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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 27th FIGHTER WING (ACC)
CANNON AIR FORCE BASE NEW MEXICO

2 7 MAY 1998

Entered

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Dear Mr. Garcia

Enclosed for your review and approval are the final revisions to the RCRA Facility Investigation (RFI) Report for Fire Training Area 4 (FT-4) at Cannon Air Force Base (AFB). The FT-4 RFI was previously approved by the New Mexico Environment Department (NMED) contingent upon submittal of the requested changes.

If you have any questions, please contact Mr. Sanford Hutsell, of my Environmental Flight, at (505) 784-6378.

Sincerely

James A. Thomas III

JAMES A. THOMAS III, Colonel, USAF

Attachment:
RFI Revisions

cc:
NMED w/o Atch (C. Will)
NMED GW Bureau (J. Jacobs)
EPA Region VI (D. Neleigh)
EPA Region VI w/o Atch (B. Sturdivant)

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RFI RPT - Phase II/APP I
SWMU 109, 110, 111, 112
FTA4 98

PHASE II RCRA FACILITY INVESTIGATION REPORT

Fire Training Area No. 4
SWMU Nos. 109, 110, 111, 112
Cannon Air Force Base
Clovis, New Mexico

APPROVED @ 06/18/1998

CMS CALL-IN @ 06/18/1998

Prepared for:

U.S. ARMY CORPS OF ENGINEERS
Omaha District

May 1998

PHASE II RCRA FACILITY INVESTIGATION REPORT (DRAFT)

FIRE TRAINING AREA No. 4
SWMU Nos. 109, 110, 111, 112
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

USACE CONTRACT No. DACW45-94-D-0044
DELIVERY ORDER No. 0006

May 13, 1998

PHASE II RCRA FACILITY INVESTIGATION REPORT

FIRE TRAINING AREA No. 4
SWMU Nos. 109, 110,111,112
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

USACE CONTRACT No. DACW45-94-D-0044
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MAY 13, 1998

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TABLE OF ACRONYMS

ADI	Chronic Daily Intake
AFB	Air Force Base
ARAR	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
BTAG	Biological Technical Advisory Group (USEPA)
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Compensation and Liability Act
COEC	Chemical of Ecological Concern
COPC	Chemical of Potential Concern
CSM	Conceptual Site Model
CUZ	Compatible Use Zone
DQCR	Daily Quality Control Report
EPC	Exposure Point Concentration
ePTFE	Expanded Polytetrafluorethylene
FTA4	Fire Training Area No. 4
Harza	Harza Environmental Services, Inc.
HI	Hazard Index
HQ	Hazard Quotient
IRIS	Integrated Risk Information System (USEPA)
K_d	Soil-water Distribution Coefficient
K_{oc}	Organic Carbon Partition Coefficient
K_{ow}	Octanol/water Partition Coefficient
L/day	Liters Per Day
LOAEL	Lowest Observed Effect Level
MDL	Method Detection Limit
MF	Modifying Factor
mg/kg	milligrams Per Kilogram
MSSL	Human health Media-Specific Screening Level
NOAEL	No Observed Effect Level
°C	Degrees Centigrade
°F	Degrees Fahrenheit
PEF	Particulate Emission Factor
PNA	Polynuclear Aromatic Hydrocarbon
POL	Petroleum Oil and Lubricants
PSGS	Passive Soil Gas Survey
QA	Quality Assurance
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund (USEPA)
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RFI	RCRA Facility Investigation
RME	Reasonable Maximum Exposure

RTV	Reference Toxicity Value
SC	Clayey Sand (USCS)
SCS	USDA Soil Classification System
SF	Cancer Slope Factor
SM	Silty Sand (USCS)
SOP	Standard Operating Procedure
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TBC	To Be Considered
TRPHs	Total Recoverable Petroleum Hydrocarbons
TSC	Testing Service Corporation, Carol Stream, IL
UCL	Upper Confidence Limit
UF	Uncertainty Factor
ug/kg	Micrograms Per Kilogram
UR	Unit Risk
USACE	U. S. Army Corps of Engineers
USAF	U. S. Air Force
USCS	Unified Soil Classification System
USDA	U. S. Department of Agriculture
USEPA	U. S. Environmental Protection Agency
USGS	U. S. Geological Survey
VOC	Volatile Organic Compound

1.0 EXECUTIVE SUMMARY

1.0 EXECUTIVE SUMMARY

Harza Environmental Services, Inc. conducted a Phase II RCRA Facility Investigation (RFI) between October 16, 1996 and February 26, 1997 at Fire Training Area No. 4, Cannon Air Force Base, Curry County, New Mexico. Fire Training Area No. 4, a former fire training facility, encompasses four Solid Waste Management Units (SWMUs), Nos. 109, 110, 111 and 112.

1.1 OBJECTIVES

RFI objectives were to sample potentially affected media at the site and perform the necessary analyses on a sufficient number of samples collected at appropriate locations and/or intervals to: (1) Delineate the vertical and lateral extent of contamination in each contaminated media; (2) Identify all contaminants of concern; (3) Determine the fate and transport characteristics of each contaminant of concern; (4) Perform a human health and environmental risk assessment to determine if site conditions pose a risk to human health or the environment according to USEPA policy; and (5) Support a decision for no further action or the selection of corrective measures/remedial alternatives and remedial design.

1.2 SCOPE

The RFI was completed in substantial accordance with procedures detailed in the RFI Work Plan (Harza 1996), supplemented or modified in the field as necessary, and included the following:

- A Passive Soil Gas Survey consisting of installing, retrieving, and analyzing soil gas screening modules at forty (40) locations, plus associated quality control samples.
- Completion of nineteen (19) soil borings, between 20 and 90 feet deep, for collection of surface and subsurface soil samples.
- Collection of seventy-seven (77) surface and subsurface soil samples, plus associated quality control samples, for field TPH immunoassay screening, field headspace screening, and fixed laboratory chemical analysis.
- Collection of twelve (12) soil samples for geotechnical testing, including particle size analysis and moisture content testing
- Collection of continuous soil samples from each boring for lithologic description

Principal findings of the RFI are summarized in the following sections.

1.3 INVESTIGATION FINDINGS

1.3.1 Nature and Extent of Contamination

Volatile Organic Compounds. Volatile organic compounds were detected above the method reporting limits (MRLs) only in one boring (SB01) located at the former fire training pit (SWMU No. 109). VOCs detected in SB01 included toluene, ethylbenzene, m&p-xylene, o-

xylene, isopropylbenzene, n-propylbenzene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, sec-butylbenzene, p-isopropyltoluene, n-butylbenzene, 1,2-dibromo-3-chloropropane, naphthalene, and 2-butanone. Individual detections in boring SB01 were recorded at depths of 3 feet, 19 feet, 27 feet, 38 feet, 42 feet, 55 feet, and 65 feet. Where detected, concentrations of individual VOCs ranged as follows:

- toluene (17.4 - 4,370 μg/kg);
- ethylbenzene (34.6 - 7,230 μg/kg)
- m&p-xylene (166 - 34,100 μg/kg);
- o-xylene (81.1 - 18,900 μg/kg);
- isopropylbenzene (16.6 - 1,940 μg/kg);
- n-propylbenzene (29.3 - 4,450 μg/kg);
- 1,3,5-trimethylbenzene (92.6 - 15,500 μg/kg);
- 1,2,4-trimethylbenzene (11.2-41,800 μg/kg);
- sec-butylbenzene (15.6 μg/kg);
- p-isopropyltoluene (51.8 - 9,530 μg/kg);
- n-butylbenzene (26.2 - 4,620 μg/kg);
- naphthalene (10.7 - 8,580 μg/kg); and
- 2-butanone (89.8 μg/kg).

Semi-Volatile Organic Compounds. Semi-volatile organic compounds were detected above the MRLs only in soil boring SB01. Detection of naphthalene and 2-methylnaphthalene occurred in five instances, in soil boring SB01 at depths of 3 feet, 19 feet, 27 feet, 38 feet, and 42 feet. Detected concentrations in these samples ranged as follows: naphthalene (586 - 3,800 μg/kg) and 2-methylnaphthalene (3,500 - 11,700 μg/kg).

Total Recoverable Petroleum Hydrocarbons (TRPH). TRPH was detected in each of the nineteen (19) soil borings drilled in the RFI. The highest concentrations were detected in borings drilled near SWMU No. 109 (SB01, SB19, SB04, and SB11) and SWMU No. 111/112 (SB14). The highest concentrations were detected in boring SB01 at a depth of 19 feet (5,560 mg/kg), boring SB19 at a depth of 4 feet (1,530 mg/kg), boring SB04 in the surface sample (3,270 mg/kg), boring SB11 in the surface sample (14,400 mg/kg), and boring SB14 in the surface sample (1,040 mg/kg).

Detected TRPH concentrations generally decrease rapidly with depth, with the highest relative concentration in each boring detected in surficial or near-surface samples (within the upper 4 feet). This is seen in all borings with exception of boring SB01 where the highest detected concentration of TRPHs was detected at a depth of 19 feet and concentrations greater than 1,000 mg/kg were detected to a depth of 42 feet.

Field immunoassay screening data further indicates that detectable concentrations (greater than 10 ppm) were found in soil borings SB01 and SB12. In boring SB01, TRPH was detected to a depth of 65 feet. Samples collected from boring SB01 from depths of 65 feet and 73 feet indicated non-detectable concentrations (less than 10 ppm). In boring SB12, TRPH was detected

at a depth of 10 feet. Samples collected from boring SB12 at a depth of 2 feet, 21 feet, and 31 feet indicated non-detectable concentrations. TRPHs were not detected in any other sample using field immunoassay screening methods. Comparison of the field immunoassay screening data with laboratory analytical data indicates a positive qualitative correlation.

Target Analyte List Metals. Analytical results indicated detectable concentrations of target analyte list metals in each of the nineteen (19) soil borings drilled in the RFI. Where detected, concentrations of individual compounds ranged as follows:

- aluminum (1,230 - 9,990 mg/kg);
- antimony (2.3 - 6.2 mg/kg);
- arsenic (0.6-3.3 mg/kg);
- barium (15.3 - 1,250 mg/kg);
- beryllium (0.15 - 0.74 mg/kg);
- calcium (1,680 - 253,000 mg/kg);
- chromium (2.2 - 20.9 mg/kg);
- cobalt (1.1 - 5.4 mg/kg);
- copper (1.1 - 8.4 mg/kg);
- iron (1,830 - 10,700 mg/kg);
- lead (0.91 - 21.5 mg/kg);
- magnesium (702 - 5,300 mg/kg);
- manganese (18.8 - 1,350 mg/kg);
- nickel (2.9 mg/kg - 10.7 mg/kg);
- potassium (285 - 2,360 mg/kg);
- selenium (0.067 - 0.69);
- sodium (51.3 - 860 mg/kg);
- thallium (0.12 mg/kg);
- vanadium (4.2 - 24.7 mg/kg); and
- zinc (4.5 - 27.6 mg/kg)

Concentrations generally decrease with increasing depth below the ground surface, noticeable for most of the metals analyzed (i.e. aluminum, beryllium, chromium, cobalt, copper, lead, manganese, vanadium, zinc) and especially evident in the deeper soil borings (i.e. SB01, SB17, SB18, SB19). Eleven (11) metals were detected at concentrations exceeding background concentration ranges at Cannon AFB. These included barium, beryllium, calcium, chromium, cobalt, iron, lead, manganese, nickel, silver, and zinc. For these metals, most of the elevated concentrations occur at the ground surface or within soils with a high silt/clay content. The trend of decreasing concentrations at depth below the ground surface appears to coincide with the presence of soils with increased silt and clay content. Additionally, comparison of the detected concentrations for each of these eleven metals with the background concentration ranges indicates that, in general, the detected concentrations only marginally exceed the background concentrations.

1.3.2 Human Health Evaluation

A Human Health Risk Assessment was conducted to assess potential adverse human health effects that could occur due to exposure to site contaminants at FTA4, in the event no action is taken to remove contaminants and/or prevent their migration. Five chemicals; barium, beryllium, manganese, benzo(a)pyrene, and benzo(b)fluoranthene, were identified as Chemicals of Potential Concern (COPCs) and in the risk assessment. Four categories of receptors, military personnel, visitors/trespassers, construction workers, and military personnel engaged in construction, were postulated and evaluated for exposure to the four chemicals. Results show that cancer or noncancer risks to any of the receptors are several orders of magnitude smaller than the regulated cancer risk of 10^{-6} or noncancer hazard quotient of 1, indicating that exposure the site contaminants is negligible. Based on the conservative nature of risk assessment, the true risks may be even less than the calculated risks. In conclusion, site contaminants poses no significant risks to any of the populations.

1.3.3 Ecological Risk Assessment

An ecological risk assessment was performed as part of the overall RFI effort to evaluate the potential for biological resources in the vicinity of FTA4 to be adversely affected by site contaminants. Concentrations of chemicals found at FTA4 were evaluated specifically in terms of potential risks to the Deer mouse population, selected as the indicator species. The chemicals phenanthrene, fluoranthene, pyrene, beryllium, lead, and zinc were detected in site soils and were considered to be chemicals of ecological concern. Concentrations of these chemicals in soils were very low and were not considered to pose an ecological concern. The results of the ecological risk assessment are presented below.

Risk characterization is based on a hazard quotient approach (USACE 1996). This screening-level ecological risk assessment indicates a hazard quotient for pyrene of 0.004. Hazard quotients for other COECs are lower: 0.002 for fluoranthene, 0.002 for phenanthrene and 0.24 for lead. When more than one contaminant is involved in the risk calculation, and if the contaminants exhibit consistent modes of toxicity and effects on endpoints, then it is appropriate to sum the hazard quotients to compute a hazard index. The ecological hazard index for FTA4 is 0.2, which suggests that the likelihood of adverse ecological effects occurring at the site from the COECs is low. In summary, the screening of ecological risk at FTA4 indicates a low potential for adverse ecological effects. Moreover, this is a conservative estimation and the actual risks may be even less than those calculated.

1.4 RECOMMENDATIONS

Based on the results of the RFI and subsequent human health and ecological risk assessments, a "No Action" remedial alternative is recommended for FTA4, including the following SWMUs:

- SWMU No. 109 - Fire Training Pit
- SWMU No. 110 - Underground Waste Oil Tank #2336

- SWMU No. 111 - Unlined Pit; and
- SWMU No. 112 - Oil/Water Separator #2336

2.0 INTRODUCTION

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF REPORT

This Phase II RCRA Facility Investigation (RFI) report was prepared by Harza Environmental Services, Inc. (Harza) for the US Army Corps of Engineers, Omaha District (USACE) for Fire Training Area No. 4, Cannon Air Force Base (Cannon AFB), Curry County, New Mexico. It has been prepared to document the results of the investigation of potential hazardous waste releases from Fire Training Area No. 4 (FTA4), Solid Waste Management Unit (SWMU) Nos. 109, 110, 111 and 112. Information obtained from the field investigations was used in the Human Health and Ecological Risk Assessments which were also completed as part of the overall RFI effort.

Harza was contracted by the USACE to perform the RCRA Facility Investigation (RFI) described herein. The activities performed during the RFI effort were conducted in accordance with the RFI Work Plan prepared by Harza for this specific investigation. The RFI Work Plan (Harza 1996) included a Data Management Plan, Field Sampling Plan, Data Quality Assurance Project Plan, and Site Safety and Health Plan.

2.2 INVESTIGATION OBJECTIVES

The objectives of this RFI were to sample potentially affected media at FTA4 and perform the necessary analyses on a sufficient number of samples collected at appropriate locations and/or intervals to:

- Delineate the vertical and lateral extent of contamination in each contaminated media;
- Identify all contaminants of concern;
- Determine the fate and transport characteristics of each contaminant of concern;
- Perform a human health and environmental risk assessment to determine if site conditions pose a risk to human health or the environment according to USEPA policy; and
- Support a decision for no further action or the selection of corrective measures/remedial alternatives and remedial design.

2.3 REPORT ORGANIZATION

This report summarizes the results of the RFI performed by Harza at FTA4, Cannon Air Force Base, Curry County, New Mexico, and incorporates the results of previous investigations, where appropriate, to provide a basis for further actions under the Resource Conservation and Recovery

Act (RCRA) of 1976. This investigation and report also satisfy the requirements of the Comprehensive Environmental Response Compensation, and Liability Act (CERCLA) of 1980. The report was prepared using guidance obtained from United States Environmental Protection Agency's (USEPA's) *RCRA Facility Investigation Guidance* and the report generally follows the format suggested in USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.*

This RFI report is organized as follows: Section 1.0 outlines the purpose and scope of the report, investigation objectives, report organization, and previous investigations at FTA4. Section 2.0 provides a description of the physical setting at Cannon AFB, including available information on facility conditions, physical geography, land use and demography, climatology, geology, hydrogeology, surface water hydrology, soils, and ecology for Cannon AFB and surrounding areas. Section 3.0 presents applicable or relevant and appropriate requirements (ARARs). Section 4.0 presents the results of the field investigations at FTA4, within the boundaries of which, SWMUs 109, 110, 111, and 112 are located. Section 5.0 discusses contaminant fate and transport of the chemicals detected during the RFI. Sections 6.0 and 7.0, respectively, present the results of the baseline risk assessment for human health and the ecological risk assessment. Section 6.0 provides the conclusions and recommendations based on the results of the field investigations and baseline risk assessment. References are contained in Section 7.0.

