxide	0.16[b]	0.07	7	4
Endosulfan I	NA	NC	NC	10
4,4'-DDE	NA	2	200	NC
Dieldrin	NA	0.04	4	10
Endrin	0.4[b]	NC	NC	80
Endosulfan II	NA	NC	NC	10
4,4'-DDD	NA	3	300	NC
Endosulfan sulfate	NA	NC	NC	NC
4,4'-DDT	NA	2	200	100

DDT exceeded its RBC in 13 samples. The maximum detected concentrations of DDD and DDT in surface soils, 220 mg/kg and 85 mg/kg, respectively, were found in sample 92GFTP023L, one of a triplicate set collected from the stained soil area. The associated triplicate concentrations were 170 mg/kg and < 1.90 mg/kg for DDD; and 51 mg/kg and 48 mg/kg for DDT. DDE was detected at a maximum concentration of 6.0 mg/kg, three times its RBC. Based on a comparison of the maximum observed concentrations in surface soil with the RBC screening value, which is based on residential exposure, the estimated cancer risks for the individual pesticides fall within the 10^{-6} to 10^{-4} range, and result in a total estimated risk of approximately 10^{-4}.

PCDDs/PCDFs were detected in all of the seven surface soil samples analyzed, and the 2,3,7,8-TCDD equivalents concentrations exceeded the RBC for a 10^{-6} cancer risk in five of these samples. As explained in Section 5.3.2.6, the 2,3,7,8-TCDD equivalents concentrations may be overestimates, because of the conservative approach used in the calculations. The maximum reported concentration was 2.99×10^{-5}, found in sample 260, one of a triplicate set. This concentration corresponds to an estimated cancer risk for residential exposure that falls within the 10^{-6} to 10^{-4} range considered acceptable by EPA. The other 2,3,7,8-TCDD equivalent concentrations reported for samples collected at this location were 1.7×10^{-5} mg/kg and 3.5×10^{-6} mg/kg.

VOC concentrations at GFTP-4B were well below Region 10 RBCs and are not of concern. Lead concentrations were found to be elevated in four surface soil samples and three subsurface samples. Only one sample had a concentration exceeding the 500 mg/kg lead guidance level. Sample 92GFTP259SL, which is one of a triplicate set, had the maximum value of 746 mg/kg reported for lead in Table 6-6. Concentrations of 330 mg/kg and 200 mg/kg were also reported for the other two samples in the set, which results in an average concentration at this sample location of 425 mg/kg, which is below the level of concern.

6.4.2.3 GFTP-4D

Organic chemicals data for GFTP-4D is summarized in Table 6-5. DDT and its residues were detected in over half of the surface samples and in 24 subsurface soils samples. Generally, the concentrations found in surface soils were higher than in subsurface soils. In surface soils, the DDD concentration in one sample exceeded its RBC for a 10^{-6} cancer risk, and DDT exceeded its RBC in seven samples. The maximum concentrations of DDD and

DDT, 41 mg/kg and 63 mg/kg, respectively, were found in sample 92GTFP017SL, which was collected from the eastern portion of GFTP-4D area (DDT was detected at a similar level in the western portion also). Based on these maximum observed concentrations compared to the RBCs, the estimated cancer risks for individual COPCs and the total risk for all COPCs fall within the 10^{-6} to 10^{-4} range. Concentrations of other organic chemicals detected in soils were well below the RBCs and are not of concern.

Lead concentrations were elevated above background levels in five surface soil samples collected from GFTP-4D; however, the maximum concentration detected, 330 mg/kg, did not exceed the level of concern. Arsenic was found in one subsurface soil sample, 9130GFTP080SL, at a concentration of 13.9 mg/kg (see Table 6-6), which slightly exceeds the 90th percentile background level. Since 10% of natural soil concentrations would be expected to exceed the 90th percentile value, this slight exceedance in one sample probably reflects natural variability in the soil and is not due to contamination. No other metals exceeded natural background levels.

6.4.3 Health Effects Summaries

This section includes brief health effect summaries for the COPCs identified at the FTPs: carcinogenic PAHs (GFTP-4A); pesticides DDT, DDD, and DDE (GFTP-4B and -4D); and PCDDs/PCDFs (RFTP-2 and GFTP-4B). In most cases, the information in the summaries is drawn from the Public Health statement in the Agency for Toxic Substances and Disease Registry's (ATSDR) toxicological profile for the chemical (ATSDR 1988-1992).

Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans

Polychlorinated dibenzodioxins and polychlorinated dibenzofurans (PCDDs/PCDFs) are two classes of related chemicals. There are 75 different forms of PCDD and 135 forms of PCDF. Most studies, therefore, focus on 2,3,7,8-TCDD, commonly called dioxin, which is the most toxic member of this family of chemicals. For risk assessment purposes, the concentrations of other PCDDs/PCDFs are converted to equivalent concentrations of 2,3,7,8-TCDD using toxicity equivalence factors (TEFs). The PCDDs/PCDFs are then evaluated as if they were the single chemical, 2,3,7,8-TCDD.

The compound 2,3,7,8-TCDD is colorless and odorless. It does not dissolve in water and can persist in the environment for a long time. Neither PCDDs nor PCDFs are known to occur naturally, nor were they deliberately produced or released to the environment. Rather, they are unwanted trace contaminants formed during the manufacture or burning of certain chlorinated chemicals. These compounds are present in certain pesticides and automobile exhaust, and are also formed during the incineration of municipal waste.

Workers in the chemical industry, at municipal and industrial incinerators, and at hazardous waste sites can be exposed to 2,3,7,8-TCDD. The general public can be exposed to 2,3,7,8-TCDD by skin contact with contaminated soil and by consuming contaminated fish, meat, milk, or root vegetables grown in contaminated soil. It is unlikely that significant amounts of 2,3,7,8-TCDD are carried by drinking water or contaminated air. However, an exception is presented by the inhalation of small particles of contaminated fly ash, which may be a major source of exposure for populations near an incinerator.

In humans, overexposure to 2,3,7,8-TCDD has caused chloracne, a severe skin lesion. Chloracne can be very disfiguring and often lasts for years after exposure. There is limited evidence to suggest that 2,3,7,8-TCDD causes liver damage, loss of appetite, weight loss, and digestive disorders in humans.

Animal studies have shown many different adverse effects of 2,3,7,8-TCDD. The severity and type of adverse effects varies with species. Animal studies have demonstrated severe liver damage, severe weight loss followed by death, toxicity to the immune system, spontaneous abortions, and malformations in offspring whose mothers were exposed to the chemical during pregnancy. In addition, 2,3,7,8-TCDD has been demonstrated to cause cancer in rats and mice, and it is classified as a Group B2 probable human carcinogen by EPA.

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs contain only carbon and hydrogen and consist of two or more fused benzene rings in linear, angular, or cluster arrangements. PAHs are formed during the incomplete burning of fossil fuel, garbage, or other organic matter. PAHs produced by burning may be carried into the air on dust particles and distributed into water and soil. In general, PAHs do not evaporate easily and do not dissolve in water.

Exposure to PAHs may occur by inhaling airborne particles, drinking water, or accidentally ingesting soil or dust containing PAHs. In addition, smoking tobacco or eating charcoal-broiled food are common routes of exposure to PAHs.

Some PAHs are known carcinogens, and potential health effects caused by PAHs are usually discussed in terms of an individual PAH compound's carcinogenic or noncarcinogenic effects. Little attention has been paid to the noncarcinogenic effects of PAHs. Rapidly growing tissues, such as the intestinal lining, bone marrow, lymphoid organs, blood cells, and testes seem to be especially susceptible targets to noncarcinogenic effects. Concentrations of 150 mg/kg or more administered to laboratory animals have been shown to inhibit body growth.

Exposure to benzo(a)pyrene (B[a]P) and other carcinogenic PAHs can cause cancer at the point of exposure. B(a)P is used as the surrogate for evaluation of the toxicity of all of the Class B2 carcinogenic PAHs because only B(a)P has been assigned a SF by EPA. Animals exposed to high levels of B(a)P in air develop lung tumors; when exposed via the dietary route they develop stomach tumors; and when B(a)P is painted on skin, animals develop skin tumors. Although reference doses (RfDs) and SFs for dermal exposure to other chemicals are routinely extrapolated from oral-route values, it is inappropriate to use the oral SF of B(a)P to evaluate carcinogenic risks from dermal exposure because dermal exposure to B(a)P directly causes skin cancer.

DDT/DDE/DDD

DDT is a man-made chemical that has been used extensively throughout the world as a broad-spectrum insecticide. Technical grade DDT typically contains 80% to 90% 4,4'-DDT as well as other components, including DDD and DDE. Although the agricultural use of DDT in the United States was banned by EPA in 1972, it is presently widely distributed in the environment as a result of its extensive past use, high stability, and persistence.

Absorption of DDT has been demonstrated following oral, inhalation, and dermal exposure. The primary route of exposure, however, is oral.

The major adverse effects of DDT appear to involve the nervous system, the liver, and reproduction and development of offspring. In humans, doses of DDT up to 6 mg/kg usually produce no general illness, but headaches, excessive perspiration, and nausea have been reported. Vomiting, due to nervous system effects rather than gastrointestinal irritation, appears at doses of approximately 10 mg/kg, and convulsions appear at doses of approximately 16 mg/kg. Tests in animals suggest that DDT exposure may adversely affect reproduction, and long-term exposure may also affect the liver.

Although there is insufficient evidence to classify DDT, DDE, and DDD as carcinogens based on human studies, they have been found to be carcinogenic in a number of animal studies, primarily producing liver tumors. EPA classifies DDT, DDE, and DDD as Group B2 probable human carcinogens.

6.5 CONCLUSION

6.5.1 Risk-Based Screening

Chemicals were found in each of the FTPs under investigation at concentrations that may potentially result in significant adverse health effects if the areas were to be used for residential purposes. Residential exposure is the standard default exposure scenario used for screening purposes because it is usually the most sensitive potential use of an area. The COPCs found in each area, and the risks they may pose in the event of residential use of these areas, are summarized below.

The presence of chemicals at concentrations above their risk-based screening levels does not necessarily mean that the chemicals pose an actual risk or that remedial measures are warranted. It is simply an indication that the area may not be suitable for the most sensitive potential uses and that a more detailed site-specific baseline risk assessment may be needed to accurately assess the risks the site may pose. Conversely, if no chemicals are found at concentrations above their risk-based screening levels, the site is not expected to pose any significant risks, even under the most sensitive potential uses, and no further investigation or assessment is needed.

Final remedial goals suitable for use in an actual site remediation are usually based on the results of a site-specific baseline risk assessment and other considerations, such as ARARs. The risk-based concentrations used as screening criteria in this preliminary hazard evaluation are often used as preliminary remedial goals for screening remedial technologies in the early stages of a feasibility study. The RBCs are sufficiently health-protective to be used as remedial goals for virtually any potential site use. However, they may be unnecessarily stringent if residential use of an area is not a realistic possibility or if other site-specific considerations indicate that exposures are likely to be less than those predicted using EPA's standard default exposure factors.

6.5.2 Summary of COPCs

The contaminants identified in Section 6.4 as COPCs at each of the FTPs are summarized below. The risk levels cited are based on EPA's standard default exposure factors for residential use.

Fort Richardson RFTP-2

- PCDDs/PCDFs were found in four of seven surface soil samples at concentrations which, after conversion to 2,3,7,8-TCDD equivalents, exceeded the Region 10 RBC for a 10^{-6} cancer risk. The maximum observed concentration was approximately 10 times the RBC.

Fort Greely GFTP-4A

- Six cPAHs were detected at concentrations exceeding the RBCs for a 10^{-6} cancer risk in approximately half of nine surface soil samples and one-quarter of 23 subsurface samples. The highest observed individual cPAH concentrations, found in one surface soil sample, were each 200 to 300 times the RBC for a 10^{-6} cancer risk, also exceeding the Region 10 RBCs for a 10^{-4} cancer risk.

Fort Greely GFTP-4B

- Pesticides DDT, DDD, and DDE. The concentrations of at least one of these compounds exceeded its RBC for a 10^{-6} cancer risk in over three-quarters of 16 surface soil samples analyzed. The maximum observed concentrations of DDD and DDT in surface soil, which were found in one sample of a triplicate set, exceeded their RBCs by approximately 70 times and 40 times, respectively. The maximum observed DDE concentration was three times its RBC.

- PCDDs/PCDFs were present in five of seven soil samples at concentrations which, after conversion to 2,3,7,8-equivalents, exceeded the Region 10 RBC for a 10^{-6} cancer risk. The maximum observed concentration was approximately seven times the RBC.

Fort Greely GFTP-4D

- Pesticides DDT, DDD, and DDE. DDT concentrations exceeded the Region 10 RBC for a 10^{-6} cancer risk in seven of 11 surface soil samples and four of 25 subsurface samples; the maximum DDT concentration was 30 times the RBC. DDD exceeded the RBC in one surface soil sample, with a concentration over 10 times the RBC.

All COPCs found at the FTPs are classified as Group B2 probable human carcinogens, based on a combination of sufficient evidence of carcinogenicity in animals and inadequate evidence of carcinogenicity in humans.

6.5.3 Discussion of Uncertainties

The selection of COPCs at the FTP sites was based primarily on comparisons of the concentrations of chemicals detected in site soils with Region 10 RBCs corresponding to target risk levels, i.e., a HQ of 1 for noncarcinogens and a cancer risk of 10^{-6} for carcinogens. Although these RBCs are based on only a single exposure pathway (ingestion of site soils), the standard default exposure parameters used in the calculations probably overestimate the extent of exposure that would actually occur, given the climate in this region, even if these sites were converted to residential use. The extent of current exposures of site visitors or army personnel is probably much less than the standard default estimate, perhaps by as much as two orders of magnitude.

In addition to the conservative exposure assumptions used in the RBC calculations, the toxicity indices used have also been conservatively derived to compensate for uncertainties, such as variable responses between species, involved in extrapolating the results from the underlying scientific studies to the exposure situation being evaluated. The use of uncertainty factors to derive an RfD or the use of a 95% upper confidence limit from the linear multistage model to derive a SF ensures that these toxicity indices are much more likely to overestimate rather than underestimate a chemical's true toxicity.

The extrapolation of the SF of benzo(a)pyrene to calculate RBCs for the other cPAHs, which are generally less potent carcinogens, is also conservative. If relative potency factors (EPA 1990) had been applied, the RBCs for most of the cPAHs would have been higher, by one to three orders of magnitude.

Given the many conservative assumptions used to derive the Region 10 RBCs, it was assumed that if chemical concentrations detected in site soils were below the RBC screens, they do not pose significant risks to human health. Chemicals detected at concentrations exceeding the RBC screens may potentially pose significant risks, depending on site-specific exposures, and were therefore selected as COPCs.

None of the chemical concentrations detected in soils at the FTPs exceeded RBCs that corresponded to a HQ of 1, indicating that noncarcinogenic adverse health effects are not expected at these sites.

All of the chemicals selected as COPCs were detected at concentrations exceeding RBCs corresponding to an estimated excess lifetime cancer risk of 10^{-6}, the lower end of the 10^{-4} to 10^{-6} range specified as acceptable in the NCP (EPA 1992b). Chemical concentrations more than 100 times the RBC screening value also exceed the Region 10 RBC corresponding to a 10^{-4} cancer risk.

The Region 10 RBCs are useful as conservative screening values for selecting COPCs and for making comparative order-of-magnitude estimates of the associated risks. However, quantitative estimates of potential human health risks depend on the overall distribution of chemical concentrations at the sites, not just the highest concentrations, and on site-specific assumptions about exposure pathways and the extent of potential exposures. The RBCs should not be used as cleanup goals without consideration of these site-specific factors.

Table 6-1

SUMMARY OF ORGANIC CHEMICAL RESULTS FOR FORT RICHARDSON RFTP-2 (mg/kg)

Chemical	Region 10 RBC[a]	Surface and Near-Surface Soils			Subsurface Soils		
		Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency	Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency
VOCs							
Benzene	20[c]	0/26	—	0/26	10/94	1.3	0/94
Ethylbenzene	30,000[b]	6/26	0.110	0/26	16/94	7.7	0/94
Toluene	50,000[b]	9/26	2.00	0/26	32/94	12.0	0/94
Xylenes	500,000[b]	8/26	3.40	0/26	27/94	94.5	0/94
Acetone	NC	0/1	—	—	5/13	0.283	—
2-Butanone	10,000[b]	0/1	—	0/1	2/13	0.025	0/13
Chlorobenzene	5,000[b]	0/1	—	0/1	4/13	5.3	0/13
Chloroform	100[c]	0/1	—	0/1	2/13	0.002	0/13
1,2-Dichloroethane	7[c]	0/1	—	0/1	3/13	0.012	0/13
1,2-Dichloroethene(Total)	3,000[bd]	0/1	—	0/1	3/13	0.010	0/13
Methylene Chloride	90[c]	1/1	0.683	0/1	1/13	0.001	0/13
Tetrachloroethene	10[c]	1/1	2.10	0/1	4/13	7.10	0/13
Trichloroethene	60[c]	1/1	0.278	0/1	7/13	73	1/13

Key at end of table.

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Table 6-1

SUMMARY OF ORGANIC CHEMICAL RESULTS FOR FORT RICHARDSON RFTP-2 (mg/kg)

Chemical	Region 10 RBC[a]	Surface and Near-Surface Soils			Subsurface Soils		
		Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency	Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency
BNAs							
Pyrene	8,000[b]	1/1	1.25	0/1	0/4	—	0/4
Bis(2-ethylhexyl)phthalate	50[c]	1/1	0.75	0/1	0/4	—	0/4
Di-n-butylphthalate	30,000	1/1	4.10	0/1	1/4	0.50	0/4
Dioxins/Furans							
2,3,7,8-TCDD equivalents	4×10^{-6}	7/7	4.54×10^{-5}	4/7	1/8	2.8×10^{-6}	0/8

a Based on residential exposure by soil ingestion route USEPA Region 10, October 1992, Human Health-based Risk Concentration, Revised Cheat Sheets, Seattle, WA.

b Concentration corresponds to a noncancer hazard index of 1.

c Concentration corresponds to a lifetime cancer risk of 10^{-6}.

d RBC value is the lower of those reported for the cis and trans isomers.

Key:

NC = Not calculated. No approved toxicity index.

Table 6-2

SUMMARY OF METALS RESULTS FOR FT. RICHARDSON RFTP-2 (mg/kg)

Chemical	Local Background Concentration	90th Percentile for Western US Soil[b]	Region 10 RBC[c]	Surface Soil: Detection Frequency	Surface Soil: Maximum Concentration	Surface Soil: 90th Percentile Exceedance Frequency	Surface Soil: Region 10 RBC Exceedance Frequency	Subsurface Soil: Detection Frequency	Subsurface Soil: Maximum concentration	Subsurface Soil: 90th Percentile Exceedance Frequency	Subsurface Soil: Region 10 RBC Exceedance Frequency
Aluminum	6,770	141,000	NC	1/1	21,600	0/1	—	3/3	16,500	0/3	—
Arsenic	2.9	13.2	0.4[e]	1/1	4.6	0/1	1/1	3/3	8.8	0/3	3/3
Barium	17.9	1,162	20,000[d]	1/1	1,150	0/1	0/1	3/3	41.5	0/3	0/3
Cadmium	ND	NR	100	1/1	12.8	NA	0/1	0/3	—	NA	0/3
Calcium	2,490	75,200	NC	1/1	8,080	0/1	—	3/3	7,050	0/3	—
Chromium	10.6	112	NC[g]	1/1	97.3	0/1	—	3/3	28.8	0/3	—
Cobalt	4.5	16.9	NC	1/1	15.3	0/1	—	3/3	13.0	0/3	—
Copper	5.6	53.4	10,000[d]	1/1	174	1/1	0/1	3/3	34.5	0/3	0/3
Iron	11,400	49,400	NC	1/1	32,300	0/1	—	3/3	30,000	0/3	—
Lead	3.7	36.1	500[f]	26/26	543[h]	18/26	1/26	95/95	300	2/95	0/95
Magnesium	3,700	20,500	NC	1/1	10,700	0/1	—	3/3	9,650	0/3	—
Manganese	235	912	30,000[d]	1/1	633	0/1	0/1	3/3	762	0/3	0/3
Nickel	12.9	38.8	5,000[d]	1/1	39.7	1/1	0/1	0/3	33.2	0/3	0/3
Potassium	309	34,400	NC	1/1	1,760	0/1	—	3/3	997	0/3	—
Silver	ND	NR	1,000[d]	1/1	4.2	—	0/1	3/3	3.4	NA	0/3

Key at end of table.

