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Source Removal Action Plan Fire Training Area

120th Fighter Interceptor Group
Montana Air National Guard
International Airport, Great Falls, Montana

February 1992



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The source removal action plan (SRAP) is an evaluation of the soil removal action alternatives for site 1 - the current fire training area. The site is located at the Montana Air National Guard, Great Falls International Airport, Montana. The SRAP assess' the study area characteristics and justifies the need for a removal action, it identifies the removal action objectives, it identifies the removal action alternatives, it evaluates the removal action alternatives and selects a removal action which will achieve the removal action objectives. The SRAP will serve as the basis for an action memorandum, as well as design implementation of the removal action. The selected SRAP alternative was bioremediation.

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ABBREVIATIONS AND ACRONYMS

AM	Action memorandum
ARAR	Applicable or relevant and appropriate requirements
bgl	Below ground level
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DOD	Department of Defense
DOE	Department of Energy
EPA	United States Environmental Protection Agency
ES	Engineering-Science, Inc.
FIG	Fighter Interceptor Group
FTA	Fire Training Area
GC	Gas chromatograph
HAZWRAP	Hazardous Waste Remedial Action Program
HMTC	Hazardous Materials Technical Center
IRP	Installation restoration program
MW	Monitoring well
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NGB	National Guard Bureau
NOAA	National Oceanic and Atmospheric Administration
O&M	Operations and maintenance
PA	Preliminary Assessment
PRE	Preliminary risk evaluation
PVC	Polyvinyl chloride
RI	Remedial investigation
SB	Soil boring
SCS	Soil Conservation Service
SI	Site investigation
SOV	Soil organic vapor
SRAP	Source removal action plan
TBC	To be considered
TPH	Total petroleum hydrocarbons
UST	Underground storage tank
VOC	Volatile organic compounds

SECTION 1

INTRODUCTION

1.1 PURPOSE, SCOPE, AND OBJECTIVES

This document is a source removal action plan (SRAP) that has been completed for the 120th Fighter Interceptor Group (FIG) by Engineering-Science (ES) under subcontract to the HAZWRAP Support Contractor Office. The HAZWRAP Support Contractor Office is operated by Martin Marietta Energy Systems, Inc. (Martin Marietta) for the U.S. Department of Energy (DOE). DOE is assisting the National Guard Bureau (NGB) by administering certain aspects of the NGB Installation Restoration Program (IRP).

This report is based on the preliminary assessment (PA) for the 120th FIG (HMTC, 1988) and data gathered during the site investigation (SI) at the 120th FIG, Montana Air National Guard, Great Falls International Airport, Great Falls, Montana. The PA identified, through records search and interviews, eight sites at the base where waste management or spills may have resulted in environmental damage. This SRAP addresses one of those sites, the site identified as site 1, "the current fire training area."

The SI was conducted according to the SI work plan (ES, 1990) finalized on May 24, 1990. SI field activities at the base officially began July 30, 1990, and were completed on October 29, 1990. Activities conducted at the base as part of the SI were soil gas surveys, soil borings to gather stratigraphic information, soil samples for analytical testing, construction of piezometers to determine groundwater flow direction, and construction and sampling of groundwater monitoring wells.

This SRAP has been prepared in support of the proposed removal action for soils at the current fire training area (FTA). The soils in this area have been contaminated as a result of fire training activities. The materials used in the burns were primarily waste fuels. There are no records documenting the quantities or types of materials that were burned. The analytical data indicate that fuel constituents remain in the soil.

The removal action is completed parallel to the PA/SI and RI/FS process between the SI and the remedial investigation (RI). Once the removal action is complete, this site will return to the PA/SI and RI/FS process. If the site no longer poses a threat, a decision document will be written. If a threat remains, the site will be included in the base RI.

Purpose

The SRAP is an evaluation of the removal action alternatives for a site. The purpose of the SRAP is to:

- Assess the study area characteristics and justify the need for a removal action
- Identify removal action objectives
- Identify removal action alternatives
- Evaluate removal action alternatives
- Propose a removal action which will achieve the removal action objectives.

Additionally, the SRAP serves as a basis for an action memorandum, as well as design and implementation of the removal action. The action memorandum documents the need for a removal action and the decision process leading to a removal action.

The overall objective of a removal action is to eliminate or reduce the potential for exposure to chemical contaminants in order to minimize threats to human health or the environment. The primary threat from the contaminated soil at this site is the potential for uncontrolled releases of hazardous constituents from the subsoils or the ground surface. The removal and/or proper treatment of the contaminated soil is necessary for the protection of human health and the environment.

1.2 STATUTORY AUTHORITY

Authority for responding to releases or threats of releases from a hazardous waste site is addressed in section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended. Executive Order 12580 delegates to the NGB the response authority for Air National Guard sites, whether or not the sites are on the National Priorities List of the U.S. Environmental Protection Agency (EPA). Under CERCLA Section 104(b), the NGB is authorized to investigate, survey, test, or gather other data required to identify the existence, extent, and nature of contaminants, including the extent of danger to human health or welfare and the environment. In addition, the NGB is authorized to undertake planning, engineering, and other studies or investigations appropriate to directing response actions that prevent, limit, or mitigate the risk to human health or welfare and the environment.

SECTION 2

SITE CHARACTERIZATION

2.1 BASE DESCRIPTION AND HISTORY

Base History

The 120th FIG is located at the Great Falls International Airport, Cascade County, Montana, approximately 3 miles southwest of Great Falls. Great Falls is located in central Montana, as shown on Figure 2.1. The base's facilities consist of over fifty buildings, occupying approximately 125 acres of land leased from the airport authority on the southeast corner of the 1,762-acre airport. Agricultural land borders the base on the west. The area immediately south of the base along Interstate 15 is designated for industrial and commercial uses. Part of the open area southwest of the airport is used for outdoor recreation. Residential areas are located on and below the Sun River bench north and northeast of the base.

The 120th FIG's mission is to serve the U.S. Air Force and the Department of Defense (DOD) with a defense fighter group that can be mobilized in time of war or national emergency. In addition, the 120th FIG ensures air sovereignty in its assigned air defense sectors, and provides aircraft to intercept airborne objects posing a threat to the U.S. as part of the overall air defense system for the North American continent.

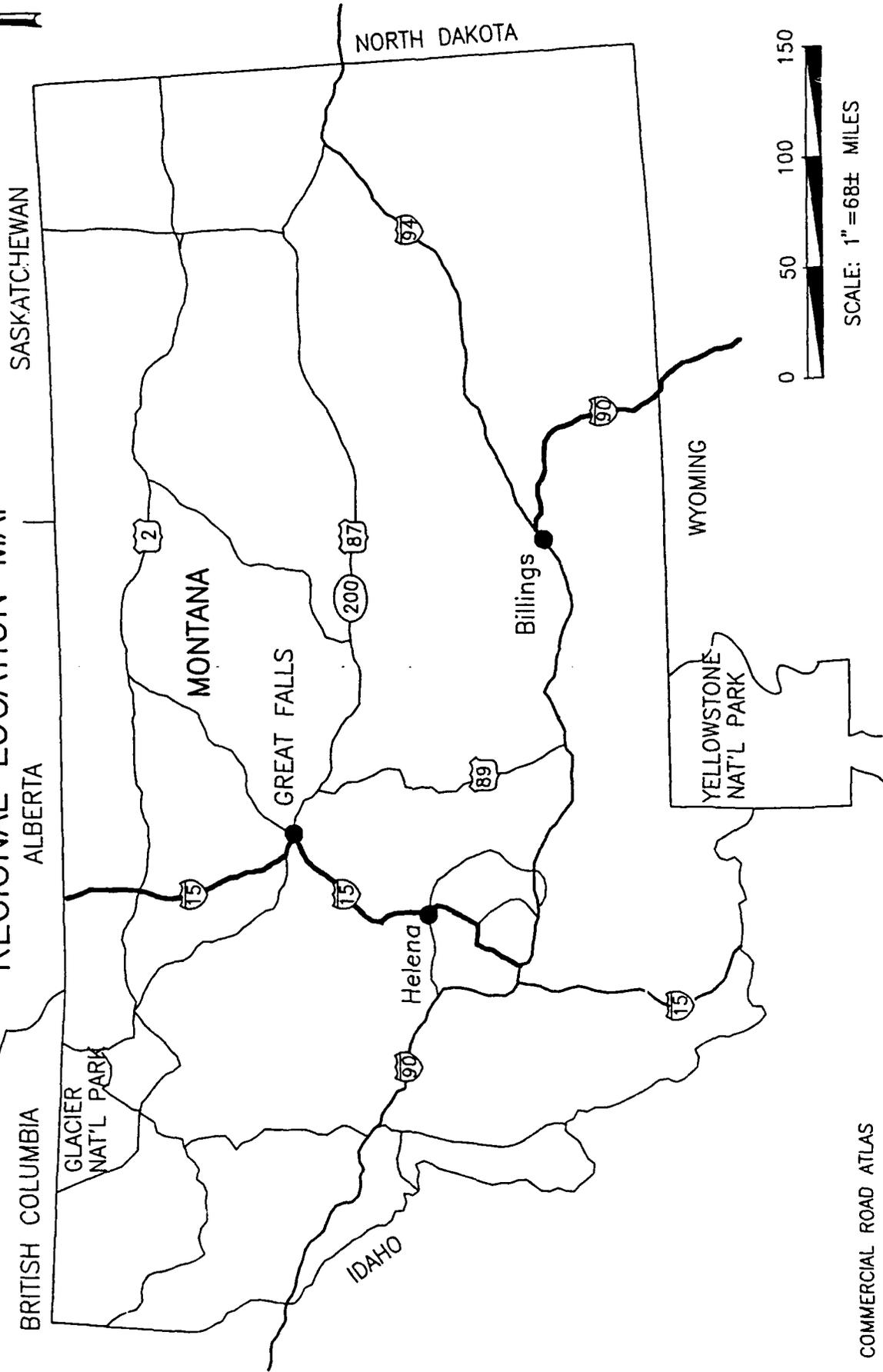
The base was first used as a military installation before and during World War II, when the Army Air Corps 7th Ferry Group was headquartered at what was then called Gore Field. The 7th Ferry Group airlifted lend-lease equipment and supplies to the Soviet Union. The Air Force and the Air National Guard were formed after the war.

The present Montana Air National Guard began as the 186th Fighter Squadron on June 27, 1947, with Lt. Col. Willard S. Sperry as commander. The 186th was activated during the Korean police action and served at Moody Air Force Base (AFB), Georgia, and later at George AFB, California. Some 186th personnel served in Korea, Ohio, or at Malmstrom AFB, Montana, during this period. The unit was deactivated on December 31, 1952.

In 1953, the 186th became the first National Guard unit in the United States to fly the F-86A jet fighter. Six new buildings were constructed during the expansion program of 1954. The 120th FIG came into existence on April 16, 1956. The runway was extended in 1960 to accommodate the F-89J aircraft. In 1984, the unit's

FIGURE 2.1
GREAT FALLS

REGIONAL LOCATION MAP



SOURCE: COMMERCIAL ROAD ATLAS

120th ITC International Airport, Great Falls, Montana

mission was expanded when it was assigned the additional task of operating an alert detachment at Davis-Monthan AFB, Tucson, Arizona. Since July 1, 1987, the unit has flown the F-16 "Fighting Falcon."

Geological and Hydrogeological Setting

The base is situated on sandy, silty loams and loamy sands of the Tally-Azar-Litten Association. These soils typically have a low shrink-swell potential and a high infiltration rate, with estimated permeabilities ranging from 2 to 20 inches per hour. The low clay content of the soils results in a low available water capacity (SCS, 1982).

The base is situated on the northeastern edge of the Sun River bench, a plateau of Cretaceous-aged rock which rises about 350 feet above Great Falls and slopes gently to the northwest. The rock units that underlie the base are, in descending order, the Taft Hill and Flood Members of the Blackleaf Formation, which belongs to the Colorado Group, and the Kootenai Formation, all of which are of Cretaceous age; Morrison and Swift Formations of Jurassic age; and the Madison Group of Mississippian age.

Groundwater is present in each of the rock units described above. The shallowest groundwater encountered at the base occurs in the upper sandstone of the Flood Member. Regional groundwater flow in the area is to the west-northwest. Wells completed in the Flood are less than 100 feet deep and are sources of water for both domestic and stock uses on the bench. The Flood Member is recharged mainly from infiltration of precipitation on the bench. A complete discussion of the regional hydrogeology is presented in the SI report (ES, 1991).

Site-Specific Geologic and Hydrogeologic Investigation Results

The geology and hydrogeology of the FTA was evaluated with an adjacent site since the two sites are close together. The subsurface lithology in this area consists of soil and weathered sandstone underlain by hard sandstone. Surface soils consisting of light brown sandy, silty soil extend to 2 feet below ground level (bgl). Weathered sandstone was encountered at depths as shallow as 2 feet. Table 2.1 lists the depths below ground level to top of competent sandstone, the depth to the contact of tan sandstone to grey sandstone, and the thickness of the sandstone in each of the wells and piezometers. The grey sandstone is a transition layer between the tan sandstone and an underlying shale layer. The shale layer was not encountered at the FTA, but was encountered in other areas of the base. The thickness of the hard, competent sandstone ranges from 29 to 42 feet in the vicinity of the site. Four piezometers were used to define the lithology and groundwater flow direction for the two sites. The data gathered from the two monitoring wells were also used to help define the hydrogeology of the study area. The depth to water at the site ranged from 43 to 51 feet below the ground surface during the SI. The groundwater elevations and flow direction at the site are shown in Figure 2.2. The groundwater flow at the site was generally to the northeast.

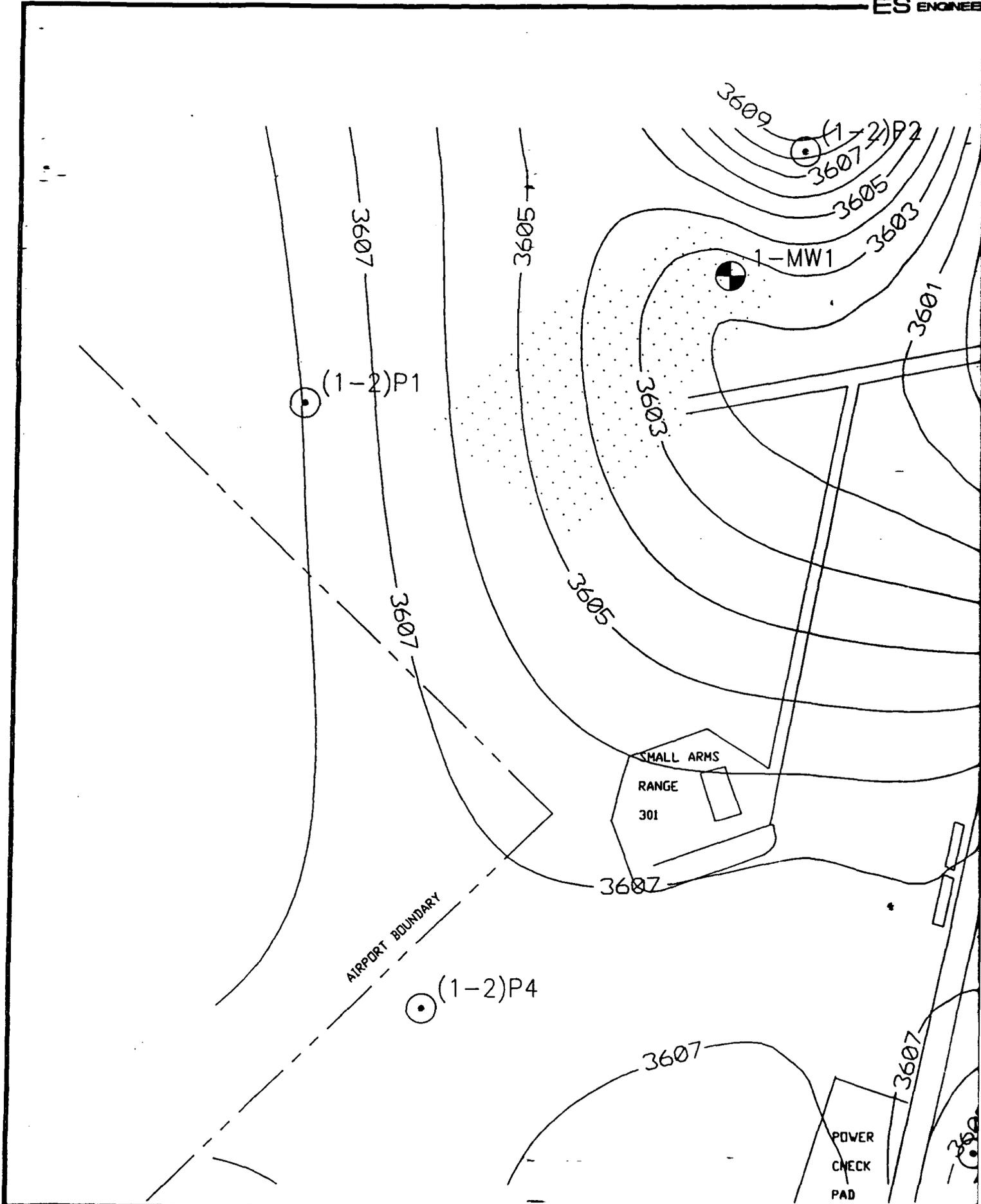
A cross section was drawn using the lithologic logs of the well and piezometer borings in the study area. The orientation of the cross section is shown on