2.4 PREVIOUS INVESTIGATIONS

Information concerning previous investigations at FTA4 was obtained from excerpted information provided by USACE, and included in Appendix A. Previous investigations completed at FTA4 are summarized as follows:

- In 1985, Radian Corporation completed two deep soil borings; one about 50 feet east of training pit (SWMU No. 109) and one about 100 feet south of the fire training pit (SWMU No. 109). Sample results from the boring to the east indicated the presence of oil and grease up to 280 mg/kg and lead between 4.1 and 39 mg/kg at a depth of 10.5 to 11.5 feet. Results from the boring to the south indicated 37 mg/kg oil and grease at a depth of 43 to 45 feet. No purgeable organic compounds were detected in these borings.

- In 1988, Walk, Haydel and Associates completed nine borings in the area of SWMU Nos. 111/112 and SWMU No. 110, ranging in depth from 5 to 100 feet. Analytical results indicated the presence of JP-4 constituents ethylbenzene, benzene, toluene, and xylene in soils from three (3) borings near the underground tank (SWMU No. 110). Concentrations were reportedly detected to a depth of 100 ft and ranged from: 2,030 to 15,200 µg/kg benzene; 620 to 56,200 µg/kg ethylbenzene; 280 to 64,000 µg/kg toluene; and 1,500 to 93,800 µg/kg xylene (total). Four metals analyzed (arsenic, selenium, cadmium, and silver) were detected and ranged from 50.7 to 114.6 mg/kg arsenic, 679.6 to 1713.5 mg/kg barium, 80.6 to 198.4 mg/kg selenium, and 5.1 to 154.8 mg/kg silver.

- In 1991, Woodward-Clyde Consultants collected four surface soil samples and completed four soil borings. Analytical results indicated the presence of ethylbenzene and xylenes as well as total petroleum hydrocarbons (TPH) in the area of SWMU No. 109. In a boring immediately south of SWMU No. 109, ethylbenzene was found at an estimated concentration of 19,000 µg/kg from a depth of 4 to 6 feet, xylene (total) between 6,700 and 290,000 µg/kg from depths of 4 to 12 feet, and TPH between 46.7 and 13,600 µg/kg from the surface to depths of 22 feet. In the boring immediately north of SWMU No. 109, TPH was reported between 12,900 and 38,500 µg/kg from the upper 6 feet and between 203 and 215 µg/kg at a depth of 50 to 62 feet. No other organic detections were reported. One elevated lead level (estimated at 19.6 mg/kg) was detected at the surface at the boring completed immediately north of SWMU No. 109.

3.0 PHYSICAL SETTING

3.1 FACILITY DESCRIPTION

Cannon AFB is located in Curry County, New Mexico, approximately seven miles west of the City of Clovis (Figure 3-1). The base is situated on approximately 4,320 acres and principally includes the airfield area with operation, maintenance, and support facilities located primarily northwest of the airfield area. Housing facilities are located in the northwest portion of the base, west of Highway 277. Additional base support facilities such as the wastewater lagoons, munitions storage area, and fire department training area are located south and east of the airfield.

The primary mission of Cannon AFB is to develop and maintain a tactical fighter wing capable of day, night, and all weather operations and to provide replacement training of combat crews for tactical operations worldwide. Currently, three squadrons of F-16 aircraft and one squadron of EF-111 aircraft are assigned to Cannon AFB. Cannon AFB's 4,000 member work force includes 3,500 military and 500 civil service personnel.

3.2 PHYSICAL GEOGRAPHY

Cannon AFB is situated in the Southern High Plains Physiographic Province in the Llano Estacado subprovince (Figure 3-2) (Hawley et al. 1976). The Llano Estacado is a nearly flat plain sloping gently (10 to 15 feet per mile) to the east and southeast. In the vicinity of Cannon AFB, ground elevations range from 4,250 feet to 4,350 feet above mean sea level (msl).

The most prominent geomorphic features in the vicinity of Cannon AFB are blowouts and broad, widely spaced valleys. Less common landforms are relict sand dunes located along the northern side of the Portales Valley south of the base. Relict dunes are not found on or near Cannon AFB.

Blowouts are broad shallow depressions which form as the result of soil erosion by wind. Blowouts commonly collect surface runoff from small to moderate sized drainage areas. During periods of rainfall, runoff collects in blowouts to form ephemeral playa lakes, which have no external surface drainage. Water is lost from the playa lakes by infiltration to the soil and evaporation; and without, recharge playa lakes persist for only a few days or weeks. Three playas are located within the base, and several more are found to the north and east of the base.

Stream valleys tend to be fairly broad and widely spaced. Streams are ephemeral and drainages are poorly developed. No streams exist on or near Cannon AFB. Running Water Draw and Frio Draw, located about 10 and 20 miles, respectively, north of Cannon AFB, are the nearest streams (USGS 1985).

3.3 LAND USE AND DEMOGRAPHY

Cannon AFB is located in southern Curry County, approximately seven miles west of the City of Clovis, New Mexico, which is the county seat. The bureau of Census data for 1990 reports the

population of Curry County and the City of Clovis as 42,207 and 30,954, respectively. In 1990, Cannon AFB had a resident population of approximately 3,800, including military personnel and their dependants (USAF 1991).

Currently, 1,841 housing units are controlled by Cannon AFB. Unaccompanied enlisted military personnel reside in 830 dormitory units located on-base. Military families live in 1,011 units, 250 of which are located off-base. Typically, military family housing is maintained at 95 percent occupancies, while 5 percent undergo repairs and maintenance.

Major industries by employment in Curry County include retail trade, government, and services. Cannon AFB is the largest single employer within the county. Base related employment totaled approximately 4,900 positions, which included approximately 4,000 uniformed military, 460 appropriated-fund civilians, and approximately 400 other base civilians (USAF 1991).

Medical services are provided for Cannon AFB personnel and their dependants by two general hospitals in the surrounding communities and by the base hospital. Education of student dependants is provided by the Clovis Municipal School District. A total of 1,735 dependants of Cannon AFB personnel enrolled in Clovis schools during the 1989-1990 school year (USAF 1990).

Land use within Curry County is primarily agricultural. The county has a total land area of 897,000 acres with 837,200 acres designated as farmland (USAF 1990); 133,700 acres of this are considered prime farmland. Land surrounding Cannon AFB is classified as irrigated farmland of state importance. Principal crops include corn, grain, sorghum, wheat, barley, oats, alfalfa, cotton, and various vegetables. Cattle ranching occur throughout the county.

The city of Clovis is the commercial center for eastern New Mexico and western Texas and is one of the primary growth centers in a 17-county area. The Clovis planning area boundary extends for a five-mile area around the city. Currently, no land use or zoning controls restrict the type and amount of construction in proximity of Cannon AFB.

Within Cannon AFB there are several land uses, including residential, commercial, industrial, recreational, and vacant land. The USAF has also designated Compatible Use Zones (CUZs) around Cannon AFB. The CUZs provide recommendations for compatible uses in areas subject to noise and accident hazards. The local communities or county governments are responsible for adopting appropriate land use controls to prevent incompatible development. The county has not passed zoning ordinances controlling development around Cannon AFB. Incompatible land uses (with reference to USAF CUZs) have occurred to the northeast of the base and included both commercial and residential development.

3.4 CLIMATOLOGY

The climate of east-central New Mexico is classified as tropical semi-arid, with summer temperature and precipitation maxima. Average monthly temperatures range from a January low

of 39°F to a July high of 79°F. Extreme daily temperatures range from -11°F to 106°F (Lee Wan and Associates 1990). Average monthly precipitation ranges from 0.4 inches in winter to 2.7 inches in July (USAF 1990). The maximum recorded 24-hour rainfall is 4.7 inches, which occurred in August 1985 (Hale 1992). Rainfall occurs on eight or more days per month during the summer precipitation maximum. Mean annual precipitation is approximately 15 inches. The mean annual lake evaporation is 69 inches per year. Prevailing winds are from the west at an average of 8 mph (USAF 1990).

The atmosphere around Cannon AFB is generally well mixed. The seasonal and annual average mixing heights can vary from 400 meters in the morning to 4,000 meters in the afternoon. The afternoon mixing heights are typically greater during the spring and fall seasons. The morning mixing heights are usually low, due to nighttime ground heat loss producing surface-based temperature inversions. After sunrise, these inversions generally break up, and solar heating of the earth's surface causes vertical mixing in the atmosphere (USAF 1990).

Dust is frequently entrained into the atmosphere in this region of the country because of gusty winds and the semiarid climate. The Texas Panhandle-eastern New Mexico area is considered the worst area in the United States for windblown dust. Occasionally, this windblown dust is of sufficient quantity to restrict visibility. Most of the seasonal dust storms occur in March and April, when the wind speeds are typically high.

3.5 GEOLOGY

The near-surface stratigraphic units of interest at Cannon AFB are the Late Miocene-Late Pliocene age Ogallala Formation and the Early Triassic Dockum Group (Figures 3-3 and 3-4).

The Dockum Group consists of three formations. The stratigraphically lowest unit is the Santa Rosa Sandstone. Overlying the Santa Rosa Sandstone are the Chinle and Redonda Formations. The Chinle and Redonda Formations are composed mainly of red shales with lesser interbedded sands and are known locally as "redbeds." The top of the Dockum Group is marked by an erosional unconformity having relief of up to several hundred feet (Lee Wan and Associates 1990).

Overlying the Dockum Group redbeds is the Ogallala Formation. The Ogallala Formation extends from eastern New Mexico and Colorado into Texas, Oklahoma, Kansas, Nebraska, and South Dakota. Drillers logs from Cannon AFB indicate that the Ogallala Formation varies from 360 feet to 415 feet in thickness. The incised upper surface of Triassic redbeds strongly influences Ogallala thickness. Stream valleys in the post-Triassic unconformity are deep and trend dominantly east to west. Ogallala thickness may thus vary significantly over short north to south distances.

The Ogallala is erosionally truncated to the south along the abandoned Portales Valley, to the west along the Pecos River Valley, and to the north in a series of ephemeral stream valleys. The Ogallala Formation extends more than 125 miles to the east before terminating as an escarpment

in Briscoe County, Texas. Springs and seeps are common along the erosional margins of the Ogallala.

The Ogallala dips gently and monoclinally to the southeast in the vicinity of Cannon AFB. As reported in Lee Wan and Associates (1990), data suggest that some Quaternary warping may have occurred, but most of the structures recognized are well to the northwest and southwest of Cannon AFB. No faults or buried structural lineaments are known to exist in the vicinity of Cannon AFB.

The Ogallala Formation is composed of unconsolidated poorly sorted gravel, sand, silts, and clays. The base of the Ogallala is generally marked by a gravel, cobble, and boulder deposit. This basal member contains sediments derived from igneous and sedimentary rocks transported from the mountains located to the west. The Ogallala Formation was laid down by stream and overbank deposits formed within coalescing alluvial fans. These fans form a broad pediment along the eastern flank of the Rocky Mountains. As is typical of alluvial deposits, Ogallala internal stratigraphy varies vertically and horizontally over short distances.

Except where strongly cemented by calcium carbonate (caliche), the sediments of the Ogallala are loose and friable. Authigenic and allogenic clays are found as a trace to abundant matrix mineral (Lee Wan and Associates 1990). As reported by Lee Wan and Associates (1990), five zones have been identified within the Ogallala of east central New Mexico on the basis of clay minerals. Smectites (montmorillonites) and attapulgite (with sepeolite) are the dominant clays throughout the Ogallala. Illite is a lesser, but persistent clay, as is kaolinite. Smectite is a swelling clay, causing deep cracks to form in dry surface soils. Smectite in particular and, to a lesser extent, attapulgite and illite, are clays with moderate to high cation exchange capacities (CEC). The formation as a whole should therefore have a relatively high CEC, which should inhibit the migration of charged contaminants, and especially ionic forms of metals.

Caliche is a major feature of the Ogallala Formation, occurring as nearly continuous to discontinuous layers. Caliche is hard, white to pale tan on fresh surfaces, weathering to gray, and has a chalky appearance. Caliche forms as calcium carbonate, leached from overlying sediments and precipitated in the pore space of the host sediments. Precipitation is caused by the evaporation of downward percolating water. The caliche may thus mark the position of ancient vadose zones.

Caliche is relatively soluble in acidic water ($pH < 7$) or in waters containing dissolved CO_2. The top surface of the upper caliche in fresh outcrop shows solution etching. The Ogallala has numerous continuous to discontinuous caliche layers throughout its thickness. The uppermost caliche, termed the "climax" caliche, is pisolitic (Lee Wan and Associates 1990). As reported in Lee Wan and Associates (1990), radiocarbon dates for the upper "climax" caliche range from approximately 27,000 years before present (B.P.) to approximately 42,000 years B.P. The pisolites are thought to have formed as the caliche was repeatedly chemically-weathered and brecciated during Pleistocene pluvials and later recemented during drier intervals. This upper caliche outcrops around playas and the bounding escarpments of the Ogallala, and is locally termed "caprock." The "climax" caliche is typically 3 to 5 feet thick. Caliches which occur lower in the Ogallala are platy and harder. Caliche is likely thin or absent below playas.

3.6 HYDROGEOLOGY

The lower portion of the Ogallala Formation is the primary regional aquifer for both potable and irrigation water. No deeper aquifers are used in the vicinity of Cannon AFB. The Ogallala aquifer is part of the High Plains Aquifer which extends continuously from Wyoming and South Dakota into New Mexico and Texas. In east central New Mexico, the Ogallala aquifer rests on Dockum Group redbeds, which serve as the basal confining layer (aquiclude). The Ogallala is a water table, or unconfined aquifer (Weeks and Gutentag 1981). The Ogallala aquifer has a southeasterly regional gradient of about 13 ft/mile. Well yields vary from less than one gallon per minute (gpm) in thin silts and sands up to 1,600 gpm in thick sands and gravels. Water quality is generally good with dissolved solids ranging from 250 to 500 mg/L (Gutentag et al. 1984) and fluorides ranging from 2.2 to 2.7 mg/L (William Matotan and Associates Inc. 1985).

The dominant uses of groundwater in the Cannon AFB area are for potable and irrigation water. Numerous wells are found in the Cannon AFB area; most provide only irrigation water (Figure 3-5).

At Cannon AFB, the Ogallala aquifer has an average saturated thickness of 120 feet based on mid-1960's data. Saturated thickness ranges from 93 to 143 feet, and is influenced by the configuration of the erosional unconformity surface marking the top of the Dockum Group. The local groundwater gradient is southeasterly at 7 to 15 feet/mile (USAF 1990). Flow within the saturated zone may be influenced by the configuration of the top of the Dockum Group. Yields in tests of Cannon AFB water wells have ranged from 205 gpm to 1,150 gpm. Specific capacities range from 11.4 gal/ft to 27.9 gal/ft (Lee Wan and Associates 1990).

Very rough estimates of hydraulic conductivity were made from well pump tests in water wells 5 and 9 using the Theis equation. An estimate of hydraulic conductivity for water well 8 was based on water level recovery data using the Bouwer and Rice approach (Lee Wan and Associates 1990). The data used in these calculations were obtained to evaluate pump rates, efficiency, and well yield, and were not intended for use in calculating aquifer properties. The results of these calculations should, therefore, be considered as first approximations.

Hydraulic conductivity values for water wells 5 and 9 were approximately 2.0×10^{-3} cm/sec. Calculations for water well 8 result in a hydraulic conductivity of 2.0×10^{-2} cm/sec. These estimates appear to be low when compared to published hydraulic conductivity data for sands and gravels (Freeze and Cherry 1979). As reported in Kearney (1987), a groundwater flow velocity of about 150 ft/yr has been estimated. This calculates out to a hydraulic conductivity of approximately 1.0×10^{-1} cm/sec.

The presence of interstitial clays may account for both the variability and low values of hydraulic conductivities. Boring logs from Cannon AFB IRP projects and published reports (Lee Wan and Associates 1990) indicated that interstitial and interstratified clays are abundant in the Ogallala Formation.

Recharge to the Ogallala is primarily through precipitation. Kearney (1987) indicated that the recharge rate may be as much as 1.0 in/yr. Due to the high evapotranspiration rate and low precipitation, recharge occurs only during heavy rainfall events in which the infiltration capacity of the soil is exceeded and runoff occurs, or during cool months when precipitation exceeds evapotranspiration. Excess runoff flows to playas and the presence of water in playas allows deep percolation to the aquifer. The occurrence of this process is evidenced by the presence of clay deposits in playas and the possibility that caliche is thin or absent directly below playas. Caliche is soluble in acidic rain waters and is leached over time to form percolation pathways.

Discharge from the Ogallala occurs through well pumping and springs along the eroded margins. Spring discharge does not occur on or near Cannon AFB. Domestic and irrigation water wells are common on and around the base, however. The rate of discharge exceeds recharge as water levels in the Ogallala have declined steadily from the 1930s to the present. From the 1930s to 1980, a decline of 50 to 100 feet has been observed in the area around Clovis, New Mexico. Luckey et al. (1981) states, "the largest area of water level decline exceeding 100 ft occurs south of the Canadian River extending from Curry County, New Mexico to Crosby County, Texas."

The Ogallala will continue to be used as the primary source of potable and irrigation water for eastern New Mexico. The New Mexico State Engineer designated Curry County as a Water Basin in 1989. This designation allows for regulation of water rights, usage, and well drilling.