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Table 6-2

SUMMARY OF METALS RESULTS FOR FT. RICHARDSON
RFTP-2 (mg/kg)

Chemical	Local Background Concentration	90th Percentile for Western US Soil[b]	Region 10 RBC[c]	Surface Soil				Subsurface Soil			
				Detection Frequency	Maximum Concentration	90th Percentile Exceedance Frequency	Region 10 RBC Exceedance Frequency	Detection Frequency	Maximum concentration	90th Percentile Exceedance Frequency	Region 10 RBC Exceedance Frequency
Sodium	116	22,800	NC	1/1	390	0/1	—	3/3	411	0/3	—
Vanadium	20.5	195	2,000[d]	1/1	59.7	0/1	0/1	3/3	51.0	0/3	0/3
Zinc	24.5	116	80,000[d]	1/1	2,180	1/1	0/1	3/3	66.6	0/3	0/3

a Results of 1 local background soil sample.
b Shacklette and Boerngen, 1984, USGS Paper 1270.
c Based on residential exposure by soil ingestion route USEPA Region 10, October 1992, Human Health-based Risk Concentration, Revised Cheat Sheets, Seattle, WA.
d Concentration corresponds to a noncancer hazard index of 1.
e Concentration corresponds to a lifetime cancer risk of 10^{-6}.
f Interim soil cleanup level for soil on sites characterized as residential. USEPA, August 29, 1991, Update on OSWER Soil Lead Cleanup Guidance, OSWER Directive 9355.4-02a.
g Risk based concentration based on the soil ingestion pathway may not be appropriate because of potentially greater inhalation toxicity.
h Highest of triplicate results for lead. The other two values reported for this sample were 330 mg/kg and 80.8 mg/kg.

Key:

NC = Not calculated.
ND = Not detected.
NR = Not reported.

Table 6-3

SUMMARY OF ORGANIC CHEMICAL RESULTS FOR FORT GREELY GFTP-4A (mg/kg)

Chemical	Region 10 RBC[a]	Surface and Near-Surface Soils			Subsurface Soils		
		Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency	Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency
VOCs							
Benzene	20[c]	0/10	—	0/10	4/25	12	0/25
Ethylbenzene	30,000[b]	1/10	0.073	0/10	3/25	120	0/25
Toluene	50,000[b]	0/10		0/10	3/25	260	0/25
Xylenes	500,000[b]	2/10	0.760	0/10	4/25	920	0/25
Acetone	NC	NA	—	—	1/2	0.026	—
Methylene Chloride	90[c]	NA	—	—	2/2	0.007	0/2
BNAs							
Acenaphthene	2,000[b]	0/9	—	0/9	1/5	0.200	0/5
Anthracene	10,000[b]	0/9	—	0/9	1/5	0.064	0/5
Benzo(a)anthracene	0.09[c]	4/9	15.0	4/9	5/23	3.90	5/23
Benzo(b)fluoranthene	0.09[c]	4/9	33.0	4/9	5/23	6.60	5/23
Benzo(k)fluoranthene	0.09[c]	4/9	18.0	4/9	5/23	630	5/23
Benzo(a)pyrene	0.09[c]	5/9	32.0	5/9	6/23	8.40	6/23
Benzo(ghi)pyrene	NC	5/9	25.0	—	6/23	7.30	—
Chrysene	0.09[c]	5/9	20.0	5/9	6/23	6.20	6/23
Fluoranthene	10,000[b]	5/9	19.0	0/9	6/23	4.80	0/23

Key at end of table.

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Table 6-3

SUMMARY OF ORGANIC CHEMICAL RESULTS FOR FORT GREELY GFTP-4A (mg/kg)

Chemical	Region 10 RBC[a]	Surface and Near-Surface Soils			Subsurface Soils		
		Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency	Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency
Indeno(1,2,3-cd)pyrene	0.09[c]	4/9	22.0	4/9	8/23	6.50	8/23
2-Methyl naphthalene	NC	0/9	—	—	3/23	55.0	—
Naphthalene	10,000[b]	0/9	—	0/9	3/23	43.0	0/23
Phenanthrene	NC	2/9	4.70	—	2/23	0.260	—
Pyrene	8,000[b]	5/9	19.0	0/9	6/23	2.20	0/23
Pesticides/PCBs							
4,4'-DDD	3[c]	5/10	0.190	0/10	5/21	0.100	0/21
4,4'-DDE	2[c]	1/10	0.033	0/10	0/21	—	0/21
4,4'-DDT	2[c]	3/10	0.390	0/10	6/21	0.230	0/21
Dioxins/Furans							
2,3,7,8-TCDD equivalents	4×10^{-6}[c]	1/5	1.3×10^{-7}	0/5	1/4	3.3×10^{-6}	0/4

[a] Based on residential exposure by soil ingestion route. USEPA Region 10, October 1992, Human Health-based Risk Concentration, Revised Cheat Sheets, Seattle, WA.
[b] Concentration corresponds to a noncancer hazard index of 1.
[c] Concentration corresponds to a lifetime cancer risk of 10^{-6}.

Key:

NA = Not analyzed.
NC = Not calculated. No approved toxicity index.

19:KM5900_A199_T63-09/23/93-F1

Table 6-4

SUMMARY OF ORGANIC CHEMICAL RESULTS FOR FORT GREELY
GFTP-4B (mg/kg)

Chemical	Region 10 RBC[a]	Surface and Near-Surface Soils			Subsurface Soils		
		Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency	Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency
VOCs							
Benzene	20[c]	1/15	0.017	0/15	11/65	0.550	0/65
Ethylbenzene	30,000[b]	0/15	—	0/15	5/65	0.280	0/65
Toluene	50,000[b]	7/15	0.013	0/15	21/65	1.4	0/65
Xylenes	500,000[b]	2/15	0.015	0/15	12/65	1.5	0/65
Acetone	NC	NA	—	—	3/8	0.006	—
Chloroform	100[c]	NA	—	—	2/8	0.001	0/8
Methylene Chloride	90[c]	NA	—	—	5/8	0.008	0/8
Tetrachloroethene	10[c]	NA	—	—	4/8	0.177	0/8
1,1,1-Trichloroethane	20,000[b]	NA	—	—	1/8	0.013	0/8
BNAs							
Benzo(a)anthracene	0.09[c]	NA	—	—	1/8	0.050	0/8
Chrysene	0.09[c]	NA	—	—	1/8	0.060	0/8
Pyrene	8,000[b]	NA	—	—	1/8	0.190	0/8
Pentachlorophenol	5[c]	NA	—	—	1/8	0.225	0/8

Key at end of table.

19:KM5900_A199_T64-09/23/93-F1

Table 6-4

SUMMARY OF ORGANIC CHEMICAL RESULTS FOR FORT GREELY GFTP-4B (mg/kg)

Chemical	Region 10 RBC[a]	Surface and Near-Surface Soils			Subsurface Soils		
		Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency	Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency
Pesticides/PCBs							
4,4'-DDD	3[c]	9/16	220[d]	3/16	16/71	140	4/71
4,4'-DDE	2[c]	12/16	6.2[e]	2/16	3/71	2.90	1/71
4,4'-DDT	2[c]	16/16	85.0[f]	13/16	17/71	150	4/71
Dioxins/Furans							
2,3,7,8-TCDD equivalents	4×10^{-6}[c]	7/7	2.99×10^{-5}[g]	5/7	0/6	—	—

a Based on residential exposure by soil ingestion route. USEPA Region 10, October 1992, Human Health-based Risk Concentration, Revised Cheat Sheets, Seattle, WA.
b Concentration corresponds to a noncancer hazard index of 1.
c Concentration corresponds to a lifetime cancer risk of 10^{-6}.
d Highest of triplicate results for DDD; the other two values reported for this sample were 170 mg/kg and <1.9 mg/kg.
e Highest of triplicate results for DDE; DDE was not detected in the other two replicates.
f Highest of triplicate results for DDT; the other two values reported for this sample were 51 mg/kg and 48 mg/kg.
g Highest of triplicate results for TCDD equivalents. The other two values reported for this sample were 1.7×10^{-5} mg/kg and 3.5×10^{-6} mg/kg.

Key:

NA = Not analyzed.
NC = Not calculated. No approved toxicity index.

Table 6-5

SUMMARY OF ORGANIC CHEMICAL RESULTS FOR FORT GREELY
GFTP-4D (mg/kg)

Chemical	Region 10 RBC[a]	Surface and Near-Surface Soils			Subsurface Soils		
		Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency	Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency
VOCs							
Benzene	20[c]	0/9	—	0/9	0/32	—	—
Ethylbenzene	30,000[b]	0/9	—	0/9	0/32	—	—
Toluene	50,000[b]	1/9	0.008	0/9	5/32	0.011	0/32
Xylenes	500,000[b]	0/9	—	0/9	5/32	0.029	0/32
Acetone	NC	1/1	0.013	—	3/6	0.029	—
Chloroform	100[c]	1/1	0.001	0/1	1/6	0.001	0/6
Tetrachloroethene	10[c]	0/1	—	0/1	4/6	0.182	0/6
1,1,1-Trichloroethane	20,000[b]	0/1	—	0/1	2/6	0.015	0/6
Pesticides/PCBs							
4,4'-DDD	3[c]	4/11	41.0	1/11	6/24	4.80[d]	1/25
4,4'-DDE	2[c]	3/11	0.250	—	3/24	2.80[d]	1/25
4,4'-DDT	2[c]	8/11	63.0	7/11	17/24	34.0[d]	4/25
4,4-Endrin	80[b]	0/11	—	—	2/24	0.340	0/25

Key at end of table.

19:KM5900_A199_T65-09/23/93-F1

Table 6-5

SUMMARY OF ORGANIC CHEMICAL RESULTS FOR FORT GREELY
GFTP-4D (mg/kg)

Chemical	Region 10 RBC[a]	Surface and Near-Surface Soils			Subsurface Soils		
		Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency	Detection Frequency	Maximum Concentration	Region 10 RBC Exceedance Frequency
Dioxins/Furans							
2,3,7,8-TCDD equivalents	4×10^{-6}[c]	1/9	2×10^{-7}	0/9	0/8	—	—

a Based on residential exposure by soil ingestion route USEPA Region 10, October 1992, Human Health-based Risk Concentration, Revised Cheat Sheets, Seattle, WA.

b Concentration corresponds to a noncancer hazard index of 1.

c Concentration corresponds to a lifetime cancer risk of 10^{-6}.

d Highest of triplicate results for DDD, DDE and DDT. DDE and DDT were reported as ND in the other two replicates. The other two DDT values reported for this sample were 33 mg/kg and 18 mg/kg.

Key:

NC = Not calculated. No approved toxicity index.

Table 6-6

SUMMARY OF METALS RESULTS FOR FORT GREELY FTPs

Chemical	Local Background concentration[a]	90th Percentile for Western Soils[b]	Region 10 RBC[c]	Detection Frequency	Maximum Concentration	90th Percentile Exceedance Frequency	Region 10 RBC Exceedance Frequency
Aluminum	7,950	141,000	NC	16/16	15,700	0/16	—
Arsenic	11.4	13.2	0.4[e]	16/16	13.9	1/16	16/16
Barium	122	1,162	20,000[d]	16/16	132	0/16	0/16
Calcium	2,420	75,200	NC	16/16	5,380	0/16	—
Chromium	8.6	112	NC[g]	16/16	25	0/16	—
Cobalt	7.9	16.9	NC	16/16	8.6	0/16	—
Copper	13.0	53.4	10,000[d]	16/16	44.7	0/16	0/16
Iron	19,100	49,400	NC	16/16	24,800	0/16	—
Lead	14.9	36.1	500[f]	135/135	746[h]	19/135	1/135
Magnesium	2,740	20,500	NC	16/16	5,540	0/16	—
Manganese	211	912	30,000[d]	16/16	457	0/16	0/16
Nickel	15.2	38.8	5,000[d]	16/16	32.0	0/16	0/16
Potassium	916	34,400	NC	16/16	2,820	0/16	—
Sodium	22,800	22,800	NC	16/16	418	0/16	—
Vanadium	195	195	2,000[d]	16/16	43	0/16	0/16
Zinc	116	116	80,000[d]	16/16	51.4	0/16	0/16

Key at end of table.

19:KM5900_A199-_T66-09/23/93-F1

OUA 0001433

Table 6-6 (Cont.)

a Higher of the results for two local background soil samples.

b Schacklette and Boerngen, 1984, USGS Paper 1270.

c Based on residential exposure by soil ingestion route USEPA Region 10, October 1992, Human Health-based Risk Concentration, Revised Cheat Sheets, Seattle, WA.

d Concentration corresponds to a noncancer hazard index of 1.

e Concentration corresponds to a lifetime cancer risk of 10^{-6}.

f Interim soil cleanup level for soil and sites characterized as residential. USEPA, August 29, 1991, Update on OSWER Soil Lead Cleanup Guidance, OSWER Directive 9355.4-02a.

g Risk-based concentration based on the soil ingestion pathway may not be appropriate because of potentially greater inhalation toxicity.

h Highest of triplicate results for lead. The other two values reported for this sample were 330 mg/kg and 200 mg/kg.

Key:

NC =Not calculated.

Table 6-7

FREQUENCY OF DETECTION AND RANGE OF CONCENTRATIONS FOR INORGANIC CHEMICALS OF POTENTIAL CONCERN (1991) FORT GREELY, ALASKA

Inorganic Chemical	Region 10 RBC	Highest Background Sample (mg/kg)	Number of Samples in Which the Concentration Exceeded the Background Concentration	Sample Medium[a]	Value/Range of Concentrations Above the Background Concentration (mg/kg)
Aluminum	—	7,950	4 / 34	Subsurface soil	8,480 - 15,700
Barium	20,000	122	2 / 34	Subsurface soil	127 - 132
Cobalt	—	7.9 7.9	1 / 34 2 / 34	Surface soil Subsurface soil	8.6 8 - 10
Copper	10,000	13.0 13.0	17 / 34 1 / 34	Subsurface soil Surface soil	13.3 - 44.7 14.5
Iron	—	19,100	1 / 34	Subsurface soil	24,800
Lead	500[b]	14.9	4 / 34	Subsurface soil	16 - 29
Manganese	30,000	211 211	1 / 34 16 / 34	Surface soil Subsurface soil	358 218 - 457
Vanadium	2,000	23.0 23.0	6 / 34 1 / 34	Subsurface soil Surface soil	23.1 - 43 24.5

[a] Subsurface soil samples were collected 4.5 to 16.5 feet below ground surface. Surface soil samples were collected 0 to 3 feet below ground surface.
[b] EPA OSWER directive risk-based benchmark.

Key:

— = No Region 10 RBC available.

Source: Ecology and Environment, Inc. 1993.

19:KM5900_A199_T67-09/23/93-F1

7. REMEDIAL OPTIONS

The analysis of remedial options for the Fort Richardson and Fort Greely fire training pits (FTPs) was conducted in six phases. These phases are described below.

- **Summary and Basis for Remedial Action** — This phase summarizes the information discussed in Sections 5 and 6 to identify the contaminants requiring remedial action. A presentation of the identified contaminants, concentrations, and assumed action levels will provide a basis for development of remedial action recommendations;

- **Development of Remedial Action Objectives** — This phase identifies the remedial goals, which were developed based on site- and contaminant-specific information and Alaska Department of Environmental Conservation (ADEC) and United States Environmental Protection Agency (EPA) cleanup requirements;

- **Identification of Applicable Remedial Options** — This phase initiates the process of remedial option selection. All applicable options are identified and summarized;

- **Prescreening of Applicable Remedial Options** — This phase determines the viability of options and selects options for a more detailed analysis. Options are prescreened based on proven performance, technical feasibility, ability to meet remedial action objectives and cleanup requirements, and ability to protect human health and the environment;

- **Analysis of Selected Alternatives** — This phase includes a more detailed, site-specific analysis of prescreened options. The detailed analysis evaluates the technical effectiveness, implementability, and cost of each alternative; and

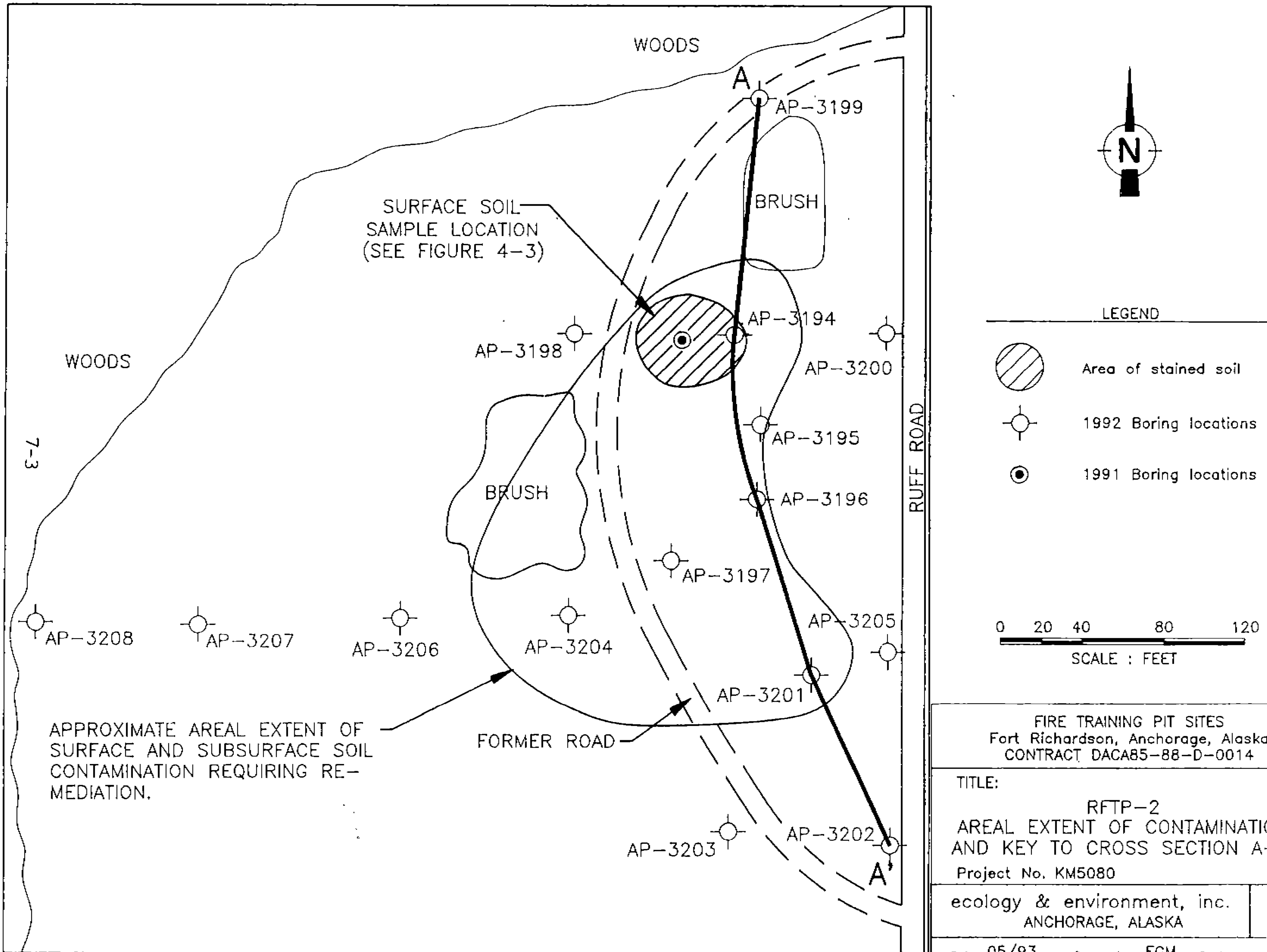
- **Comparison of Remedial Options** — This phase includes a comparison of all selected options. A remedial option is recommended for implementation at each of the two locations.

7.1 SUMMARY AND BASIS FOR REMEDIAL ACTION

As discussed in Section 5, chemical analyses were performed on soil samples collected from numerous locations at both the Fort Richardson and Fort Greely FTPs. Results from these analyses were used to define areas potentially requiring cleanup or remediation. Areas of nonunderground storage tank petroleum, oil, and lubricant (POL) contamination that exceed the ADEC cleanup levels (18 Alaska Administrative Code 75.140) were identified as described in Section 5. In Section 6, areas that may present a potential human health hazard were identified using EPA Region 10 *Supplemental Risk Assessment Guidance for Superfund*, August 16, 1991, and *Revised Cheat Sheets*, October 30, 1992, as guidelines. Analytical results from sampling activities conducted at the Fort Richardson FTPs are presented in Tables 5-2 through 5-5. Analytical results from sampling activities conducted at the Fort Greely FTPs are presented in Tables 5-6 through 5-14. Graphic representations of the nature and extent of contamination at the Fort Richardson FTPs are presented in Figures 5-1 and 5-2. Similar graphic representations for the Fort Greely FTPs are shown in Figures 5-3 through 5-8.

A summary of the nature and extent of contaminants identified for remedial action at both the Fort Richardson and Fort Greely FTPs is provided in Table 7-1. Figures 7-1 through 7-9 depict the areal and vertical extent of contamination at each of the FTPs, and with the information provided in Table 7-1, they provide the basis for the development of site-specific remedial action alternatives.

Cleanup levels for the remediation of POL-related contaminants were based on a preliminary scoring of the ADEC matrix scoresheet. All of the FTPs were classified as Level B sites; therefore, the following cleanup levels were used: diesel-range organics (200 milligrams per kilogram [mg/kg]); gasoline-range organics (100 mg/kg); benzene (0.5 mg/kg); benzene, toluene, ethylbenzene, and total xylenes (BTEX; 15 mg/kg); and total recoverable petroleum hydrocarbons (2,000 mg/kg). Cleanup levels for organochlorine pesticides are based on a total DDT concentration (DDT-T). A level of 200 mg/kg of DDT-T was used since it corresponds to an estimated cancer risk for residential exposure of 10^{-4}. Polychlorinated dioxin/furans contamination at RFTP-2 and GFTP-4B falls within EPA's guidelines for protection of public health and will not be addressed in this section.