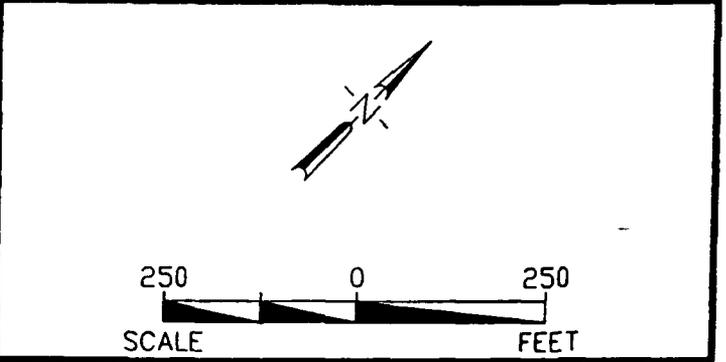
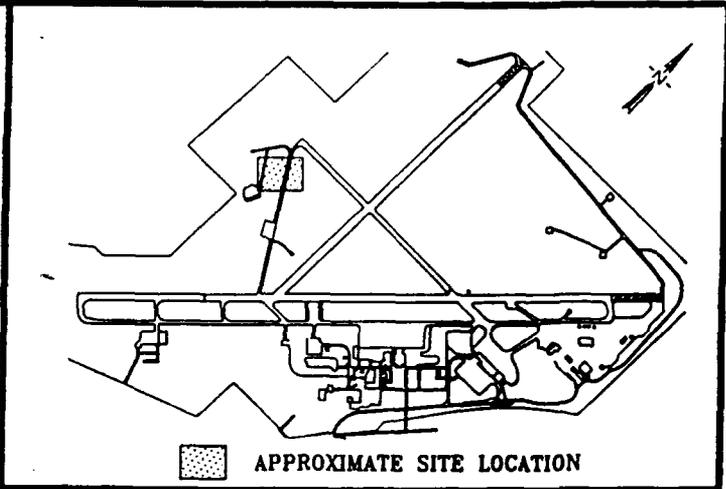
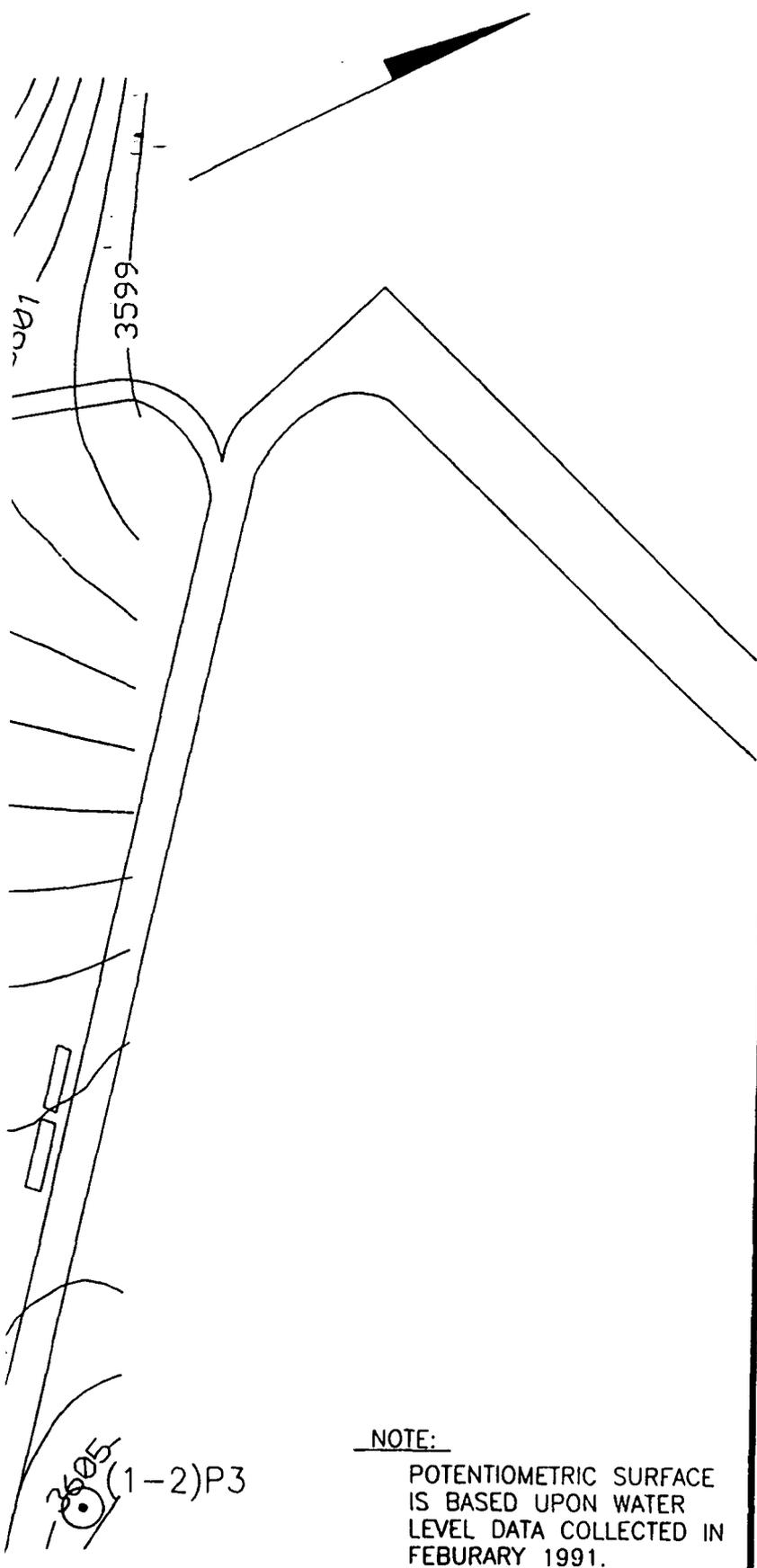
Table 2.1 Bedrock Data for Fire Training Area
120th Fighter Interceptor Group
Great Falls, Montana

Well/ Piezometer ID	Depth to Top of Competent Sandstone*	Depth to Base of Competent Sandstone*	Thickness of Competent Sandstone (feet)
MANG-1-MW1	17.7	**	**
MANG-2-MW1	15.0	55.0	40.0
MANG-P1	17.7	56.6	38.9
MANG-P2	17.1	58.4	41.3
MANG-P3	15.0	56.8	41.8
MANG-P4	20.8	**	**

* All depths are in feet below ground level.

** Base of sandstone was not encountered.





- LEGEND**
- P5
PIEZOMETER LOCATION AND NUMBER
 - ⊕ 2-MW1
MONITOR WELL LOCATION AND NUMBER
 - GENERAL DIRECTION OF WATER FLOW
 - 3607— POTENTIOMETRIC SURFACE CONTOUR ELEVATIONS (FEET, MEAN SEA LEVEL)

FIGURE 2.2
POTENTIOMETRIC SURFACE
FIRE TRAINING AREA

NOTE:
POTENTIOMETRIC SURFACE IS BASED UPON WATER LEVEL DATA COLLECTED IN FEBRUARY 1991.

Figure 2.3, while the cross section is shown on Figure 2.4. The cross section shows relatively flat-lying bedrock with no major structural displacement overlain by unconsolidated material. The cross section does not differentiate weathered sandstone from the underlying competent sandstone.

Area Meteorology

The meteorological data presented in the PA were derived from local climatological data for the Great Falls area compiled by the National Oceanic and Atmospheric Administration (NOAA). The climate of the Great Falls area is semiarid. Mean annual precipitation is about 15 inches. About 70 percent of the annual total rainfall normally occurs between April and September. The mean annual temperature is about 45°F, with winters averaging 25°F and summers averaging 66°F.

Calculations performed by the method outlined in the *Federal Register* (47 FR 31224) indicate a net precipitation value of -19 inches per year in the area. The maximum rainfall intensity, based on a 1-year, 24-hour rainfall, is 1.25 inches (47 FR 31235).

2.2 SITE DESCRIPTION AND HISTORY

The site was used as a fire training area (FTA) from 1968 until early in 1989. Figure 2.5 is an overview of the site in relation to the airport. The site is located on the west side of the airport facility, west of the power check pad and the small arms range, and consists of one large and three smaller FTAs. The total area of the site is less than 1 acre (5,000 square yards, or 45,000 square feet).

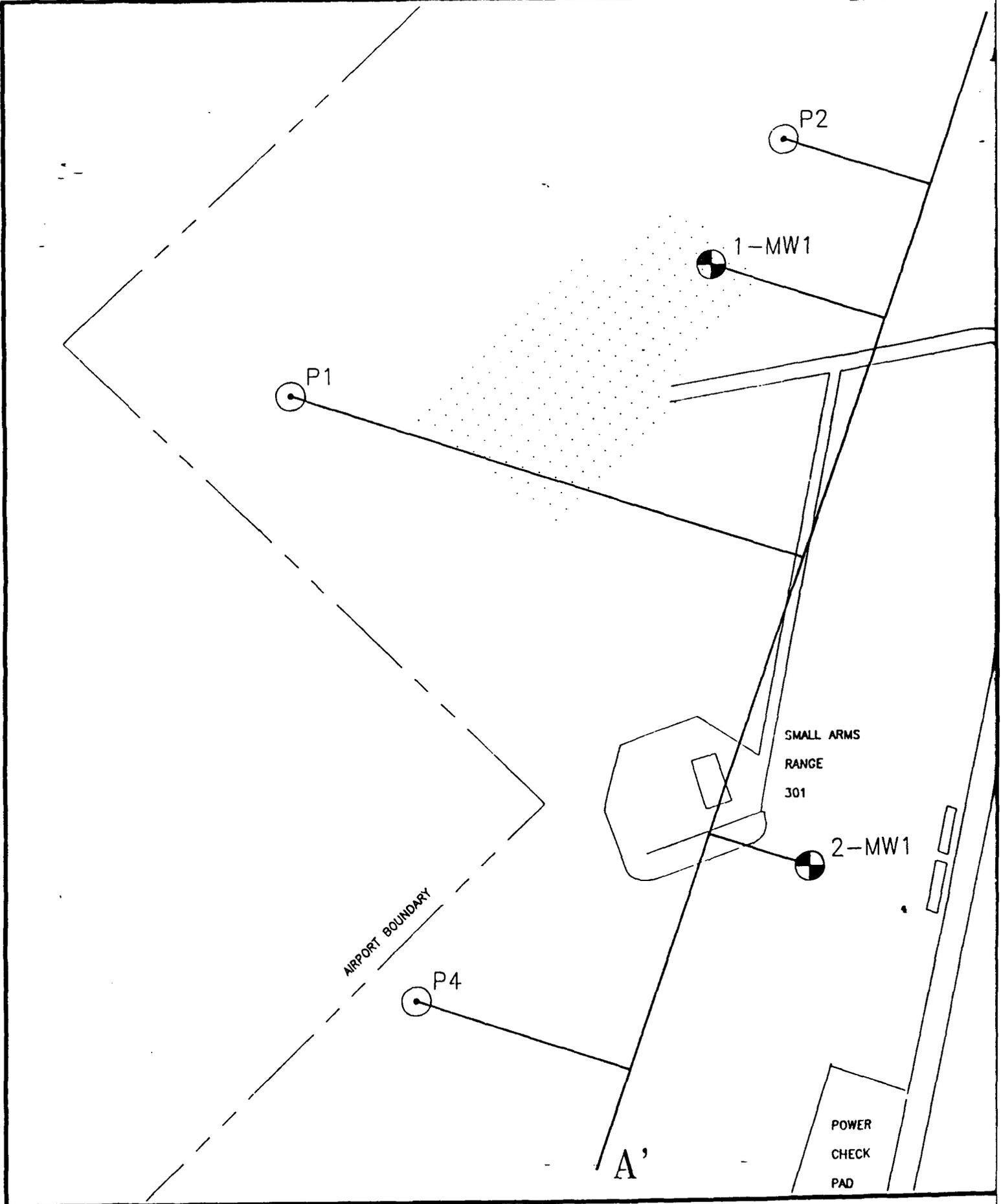
The PA reported stained soil in all areas and cans, wood, metal, and tire debris in the smaller areas. The site was mostly clear of small debris during the SI, but a large cylindrical, metal object remained in the center of the large FTA. This object aided in simulation of a burning aircraft during the fire training exercises. Waste fuels were poured on the ground and burned during the exercises (HMTC, 1989).

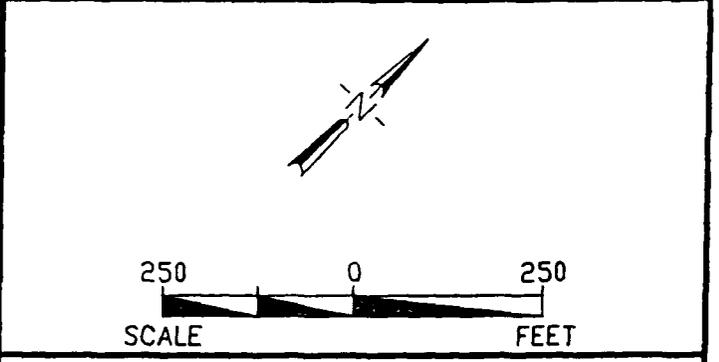
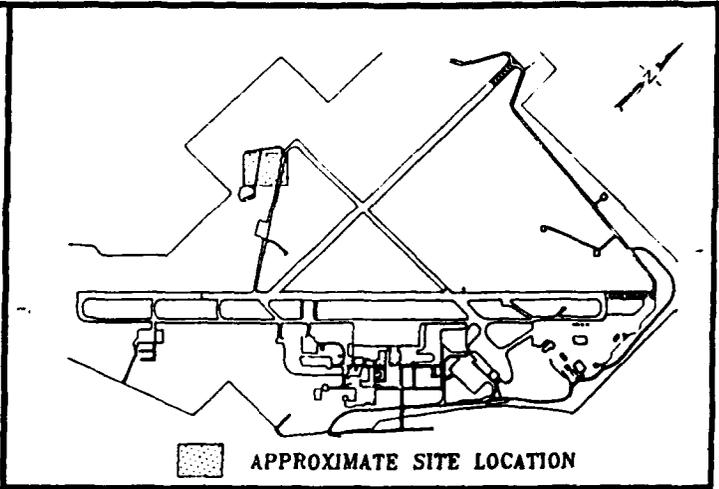
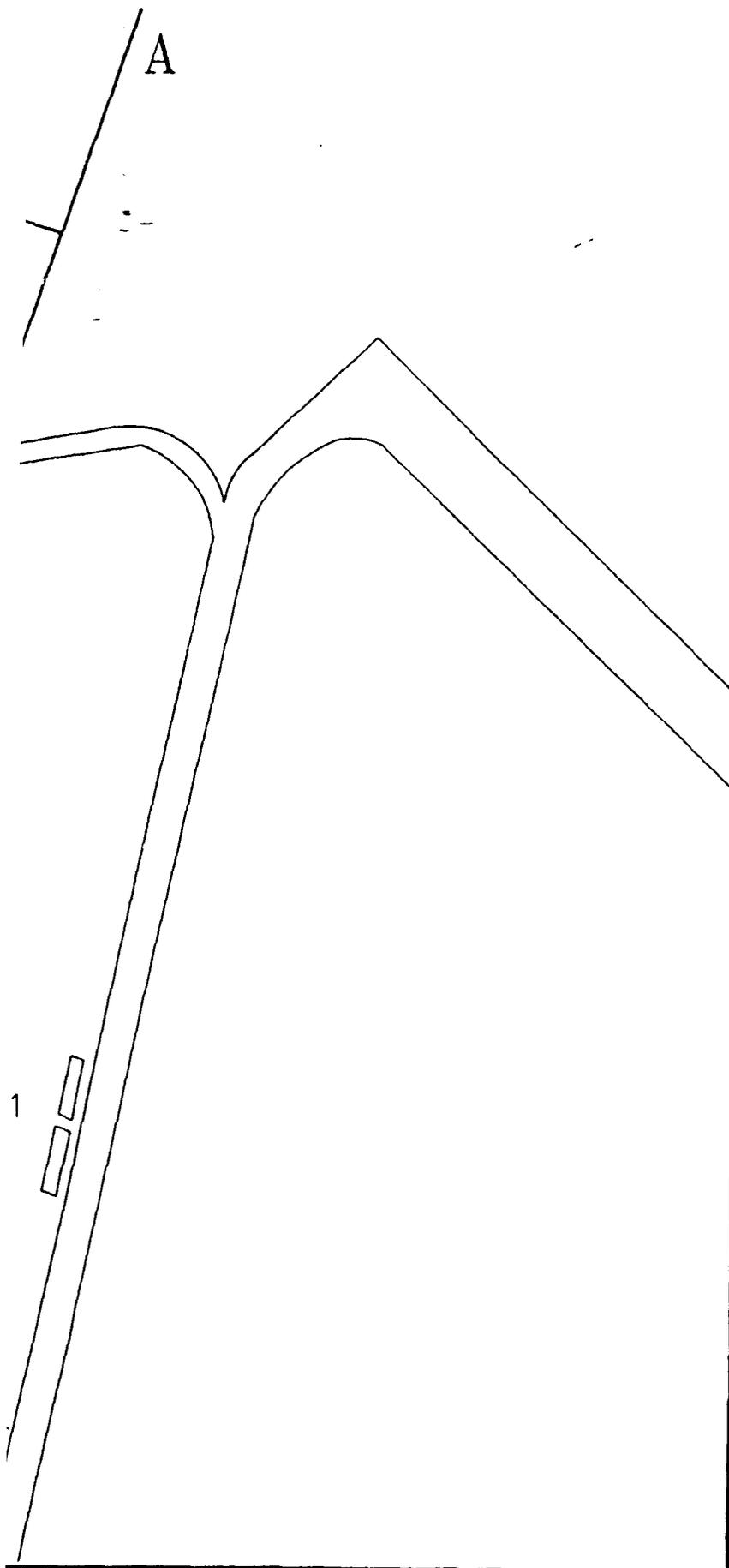
2.3 CONTAMINATION ASSESSMENT

The results of the SI activities are summarized below. These activities include both screening (such as soil gas surveys) and confirmation sampling. The primary purpose of the screening activities was to provide information to be used in locating the soil borings. Confirmation sampling was used to confirm the extent of the contamination and to positively identify the contaminants present.