3.7 SURFACE WATER HYDROLOGY

Cannon AFB is located in the Southern High Plains region. This region is typified by smooth and gently sloping, undulating surface topography on which scattered, normally dry, flat-bottomed depressions are the dominant relief feature. The dominant surface features in the vicinity of Cannon AFB are small temporary lake basins known as playas. A playa located near the southwest corner of Cannon AFB collects the majority of the stormwater runoff from the base. Two wastewater lagoons are located on the base which have a combined surface area of 32 acres. The treated wastewater effluent from the lagoons is channeled into an adjoining playa lake. Cannon AFB has no permanent surface water features other than the wastewater lagoons and the associated playa lake (USAF 1990).

Regional drainage in Curry County is predominantly to the southeast and east. Stream drainage is poorly developed because of the low annual rainfall and the minimal relief. The drainage pattern consists of long shallow valleys (known as draws) that extend almost from the western edge of the Southern High Plains to the eastern boundary of the plateau. The valleys and draws eventually drain into one of three major river valleys : the Red, the Brazos, or the Colorado River valleys. Although the draws extend to the river valleys as drainage systems, they seldom contribute actual flow to the rivers except during periods of unusually high rainfall. The majority of the precipitation is lost to evapotranspiration and infiltration. The playa lakes serve as low-point collection areas not drained by the draws. The playa lakes have no surface outlet, and any water they collect is eventually lost to evaporation and infiltration (USAF 1990).

3.8 SOILS

Soils in the vicinity of Cannon AFB are classified as silty sand (SM) to clayey sand (SC) under the Unified Classification System, and as aridisols (calciorthids) under the United States Department of Agriculture - Soil Conservation Service Comprehensive Soil Classification System (USDA-SCS). The following summary is based on the Curry County Soil Survey (USDA 1958). Figure 3-6 depicts the various soil types mapped at Cannon AFB. Soil characteristics are briefly described in the following paragraphs.

The most common soil type on the base is the Amarillo fine sandy loam, 0 to 2 percent slope phase (map symbol Ab). This soil consists of a thin sandy A horizon, well defined clayey B_{1-3} horizons, with a calcic B_3 horizon at depths below 40 inches. The calcic B_3 horizon lies on a calcic C horizon, or on caliche. The color of the surface soil is brown (7.5 YR 5/5, dry) and subsurface soils are reddish-brown (5 YR 4/4, dry) to yellowish-red (15 YR 5/6, dry). The calcic C horizon underlying the Amarillo Fine Sandy loam is white in color. The Amarillo fine sandy loam soil type is present on all relatively flat surfaces at the base but is also found on slopes associated with playas (map symbol Ac). A small area of Amarillo loamy fine sandy 0 to 2 percent slope phase (map symbol Ag) is mapped in the southeast corner of the base.

Clovis fine sandy loams, 0-2 percent slope phase (map symbol Cb) and 2-5 percent slope phase (map symbol Cc), are similar to Amarillo fine sandy loams. Clovis soils are reddish-brown on the surface and in the subsurface, with a white Calcic C horizon. In the Clovis soils, the depth to the calcic C horizon ranges from 28 to 56 inches. The depth to caliche exceeds 56 inches. Clovis and Amarillo fine sandy loams occur in close association.

In a few limited areas, particularly along the steeper slopes around playas, Mausker fine sandy loam, 0 to 2 percent slope phase (map symbol Ma), and 2 to 5 percent phase (map symbol Mb) are found. Mausker fine sandy loams have no B horizons and are very calcareous. Mausker fine sandy loam soils are brown (10 YR 5/3, dry) to light brown (7.15 YR 6/4, dry) at the surface with a pink to reddish-yellow (7.5 YR 7/5, dry) calcic C horizon. Associated with the Mausker fine sandy loam soils around the base Playa Lake are Potter fine sandy loam soils, 0 to 5 percent slope phase (map symbol Pa). This soil typically has a thin A horizon, grayish brown (10 YR 5/2, dry) in color, with no B horizon; similar to Mausker soils. Potter soils are shallow and strongly calcareous, and overlie hard consolidated caliche. The calcic C horizon is within two feet of the surface.

The A and B horizons of Amarillo and Clovis fine sandy loams are rapidly to moderately permeable. Mausker fine sandy loam A and Ac horizons are rapidly permeable. Permeabilities in calcic B and C horizons are moderate (USDA 1958).

3.9 ECOLOGY

Land adjacent to Cannon AFB is primarily used for agriculture and little natural vegetation remains in the area. The wildlife species that are common to agricultural areas throughout the

region include bobwhite quail and pheasant. The few playa lakes in the area are used by upland game for cover, by waterfowl for resting and feeding, and by wildlife in general for drinking. Nearby riverbeds also provide water sources during rainy seasons. During periods of low rainfall, the riverbeds are dry.

The climate of the Base area is considered to be semiarid. The thin layer of topsoil in the vicinity of Cannon AFB is sandy loam, which is highly susceptible to wind erosion. The undisturbed natural vegetation is mostly shortgrass prairie, including blue grama grassland and mixed grama grassland vegetation types.

Much of the study area has been previously cleared for agricultural crops. The predominant land use of the region is rangeland, primarily for cattle grazing. In general, moderately grazed rangeland areas of the types occurring in the project area are highly productive in terms of both forage quality and quantity. The rangeland in the vicinity may support up to 15 to 20 head of cattle per section, depending on the rainfall. Large trees do not uniformly exist in the vicinity of the range except where planted around buildings and other structures on the Base. Woodlands composed of large shrubs and small trees are confined to riparian areas and playa lakes in the vicinity.

The eastern New Mexico area contains many nongame wildlife species that are typical of the High Plains. Most of these species are distributed widely throughout the western United States. Wildlife diversity is low in most areas because of the low vegetation diversity. Most amphibian species are associated with riparian habitats and playa lakes. Reptiles are found in all terrestrial habitat types but are most abundant in scrub/grasslands. Nocturnal rodents are the most abundant members of the small mammal community.

Grasslands on the High Plains support a variety of seed-eating sparrows and other ground-dwelling birds, both as residents and migrants. Raptors (hawks and owls) are relatively abundant in all habitats in the region. Insectivorous and tree-nesting species are most abundant in riparian areas. Shorebirds and waterbirds and migratory waterfowl in general use the rivers, playa lakes, and reservoirs of the region.

Big-game species in the area include mule deer, white-tailed deer, pronghorn, and barbary sheep. Pronghorn are the most abundant game animal in the area. Several species of upland game such as quail, ring-necked pheasant, and turkey are common in the area.

Information obtained from the New Mexico Department of Game and Fish, Conservation Services Division (1997), indicates that the federal- and state-protected species indicated on the following table may be found within Curry County.

Federal and State Protected Animals Potentially Occurring in the Vicinity of Cannon Air Force Base

Common Name	Scientific Name	Federal Status	State Status
Reptiles			
Texas horned lizard	*Phrynosama cornutum*	C2	
Birds			
Baird's sparrow	*Ammodramus bairdii*	C2	Threatened
Ferruginous hawk	*Buteo regalis*	C2	
Bald eagle	*Haliaeetus leucocephalus*	Threatened	Threatened
Peregrine falcon	*Falco peregrinus*	Endangered	Endangered
Mammals			
Plains pocket gopher	*Geomys burarius*	C2	
Swift fox	*Vulpes velox*	C	
American bison	*Bos bison*		Extirpated
Merriam's elk	*Cervus elaphus merriami*	Extinct	
Gray wolf	*Canis lupus*	Endangered	Extirpated
Black-footed ferret	Mustela nigripes	Endangered	Extirpated

Notes:

Endangered	Species whose prospects of survival or recruitment within the state are in jeopardy
Threatened	Species whose prospects of survival or recruitment within the state are likely to become jeopadized in the foreseeable future
C	Proposed as a candidate for listing
C2	Of concern, but has no legal standing or protection
Extirpated	No longer living in the state

Texas horned lizard, or horny toad, is not protected but is of concern at the federal level. This animal is known to occur in Curry County and has recently been found on the base. They inhabit open areas with sparse vegetation, digging dens for hibernation, nesting and insulation, in loose sand or loamy soils. They are insectivores and prefer to eat harvester ants.

Three of the four state-protected birds known to occur in the vicinity of the Base are the raptors ferruginous hawk, bald eagle and peregrine falcon. The ferruginous hawk may be found as either a winter migrant or a year-round resident. The bald eagle migrates and winters from the northern border of New Mexico to the Gila, lower Rio Grande, middle Pecos, and Canadian valleys. It is seen occasionally in summer and as a breeding bird, with nests reported in the extreme northern and western parts of the state. Winter and migrant populations appear to have increased with reservoir construction. The peregrine falcon is widely distributed but population numbers are low

but increasing. The American subspecies breeds statewide in New Mexico, but mainly west of the eastern plains. The protected songbird Baird's sparrow migrates through the area during autumn and may breed in New Mexico. Baird's sparrow is a grassland bird, eating seeds of grasses and forbs, as well as insects. Its numbers continue to decline.

Protected mammals that still live in the state include the Plains pocket gopher and swift fox. The Plains pocket gopher inhabits sandy or loamy soils, where burrowing is easier. While it has been found in alfalfa fields, the shortgrass prairie is its normal habitat, where it feeds primarily on grass seeds. The swift fox is closely related to the kit fox, and may hybridize with kit fox in eastern NM and western Texas. The fox is largely nocturnal, eating rodents, insects, lizards and vegetation. Dens are burrowed in sandy loam soils and they are used year-round. Its numbers have diminished due to habitat loss and the taking of poisoned bait.

4.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

4.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Any remedial or corrective action measures which may be required are required to be evaluated to assess the degree to which they attain or exceed applicable and relevant federal and state public health and environmental standards. A discussion of the Applicable or Relevant and Appropriate Requirements (ARARs) applicable to FTA4 is presented below. Review of these ARARs will identify any site-specific regulatory conditions that may limit the choices of remedial alternatives or place limits on contaminant concentrations at the site. The ARARs presented herein are chemical-specific and location-specific. Chemical-specific ARARs are presented for soil media only, as groundwater does not appear to be a pathway for exposure or contaminant transport based on the analytical data obtained at FTA4, the nature and extent discussion (Section 5.0), and the thickness of the unsaturated zone.

4.1 CHEMICAL SPECIFIC ARARS

The chemical-specific ARARs and other criteria or guidelines to be considered are presented in Table 4-1. These requirements are based on health or risk-based concentration limits for specific hazardous chemicals. These requirements may be used to set cleanup levels for the chemicals of concern in the designated media. Sources of potential target cleanup levels include standards, criteria and other guidelines that are typically considered as ARARs for remedial actions under CERCLA, as well as published guidance and proposed action levels developed under RCRA. Additionally, the State of New Mexico has developed soil cleanup levels for underground storage tank remediation. New Mexico Underground Storage Tank regulations are listed as an ARAR for soils contaminated with petroleum hydrocarbons. This ARAR provides a cleanup level of 1,000 mg/kg TPH in soil which is exceeded at FTA4.

4.2 LOCATION-SPECIFIC ARARS

Location-specific ARARs are restriction placed on the types of activities that may occur in specific locations. Potential location-specific ARARs are presented in Table 4-2. The location of a site may be an important characteristic in determining its impact on human health and the environment; thus individual states may establish location specific ARARs. Examples of location-specific ARARs include federal and state requirement for the preservation of historic landmarks and endangered species.

4.3 TO BE CONSIDERED MATERIALS

"To be considered" materials (TBCs) are non-promulgated advisories, proposed rules, criteria, or guidance documents issued by federal or state governments that do not have the status of potential ARARs. However, these advisories and guidance are to be considered when determining cleanup levels where no ARARs exist, or where ARARs are not sufficiently protective of human health and the environment. In these circumstances, TBCs are used to establish cleanup levels. TBC screening values for inorganic compounds are provided in Table 4-3.

5.0 INVESTIGATION RESULTS

5.0 INVESTIGATION RESULTS

Field investigations by Harza at Fire Training Area No. 4 were conducted between October 16, 1996 and October 30, 1996, and between February 19, 1997 and February 26, 1997. The investigation activities were completed as described in the RFI Work Plan (Harza 1996), except as noted in this report. Investigations included:

- Passive soil gas survey to better delineate the lateral extent of contamination and provide information used to select boring locations.
- Drilling of nineteen (19) soil borings for the collection of surface and subsurface soil samples;
- Collection and analysis of 77 soil samples and associated quality assurance/quality control (QA/QC) samples for laboratory chemical analysis, headspace analysis, and immunoassay screening;
- Collection and testing of 12 soil samples for particle size analysis and moisture content;
- Collection of continuous soil samples from each boring for lithologic description.

This section summarizes site conditions and presents and summarizes results of the investigations.

5.1 SITE DESCRIPTION

FTA4 is located near the southeast corner of Cannon AFB approximately 2,000 feet southeast of the end of Runway 31. Between 1961 and 1974, Fire Training Area No. 4 was reportedly used for fuel truck cleaning. In 1974, it was activated as a fire training area and was actively used for this purpose until 1995. Fire Training Area No. 4 is comprised of four Solid Waste Management Units (SWMUs):

- SWMU No. 109 - Fire Training Pit
- SWMU No. 110 - Underground Waste Oil Tank #2336
- SWMU No. 111 - Unlined Pit; and
- SWMU No. 112 - Oil/Water Separator #2336

A map showing SWMU locations and existing site features is included as Figure 5-1. SWMU No. 109 consists of a concrete lined pit and berm. A mock airplane was formerly located in the center of the pit and was used for fire training exercises. The pit contains internal drainage features such that excess fuel/water was drained to the oil-water separator (SWMU No. 112) in the northeast part of the site. The oil-water separator was activated in 1985, allegedly at the location of the former unlined pit (SWMU No. 111). Prior to 1985, the unlined pit had been used to collect runoff from the area after fires were extinguished during fire training exercises. The underground waste oil tank (SWMU No. 110) was a 2,000 gallon storage tank used to store recovered JP-4 fuel for use during fire training exercises. The tank has been removed and soil from around the tank is currently being land farmed on a plot adjacent to the westernmost site access gate. To prevent the downward migration of contaminants, the land farmed soil was placed on top of heavy gauge

plastic. During some, but not all fire training exercises, the ground reportedly was saturated with water.

Historic usage records indicate no evidence that Cannon AFB, including Fire Training Area No. 4 was used for activities involving uncommon hazardous constituents or industrial formulations. Rather, the activities at FTA4 were related to fire training exercises utilizing JP-4 and other appropriate materials generated by routine maintenance tasks elsewhere at Cannon AFB, such as cleaning engines, painting and repainting, paint stripping, and aircraft maintenance. Reportedly, fuel was introduced to the ground surface between 1961 and 1974 for fire training exercises. From 1974 to 1975, co-mingled waste oils, solvents, and recovered JP-4 were used. Between 1975 and 1995, only recovered JP-4 had reportedly been used.

Based on the historical uses of the area, potential contaminants at FTA4 fall into the general categories of fuels, solvents, and waste petroleum oil and lubricants (POL), and include the following:

- Inorganics
  - heavy metals
- Organics
  - volatile organic compounds (VOCs)
  - semi-volatile organic compounds (SVOCs)
  - halogenated solvents

5.2 SOILS

Soils underlying FTA4 consist of sandy loam and loamy sand of the Amarillo Soil group. The soils consist primarily of a fine-grained, well sorted silty/clayey, unconsolidated brown/reddish brown sand. Such soils are generally classified as SM (silty sand) to SC (clayey sand) under the Unified Soil Classification System (ASTM D 2488).

5.3 STRATIGRAPHY

The near-surface (upper 90 feet) stratigraphy at FTA4 consists of Miocene to Pliocene fluvial deposits of the Ogallala Formation. Two geologic cross-sections, A-A' and B-B' (Figures 5-3 and 5-4), were constructed using information on the lithologic boring logs from this RFI. Cross-section A-A' is oriented west-east and cross-section B-B' is oriented north-south. The locations of the cross-section are indicated in Figure 5-2.

FTA4 is underlain by Ogallala fluvial deposits consisting primarily of well sorted sand classified as SM (silty sand) to SC (clayey sand) using the Unified Soil Classification System. The total thickness of these Ogallala deposits beneath the site is not known, as bedrock was not encountered during field investigation activities. Based on available regional information, they may be as thick as 390 feet.

Geologic materials underlying FTA4 are relatively homogeneous, consisting of dense, generally

brown, tan, or gray, fine sand, silt, and clay admixtures. The granular soils generally are uncemented, but contain sporadic caliche layers and more extensive zones containing caliche-cemented nodules.

Two lithologic units may be distinguished from the cross-sections and results of geotechnical testing, consisting of a comparatively coarser grained silty sand overlain by comparatively finer grained silt and clayey sand mixtures. Locally, as in boring SB04, slightly coarser silty sand also is present at the surface.

The lower deposit is field classified as predominantly silty sand (SM) with lesser percentages of silt and clay. It extends from depths between about 6 and 44 feet to the maximum drilled depth (90 feet). Geotechnical testing (grain size and moisture content) was performed on nine samples from this unit at depths ranging from 19 to 56 feet. Results indicate that samples from this lower unit were generally comprised of approximately 55 to 72 percent sand, 14 to 29 percent silt, and 5 to 29 percent clay, with a moisture content ranging from 6 and 14.9 percent.

The upper deposit overlies the silty sands in most locations, extending from the ground surface to depths between approximately 6 and 44 feet, generally averaging about 20 feet. These deposits consist predominantly of silt/clay mixtures with lesser percentages of sand and are more variable in thickness and consistency. Three samples were collected for geotechnical testing from this unit at depth ranging from 3 to 9. Results indicate that these samples were generally comprised of approximately 30 to 35 percent sand, 17 to 21 percent silt, and 48 to 49 percent clay, with a moisture content ranging from 11.4 to 21.3 percent.