7-3

FIRE TRAINING PIT SITES
Fort Richardson, Anchorage, Alaska
CONTRACT DACA85-88-D-0014

TITLE:

RFTP-2
AREAL EXTENT OF CONTAMINATION AND KEY TO CROSS SECTION A-A'

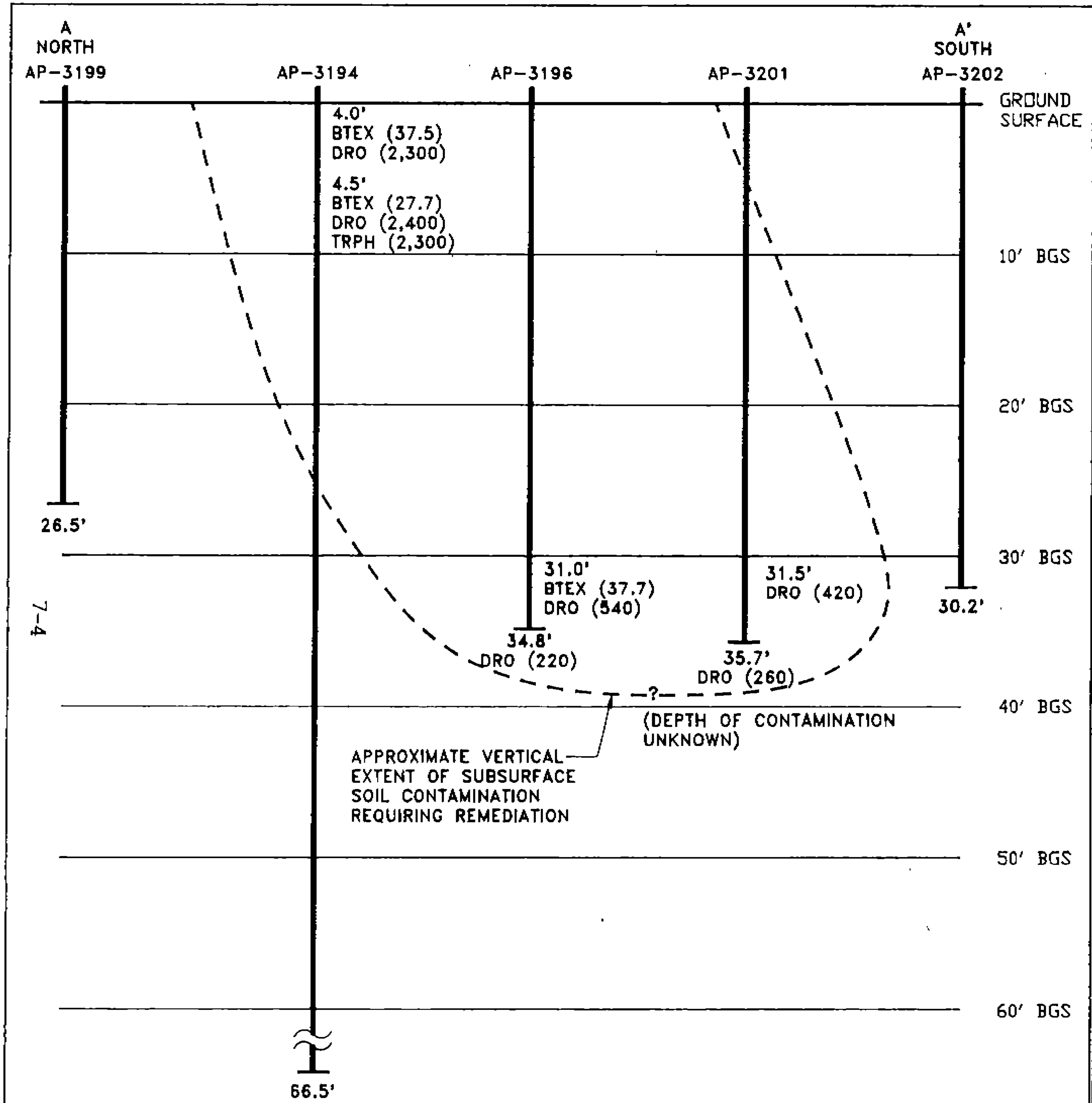
Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 7-1

Date: 05/93 Drawn by: EGM Scale:

C:\CORP\KM5080\KM5S7-1.DWG\ MAY 22, 1993



LEGEND

HORIZONTAL SCALE: 1"=60'
VERTICAL SCALE: 1"=10'

COMPOUND CONCENTRATIONS IN mg/Kg

FIRE TRAINING PIT SITES
Fort Richardson, Anchorage, Alaska
CONTRACT DACA85-88-D-0014

TITLE:

RFTP-2
CROSS SECTION A-A'

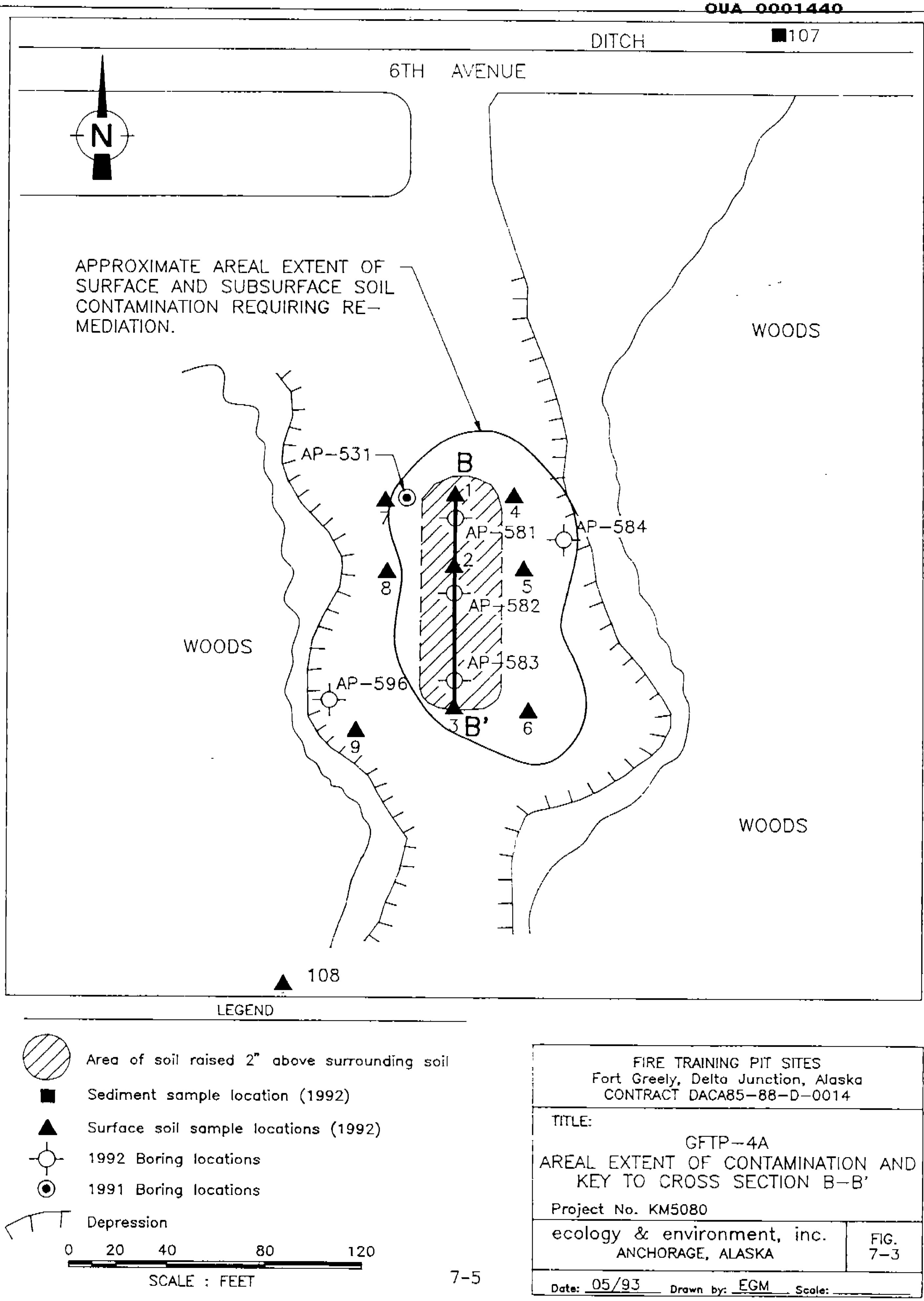
Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 7-2

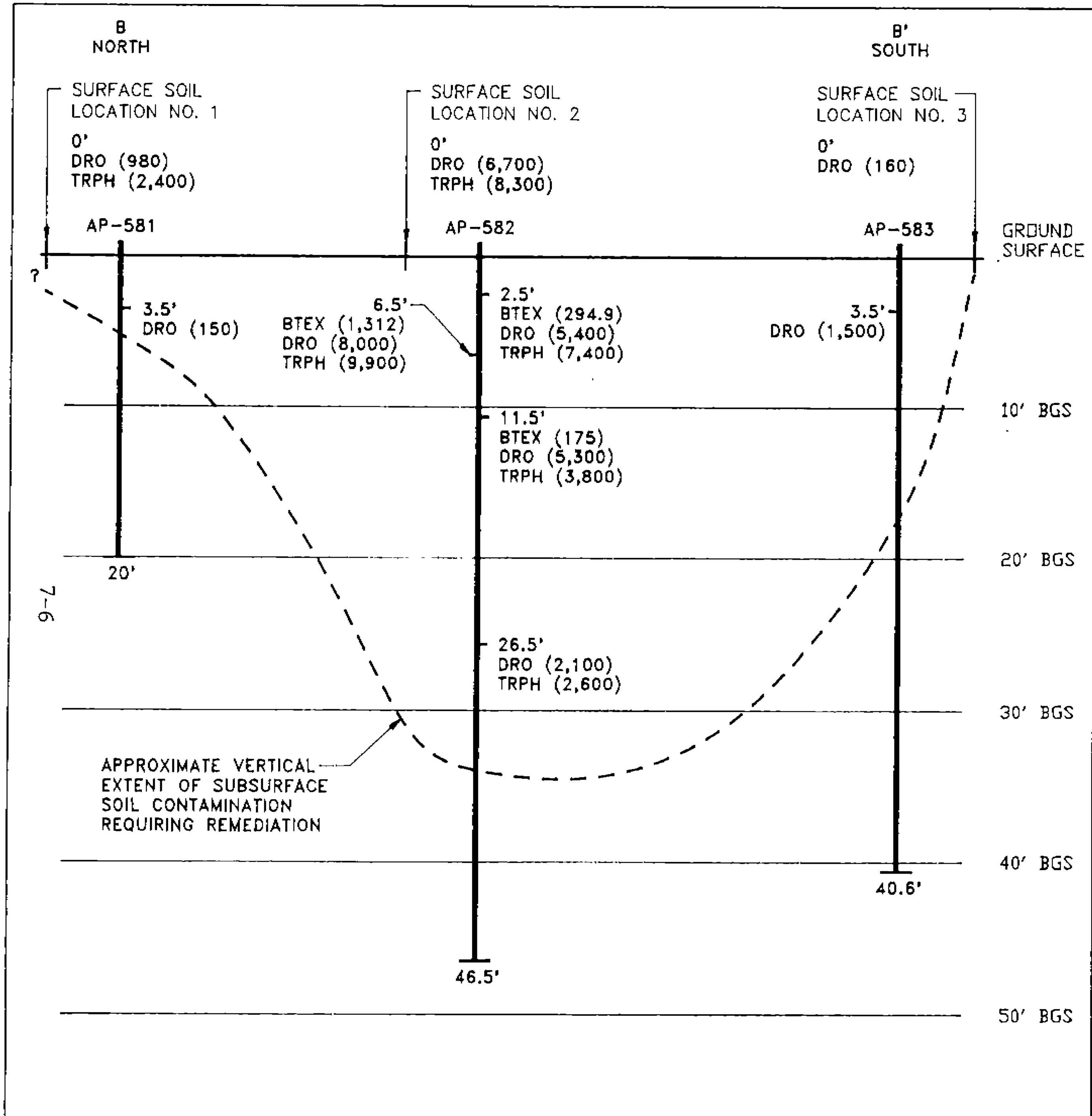
Date: 05/93 Drawn by: EGM Scale:

C:\CORP\KM5080\KM5S7-2.DWG\ MAY 22, 1993



FIRE TRAINING PIT SITES Fort Greely, Delta Junction, Alaska CONTRACT DACA85-88-D-0014	
TITLE: GFTP-4A AREAL EXTENT OF CONTAMINATION AND KEY TO CROSS SECTION B-B' Project No. KM5080	
ecology & environment, inc. ANCHORAGE, ALASKA	FIG. 7-3
Date: 05/93 Drawn by: EGM Scale:	

C:\CORP\KM5080\KM5S7-3.DWG\MAY 25,1993



LEGEND

HORIZONTAL SCALE: 1"=15'
VERTICAL SCALE: 1"=10'

COMPOUND CONCENTRATIONS IN mg/Kg

FIRE TRAINING PIT SITES
Fort Richardson, Anchorage, Alaska
CONTRACT DACA85-88-D-0014

TITLE:

GFTP-4A
CROSS SECTION B-B'

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 7-4

Date: 05/93 Drawn by: EGM Scale:

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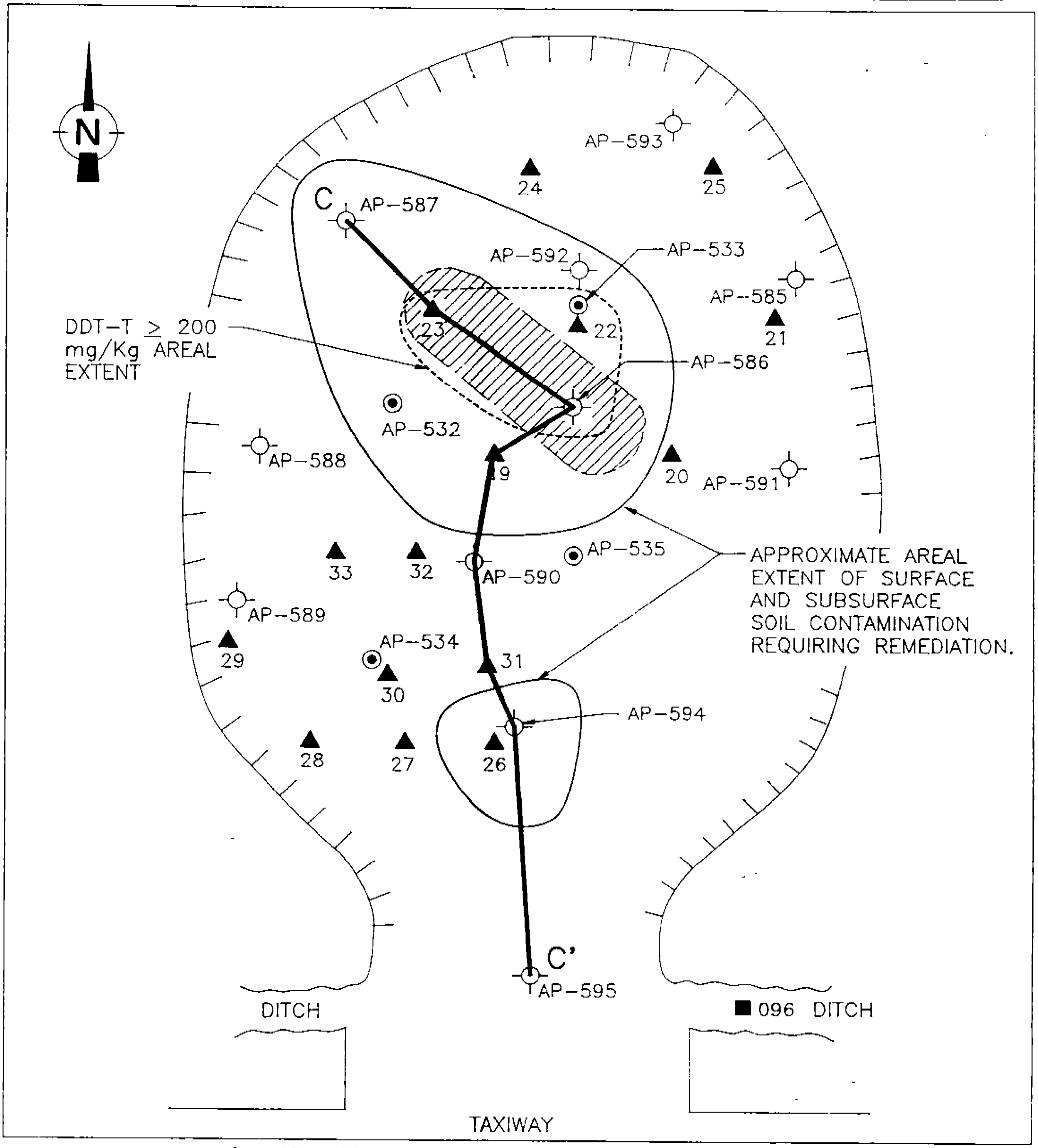

LEGEND

SCALE : FEET (0, 10, 20, 40, 60)

- Black stained soil at 2" bgs
- Sediment sample location (1992)
- Surface soil sample locations (1992)
- 1992 Boring locations
- 1991 Boring locations
- Depression
- Drainage ditch

FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85-88-D-0014

TITLE:
GFTP-4B
AREAL EXTENT OF CONTAMINATION AND KEY TO CROSS SECTION C-C'

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 7-5

Date: 05/93 Drawn by: EGM Scale: ______

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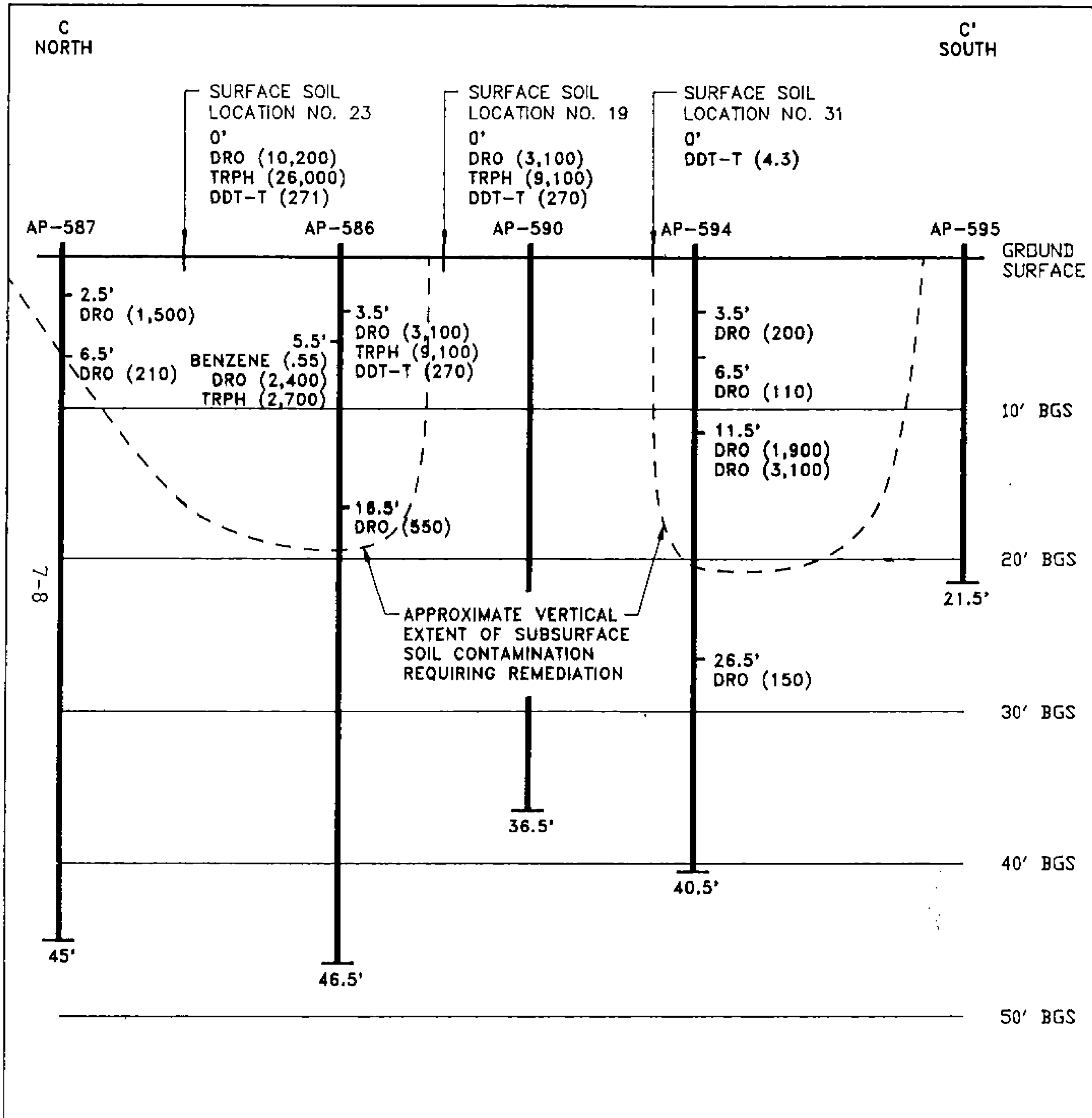