Soil Gas

The compounds detected in the soil gas survey (also known as a soil organic vapor (SOV) survey) are shown in Figure 2.6 and Table 2.2. Samples were collected on a 300- by 600-foot grid with 50-foot spacing and analyzed with a portable gas chromatograph (GC). The grid was set up to surround the fire training area, which was identified by its dark stained soil. Soil gas samples were not collected in burn areas because there was already clear visual evidence of contamination and because several SOV samples collected adjacent to the burn area had soil gas readings which





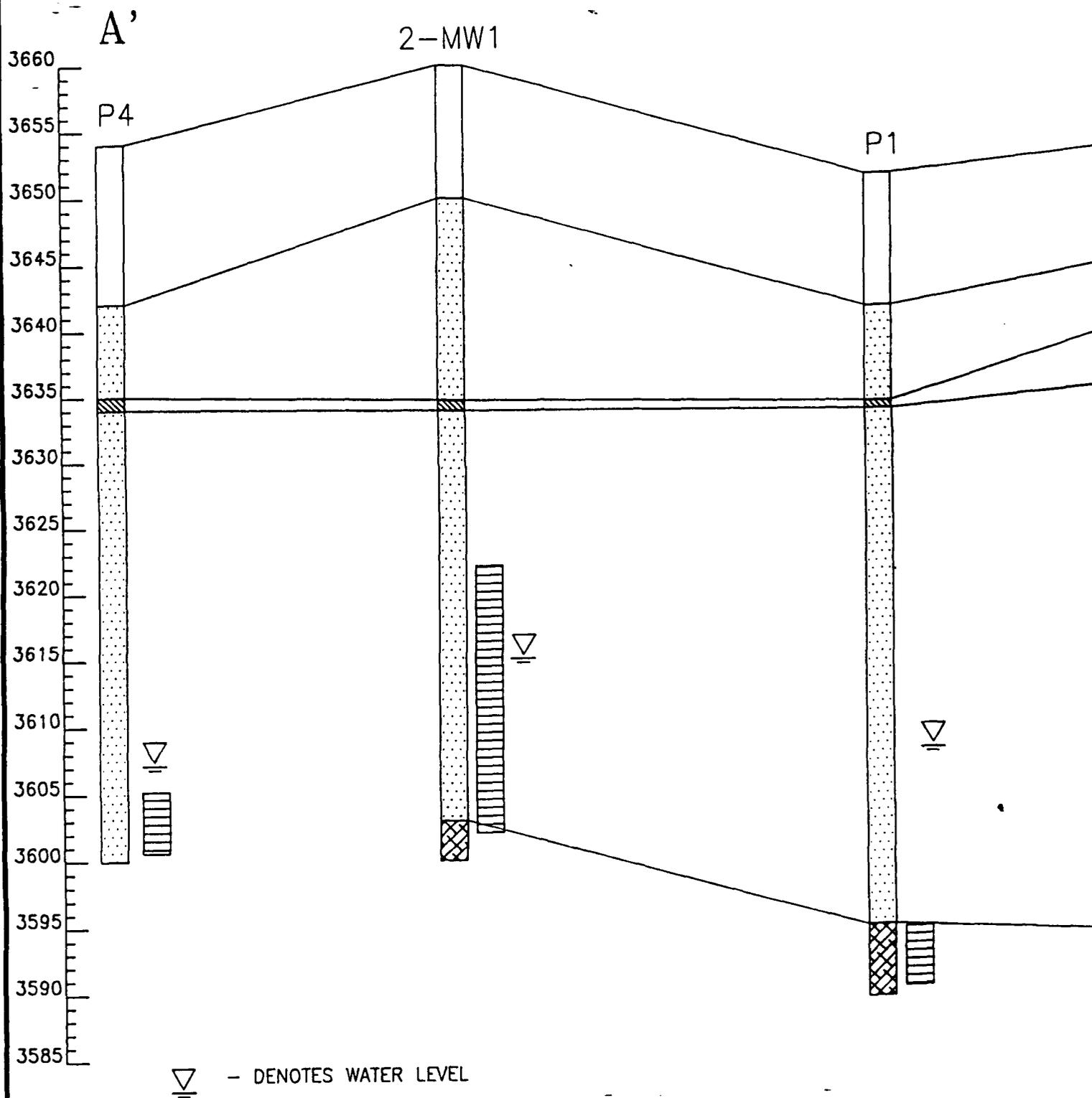
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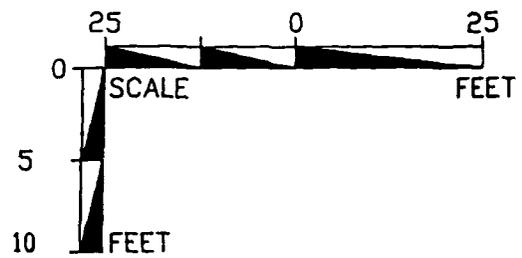
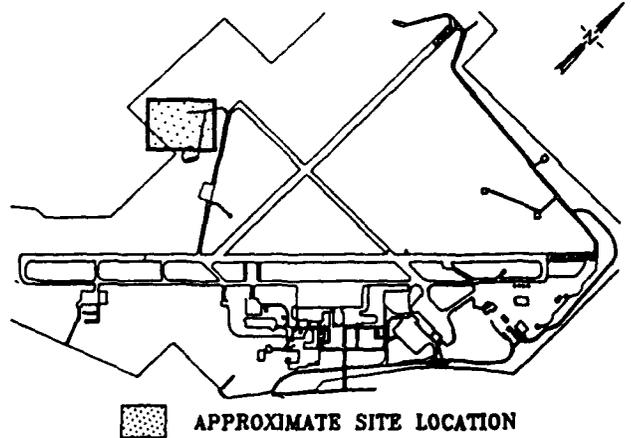
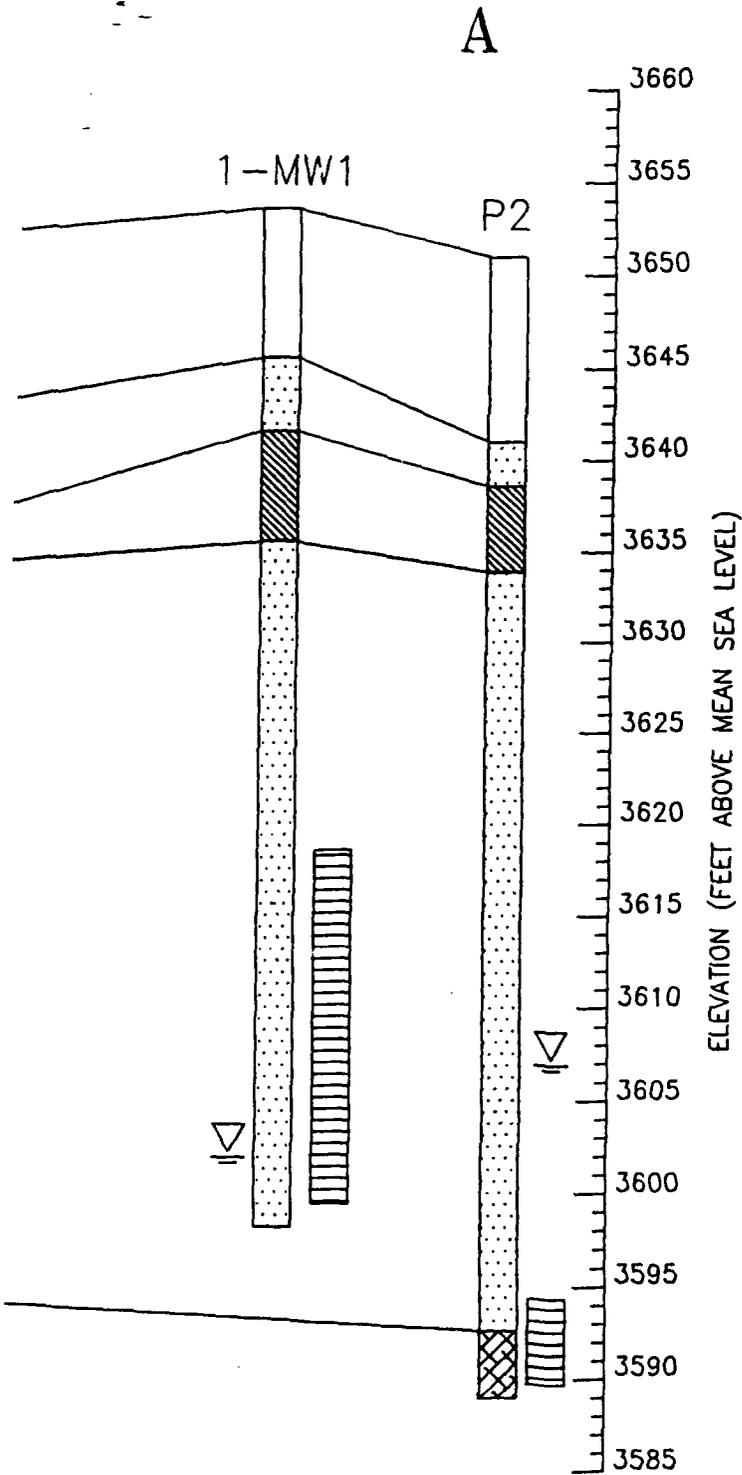
 P3
 PIEZOMETER LOCATION
 AND NUMBER

 2-MW1
 MONITOR WELL
 LOCATION AND NUMBER

 APPROXIMATE SITE
 LOCATION

FIGURE 2.3
CROSS SECTION
ORIENTATION
FIRE TRAINING AREA





LEGEND

-  SOIL OR WEATHERED ROCK
-  SANDSTONE (TAN)
-  CLAY
-  SANDSTONE (GRAY)
-  WELL SCREEN

FIGURE 2.4
GENERALIZED
CROSS SECTION
FIRE TRAINING AREA

LEGEND

- 1-MW1 MONITORING WELL
- ⊙ P1 PIEZOMETER

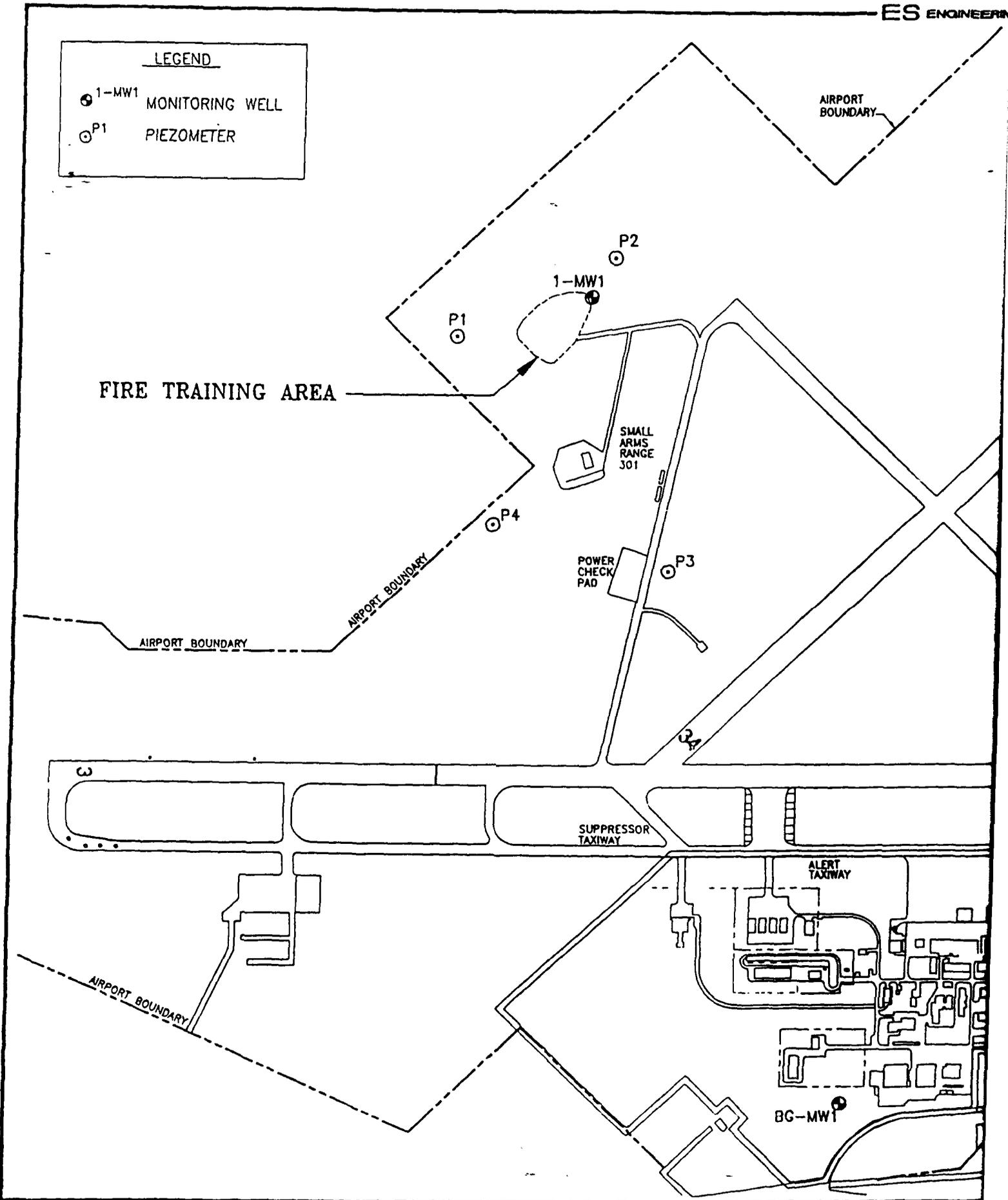
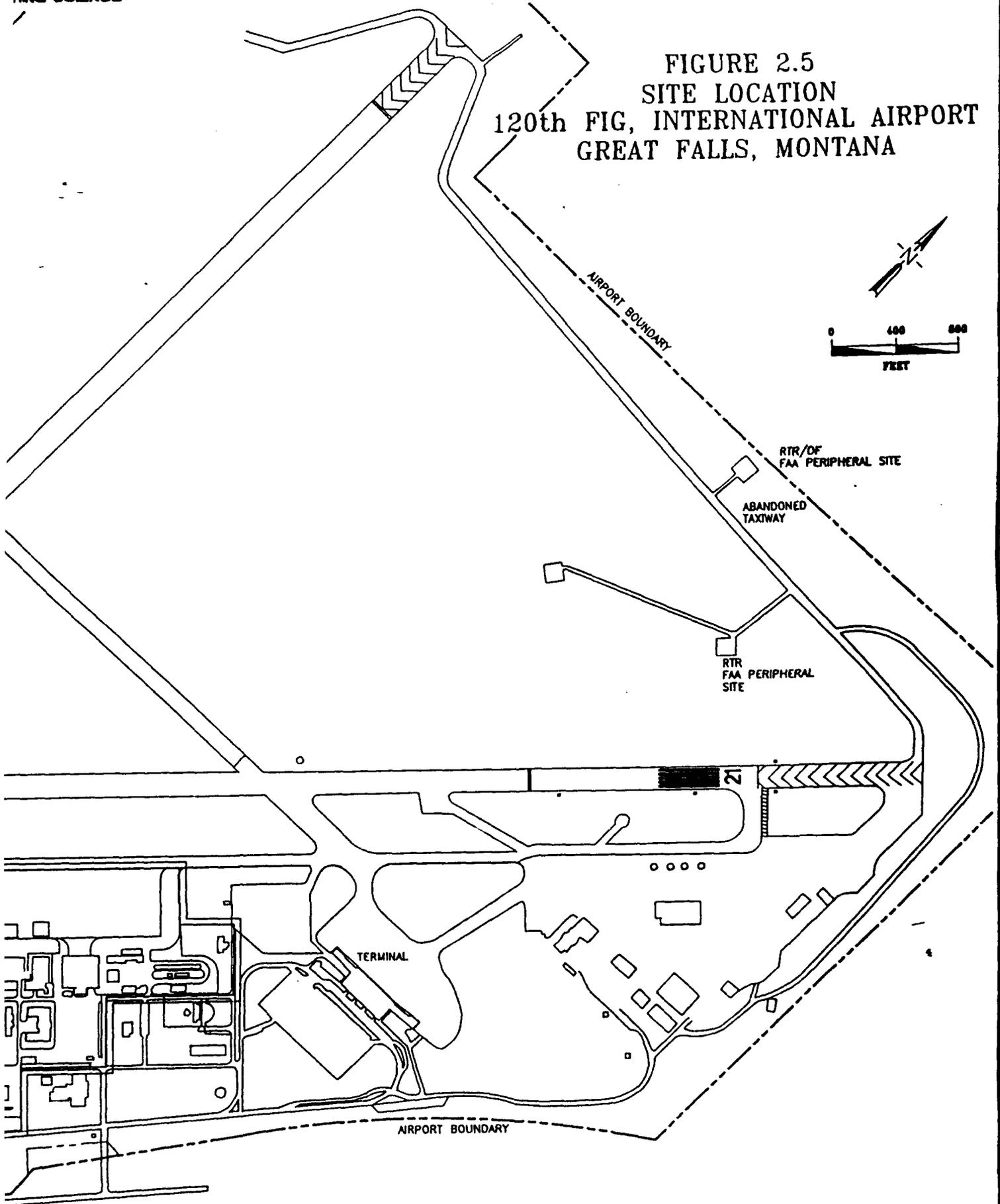
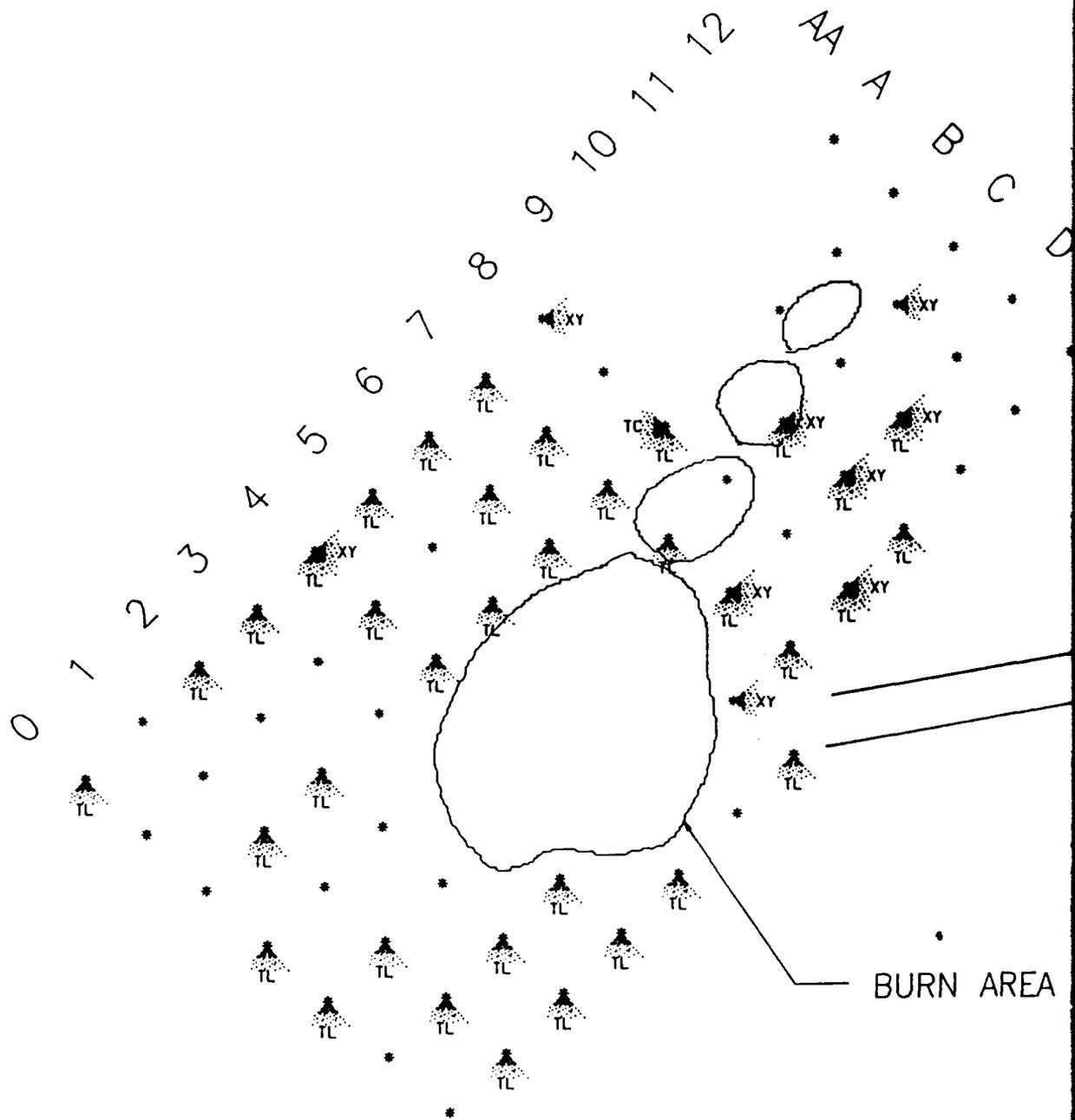