5.3 GROUNDWATER

No groundwater was encountered at FTA4 to the maximum drilled depth of 90 feet. Groundwater reportedly occurs at a depth between 240 feet and 295 feet beneath Cannon AFB.

5.4 NATURE AND EXTENT OF CONTAMINATION

This section summarizes the nature and extent of contamination identified at FTA4. The discussion is organized by media investigated, including soil gas and surface and subsurface soils, which, by the distribution and nature of contamination, may be of potential concern from a human health, environmental, or regulatory standpoint. The human health and ecological risk assessments (Sections 6.0 and 7.0, respectively) identify these concerns if they exist.

For clarity, the term contamination is used herein to describe detectable concentrations of chemical compounds that do not occur naturally in the environment or that may be present above site background concentrations. The baseline risk assessment performed as part of this RFI defines the potential risk to public health and the environment and were primary considerations, along with ARARs, in determining whether or not corrective measures or additional investigations are warranted.

Soil was the primary media investigated as part of the RFI. Soil sampling completed during the RFI investigated the vertical and horizontal extent of contamination and the four SWMUs within FTA4. As is noted in Section 5.4.2, SVOCs and TPH were detected in the deepest sampling points of some borings. Therefore, the vertical extent of contamination has not been determined fully at all locations. However, potential impacts to groundwater are not likely since the Ogallala aquifer is found at a depth of approximately 270 feet. No monitoring wells exist within the boundary of FTA4 and groundwater was not encountered during the field investigations. Groundwater flow in the Ogallala aquifer near FTA4 is generally southeasterly based on information from monitoring wells at nearby Landfill No. 5. Most, if not all of the monitoring wells for Landfill No. 5 are located in the downgradient flow direction from FTA4. The closest monitoring wells (MW-A and MW-Q) are upgradient monitoring wells for Landfill No. 5 and are in relatively clost proximity to FTA4. These wells should provide information on groundwater quality in the Ogallala in the unlikely event that a release occurred at FTA4.

5.4.1 Soil Gas

The Passive Soil Gas Survey (PSGS) was conducted to evaluate the lateral extent and distribution of contamination by volatile and semi-volatile organic compounds. The results of the PSGS were used to provide information for the placement of soil borings for surface and subsurface soil sampling.

The PSGS consisted of installing 44 soil gas screening modules (including four field duplicate modules) at 40 sampling locations identified as SG1 through SG40 in Figure 5-5. Modules were installed on a 50-ft grid referenced to the fire training pit (SWMU No. 109). Sample locations were placed between 0.5 and 0.8 feet west of each grid survey stake, which varied with location. At four locations, duplicate screening modules were installed for QC testing purposes. Duplicate samples were located between 0.5 and 0.7 feet west of the corresponding field sample. Modules were installed over a 2-day period beginning on October 16, 1996, left in-place to react with soil gases for a period of approximately two weeks, and retrieved on October 30, 1996. The actual time of installation and retrieval of each module is summarized in Table 5-1. All of the screening modules were recovered and analyzed except module #128666 at location SG34, which could not be retrieved due to a break in the retrieval cord approximately 2.5 feet below the ground surface. After completion of sampling activities, the dimensions and locations of aboveground physical features were verified from existing site maps and an updated site plan was prepared.

Retrieved modules were analyzed by W.L. Gore & Associates for selected target volatile organic and semi-volatile organic compounds, as follows:

- methyl t-butyl ether
- trans-1,2-dichloroethene
- 1,1-dichloroethene
- cis-1,2-dichloroethene
- chloroform
- 1,1,1-trichloroethane

- 1,2-dichloroethane
- benzene
- trichloroethene
- toluene
- octane
- tetrachloroethene
- chlorobenzene
- ethylbenzene
- m-, p-, o-xylene
- 1,3,5-trimethylbenzene
- 1,2,4-trimethylbenzene
- 1,4-dichlorobenzene
- carbon tetrachloride
- undecane, tridecane, and pentadecane (Diesel Range Organics)
- napthalene
- 2-methylnapthalene

Soil gas analytical data for individual target compounds are summarized in Table 5-2 and a copy of the GORE-SORBER^{SM} Screening Survey Final Report prepared by W.L. Gore & Associates is provided in Appendix E. Results indicate that the following individual compounds and groups of compounds were detected in field samples with the greatest relative frequency:

- undecane
- tridecane
- pentadecane
- total target diesel range organics (DRO)
- tetrachloroethene
- total target volatile organics
- toluene

Toluene was detected in all field samples with the exception of module #128640 at location SG11, but also in quality control samples (trip blanks). Review of the toluene data indicated that detected concentrations in field samples and the trip blanks were within five times (5x) the trip blank concentrations, except for one sample. According to data validation procedures in *Data Quality Review Guidelines, USEPA, 1994*, any detected volatile compound, that was also detected in any associated blank, is qualified if the sample concentration is less than five times (5x) the blank concentration and should be considered and reported as not detected. Therefore, toluene data is not considered usable for evaluation purposes.

Results of the Passive Soil Gas Survey are illustrated on isoconcentration maps included as Figures 5-6, 5-7 and 5-8. For illustration purposes and based on the relative frequency of detection, isoconcentration maps were prepared for the following individual compounds or groups of compounds:

- Total target volatile organics *(combined masses of methyl t-butyl ether, trans-1,2-dichloroethene, 1,1-dichloroethene, cis-1,2-dichloroethene, chloroform, 1,1,1-trichloroethane, 1,2-dichloroethane, benzene, ethylbenzene, xylene, carbon tetrachloride, trichloroethene, tetrachloroethene, chlorobenzene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene and 1,4-dichlorobenzene)*
- Total target diesel range organics *(combined masses of undecane, tridecane, and pentadecane*
- Tetrachloroethene

The isoconcentration contours on these maps are representative of other target compounds. The highest relative concentrations of volatile organics and diesel range organics in soil gas were found within and immediately adjacent to the fire training pit (SWMU No 109). Figure 5-6 shows that volatile organic soil gas concentrations generally decrease with lateral distance from the fire training pit area with equivalent concentration contours skewed to the south and east. Figure 5-7 shows a similar focus of diesel range organic soil gas concentrations, although relatively higher concentrations extend north/northwest toward locations SG31 and SG32, and northeast toward location SG20. An anomalous area of concentrations of target volatile and diesel range organics in soil gas is also noted at location SG35. Figure 5-8 indicates that the area with the highest relative concentrations of tetrachloroethene in soil gas is located southeast of the fire training pit (SWMU No. 109). In contrast, tetrachloroethene was not detected in soil gas within the fire training pit and several adjacent locations (SG15 and SG16). An anomalous area of tetrachloroethene in soil gas is noted near locations SG18 and SG07 adjacent to SWMU No. 100.

Principal conclusions derived from the results of the passive soil gas survey are as follows:

- Frequently detected target compounds and groups of compounds in soil gas at FTA4 include total target volatile organics, total target diesel range organics (undecane, tridecane, and pentadecane), and tetrachloroethene.

- Target compounds detected in soil gas at FTA4, but at a relatively low frequency include methyl t-butyl ether, trans-1,2-dichloroethene, cis-1,2-dichloroethene, chloroform, 1,1,1-trichloroethane, benzene, trichloroethene, octane, chlorobenzene, ethylbenzene, xylene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, 1,4-dichlorobenzene, naphthalene, and 2-methyl naphthalene.

- The highest relative soil gas concentrations of target volatile organics and diesel range organics correlate with the location of the fire training pit (SWMU No.109).

- The highest relative soil gas concentrations of tetrachloroethene are located southeast of the fire training pit (SWMU No. 109).

- Frequently detected compounds in soil gas extend beyond the limits of the survey area.

5.4.2 Surface and Subsurface Soil

The objective of the subsurface drilling and sampling program was to identify the type and concentration of hazardous waste or hazardous waste constituents which may be present at FTA4. The data obtained were used to identify contaminants of concern, delineate the vertical and lateral extent of contamination in each contaminated media, determine the fate and transport characteristics of each contaminant of concern, perform a human health and environmental assessment to determine if site conditions pose a risk to human health or the environment according to USEPA policy, and support a decision for no further action or the selection of corrective measures/remedial alternatives and remedial design.

Based on the passive soil gas results a total of nineteen (19) soil borings initially were drilled and sampled using Rotosonic methods at locations determined jointly by USACE, Cannon AFB, USEPA, NMED. Locations are shown in Figure 5-5. Soil boring locations SB01 through SB13 were selected based on the PSGS and were drilled initially. Specific locations were selected to characterize conditions across FTA4 and in individual SWMUs. The rationale for boring locations is as follows:

- SB01 was placed near SG14 in the area with the highest concentrations of total detected target compounds. This boring was completed primarily to define the vertical extent of contamination near the suspected contaminant source.
- SB02 and SB03 were completed near the west access road northwest of the fire training pit to examine anomalous concentrations of DRO and VOCs in soil gas.
- SB04, SB05, and SB06 were completed north/northeast of the fire training pit, where previous analytical data indicated the presence of DRO beyond the limits of the survey area.
- SB07, SB08, and SB09 were completed southeast and southwest of the fire training pit, where analytical data indicates total VOCs and tetrachloroethane soil gas concentrations extend beyond the limits of the survey area.
- SB10 was completed west of the soil gas survey area where analytical data suggested relatively high total volatile organics and tetrachloroethane soil gas concentrations extend beyond the limits of the survey area.
- SB11 was completed northeast of the fire training pit to delineate lateral and vertical extent in the area of anticipated contamination at SWMU 109.
- SB12 was completed west of the fire training pit at the former underground waste oil tank (SWMU No. 110).
- Soil boring 13 was completed to delineate the extent of contamination on the eastern site boundary.

Following completion of the initial borings, six (6) additional locations (SB14 through SB19), were selected to further delineate the horizontal and vertical extent of contamination. Based on the initial field results, borings SB14, SB15, and SB16 were selected in consultation with USACE.

- SB14 was drilled within the former oil/water separator to determine the nature and extent of contamination within this utility.
- SB15 and SB16 were drilled southwest and east of the fire training pit (SWMU No. 109),

to more closely define the extent of contamination identified in SB01.

Based on these field results, soil borings SB17, SB18, and SB19 were located in consultation between USACE, NMED, and Harza. These borings were placed within approximately 50 to 75 feet of SB01 to delineate the extent of contamination more closely toward the west, southeast, and north, respectively, of SB01. These three borings were specified to be drilled to a minimum depth of 60 feet, each.

Soil borings were drilled over a eight day period beginning on February 19, 1997 and completed on February 26, 1997. A summary of subsurface drilling and sampling activities is provided in Table 5-3. Soil boring logs are provided in Appendix C. Drilling was performed by Alliance Environmental Inc., of Marietta, Ohio using a truck mounted drill rig and Rotosonic drilling methods. Potable water was added, as required, during the advancement of the outer drill pipe to flush out cuttings in the annular space between the inner and outer drill pipe. This added potable water was lost to the formation. No bentonite, polymers, or other additives or viscosifying agents were added to water introduced into the borehole during drilling. Intact surface and subsurface soil samples were taken for physical description, headspace screening, immunoassay screening, chemical analysis, and geotechnical testing. Samples were recovered on a continuous basis from the ground surface to the terminal depth of each boring.

Preliminary ("informal") headspace screening was performed at 1-foot intervals along the sample and readings recorded in column 'd' of the boring log. The 1-foot interval with the highest headspace reading in each 10-foot interval was selected for final ("formal") headspace screening (recorded in column 'h' of the boring log), chemical analysis, and immunoassay screening.

A total of fifty nine (59) subsurface soil samples were collected for field immunoassay screening for TRPHs. Copies of the field analytical data sheets are included in Appendix B and results are summarized in Table 5-4. Except for borings SB17, SB18, and SB19, which were specified to minimum depths of 60 ft, the terminal depth of the borings was determined in the field at the depth at which two consecutive non-detect results were obtained from the immunoassay screening. Results of the field immunoassay screening were recorded on PETRO-RISc® Soil Test Data Sheets (Appendix B) and on the soil boring logs (Appendix C).

A total of seventy seven (77) surface and subsurface soil samples were collected at FTA4 for laboratory chemical analysis and analyzed for volatile organic compounds, semi-volatile organic compounds, cyanide, TRPHs, and target analyte list metals. Analysis was performed by Applied Research and Development Laboratory (ARDL), of Mt. Vernon, Illinois. Analytical parameters and methods were as follows:

- Volatile organic compounds (SW-846 Method 8260A);
- Semi-volatile organic compounds (SW-846 Method 8270B);
- Cyanide (SW-846 Method 9012);
- Target analyte list metals (SW-846 Methods 6010, 7061, 7421, 7470, 7741, 7841, 9012)

- Total recoverable petroleum hydrocarbons (SW-846 Method 9071/418.1)

Copies of the analytical data reports are provided in Appendix F and results are summarized in Tables 5-5 through 5-13. Detections above the method detection limits have been shaded in the tables. MRLs for each analyses are provided on the laboratory data sheets in Appendix F.

A representative soil sample from each 10 foot boring interval also was retained for possible geotechnical analysis. Based on laboratory analytical results and soil types, selected samples were submitted later for particle size analysis and moisture content testing. Geotechnical testing was performed by Testing Service Corporation (TSC), Carol Stream, Illinois and included particle size analysis (ASTM D-421 and ASTM D-422) and moisture content (ASTM D-2216).

5.4.2.1 Volatile Organic Compounds

Volatile organic compounds were detected with the greatest frequency and highest concentrations at SWMU No. 109 (boring SB01). Volatile organic compounds, at lower concentrations (generally below the method reporting limits or MRLs) and lower frequency of detection, were also detected in borings SB02, SB06, SB07, SB11, and SB12. Total VOCs are plotted in vertical profile in Figures 5-10 and 5-11 (profile locations are shown in Figure 5-9). Total concentrations of benzene, toluene, ethylbenzene, and xylene (BTEX) are plotted in profile in Figures 5-12 and 5-13. VOCs detected above the MDLs in individual samples are summarized in Tables 5-5 through 5-13. In the following, however, only those compounds that were above the method reporting limits are discussed. "Detection" hereafter refers to concentrations above the MRLs.

Of the 19 soil borings, only SB01 contained detectable VOCs, which included toluene, ethylbenzene, m&p-xylene, o-xylene, isopropylbenzene, n-propylbenzene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, sec-butylbenzene, p-isopropyltoluene, n-butylbenzene, 1,2-dibromo-3-chloropropane, naphthalene, and 2-butanone. Individual detections in boring SB01 were recorded at depths of 3 feet, 19 feet, 27 feet, 38 feet, 42 feet, 55 feet, and 65 feet. Where detected, concentrations of individual compounds ranged as follows:

- toluene (17.4 - 4,370 μg/kg);
- ethylbenzene (34.6 - 7,230 μg/kg)
- m&p-xylene (166 - 34,100 μg/kg);
- o-xylene (81.1 - 18,900 μg/kg);
- isopropylbenzene (16.6 - 1,940 μg/kg);
- n-propylbenzene (29.3 - 4,450 μg/kg);
- 1,3,5-trimethylbenzene (92.6 - 15,500 μg/kg);
- 1,2,4-trimethylbenzene (11.2-41,800 μg/kg);
- sec-butylbenzene (15.6 μg/kg);
- p-isopropyltoluene (51.8 - 9,530 μg/kg);
- n-butylbenzene (26.2 - 4,620 μg/kg);
- naphthalene (10.7 - 8,580 μg/kg); and
- 2-butanone (89.8 μg/kg).

Acetone and methylene chloride also were detected in many of the samples and in many, but not all, of the laboratory blanks. Concentrations in the samples and blanks, where detected, were similar and these are common laboratory contaminants. Although not always flagged "B", their occurrence is judged to be attributable to laboratory contamination.

Previous investigations by Walk, Haydel and Associates (1987) suggest the presence of volatile organic compounds to depths greater than 100 feet in proximity to SWMU No. 110 (Appendix A). However, this analytical also indicated the presence of volatile organic compounds in the drilling mud at concentrations generally consistent with the field data, which questions the validity of the field data obtained. Data collected by Harza at soil boring SB12, drilled in proximity to SWMU No. 110, indicates that contamination by volatile organic compounds is limited to surface and near-surface soils (upper 20 feet).

Previous investigations by Woodward-Clyde Consultants (1991) indicates concentrations of ethylbenzene (19000 μg/kg) and xylene (4100 and 290000 μg/kg) in proximity to SWMU No. 109 at a depth of 4 to 6 feet in borings 1098 and 1097, respectively (Appendix A). Data obtained by Harza (1997) in this general area (boring SB01) also indicate detectable concentrations of ethylbenzene and xylene, but at lower detected concentrations.

5.4.2.2 Semi-Volatile Organic Compounds

like VOCs, semi-volatile organic compounds were detected only in boring SB01 (SWMU No. 109) and only two chemicals were found:naphthalene and 2-methylnaphthalene. Results of specific analytes in individual samples are summarized in Tables 5-5 through 5-13. Results with depth are plotted in vertical profiles in Figures 5-14 and 5-15.

Detection of naphthalene and 2-methylnaphthalene occurred in five instances, in soil boring SB01 at depths of 3 feet, 19 feet, 27 feet, 38 feet, and 42 feet. Detected concentrations in these samples ranged as follows: naphthalene (586 - 3,800 μg/kg) and 2-methylnaphthalene (3,500 - 11,700 μg/kg).