LEGEND

HORIZONTAL SCALE: 1"=27'
VERTICAL SCALE: 1"=10'

COMPOUND CONCENTRATIONS IN mg/Kg

FIRE TRAINING PIT SITES
Fort Richardson, Anchorage, Alaska
CONTRACT DACA85-88-D-0014

TITLE:

GFTP-4B
CROSS SECTION C-C'

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 7-6

Date: 05/93 Drawn by: EGM Scale:

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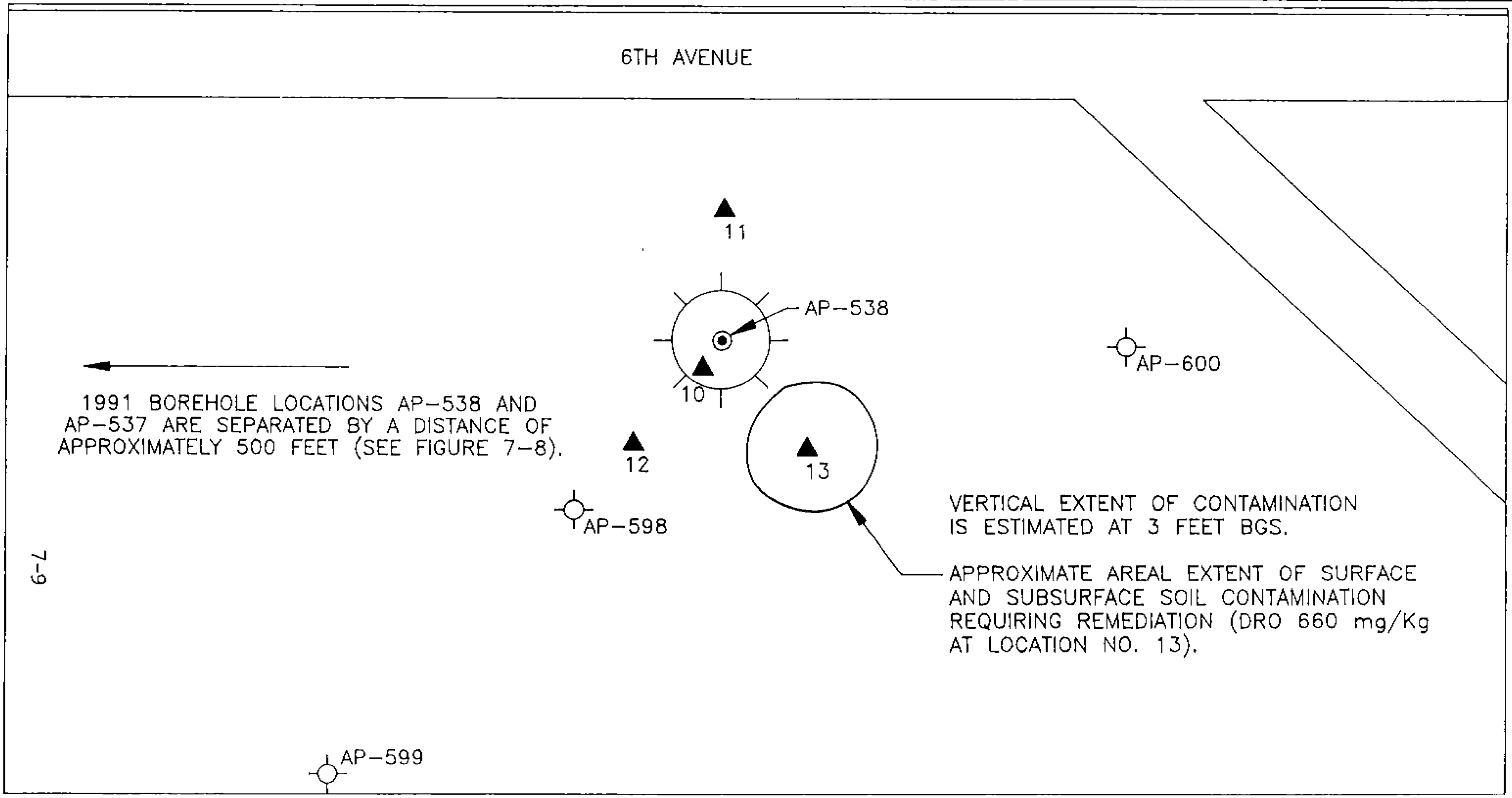

LEGEND

- 1992 Boring locations
- 1991 Boring locations
- Surface soil sample locations (1992)
- Raised area

N

0 4 8 12
SCALE : FEET

FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85-88-D-0014

TITLE:
GFTP-4D (EAST)
AREAL EXTENT OF CONTAMINATION

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 7-7

Date: 05/93 Drawn by: EGM Scale:

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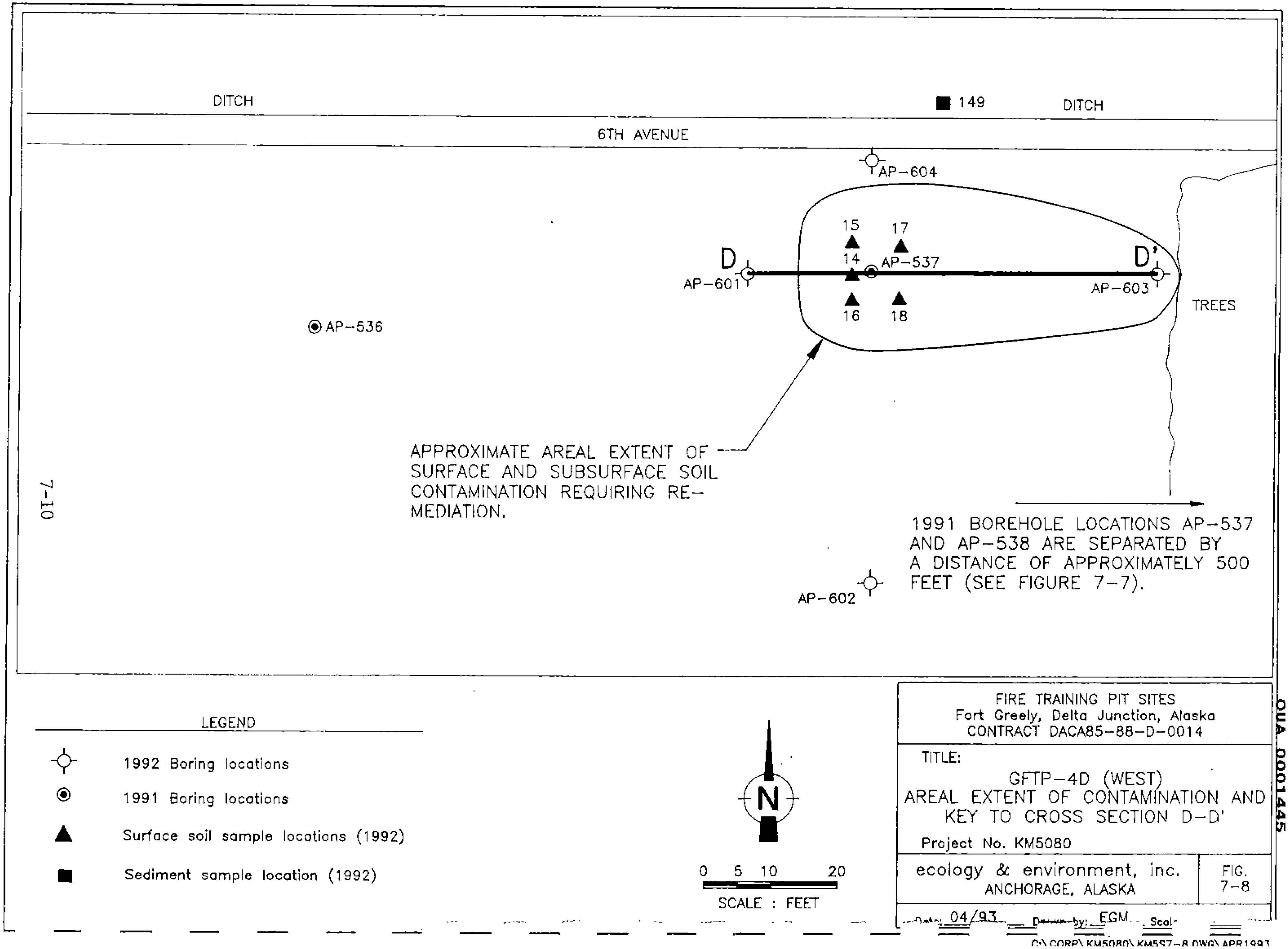
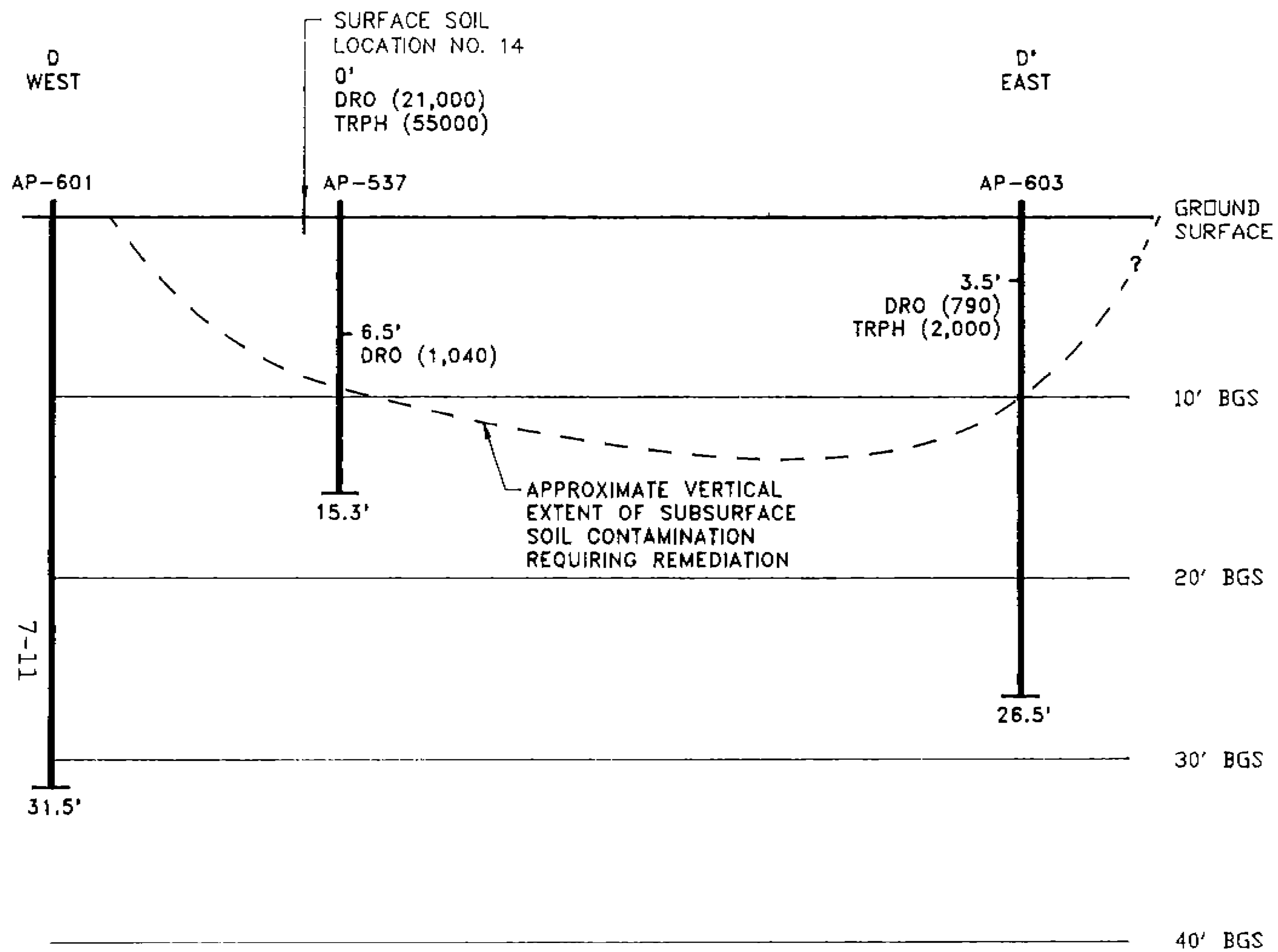

DITCH
149
DITCH
6TH AVENUE
AP-604
15
17
D
14
AP-537
D'
AP-601
AP-603
16
18
TREES
AP-536
APPROXIMATE AREAL EXTENT OF SURFACE AND SUBSURFACE SOIL CONTAMINATION REQUIRING RE-MEDIATION.
1991 BOREHOLE LOCATIONS AP-537 AND AP-538 ARE SEPARATED BY A DISTANCE OF APPROXIMATELY 500 FEET (SEE FIGURE 7-7).
AP-602
LEGEND
1992 Boring locations
1991 Boring locations
Surface soil sample locations (1992)
Sediment sample location (1992)
N
0 5 10 20
SCALE : FEET
FIRE TRAINING PIT SITES
Fort Greely, Delta Junction, Alaska
CONTRACT DACA85-88-D-0014
TITLE:
GFTP-4D (WEST)
AREAL EXTENT OF CONTAMINATION AND
KEY TO CROSS SECTION D-D'
Project No. KM5080
ecology & environment, inc.
ANCHORAGE, ALASKA
FIG.
7-8
04/93
EGM



7-11

LEGEND

HORIZONTAL SCALE: 1"=25'
VERTICAL SCALE: 1"=10'

COMPOUND CONCENTRATIONS IN mg/Kg

FIRE TRAINING PIT SITES
Fort Richardson, Anchorage, Alaska
CONTRACT DACA85-88-D-0014

TITLE:

GFTP-4D WEST
CROSS SECTION D-D'

Project No. KM5080

ecology & environment, inc.
ANCHORAGE, ALASKA

FIG. 7-9

Date: 05/93 Drawn by: EGM Scale:

7.2 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

The objective of remedial actions at Fort Richardson and Fort Greely FTPs is to protect human health and the environment, and based on site-specific information, to propose remedial technologies to meet all federal and state regulatory cleanup requirements for contaminated soils.

Based on the site-specific nature and extent of contamination referred to above, specific objectives for remediation of the FTPs include the following:

- Remediate soil contaminated with POLs and organochlorine pesticides to satisfy both EPA and ADEC cleanup requirements;
- Prevent migration of contaminants for which removal or destruction is not feasible;
- Provide adequate protection to human health and the environment; and
- To the extent practicable, enhance or maintain conditions associated with future site uses.

7.3 IDENTIFICATION OF APPLICABLE REMEDIAL OPTIONS

Remedial options for the Fort Richardson and Fort Greely FTPs were developed based on data collected during the field investigations conducted by Ecology and Environment, Inc. (E & E). Based on the results of the field investigations, groundwater was not affected by releases at the sites (see Table 7-1). The remedial options chosen for analysis will address contaminants and action levels presented in Section 7.1 for remediation of hazardous materials in soils.

To accomplish the above objectives, nine remedial options were identified as potentially applicable to the sites. Where required, the remedial options were developed assuming that the sites would not be in use during the remedial period, but that future land use would be required at a later date. For this reason, both *in situ* and *ex situ* treatment technologies were explored. Options for remediating soil contamination at the four sites are summarized below.

7.3.1 Option 1: No Action

The no-action alternative is included as a baseline for comparison to potentially active remedial options. The no-action alternative could only be justified if quantitative risk assessment results determine that there is no significant risk posed by leaving the contaminants in place. Implementation of this option is subject to regulatory agency approval.

Since no active treatment would be done under this option, fate and transport of the contaminants would be subject only to the natural processes under existing conditions.

7.3.2 Option 2: Vacuum Extraction/Bioventing

The vacuum extraction or soil-venting process is a contaminant separation technique for the removal of volatile organic compounds (VOCs) from unsaturated soils. Extraction wells are installed in or around the defined contamination zone. Air flow is induced through the contaminated soils by connecting a vacuum system to the extraction wells, and if needed, injecting air through a system of injection wells. VOCs are stripped and volatilized from the soil matrix into the air stream, which then can be treated by activated carbon canisters or discharged directly into the atmosphere, depending on concentration (EPA 1988b). Increasing the vacuum enhances the volatilization of VOCs by increasing their partial pressure in the air stream.

Since POLs contain a nonvolatile fraction that cannot be stripped, bioventing would be used in addition to the vacuum extraction process. Bioventing involves introducing or enhancing indigenous subsurface microorganisms to completely degrade or transform soil contaminants into more innocuous forms (carbon dioxide, biomass, and water). If satisfactory indigenous microbes are not present, adapted or engineered microbes can be added along with an appropriate amount of nutrients (Major and Fitchko 1990). Bioventing requires identifying and alleviating factors that potentially could limit microbial activity. These factors can include microbes in insufficient numbers, insufficient moisture, unsatisfactory pH, lack of nutrients, unsatisfactory temperature, and insufficient or toxic contaminant concentrations (EPA 1990b). Nutrients, pH adjusters, and possibly microbes would be added by allowing an aqueous solution to infiltrate the contaminated zone. This technique relies heavily on controlling adequate mixing of microbes, nutrients, and contaminants. Because of the air flow generated by the vacuum extraction, microbes capable of aerobic respiration would be required.

7.3.3 Option 3: Land Farming

Land farming involves spreading contaminated soil in a thin layer (1 feet to 2 feet) at the ground surface and periodically tilling the soil to aerate the soil and stimulate bioremediation. Biological activity can be enhanced by the addition of microbes, nutrients, water, and pH adjusters. Volatilization, chemical degradation, and photochemical degradation processes also occur during land farming operations.

Cell bioremediation is a variation of land farming in which the contaminated soil is placed in a liner, tank, pad, or other structure designed to completely contain any leachate that may be generated.

Effective land farming is limited by many of the same factors explained in Option 2.

7.3.4 Option 4: Soil Flushing

The soil flushing process is a contaminant separation technique that removes contaminants from the *in situ* soils by extraction with a washing fluid or elutriate. The elutriate is usually water; however, additives such as acids, bases, surfactants, chelating agents, reducing agents, or oxidizing agents can be added to aid in the removal and separation of contaminants from the soil (EPA 1988b). The extracted contaminants are collected at an extraction well or infiltration gallery and then can be separated from the washing fluid by liquid treatment technologies. The wash fluid then can be either reinjected back into the ground or disposed of appropriately. The effectiveness of soil flushing depends on soil characteristics, site hydrology/hydrogeology, and the nature and extent of contamination. The most important factors include the homogeneity, permeability, and hydrogeology of the contaminated zone, and selection of a suitable type and amount of elutriate. The extraction system must be located such that elutriate flow is completely controlled to ensure that flushed contaminants and elutriates do not migrate into zones that are beyond the influence of the system.

7.3.5 Option 5: Soil Washing

The soil washing process can be implemented in much the same manner as soil flushing except that soil washing is performed *ex situ* and thus requires excavation and replacement or disposal of contaminated/treated soils. Unlike soil flushing, soil washing is a physical/chemical separation technology in which the excavated soil is pretreated to remove large objects and to break up soil clods. The pretreated soil then is washed with fluids to remove contaminants, either by transferring the contaminants to the wash fluid or by concentrating the contaminants using size separation techniques. Typically, soil washing systems incorporate a four-stage process in which screened or otherwise pretreated soils are mixed with an appropriate amount of wash fluid and energetically mixed by high-pressure water jets, counterflow, or vibration, forcing contaminated soil to come into contact with the wash fluid. The contaminants are dispersed in the wash water, and the wash water is separated from the solids and recycled following treatment. Standard wastewater treatment technologies typically are used to treat contaminated wash water, and if the remaining volume of soil contains hazardous constituents, these can be treated further by other techniques or disposed of appropriately. Unlike soil flushing, recovery of the wash water is simplified because complex subsurface extraction procedures are not required.

7.3.6 Option 6: Low-Temperature Thermal Desorption

This technology is an *ex situ* thermal separation process designed to remove organic contaminants from soils. Because of the lower operating temperatures and gas-flow rates, this process is less expensive than incineration.

An externally fired rotary dryer is used to volatilize the moisture and organic contaminants. The processed solids then are cooled with condensed water to eliminate dust. The feed rate, dryer temperature, and residence time of the materials in the dryer can be adjusted to control the degree of contaminant removal. The organic contaminants and water vapor produced from volatilization then enter a secondary chamber where the contaminants are incinerated. The products of combustion and the water vapor are condensed into a liquid in the heat exchangers.

7.3.7 Option 7: *Ex situ* Incineration

High-temperature incineration of solid wasted typically is performed using rotary kiln incinerators. This technology involves burning the contaminated soils at temperatures ranging from 1,500°F to 2,900°F in refractory-lined cylinders fueled by natural gas, oil, or pulverized coal. The cylinder is rotated to facilitate mixing of wastes with combustion air and to promote transfer of wastes through the reactor. Constant rotation of the kiln provides continuous exposure of fresh surfaces to oxidation and promotes contaminant destruction. A conventional rotary kiln includes the kiln and a secondary combustion chamber. However, a more involved application would include a waste drying and ignition section in addition to the kiln and secondary combustion chamber. Contaminants are vaporized and destroyed during the incineration process.