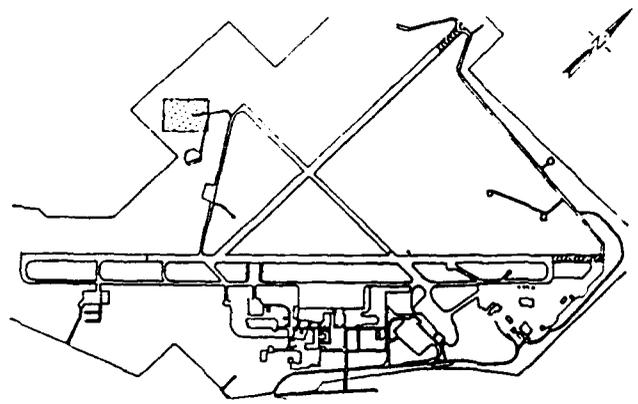
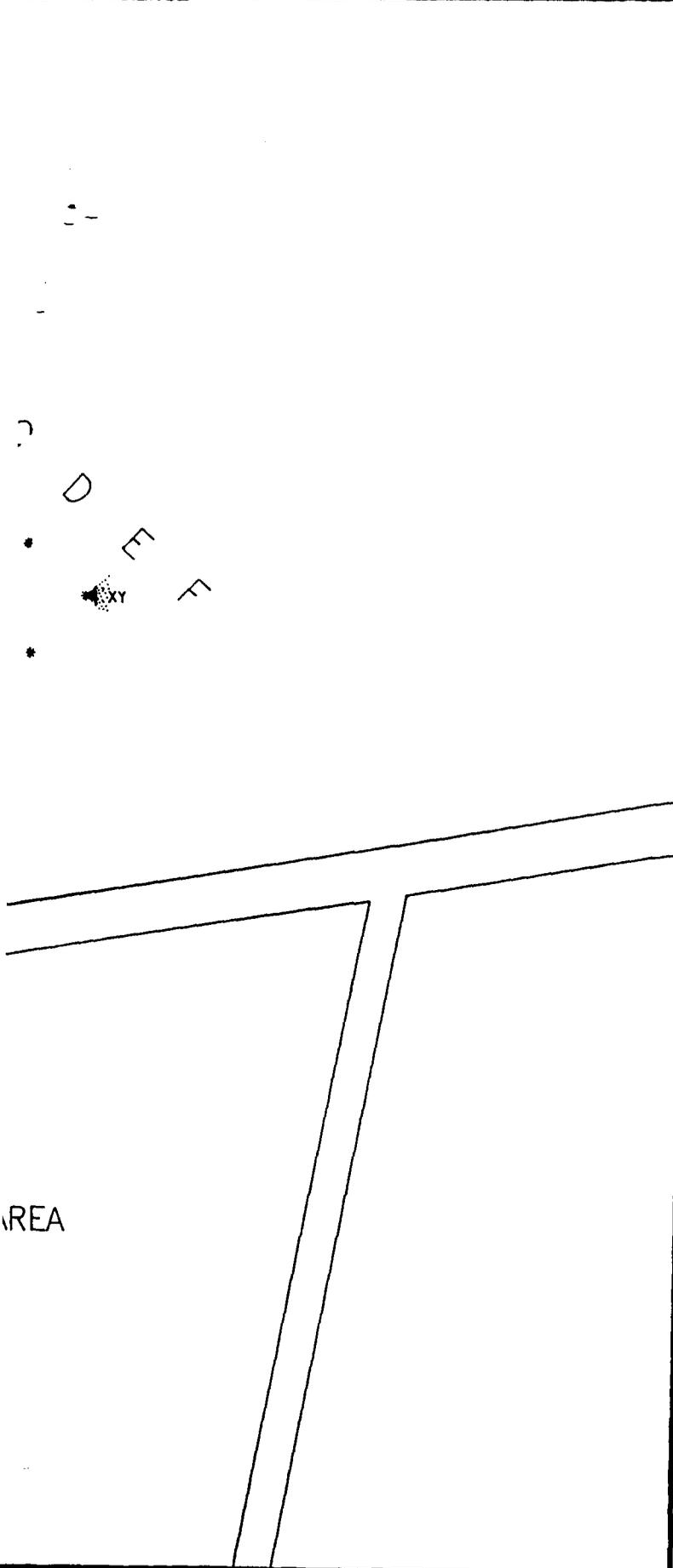
FIGURE 2.5
SITE LOCATION
120th FIG, INTERNATIONAL AIRPORT
GREAT FALLS, MONTANA



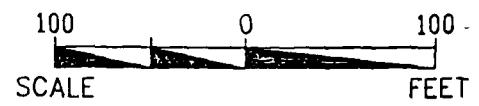
120th FIG International Airport, Great Falls, Montana



NOTE: SOIL GAS SAMPLES WERE NOT COLLECTED IN THE BURN AREAS BECAUSE THERE WAS CLEAR VISUAL EVIDENCE OF CONTAMINATION IN THESE AREAS.



APPROXIMATE SITE LOCATION



LEGEND

- TCE DETECTED
- TOLUENE DETECTED
- O-XYLENE DETECTED
- SOV GRID POINT

FIGURE 2.6
RESULTS OF SOIL
GAS SURVEY
FIRE TRAINING AREA

Table 2.2 Organic Constituents Detected in Soil Gas Survey
 Fire Training Area
 120th Fighter Interceptor Group, Great Falls, Montana
 (ppb by volume, GC)

Sample ID	Grid Coordinates		TCE*	Toluene	o-Xylene
F0	0	0	ND	ND	ND
F1	0	-50	ND	18	ND
F2	0	-100	ND	19	ND
F3	0	-150	ND	8	ND
F4	0	-200	ND	21	ND
F5	0	-250	ND	0	ND
F6	0	-300	ND	14	ND
E0	50	0	ND	ND	ND
E1	50	-50	ND	***	ND
E2	50	-100	ND	8	ND
E3	50	-150	ND	***	ND
E6	50	-300	ND	ND	150
E7	50	-350	ND	8	ND
E8	50	-400	ND	10	28
E9	50	-450	ND	8	ND
E10	50	-500	ND	ND	ND
E11	50	-550	ND	ND	ND
E12	50	-600	ND	ND	290
D0	100	0	ND	19	ND
D1	100	-50	ND	22	ND
D2	100	-100	ND	ND	ND
D7	100	-350	ND	8	300
D8	100	-400	ND	ND	ND
D9	100	-450	ND	9	52
D10	100	-500	ND	33	97
D11	100	-550	ND	ND	ND
D12	100	-600	ND	ND	ND
C0	150	0	ND	8	ND
C1	150	-50	ND	ND	ND
C2	150	-100	ND	ND	ND
C7	150	-350	ND	***	ND
C8	150	-400	ND	ND	ND
C9	150	-450	ND	14	240
C10	150	-500	ND	ND	ND

Sample ID	Grid Coordinates		TCE	Toluene	o-Xylene
C11	150	-550	ND	ND	1,680
C12	150	-600	ND	ND	ND
B0	200	0	ND	ND	ND
B1	200	-50	ND	18	ND
B2	200	-100	ND	23	ND
B3	200	-150	ND	ND	ND
B4	200	-200	ND	8	ND
B5	200	-250	ND	8	ND
B6	200	-300	ND	12	ND
B7	200	-350	ND	8	ND
B8	200	-400	9	16	ND
B10	200	-500	ND	ND	ND
B11	200	-550	ND	ND	ND
B12	200	-600	ND	ND	ND
A0	250	0	ND	ND	ND
A1	250	-50	ND	ND	ND
A2	250	-100	ND	ND	ND
A3	250	-150	ND	ND	ND
A4	250	-200	ND	11	ND
A5	250	-250	ND	ND	ND
A6	250	-300	ND	12	ND
A7	250	-350	ND	12	ND
A8	250	-400	ND	ND	ND
A12	250	-600	ND	ND	ND
AA0	300	0	ND	8	ND
AA1	300	-50	ND	ND	ND
AA2	300	-100	ND	49	ND
AA3	300	-150	ND	12	ND
AA4	300	-200	ND	24	340
AA5	300	-250	ND	17	ND
AA6	300	-300	ND	19	ND
AA7	300	-350	ND	8	ND
AA8	300	-400	ND	ND	190

E5\AU23409\5T2-1.WK1

ND = not detected
 *TCE = trichloroethene
 *** = Too high to quantify

exceeded the working range of the analytical equipment. The soil gas survey revealed little or no contamination outside the burn areas.

Soil Borings

A total of nine soil borings were drilled and sampled at the FTA. Figure 2.7 shows the locations of the soil borings. All of the borings were drilled within the soil gas survey area except for SB7, which was drilled directly into a burn area, and SB9, which was drilled outside the soil gas grid to verify the areal extent of contamination. The deepest boring was 4 feet below ground level, the depth at which sandstone was encountered. The soil borings were not continued into the sandstone. No staining or other observations indicated contamination in the soil borings except in SB7, where black-stained soil extended to a depth of 1.5 feet below the surface.

Soil Sampling

Thirteen subsurface soil samples and one duplicate subsurface soil sample were collected at the FTA for chemical analysis. Several volatile organic, semivolatile organic, and petroleum hydrocarbon compounds as well as metals were detected in the analyses. The organic compounds detected are all common components of fuels. The constituents detected and their respective concentrations are shown on Table 2.3 and the contaminants of concern are shown on Figure 2.7.

Several volatile organics were found in the subsurface soil samples collected at site 1: toluene (up to 8,800 $\mu\text{g}/\text{kg}$ ¹), ethyl benzene (up to 22,000 $\mu\text{g}/\text{kg}$), m/p-xylene (up to 150,000 $\mu\text{g}/\text{kg}$), o-xylene (up to 77,000 $\mu\text{g}/\text{kg}$), acetone (up to 220 $\mu\text{g}/\text{kg}$), and 2-butanone (up to 14 $\mu\text{g}/\text{kg}$).

Semivolatile organics detected in the subsurface soil samples collected at site 1 are 2-methylnaphthalene (up to 13,000 $\mu\text{g}/\text{kg}$), phenanthrene (up to 9,500 $\mu\text{g}/\text{kg}$), fluoranthene (up to 4,900 $\mu\text{g}/\text{kg}$), and pyrene (up to 14,000 $\mu\text{g}/\text{kg}$), and diethylphthalate (up to 270 $\mu\text{g}/\text{kg}$). Phthalates are common laboratory and sampling contaminants.

The total petroleum hydrocarbons (TPH) analyses indicated contamination at the site. The concentrations of total petroleum hydrocarbons range up to 120,000 mg/kg ².

Concentrations of the majority of the metals detected in subsurface soils at site 1 were below the levels detected in background samples taken in an undisturbed area of the base; these are listed in Table 2.3. The background range was defined as the average of the background concentrations plus or minus two standard deviations. The metals detected above background concentrations were lead, arsenic, copper, cadmium, nickel, mercury, and zinc. While these metals were present at levels slightly above background, none of them were present at levels exceeding health criteria. The health criteria used are discussed in section 2.4.

¹ $\mu\text{g}/\text{kg}$ = micrograms per kilogram

² mg/kg = milligrams per kilogram

Table 2.3 Chemical Constituents Detected in Subsurface Soil
 Fire Training Area
 120th Fighter Interceptor Group
 Great Falls, Montana

Chemical	Background (1)	MANG-1 SB1-2	MANG-1 SB2-3	MANG-1 SB3-1	MANG-1 SB3-3	MANG-1 SB4-1.5	MANG-1 SB4-1.5(D)	MANG-1 SB5-1	MANG-1 SB5-3.5	MANG-1 SB6-1	MANG-1 SB6-3.5	MANG-1 SB7-1	MANG-1 SB8-1	MANG-1 SB9-1	Health (2) Criteria
Volatile organics (µg/g):															
Acetone	ND-157	ND	15 J	ND	90 J	ND	ND	ND	22 J	220	22 J	ND	ND	ND	8E06
2-Butanone	ND	ND	ND	ND	14 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	4E06
Toluene	ND-9	ND	ND	ND	92	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.6E07
Ethyl benzene	ND	ND	ND	ND	16	ND	ND	ND	ND	ND	ND	ND	ND	ND	8E06
m/p-Xylene (3)	ND	ND	ND	ND	54	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.6E08
o-Xylene	ND	ND	ND	ND	40	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.6E08
BNA organics (µg/g):															
2-Methylanthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--
Dibenzophthalene	ND	ND	ND	ND	ND	150 J	ND	ND	ND	ND	ND	ND	ND	ND	6.4E07
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.2E06
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.4E06
Metals (mg/kg):															
Arsenic	1.9-9.9	13.6	3.8	11.2	8.6	8.4	8.4	6.2	6.2	10	13.3	6.3	8.7	17.7	30
Barium	ND-1,231	714	127	113	382	52	763	217	548	279	315	197	244	136	5,000
Cadmium	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	40
Chromium	8.7-22.7	10.2	13.8	15.2	9.8	1.7	5.9	15.5	10.3	19.5	9.6	16.8	17.4	14.9	80,000
Copper	3.3-19.7	22.3	8.8	20.5	18.1	1.3	13.4	15.9	14	20.4	13.7	8.5	13.7	20.4	--
Lead	3.4-13.0	7	13.3	18.1	3.3	16.6	11.4	14.9	7.7	11.7	4	139	17	11.2	500
Mercury	ND	ND	ND	ND	ND	ND	ND	0.16	ND	ND	ND	ND	ND	ND	24
Nickel	3.6-17.6	ND	8.2	7.5	7.9	17.7	ND	10.7	7.1	15.5	ND	10.1	10.6	ND	1,600
Selenium	ND-0.66	0.45	ND	ND	ND	0.38	0.38	ND	ND	ND	0.42	ND	0.36	0.35	2,400
Zinc	21.6-61.3	41.4	39.5	62.9	21.9	51.9	23.5	43.4	26.1	46.5	23.5	54.7	43.5	42.7	16,000
Total petroleum hydrocarbons (mg/kg)	ND	11	ND	25	ND	ND	ND	ND	ND	ND	ND	120,000	ND	ND	--

(1) Background is the average background concentration +/- two standard deviations. Values were obtained from samples collected at the base.