Di-n-butyl-phthalate also was detected in many of the samples and in many, but not all, of the laboratory blanks. Concentrations in the samples and blanks, where detected, were similar and this is a common laboratory contaminant. Although not always flagged "B", its occurrence is judged to be attributable to laboratory contamination.

5.4.2.3 Cyanide

Cyanide was not detected in any sample analyzed as part of this RFI.

5.4.2.4 Total Recoverable Petroleum Hydrocarbons

Laboratory analytical data indicates that TRPH was detected in all nineteen (19) soil borings drilled as part of this RFI. Detected concentrations of TRPHs in individual samples are

summarized in Tables 5-5 through 5-13. TRPH results with depth in the borings are plotted in Figures 5-16 and 5-17.

The highest concentrations of TRPHs were detected in borings drilled near SWMU No. 109 (SB01, SB19, SB04, and SB11) and SWMU No. 111/112 (SB14). The highest concentrations were detected in boring SB01 at a depth of 19 feet (5,560 mg/kg), boring SB19 at a depth of 4 feet (1,530 mg/kg), boring SB04 in the surface sample (3,270 mg/kg), boring SB11 in the surface sample (14,400 mg/kg), and boring SB14 in the surface sample (1,040 mg/kg).

Detected concentrations of TRPHs generally decrease rapidly with depth, with the highest relative concentration in each boring detected in surficial or near-surface samples (within the upper 4 feet). This is seen in all borings with exception of boring SB01 where the highest detected concentration of TRPHs was detected at a depth of 19 feet and concentrations greater than 1,000 mg/kg were detected to a depth of 42 feet.

Previous investigations by Woodward-Clyde Consultants (1991) indicates detectable concentrations of TRPHs in proximity to SWMU No. 111/112 at a depth of 0-0.5 feet (27.3 mg/kg) in boring 1091 and at a depth of 5-7 feet (56.6 mg/kg) in boring 1095 (Appendix A and Figure 5-9). This data is comparable with data obtained by Harza during this RFI in soil boring SB14. Data obtained by Woodward-Clyde Consultants (1991) also indicates detectable concentrations of TRPHs near SWMU No. 109 in soil borings 1093, 1097, 1094, and 1098 (Appendix A and Figure 5-4). This data is comparable with data obtained by Harza during this RFI, although detected concentrations of TRPHs in soil boring SB01 are lower than detected concentrations in borings 1093, 1097, 1094, and 1098.

As discussed before, the field immunoassay screening was intended to guide the terminal depths for the soil borings. Because the field immuniassay screening could only determine wether TPH concentration in a sample is greater or less than 10 mg/kg, a quantitative comparison between the immuniassay data and the fixed lab data for TRPHs is not possible. Nerverthless, the immuniassay results for TRPHs still provide useful information on whether additional samples should be taken to define the extent of contamination, if the screening test results correlate with the confirmation results from fixed lab. A comparison between the screening results and the fixed lab for TRPHs at each of the sampling locations at FTA4 is presented in Table 5-16. It should be noted that the method detection limit (MDL) for TPH from the fixed lab was about 16.5 mg/kg and that of immuniassay screenng method was 10 mg/kg. As shown in the table, there is a positive correlation between the results. Those samples that had nondetectable TPH (i.e., < 10 mg/kg) by the immuniassay method also showed nondetects by the fixed lab (< 16.5 mg/kg). Conversely, those samples containing detectable TRPHs by the immuniassays also had relatively high levels of TRPHs. Briefly, detectable concentrations (greater than 10 ppm) TRPHs were found in soil borings SB01 and SB12. In boring SB01, TRPHs were detected to a depth of 65 feet. Samples collected from boring SB01 from depths of 65 feet and 73 feet indicated non-detectable concentrations (less than 10 ppm). In boring SB12, TRPHs were detected at a depth of 10 feet. Samples collected from boring SB12 at a depth of 2 feet, 21 feet, and 31 feet indicated non-detectable concentrations. TRPHs were not detected in any other sample using field

immunoassay screening methods. Comparison of the field immunoassay screening data with laboratory analytical data indicates a positive qualitative correlation.

5.4.2.5 Target Analyte List Metals

Analytical results indicated detectable concentrations of target analyte list metals in each of the nineteen (19) soil borings drilled as part of this RFI. Where detected, concentrations of individual compounds ranged as follows:

- aluminum (1,230 - 9,990 mg/kg);
- antimony (2.3 - 6.2 mg/kg);
- arsenic (0.6-3.3 mg/kg);
- barium (15.3 - 1,250 mg/kg);
- beryllium (0.15 - 0.74 mg/kg);
- calcium (1,680 - 253,000 mg/kg);
- chromium (2.2 - 20.9 mg/kg);
- cobalt (1.1 - 5.4 mg/kg);
- copper (1.1 - 8.4 mg/kg);
- iron (1,830 - 10,700 mg/kg);
- lead (0.91 - 21.5 mg/kg);
- magnesium (702 - 5,300 mg/kg);
- manganese (18.8 - 1,350 mg/kg);
- nickel (2.9 mg/kg - 10.7 mg/kg);
- potassium (285 - 2,360 mg/kg);
- selenium (0.067 - 0.69);
- sodium (51.3 - 860 mg/kg);
- thallium (0.12 mg/kg);
- vanadium (4.2 - 24.7 mg/kg); and
- zinc (4.5 - 27.6 mg/kg)

The detected concentration range for individual borings is presented in Tables 5-5 through 5-13.

The results for metal analysis in surface and subsurface soil samples indicate that there is generally a trend of decreasing concentration with depth. This trend is noticeable in all soil borings for most of the metals analyzed (i.e. aluminum, beryllium, chromium, cobalt, copper, lead, manganese, vanadium, zinc) and is especially evident in soil borings sampled to greater depths (i.e. SB01, SB17, SB18, SB19). Occasionally, concentrations of a few metals (i.e. magnesium and sodium) increase at depth below the ground surface, reversing the trend of decreasing concentration with depth. Such trend changes may result in variations in stratigraphy (e.g., the presence of caliche, variations in clay content) where soil chemisty would be expected to change.

A comparison of the detected metals with regional and Cannon AFB background concentration ranges (Table 5-15) indicate that eleven (11) different metals were detected at concentrations which are not within the estimated background concentration range at Cannon AFB. The following

metals had detected concentrations not within the background concentration range for Cannon AFB soils: barium, beryllium, calcium, chromium, cobalt, iron, lead, manganese, nickel, silver, and zinc.

Of these, barium, beryllium, manganese, and zinc were identified as COPCs for human health or ecological risk assessment (see Sections 7.0 and 8.0). Therefore, concentrations of these four metals were plotted in vertical profile in Figures 5-18 through 5-25 to evaluate their vertical and lateral distribution. From these figures, most of these elevated metal concentrations occur at the ground surface or within soils with a high silt/clay content. The trend of decreasing concentrations at depth below the ground surface appears to coincide with the presence of soils with increased silt and clay content. Additionally, comparison of the detected concentrations for each of these eleven metals with the background concentration ranges indicates that, in general, the detected concentrations only marginally exceed background concentrations.

5.5 SUMMARY OF THE PSGS AND ANALYTICAL RESULTS

Figures 5-10 through 5-25 show the vertical distributions of total VOCs, BTEX, total SVOCs (BNAs), TPH, and metals that are of human health or ecological concern. VOCs that are above MRLs were only present in SB01, with total VOC concentrations ranging from 27.2 to 145,440 μg/kg, and to the depth of 65 ft. SVOCs were detected above the MRLs in borings SB01 and SB16. SVOCs were mainly present in SB01, having concentrations varying from 180.5 to 17,089 μg/kg to a depth about 80 ft. However, most of the SVOCs were found between the soil surface and 40 ft in boring SB01 and above 10 ft in boring 16. Similarly, BTEX were also detected only in SB01,with concentration ranging from 299.1 to 63,640 μg/kg. TRPHs were detected in all soil borings. However, high levels of TRPHs were only limited to SB01. Unlike the organics, metals were present in all soil borings.

The purpose of the PSGS was to identify "hot" spots and guide subsequent boring and sampling locations. The passive soil gas data and the data from the fixed laboratory (ARDL) are summarized in Tables 5-2 and 5-6 through 5-14, respectively. A good correlation between these two types of data would indicate that the soil gas data provided helpful information on selecting sampling locations that would effectively delineate the nature and extent of contamination. It is noted that: (1) comparison of PSGS data to fixed laboratory data is only applicable for the upper 3 feet, as the soil gas screening modules were buried at a depth of 30 inches; (2) Soil gas concentrations for a given chemical can be positively, but only qualitatively, related to that of the same chemicals on the solid phase of the soil (μg/kg); (3) only part of the VOCs and SVOCs that can be quantified by fixed lab could be identified and determined by the soil gas method and vice versa; and (4) the sampling locations for the passive soil gas and the fixed laboratory analysis were not exact the same. Therefore, only a qualitative comparison is possible.

With the above limitations in mind, the fixed laboratory data are, in general, consistent with the passive soil results and provided appropriate guidance in locating soil borings (Figure 5-26). The PSGS indicated that the highest relative concentrations of VOCs and diesel range organics in soil gas were located within and immediately adjacent to the fire training pit (SWMU No. 109) and

VOC concentrations generally decreased with lateral distance from the fire training pit. Soil borings were located accordingly, but also to explore other specific SWMUs and several anomolous areas identified by the PSGS. Subsequent fixed laboratory data identified SB01, located at the fire training pit, as the only significant area of soil contamination, in agreement with the PSGS. With respect to individual chemicals, PSGS results at SG14 and SG15 and results from fixed lab at soil boring location No. 1 (SB01) were shown in Figure 5-11. The soil gas data showed high concentrations of ethylbenzene, xylene, 1,2,4-trimethylebenzene, 1,3,5-trimethylebenzene, naphthalene, and 2-methylenaphalene. The concentrations of these chemicals were also high in the surface soil (first 3 ft) of SB01. It is noted, however, that the soil gas data also indicated relatively high concentrations of benzene, toluene, cis-1,2-dichloroethene, which were not detected in the fixed laboratory. Conversely, some of the organic chemicals that were detected in the fixed laboratory were not picked up by the soil gas technique. Most of the remaining sampling locations were shown to contain either nondetectable or low concentrations of VOCs and SVOCs by both soil gas and fixed lab methods, with few exceptions.

6.0 CONTAMINANT FATE AND TRANSPORT

6.0 CONTAMINANT FATE AND TRANSPORT

his section examines potential contaminant pathways and discusses the fate and transport of the chemicals of potential concern in site soils that were identified for the baseline risk assessment (Sections 7.0 and 8.0) at FTA4. The fate and transport discussion, along with nature and extent of contamination, provides a basis for detailed examination of pathways, a key component of the risk assessment.

This section reviews those potential pathways (e.g. air, surface water, groundwater) that may have relevance to FTA4. For each of the chemicals of potential concern, the physical and chemical properties are presented and their importance to transport mechanisms is discussed. Given the limited presence of the chemicals of potential concern, they are discussed as a whole for SWMU Nos. 109, 110, 111, and 112, and not for individual SWMUs or on a boring-specific basis. Chemicals of potential concern (COPCs) at FTA4 includes five semi-volatile organic compounds (benzo(a)pyrene, benzo(b)fluoranthene, fluoranthene, phenanthrene, and pyrene) and five metals (barium, beryllium, manganese, lead and zinc), as discussed in Sections 7.0 and 8.0.

6.1 POTENTIAL CONTAMINANT TRANSPORT MECHANISMS

Potential transport mechanisms identified for FTA4 include (1) volatilization of organics and movement within soil gas or the atmosphere, and wind transport of metals or organics both on- and off-site; (2) surface water runoff; (3) surface water infiltration to the water table and subsequent migration through groundwater flow. Each of these potential mechanisms is briefly discussed below.

6.1.1 Volatilization and Wind Transport

Air transport mechanisms include volatilization and wind transport. Volatilization is a process by which an organic compound is transferred from one media to another (e.g. soil into soil gas and/or the atmosphere). Volatilization will influence the migration of volatile organic compounds, however, it will have little impact on semi-volatile organic compounds and will not influence metals. Wind transport of metals and organic compounds can occur due to contaminants adsorbed to dust particles. Air transport could potentially modify concentrations of organic compounds, however, the extent to which such modification may occur is dependant on the physiochemical properties of the specific chemical.

As discussed in Section 2.3, dust is frequently present in the region. Exposure to fugitive dusts containing the COPCs via inhalation is a potential pathway to receptors who may be exposed to these chemicals. However, fugitive dust would not affect residents on the Cannon AFB, primarily because the prevailing winds go from west to east. More discussion is provided in Section 7. Since the organic COPCs identified at FTA4 are semivolatiles or metals, volatilization is not considered an significant transport mechnism. Despite of this, exposure to the semovolatile COPCs via inhalation was evaluated in the risk assessment.

6.1.2 Runoff, Infiltration, and Surface Water

Both organic and metal contaminants can be transported in surface water during period of precipitation via adsorption on sediments or in solution. The organic and metal contaminants transported in storm water runoff may be deposited elsewhere, infiltrate into the subsurface, be transported into a surface water body, or be lost to volatilization (organic compounds only). The extent to which the COPCs may be adsorbed, placed into solution, or lost to the atmosphere will depend on their particular physiochemical properties.

The dominant surface water features in the vicinity of Cannon AFB are small temporal lake basins known as playas. A playa located near the southwest corner of Cannon AFB collects the majority of stormwater runoff from the base. The wastewater lagoons and associated playa lake, located approximately 5,000 feet north of FTA4, represent the only permanent surface water feature at Cannon AFB. The playas have no surface water outlets, and any water they collect is eventually lost to evaporation or infiltration. The mean annual precipitation at the site is approximately 15 inches per year, most of which falls during the summer months. The mean annual lake evaporation rate is 69 inches per year.

Because there are no permanant surface water bodies at FTA4, exposure to surface water does not constitute a pathway.

6.1.3 Groundwater Flow

Dissolution of organics and metals through the leaching of infiltrating surface water originating from precipitation is a means by which contaminants can enter groundwater. In the near-surface, the extent to which contaminants can migrate through surface water infiltration is dependant upon their physiochemical properties and the subsurface soil conditions.

The lower portion of the Ogallala Formation is the primary regional aquifer for both potable and irrigation water. The Ogallala Aquifer consists of gravels, sands, silts, and clays which vary in thickness from 360 to 415 feet in thickness at Cannon AFB. The Ogallala Aquifer is an unconfined aquifer which has a saturated thickness of about 95 to 145 feet, influenced by the configuration of an underlying erosional unconformity. According to Lee Wan and Associates (1990), five zones have been identified within the Ogallala of east central New Mexico on the basis of clay minerals. Smectites and attapulgite (with sepeolite) are the dominant clays throughout the Ogallala. Clays such as smectite and, to a lesser extent, attapulgite and illite, are soil constituents with moderate to high CECs. This indicates that the formation has a high adsorbing capacity for ionic contaminants (Bohn et al. 1985), prohibiting them from leaching to the groundwater.

The recharge rate of the Ogallala Aquifer is estimated to be as little as 1 inch per year. Due to the high evapotranspiration rate and low precipitation, recharge to the aquifer occurs during rain events in which the infiltration capacity of the soil is exceeded and runoff occurs, or during cool months when the precipitation exceeds evapotranspiration.

Based on the analytical data obtained at FTA4, the nature and extent of contamination discussion (Section 5.0), and the thickness of the unsaturated zone, it is judged that groundwater does not appear to be a pathway for contaminant transport.

6.2 PHYSICAL AND CHEMICAL PROPERTIES

This section provides a discussion of the physical and chemical properties of the COPCs as they relate to environmental fate and transport, including brief description of the relevance of these properties to principal transport processes (e.g. volatilization, aqueous solubility, adsorption and biodegradation) applicable to FTA4. It is important to note that other processes also exist which could contribute to contaminant mobility (e.g. hydrolysis, oxidation, reduction). However, it is judged that such processes, individually, are not as significant to the overall environmental fate of the identified COPCs as volatilization, aqueous solubility, adsorption and biodegradation.

6.2.1 Volatilization

Volatilization affects the persistence of an organic compound by governing the rate at which it may be transferred to a gaseous phase. Volatilization is a complex process that is dependant on numerous factors including a chemicals solubility and vapor pressure. The rate at which organics are influenced by this process is best represented by Henry's Law constant. The greater the Henry's law constant of a compound, the greater will be the tendency of the compound to volatilize from an aqueous solution. Henry's Law constant values greater than 10^{-3} atm-m^3/mole (cubic meters of atmosphere per mole) can be expected to volatilize rapidly from water while those values less than 10^{-7} atm-m^3/mole are less volatile than water and will tend to concentrate in water as it evaporates (Lyman et al. 1990). The Henry's Law constants for each of the organic chemicals of potential COPCs are less than 10^{-3} atm-m^3/mole (Table 6-1) and are, therefore, not considered to be highly volatile. It should be noted that moisture content, temperature and atmospheric conditions (i.e. wind speed and sunlight) may also influence the rate of volatilization from soil.