7.3.8 Option 8: Off-Site Land Disposal

Off-site land disposal involves the excavation, transport, and disposal of contaminated or partially treated soils at an approved landfill. Excavation of the contaminated soils can be accomplished with standard construction equipment such as excavators and loaders. Transportation of the soils to the landfill could then be accomplished by truck, barge, or train. Land disposal of soils at Fort Richardson and Fort Greely may require pretreatment or volume reduction. This alternative does not treat, immobilize, or destroy the contaminants. Potential adverse human health and environmental effects are limited to short-term impacts during excavation, pretreatment, and transportation. These impacts would include fugitive dust emissions, noise, increased traffic, and possible contaminant migration.

7.3.9 Option 9: Capping

Capping, paving, or surface sealing involves the installation of a barrier over the contaminated soil to restrict direct contact, wind entrainment, and erosion, and if required, to reduce surface water infiltration. A cap also can be used to prevent short-circuiting or bypassing of the air stream during the vacuum extraction process. In general, capping isolates the contaminated soil from potential receptors, controls off-site migration, and can provide necessary ground cover for revegetation. Capping usually is performed when excavation, treatment, or removal of contaminants is not suitable because of potential hazards during excavation, lack of another suitable treatment technology, and/or excessive treatment costs of other technologies.

7.4 PRESCREENING OF APPLICABLE REMEDIAL OPTIONS

All remedial action options presented above will be prescreened to determine each option's viability and to identify the remedial options that warrant more detailed evaluation. Because this evaluation involves five sites at two locations (one at Fort Richardson and four at Fort Greely), each location will be matched with four to five of the most appropriate remedial options, including the no-action option. Each site will be discussed independently when necessary. The remedial options will be evaluated for the following prescreening requirements:

- Proven performance;
- Technical feasibility;
- Ability to meet remedial action objectives and cleanup levels; and
- Ability to protect human health and the environment.

7.4.1 Fort Richardson

RFTP-2 is contaminated with gasoline constituents, kerosene, and diesel-range oils to depths of approximately 36 feet. The contaminants appear to have migrated vertically in the area of stained soil and then migrated laterally at depth (see Figures 5-1 and 5-2). Because of the subsurface configuration of the contamination, substantial volumes of clean soil would require removal in order to excavate down to the contaminated soils. The following *in situ* and *ex situ* remedial options will be prescreened for implementation at RFTP-2:

- No action;
- Vacuum extraction/bioventing;
- Land farming;
- Soil flushing; and
- Soil washing with low-temperature thermal desorption (LTTD).

7.4.1.1 No Action

The use of the no-action option at this site would require justification of alternate cleanup levels (ACLs) at or above the contaminant levels existing at the site. Based on preliminary observations of the soil type, the significant depth to groundwater, the fact that the contaminants are not the result of a recent spill, and the lack of significant amounts of highly mobile contaminants, the use of ACLs at this site is feasible. However, the calculated ACLs may not result in justification for no action, but would almost certainly result in higher cleanup levels than are calculated using the ADEC matrix score sheet.

7.4.1.2 Vacuum Extraction/Bioventing

In situ vacuum extraction is a proven and reliable technology for separating and removing the volatile fraction of POLs. When vacuum extraction is combined with bioventing, the nonvolatile fraction can be degraded as well. The highly permeable gravels and sands that underlie the site will allow excellent subsurface air flow and infiltration of nutrients, microbes, etc. A system of injection and extraction wells would be installed to control the subsurface movement of air, which would enhance bioremediation of nonvolatile contaminants and remove volatile contaminants. This combination of volatile separation and nonvolatile bioremediation is technically feasible under conditions that exist at RFTP-2. The vacuum extraction/bioventing option is theoretically capable of meeting the remedial action objectives and cleanup levels. This option is viable for remediation of RFTP-2, and therefore it will be retained for further analysis.

7.4.1.3 Land Farming

Land farming is a process that involves excavating the contaminated soils, placing them in a constructed bioremediation cell, and providing an environment in which biodegradation can occur readily. Land farming is proven to be an effective method of remediating POL-contaminated soils. Factors that affect successful land farming, such as indigenous microbial populations, contaminant concentration, pH, nutrient availability, moisture content, and available oxygen, can be monitored and adjusted to provide optimal conditions for POL remediation. To minimize the quantity of soil that is land farmed, the site would require selective excavation to separate the uncontaminated overburden from the deeper contaminated soils. Adequate land space is available near the site for land farming operations. Land farming is capable of meeting the remedial action objectives, and since the process destroys the contaminants, it will provide adequate protection to human health and the environment. Therefore, the land farming option will be retained for a more detailed analysis.

Based on the above prescreening analysis, the no-action, vacuum extraction/ bioventing, soil washing with LTTD, and land farming options will be retained for a more detailed analysis. These options will be discussed further in Section 7.5.

7.4.1.4 Soil Flushing

The soil flushing technology is not proven to be effective or technically feasible on sites with conditions and contaminants similar to RFTP-2. The elutriate or wash fluid could be dispersed effectively throughout the permeable soils that underlie the site. However, the absence of a confining layer or aquitard and the presence of a deep groundwater table would make elutriate recovery difficult. Soil flushing is not proven to remove BTEX constituents to low parts per million (ppm) levels in soil. Since POL contamination cannot be separated with water alone, surfactants or solvents would be required. These elutriates pose additional hazards to the site and could add to the subsurface contamination. Insufficient data are available to evaluate this option's ability to meet the objectives of the remedial action and effectively protect human health and the environment. This option will not be retained for further analysis.

7.4.1.5 Soil Washing with Low-Temperature Thermal Desorption

Ex situ soil washing technology may be applied to separate various-size fractions to reduce the volume of contaminated wastes. The application of this technology is based on the premises that contaminants tend to be concentrated on the fine fraction, and that the contaminants associated with coarse fraction are primarily surficial and can be removed through physical scrubbing or are already below cleanup levels. POLs then could be removed from the fine fraction by additional washing with a surfactant solution or LTTD treatment. Since insufficient data are available to evaluate the use of a surfactant solution to remediate the soils to the required cleanup levels, LTTD will be evaluated for remediation of the finer fraction. To minimize the quantity of soil that is thermally desorbed, the site would require selective excavation to separate the uncontaminated overburden from the deeper contaminated soils.

Volatilization is the primary mechanism by which contaminants are removed from soils in the LTTD process. Hence, temperature and residence time achieved in a typical LTTD unit directly control those compounds that are removed. LTTD units are operated at temperatures varying from 600°F to 1,500°F. These ranges are adequate to volatilize gasoline compounds and the heavier semivolatiles found in diesel and waste oils (EPA 1991). Removal efficiencies ranging from approximately 93% to 99.9% were reported for BTEX- and petroleum-related semivolatile compounds. At these ranges, LTTD systems can be expected to remediate the POL-contaminated soil to the cleanup levels specified in Section 5 and provide adequate protection to human health and the environment. The combined option of soil washing and LTTD is viable for remediation of RFTP-2, and therefore will be retained for a more detailed analysis.

7.4.2 Fort Greely

The following remedial options will be prescreened for implementation at GFTP-4A, GFTP-4B, GFTP-4D East, and GFTP-4D West:

- No action;
- Vacuum extraction/bioventing with capping;
- Soil washing with LTTD and *ex situ* incineration; and
- Soil washing with LTTD and off-site land disposal.

7.4.2.1 No Action

Based on preliminary observations of the soil type, the significant depth to groundwater, the fact that the contaminants are not the result of a recent spill, and the lack of significant amounts of highly mobile contaminants, the use of ACLs at this site is feasible for soils contaminated with POLs. However, the action level for total DDT and breakdown products is risk-based and likely would not change upward. Therefore, the no-action option will not meet the objectives of the remedial action for organochlorine pesticide-contaminated soil at GFTP-4B. This option will be retained for further analysis at GFTP-4A and GFTP-4D, but will be retained only to provide a baseline for comparison at GFTP-4B.

7.4.2.2 Vacuum Extraction/Bioventing with Capping

In situ vacuum extraction is a proven and reliable technology for separating and removing the volatile fraction of POLs. When vacuum extraction is combined with bioventing, the nonvolatile fraction can be degraded by aerobic-respiring microorganisms (Major and Fitchko 1990). The highly permeable gravelly sands and sandy gravels that underlie the site will allow satisfactory subsurface airflow and infiltration of nutrients, microbes, etc. A system of injection and extraction wells would be installed to control the subsurface movement of air, which would enhance bioremediation of nonvolatile contaminants and remove volatile contaminants. This combination of volatile separation and nonvolatile bioremediation is technically feasible under conditions that exist at Fort Greely. However, the organochlorine pesticides (4,4'-DDD, 4,4'-DDE, and 4,4'-DDT) that exist on the surface and in the subsurface at GFTP-4B, GFTP-4D East, and GFTP-4D West would not be remediated by bioventing. For this reason, an impermeable long-term cap would be installed at these sites. Impermeable caps are proven successful for isolation of hazardous wastes and easily could be implemented at Fort Greely. However, placement of a cap would require future land-use restrictions on these sites. The ability of the cap to isolate extremely persistent wastes, such as 4,4'-DDT and its metabolites, depends on its long-term integrity. An adequately designed cap, combined with proper maintenance, could meet the objectives of the remedial action and effectively protect human health and the environment through isolation of the organochlorine pesticides. Therefore, this option will be retained for further analysis.

7.4.2.3 Soil Washing with LTTD and *Ex Situ* Incineration

Selective excavation and soil washing would be applied as in the previous option to separate and/or reduce the volumes of contaminated wastes. The portion of the finer fraction that is contaminated only with POLS would be treated by LTTD. The remaining soil would be shipped by truck and train, or barge, to a facility permitted to incinerate POLs and pesticides. A single soil washing and LTTD facility could be used to pretreat all four sites. This process is a viable option for implementation at Fort Greely. The contaminated soils either would be remediated or removed and destroyed, which would provide adequate protection to human health and the environment. Therefore, the combined option of soil washing, LTTD, and incineration will be retained for further analysis.

7.4.2.4 Soil Washing with LTTD and Off-Site Land Disposal

Prior to treatment of soils with this option, the contaminated soils at each of the four Fort Greely sites would require excavation. Organochlorine pesticide-contaminated soil would have to be excavated and treated separately from the POL-contaminated soils because of the different treatment methods.

The soil washing technology then would be applied to separate various-size fractions to reduce the volume of contaminated wastes. The application of this technology is based on the premises that contaminants tend to be concentrated on the fine fraction, and that the contaminants associated with coarse fraction are primarily surficial and can be removed through physical scrubbing or are already below cleanup levels. The portion of the fine fraction that is contaminated only with POLs then could be treated by LTTD. The remaining volume of soils would require off-site land disposal at a facility permitted to receive organochlorine pesticides. A single soil washing and LTTD facility could be used to pretreat all four sites. This process is a viable option for implementation at Fort Greely. The contaminated soils either would be remediated or removed to a more controlled area, which would provide adequate protection to human health and the environment. Therefore, the combined option of soil washing, LTTD, and off-site land disposal will be retained for further analysis.

7.5 ANALYSIS OF SELECTED ALTERNATIVES

The options meeting the prescreening requirements discussed in Section 7.3 were further evaluated to select the most appropriate alternatives for remediation of contaminated soils at Fort Richardson and Fort Greely. The detailed evaluation was performed in accordance with the expanded criteria descriptions presented below.

- **Technical effectiveness.** This criterion addresses both the potential effectiveness of the technologies in handling the estimated areas or volume of media, and in meeting the remediation goals identified in the remedial action objectives. The process will be evaluated for proven performance and reliability based on similar contaminants under similar site conditions;

- **Implementability.** This criterion encompasses both the technical and administrative feasibility of implementing a technology. This includes access, permitting requirements, and availability of competitive subcontractors; and

- **Costs.** The cost of each alternative will be calculated to provide an estimated cost that is accurate to -30% to +50%. Both capital cost and operation and maintenance (O & M) costs will be combined to evaluate the estimated present worth. Estimated unit costs are presented in 1993 dollars, and future costs are discounted to a common base year based on a 10% annual interest rate and an appropriate project life. A detailed cost breakdown of each remedial alternative is provided in Appendix C.

7.5.1 Fort Richardson

The options that will be evaluated for remediation of POL-contaminated soils at RFTP-2 include the following:

- No action;
- Vacuum extraction/bioventing;
- Land farming; and
- Soil washing with LTTD.

The detailed analyses of these option are presented below.

7.5.1.1 No Action

Technical effectiveness. This option does not prevent or mitigate exposure to or migration of the contaminants. Since the wastes would not be removed or actively remediated, no additional protection to human health and the environment is provided beyond what would occur naturally.

Implementability. The no-action option can be implemented at Fort Richardson through the justification of ACLs. ACLs must be supported by a contaminant leaching assessment and a risk assessment to show that the site poses no significant threat to human health, welfare, or the environment in its present state.

A soil leachability assessment will require laboratory analyses of soil samples to provide site-specific input for a computer model of contaminant migration in the unsaturated zone soils.

Costs. Contaminant leaching assessment and risk assessment costs would be incurred if this option is selected for implementation and are estimated at $100,000.

7.5.1.2 Vacuum Extraction/Bioventing

Technical effectiveness. *In situ* vacuum extraction is most effective at removing contaminants that volatilize easily. Specifically, the effectiveness is influenced by the following relationships: contaminant-air equilibrium (partial vapor pressure), equilibrium between contaminants dissolved in standing pore water and soil vapor (Henry's Law constant), and equilibrium between the contaminant dissolved in pore water and contaminant adsorbed to soil particles (soil-sorption coefficient; EPA 1987). Generally, contaminants that are amenable to vacuum extraction exhibit high vapor pressures and Henry's Law constants.

The soils at RFTP-2 exhibit favorable characteristics because they are predominantly coarse-grained and will exhibit high air conductivity. Higher flow rates and partial pressures will be attainable, and volatilization will increase.

Soils at RFTP-2 are contaminated with gasoline constituents that exhibit favorable properties for successful vacuum extraction. In addition to gasoline, the soils are contaminated with other, less volatile diesel-range oils, bunker C, and kerosene. To enhance recovery of these contaminants, air stream flow rate, partial pressure, and remediation time can be increased. Although many constituents in these heavier contaminants exhibit favorable extraction properties, they also contain constituents that are degraded more easily by bioremediation. The effectiveness of bioremediation in POL-contaminated soil depends on contaminant concentration, suitable indigenous microbial populations, pH, nutrient availability, temperature, moisture content, and available oxygen. These factors can be adjusted by infiltration of an aqueous solution containing adapted or engineered microbes to augment the indigenous population, alkaline or acidic solutions to adjust the pH to a range of 6.0 to 7.5 (Freeman 1989), nitrogen and phosphorus to provide necessary nutrients, heated air to achieve subsurface temperatures above 20°C, water to attain between 50% and 80% of saturation, and oxygen that will be available through the induction of subsurface air flow.

Specific requirements of the vacuum extraction/bioventing system will include evaluation of a treatability study and/or pilot-scale testing prior to implementation of full-scale operations. The treatability study will identify limiting conditions that exist at the site, and mitigation of the limiting factors will ensure that the cleanup requirements are met. Successful vacuum extraction/bioventing is a contaminant destruction process that converts contaminants to carbon dioxide, biomass, and water. Following complete remediation, future liabilities will be eliminated.

Implementability. The vacuum extraction/bioventing option consists of extraction wells, air injection wells (if appropriate), heaters for injected air, air treatment equipment, an infiltration gallery, centrifugal blowers with housings, piping, valves, and electrical instrumentation. The extraction and injection wells would require an installation configuration based on the results of supplemental testing/treatability studies to determine optimal vacuum flow rates and radius of influence. Air emission treatment equipment, usually granular activated carbon canisters, can be installed to treat VOC off gas, depending on concentrations.

The infiltration gallery would be installed by excavating and lining strategically located trenches with granular materials and allowing the aqueous, nutrient bearing solution to infiltrate the contaminated zones. The POL contamination at RFTP-2 is primarily in the deep subsurface and in a configuration that is favorable for vacuum extraction. The above treatment components can be implemented at RFTP-2 without access restriction or the need for permits.

Costs. The capital costs associated with the option include pilot testing and treatability studies; installation of the wells and infiltration gallery; the vacuum extraction/heated air injection system; piping; a potential off-gas treatment system; and purchase of nutrients, microbes, and pH adjusters. These capital costs are estimated to be $323,000.

O & M costs include costs associated with system maintenance and infiltration gallery operation. These costs are estimated to be $109,000 annually.

The present worth of this option is estimated to be $512,000. A detailed cost analysis of this option is included in Appendix C, Tables C-1 and C-2.

7.5.1.3 Land Farming

Technical effectiveness. The effectiveness and rate of bioremediation of petroleum-contaminated soils depends on indigenous microbial population, pH, nutrient availability, temperature, moisture content, and oxygen content. As in the other alternatives, selective excavation would be used to separate the clean soils from soils with POL contamination.

More than 200 soil microbes are capable of degrading petroleum products. Total microbial counts of fertile soils range from 10^7 to 10^9 per gram of dry soil, and hydrocarbon degraders range from 10^5 to 10^6 per gram in soils. Soils exposed to petroleum have total microbial counts ranging from 10^6 to 10^8 per gram of soil (EPA 1988). Therefore, indigenous soil microbial populations would degrade petroleum products if environmental conditions support growth. In addition, engineered or acclimated microorganisms can be introduced to enhance the process.

Soil pH can influence the rate of petroleum degradation. The pH level most conducive to microbial activity and efficiency is within the range of 6.0 to 7.5 (Freeman 1989). Optimal pH levels can be achieved by the addition of pH adjusters such as lime or acidic aqueous solutions.

The absence of soil micronutrients, such as nitrogen and phosphorus, may limit hydrocarbon degradation. The availability of micronutrients present in soils is optimum at approximately neutral pH values. Nutrient availability can be enhanced by the addition of commercial fertilizers.

Optimum temperature for the microbial degradation of hydrocarbons is above 20°C, although degradation at 4°C was reported (EPA 1988). Due to the weather conditions in Alaska, bioremediation may occur at significant rates only during spring and summer.

Microbes require water to maintain metabolic processes. The amount of water a soil contains varies with time in response to precipitation, drainage, and evapotranspiration. Optimal microbial activity occurs between 50% to 80% of water-holding capacity and is affected adversely at 10% or less (EPA 1988). Moisture content of soils can be maintained by the addition of water through sprinklers.

Oxygen availability is normally the rate-limiting factor for aerobic hydrocarbon degradation in soils. Therefore, land farming techniques include periodic tilling of soils to provide adequate oxygen to support microbial population growth.

In summary, all of the factors except temperature can be monitored and adjusted to optimize bioremediation rates. Specific requirements of the process would be estimated based on the results of a treatability study performed prior to full-scale implementation. Temperatures at the Alaska sites would limit the active season of bioremediation to approximately five months per year. Microbial degradation is proven effective at reducing POL contamination in soils, and if properly implemented, would meet remedial objectives.

Bioremediation is a contaminant-destruction process converting organics to biomass, carbon dioxide, and water.

Implementability. Implementation of land farming or cell bioremediation will require a sufficient surface area to spread 6,000 cubic yards of contaminated soil. Virtually unlimited space is available near RFTP-2 for placement of a land farm. A typical land farm treatment facility consists of a shallow excavated basin lined with an impermeable geomembrane. A drainage system of gravel and geotextile fabric would be placed above the liner. A retention basin for excess water with a pumping system also would be incorporated into the design. Contaminated soils are spread to a 2-foot depth within the bioremediation cell. Cell construction would be accomplished using standard construction equipment. Land farming could be implemented at RFTP-2 without access restrictions and the need for permits, etc.

Costs. Capital costs associated with the land farming alternative include costs for treatability studies; construction costs for a bioremediation cell capable of remediating 6,000 cubic yards of contaminated soils, costs for excavation and placement of the soils in the land farm; and purchase of nutrients, microbes (if necessary), and pH adjusters. These capital costs are estimated to be $4,470,000.

O & M costs include costs associated with the land farm maintenance, tilling for aeration, and periodic sampling. These costs are estimated to be $57,000 annually. The present worth of this option is estimated to be $4,570,000. A detailed cost analysis is included in Appendix C, Tables C-4 and C-5.

7.5.1.4 Soil Washing with Low-Temperature Thermal Desorption

Technical effectiveness. At Fort Richardson, selective excavation would be implemented to separate approximately 15,000 to 20,000 cubic yards of uncontaminated overburden from approximately 6,000 cubic yards of deeper contaminated soils. The uncontaminated soils then would be used as backfill for the excavation. Soil washing would be used on the contaminated portion to separate the coarse fraction from the contaminated finer fraction in order to reduce the volume of contaminated soils. Studies cited by EPA (USI manual) indicated that only 5% to 6% of the hydrocarbon contaminants may be associated with stone to coarse-gravel-size fractions in contaminated soils. The results of grain-size analyses at Fort Richardson indicate that a contaminated soil volume reduction of approximately 90% would occur during the mechanical separation phase; thus, only 600 cubic yards would remain contaminated following selective excavation and mechanical separation. The washed gravels and sands then should be below cleanup requirements and could be placed back into the excavation. The remaining material would be contaminated with POLs and would be treated by LTTD.