(2) Based upon soil ingestion, see SI report.

(3) Meta- and para-xylene coelute and are not distinguishable by this method.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Organics:

J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

B Reported value is less than reporting limit but greater than the instrument detection limit.

N Spiked sample recovery not within control limits set by lab QA/QC.

S Reported value was determined by the method of standard additions.

• Duplicate analysis not within control limits set by lab QA/QC.

W Postdigestion spike for furnace AA analysis out of control limits (85 to 115%), while sample absorbance is less than 50% of spike absorbance.

Metals:

ES/AU03409/STBI.3.3.w.1

MW1 (SITE 1)	ROU
CLP semivolatile organics (ug/L):	
bis (2-ethylhexyl) phthalate	ND
Metals (mg/L):	
Barium	138
Lead	6.4
Selenium	4.2
Zinc	952

SB8 (1 ft.)	
VOA organics (ug/kg):	
Toluene	5 J

SB5 (1 ft.)	
BNA organics (ug/kg):	
Diethylphthalate	120 J
Metals (mg/kg):	
Lead	14.9 N+S
Mercury	0.16
SB5 (3.5 ft.)	
VOA organics (ug/kg):	
Acetone	22 J

SB2 (1 ft.)	
Diethylphthalate	270 J
Metals (mg/kg):	
Lead	13.3 N+S
SB2 (3 ft.)	
VOA organics (ug/kg):	
Acetone	15 J

SB4 (1.5 ft.)	
Metals (mg/kg):	
Lead	16.6 N+S
Nickel	17.7
SB4 (1.5 ft.) (D)	
Diethylphthalate	150 J

SB1 (2 ft.)	
Metals (mg/kg):	
Arsenic	13.6
Cadmium	0.4 B
Copper	22.3
TPH (mg/kg):	11

SB3 (1 ft.)	
Metals (mg/kg):	
Arsenic	11.2
Copper	20.5
Lead	18.1
Zinc	62.9
TPH (mg/kg):	25
SB3 (3 ft.)	
VOA organics (ug/kg):	
Acetone	90
2-Butanone	14
Toluene	92
Ethyl benzene	16
m/p-Xylene	5
o-Xylene	40

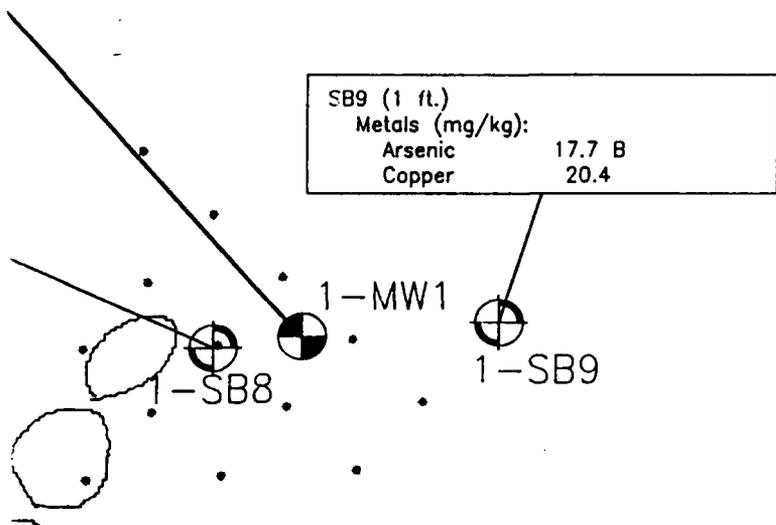
P1

ROUND 1	ROUND 2
ND	62
138 BJ	107 B
6.4 J	2.5 BNJ
4.2 B	8.5 BS
952 *	527



SB9 (1 ft.)
Metals (mg/kg):

Arsenic	17.7 B
Copper	20.4



SB7 (1 ft.)
VOA organics (ug/kg):

Toluene	8,800
Ethyl benzene	22,000
m/p-Xylene	150,000
o-Xylene	77,000

BNA organics (ug/kg):

2-Methylnaphthalene	13,000
Phenanthrene	9,500
Fluoranthene	4,900 J
Pyrene	14,000

Metals (mg/kg):

Lead	139 N*
------	--------

TPH (mg/kg): 120,000

SB6 (1 ft.)
VOA organics (ug/kg):

Acetone	220
---------	-----

Metals (mg/kg):

Arsenic	10
Copper	20.4

SB6 (3.5 ft.)
VOA organics (ug/kg):

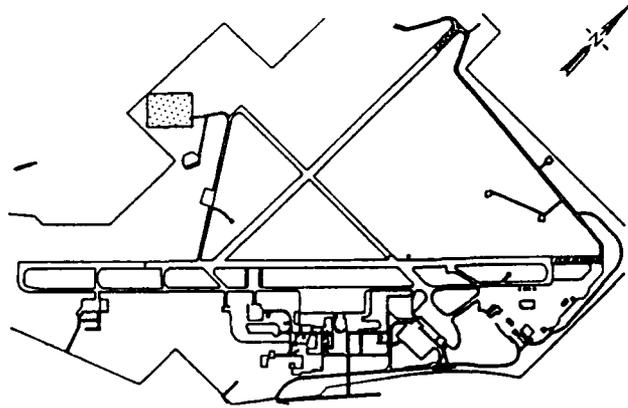
Acetone	22 J
---------	------

Metals (mg/kg):

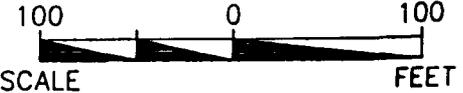
Arsenic	13.3
---------	------

g/kg):

11.2
20.5
18.1 N*
62.9
25
90 J
14 J
92
16
54
40



APPROXIMATE SITE LOCATION



LEGEND

- ⊕ 1-SB1 SOIL BORING LOCATION AND NUMBER
- ⊗ 1-MW1 MONITOR WELL LOCATION AND NUMBER
- ⊙ (1-2)P1 PIEZOMETER LOCATION AND NUMBER
- SOV GRID POINT
- ⊗ SURFACE SOIL LOCATION

NOTE: SEE ANALYTICAL SUMMARY TABLES FOR LABORATORY QUALIFIERS

FIGURE 2.7
SELECTED ANALYTES DETECTED
IN SOIL AND GROUNDWATER
FIRE TRAINING AREA

In addition to the samples collected for the SI, two surface soil samples were collected to provide additional data for this SRAP. These samples were collected from the surfaces of two of the burn areas and analyzed for metals only. The locations of these samples are shown in Figure 2.7. The results are in Table 2.4. Most of the metals concentrations are similar to those found in the subsurface soils. An exception is the lead concentration in the small burn area. The concentration of lead in the sample taken from the small burn area was 660 mg/kg. Soil pH measurements were also taken. The range of pH values for the soils at the FTA was 7.44 to 9.09.

Groundwater Sampling

Groundwater was sampled in October 1990 and in February 1991. The results of the analyses of the groundwater from both rounds of sampling of well MANG-1-MW1 are presented in Table 2.5, and selected analytes are shown on Figure 2.7. Chloroform was the only organic compound detected in the groundwater during the first round of sampling, and it was not detected during the second round. The compound bis(2-ethylhexyl) phthalate was the only semivolatle organic compound detected (second round only). Chloroform was also present in a field blank. Bis(2-ethylhexyl)phthalate was not found in any of the blanks associated with the samples collected at this site. Chloroform and bis(2-ethylhexyl) phthalate are common laboratory and sampling contaminants. Chloroform is used as a solvent in analytical laboratories and often appears in analytical results. Phthalates are found in many plastic and rubber materials, and many samples become contaminated with phthalates. Since neither compound was present in both rounds of samples, it is possible that the presence of chloroform and bis(2-ethylhexyl) phthalate is due to post-sampling contamination.

The metals detected in groundwater at the FTA from both rounds of sampling were barium (up to 138 $\mu\text{g}/\text{L}^3$), lead (up to 6.4 $\mu\text{g}/\text{L}$), selenium (up to 8.5 $\mu\text{g}/\text{L}$), and zinc (up to 952 $\mu\text{g}/\text{L}$). In addition, nickel was detected during the second round at 25 $\mu\text{g}/\text{L}$. One background well was sampled to establish a baseline for chemical constituents in the groundwater. The location of the background well is shown in Figure 2.4. The results of these analyses are also presented in Table 2.5. Comparison with background data discloses some metals concentrations in site groundwater samples above the background concentrations, but none above health effects levels (ES, 1992).

Contamination Assessment Summary

The results of screening activities at the FTA aided in placement of the soil borings. Soil gas survey results were off scale on the perimeter of the visibly contaminated burn areas, preventing soil gas investigation in the actual burn areas. The soil gas survey and visual observations proved to be sufficient indicators of gross waste fuel contamination of the stained burn areas.

³ $\mu\text{g}/\text{L}$ = micrograms per liter

Table 2.4 Metals Detected in Surface Soils
 Fire Training Area
 120th Fighter Interceptor Group, Great Falls, Montana

Metal	Concentration (mg/kg)	
	Large Burn Area	Small Burn Area
Arsenic	4.4	2.2
Barium	140.0	170.0
Cadmium	1.8	1.5
Chromium	15.0	55.0
Copper	19.0	20.0
Lead	160.0	660.0
Mercury	0.10	0.11
Nickel	8.1	11.0
Zinc	95.0	180.0

Table 2.5 Chemical Constituents Detected
in Groundwater, Fire Training Area
120th Fighter Interceptor Group, Great Falls, Montana

Chemical	Round 1 MANG-1 MW1	Round 2 MANG-1 MW1	Background		ARARs(1)
			Round 1 MANG-BG MW1	Round 2 MANG-BG MW1	
GC volatile organics ($\mu\text{g/L}$):					
Chloroform	1.1 J	ND	ND	ND	100 (2)
CLP semivolatile organics ($\mu\text{g/L}$):					
bis(2-Ethylhexyl)phthalate	ND	62	ND	ND	4 (3)
Metals ($\mu\text{g/L}$):					
Arsenic	ND	ND	1.1 BJ	ND	50
Barium	138 BJ	107 B	56 BJ	62.2 B	1,000
Lead	6.4 J	2.5 BNJ	4.9 J	4.3 NJ	50
Nickel	ND	25 B	ND	ND	100
Selenium	4.2 B	8.5 BS	ND	ND	10
Zinc	952 *	527	15 B*J	9.8 BJ	5,000
Total petroleum hydrocarbons (mg/L)	ND	ND	1	ND	NA

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(1) ARARs are proposed only. These are MCL's (actual or proposed) where available, otherwise water quality criteria.

(2) The MCL for chloroform is based on the value for total trihalomethanes. There is no MCL for chloroform.

(3) Value is for total phthalate esters (Federal Register, July 25, 1990, pp. 33049-33127).

ND = not detected.

NA = not applicable.

Data qualifiers follow the data. The qualifiers are:

Organics:

J The value reported is an estimated concentration. This is used when the compound is detected at less than 5 times the amount detected in an associated blank.

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

N Spiked sample recovery not within control limits set by lab QA/QC.

S Reported value was determined by the method of standard additions.

* Duplicate analysis not within control limits set by lab QA/QC.

J The value reported is an estimated concentration. This is used when the compound is detected at less than 10 times the amount in an associated preparation blank, or less than 5 times the amount in an associated field blank.

The volatile and semivolatile organics detected in the soil at the FTA are commonly associated with fuels. The highest contamination was observed in soil borings 3 and 7. The sample from soil boring 7 had the highest concentrations of hydrocarbons. Soil boring 7 was drilled in the middle of one of the burn areas. Soil boring 3, where the sample contained low concentrations of hydrocarbons, was drilled adjacent to the largest burn area. The rest of the samples from the other soil borings contained no apparent contamination. In light of these results, contamination appears to be limited to the visibly identifiable burn areas. Additionally, since the black staining of the soil was limited to the top 1.5 feet, and since the analytical data indicated the bulk of the contamination was in the top 1 to 2 feet, it can be conservatively assumed that the depth of contamination is less than 4 feet. For the SRAP, it will be assumed that the contamination extends to the sandstone, a depth of 3 to 4 feet. Sampling performed during the removal action will determine the depth of contamination.

Analysis of groundwater samples taken from the monitoring well at the site indicates trace quantities of chloroform in the round 1 sample and low concentrations of bis(2-ethylhexyl) phthalate in the round 2 sample. Since the phthalates are common laboratory contaminants, and neither contaminant was detected in both samples, groundwater contamination from activities at the site cannot be confirmed.

2.4 RISK EVALUATION

A preliminary risk evaluation (PRE) was conducted in accordance with appropriate EPA guidance as part of the SI (ES, 1992). The preliminary risk evaluation for the 120th FIG was performed using data collected during the SI. Data collected on the site history; demographics, land use, climate, and ecology; and the results of the investigative program, including contaminant concentrations and geologic and hydrogeologic information. The objectives of the preliminary risk evaluation are to provide qualitative information on the potential risks to human and environmental receptors due to the release or threat of release of hazardous substances from the site; to aid in identifying additional data needed to complete a quantitative risk assessment during the RI; and to provide information for the determination that no further action is required if no risks to human and environmental receptors are identified.

The SI (ES, 1992) was used to identify chemicals of concern, chemical concentrations, general release characteristics, the affected environmental media, and exposed or potentially exposed human or environmental receptors. The initial objectives of the preliminary risk evaluation were to:

- Select chemicals of potential concern.
- Review the factors that affect migration of selected chemicals through the affected media, and identify and evaluate potential migration pathways.
- Evaluate the potential toxicities associated with exposure of human or environmental receptors to the selected chemicals against appropriate protective criteria.

- Identify potential risks to human or environmental receptors that may be affected by the migration of contaminants along identified pathways.

Because the SI is a screening phase of investigation, the purpose of which is to confirm or deny the presence of contamination, the potential for data gaps exists. Therefore, detailed calculations to quantify risk to human health and the environment from the sites were not performed. Rather, a qualitative approach was taken in which all potential receptors and exposure pathways were evaluated, and the potential importance of each exposure pathway was ascertained based on a comparison with standards or criteria and an evaluation of the likelihood of pathway completion. This evaluation was based on existing site information concerning migration pathways, the location and types of contaminants present, and the locations of current and possible future receptors. Conservative assumptions were employed to ensure that potential exposure pathways were not excluded from consideration.

The preliminary evaluation assumes that no remediation is performed at the site. This is referred to as the *no-action alternative*. This assumption is made to determine the need for remediation.

The PRE identified several chemicals of concern at the site. These are shown in Tables 2.6 and 2.7. The primary pathway of concern is soil exposure, either currently by base personnel, or in the future by residents, construction workers, base personnel, or trespassers. As shown in Table 2.6, none of the subsurface soil contaminants (samples taken at greater than 1 foot) were present at levels exceeding the soil ingestion health criteria, but the concentration of lead in the surface soils (Table 2.7) presents a potential threat to human health or the environment via soil ingestion. The worst-case lead data were obtained from a surface sample collected by the base to supplement the SI data. This sample was collected at the surface. This data is for screening purposes, and was not subject to the same level of quality assurance as the SI data. These tables present the worst-case data from all samples. This potential threat of lead and organic compound presence in the soils is the primary reason for the removal action. By treating or removing the source of the contamination (contaminated soil), the potential risk will be reduced or removed.

2.5 REMOVAL ACTION JUSTIFICATION

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) states that a removal action may be conducted at a site when there is a potential threat to public health, public welfare, or the environment. An appropriate removal action is undertaken to abate, minimize, stabilize, mitigate, or eliminate the release or the threat of release at a site. Section 300.415(b)(2) of the NCP outlines factors to be considered when determining the appropriateness of a removal action, such as high levels of hazardous substances, pollutants, or contaminants in soils, largely at or near the surface, that may migrate; or the threat of fire or explosion.

Once it is determined that a removal action is appropriate, the removal is designated an *emergency*, *time-critical*, or *non-time-critical* removal. *Emergencies* are those situations in which response actions must begin within hours or days after the

Table 2.6
 Comparison of Subsurface Soil Contaminant
 Concentrations with Health Criteria for Fire Training Area
 120th FIG, International Airport
 Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Subsurface Soil Ingestion	Organics				
	Acetone	9.00E-02	RfD	8.00E+03	NO
	2-Butanone	1.40E-02	RfD	4.00E+03	NO
	Ethyl benzene	1.60E-02	RfD	8.00E+03	NO
	Toluene	9.20E-02	RfD	1.60E+04	NO
	m,p-Xylene	5.40E-02	RfD	1.60E+05 c/	NO
	o-Xylene	4.00E-02	RfD	1.60E+05 c/	NO
	Inorganics				
	Arsenic	1.33E+01	RfD	8.00E+01	NO
	Barium	5.48E+02	RfD	5.60E+03	NO
	Copper	1.81E+01	-	-	-
	Selenium	4.20E-01	RfD	2.40E+02 d/	NO

a/ RfD = reference dose.

b/ mg/kg = milligram per kilogram.

c/ Value is for total xylenes.

d/ Value is for selenious acid.