6.2.2 Aqueous Solubility

Solubility governs the extent to which a contaminant will partition into the aqueous phase. For metals in solution, their solubility is controlled by a number of complex factors (e.g redox potential-pH relationships, number and concentrations of ion complexes, major ion chemistry) whose collection and/or calculation were beyond the scope of this investigation. For organic compounds, the octanol/water partition coefficient (K_{ow}) provides an indication of the extent to which a contaminant will be adsorbed in the subsurface. The octanol/water partition coefficient is the ratio of a chemical's concentration in the octanol phase to its concentration in an aqueous phase. Greater K_{ow} values indicate lower dissolution and lower solubility and therefore would have a tendency to be adsorbed. According to Lyman et al. (1990), log K_{ow} values greater than 4.0 indicate that the organic chemical is very hydrophobic and would have a low aqueous solubility, hence would be considered to be less mobile. The log K_{ow} values for each of the

organic COPCs are greater than 4.0 (Table 6-1), and are, therefore, considered to have a low mobility.

6.2.3 Adsorption

Adsorption governs the mobility of both metals and organics and is a function of several parameters. For metals, mobility is directly affected by the extent of fixation, positive and negative adsorption, exclusion, complex formation, and by reaction kinetics (Dragun 1988), which in turn are influenced by the physiochemical properties of a given soil. Although the evaluation of these factors were beyond the scope of this investigation, adsorption of metals is often referred to in terms of the soil-water distribution coefficient (K_d). The soil-water distribution coefficient is defined as the ratio of concentrations adsorbed on soil surfaces to the concentration in water. Compounds with K_d values greater than 10 are considered to be immobile, between 2 and 10 have a low mobility, between 0.5 and 2 have an intermediate mobility, between 0.1 and 0.5 are considered to be mobile, and less than 0.1 are considered to be highly mobile (Dragun, 1988).

For organics, K_d has been strongly correlated with the fraction of total organic carbon present in a soil, and has been termed as the organic carbon partition coefficient (K_{oc}). K_{oc} is defined as the ration of K_d with the fraction of total organic carbon in a soil. K_{oc} is expressed as the ratio of the amount of chemical adsorbed per unit weight of organic carbon to the chemical concentration in solution at equilibrium. The normal range of K_{oc} values is between 1 to 10^7, with higher values indicating greater sorption potential (USEPA 1986). In general, semi-volatile organic compounds show relatively high K_{oc} values, indicative of chemicals with high sorption potential. For the organic COPCs at FTA4, K_{oc} values for benzo(a)pyrene and benzo(b)fluoranthene indicate high sorption potential, while K_{oc} values for fluoranthene, phenanthrene, and pyrene indicate moderate sorption potential.

6.2.4 Biodegradation

Microbial metabolism is the major process by which organic degradation in soil environments occurs. Efficient microbial metabolism converts organic materials into energy with by-products of carbon dioxide, methane, water, inorganic salts, and biomass. The rate and extent of biodegradation of compounds in soils may be affected by soil environment, characteristics of microbial population, and the physiochemical properties of the chemicals of concerns.

Environmental factors that may influence the rate of biodegradation in soil includes temperature, nutrient availability, oxygen concentration, moisture, pH, availability of electron acceptors, and contaminant bioavailability. In general, soil microbes most suited to biodegradation prefer aerobic environments, temperature between 50 and 104°F, adequate supplies of nitrogen and phosphorus, pH between 6 and 8.5, electron acceptors such as carbon dioxide, sulfate, nitrate, and oxygen, and adequate soil moisture. Natural biodegradation will occur under many environmental conditions, requiring only nutrients and electron acceptors; but, without ideal conditions, the rate of degradation is many times slower.

Microorganisms can catalyze a wide range of oxidation, reduction, and methylation reactions involving metals. These reactions can result in mobilization, immobilization, or volatilization of metals; but, they do not destroy the metals (Ward et al. 1995). At neutral to alkaline pH, heavy metals in soils and sediments tend to be immobilized by precipitation and/or adsorption to cation exchange sites of clay minerals. Microbial production of acid and chelating agents can reverse this adsorption and mobilize the toxic metals (Atlas and Bartha 1993). Following release, select microbial populations and plants can uptake the heavy metals. Select plants and microbes can uptake metals above background concentrations and above nutrient requirement; but, for plants, leaching during non-growing seasons causes any uptake to be short-term. In general though, high levels of heavy metals have toxic effects on plants and microorganisms and any reduction in heavy metal concentrations is generally short-term.

7.0 HUMAN HEALTH EVALUATION

7.0 HUMAN HEALTH EVALUATION

7.1 INTRODUCTION

This Human Health Risk Assessment was undertaken to assess the potential adverse human health effects that could occur due to exposure to site contaminants at FTA4, in the event no action is taken to remove contaminants and/or prevent their migration. The assessment was prepared in accordance with the Risk Assessment Guidance for Superfund (RAGS), Volume 2, Human Health Evaluation (USEPA 1989) and the risk assessment requirements specified in the USACE Scope of Services (USACE 1996). To perform the risk assessment, all available data generated during field investigations were reviewed to develop a Conceptual Site Model (CSM). The CSM identifies the current and potential future pathways through which human exposure to site-related contaminants could occur. A screening analysis was then performed to identify site-related Chemicals of Potential Concern (COPCs) to human health. In the screening analysis, analytical data developed in the field investigations were compared to both Cannon AFB background concentrations and EPA Region 6 Human Health Media-Specific Screening Levels (MSSLs) (1996). Note that for exposures to soils, EPA Region 6 MSSLs consider incidental ingestion, inhalation, and dermal contact and are therefore more conservative than the Soil Screening Levels developed by USEPA (1996). Assumptions used in calculating MSSLs are generic (i.e., non site-specific). MSSLs for Class A and B carcinogens were calculated at the risk level of 10^{-6} and MSSLs for Class C carcinogens were calculated at the risk level of 10^{-5}. The MSSLs for individual non-carcinogens was calculated using a Hazard Quotient of 1. Consider that multiple chemicals are present at the site, one-tenth of the MSSLs was used in the screening of noncarcinogens. Chemicals detected at levels in excess of both background and MSSLs were identified as COPCs and evaluated in the risk assessment.

7.2 CHEMICALS OF POTENTIAL CONCERN

7.2.1 Data Evaluation and Treatment

Prior to use, all analytical data generated during this RFI were validated and evaluated in accordance with the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 1994a) and USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (USEPA 1994b) to insure the data to have sufficient quality for risk assessment. Details on data quality and evaluation are described in the Quality Control Summary Report (Harza, June 30, 1997). Data were treated following the USEPA's Guidance for Data Usability in Risk Assessment (1992). Briefly, all positively reported data, including those flagged with "J" qualifiers, were used as reported. One-half of the MDL was used as the exposure point concentration in the risk assessment for those COPCs that were reported as nondetects and that had at least one detection in a medium.

7.2.2 Identification of Chemicals of Potential Concern

Metals are naturally occurring elements in soil. To determine whether metals detected in site soils are of potential concern, the concentrations of detected metals were screened against Cannon AFB background concentrations and EPA Region 6 MSSLs. Although future residential development at this site is unlikely, residential MSSLs were used to preserve the conservative nature of risk assessment. In addition, one-tenth of the MSSLs was used in the screening of noncarcinogens to compensate for the mixed effects. Note that the EPA Region 6 MSSLs for soil differs from USEPA or other Regional USEPA risk-based concentrations or preliminary remediation goals in that they consider all three plausible exposure pathways associated with soil exposure: ingestion, inhalation, and dermal contact and, therefore, are more conservative. The result of the screening is a list of COPCs at the site for each exposure media identified in the CSM. Only those inoranic chemicals that exceed both the background and the MSSLs were retained as COPCs and evaluated in the risk assessment.

The background comparison for inorganics was based on the 95th percentile calculated from a set of data for the Target Analyte List (TAL) metals collected in the vicinity of Cannon AFB by Woodward-Clyde, Radian, and Walk, Haydel, and Associates (Woodward-Clyde Consultants 1994). To ensure the conservative nature of risk assessment, these data were assumed to be lognormally distributed. The result of the data screening against background concentrations is presented in Table 7-1. As indicated in Table 7-1, all TAL metals were detected, except mercury and cadmium and most of the detected metals exceeded their background levels. However, the frequencies of exceedance for these metals were low (fewer than 10 of 77), indicating that metal concentrations at FTA4 are generally consistent with the background levels.

Table 7-2 summarizes the results of the screening against both the background and the EPA Region 6 MSSLs for inorganics. Results of this screening indicate the following:

- Barium, berylium, and manganese levels are above both the backgrounds and their respective MSSLs in at least one sample. These metals are therefore considered inorganic COPCs. Note that beryllium is exceeded in only one of 77 samples. However, since beryllium is considered a carcinogen, this chemical is retained as a COPC.

- Manganese is retained as a COPC because of its toxicity. According to EPA (IRIS 1997), managanese is a ubiquitous element that is essential for all animal species. Both deficiencies and excess intake of manganese can result in several diseases. According to the Estimated Safe and Adequate Daily Dietary Intakes (National Research Council 1989), the Daily Recommended Allowances (DRAs) for men or women are 2 to 5 mg/day. These rates are many times greater than that in the worst case scenario that could possibly occur at the FTA4 (200 mg/day x 1350 mg/kg = 0.27 mg/day, where 200mg/day is the ingestion rate and 1350 mg/kg is the highest concentration of manganese). Depite this factor, manganese is retained as a COPC and evaluated in the risk assessment.

- Iron is exceeded in 7 of the 77 samples. However, iron is an essential nutrient for humans and is not generally considered a harmful element. The DRAs for iron for men or women are 10 to 15 mg/day (National Research Council 1989). Intake of iron under the worst exposure scenario at the FTA4 is 2.14 mg/day (200 mg/day x 10,700 mg/kg = 2.14 mg/day, where 200 mg/day is ingestion rate and 10,700 mg/kg is the highest iron concentration at the FTA4). For this reason, iron was not selected as a COPC.

- Aluminum levels are exceeded in one of the 77 samples. However, because the exceedence is only marginal and because there no spatial pattern that indicates that this chemical is site-related, it is not retained as a COPC.

Tables 7-3 summarizes the results of the screening against the EPA Region 6 MSSLs for organics Results of this screening indicates that only benzo(a)pyrene and benzo(b)fluoranthene exceed the EPA Region 6 MSSL levels and are therefore identified as organic COPCs.

Chemicals that were detected at Fire Training Area No.4 that were not eliminated using the above criteria were retained as COPCs. Based on the screening, benzo(a)pyrene, benzo(b)fluoranthene, barium, beryllium, and manganese are identified as COPCs and were evaluated in this risk assessment. Note that following the risk assessment, any COPCs that show a cancer risk greater than 10^{-6} or HQ of 1 will be identified as Chemical of Concern (COC).

7.3 EXPOSURE ASSESSMENT

The objective of the exposure assessment is to identify human receptors that are potentially exposed to site chemicals, the manner by which an exposure occurs or is likely to occur, and the amount of the chemical intake resulting from such exposures, if any. To meet the objectives, the exposure assessment identifies populations that are likely to be exposed to site chemicals, the various media in which chemicals are found or transported, the location where exposure occurs, and the estimated magnitude, frequency, and duration of exposure. Both current and future exposure scenarios are considered herein.

7.3.1 Characterization of Exposure Setting

The physical setting at Cannon AFB was discussed in Section 2.0 of this report and includes available information regarding physical geography, climatology/meteorology, geology, vegetation, soils, groundwater hydrology, surface water hydrology, land use and demography, and ecology for Cannon AFB and surrounding areas.

The only residents living in the vicinity of FTA4 are military personnel and their dependents, a population of approximately 3,800 (USAF 1991). This population is, however, unlikely to be exposed to the contaminants at the FTA4. This conclusion is supported by the following factors:

- No contaminants from the FTA4 are present at these housing units. As indicated in Figure 3-1, these housing units are located on the northwestern portion of the Base, whereas the Fire Training Area No.4 is located on the southeastern portion of the Base. The closest housing units are about 8,000 feet from FTA4.

- No transport mechnisms are available to carry the contaminants from the FTA4 to the housing units. Since the COPCs at FTA4 are mainly found in soils, the only potential transport mechnisms are surface runoff and windblown via fugitive dusts. However, as discussed in Section 2, the Base is situated in the Llano Estacado subprovince with a slope of 10 to 15 ft per mile to the east and southeast. Runoff does not normally go from th Fire Traning Area No. 4 to the housing units. A playa located near the southwest corner of the Base collects the majority of the stormwater runoff from the Base. The prevailing winds at the Base are from west to east. This prevents dusts containing contaminants from transporting to the house units. Moreover, most of the FTA4 is not directly exposed, as they are covered with asphalt-like materials. This further reduces fugitive dust transport via wind.

FTA4 is currently inactive and remains the property of the U.S. Government. No information is available which suggests or indicates that this status will change. Therefore, populations that may be exposed to site contaminants are considered to be:

- Military personnel
- Construction workers
- Visitors and Trespassers
- Military personnel with construction activities

The last category of population refers to those military personnel who are also engaged in construction activities, in addition to their routine activities. In this case, the total exposure would be the sum of the Military Personnel and the Construction Worker.

The human health risk assessment for FTA4 did not include evaluation of exposure under a potential future residential land use scenario for the following reasons: a) FTA4 is part of an actively managed industrial property situated adjacent to an active runway. U. S. EPA guidance on future land use (Land Use in the CERCLA Remedy Selection Process, OSWER Directive No. 9355.7-04, 1995) states that consideration of non-residential land use is likely to be appropriate for such properties. b) CAFB has identified potential future land use of FTA4 based on evaluation of physical constraints, restrictions imposed by the airfield, and compatibility with the development of communities surrounding the base. The Commander's Long Range Facility Improvement Plan for CAFB, dated September 8, 1993, identifies future use of FTA4 as Airfield Clearance Zone. The Chief of Engineering for CAFB indicates there are no plans to change this usage. Figure 2-5 (Future Land Use) in the CAFB Management Action Plan, dated January 1996, identifies FTA4 as "open space" and not part of any future development. Therefore, future residential development of FTA4 is not a potentially reasonable scenario. CAFB is expected to continue to operate as a military facility. The Base Realignment and Closure (BRAC) will

reevaluate potential land use scenarios in the unlikely event CAFB should close. At that time, CAFB will evaluate exposure under a residential land use scenario before the property is released for transfer or lease.

7.3.2 Identification of Potential Exposure Pathways

An exposure pathway describes the course a chemical takes from the source to the receptor and is defined by four elements: 1) A source and mechanism of release; 2) An environmental transport medium; 3) A point of potential exposure with the contaminated medium; and 4) A route of exposure at the exposure point. When all these elements are present, a pathway is considered complete. Only complete exposure pathways are selected for evaluation in a risk assessment.

At FTA4, surface and subsurface soils have been impacted as a result of fire fighting training and related activities. Plausible exposure pathways associated with soil include incidental ingestion, inhalation of volatiles, inhalation of fugitive dusts, and dermal contact. According to USEPA (1996, page 20), exposure via dermal contact is insignificant compared with ingestion, therefore was not evaluated in this risk assessment. Incidental ingestion of soil particles and inhalation of volatiles and fugitive dusts are therefore the primary soil exposure pathways.

Groundwater beneath Cannon AFB is potable and used for domestic purposes both on and off the base. Therefore, exposure to groundwater by current and future residents is possible. However, the Ogallala Aquifer is approximately 270 feet deep and groundwater monitoring well data elsewhere at Cannon AFB has revealed no aquifer contamination. Of the two organic COPCs, benzo(b)fluoranthene was found in only one soil sample, at the ground surface. The maximum depth where the other organic COPC, benzo(a)pyrene, was found is 59 feet. Only 2 of the 77 samples exceeded the EPA Region 6 MSSL level in soil for this chemical and the detected concentrations were below the method reporting limits. Moreover, based on their log K_{oc} values (Table 6-1), both benzo(a)pyrene and benzo(b)fluoranthene are highly immobile. The other three COPCs (barium, beryllium, and manganese) are all metals. Because these metals are strongly retained by soil constituents (Bohn et al. 1985) and the annual precipitation at the Cannon AFB is low, the migration potential of these metal contaminants is considered very low. Finally, the local geology/hydrogeology (which includes clay and caliche layers) appear to be protective of groundwater, and a groundwater monitoring program is in place and expected to continue at nearby Landfill No. 5 downgradient from FTA4. Taken all these factors together, it was judged that the groundwater exposure pathway is not complete at the FTA4 and was not evaluated in the risk assessment.

There are no permanent surface water features at Cannon AFB other than the wastewater lagoons and the associated playa lakes (USAF 1990). Because of the low precipitation and much greater evaporation rates in the area, these lagoons and playas are filled infrequently. Standing water, when present, infiltrate rapidly into the sandy soils. However, infiltration occurs infrequently, generally in the winter months when precipitation exceeds evapotranspiration. The lack of permanent surface water bodies indicates that exposure to the surface water pathway is not complete. Surface water pathway was therefore not evaluated in the risk assessment.

Based on the above, a conceptual site model of potential human exposures to site contaminants was developed and is presented in Figure 7-1. Individuals potentially exposed to site-related contaminants include site military personnel, construction workers, and visitor and trespassers. Since the land use is not expected to change in the future, the future receptors will be the same as current receptors. The principle current and/or potential future exposure pathways are considered to include the following:

- Incidental ingestion of contaminated surface soils by current and future military personnel and visitors, future construction workers, and trespassers.
- Inhalation of volatile and fugitive dusts from surface soils by current and future military personnel and visitors, future construction workers, and trespassers.
- Incidental ingestion of contaminated subsurface soils by future construction workers.
- Inhalation of volatile and fugitive dusts from subsurface soils by future construction workers.