LTTD performance is affected by a number of physical soil properties including moisture content, percent fines, percent rock greater than 1 inch, and percent total organics. Increased soil moisture results in higher operating costs due to the additional heat requirements and potentially low contaminant volatilization. The finer fraction would require dewatering prior to placement in the rotary dryer. Insufficient data are available to evaluate LTTD's effectiveness on fine-grained materials. However, studies indicate that as the percent of fines (less than 0.075 millimeter [mm]) increases above 30%, caking within the dryer may result and impact performance (EPA 1991). As implemented here, the soils that receive LTTD treatment would be predominantly fine-grained and may not be suitable for LTTD treatment. High fractions of fines also result in increased fugitive dust emissions. Rocks greater than 1 inch in diameter would be removed during the soil washing.

Specific requirements of the soil washing and LTTD system would require evaluation of treatability studies and/or pilot-scale testing prior to implementation of full-scale operations. These studies would identify limiting conditions (such as thermal desorption of fines), which exist with the two processes. Effective mitigation of these limiting factors could ensure that the cleanup requirements are met. Successful soil washing/LTTD operations would destroy contaminants that exist at RFTP-2. Potential adverse environmental and public health effects are limited to short-term impacts during excavation, soil washing, thermal desorption, removal, and transportation.

Implementability. The soil-washing technology used for mechanical separation has been used extensively in the mining industry, has been demonstrated through EPA's Superfund Innovative Technology Evaluation (SITE) program, and is available through vendors as modular systems or as separate components. A rotary dryer for LTTD operations is available through vendors and could be mobilized to the site without the need for permits, etc. However, the implementability of LTTD would require determination based on the results of the treatability/pilot-scale testing. Access is available at the site for both operations. Soil washing/LTTD can be implemented as a final remedial action at RFTP-2.

Costs. Capital costs for the soil-washing/LTTD option include the following: treatability and/or pilot-scale testing; excavation and materials handling; a mobile, commercial-scale soil washing system or single units assembled based on engineering design; a commercial-scale LTTD unit having the required capabilities and capacities; and labor to backfill the excavation. The capital costs for implementation of this option are estimated at $11,350,000.

There are no O & M costs associated with the soil-washing/LTTD option. The present worth of this option is estimated to be $11,350,000. A detailed cost analysis of this option is included in Appendix C, Table C-3.

7.5.2 Fort Greely

The options that will be evaluated for remediation of POLs and organochlorine pesticides at Fort Greely sites GFTP-4A, GFTP-4B, GFTP-4D East, and GFTP-4D West include the following:

- No action;
- Vapor extraction/bioventing with capping;
- Soil washing with LTTD and *ex situ* incineration; and
- Soil washing with LTTD and off-site land disposal.

The detailed analyses of these options is presented below.

7.5.2.1 No Action

Technical effectiveness. This option is not effective at meeting the remedial action objectives and regulatory cleanup requirements for organochlorine pesticides at GFTP-4B. The option does not prevent or mitigate exposure to or migration of the contaminants. Since the wastes would not be removed or destroyed, no additional protection to human health and the environment is provided.

Implementability. The no-action option can be implemented at Fort Greely for POL-contaminated soils. However, organochlorine pesticide-contaminated soil will require some type of active treatment such as removal and off-site disposal or capping. ACLs must be supported by a contaminant leaching assessment and a risk assessment to show that the site poses no threat to human health, welfare, and the environment.

A soil leachability assessment will require laboratory analyses of soil samples to provide site specific input for a computer model of contaminant migration in the unsaturated zone soils.

Costs. Contaminant leaching assessment and risk assessment costs would be incurred if this option is selected for implementation and are estimated at $100,000.

7.5.2.2 Vacuum Extraction/Bioventing with Capping

Technical effectiveness. As explained previously, vacuum extraction/bioventing is an effective means of remediating POL contaminants. The Fort Greely sites have similar contaminants and conditions to those examined at Fort Richardson; therefore, effective vacuum extraction/bioventing would require the same considerations and would be implemented in a similar fashion. However, the organochlorine pesticides will not be remediated by this technique. Thus, GFTP-4B, GFTP-4D East, and GFTP-4D West would require installation of an impermeable, long-term cap to effectively isolate the contaminants. Impermeable caps are proven effective for isolation of hazardous wastes at other sites.

Specific requirements of the vacuum extraction/bioventing system will require evaluation of a treatability study and/or pilot-scale testing prior to implementation of full-scale operations. The treatability study would identify limiting conditions that exist at the site, and mitigation of the limiting factors would ensure that the cleanup requirements are met. Successful vacuum extraction/bioventing is a contaminant-destruction process that converts contaminants to carbon dioxide, biomass, and water. However, the pesticides would remain on site, possibly creating future liabilities. The cap design would be based on the availability of near-site borrow materials, and since the soils at the three sites are typically granular, an asphaltic material probably would be required. Since there is no pesticide contamination at GFTP-4A, a cap would not be installed. Approximately 14,000 square feet of cap would be required at GFTP-4B, 500 square feet at GFTP-4D East, and 2,500 square feet at GFTP-4D West.

Implementability. The vacuum extraction/bioventing/capping option consists of the cap, extraction wells, air injection wells (if appropriate), heaters for injected air, air treatment equipment, an infiltration gallery, centrifugal blowers with housings, piping, valves, and electrical instrumentation. The extraction and injection wells would require an installation configuration based on the results of supplemental testing/treatability studies to determine optimal vacuum flow rates and radius of influence. Air emission treatment equipment, usually granular-activated carbon canisters, can be installed to treat VOC off gas, depending on concentrations. The infiltration gallery would be installed by excavating and lining strategically located trenches with granular materials and allowing the aqueous, nutrient-bearing solution to infiltrate the contaminated zones. The above treatment/isolation components can be implemented at the Fort Greely sites.

Costs. The capital costs associated with the option include pilot-scale testing and treatability studies; cap installation; installation of the wells and infiltration gallery; the vacuum extraction/heated-air injection system; piping; a potential off-gas treatment system; and purchase of nutrients, microbes, and pH adjusters. These capital costs are estimated to be $773,000.

O & M costs include costs associated with long-term cap maintenance (30 years), vacuum extraction system maintenance, and infiltration gallery operation. Cap maintenance costs are estimated to be $3,900 annually. O & M costs for the vacuum extraction/bioventing operation are estimated to be $310,000 annually for two years.

The present worth of this option is estimated to be $1,348,000. A detailed cost analysis of this option is included in Appendix C, Tables C-6 and C-7.

7.5.2.3 Soil Washing with Low Temperature Thermal Desorption and *Ex Situ* Incineration

Technical effectiveness. The soil washing and selective excavation processes would be applied as in the previous option. Again, the washed oversize and sands then should be below cleanup requirements and can be placed back into the excavation. The remaining material would be contaminated with POLs (1,375 cubic yards), or POLs and pesticides (375 cubic yards), and either would be treated by LTTD or collected and transported via truck, barge, or train to an incineration facility permitted to receive contaminants of this nature.

As before, treatability testing would be required to determine a suitable soil washing program, LTTD treatment requirements, process operating conditions, and estimated costs. Both laboratory and pilot-scale studies would be required.

LTTD and incineration are reliable and effective remedial options. The fraction of the soil exhibiting contamination exceeding cleanup requirements is either treated or removed from the site and destroyed. Potential adverse environmental and public health effects are limited to short-term impacts during excavation, soil washing, thermal desorption, removal, and transportation.

Implementability. The soil washing technology, as used for mechanical separation, has been used extensively in the mining industry, has been demonstrated through EPA's SITE program, and is available through vendors as modular systems or as separate components. The implementability of LTTD on fine-grained soils would require determination based on the findings of the treatability/pilot-scale testing. Both technologies are transportable and could be relocated to each of the four sites at Fort Greely. The incineration of hazardous wastes is transportation-intensive, but can be implemented as a final remedial action.

Costs. Capital costs for the soil washing/LTTD/incineration option include pilot-scale testing and feasibility studies to select suitable soil washing and LTTD process operations; excavation and materials handling; a mobile, commercial-scale soil washing system or single units assembled based on engineering design; a mobile, commercial-scale LTTD unit; labor to backfill the excavation; and collection, transportation, and disposal costs at the final destination. The capital costs for implementation of this option are estimated at $3,300,000.

There are no O & M costs associated with the soil washing/LTTD/incineration option. The present worth of this option is estimated to be $3,300,000. A detailed cost analysis of this option is included in Appendix C, Table C-9.

7.5.2.4 Soil Washing with Low Temperature Thermal Desorption and Off-Site Land Disposal

Technical effectiveness. At the Fort Greely sites, selective excavation would be required to separate POL-contaminated soils from those contaminated with both POLs and organochlorine pesticides. These different soils would be washed to mechanically separate the coarse fraction. The POL-contaminated soils would receive LTTD treatment, while the POL- and pesticide-contaminated soil would be transported to an off-site land disposal facility.

The soil washing process would be applied to separate the coarse fraction from the contaminated finer fraction to reduce the volume of contaminated soils. Studies cited by EPA (USI manual) indicated that only 5% to 6% of the hydrocarbon contaminants may be associated with stone to coarse, gravel-size fractions in contaminated soils. The results of the investigation at Fort Greely indicate that a volume reduction of approximately 80% would occur during the mechanical separation phase. The washed oversize and sands then should be below cleanup requirements and can be used to backfill the excavation. The remaining material would be contaminated with POLs, or POLs and pesticides, and would be treated or disposed of as described above. The soils contaminated with POLs and pesticides would require collection and transportation via truck or train to a landfill permitted to accept contaminants of this nature. At the Fort Greely sites, approximately 8,720 cubic yards of soil would be excavated. Following soil washing, approximately 1,750 cubic yards of contaminated soils would remain. Of this remaining soil, approximately 375 cubic yards would require off-site land disposal and approximately 1,375 cubic yards would be treated by LTTD.

Insufficient data are available to evaluate the effectiveness of LTTD treatment on the fine fraction of soils. Studies indicate that as the percent of fines (less than 0.075 mm) increases above 30%, caking within the dryer may result and significantly impact performance (EPA 1991).

Treatability testing would be required to determine a suitable soil washing program, LTTD treatment requirements (specifically, treatment of fines), process operating conditions, and estimated costs. Both laboratory and pilot-scale studies would be required.

Both LTTD and off-site land disposal are reliable and effective remedial options. The fraction of the soil exhibiting contamination exceeding cleanup requirements would be treated or removed from the site and transferred to a more controlled environment. Potentially adverse environmental and public health effects are limited to short-term impacts during excavation, soil washing, thermal desorption, removal, and transportation.

Implementability. The soil washing technology used for mechanical separation has been used extensively in the mining industry, has been demonstrated through EPA's SITE program, and is available through vendors as modular systems or as separate components. Rotary dryers for LTTD treatment are available through vendors and can be mobilized to the sites without the need for permits, etc. The implementability of LTTD on fine-grained soils would require determination based on the findings of the treatability/pilot-scale testing. Both technologies are transportable and could be relocated to each of the four sites at Fort Greely. The off-site land disposal of hazardous wastes is transportation-intensive, but can be implemented as a final remedial action.

Costs. Capital costs for the soil washing/LTTD/off-site land disposal option include pilot-scale testing and feasibility studies to select suitable soil washing and LTTD process operations, excavation and materials handling, a mobile, commercial-scale soil washing system or single units assembled based on engineering design, a mobile, commercial-scale LTTD unit, labor to backfill the excavation, and collection, transportation, and disposal costs at the final destination. The capital costs for implementation of this option are estimated at $3,475,000.

There are no O & M costs associated with the soil washing/LTTD/off-site land disposal option. The present worth of this option is estimated to be $3,475,000. A detailed cost analysis of this option is included in Appendix C, Table C-8.

7.6 COMPARISON OF REMEDIAL OPTIONS

7.6.1 Comparison of Remedial Options for Fort Richardson

Following prescreening, the no-action, vacuum extraction/bioventing, soil washing/LTTD, and land farming options were selected for a more detailed evaluation. The no-action option is the lowest cost option, but would require regulatory agency approval for implementation. Since substantial gains in effectiveness would not be made by implementing either the soil washing/LTTD or land farming option, the excavation of contaminated soil made both of these *ex situ* alternatives cost-prohibitive. Of the active remediation alternatives, the vacuum extraction/bioventing option is recommended based on the following:

- Vacuum extraction/bioventing can be implemented *in situ* and will not require removal of uncontaminated overburden soils;
- The option is capable of meeting cleanup levels and the objectives of the remedial action;
- The sands and gravels underlying the site are conducive to infiltration of nutrients and subsurface air flow;
- The technology is commercially available; and
- Vacuum extraction/bioventing is a proven technology at sites with similar contaminants under similar conditions.

Pilot-scale testing and feasibility studies would be required to determine optimal extraction flow rates, radii of influence, and requirements for effective bioremediation of the less volatile constituents.

7.6.2 Comparison of Remedial Options for Fort Greely

Vacuum extraction/bioventing with an impermeable cap, soil washing in conjunction with LTTD and either off-site land disposal or incineration, and the no-action options were evaluated in detail to select a remedial option for implementation at the four Fort Greely sites. The no-action option is the lowest cost option for POL-contaminated soils, but would require regulatory agency approval for implementation. If costs were the sole determinant in selection of an active remedial alternative, the vacuum extraction/bioventing/capping alternative would be chosen. However, this alternative suffers from the following disadvantages:

- The bulk of the soil contamination at the Fort Greely sites is at or near the surface and does not lend itself to remediation by vacuum extraction;
- The option would leave the organochlorine pesticides on site and could be implemented only with approval of regulatory agencies;
- The impermeable cap would require ongoing management of the wastes, including cap maintenance and monitoring;
- The cap may affect future use of the site;
- The organochlorine pesticides would be subject to changes in regulations and may require full remediation in the future; and
- Any future transfer of ownership may require that full remediation be performed.

The soil washing/LTTD/incineration alternative would fully remediate the site, but the cost would be substantially higher than implementation of the soil washing/LTTD/off-site land disposal option, with little or no gain in effectiveness. Of the active remediation alternatives, the soil washing/LTTD/off-site land disposal option is recommended based on the following:

- The soils at the Fort Greely sites are composed primarily of gravels and sands that can be separated by soil washing. The separated coarse fraction then could be used as backfill for the excavations. The remaining fines would contain the bulk of the pesticide contamination and would represent a significant volume reduction;

- The soil washing technique has been used extensively in the mining industry and is a proven method of mechanical separation;

- Soil washing systems are available commercially and can be relocated to each of the four Fort Greely sites;

- The use of LTTD to treat the portion of the fines that are contaminated with POLs will only further reduce the volume of soils requiring off-site land disposal;

- Off-site land disposal is more cost-effective than incineration; and

- The combination of soil washing, LTTD, and off-site land disposal would meet the objectives of the remedial action, would protect human health and the environment, and would not impact any future transfer of ownership or land use.

A feasibility study would be required to support the assumption that contamination in the coarse fraction would be below cleanup requirements, to select a suitable soil washing process operation, and to better estimate the amount of attainable volume reduction.

Table 7-1

SUMMARY OF SOIL CONTAMINATION AND ACTION LEVELS FORT RICHARDSON AND FORT GREELY FIRE TRAINING PITS

Fire Training Pit	Contaminants	Ranges Detected (mg/kg)	Action Level (mg/kg)	Estimated Area of Contamination (square feet)	Maximum Depth of Contamination (depth)	Estimated Volume of Contamination (cubic yards)	Estimated Depth from Contaminant to Groundwater (feet)
RFTP-2	Benzene	1.3	0.5[a]	25,000	4.0	35,000	136[d]
	BTEX	15.6 — 94.5	15[a]		31.0		109[d]
	DRO	220 — 20,000	200[a]		38.0[c]		102[d]
	TRPH	2,300 — 4,700	2,000[a]		6.5		133[d]
GFTP-4A	BTEX	175 — 1,312	15[a]	8,750	11.5	5,500	164[e]
	DRO	200 — 8,000	200[a]		32[c]		143[e]
	TRPH	2,000 — 9,900	2,000[a]		32[c]		143[e]
GFTP-4B	Benzene	0.55	0.5[a]	4,000	5.5	2,500	170[e]
	GRO	1,900	100[a]		20[c]		155[e]
	DRO	200 — 10,200	200[a]		20[c]		155[e]
	TRPH	2,700 — 26,000	2,000[a]		10[c]		165[e]
	DDT-T	233 — 271	200[b]	800	11	325	164[e]
GFTP-4D East	DRO	660	200[a]	100	3	10	175[e]
GFTP-4D West	DRO	560 — 21,000	200[a]	1,250	13[c]	600	162[e]
	TRPH	2,000 —55,000	2,000[a]		13[c]		162[e]

[a] Alaska Department of Environmental Conservation cleanup matrix for nonunderground storage tank contaminated soils, Level B.
[b] United States Environmental Protection Agency, Region 10, risk-based concentration for 10^{-4} health risk.
[c] Estimated.
[d] Groundwater estimated at 140 feet below ground surface.
[e] Groundwater estimated at 175 feet below ground surface.

Key:

BTEX = Benzene, toluene, ethylbenzene, and total xylenes.
DDT-T = Combined concentrations of 4,4'-DDT, 4,4'-DDD, and 4,4'-DDE.
DRO = Diesel-range organics (including kerosene).
GRO = Gasoline-range organics.
mg/kg = Milligrams per kilogram.
TRPH = Total recoverable petroleum hydrocarbons (including bunker C).

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APPENDIX A

BOREHOLE LOGS AND GRAIN-SIZE ANALYSIS

FORT RICHARDSON BOREHOLE LOGS

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 3
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
HOLE NO. (field): BH-1 HOLE NO. (permanent): AP-3194	NAME OF DRILLER Denali Drilling	WEATHER 30°F, clear

TYPE OF HOLE	HAMMER WEIGHT	SIZE AND TYPE OF BIT
Test Pit ( ) Auger Hole (X) Churn Drill ( )	300 pounds	8" hollow stem auger

TOTAL DEPTH OF HOLE	DATUM FOR ELEVATION SHOWN	TYPE OF EQUIPMENT
66.5	( ) MSL ______	Mobile B-61

TOTAL # OF SAMPLES	TYPE OF SAMPLES	DEPTH TO GROUNDWATER	DATE HOLE STARTED / COMPLETED
10	3" split spoon	Not encountered	DATE HOLE STARTED: 10/13/92 DATE HOLE COMPLETED: 10/15/92

ELEV. TOP OF HOLE	INSPECTOR	CHIEF SOILS SECTION	CHIEF GEOTECHNICAL BRANCH
	Jacqueline Lundberg	Jerry Raychel	Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
		2-33-42-48	50 (12")	GW	2.0-4.0' - Gravel and sand, very dense, dry, gravel 1-7 cm, fuel odor, 302SL.	15
5		Not record-ed	40 (10")	SW	4.5-6.5' - Black coarse sand and gravel, dry 303SL. FID measured 20-62 ppm in borehole.	700
10		8-31-31-66	75 (18")	GC	9.5-11.5' - Blue-green gravel, 30% medium sand, 10% silt, very dense, moist, gravel 1-5 cm, well graded, strong diesel odor, fuel soaked, 304SL.	--
15		88/4"	0 (0")		14.5-14.9 Refusal, no recovery. FID measured 72 ppm in borehole. Very hard drilling.	--
20		35-81-99/4"	75 (12")	GW	19.5-20.9' - Gravel, 30% medium sand, 0-7% silt, very dense, dry, gravel 1-7 cm, layer of diesel soaked gravel, 305SL.	8

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 3
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
	HOLE NO. (field): BH-1 HOLE NO. (permanent): AP-3194	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
					FID measured 62 ppm in cutting at 23 ft.	
25		50-95/3"	0 (0")		24.5-25.3' - Refusal. No recovery.	--
30		15-21-41	67 (12")	GW	29.5-31' - Gravel, 30% medium sand, 10% silt, very dense, diesel soaked sand and silt, 306SL.	7
35		120/72-/76	67 (12")	GW	34.5-36' - Gravel, 30% medium sand, 10% silt, very dense, diesel saturated soil, 307SL.	2
40		43-86-104	Not recorded	GW	39.5-41' - Gravel, 30% medium sand, 10% silt, very dense, diesel saturated soil, 308SL.	8
45		33-100-97	100 (18")	GW-ML	44.5-46' - Gravel, 30% medium sand, 10% silt, very dense, diesel saturated soil, with 2" silt layers, poorly layered, 309SL. FID measured >1000 ppm in borehole.	1.5
50		100-60/3"	20 (2")	GM	49.5-50.3' - Gravel, 30% medium sand, 15% silt,	6.5

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 3 OF 3
	LOCATION COORD N.	E.
	DRILLING AGENCY other (X)	USACE ( )
	HOLE NO. (field): BH-1 HOLE NO. (permanent): AP-3194	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
					very dense, diesel saturated soil, 310SL.	
55		200/5"	0 (0")		54.5-54.9' - Refusal. No recovery.	11
60						
65		56-32-48-37	Not recorded	GM	64.5-66.5 - Brown gray gravel, 15% sand, 15% silt, very dense, moist, slight odor, 311SL.	4
					Bottom of exploration at 66.5 ft. Groundwater not encountered.	
70						
75						
80						

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 3
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
HOLE NO. (field): BH-2 HOLE NO. (permanent): AP-3195	NAME OF DRILLER Denali Drilling	WEATHER 20°F, clear, calm

TYPE OF HOLE	HAMMER WEIGHT	SIZE AND TYPE OF BIT
Test Pit ( ) Auger Hole (X) Churn Drill ( )	300 pounds	8" hollow stem auger

TOTAL DEPTH OF HOLE	DATUM FOR ELEVATION SHOWN	TYPE OF EQUIPMENT
61′	(X) MSL ______	Mobile B-61

TOTAL # OF SAMPLES	TYPE OF SAMPLES	DEPTH TO GROUNDWATER	DATE HOLE STARTED / COMPLETED
9	3" split spoon	Not encountered	DATE HOLE STARTED: 10/16/92 DATE HOLE COMPLETED: 10/16/92

ELEV. TOP OF HOLE	INSPECTOR	CHIEF SOILS SECTION	CHIEF GEOTECHNICAL BRANCH
Not recorded	Brad Ackman	Jerry Raychel	Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
		9, 20, 29, 30	100	GW	2.5-4.5′ - Gravel (65%), sand (30%), silt and clay (5%) max.3", brownish gray, angular, dry, no fuel odor or sheen, 312SL.	1
5		10, 60, 41	75	GW	5-6.5′ - Gravel (60%), sand (35%) silt and clay (5%), max. 2.5", gray, angular, dry, no fuel odor or sheen, 313SL.	1
10		10, 22, 36	100	GW	10-11.5′ - Gravel (60%) sand (35%) silt and clay (5%) max. 2.5", gray, angular, dry, no fuel odor or sheen, 314SL.	7
15		35, 35, 20	100	GW-GM	15-16.5′ - Gravel (65%) sand (30%) silt and clay (5%), max. 2", gray, angular, dry to slightly damp, no fuel odor or sheen, 315SL (__ grain size).	8
20		80, 42, 43, 53	80	GW	20-22′ - Gravel (75%) sand (20%) silt and clay (5%) max. 2.5", gray, angular, damp, slight fuel odor,	15

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 3
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
	HOLE NO. (field): BH-2 HOLE NO. (permanent): AP-3195	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
					no sheen, no sample.	-
25		53, 55, 10	25	GW	25-26.5" - Gravel (60%) sand (30%), silt and clay (10%), max. 2.5", brownish gray, angular, slightly damp, slight fuel odor, no sheen, 316SL (BTEX only).	20
30		49, 59, 23	100	GW	30-31.5' - Gravel (70%) sand (20%), silt and clay (10%), max. 3", gray, angular, dry to damp, moderate fuel odor, slight sheen 317SL.	-5
35		15, 80	50	GW-SW	35-36' - Gravel (60%) sand (35%), silt and clay (5%), max. 2" brownish gray, angular, damp, moderate fuel odor slight sheen 318SL.	-10
40		48, 16	0		40-41' - No recovery, strong fuel odor, soil on site of sampler tested with OVA.	1000
45		7, 27, 38	60	GW	44.5-46' - Gravel (55%) Sub R. 1 cm to 5 cm, sand med - coarse (40%) trace fines slight green color, brown/black, moderate fuel odor, 319SL.	12
50		80/0"			No sample.	