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Table 2.7 Comparison of Surface Soil (less than 1 foot deep) Contaminant Concentrations with Health Criteria for Fire Training Area
120th FIG, International Airport
Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Surface Soil Ingestion	Organics				
	Acetone	2.20E-01	RfD	8.00E+03	NO
	Diethylphthalate	2.70E-01	RfD	6.40E+04	NO
	Ethylbenzene	2.20E+01	RfD	8.00E+03	NO
	Fluoranthene	4.90E+00	RfD	3.20E+03	NO
	2-Methylnaphthalene	1.30E+01	-	-	-
	Phenanthrene	9.50E+00	-	-	-
	Pyrene	1.40E+01	RfD	2.40E+03	NO
	Toluene	8.80E+00	RfD	1.60E+04	NO
	TPH c/	1.20E+05	-	-	-
	m,p-Xylene	1.50E+02	RfD	1.60E+05 d/	NO
	o-Xylene	7.70E+01	RfD	1.60E+05 d/	NO
	Inorganics				
	Arsenic	1.77E+01	RfD	8.00E+01	NO
	Barium	7.63E+02	RfD	5.60E+03	NO
	Cadmium	1.80E+00	RfD	4.00E+01	NO
	Chromium	5.50E+01	RfD	8.00E+04 e/	NO
	Copper	2.23E+01	-	-	-
	Lead	6.60E+02 h/	f/	5.00E+02	YES
	Mercury	1.60E-01	RfD	2.40E+01	NO
Nickel	1.77E+01	RfD	1.60E+03	NO	
Selenium	4.50E-01	RfD	2.40E+02 g/	NO	
Zinc	1.80E+02	RfD	1.60E+04	NO	

a/ RfD = reference dose.

b/ mg/kg = milligram per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Value is for total xylenes.

e/ Value is for chromium III.

f/ OSWER, 1989.

g/ Value is for selenious acid.

h/ Not CLP data.

MANGM1SS.WK1

completion of the site evaluation. *Time-critical removals* are those in which, based on a site evaluation, it is determined that less than 6 months remains before response actions must begin. *Non-time-critical removals* are those in which it is determined that more than 6 months may pass before response actions must begin. Based on the PRE, this removal action would be considered a voluntary, non-time-critical removal action.

Investigations of the FTA indicate that contaminated soils at this site pose a potential threat to human health and the environment through soil ingestion or dermal contact. This SRAP was prepared to document the identification and evaluation of removal action alternatives in support of a voluntary non-time-critical removal action.

SECTION 3

REMOVAL ACTION OBJECTIVES AND SCOPE

3.1 GENERAL STATEMENT OF THE REMOVAL ACTION OBJECTIVES

Removal action objectives and site-specific considerations are developed as a basis for identifying appropriate removal action alternatives. Removal action objectives must protect human health and the environment, and address contaminants of concern, exposure routes, and receptors. Applicable or relevant and appropriate requirements (ARARs) that establish cleanup standards are also used to identify removal action objectives. The removal action must be compatible with long-term remedial objectives at the site.

There are several general objectives to be considered for this removal action. One goal is to achieve a permanent solution, one which removes the threat to human health or the environment. Another objective is treatment. A removal objective which treats the contaminants, as opposed to moving the contaminants to another location, is preferred. It is a goal of this removal action to complete all activities on site.

The removal action for the FTA is not financed by Superfund. Therefore, the requirements of the NCP in section 300.415(b)(5) for fund-financed removal actions do not apply.

3.2 ARARS

Pursuant to section 300.415(i) of the NCP, the removal action for the site "shall, to the extent practicable considering the exigencies of the situation, attain applicable or relevant and appropriate requirements under federal environmental or state environmental or facility siting laws." ARARs are used to identify removal action objectives, formulate removal action alternatives, govern the implementation and operation of a selected removal action, and evaluate the appropriate extent of site cleanup.

In 40 CFR 300.5 EPA defines *applicable requirements* as those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and

that are more stringent than federal requirements may be applicable. *Relevant and appropriate requirements* are defined as those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

Any standard, requirement, criterion, or limitation under any federal environmental or state environmental or facility siting law may be either applicable or relevant and appropriate to a specific action. The only state laws that may become ARARs are those promulgated such that they are legally enforceable and generally applicable and equivalent to or more stringent than federal laws. A determination of applicability is made for the requirements as a whole, whereas a determination of relevance and appropriateness may be made for only specific portions of a requirement. An action must comply with relevant and appropriate requirements to the same extent as an applicable requirement with regard to substantive conditions, but need not comply with the administrative conditions of the requirement.

Three categories of ARARs should be analyzed: chemical-specific, location-specific, and action-specific. *Chemical-specific* ARARs address certain contaminants or a class of contaminants and relate to the level of contamination allowed for a specific pollutant in various environmental media (water, soil, air). *Location-specific* ARARs are based on the specific setting and nature of the site. *Action-specific* ARARs relate to specific actions proposed for implementation at a site.

Chemical-Specific ARARs

Chemical-specific ARARs are usually health- or risk-based standards limiting the concentration of a chemical found in or discharged to the environment. They govern the extent of site remediation by providing actual cleanup levels, or the basis for calculating such levels for specific media.

The primary chemicals of concern at the FTA for this removal action are petroleum hydrocarbons and lead. No soil cleanup standards for CERCLA sites have been established on a state or federal level. Examples of chemical-specific limits which may be used for CERCLA sites are the values used by the State of Montana as cleanup criteria guidelines for spills related to underground storage tanks (USTs). For petroleum hydrocarbons, the cleanup criterion used is 100 mg/kg. For lead, the UST criterion which has been used in Montana is 500 mg/kg. These are known as "to be considered" (TBC).

Location-Specific ARARs

Location-specific ARARs govern natural site features such as wetlands, floodplains, and sensitive ecosystems, and manmade features such as landfills, disposal

areas, and places of historic or archaeological significance. These ARARs generally restrict the concentration of hazardous substances or the conduct of activities based solely on the particular characteristics or location of the site. Location-specific ARARs for this site are currently being evaluated by the NGB and the State of Montana, at NGB request.

Action-Specific ARARs

Action-specific ARARs are usually technology- or activity-based- limitations that control actions at hazardous waste sites. Action-specific ARARs generally set performance or design standards, controls, or restrictions on particular types of activities. To develop technically feasible alternatives, applicable performance or design standards must be considered during the development of all removal alternatives. Action-specific ARARs are applicable to this site. The action-specific ARARs to be used are currently being determined by the NGB and the State of Montana, at NGB request.

3.3 SITE-SPECIFIC CLEANUP OBJECTIVES

Cleanup objectives will be set for this removal action. The NGB and the State of Montana, at NGB request, are concurrently determining ARAR's and cleanup objectives for this removal action. Once these become available, this report will be amended.

SECTION 4

REMOVAL ACTION ALTERNATIVES

4.1 RATIONALE FOR SELECTING ALTERNATIVES

The first step in the alternative selection process is to evaluate the contaminants of concern and then select an appropriate technology to address those contaminants. Given the organic and inorganic contaminants present at the FTA, either a treatment technology, containment technology, or combination is considered applicable.

A number of criteria are used in the selection of a treatment technology for this site. The most important criterion is effectiveness. The chosen option is one that has been proven to be effective in treating similar wastes under similar conditions. Some site-specific modifications are always necessary, but these should be minimal. The technology must be capable of treating the contaminated soil to reach the cleanup criteria established for the site, and should provide a permanent solution.

The criterion of effectiveness has many different components. It is easier to complete a removal action in a timely manner if no time is wasted in modifying a removal technology to meet site conditions. It is also more cost-effective to use a proven technology. Protection of workers and the community during the removal action, environmental impacts, and long term reliability are also considered.

Another criterion used is implementability. It is important to use an option which is technically feasible and practical for use at the site. A technology which is easier to implement and maintain is preferable to one which is more complicated. Another issue in implementability is transportation. Commercial treatment and disposal capacity is limited in Montana. Any technology which calls for offsite treatment or disposal could require transporting the contaminated soil over long distances. This is not only very expensive but could create additional threats to human health or the environment. This SRAP considers only onsite technologies.

Another item considered is scale. The volume of contaminated soil at the FTA is relatively small. With an estimated depth of 3 to 4 feet, and an estimated area of 5,000 square yards, the approximate volume of contaminated soil is 5,000 to 6,500 cubic yards. It is important to consider this in evaluating the options since most technologies are more efficient and cost-effective on large quantities.

The last item considered is cost. If two technologies are found that would achieve comparable results, the more cost-effective of the two will be selected.

However, cost is not a primary selection criterion. For this SRAP, an estimated soil volume of 6,000 cubic yards is used for comparative cost evaluations.

4.2 BASIS FOR ALTERNATIVE EVALUATIONS

The purpose of evaluating removal action alternatives is to provide decision-makers with sufficient information to select the appropriate removal action for the site. The evaluation follows HAZWRAP's SRAP guidance outline and the EPA RI/FS guidance, where applicable. The assessment of each alternative considers the following criteria:

- Effectiveness
 - .. Protection of the community during the removal action
 - .. Protection of workers during the removal action
 - .. Threat reduction
 - .. Time until protection is achieved
 - .. Compliance with ARARs
 - .. Environmental impacts
 - .. Potential exposure to remaining risks
 - .. Long-term reliability for providing continual protection
 - .. Permanent solution
- Implementability
 - .. Technical feasibility
 - .. Availability
 - .. Administrative feasibility
- Cost
 - .. Capital costs
 - .. Annual operating and maintenance (O & M) costs.

The assessment of alternatives is followed by a comparative analysis that considers the strengths and weaknesses of each alternative.

4.3 DESCRIPTION OF ALTERNATIVES

There are two general categories of potential removal actions for remediating contaminated soil at the site: treatment and containment. Treatment can be done in situ, or the soil can be removed prior to treatment. Containment actions, in which contaminated soils remain in situ, are meant to isolate or confine soil contaminants from the surrounding environment, thus limiting the movement of the contaminants into the soil, groundwater, or air.

Specific treatment activities include excavation of contaminated soil, treatment of contaminated soil using thermal, physical, chemical, or biological treatment technologies followed by disposal of the treated soil in permitted landfills, and backfilling of the treated soil into the site. A number of treatment technologies can be conducted in situ: biodegradation, soil vapor extraction (either steam or vacuum), in situ solidification, and vitrification. The treated soil is then left in place.

Specific containment technologies include capping, and the installation of subsurface barriers, such as slurry walls. The no-action alternative is a special case in this category. The no-action alternative must be considered when conducting a feasibility study under the NCP, but is not required when conducting a SRAP.

A number of technologies were considered for this removal action. These are shown in Table 4.1, a table prepared by EPA for screening remediation technologies. This list was reduced to four basic technologies which were considered in detail: bioremediation, thermal desorption, solidification/stabilization, and incineration. Combinations of these techniques were also considered. Soil vapor extraction, soil washing, and vitrification were not evaluated in detail. Soil vapor extraction is commonly used for remediation of fuel spills, but is not as effective on the heavier residues from the burned fuel. Soil washing was not considered because of the large quantities of contaminated water generated by the process; it would be necessary to construct a small wastewater treatment plant to handle the water. Vitrification was not considered because its effectiveness for organic contaminants has not been proven. Vitrification for petroleum contaminants is still an experimental technology.

Each of the technologies evaluated is discussed below. Each discussion describes the technology, evaluates some of its positive and negative aspects, and compares estimated costs. For some technologies, such as bioremediation, capital costs and operation and maintenance annual O & M costs are estimated. Others, such as onsite incineration, are bid by vendors on a turnkey basis. The cost given for such an option is the entire treatment cost, but does not cover site preparation and long-term maintenance. Comparative costs were developed based on information contained in EPA guidance documents and from vendors and are provided for comparison only. These do not reflect incidental costs such as permitting and oversight. These should not be taken as actual cost estimates, which can be completed only after the design is finalized.

Bioremediation

Description

Bioremediation is a process which uses the physical, chemical, and biological properties of the soil to immobilize and/or degrade the constituents in a waste. Attenuation and destruction of the waste constituents are accomplished through a variety of processes. The major processes that may take place are biodegradation, photodegradation, adsorption, complexation, and volatilization for organic constituents, and adsorption and complexation for inorganic constituents.

Table 4.1 Soil Remediation Technologies (EPA, 1988a)

Contaminant	Technology									
	Fluidized bed incineration	Rotary kiln incineration	Infrared thermal treatment	Soil washing	Low temperature thermal desorption	In situ vacuum/steam extraction	Stabilization/solidification	In situ vitrification	Biodegradation	In situ biodegradation (land treatment)
Organic										
Halogenated volatiles	⊙	⊗	⊗	⊙	⊙	⊗	⊙	⊙	⊙	⊙
Halogenated semivolatiles	⊙	⊗	⊗	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Nonhalogenated volatiles*	⊙	⊗	⊗	⊙	⊙	⊗	⊙	⊙	⊙	⊙
Nonhalogenated semivolatiles*	⊙	⊗	⊗	⊙	⊙	⊙	⊙	⊙	⊙	⊙
PCBs	⊙	⊗	⊗	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Pesticides	⊙	⊗	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Organic cyanides	⊙	⊗	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Organic corrosives	⊙	⊗	⊙	⊙	⊙	⊙	⊙	⊙	⊗	⊗
Inorganic										
Volatile metals*	⊗	⊗	⊗	⊙	⊙	⊙	⊗	⊙	⊗	⊗
Nonvolatile metals*	⊙	⊙	⊙	⊙	⊙	⊙	⊗	⊙	⊗	⊗
Asbestos	⊙	⊙	⊙	⊙	⊙	⊙	⊗	⊙	⊙	⊙
Radioactive materials	⊙	⊙	⊙	⊙	⊙	⊙	⊗	⊗	⊗	⊗
Inorganic corrosives	⊙	⊙	⊙	⊙	⊙	⊙	⊗	⊙	⊗	⊗
Inorganic cyanides	⊙	⊙	⊙	⊙	⊙	⊙	⊗	⊙	⊗	⊗
Reactive										
Oxidizers	⊙	⊗	⊙	⊙	⊙	⊙	⊙	⊙	⊗	⊗
Reducers	⊙	⊗	⊙	⊙	⊙	⊙	⊙	⊙	⊗	⊗

- ⊗ = Demonstrated effectiveness
- ⊙ = Potential effectiveness
- = No effectiveness
- ⊗ = Potential adverse impacts to process or environment
- * = Present in fire training area

In bioremediation, the natural properties of the soil are enhanced through site controls to achieve the best treatment. The soil is tilled and fertilized to provide oxygen and nutrients to the soil microbes. This process increases the rate of biodegradation. The tilling process also helps to breakup the waste, thereby enhancing all the treatment processes. Migration of metals may be controlled by adjusting the pH of the soil. Most of the hazardous metals, such as lead, are less soluble at pH values in the neutral to basic range. A final pH range of 6.5 to 8.0 is generally used. In this pH range, the metals are generally present as insoluble carbonates or hydroxides and are essentially immobile.

Bioremediation of contaminated soils can be accomplished in situ, or the soils can be removed from the ground prior to treatment. The basic principles are the same in either case, but removing the soil prior to treatment gives more control over the process and requires a shorter treatment time. Removing the soil is, however, more expensive. For this site, bioremediation conducted by removing the soil would be preferable.

The technique considered is known as *soil piling*. The contaminated soils are removed from the ground and stockpiled. The soil is then blended to make a more homogeneous mixture, and the soil is placed in long, narrow piles. Air, water, and nutrients are added in a controlled manner to enhance the bioremediation. The piles are covered with perforated black polyethylene to minimize rainfall infiltration. Once testing indicates that treatment is complete, the soils can be backfilled.

Effectiveness

Bioremediation has been used for many years to treat municipal wastes. In addition, it has been used for over 30 years to treat industrial wastes, primarily in the petroleum industries. Bioremediation is especially effective for the treatment of biodegradable wastes, such as petroleum hydrocarbons. Lime can be added to the soil after treatment to maintain a pH of 6.5 or greater in the backfilled soil. This helps to decrease metal solubility and mobility.

In order to achieve optimal treatment, bioremediation must be properly managed. The soil pH should be maintained between 6 and 9. This should not be a problem at the FTA. The background data indicate natural pH range is 7 to 9. The pH range in the FTA samples was 7.4 to 9.1. Enough water should be present to allow biodegradation to take place, but not so much that the soil becomes waterlogged. The soil should be checked for nutrient levels, such as nitrogen and phosphorus, and fertilizer should be added as needed. Additionally, the site should be vented or tilled so that all the contaminated soil is exposed to oxygen, since most of the degradation which takes place is aerobic.

Bioremediation reduces the potential threat to human health and the environment by degrading the organic contaminants and limiting the mobility of the inorganic contaminants. The major routes of exposure during treatment are direct contact with the contaminated soil, migration of contaminants into groundwater, and through inhalation of vapors or particulates. Protection from exposure can be accomplished through site access controls and the use of proper protective equipment for site workers, such as respirators and Tyvek protective clothing.

The effectiveness of metals treatment can be enhanced by the addition of lime after the biotreatment is complete. The addition of lime between treatment and backfilling helps to maintain a soil pH in the neutral to basic range. In this range, the metals are present as insoluble carbonates and hydroxides. If the metals are present in relatively insoluble forms, they are essentially immobile.

Runoff and leachate must be minimized to prevent contaminant migration to surface water or groundwater. Runoff can be controlled with berms or dikes around the treatment area. Leachate production from rainfall and subsequent contaminant migration to groundwater can be minimized by the use of a synthetic or clay liner beneath the treatment area and/or a synthetic liner which covers the treatment area. Leachate can be collected with PVC piping in a trench and sump system. Air monitoring may be used to determine if there is a significant threat from the inhalation of vapors or particulates. The threat to human health and the environment is minimal at a properly designed and operated facility.

If run-on and runoff are controlled, there are no effluents from the site other than the treated soil, which is usually backfilled into the area from which it was removed. Leachate can be prevented by minimizing infiltration.

Implementability

Bioremediation can be readily implemented at the FTA since there is sufficient land available. A large amount of land is needed so that the full volume of contaminated soil can be treated under aerobic conditions. The area requirements would be minimized using the technique of treating in piles.

Bioremediation can be implemented in a relatively short period of time. Site preparation and earthwork should take 1 to 2 months. Bench-scale treatability tests may also be conducted in this time period. Treatability tests can be used to determine the optimal conditions for biodegradation with respect to such site parameters as aeration, water, temperature, and nutrients. Treatment may take up to several years, depending on site conditions and cleanup criteria.