Currently, FTA4 is inactive and is not used for any specific purpose. Access to the site is very limited as Cannon AFB is securely guarded. Furthermore, most of FTA4 is covered by asphalt-like materials, which prevent direct exposure to the soil. Exposure to the surface soil is therefore negligible. However, to preserve the conservative nature of risk assessment, the following assumptions are made with respect to exposure pathways:

- The surface soil is exposed as if it was not covered by asphalt-like materials.
- Visitors/trespassers can freely enter the site without any restrictions.
- Military personnel visit and spend one half hour each day at the site, 250 days a year for 30 years. Since a normal working day is 8 hours, half hour is equivalent to 15.6 days per year.
- Construction workers will work at the site 45 days for one year. This exposure pathway does not exist under current condition as there are no construction activities taking place at Fire Training Area No. 4. This pathway is postulated for the future construction/excavation workers.
- Visitors and trespassers visit the site 50 days a year for 30 years. There are no standard or regulated exposure frequency or exposure duration for these receptors. This assumption is considered very conservative, since Cannon AFB is an active and secured Air Force Base.

The exposure frequency assumed for military personnel is consistent with EPA guidance on values

for exposure parameters (Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure, 1993). Military personnel are expected to be exposed to contaminated media at FTA4 as part of occupational exposure. EPA (1993) lists an exposure frequency of 250 days per year for non-contact adult occupational exposure. EPA (1993) suggests that adjustments to such parameter values could be made based on site-specific behavioral or meteorological conditions. FTA4 is a unique area because routine activities are not conducted and are not expected to be conducted due to its proximity to an active runway. Although military personnel do not currently visit FTA4 regularly or are expected to do so in the future, as a conservative estimate, it was assumed they will spend one half hour each day at FTA4. The exposure frequency of 15.6 days per year was estimated based on 250 days per year exposure at one half hour each day, instead of the normal 8 hour day for occupational exposure.

The Department of Defense, Air Force, or U. S. EPA do not have a default exposure frequency for construction workers. FTA4 measures about 5 acres. Construction workers are expected to be exposed to contaminated soil only during initial soil handling activities. A conservative estimate of 45 days of exposure was assumed for such initial soil handling.

U. S. EPA does not have a default exposure frequency for trespassers. U. S. EPA (Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors, OSWER Directive 9285.0-03, 1991), states that because not all sites provide the same opportunities, recreational scenarios (which often includes the "trespasser" or "site visitor" scenario) must be developed on a site-specific basis. Because FTA4 is located within a restricted military facility, a relatively low exposure frequency of 50 days per year was assumed for this risk assessment.

7.4 TOXICITY ASSESSMENT

The purpose of toxicity assessment is to compile toxicity and carcinogenicity data for the COPCs and to provide quantitative indices of toxicity necessary to calculate potential risk in the risk characterization. The following sections present the quantitative indices of toxicity to be used in estimating the relationship between the extent of exposure to a contaminant and the potential increased likelihood and/or severity of adverse effects. The quantitative indices differ between carcinogens and non-carcinogens as well as the methodology used for developing the indices. Each is therefore addressed separately.

7.4.1 Dose-Response Evaluation

Chemicals are classified as potential carcinogens or noncarcinogens because the dose-response relationships for carcinogenic and noncarcinogenic effects are different and require different assessment approaches. The dose-relationship between noncarcinogenic effect generally exhibits a threshold dose below which no adverse effects occur, whereas no threshold doses have shown to exist for most carcinogenic effects.

7.4.2 Health Effects Criteria and Assessment, Carcinogens

For chemicals exhibiting potential carcinogenic effects, USEPA's Carcinogenic Assessment Group has estimated the excess lifetime cancer risks associated with various levels of exposure to potential human carcinogens by developing cancer slope factors (SFs). SFs are expressed in terms of reciprocal dose, as units of $(mg/kg\text{-}day)^{-1}$, which indicates the dose representing a potential risk of 1 in 1,000,000. The SFs are generally derived using conservative (health protective) assumptions. Cancer SFs developed by USEPA were used in this risk assessment. The toxicity values for potential carcinogenic effects of the COPCs are listed in Table 7-4.

As indicated in Table 7-4, USEPA has developed a weight-of-evidence classifications for potential carcinogens. The weight-of-evidence classification is an attempt to determine the likelihood that an agent is a human carcinogen; the classification thus affects the likelihood that an agent will induce cancer in humans but it does not impact numerical potency or the estimation of risk. The classification of carcinogenicity relies on the overall evidence as follows:

- Human carcinogens (Group A chemicals) are agents for which there is sufficient evidence to support the causal association between exposure to the agents in humans and cancer.

- Probable Human carcinogens (Group B1 and B2) are agents for which there is limited (B1) or inadequate (B2) evidence of carcinogencity from human studies. Group B2 chemicals also may be agents which have sufficient evidence of carcinogencity from animal studies.

- Possible human carcinogens (Group C) are agents for which there is limited evidence of carcinogenicity in animals.

- Not classified as to human carcinogen (Group D) are agents with inadequate human and animal evidence of carcinogencity or for which no data are available.

- Non human carcinogen (Group E) are agents for which there is no evidence of carcinogencity in adequate human or animal studies.

According to this classification scheme, beryllium, benzo(a)pyrene, and benzo(b)fluoranthene are considered group B2 carcinogens.

EPA has developed several mathematical models to estimate low-dose carcinogenic risk from observed high dose risks. Consistent with current theories of carcinogens, EPA has selected the linearized multistage model based on prudent public health policies. In addition to using multistage mode, EPA uses the 95%UCL of the slope of the dose-response curve from high-dose animal or human studies to estimate low-dose SFs. Using SFs, lifetime excess cancer risks can be estimated by:

$$\text{Risk} = \Sigma \text{ADIj x SFj}$$

where ADIj is exposure route-specific lifetime average daily intake and SFj is route-specific slope factor. Using the multistage model, the carcinogenic risks for the oral, dermal, and inhalation routes of exposure are calculated as follows:

$$\text{Risk} = \text{ADIo x SFo} + \text{ADId x SFd} + \text{ADIi x SFi}$$

where subscript "o", "d", and "i" indicate the oral, dermal, and inhalation routes of exposure route, respectively.

Carcinogenic potency can also be expressed as the concentration of a chemical in an exposure medium such as air or water that is associated with a specific risk level. EPA prefers to express cancer potencies for inhalation exposure in this way and uses an unit risk (UR), as the reference risk level. Using the URs, the lifetime excess cancer risk associated with a particular concentration in air or water can be estimated by:

$$\text{Risk} = \text{EPC/UR}$$

where EPC is exposure point concentration. URs are expressed in $\mu g/m^3$ of air for inhalation exposure and $\mu g/L$ for ingestion of water. Inhalation URs are based on continuous exposure 24 hr/day whereas oral URs of water are based on consumption of 2 L/day by a 70-kg adult.

For this risk assessment, the inhalation route URs reported in USEPA's Integrated Risk Information System (IRIS) were converted to SFi for use with the standard exposure and risk estimation equations given in RAGS (EPA 1989) using the following equation:

$$SF_i = \frac{UR(\mu g/m^3)\ X\ 70kg\ X\ 1000\mu g/mg}{20m^3/day}$$

7.4.3 Health Effects Criteria and Assessment, Noncarcinogens

Health effects for chemicals exhibiting noncarcinogenic effects are generally developed using reference doses (RfDs). The RfD is an estimate of the daily exposure to the human population that is likely to be without an appreciable risk during a lifetime. The uncertainty associated with the RfD is at least one order of magnitude and may be as high as several orders of magnitude. RfDs are expressed in units of dose (mg/kg-day) and are developed by USEPA. Table 7-5 lists the RfDs for potential noncarcinogenic effects for beryllium by the oral route.

The RfDs are selected by identifying the lowest reliable no observed effect level (NOAEL) or lowest observed adverse effect level (LOAEL) in the scientific literature, then applying a suitable uncertainty factor (UF) and a modifying factor (MF), to allow for differences between the study conditions and the human exposure situation to which the RfDs are to be applied.

The potential for adverse health effects other than cancer is usually assessed by calculating a hazard quotient (HQ), which is the ratio of the estimated exposure to the RfD as follows:

$$HQ = \frac{ADI}{RfD}$$

HQs for chemicals causing the same type of adverse effect are summed to give a hazard index (HI). A HQ or HI greater than 1 indicates that adverse effects may be possible. The critical noncarcinogenic effects for COPCs at FTA4 area all different; therefore, HQs were not summed for all chemicals in this risk assessment.

Exposure to some chemicals may result in both carcinogenic and noncarcinogenic effects. In these cases, both the carcinogenic and noncarcinogenic effects were evaluated and considered in the risk assessment process. The four COPCs identified at FTA4 are all classified carcinogens and were evaluated for their cancer effects. Beryllium also exhibits noncarcinogenic effects. Therefore, this COPC was evaluated as both a carcinogen and noncarcinogen.

7.5 RISK CHARACTERIZATION

Risk characterization is the integration of an exposure assessment and toxicity assessment to estimate the relationship between the exposure and the potential increased likelihood and/or severity of adverse effects. Potential carcinogenic risk is assessed by multiplying the estimated ADI of a carcinogen by its estimated SF to obtain its cancer risk, which is expressed as a probability of that exposure resulting in an excess incidence of cancer. The excess cancer risk for exposure to each chemical by each route of exposure and categories of receptor is initially estimated separately. The risk estimates are then summed for all exposure routes and chemicals affecting the same organs to obtain total cancer risk for that population.

7.5.1 Estimation of Exposure Point Concentrations

Exposure Point Concentrations (EPCs) were estimated for surface and subsurface soil based on measured concentrations at the site from the soil borings. According to the RFI Work Plan (Harza 1996), FTA4 was to be evaluated as a whole. To calculate EPCs representative of Fire Training Area No.4, data were averaged across the entire site. Soil was divided into two exposure media: surface soil and subsurface soil. The EPC for surface soil was calculated by taking the average of the top 1 to 3 ft soil concentrations of the COPCs. Similarly, the EPC for the subsurface soil was determined by averaging the COPC concentrations in soil below 3 ft. According to RAGS (EPA 1989), the arithmetic mean and the 95% upper confidence limit (UCL) of the arithmetic mean should be used to characterize the average and Reasonable Maximum Exposure (RME) cases, respectively. Tables 7-9 through 7-12 show the average and 95%UCL COPC concentrations in both surface and subsurface soils.

7.5.2 Estimation of Average Daily Intake

The quantification of the COPC ADI is based on assumptions concerning the duration, frequency, and magnitude of exposure. The general equation for calculating ADIs for various exposure routes is (EPA 1989):

$$ADI\ (mg/kg\text{-}day) = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

where:

ADI	=	Chronic daily intake (mg/kg-day)
C	=	Chemical concentration in soil (mg/kg)
CR	=	Contact rate
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging time (days)

The specific parameters used to quantify chemical intakes are presented in Table 7-8. Most of the parameters are standard EPA assumptions and were taken from RAGS (EPA 1989).

Exposure to volatile chemicals is characterized by a volatilization factor (VF) and exposure to fugitive dust is measured by particulate emission factor (PEF). These factors are calculated using the new methodologies suggested by USEPA (1996). These methods replace those presented in the RAGS (EPA 1989) and are considered more reliable. The equations and parameters for each of these factors are presented in Tables 7-6 and 7-7.

Surface Soils

All three categories of potentially exposed populations identified can be exposed to surface soils. They may be exposed to surface soil through direct contact with, and subsequently incidental ingestion of, surface soil as well as the potential inhalation of volatiles and fugitive dust emissions from the soils. The ADI for these pathways is calculated using the following equation (EPA 1991):

$$ADI(mg/kg\text{-}day) = \frac{Cs \times EF \times ED \times [(IRs \times CF) + IRi \times (\frac{1}{VF} + \frac{1}{PEF})]}{BW \times AT}$$

where:

ADI	=	Chronic average daily intake (mg/kg-day)
Cs	=	Chemical concentration in soil (mg/kg)
IRs	=	Soil ingestion rate
IRi	=	Inhalation rate (m^3/L)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
CF	=	Conversion factor of 10^{-6} kg/mg
BW	=	Body weight (kg)
AT	=	Averaging time (days)
VF	=	Volatilization factor (m^3/kg)
PEF	=	Particulate emission factor (m^3/kg)

The values used to characterize each of the above parameters are presented in Table 7-8.

Subsurface Soil

Potential exposure to subsurface soils may occur to construction and/or excavation workers, who can be those military personnel engaged in construction or digging activities. The ADI for these workers is calculated based on the same equation as described for the surface soil exposure. Hence, exposure to subsurface soil considers both incidental ingestion of soil and inhalation of volatiles and fugitive particulate. The values for the construction/excavation scenario are assumed and are provided in Table 7-8.

7.5.3 Risk Characterization

Quantitative human risk estimates were derived by combining the estimates of chemical intake derived in the Exposure Assessment with the health effects criteria presented in the Toxicity Assessment. For potential carcinogenic chemicals, lifetime excess cancer risks are estimated by multiplying the cancer slope factor by the estimated daily chemical intake. Because the intake is assumed to occur by both inhalation and ingestion for some exposures, additivity of effects is assumed such that the total excess lifetime cancer risk for each chemical is obtained by summing the chemical specific risk estimated for both pathways as it relates to a specific medium. The estimated excess lifetime cancer risk estimates represent a high-end probability that an individual could contract cancer due to exposure to the potential carcinogen under the specified exposure conditions. A risk level of 10^{-6} represents a high end probability of 1 in 1,000,000.

For noncarcinogens, potential impacts are presented as the ratio of the daily intake to the RfD or HQ. Additivity of noncarcinogenic effects by each pathway, e.g., inhalation and ingestion, for a medium is also assumed for each chemical such that the risk is represented as the sum of the HQ. The HQ is useful as a reference point for gauging the potential effects of the environmental exposures to complex mixtures. A HQ greater than one suggests that human effects would be

possible if exposure occurred under the conditions evaluated in the assessment. In general, a HQ less than one is unlikely associated with any health risks.

Potential carcinogenic risks and noncarcinogenic hazards are estimated for each medium under exposure scenarios characterized in the CSM and under the assumptions used in calculating the ADIs. The methods for calculating the risks as an integration of the exposure assessment and toxicity assessment are provided in Table 7-8 for surface and subsurface soils. The physical and chemical parameters necessary to calculate the VFs and PEFs for the COPCs are provided in Tables 7-6 and 7-7. The risk characterization results are summarized below.

Military Personnel

This population is defined for this report to include military personnel stationed at Cannon AFB, but not engaged in construction or excavation activities. Military personnel are considered to be potentially exposed to surface soil only. The total risk is therefore the sum of risks resulting from incidental ingestion of soil particles and inhalation of volatiles and fugitive dusts. Tables 7-9 and 7-10 show the cancer and noncancer risks to the military personnel, respectively. No cancer risks of any of the COPCs exceeded the 10^{-6} level. Similarly, none of the COPCs has HQ greater than 1. Therefore, no COPCs are identified as COCs with respect to exposure to the site contaminants.

Construction Workers

Construction workers are exposed to both the surface soil and the subsurface soil. Tables 7-9 and 7-11 present the cancer risks to construction workers as a result of exposure to the surface and subsurface soil, respectively. Tables 7-10 and 7-12 show the respective noncancer hazard quotients. The total risks resulting from exposure to both surface and subsurface soil are summarized in Table 7-13. Evidently, the total cancer or noncancer risks are 2 to 3 orders of magnitude smaller than the regulated cancer risk of 10^{-6} or the HQ value of 1. Therefore, none of the COPCs are identified as COCs at the site for construction workers.

Visitors/Trespassers

Visitors/Trespassers are considered to be exposed to surface soil only. The total risk is therefore the sum of risks resulting from exposure to surface. Tables 7-9 and 7-10 show the cancer and noncancer risks to the visitors/trespassers, respectively. No cancer risks of any of the COPCs exceeded the 10^{-6} level. Similarly, none of the COPCs have a HQ greater than 1. Therefore, no COPCs are identified as COCs with respect to exposure to the site contaminants.

Military Personnel and Construction Worker

This population is considered to include those military personnel stationed at Cannon AFB, but who also engage in construction, excavation, or digging activities at the FTA4. The total risk for these receptors is therefore the sum of the risks for both Military Personnel and Construction Workers. The result of the cancer and noncancer risks are presented in Table 7-13. As shown in

the table, the regulated risk levels are not exceeded for both cancer and noncancer risks.

7.5.4 Uncertainty in the Risk Assessment

The uncertainties in the quantitative risk estimates are product of the uncertainties associated with all data and assumptions used in the risk assessment process. The uncertainties are associated with the environmental sampling and analysis, exposure parameter estimation, and toxicological data. A discussion of the risk uncertainties associated with the risk estimates is critical to understanding the true nature of the predicted risks and to placing the predicted risks in the proper perspective.

Qualitative evaluation of uncertainty focuses on identifying the principal sources of uncertainty to discuss whether each tends to overestimate or underestimate risks. Because the risk characterization combines and integrates the information developed in the exposure and toxicity assessment, the uncertainties associated with these assessments also affect the degree of confidence that can be placed in risk characterization results. Discussions of these factors causing uncertainty in the exposure and toxicity assessments are summarized below.