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 3 OF 3
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
	HOLE NO. (field): BH-2 HOLE NO. (permanent): AP-3195	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
55		15.3/3"	0		No sample petroleum odor 40-55 ft.	
60		18/54-/64	80	GW	59.5-61' - Gravel (50%), Subrounded 1 cm to 7 cm; sand (45%), coarse, trace fineds, slight fuel odor 320SL. Bottom of exploration at 61 ft. Groundwater not encountered.	8
65						
70						
75						
80						

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
HOLE NO. (field): BH-3 HOLE NO. (permanent): AP-3196	NAME OF DRILLER Denali Drilling	WEATHER Clear, 30°F

TYPE OF HOLE	HAMMER WEIGHT	SIZE AND TYPE OF BIT
Test Pit ( ) Auger Hole (X) Churn Drill ( )	300 pounds	8" hollow stem auger

TOTAL DEPTH OF HOLE	DATUM FOR ELEVATION SHOWN	TYPE OF EQUIPMENT
34.8'	( ) MSL ____	Mobile B-61

TOTAL # OF SAMPLES	TYPE OF SAMPLES	DEPTH TO GROUNDWATER	DATE HOLE STARTED / COMPLETED
8	3" split spoon	Not encountered	DATE HOLE STARTED: 10/19/92 DATE HOLE COMPLETED: 10/19/92
ELEV. TOP OF HOLE	INSPECTOR Jacqueline Lundberg	CHIEF SOILS SECTION Jerry Raychel	CHIEF GEOTECHNICAL BRANCH Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
				SW	1.5-3.5' - Medium sand, 23-30% gravel, 0-7% silt, no fuel odor, 321SL.	0.2
5		14-16-28	40 (10")	GW	4.5-6' - Cobbles and gravel, 40% coarse sand, 5% silt, dense, subrounded gravel 1-7 cm, 322SL.	0.9
10		15-100/3"	25 (6")	GW	9.5-10.3' - Gravel, 25-30% coarse sand, 5% silt, very dense, subrounded gravel 1-7 cm, 323SL.	0
15		Not recorded	90 (10")	GW	14.5-16' - Gravel, 35% medium sand, 5% silt, moist, subrounded gravel 1-7 cm, 324SL.	2.5
20		20-100-49	Not recorded	GW	19.5-21' - Gravel, 35% medium sand, 5% silt, moist, subrounded gravel 1-7 cm, very dense, 325SL.	5.8

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 2
	LOCATION COORD N.	E.
	DRILLING AGENCY other (X)	USACE ( )
	HOLE NO. (field): BH-3 HOLE NO. (permanent): AP-3196	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOVERY	CLASSIFICATION	DESCRIPTION AND REMARKS	FID (ppm)
25		100/3"	100 (3")	GW	24.5-24.8' - Gravel, 30-35% coarse sand, 5-10% silt, very dense, very moist, gravel 1-7 cm, no fuel odor detected, 326SL.	1.7
30		33-60-38	Not record-ed	GW	29.5-31' - Gravel, 25% coarse to medium sand, 5% silt, very dense, strong fuel odor, 327SL.	1000
35		100/3"	67 (2")	SP	34.5-34.8' - Black coarse sand, very dense, wet, 328SL. Bottom of exploration at 34.8 ft. Perched water lens at approximately 34.5 ft.	700
40						
45						
50						

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
HOLE NO. (field): BH-4 HOLE NO. (permanent): AP-3197	NAME OF DRILLER Denali Drilling	WEATHER Cloudy, 28°F

TYPE OF HOLE	HAMMER WEIGHT	SIZE AND TYPE OF BIT
Test Pit ( ) Auger Hole (X) Churn Drill ( )	300 pounds	8" hollow stem auger

TOTAL DEPTH OF HOLE	DATUM FOR ELEVATION SHOWN	TYPE OF EQUIPMENT
34.6'	( ) MSL ______	Mobile B-61

TOTAL # OF SAMPLES	TYPE OF SAMPLES	DEPTH TO GROUNDWATER	DATE HOLE STARTED / COMPLETED
6	3" split spoon	Not encountered	DATE HOLE STARTED: 10/20/92 DATE HOLE COMPLETED: 10/20/92

ELEV. TOP OF HOLE	INSPECTOR	CHIEF SOILS SECTION	CHIEF GEOTECHNICAL BRANCH
	Jacqueline Lundberg	Jerry Raychel	Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
				SW	1.0-2.5' - Brown medium sand, 30% gravel, 10% silt, moist, gravel rounded to subrounded 1-4 cm, no fuel odor detected, 329SL.	0.2
5		20-27-48	33 (6')	GW	4.5-6' - Brown gravel, 35-40% medium sand, 5% silt, very dense, gravel 1-7 cm, 330SL.	0
10		13-33-75/3"	33 (4")	GW	9.5-10.8' - Brown and gray gravel, 25-30% sand, 5% silt, very dense, gravel 1-7 cm, unidentified odor, 331SL.	7
15		17-29-27	20 (4")	SRT	14.5-16.0' - Brown and gray gravel, 30% medium sand, very dense, dry to slightly moist, subrounded gravel, no fuel odor, 332SL.	9.5
20		1-3-17	Not recorded	SW	19.5-21' - Coarse to medium sand and gravel, 5% silt, medium dense, very moist, subrounded gravel 1-4 cm.	10.5

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 2
	LOCATION COORD N.	E.
	DRILLING AGENCY other (X)	USACE ( )
	HOLE NO. (field): BH-4 HOLE NO. (permanent): AP-3197	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
25		100/3"	100 (3")	SW	24.5-24.8' - Coarse to medium sand and gravel, 5% silt, very dense, very moist, subrounded gravel 1-4 cm slight fuel odor, 333SL.	12
30		17-33-76	67 (12")	GW	29.5-31' - Gravel, 35-40% coarse to medium sand, 5% silt, very dense, subrounded gravel 1-7 cm, strong fuel odor, 334SL.	1000
35		100/1"	0 (0")		34.5-34.6' - Refusal. No recovery. Bottom of exploration at 34.6 ft. Groundwater not encountered.	>1000
40						
45						
50						

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
HOLE NO. (field): BH-5 HOLE NO. (permanent): AP-3198	NAME OF DRILLER Denali Drilling	WEATHER 35°F, cloudy, calm

TYPE OF HOLE Test Pit ( ) Auger Hole (X) Churn Drill ( )	HAMMER WEIGHT 300 pounds	SIZE AND TYPE OF BIT hollow stem auger

TOTAL DEPTH OF HOLE 40'	DATUM FOR ELEVATION SHOWN (X) MSL _____	TYPE OF EQUIPMENT Mobile B-61

TOTAL # OF SAMPLES 9	TYPE OF SAMPLES 3" split spoon	DEPTH TO GROUNDWATER Not encountered	DATE HOLE STARTED: 10/20/92 DATE HOLE COMPLETED: 10/21/92
ELEV. TOP OF HOLE	INSPECTOR Brad Ackman	CHIEF SOILS SECTION Jerry Raychel	CHIEF GEOTECHNICAL BRANCH Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
				SW	2.5' - Gravel (30%) sand (65%) silt and clay (5%), max. 4", dark brown, subangular, dry, no fuel odor or sheen, 335SL, 402SL, 403SL (14:08).	0
5		18, 39, 44	12"/18"	GW	5-6.5' - Gravel (50%) sand (40%) silt and clay (10%), max. 3", dark gray, subangular, dry, slight fuel odor no sheen, 336SL (14:15).	2
10		16, 39	8"/12"	GW	10-11' - Gravel (60%) sand (35%) silt and clay (5%), max. 2", dark gray, subangular, damp, no fuel odor or sheen 337SL (14:33).	11
15		22, 24, 36	18"/18"	GW	15-16.5' - Gravel (70%) sand (25%) silt and clay (5%), max. 3", dark gray, subangular - angular, dry to damp, slight fuel odor, no sheen 338SL (14:48).	10
20		10, 20, 39	18"/18"	GW	20-21.5' - Gravel (65%), sand (30%) silt and clay (5%) max. 3", dark gray, subangular, damp, slight fuel odor,	10

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
	HOLE NO. (field): BH-5 HOLE NO. (permanent): AP-3198	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
					no sheen 339SL (15:03).	
25		65, 23, 19	10"/18"	GW	25-26.5' - Gravel (65%) sand (30%) silt and clay (5%), max. 2", dark gray, subangular, damp, slight fuel odor, no sheen, 340SL (15:20).	8
30		22, 41, 59	16"/18"	GW	30-31.5' - Gravel (50%) sand (40%) silt and clay (10%), max. 2", dark gray, subangular, damp, slight fuel odor, no sheen 341SL (15:43).	7
35		98, 70	10"/12"	GW	35-36' - Gravel (75%), sand (20%) silt and clay (5%), max. 3", dark gray, angular, dry to damp, no fuel odor or sheen 342SL (09:19).	2
40		100	0"/1"		40' - No recovery. Soil adhering to split-spoon was analyzed with OVA. Total depth 40' due to sloughing of borehole sidewall. Drillers call refusal. Backfill 50 # bentonite, clean cuttings, 50 # bentonite at top of hole.	0
45						
50						

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
HOLE NO. (field): BH-6 HOLE NO. (permanent): AP-3199	NAME OF DRILLER Denali Drilling	WEATHER 25°F, cloudy, calm

TYPE OF HOLE	HAMMER WEIGHT	SIZE AND TYPE OF BIT
Test Pit ( ) Auger Hole (X) Churn Drill ( )	300 pounds	hollow stem auger

TOTAL DEPTH OF HOLE	DATUM FOR ELEVATION SHOWN	TYPE OF EQUIPMENT
26.5'	(X) MSL ______	Mobile B-61

TOTAL # OF SAMPLES	TYPE OF SAMPLES	DEPTH TO GROUNDWATER	DATE HOLE STARTED / COMPLETED
6	3" split spoon	Not encountered	DATE HOLE STARTED: 10/21/92 DATE HOLE COMPLETED: 10/21/92

ELEV. TOP OF HOLE	INSPECTOR	CHIEF SOILS SECTION	CHIEF GEOTECHNICAL BRANCH
	Brad Ackman	Jerry Raychel	Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
				SW	2.5' - Gravel (30%), sand (60%) silt and clay (10%), max. 3", dark brown, subrounded, damp, no fuel odor on sheen 343SL, 404SL, 405SL (10:58).	0
5		100	0"/6"		5' - No recovery.	0
10		26, 21, 39	14"/18"	GW	10-11.5 - Gravel (70%) sand (25%) silt and clay (5%), max. 3", dark gray, angular, damp, no fuel odor or sheen, 344SL (11:33).	7
15		26, 19, 39	10"/18"	GW	15-16.5' - Gravel (60%) sand (35%) silt and clay (5%), max. 3", dark gray, angular, damp, no fuel odor or sheen 345SL (12:21).	21
20		49, 62	10"/12"	GW	20-21' - Gravel (55%) sand (40%) silt and clay (5%), max. 2", brownish gray, subangular, damp, no	20

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
	HOLE NO. (field): BH-6 HOLE NO. (permanent): AP-3199	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOVERY	CLASSIFICATION	DESCRIPTION AND REMARKS	FID (ppm)
					fuel odor on sheen 346SL (12:55).	
25		36, 39, 22	18"/18"	GW	25-26.5' - Gravel (50%) sand (40%) silt and clay (10%), max. 1.5", dark brownish gray, angular, damp, no fuel odor or sheen 347SL (13:21).	40
					Total depth = 26.5' due to sloughing of borehole sidewall. Drillers call refusal.	
					Backfill; 50# bentonite, clean cuttings, 50# bentonite at top of hole.	
30						
35						
40						
45						
50						

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 3
	LOCATION COORD N.	E.
	DRILLING AGENCY other (X)	USACE ( )
HOLE NO. (field): BH-7 HOLE NO. (permanent): AP-3200	NAME OF DRILLER Denali Drilling	WEATHER 33°F, cloudy, calm

TYPE OF HOLE Test Pit ( ) Auger Hole (X) Churn Drill ( )	HAMMER WEIGHT 300 pounds	SIZE AND TYPE OF BIT hollow stem auger
TOTAL DEPTH OF HOLE 51'	DATUM FOR ELEVATION SHOWN (X) MSL ____	TYPE OF EQUIPMENT Mobile B-61

TOTAL # OF SAMPLES 11	TYPE OF SAMPLES 3" split spoon	DEPTH TO GROUNDWATER Not encountered	DATE HOLE STARTED: 10/21/92 DATE HOLE COMPLETED: 10/22/92
ELEV. TOP OF HOLE	INSPECTOR Brad Ackman	CHIEF SOILS SECTION Jerry Raychel	CHIEF GEOTECHNICAL BRANCH Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
				SW	2.5' - Gravel (30%), sand (60%), silt and clay (10%), max. 2", brown, subrounded, dry, no fuel odor or sheen, 348SL, 406SL, 407SL (14:50).	0
5				SW	5' - Gravel (40%) sand (50%), silt and clay (10%), max. 2", brownish gray, subangular, dry, no fuel odor or sheen 349SL (14:59).	2
10		34, 49	2"/12"	Wood	10-11' - Wood, several gravel clasts, no sample, no fuel odor.	2
15		100	1"/1"	Wood	15' - Wood, no fuel odor, no sample.	10
20		41, 100	8"/12"	GW	20-21' - Gravel (75%), sand (20%), silt and clay (5%), max. 3", gray, angular, damp, no fuel odor or sheen	30

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 3
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
	HOLE NO. (field): BH-7 HOLE NO. (permanent): AP-3200	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
					350SL (15:47).	
25		100	4"/6"	GW	25-25.5' - Gravel (60%), sand (35%), silt and clay (5%), max. 2.5", dark gray, subangular, damp, no fuel odor or sheen, 351SL (BTEX only)-(09:10).	7
30		115	3"/6"	GW	30-30.5' - Gravel (70%), sand (25%), silt and clay (5%), max. 3", medium gray, subangular, damp, no fuel odor or sheen, 352SL (BTEX only)-(09:33).	7
35		34, 67, 61	16"/18"	GW	35-36.5' - Gravel (60%) sand (35%) silt and clay (5%), max. 2", medium gray, subangular to angular, damp, slight fuel odor, no sheen, 353SL (09:53).	10
40		32, 33, 42	18"/18"	GW	40-41.5' - Gravel (60%) sand (30%), silt and clay (10%), max. 3", medium gray, angular, damp, slight fuel odor, no sheen, 354SL (10:14).	30
45		100	1"/4"	GW	45' - Gravel (60%) sand (30%) silt and clay (10%) max. 1.5", medium gray, subangular, damp, no fuel odor or sheen, no sample (lack of soil).	10
50		36, 100	10"/12"	GW	50-51' - Gravel (65%)	20

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 3 OF 3
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
	HOLE NO. (field): BH-7 HOLE NO. (permanent): AP-3200	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
					sand (30%) silt and clay (5%), max. 2", dark gray, subangular, damp, no fuel odor or sheen, 355SL (11:12).	
55					Total depth is 51' by E & E determination. No significant contamination exists to prompt further drilling.	
					Borehole abandonment; 50# bentonite, clean cutting and 50# bentonite at top.	
60						
65						
70						
75						
80						

19:KM5900_A199_APP_A_FT_RICH_92-09/23/93-F1

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
HOLE NO. (field): BH-8 HOLE NO. (permanent): AP-3201	NAME OF DRILLER Denali Drilling	WEATHER 35°F, cloudy, light north wind

TYPE OF HOLE Test Pit ( ) Auger Hole (X) Churn Drill ( )	HAMMER WEIGHT 300 pounds	SIZE AND TYPE OF BIT hollow stem auger
TOTAL DEPTH OF HOLE 35.7'	DATUM FOR ELEVATION SHOWN ( ) MSL ______	TYPE OF EQUIPMENT Mobile B-61

TOTAL # OF SAMPLES 8	TYPE OF SAMPLES split spoon	DEPTH TO GROUNDWATER Not Encountered	DATE HOLE STARTED: 10/22/92 DATE HOLE COMPLETED: 10/23/92
ELEV. TOP OF HOLE	INSPECTOR Brad Ackman	CHIEF SOILS SECTION Jerry Raychel	CHIEF GEOTECHNICAL BRANCH Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
				SW	2.5' - Gravel (25%), sand (65%), silt and clay (10%), max. 2.5", dark brown, subrounded, damp, no fuel odor or sheen, 356SL, 408SL, 409SL (12:58).	0
5				SW	5' - Gravel (30%), sand (65%), silt and clay (5%), max. 2", dark brown, subrounded, damp, no fuel odor or sheen, 357SL (13:06).	0
10		15, 36, 32	10"/18"	GW	10-11.5' - Gravel (65%), sand (30%), silt and clay (5%) , max. 3", dark brownish gray, subangular, damp, no fuel odor or sheen, 358SL (13:39).	0
15		15, 42, 30	14"/18"	GW	15-16.5' - Gravel (60%), sand (30%), silt and clay (10%), max. 3", dark gray, subangular, damp, no fuel odor or sheen 359SL (13:58).	80
20		4, 12, 52	4"/18"	GW	20-21.5' - Gravel (70%), sand (25%), silt and clay (5%), max. 2", dark gray, subangular, damp, moderate fuel	1000

19:KM5900_A199_APP_A_FT_RICH_92-09/23/93-F1

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 2
	LOCATION COORD N.	E.
	DRILLING AGENCY other (X)	USACE ( )
	HOLE NO. (field): BH-8 HOLE NO. (permanent): AP-3201	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOVERY	CLASSIFICATION	DESCRIPTION AND REMARKS	FID (ppm)
					odor, no sheen, 360SL (14:18).	
25		42, 69	2"/18"	GW	Gravel (90%), sand (10%), max. 3", medium gray, angular, dry, moderate fuel odor, no sheen, no sample (lack of soil).	1000
30		17, 100, 52	12"/18"	GW	30-31.5' - Gravel (60%) sand (30%), silt and clay (10%), max. 2.5", dark gray, angular, damp, moderate fuel odor, no sheen, 361SL (15:40).	1000
35		32, 100+	6"/2"	GW	35-35.7' - Gravel (60%) sand (30%), silt and clay (10%), max. 2.5", dark gray, angular, damp, slight odor, no sheen, 362 (cobble re-fusal).	20
40						
45						
50						