Generally, the microbes necessary to degrade the organic contaminants at the FTA are already present in the soil. These microbes are already acclimated to local conditions. Some vendors have developed microbes to degrade specific compounds, but the use of these microbes in the field has not consistently been demonstrated to be effective. The extreme weather conditions in Great Falls make the use of unacclimated microbes less desirable.

The equipment used for land treatment is readily available in the Great Falls area. Much of the equipment used is standard farm or construction equipment. Some vendors have specially modified farm equipment available, but this is not necessary. Polyethylene liners and PVC pipe are available from a number of vendors.

There are some monitoring requirements for bioremediation: air monitoring to determine if volatile contaminants are presenting a threat to human health or the environment, groundwater monitoring to detect contaminant migration, and soil monitoring to maintain the optimal conditions for biodegradation and to monitor the progress of the remediation. Air monitoring can be accomplished by collecting

air samples at the periphery of the site. The values obtained are entered in air emissions models to determine if the concentrations leaving the site pose a threat to human health or the environment. Some groundwater monitoring is necessary at this site to confirm that no hazardous leachate will leave the site. Soil is sampled during treatment to evaluate the nutrient availability, and sampled after treatment to ensure that the treatment criteria have been met.

The required maintenance of a soil piling bioremediation system is minimal. The farm equipment will undergo general maintenance. In addition, any site controls, such as run-on and runoff berms, polyethylene liners, and air or water pipelines must be maintained.

Cost

The cost of land treatment or other bioremediation technologies is often far less than most other technologies. For a site with a contaminated soil volume of 6,000 cubic yards, the estimated capital cost ranges from \$50,000 to \$90,000, with annual maintenance cost ranging from \$20,000 to \$40,000 over the treatment period. Capital costs include the polyethylene liners, the leachate collection system, the earthmoving equipment, the air delivery system, and monitoring equipment. O&M costs include sample analysis, labor, and fertilizer (nutrients) during the active treatment period. Once treatment is complete, no O&M costs should be incurred. Several years of treatment will likely be necessary to meet the treatment standards. For 3 years of treatment and 6,000 cubic yards of soil, the total cost could be \$110,000 to \$200,000. No long-term maintenance should be required once treatment is complete.

Thermal Desorption

Description

Thermal desorption, otherwise known as low-temperature thermal stripping, is a process in which the contaminated soil is passed through an oven in order to drive off the organic contaminants. The gas then passes through an additional treatment unit, either an incinerator or a carbon adsorption system, in which the organics are destroyed or captured. Unlike incinerators in which the soil is subjected to high temperatures and combustion in the primary chamber, thermal desorbers rely on indirect heating.

The primary chamber is operated in the range of 300°F to 850°F. For the FTA, a high temperature will be necessary because of the heavy residuals present in the soil. If a secondary chamber is used for combustion, the operating temperature in this chamber is usually in the range of 1,500°F to 2,200°F. The primary advantage to this system over incineration is that only the vaporized organics and water from the contaminated soil enter the combustion chamber, thus minimizing the residuals in the vapor, such as HCl and NO_x⁴ which must be removed.

Emissions controls are necessary for these units. In addition to the organic controls, baghouses and scrubbers are often used. Scrubbers are used to remove acid

⁴ HCl = hydrochloric acid; NO_x = nitrogen oxides

gases, and baghouses are used to remove particulate matter. Scrubber effluent can be passed through a carbon system and reused. The exact configuration of the emissions controls depends on the design of the thermal desorber and the characteristics of the contaminated soil.

Effectiveness

Thermal desorption has been demonstrated effective for the removal of organics from contaminated soils. Specifically, thermal desorption has been used to treat soils contaminated with fuels, such as the FTA soils, to levels less than 10 mg/kg. Thermal desorption is more efficient for the lighter, more volatile components in fuels. The heavy residuals remaining in the soils at the FTA will be more difficult to desorb, but are still treatable by this method.

Thermal desorption is ineffective in treating metals. While the organics are removed in the thermal desorption unit, the metals pass through. Some form of solidification/stabilization may be necessary to reduce the toxicity or mobility of any metals in the soil. Lime may be added to the soil after treatment in order to increase soil pH and thereby reduce lead mobility. The treated soil may be backfilled, or sent offsite for further treatment or disposal.

There are potentially four effluents from this system: the treated soil, scrubber water, baghouse filters, and spent carbon canisters. If an afterburner is used, no spent carbon is generated. The scrubber water can be neutralized and sent to a local wastewater treatment plant. The spent carbon can be thermally regenerated and reused. The soil is either backfilled or sent off site for treatment and disposal. The baghouse filters are sent to an appropriate disposal facility.

The major routes of exposure during treatment are direct contact with the contaminated soil and inhalation of vapors or particulates, primarily in the event of a process upset. Protection from exposure can be accomplished through site access controls and the use of proper protective equipment for site workers, such as respirators and Tyvek protective clothing. Air monitoring may be used to determine if there is a significant threat from the inhalation of vapors or particulates. The threat to human health and the environment is minimal at a properly designed and operated facility.

There are few monitoring requirements. The effluent soil is checked periodically to ensure that sufficient treatment has occurred. The effluent air is checked to make sure that the levels of organics do not exceed design criteria. The temperature of the reaction vessel must be monitored to ensure proper treatment.

Implementability

Thermal desorption is readily implementable. Either mobile or stationary units are available from Clean Soils, Inc., in Minnesota, Ryan-Murphy Company in Denver, Canonie Environmental in Ohio, and Roy F. Weston in Pennsylvania. Bench- or pilot-scale tests can be run to determine optimal operating conditions. Additionally, all of the necessary emissions control units are commonly employed in industry for air pollution controls.

The bulk of the monitoring and maintenance requirements occur only if the thermal desorption is conducted on site. Monitoring is required for the air emissions and other parameters associated with the air pollution control equipment. There may be regulatory requirements associated with the air emissions. These requirements vary from state to state. The treated soil must be checked periodically to ensure that sufficient treatment is occurring.

The thermal desorption unit requires routine maintenance, but this is generally provided by the vendor. The earthmoving equipment also requires routine maintenance.

Mobilization time for thermal desorption is in the range of 1 to 2 months, covering setup time, site preparation, and testing. Treatment time is in the range of 1 to 2 months for 6,000 cubic yards of soil.

Cost

The cost of thermal desorption is often less than incineration. Treatment cost estimates obtained from vendors ranged from \$60 to \$280 per cubic yard, depending on the type of desorption required and the soil and waste properties. Counting excavation, mobilization, backfill, and other costs, the total treatment cost for 6,000 yards of soil is \$460,000 to \$1,850,000. These costs are anticipated to be almost entirely capital costs. For the FTA, the cost would likely be in the middle to high end of the range because of the large amount of heavy residuals remaining. Once the soil is backfilled, there should be no long-term maintenance costs. Costs could be higher if offsite disposal of the treated soil or extensive testing is necessary.

Solidification/Stabilization

Description

Solidification/stabilization is a process in which a setting agent is added to the soil to form a mixture which entraps the contaminants. The different setting agents used are described below. The primary goals of solidification are to:

- Improve the handling and physical characteristics of the waste
- Decrease the solubility and mobility of the contaminants in the soil
- Decrease the surface area across which the migration of contaminants may occur.

Solidification/stabilization is a process in which the contaminants are converted to less toxic, mobile, and/or soluble forms. The physical properties of the soil or waste are not necessarily changed by this process (EPA 1990).

Solidification/stabilization has been used primarily for the treatment of soils containing inorganic contaminants. Solidification has been shown effective for inorganic wastes, but generally ineffective for organic wastes. Some organics interfere with the setting process, and others may not be bound up in the finished product. Bench-scale tests may be conducted to assess the adequacy of a given additive to a specific soil-waste mixture.

Four types of mixtures are generally used for solidification/stabilization. Inorganic solidification/stabilization is often achieved with cement or pozzolanic additives. Organic solidification/stabilization is often accomplished with thermoplastic or organic polymerization additives (EPA, 1989a). A combination of these processes may be used for a soil containing both organic and inorganic contaminants.

In cement-based solidification/stabilization, the soil is mixed with Portland cement. Water is added to the mixture. Inorganic materials then become bound up in the cement matrix. Pozzolanic solidification/stabilization involves mixing the waste with a siliceous material, such as fly ash, pumice, or lime kiln dust. The mixture is often combined with lime or cement and water to form a cement-like final product. The end result of inorganic solidification/stabilization can be a granular material or a cohesive solid (EPA, 1989a).

Thermoplastic solidification/stabilization is a process in which a material such as asphalt or polyethylene is added to the soil to bind the organic contaminants. In organic polymer solidification/stabilization a polymer is used to bind up the waste material. The most commonly used polymer is urea formaldehyde (EPA, 1989a). Organic solidification/stabilization has not been widely used.

Solidification/stabilization can be conducted either in situ or in a batch mode. For in situ solidification/stabilization, the mixtures are injected into the soil and then mixed. Farm equipment such as tillers can be used in this process. In batch operations, the material is removed from the ground with standard earthmoving equipment and mixed in units such as standard cement trucks. The solidified material is then replaced in the ground. Batch processes require more area than in situ processes because space is necessary to store the untreated soil when it is removed from the ground.

Effectiveness

Solidification/stabilization has been widely used to treat inorganic contaminated soils. It has been demonstrated effective in controlling inorganic contaminants. It has not been proven effective for organic contaminants. The primary contaminants at the FTA are organic petroleum hydrocarbons. There is also some metal contamination. Solidification/stabilization may not be effective for the petroleum hydrocarbons, but would be effective for the lead and other metals present.

The solidification/stabilization process improves the handling of the soil. The cement process is effective for metals, not only because of encapsulation, but because the elevated pH of the soil-cement mixture causes the majority of the metals to be converted to less soluble hydroxides or carbonates. The volume of the soil is increased.

The only effluent from the solidification/stabilization is the soil-additive mixture. If the process has been shown to significantly reduce the toxicity or mobility of the hazardous contaminants, the material may be replaced in the ground from which

it was removed. If not, the material will have to be disposed of in an appropriate facility, such as a permitted landfill.

Solidification/stabilization reduces the potential threat to human health and the environment if contaminant mobility is successfully reduced. The major routes of exposure during treatment are direct contact with the contaminated soil and inhalation of vapors or particulates. Protection from exposure can be minimized through site access controls and the use of proper protective equipment for site workers, such as respirators and Tyvek protective clothing. Air monitoring may be used to determine if there is a significant threat from the inhalation of vapors or particulates.

Implementability

Solidification/stabilization mixtures are readily available. A number of vendors market solidification additives, some of which contain proprietary materials. The equipment is also readily available in the Great Falls area, since it is primarily farm and construction equipment.

Startup time to implement solidification/stabilization is several months. Bench-scale tests are necessary to determine the proper additives and ratios of additives to contaminated soil. These must be brought to the site along with the earthmoving and mixing equipment. Total treatment time for a site such as the FTA is approximately 3 to 6 months, including the treatability studies.

Several monitoring requirements govern the solidification/stabilization process. The additives must be properly metered into the soil to assure proper treatment. The soil which has been treated must be tested to ensure that the contaminants have been stabilized. Air monitoring will likely be necessary to determine if movement of the soil is releasing contaminants to the air.

Cost

Costs for solidification/stabilization vary depending on quantities and types of additives and the field mixing techniques used. Treatability study costs range from \$10,000 to \$30,000, and treatment costs range from \$50 to \$120 per cubic yard. There are also site preparation and post-treatment monitoring costs to consider. The total cost of treatment, including the treatability study and other costs for 6,000 cubic yards of contaminated soil is estimated at \$310,000 to \$750,000. These costs are anticipated to be primarily capital costs.

Incineration

Description

Incineration is a technique which uses high-temperature oxidation to destroy a waste. Incineration is effective for a wide variety of organic wastes, even those resistant to biodegradation. During the process, organic materials are generally reduced to CO₂ and H₂O⁵. Residuals from the process may include SO₂⁶, NO_x, HCl, and ash.

⁵ CO₂ = carbon dioxide; H₂O = water

⁶ SO₂ = sulfur dioxide

Any metals in the soil generally end up in the ash. Emissions control devices are effective in minimizing the emissions of these oxidation products.

There are two ways incinerators may be used for a site remediation. Portable units may be brought to a site so contaminated soils may be placed directly into the incinerator. This is generally done for sites having large volumes of contaminated soil. For sites that have relatively small volumes of contaminated soil, the soil can be hauled to a permitted permanent incinerator. For this site, portable units were considered to meet the objective of onsite treatment.

Two main types of incinerators can be used to treat contaminated soils: rotary kiln and fluidized bed. Another system which may be used to treat contaminated soils is infrared thermal treatment.

Several operational parameters are important in understanding incineration: temperature, residence time, and mixing. The temperature must be high enough to destroy the organic contaminants present in the soil. Residence time is important because the material must remain in the incinerator long enough to be destroyed. The last important operational parameter is mixing. The incinerator must be designed such that the material is fully dispersed in order to maximize the treatment efficiency.

Rotary-kiln incinerators are often used to treat contaminated soils. They are specifically designed to handle solid materials. The range of combustion temperatures is 1,500°F to 3,000°F, with varying residence times depending on the soil and contaminant characteristics.

Fluidized-bed incinerators are used primarily for liquid and slurry wastes, but can be designed to handle soils and other solid materials. Fluidized-bed incinerators are designed to provide better mixing and thus achieve efficient treatment at lower temperatures than rotary-kiln units.

Infrared thermal treatment is somewhat different from the incineration technologies. In this system, the soil is conveyed through an infrared chamber, where it is subjected to infrared radiation at a temperature of approximately 1,400°F. The combustion products then flow to a secondary chamber, which may be either an infrared unit or a standard incineration unit. The temperature of the secondary chamber is approximately 1,600°F. The residence time in an infrared unit is generally in the range of 5 to 50 minutes (EPA, 1988a).

Effectiveness

Incineration can be extremely effective in destruction of organic contaminants such as the petroleum hydrocarbons present in the FTA soils. Destruction and removal efficiencies of 99.99 percent and 99.9999 percent have been documented (EPA, 1988b). Incineration is not as effective for metals. Metals generally remain in the ash, but may be released to the offgas as particulates or volatiles. Control technologies must be implemented for the metals released to the offgas.

The two major effluents from incineration are the soil-ash mixture and the air stream. Other effluents are baghouse dust from particulate emissions control

equipment, and any liquid streams from scrubbers used as emissions control equipment. The soil-ash, and other solid material must be analyzed and, if necessary, disposed of in an appropriate facility such as a permitted landfill. It may be possible to backfill the soil and solid materials if testing indicates that these materials are not hazardous. Liquid effluent may be able to go to a local wastewater treatment facility.

Incineration reduces the potential threat to human health and the environment by destroying the organic contaminants in the soil. Metal contaminants remain in the ash and the baghouse dust and must be properly disposed of. Additional treatment of the metals may be necessary prior to disposal.

The major routes of exposure during treatment are direct contact with the contaminated soil and inhalation of vapors or particulates. Protection from exposure can be accomplished through site access controls and the use of proper protective equipment for site workers, such as respirators and Tyvek protective clothing. Air emissions control equipment is used to minimize the threat from airborne contaminants. Air monitoring is often used to ensure that there is no significant threat from the inhalation of vapors or particulates.

Implementability

Incineration has been used for a number of years to treat a variety of hazardous wastes. It is generally not used for soils contaminated only with fuel constituents since it is very expensive. In addition, a number of EPA studies have been conducted on the use of incineration as a tool for remediation of contaminated soil. Ogden Environmental Services, Inc., in San Diego (among others) has mobile equipment available.

The startup period for onsite incineration is several months. Time is required to transport the equipment to the site. Testing and trial burns with the site soil are necessary to determine the optimal operating parameters for the site. The regulatory requirements for incinerators are often more stringent than for other technologies because of the air emissions.

The capacity of most mobile incinerators is 2 to 5 tons per hour. Since a cubic yard of soil weighs about 1 to 2 tons, incineration capacity is 1 to 3 cubic yards per hour. Therefore, the treatment time for the FTA is in the range of 1 to 2 months, if operated 24 hours a day.

Cost

This FTA would be considered a small site (EPA, 1988b). Incineration costs in 1988 for this size site were estimated to be \$1,000 to \$1,500 per ton, or \$1,000 to \$3,000 per cubic yard, covering treatment, mobilization, demobilization, ash disposal, and other incidental costs. Actual treatment costs are only a small part of the total. Costs for mobilization and demobilization to Great Falls were estimated by one vendor to be \$1,200,000. Treatment costs were estimated at \$200 per cubic yard. For 6,000 cubic yards, the treatment cost would be \$1,200,000. When other costs, such as those for permitting and site preparation, are added, the total treatment cost reaches \$3,000,000 to \$3,500,000. These costs are anticipated to be

almost entirely capital costs. If it is necessary to landfill the residuals, this will likely cost over \$200 per cubic yard to cover both landfill and transportation costs. Long-term costs should be minimal. Once the residuals are backfilled or landfilled, there will be no continuing costs.

4.4 COMPARATIVE ANALYSIS

There are number of advantages and disadvantages to each of the technologies considered. These are summarized in Table 4.2.

The primary advantages of bioremediation are its known effectiveness for organics, the simple equipment, and low cost. The main disadvantages are their longer treatment time and ineffectiveness for metals. The pH can be adjusted after treatment with lime addition to ensure a range of 6.5 to 8.0. This will decrease metal mobility by decreasing the solubility.

The primary advantages of thermal desorption and incineration are their effectiveness for organics. These are the two most effective techniques for organic treatment. However, they embody a number of disadvantages. First, these techniques generate the most effluents: treated soil, air, and air abatement equipment effluents such as scrubber water and spent carbon. Second, these techniques do not treat metals. Further treatment may be necessary to handle the metal contaminants. These technologies have greater regulatory requirements because of the air emissions. Another disadvantage is cost. These are by far the most expensive technologies considered.