19:KM5900_A199_APP_A_FT_RICH_92-09/23/93-F1

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
HOLE NO. (field): BH-9 HOLE NO. (permanent): AP-3202	NAME OF DRILLER Denali Drilling	WEATHER Cloudy, 25°F

TYPE OF HOLE	HAMMER WEIGHT	SIZE AND TYPE OF BIT
Test Pit ( ) Auger Hole (X) Churn Drill ( )	300 pounds	8" hollow stem auger

TOTAL DEPTH OF HOLE	DATUM FOR ELEVATION SHOWN	TYPE OF EQUIPMENT
30.2'	( ) MSL ______	Mobile B-61

TOTAL # OF SAMPLES	TYPE OF SAMPLES	DEPTH TO GROUNDWATER	DATE HOLE STARTED / COMPLETED
7	3" split spoon	Not encountered	DATE HOLE STARTED: 10/23/92 DATE HOLE COMPLETED: 10/23/92

ELEV. TOP OF HOLE	INSPECTOR	CHIEF SOILS SECTION	CHIEF GEOTECHNICAL BRANCH
	Jacqueline Lundberg	Jerry Raychel	Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOVERY	CLASSIFICATION	DESCRIPTION AND REMARKS	FID (ppm)
				SM	2.5' - Brown silty sand with gravel, slightly moist, no odor, no sheen, 363SL.	0.2
5		Not recorded	Not recorded	SM	5' - Brown silty sand with gravel, slightly moist, no odor, no sheen, 364SL. Increased gravel content at 7'.	0.4
10		20-60-37	67 (12")	GW	9.5-11' - Brown to gray brown gravel, 40% sand, 10% silt, 5% cobbles, very dense, 365SL.	3
15		22-38-40	80 (14")	GW	14.5-16' - Gray brown sandy gravel, very dense, 366SL.	1
20		100	90 (5")	GW	19.5-20' - Gray gravel, 40% sand, 10% silt, very dense, no diesel odor, no sheen, 367SL.	0.5

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 2
	LOCATION COORD N.	E.
	DRILLING AGENCY other (X)	USACE ( )
	HOLE NO. (field): BH-9 HOLE NO. (permanent): AP-3202	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
25		100/5"	0 (0")		24.5-24.9' - Refusal. No recovery. Auger cuttings indicate same lithology as above.	
30		90-70/2"	50 (4")	GW	29.5-30.2' - Gravel, 30% sand, 10% silt, very dense, 368SL. Bottom of exploration at 30.2 ft. Groundwater not encountered.	
35						
40						
45						
50						

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
HOLE NO. (field): BH-10 HOLE NO. (permanent): AP-3203	NAME OF DRILLER Denali Drilling	WEATHER Cloudy, 30°

TYPE OF HOLE	HAMMER WEIGHT	SIZE AND TYPE OF BIT
Test Pit ( ) Auger Hole (X) Churn Drill ( )	300 pounds	8" hollow stem auger

TOTAL DEPTH OF HOLE	DATUM FOR ELEVATION SHOWN	TYPE OF EQUIPMENT
34.9'	( ) MSL ______	Mobile B-61

TOTAL # OF SAMPLES	TYPE OF SAMPLES	DEPTH TO GROUNDWATER	DATE HOLE STARTED / COMPLETED
8	3" split spoon	Not encountered	DATE HOLE STARTED: 10/23/92 DATE HOLE COMPLETED: 10/23/92

ELEV. TOP OF HOLE	INSPECTOR	CHIEF SOILS SECTION	CHIEF GEOTECHNICAL BRANCH
	Jacqueline Lundberg	Jerry Raychel	Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
		Grab sample		GM	2.5' - Gray silty sandy gravel, 369SL.	2.5
5		Grab sample		ML	5' - Gray brown clayey silt with sand, 5% organic material, no diesel odor.	20
10		15-18-14	30 (5")	GM	9.5-11' - Gray silty sandy gravel, 5% clay, dense, wet at 9.5', 371SL.	4.5
15		28-32-29	100 (18")	GM	14.5-16' - Gray brown gravel, 20% sand, 20% silt, 5% clay, very dense, 372SL.	10
20		20-40-30	100 (18")	GW	19.5-21' - Gray brown gravel, 30% sand, 10% silt, very dense, 373SL.	1

DEPARTMENT OF THE ARMY
NORTH PACIFIC DIVISION
U.S. ARMY ENGINEER DISTRICT, ALASKA
EXPLORATION LOG

PROJECT: Fort Richardson Fire Training Pits

SHEET # 2 OF 2

LOCATION COORD N. E.

DRILLING AGENCY other (X) USACE ( )

HOLE NO. (field): BH-10
HOLE NO. (permanent): AP-3203

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOVERY	CLASSIFICATION	DESCRIPTION AND REMARKS	FID (ppm)
25		15-30-20	95 (17")	GW	24.5-26' - Gray brown gravel, 30% sand, 10% silt, very dense, 374SL.	3
30		110	33 (2")	GP	29.5-30' - Gravel, some silt and sand.	0.5
35		115/5"	20 (1")	GP	34.5-34.9' - Gravel, some silt and sand. Bottom of exploration at 34.9 ft. Groundwater not encountered.	3
40						
45						
50						

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N.	E.
	DRILLING AGENCY other (X)	USACE ( )
HOLE NO. (field): BH-11 HOLE NO. (permanent): AP-3204	NAME OF DRILLER Denali Drilling	WEATHER Cloudy, 40°F

TYPE OF HOLE Test Pit ( ) Auger Hole (X) Churn Drill ( )	HAMMER WEIGHT 300 pounds	SIZE AND TYPE OF BIT 8" hollow stem auger

TOTAL DEPTH OF HOLE 29.7'	DATUM FOR ELEVATION SHOWN ( ) MSL ______	TYPE OF EQUIPMENT Mobile B-61

TOTAL # OF SAMPLES 7	TYPE OF SAMPLES 3" split spoon	DEPTH TO GROUNDWATER Not encountered	DATE HOLE STARTED: 10/26/92 DATE HOLE COMPLETED: 10/26/92
ELEV. TOP OF HOLE	INSPECTOR John Caoile	CHIEF SOILS SECTION Jerry Raychel	CHIEF GEOTECHNICAL BRANCH Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
				GW	2.5' - Gravel, 30% sand, 10% silt, 375SL.	0
5				SW	5' - Silt and sand with gravel, 5% wood fragments, 376SL.	0
10		41-23-42	75 (14")	GW	9.5-11' - Gravel, 30% sand, 10% silt, very dense, fuel odor, 377SL.	1000
15		4-4-18	95 (17")	GM	14.5-16' - Silty sandy gravel, medium dense, fuel odor, 378SL.	1000
20		2-14-36	90 (16")	SM	19.5-21' - Blue gray sand, 40% silt, 10% gravel, very dense, fuel odor, 379SL.	1000

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
	HOLE NO. (field): BH-11 HOLE NO. (permanent): AP-3204	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOVERY	CLASSIFICATION	DESCRIPTION AND REMARKS	FID (ppm)
25		2-14-57	80 (15")	SM	24.5-26' - Blue gray sand, 40% silt, 10% gravel, very dense, fuel odor, 380SL.	700
30		100/2"	50 (1")	GM	29.5-29.7' - Gray silty sandy gravel, very dense, 381SL. FID measured 600 ppm in borehole. Bottom of exploration at 29.7 ft. Groundwater not encountered.	100
35						
40						
45						
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DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
HOLE NO. (field): BH-12 HOLE NO. (permanent): AP-3205	NAME OF DRILLER Denali Drilling	WEATHER Snow, 32°F

TYPE OF HOLE Test Pit ( ) Auger Hole (X) Churn Drill ( )	HAMMER WEIGHT 300 pounds	SIZE AND TYPE OF BIT 8" hollow stem auger

TOTAL DEPTH OF HOLE 29.5'	DATUM FOR ELEVATION SHOWN ( ) MSL ____	TYPE OF EQUIPMENT Mobile B-61

TOTAL # OF SAMPLES 7	TYPE OF SAMPLES 3" split spoon	DEPTH TO GROUNDWATER Not encountered	DATE HOLE STARTED: 10/27/92 DATE HOLE COMPLETED: 10/27/92
ELEV. TOP OF HOLE	INSPECTOR John Caoile	CHIEF SOILS SECTION Jerry Raychel	CHIEF GEOTECHNICAL BRANCH Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
		Grab sample		ML	2.5' - Silt, 30% sand, 10% gravel, 382SL.	3
5		Grab sample		ML	5' - Silt, 30% sand, 10% gravel, 383SL. Increased gravel content 5'-9.5'. Cobbles at 9'.	3
10		44	0 (0")	GM	9.5-10' - No recovery. Cuttings are silty sandy gravel.	
15		70/1"	0 (0")	GP	14.5-14.6' - Refusal. No recovery. Cuttings are gravel and cobbles. FID measured 1-2 ppm in borehole.	
20		27-42/1"	30 (2")	GW	19.5-20.1' - Gravel and cobbles, very dense, 384SL.	30

DEPARTMENT OF THE ARMY
NORTH PACIFIC DIVISION
U.S. ARMY ENGINEER DISTRICT, ALASKA
EXPLORATION LOG

PROJECT: Fort Richardson Fire Training Pits

SHEET # 2 OF 2

LOCATION COORD N. E.

DRILLING AGENCY other (X) USACE ( )

HOLE NO. (field): BH-12
HOLE NO. (permanent): AP-3205

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOVERY	CLASSIFICATION	DESCRIPTION AND REMARKS	FID (ppm)
25		77/1"	100 (1")	GW	24.5-24.6' - Gravel, 20% sand, 10% cobbles, 10% silt, very dense.	90
		77-80-105	75 (14")	GM	28-29.5' - Silty sandy gravel and cobbles, very dense, 385SL.	3
30					Bottom of exploration at 29.5 ft. Groundwater not encountered.	
35						
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DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
HOLE NO. (field): BH-13 HOLE NO. (permanent): AP-3206	NAME OF DRILLER Denali Drilling	WEATHER Cloudy, 30°F

TYPE OF HOLE Test Pit ( ) Auger Hole (X) Churn Drill ( )	HAMMER WEIGHT 300 pounds	SIZE AND TYPE OF BIT 8" hollow stem auger

TOTAL DEPTH OF HOLE 36'	DATUM FOR ELEVATION SHOWN ( ) MSL ______	TYPE OF EQUIPMENT Mobile B-61 Track Vehicle

TOTAL # OF SAMPLES 7	TYPE OF SAMPLES 3" split spoon	DEPTH TO GROUNDWATER Not encountered	DATE HOLE STARTED: 11/03/92 DATE HOLE COMPLETED: 11/03/92
ELEV. TOP OF HOLE	INSPECTOR John Caoile	CHIEF SOILS SECTION Jerry Raychel	CHIEF GEOTECHNICAL BRANCH Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
				GW	2.5' - Gray gravel, 30% sand, 10% silt, 386SL.	1.5
5				GW	5' - Gray gravel, 30% sand, 10% silt, 387SL. No odor detected.	6.5
10		22-50-73	100 (18")	GW	9.5-11' - Gray gravel, 30% sand, 10% silt, very dense, 388SL. No odor detected.	5.2
15		4-36-110	60 (10")	GM	14.5-16' - Gray silty sandy gravel, very dense, slight to no odor, 389SL.	20
20		2-4-31	60 (10")	GM	19.5-21' - Gray brown gravel, 20% sand, 20% silt, dense, no odor, 390SL.	20

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 2
	LOCATION COORD N.	E.
	DRILLING AGENCY other (X)	USACE ( )
	HOLE NO. (field): BH-13 HOLE NO. (permanent): AP-3206	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
25		25-26-27	80 (15")	GM	24.5-26' - Gray brown gravel, 20% sand, 20% silt, very dense, no odor, no sheen, 391SL.	10
30						
35		40-33-52	80 (15")	GM	34.5-36' - Gray green silty sandy gravel, very dense, fuel odor and sheen, 392SL. Bottom of exploration at 36'. Groundwater not encountered.	750
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DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N. E.	
	DRILLING AGENCY other (X) USACE ( )	
HOLE NO. (field): BH-14 HOLE NO. (permanent): AP-3207	NAME OF DRILLER Denali Drilling	WEATHER Cloudy, 32°F

TYPE OF HOLE Test Pit ( ) Auger Hole (X) Churn Drill ( )	HAMMER WEIGHT 300 pounds	SIZE AND TYPE OF BIT 8" hollow stem auger

TOTAL DEPTH OF HOLE 36'	DATUM FOR ELEVATION SHOWN ( ) MSL _____	TYPE OF EQUIPMENT

TOTAL # OF SAMPLES 8	TYPE OF SAMPLES 3" split spoon	DEPTH TO GROUNDWATER Not encountered	DATE HOLE STARTED: 11/04/92 DATE HOLE COMPLETED: 11/04/92
ELEV. TOP OF HOLE	INSPECTOR John Caoile	CHIEF SOILS SECTION Jerry Raychel	CHIEF GEOTECHNICAL BRANCH Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
				SM	2.5' - Brown sand, 30% silt, 20% gravel, 5% clay, no odor, 395SL.	0.5
5				SM	5' - Brown sand, 30% silt, 20% gravel, 5% clay, no odor, 396SL.	0.5
					Increased gravel content.	
10		18-25-28	67 (12")	GM	9.5-11' - Gray gravel, 30% sand, 20% silt, very dense, no odor, no sheen, 397SL.	3
15		16-29-49	Not recorded	GW	14.5-16' - Gray gravel, 20% sand, 10% silt, very dense, 398SL.	15
20		100	33 (2")	GM	19.5-20' - Gray gravel, 30% silt, 20% sand, very dense, no odor or sheen, 399SL.	20

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 2
	LOCATION COORD N.	E.
	DRILLING AGENCY other (X)	USACE ( )
	HOLE NO. (field): BH-14 HOLE NO. (permanent): AP-3207	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
25				GM	FID measured 0.5 ppm in borehole. Cuttings indicate lithology same as above.	
				SW		
30		32-71-39	70 (14")		29.5-31' - Gray sand and gravel, very dense, angular gravel, 500SL. Difficult drilling.	
				GW		
35		17-30-28	Not recorded		34.5-36' - Gray gravel, 40% sand, 10% silt, very dense, 501SL. Bottom of exploration at 36 ft. Groundwater not encountered.	
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DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N.	E.
	DRILLING AGENCY other (X)	USACE ( )
HOLE NO. (field): BH-15 HOLE NO. (permanent): AP-3208	NAME OF DRILLER Denali Drilling	WEATHER Cloudy, 32°F

TYPE OF HOLE	HAMMER WEIGHT	SIZE AND TYPE OF BIT
Test Pit ( ) Auger Hole (X) Churn Drill ( )	300 pounds	8" hollow stem auger

TOTAL DEPTH OF HOLE	DATUM FOR ELEVATION SHOWN	TYPE OF EQUIPMENT
38.6'	( ) MSL ______	Mobile B-61

TOTAL # OF SAMPLES	TYPE OF SAMPLES	DEPTH TO GROUNDWATER	DATE HOLE STARTED / COMPLETED
9	3" split spoon	Not encountered	DATE HOLE STARTED: 11/05/92 DATE HOLE COMPLETED: 11/05/92

ELEV. TOP OF HOLE	INSPECTOR	CHIEF SOILS SECTION	CHIEF GEOTECHNICAL BRANCH
	John Caoile	Jerry Raychel	Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
				GW	2.5' - Gray gravel, 30% sand, 10% silt, 502SL.	0.5
5				GW	5' - Gray gravel, 30% sand, 10% silt, 503SL.	0.5
10		28-65-89	95 (17")	GW	9.5-11' - Gray gravel, 30% sand, 10% silt, 504SL.	21
15		47-54-48	90 (16")	GW	14.5-16' - Gray gravel, 30% sand, 10% silt, 505SL.	15
20		40-43-45	90 (16")	GW	19.5-21' - Gray gravel, 30% sand, 10% silt, no sheen, no odor detected, 506SL.	28

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DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 2
	LOCATION COORD N.	E.
	DRILLING AGENCY other (X)	USACE ( )
	HOLE NO. (field): BH-15 HOLE NO. (permanent): AP-3208	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOVERY	CLASSIFICATION	DESCRIPTION AND REMARKS	FID (ppm)
25		55-54-110	70 (14")	GW	24.5-26' - Gray gravel, 30% sand, 10% silt, no sheen or odor detected, 507SL.	10
30		100	15 (1")	GW	29.5-30' - Gray gravel, 20% sand, 10% silt, very dense. Difficult drilling.	15
35		100/1"	0 (0")	GW	34.5-34.6' - Refusal. No recovery. FID measured 50 ppm in borehole.	--
		42-100/1"	35 (2")	GW	38-38.6' - Refusal. No recovery. FID measured 50 ppm in borehole, 508SL. Bottom of exploration at 38.6 ft. Groundwater not encountered.	10
40						
45						
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DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 2
	LOCATION COORD N. 121520	E. 139100
	DRILLING AGENCY other ( )	USACE (X)
HOLE NO. (field): RFTP-2-1 HOLE NO. (permanent): AP-3054	NAME OF DRILLER C. Mitchell, J. Alden	WEATHER Cloudy, 60°F

TYPE OF HOLE Test Pit ( ) Auger Hole (X) Churn Drill ( )	HAMMER WEIGHT 300 pounds	SIZE AND TYPE OF BIT 8" hollow stem auger
TOTAL DEPTH OF HOLE 19.8'	DATUM FOR ELEVATION SHOWN ( ) MSL ______	TYPE OF EQUIPMENT Acker Soil Max

TOTAL # OF SAMPLES 10	TYPE OF SAMPLES 3" split spoon	DEPTH TO GROUNDWATER Not encountered	DATE HOLE STARTED: 06/24/91 DATE HOLE COMPLETED: 06/24/91
ELEV. TOP OF HOLE Not recorded	INSPECTOR Jacqueline Lundberg	CHIEF SOILS SECTION Jerry Raychel	CHIEF GEOTECHNICAL BRANCH Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOVERY	CLASSIFICATION	DESCRIPTION AND REMARKS	PID (ppm)
5		40-68-57	90 (16")	GM	4.5-6' - Green gray gravel, broken rock, ash, and fill, very dense, petroleum odor, 025SL, 031SL, 032SL. Portion of ash wet with charcoal smell. PID measured 190 ppm in borehole.	20
10		16-28-36	100 (18")	GW	9.5-11' - Dark green to gray gravelly fill, angular rock fragments, very dense, wet from 9.5 to 10.5', 026SL, 033SL, 034SL. Gray fill, dry, 10.5 to 11'. PID measured 180 ppm in borehole.	4
15		6-13-33/2"	100 (15")	GW	14.5-15.8' - Dark green gravel, very dense, wet, strong petroleum odor, 027SL, 035SL, 036SL. Gray gravel and charcoal not observed. PID measured 180 ppm in borehole.	20
20		71/4"	25 (1")	GW	19.5-19.8' - Dark green gravel, very dense, 030SL. Very little sand, no salt observed. PID measured 200 ppm in borehole.	0

DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 2 OF 2
	LOCATION COORD N. 121520	E. 139100
	DRILLING AGENCY other ( )	USACE (X)
	HOLE NO. (field): RFTP-2-1 HOLE NO. (permanent): AP-3054	

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	FID (ppm)
					Bottom of Exploration at 19.8 feet. Groundwater not encountered.	
25						
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35						
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DEPARTMENT OF THE ARMY NORTH PACIFIC DIVISION U.S. ARMY ENGINEER DISTRICT, ALASKA EXPLORATION LOG	PROJECT: Fort Richardson Fire Training Pits	SHEET # 1 OF 1
	LOCATION COORD N. 120800	E. 139260
	DRILLING AGENCY other ( )	USACE (X)
HOLE NO. (field): RFTP-Background HOLE NO. (permanent): AP-3055	NAME OF DRILLER C. Mitchell, J. Alden	WEATHER Cloudy, 60°F

TYPE OF HOLE Test Pit ( ) Auger Hole (X) Churn Drill ( )	HAMMER WEIGHT 300 pounds	SIZE AND TYPE OF BIT 8" hollow stem auger

TOTAL DEPTH OF HOLE 6'	DATUM FOR ELEVATION SHOWN ( ) MSL _____	TYPE OF EQUIPMENT Acker Soil Max

TOTAL # OF SAMPLES 1	TYPE OF SAMPLES 3" split spoon	DEPTH TO GROUNDWATER Not encountered	DATE HOLE STARTED: 1991 DATE HOLE COMPLETED: 1991
ELEV. TOP OF HOLE Not recorded	INSPECTOR Jacqueline Lundberg	CHIEF SOILS SECTION Jerry Raychel	CHIEF GEOTECHNICAL BRANCH Del Thomas

DEPTH IN FEET	GROUND-WATER	BLOW COUNTS	% RECOV-ERY	CLASSIFI-CATION	DESCRIPTION AND REMARKS	PID (ppm)
5		Not record-ed	Not record-ed	SM	4.5-6' - Brown silty sand, 75% sand, 20% silt, 5% pebbles, very dry, 2 cm pebbles, 028SL. Bottom of Exploration at 6 feet. Groundwater not encountered.	0
10						
15						
20						