The primary advantages to solidification/stabilization are effectiveness for metals, simple equipment, and low cost. The major disadvantage is ineffectiveness for organics, the primary contaminants at the site.

Table 4.2 Remedial Technology Comparison
 Fire Training Area
 120th Fighter Interceptor Group, Great Falls, Montana

Technology	Effectiveness	Treatment Time	Monitoring Requirements	Effluents	Comparative Cost Estimates	Advantages	Disadvantages
Land treatment/ bioremediation	Known to be effective for organic contaminants. Not effective for metals	over 1 year	Soil Air	Treated soil, Possibly leachate or air emissions	\$100,000 to \$200,000	Effective for organics Cost effective No specialized equipment Few effluents Little monitoring	Requires more time Not effective for metals
Thermal desorption	Known to be effective for organic contaminants. Not effective for metals	3 to 6 months	Soil Air	Treated soil, air emissions, abatement residuals (spent carbon, scrubber water)	\$500,000 to \$1,000,000	Very effective for organics. Proven technology	Needs specialized equipment. Several effluents Not effective for metals
Solidification/ Stabilization	Generally effective in minimizing the migration of metals. Not effective for organics	3 to 6 months	Soil Additives Air	Treated soil Possibly air emissions	\$100,000 to \$200,000	Most effective for metals Little or no specialized equipment Cost effective	Not effective for organics
Incineration	Very effective at destruction of organic contaminants. Further treatment may be necessary for metals	3 to 6 months	Air Ash	Ash, air emissions, baghouse dust, scrubber water	\$1,000,000 to \$3,000,000	Most effective for organics Proven technology	Costly Several effluents Requires monitoring Not effective for metals

SECTION 5

RECOMMENDATION AND ANTICIPATED SCHEDULE

5.1 RECOMMENDATION

The remedial technique recommended for this site is onsite bioremediation for the organic contaminants. This technology has been shown to be effective at other sites with similar contamination. It produces few effluents, and the threat of exposure during treatment is minimal. In addition, this technology can be implemented quickly and is cost-effective. The primary disadvantage is the extended treatment time which may be necessary, but this is not a problem if the land will not be used for several years. For lead, lime addition may be used for immobilization.

Solidification/stabilization was discounted because it is not effective for petroleum hydrocarbons, which are the primary contaminants at the FTA. Incineration was discounted for several reasons. First, the incineration process generates the most effluents, such as soil, ash, scrubber water, and air, which must be treated and/or properly disposed of. Second, the regulatory requirements are the strictest of the technologies considered. Third, incineration is far more expensive than the other technologies considered. Thermal desorption was discounted for most of the same reasons as incineration. It produces several effluents, there are more regulatory requirements, and the cost is higher than with bioremediation.

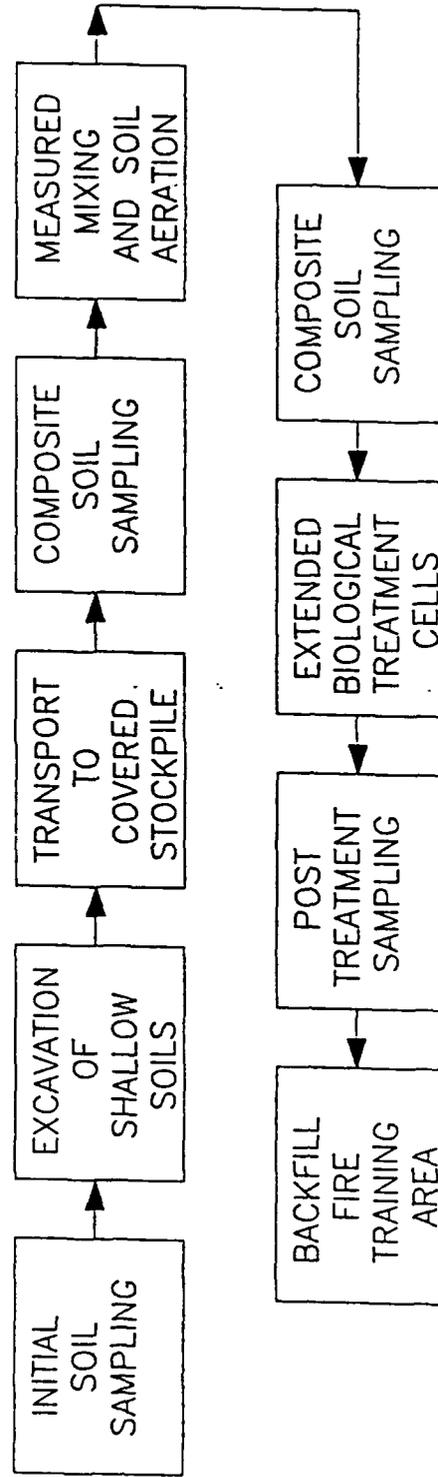
5.2 CONCEPTUAL DESIGN

It is anticipated that the treatment area will be located on open land near the FTA. The exact location of the treatment area has not been determined.

The soil processing area will be divided into three zones: a covered soil stockpile, an active mixing area, and an extended bioremediation area. The exact dimensions of each area will be determined following a pilot test in which aeration and biodegradation rates will be verified. Based on engineering estimates of these rates: approximately one-fourth of the area will be used for stockpiling, one-fourth for active mixing, and the remaining one-half for extended biological treatment.

The basic outline of the soil treatment process is shown in Figure 5.1. Soil will be removed from the FTA and stockpiled in a predetermined location. The total depth of the excavation will be approximately 4 to 5 feet, the depth of the soil. Any applicable OSHA requirements would be considered in the detailed design. The

FIGURE 5.1
TREATMENT PROCESS PLAN
FUEL HYDROCARBON
CONTAMINATED SOILS



stockpile will be situated on a polyethylene liner and covered with a polyethylene liner to minimize volatilization and leachate production caused by rainfall. Soil removed from the stockpile will be placed in the soil mixing area, where it will be tilled to expose the optimum amount of surface area and improve oxygen transfer to the microorganisms. If necessary, a nitrogen and phosphate fertilizer will be added to provide nutrients for the microorganisms.

After each mixing period, soils will be moved from the mixing area and placed in noncompacted long piles, or treatment cells, for continued biological treatment. Figure 5.2 is a drawing of a treatment pile. Perforated PVC pipes will be placed down the centerline of each soil pile and connected to a pressure-vacuum blower to enhance aeration. A black perforated polyethylene sheet will be placed over each pile to protect the soils from rainfall and reduce leachate production. The perforations will be small, and the liner will be sloped (Figure 5.2) so that most of the rainwater will run off the sides of the plastic. Perforations are needed to allow air to enter or leave the piles. The black plastic cover will also increase daytime and nighttime soil temperatures and further enhance the metabolic activity of the microbial population. Soils will remain in these biotreatment piles until composite samples from each pile indicate total petroleum hydrocarbon levels have been reduced and the soil meets compliance criteria.

The time intervals for soil mixing and extended biological treatment can be determined only through pilot testing and will also vary with the type, of hydrocarbon contamination, soil type, and seasonal temperatures.

Contaminated soils will be placed in a dedicated dump truck and covered for transport to the soil treatment area. If fuel-saturated soils are encountered, no large quantities will be transferred in a single load in order to avoid potential explosion and health hazards. Drivers should proceed directly to the soil treatment area for unloading in the stockpile zone. Spotters will be used for proper soil placement, and all personnel involved in soil handling will be equipped with proper respiratory and skin protection.

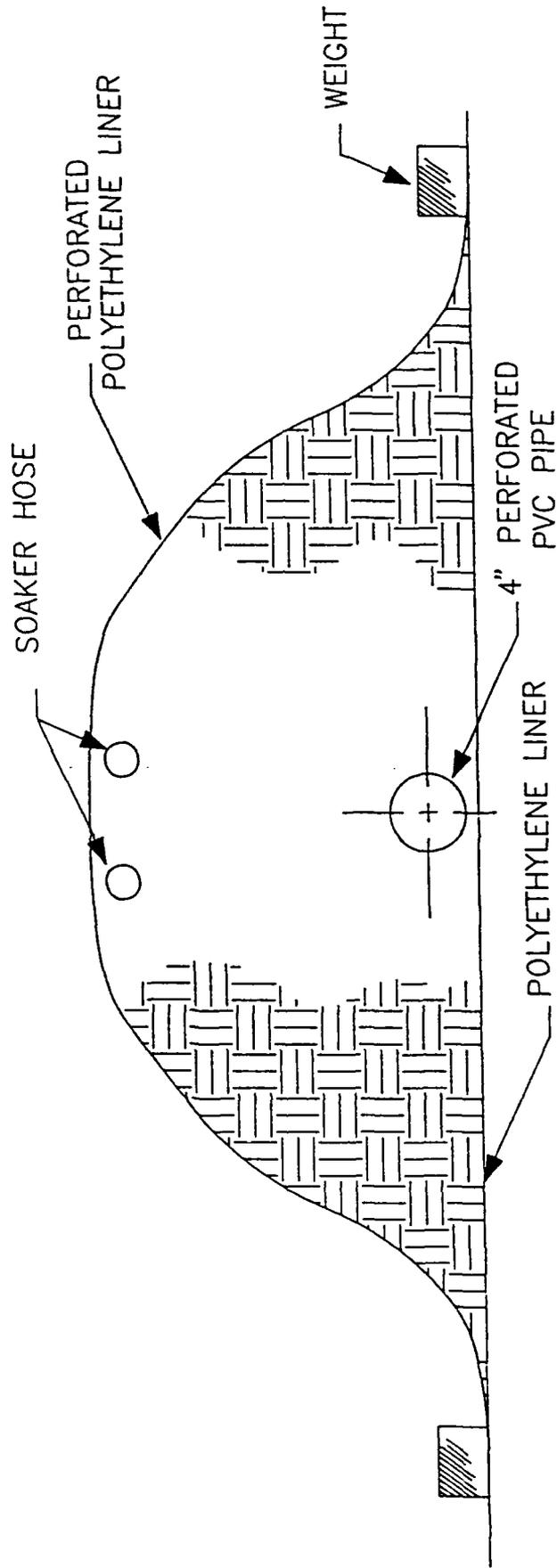
Soil Stockpiling

The purpose of soil stockpiling is twofold. First, soil excavation and stockpiling isolates contaminants from the subsurface environment, preventing further transport of contaminants. Second, stockpiling can provide the treatment process with a more homogeneous feedstock. If possible, soils should be placed in the stockpile area with the most contaminated material at one end and the least contaminated at the other end. This will allow more flexibility in soil blending and achieve consistent initial concentrations. A polyethylene cover will be placed over the pile and weighted around the bottom edge to prevent VOC emissions and water intrusion.

Soil Mixing

Several processes take place in the mixing area. First, volatilization of some organic constituents will occur. This can be minimized by blending in small quantities of contaminated soil on a daily basis. Next, the soil will be blended so

FIGURE 5.2
CONCEPTUAL DESIGN
BIODEGRADATION CELL



BIODEGRADATION CELL CROSS-SECTION

that the concentrations of the contaminants in the soil are more uniform. Contamination in the FTA is much more concentrated in some spots than others. Mixing will even out this concentration and facilitate improved treatment. Excessive concentrations of petroleum hydrocarbons may be toxic to the microbes.

In addition, the soils in the mixing area will be aerated, and fertilizer will be added if necessary. A carbon:nitrogen:phosphorus (C:N:P) ratio of 120:10:1 is often used in biological treatment and is considered optimal for microbial metabolism (EPA, 1989b). The amount of fertilizer to be added will likely be determined by pilot testing. If necessary, water may be added to maintain an optimum soil moisture.

A small tractor equipped with skid shoe and tiller would be effective for mixing the soil. The same tractor could be equipped with a front loader for moving soils across the pad. This equipment can either be purchased or rented, depending on the results of a detailed cost comparison.

Extended Biological Treatment

The final step in the treatment process is extended biological treatment. Soils will be moved from the mixing area and formed into a long, narrow pile or cell. Perforated PVC pipes will be placed down the center of each cell and then connected to an air compressor manifold. The purpose of the vent is to supply oxygen for continued microbial degradation. A soaker hose will be placed on the top of each cell to maintain moisture and nutrients at optimum levels. Figure 5.2 is a cross sectional view of a typical cell.

Once air and water supply systems are installed, a polyethylene cover will be placed over each cell to prevent rain from interfering with the process and increasing water content to the point where undesired leachates are produced. Prior to installation, the plastic cover will be perforated with ¼-inch air inlet holes to distribute oxygen through the soil. The number of perforations per square foot and air flow rates can be determined during pilot testing. Black plastic is used to increase the soil temperature during the day and maintain a more constant temperature during the night. The metabolism and biodegradation potential of many bacteria is known to double with each 10°C temperature increase.

The remediation progress of each treatment cell can be monitored by measuring volatile hydrocarbons, oxygen uptake, and carbon dioxide production in the vented offgas or by measuring the residual hydrocarbons in the soil. The time required for attaining cleanup levels in each cell will vary based on initial hydrocarbon concentrations, soil types, and average temperatures. Pilot testing can assist in establishing treatment intervals.

Postbiological Treatment

When monitoring and/or calculated hydrocarbon removals indicate that a treatment cell has exceeded cleanup goals, the cover will be removed and composite soil samples will be collected. The frequency of sampling may be determined during pilot testing. Soils will then be analyzed for TPH to determine if the cleanup criterion has been met and for a full suite of organic constituents to ensure that there are

no health risks associated with the treated soil. The soils will also be tested for lead to confirm that no soil has lead concentrations in excess of 500 mg/kg. The cell will be covered until the results of soil analysis are received indicating a "clean" or "not clean" condition. Clean soils will be ready for removal from the treatment area and can be backfilled in the FTA. Cells requiring additional treatment will be allowed to continue biodegradation until remediation goals are satisfied.

A final step in the treatment process may be lime addition. Lime addition provides an extra measure of control for metal contaminants by converting the metals present into relatively insoluble and immobile carbonate and hydroxide forms. Even though no soils will be backfilled with lead concentrations exceeding the 500 mg/kg standard, lime addition may still be used since it offers increased protection of human health and the environment at minimal cost.

5.3 PROPOSED SCHEDULE

The first step in the removal action is completion of the SRAP. Next, the AM will be completed. The next step in the schedule calls for completion of the plans and specifications for this removal action. At that point, the removal action work will be put out for bids. Contracting should be completed within 4 to 6 months and work can commence shortly thereafter, weather permitting. Two summers will likely be required for treatment.

SECTION 6

PUBLIC COMMENT

According to the NCP (section 300.415 [m][4]), where a removal action is appropriate at a site and where a planning period of at least 6 months exists prior to initiation of site activities, the lead agency (i.e., the NGB) must publish a notice of availability and a brief description of the SRAP. The public will then have an opportunity for not less than 30 calendar days to submit written and oral comments on the SRAP to the NGB. A public meeting could be held, if requested. Also, the NCP states that a written response to significant comments must be produced after the public comment period (i.e., the responsiveness summary and the action memorandum). Once the action memorandum and the responsiveness summary have been prepared, the removal action is initiated.

REFERENCES

- API, 1983. *Land Treatment Practices in the Petroleum Industry*. Washington, D.C.: American Petroleum Institute.
- API, 1984. *The Land Treatability of Appendix VIII Constituents in Petroleum Industry Wastes*. Publication number 4379. Washington, D.C.: American Petroleum Institute.
- Brown, 1983. *Hazardous Waste Land Treatment*. K. Brown et al. Butterworth Publishers.
- ES, 1990. "Site Investigation Sampling and Analysis Plan, 120th Fighter Interceptor Group, Montana Air National Guard, Great Falls, Montana." Engineering-Science, Inc.
- ES, 1992. "Site Investigation Report, 120th Fighter Interceptor Group, Montana Air National Guard, Great Falls, Montana." Engineering-Science, Inc.
- Freeman, 1989. *Standard Handbook of Hazardous Waste Treatment and Disposal*. Harry M. Freeman, editor. New York: McGraw-Hill Book Company.
- HMTC, 1989. Preliminary Assessment for 120th Fighter Interceptor Group, Montana Air National Guard, Great Falls International Airport. Hazardous Materials Technical Center.
- Martin and Johnson, 1989. *Hazardous Waste Management Engineering*. Edward J. Martin, and James H. Johnson, Jr., editors. New York: Van Nostrand Reinhold Company.
- Sims, 1990. "Soil Remediation Techniques at Uncontrolled Hazardous Waste Sites, a Critical Review," by Ronald C. Sims. *Journal of the Air and Waste Management Association*, (May 1990) 703-732.
- SCS, 1982. *Soil Survey of Cascade County, Montana*. U.S. Department of Agricultural, Soil Conservation Service.
- EPA, 1986. *Handbook for Stabilization/Solidification of Hazardous Waste*. EPA/540/2-86/001. Washington, D.C.: U.S. Environmental Protection Agency.
- EPA, 1988a. *Technology Screening Guide for Treatment of CERCLA Soils and Sludges*. EPA/540/2-88/004. Washington, D.C.: U.S. Environmental Protection Agency.
- EPA, 1988b. *Experience in Incineration Applicable to Superfund Site Remediation*. EPA/625/9-88/008. Washington, D.C.: U.S. Environmental Protection Agency.

- EPA, 1989a. *Stabilization/Solidification of CERCLA and RCRA Wastes*. EPA/625/6-89/022. Washington, D.C.: U.S. Environmental Protection Agency.
- EPA, 1989b. *Bioremediation of Contaminated Surface Soils*. EPA/600/9-89/073. Washington, D.C.: U.S. Environmental Protection Agency.
- EPA, 1990. *Handbook on In Situ Treatment of Hazardous Waste-Contaminated Soils*. EPA/540/2-90/002. Washington, D.C.: U.S. Environmental Protection Agency.