Exposure Assessment

The exposure estimates used in this risk assessment are conservative and designed to be on the side of overestimating actual risks when there is an uncertainty in order to be health protective. Several of the factors adding uncertainty to the estimates, resulting in probable over estimation of exposure, include:

- The directed nature of much of the sampling plan; i.e., focusing on the most of the contaminated parts of the site;
- The use of the upper bound of 95% UCL values in the exposure estimation;
- The use of steady state assumptions for the source concentration estimates; i.e., the COPC concentrations are not subject to decrease due to attenuation and/or degradation for the duration of the exposure period.
- The use of overly conservative assumptions on exposure frequency and exposure duration for military personnel and visitors/trespassers. As stated before, FTA4 is inactive and is not used for any specific purpose. Exposure to this area by military personnel is negligible. Cannon AFB is an active Air Force Base and is fully secured, therefore access to Cannon AFB via trespassing is almost impossible. Exposure to the contaminants via trespassing is therefore highly unlikely.

A factor which could lead to either over- or underestimation of the exposures is:

- The use of one-half MDL to estimate the nondetects.

Toxicity Assessment

Basic uncertainties underlying the assessment of the toxicity of a chemical include:

- Uncertainties arising from the design, execution, or relevance of the scientific studies that form the basis of USEPA's risk assessment; and

- Uncertainties involved in extrapolating from underlying scientific studies to the exposure scenarios being evaluated, including variable responses to chemical exposures in human and species and between species.

These basic uncertainties could result in a toxicity estimate, that either can under- or overestimate the true toxicity of a chemical present at the site. However, USEPA's toxicity assessment process compensates for these uncertainties through the use of uncertainty factors and modifying factors when deriving RfDs for noncarcinogens, and the use of 95% confidence limit when deriving the SFs for carcinogens.

Overall Risk Characterization

When discussing uncertainties associated with the overall risk assessment, several additional factors need to be considered. These include the cumulative effect of using conservative assumptions throughout the assessment process and the likelihood of the exposures postulated and estimated in the exposure assessment actually occurring.

The cumulative effect of using conservative assumptions throughout the risk assessment is that the estimated risks may substantially overestimate the true risks. USEPA guidance recommends that individual exposure parameters be selected so that the resulting overall estimates of exposure represents a RME. However, in many cases, the actual statistical distribution of a parameter is unknown (i.e., the amount of soil ingested). When there is a doubt, USEPA has erred in favor of protecting human health, and selected an RME default value that result in overestimating the risks. Therefore, the nature of risk estimation process ensures the true risks are more likely to be overestimated than underestimated.

The last major uncertainty factor to consider is the likelihood of postulated exposures actually occurring. The exposure pathways identified are plausible and exposure may be expected to occur. However, postulated frequencies of occurrence for all exposure scenarios were chosen to overestimate routine occurrence but more likely reflect an upper bound frequency of occurrence. For example, it is assumed that military personnel will visit these units every day for 250 days a year and stay there for 30 minutes each day. The reality is that they more likely drive through these units, rather than walk, and there is very little chance to contact the soils.

7.5.5 Summary of Baseline Human Health Risk Assessment

This Human Health Risk Assessment has been conducted to assess the potential adverse human health effects that could occur due to exposure to site contaminants at FTA4, in the event no action is taken to remove contaminants and/or prevents their migration. The assessment was prepared in accordance with the RAGS (USEPA 1989). Three chemicals, beryllium, benzo(a)pyrene, and benzo(b)fluorathene, were identified as COPCs and were evaluated in this risk assessment. Beryllium levels at the site are above the EPA Region 6 Media-Specific Screening Levels, but are below their respective background, indicating they are not site-related chemicals. Three categories of receptors, military personnel, visitors/trespassers, and future construction workers, were postulated and evaluated for exposure to the four chemicals. The result shows that the cancer or noncancer risks to any of the receptors are several orders of magnitude smaller than the regulated cancer risk of 10^{-6} or noncancer hazard quotient of 1, indicating that exposure the site contaminants is negligible. Moreover, to ensure the conservative nature of risk assessment, most of the parameters used in the risk assessment are generic, the true risks may be even smaller than the calculated risks. In conclusion, the site contaminants pose no significant risks to any of the populations.

8.0 ENVIRONMENTAL ASSESSMENT

8.0 ENVIRONMENTAL ASSESSMENT

The objective of this environmental assessment is to evaluate the potential for biological resources in the vicinity of FTA4 to be adversely affected by contaminants at the site. This evaluation uses the guidance provided by the U.S. Army Corps of Engineers for a screening-level environmental assessment (USACE 1996). Herein we summarize the ecological setting, identify chemicals of ecological concern (COECs) and receptors, and present a conceptual site model for exposure pathways.

8.1 ECOLOGICAL SETTING

Land adjacent to Cannon AFB is primarily used for agriculture and little natural vegetation remains in the area. The wildlife species that are common to agricultural areas throughout the region include bobwhite quail and pheasant. The few playa lakes in the area are used by upland game for cover, by waterfowl for resting and feeding, and by wildlife in general for drinking. Nearby riverbeds also provide water sources during rainy seasons. During periods of low rainfall, the riverbeds are dry.

The climate of the Base area is considered to be semiarid. The thin layer of topsoil in the vicinity of Cannon AFB is sandy loam, which is highly susceptible to wind erosion. The undisturbed natural vegetation is mostly shortgrass prairie, including blue grama grassland and mixed grama grassland vegetation types.

Much of the study area has been previously cleared for agricultural crops. The predominant land use of the region is rangeland, primarily for cattle grazing. In general, moderately grazed rangeland areas of the types occurring in the project area are highly productive in terms of both forage quality and quantity. The rangeland in the vicinity may support up to 15 to 20 head of cattle per section, depending on the rainfall. Large trees do not uniformly exist in the vicinity of the range except where planted around buildings and other structures on the Base. Woodlands composed of large shrubs and small trees are confined to riparian areas and playa lakes in the vicinity.

The eastern New Mexico area contains many nongame wildlife species that are typical of the High Plains. Most of these species are distributed widely throughout the western United States. Wildlife diversity is low in most areas because of the low vegetation diversity. Most amphibian species are associated with riparian habitats and playa lakes. Reptiles are found in all terrestrial habitat types but are most abundant in scrub/grasslands. Nocturnal rodents are the most abundant members of the small mammal community.

Grasslands on the High Plains support a variety of seed-eating sparrows and other ground-dwelling birds, both as residents and migrants. Raptors (hawks and owls) are relatively abundant in all habitats in the region. Insectivorous and tree nesting species are most abundant in riparian areas. Shorebirds and waterbirds and migratory waterfowl in general use the rivers, playa lakes, and reservoirs of the region.

Big-game species in the area include mule deer, white-tailed deer, pronghorn, and barbary sheep. Pronghorn are the most abundant game animal in the area. Several species of upland game such as quail, ring-necked pheasant, and turkey are common in the area.

We contacted the New Mexico Department of Game and Fish, Conservation Services Division, to obtain the most recent information on protected animal species that might be found in Curry County. The federal- and state-protected species are summarized in Table 8-1.

Texas horned lizard, or horny toad, is not protected but is of concern at the federal level. This animal is known to occur in Curry County and has recently been found at Cannon AFB. They inhabit open areas with sparse vegetation, digging dens for hibernation, nesting and insulation, in loose sand or loamy soils. They are insectivores and prefer to eat harvester ants.

Three of the four state-protected birds known to occur in the vicinity of Cannon AFB are the raptors ferruginous hawk, bald eagle and peregrine falcon. The ferruginous hawk may be found as either a winter migrant or a year-round resident. The bald eagle migrates and winters from the northern border of New Mexico to the Gila, lower Rio Grande, middle Pecos, and Canadian valleys. It is seen occasionally in summer and as a breeding bird, with nests reported in the extreme northern and western parts of the state. Winter and migrant populations appear to have increased with reservoir construction. The peregrine falcon is widely distributed but population numbers are low but increasing. The American subspecies breeds statewide in New Mexico, but mainly west of the eastern plains. The protected songbird Baird's sparrow migrates through the area during autumn and may breed in New Mexico. Baird's sparrow is a grassland bird, eating seeds of grasses and forbs, as well as insects. Its numbers continue to decline.

Protected mammals that still live in the state include the Plains pocket gopher and swift fox. The Plains pocket gopher inhabits sandy or loamy soils, where burrowing is easier. While it has been found in alfalfa fields, the shortgrass prairie is its normal habitat, where it feeds primarily on grass seeds. The swift fox is closely related to the kit fox, and may hybridize with kit fox in eastern New Mexico and western Texas. The fox is largely nocturnal, eating rodents, insects, lizards and vegetation. Dens are burrowed in sandy loam soils and they are used year-round. Its numbers have diminished due to habitat loss and the taking of poisoned bait.

8.2 CHEMICALS OF ECOLOGICAL CONCERN

Soil analytical data collected by Harza in this RFI was reviewed and screened to identify chemicals that may be released from the site, expose organisms at the site, and cause adverse effects. Chemicals of ecological concern (COECs) were selected through a six-step screening procedure:

1. Chemicals that were not detected in at least one soil sample were eliminated from further consideration.

2. Chemicals that were deemed to be laboratory contaminants were eliminated from further consideration.

3. Samples with contaminant concentrations less than the ecotoxicity threshold concentrations of the USEPA Region 3 BTAG (Biological Technical Advisory Group (USEPA, Draft, 1995) were deemed to present no risk and were eliminated from further consideration.

4. Samples with contaminants present at concentrations less than Cannon AFB background concentrations, were deemed to present no risk and were eliminated from further consideration.

5. Samples collected below three feet were eliminated as an exposure pathway to animals, as most burrowing animals at the site will not burrow deeper than this depth. Soils below five feet were eliminated as an exposure pathway to plants.

6. Non-biomagnifying chemicals above background or ecotoxicity thresholds but were limited in occurrence to a single sample site do not represent a significant exposure pathway, and were eliminated from further consideration.

Tables 8-2 and 8-3 present data from this screening process. Chemicals passing this initial screening process include phenanthrene, fluoranthene, pyrene, benzo(k)fluoranthene, iron and zinc (Table 8-4). Iron, while exceeding Cannon AFB background concentrations 6 out of 22 times tested for, is well within the levels expected for general terrestrial soils, about 4% by weight (40,000 mg/kg). Also, iron is a minor essential element for receptor plants and animals. On these bases, iron is not considered to represent significant adverse risk and was eliminated from further consideration.

8.3 IDENTIFICATION OF POTENTIAL RECEPTORS

FTA4 and the surrounding land is open, poorly vegetated and is maintained for military activities. Being adjacent to the runway clear zone, the site offers very limited habitat for wildlife. Common receptors would include plants, insects, soil invertebrates, reptiles and small mammals. Birds are also present and potentially at risk, both from directly ingesting contaminated soil and ingesting contaminated seeds and prey animals. If bioaccumulating contaminants were present, additional receptors potentially at risk would include snakes and lizards, raptors and some mammals (e.g. skunk, coyote, etc.).

Animals potentially at highest risk are small borrowing mammals. These animals are among the more common animals likely to be in the vicinity of FTA4 and are exposed through inhalation, dermal contact and ingestion pathways. Given this, the deer mouse, a species for which ecotoxicity data is available, was selected as the indictor organism. Deer mouse is a common prey item for higher organisms such as raptors and likely has similar exposures routes as other small mammals, including species of special management interest (Plains pocket gopher).

Figure 8-1 illustrates a conceptual ecological model developed for the site. Because the COECs

are not volatile (Section 6.2.1) and wind entrainment of soils are believed to be minor, inhalation exposures are deemed negligible. Surface runoff from the site is believed to also be negligible, as field visits indicated no evidence of runoff. Most rainfall is lost to evapotranspiration, however some infiltration which may leach some contaminants into subsurface soils. However, based upon the fate and transport characteristic of the COECs, groundwater does not present an exposure pathway. Therefore, the only significant exposure pathway present at the site involves direct contact to contaminants in soil.

8.4 EXPOSURE AND EFFECTS CHARACTERIZATION

Given the conceptual site model (Figure 8-1), the assessment endpoint for this evaluation is the mortality of the deer mouse population. The corresponding measurement endpoint is chemical toxicity, obtained from published literature.

8.4.1 Exposure Evaluation

The risk screening evaluation focuses on those pathways with maximum exposure potential based on professional judgement. Exposure is estimated with respect to the magnitude, duration and frequency of exposures, to derive an estimate of chemical intake. Chemical intake is generally estimated for terrestrial consumers such as deer mouse as a product of chemical concentration and intake/exposure factors. Standard reference body data are taken from SRC (1985) and included in Table 8-5.

In a study in Colorado of deer mouse in shortgrass prairie habitat (Flake 1973), their diet was composed of 66% plant material (seeds, forbs, grasses, sedges, and shrubs) and 34% arthropods (beetles, grasshoppers, leafhoppers, lepidopterans, and spiders). While few studies have been done on these arthropods, PNAs do not generally bioaccumulate in terrestrial organisms. Beyer and Stafford (1993) found PNAs in earthworms to be well below those levels found in soil. Lead is also found in diminishing concentrations at increased trophic order (Pain 1995). Therefore, a conservative assumption was made that all COECs in the deer mouse diet are derived from plants. Further, in arid areas such as New Mexico, up to 100% of a deer mouse's water requirements may be met through its diet (USACE 1996) and contaminant intake via drinking will be minimal and was not considered further.

Contaminant concentrations in plant material at the site were estimated using bioaccumulation factors, defined as the dry weight ratio of the contaminant in plant tissue to that in soil, and are presented in Table 8-7. Polynuclear Aromatic Hydrocarbons (PNAs) in general have limited entry into plant roots and minimal translocation once inside the plant (Will and Suter 1994). Most researchers agree that the primary route for entry of PNAs into terrestrial plants is through foliar deposition and absorption, and is generally significant only in areas adjacent to atmospheric sources. In his review of PNA environmental hazards, Eisler (1987) stated that lower molecular weight PNAs are absorbed by plants more readily than higher molecular weight PNA compounds. In addition, plant PNA uptake is governed by PNA concentration, water solubility, and soil type. Edwards (1983) reviewed PNA fate in the terrestrial environment, and cited numerous studies of

PNA accumulation by plants. Most of those studies relied on benzo(a)pyrene (BaP) as their PNA of interest. The average bioaccumulation factor for nine studies of BaP cited by Edwards (1983) was 0.022, ranging from 0.00012 to 0.085. When mixtures of multiple PNAs were cited, as they were in 11 studies, the average bioaccumulation factor was 0.087, and ranged from 0.0011 to 0.224. Given these data and the physiochemical characteristics of the PNA COECs (Table 8-6), a bioaccumulation factor of 0.1 was selected for all four PNA COECs. As a final note in estimating plant bioaccumulation factors for PNAs, most plants can catabolize BaP and possibly other PNAs, but metabolic pathways have not yet been clearly defined. The bioaccumulation factor for zinc was taken from Bohn *et al.* 1979.

Daily intake estimates of COECs for deer mouse are given in Table 8-8. COEC dietary intake was estimated as the product of plant COEC concentration and food intake. COEC dose from incidental soil ingestion was estimated as the product of the maximum COEC concentration in soil and 2% of the food intake. Finally, the intake was converted to a body weight basis by dividing by 30 g, the weight of a reference deer mouse.

8.4.2 Effects Evaluation

An evaluation of effects is based upon appropriate reference toxicity values (RTV), developed from published literature. The RTV ideally corresponds to the measurement endpoint, or chemical toxicity to deer mouse. RTVs for each of the COECs are included in Table 8-9.

Chronic oral toxicity values for acenaphthene and pyrene were obtained from USEPA's Integrated Risk Information System (IRIS). The NOAEL oral reference dose for fluoranthene cited in IRIS is 125 mg/kg/d, derived from mouse subchronic studies. Assuming an uncertainty factor of 10, to account for study duration uncertainty, an RTV of 12.5 mg/kg/d was derived. Similarly for pyrene, the oral does for NOAEL in IRIS is 75 mg/kg/d, also from mouse studies. Again an uncertainty factor of 10 was applied to derive a RTV of 7.5 mg/kg/d.

IRIS however does not contain RTVs for phenanthrene, benzo(k)fluoranthene and lead. Based on the physiochemical data for PNAs (Table 8-6), an oral RTV for benzo(k)fluoranthene was derived from the NOAEL for benzo(a)pyrene given by Opresko *et al.* (1994) as 1.108 mg/kg/d for white-footed mouse. We applied an uncertainty factor of ten to this value, estimating the RTV at 0.111 mg/kg/d. The oral RTV for phenanthrene was taken as one-half that of fluoranthene, applying an uncertainty factor of 10 for phenanthrene. Opresko et al. (1994) also provides NOAEL doses for zinc when white-footed mouse is the endpoint species. The NOAEL for zinc is 398.7 mg/kg-d. Again, using an uncertainty factor of 10, the RTV for zinc is 39.9 mg/kg/d.

8.5 RISK AND UNCERTAINTY CHARACTERIZATION

Risk characterization is based on a hazard quotient approach; all computational methods are found in USACE (1996). Similar to the assessment of risk to human health, the potential for adverse ecological effects, that is, the hazard quotient (HQ), is the ratio of the estimated exposure to the RTV, or:

$$HQ = \frac{ADI}{RTV}$$

HQs for chemicals causing the same type of adverse effect are summed to give a hazard index (HI). A HQ or HI greater than 1 indicates that adverse effects may be possible. Based on available data, current ecological risk assessment methods indicate that the deer mouse population at FTA4 is not at significant risk from chemical contaminants of concern in the soil. This screening-level ecological risk assessment indicates a hazard quotient for pyrene of 0.004. Hazard quotients for other COECs are: 0.002 for fluoranthene, 0.002 for phenanthrene, 0.12 for benzo(k)fluoranthene, and 0.01 for zinc. When more than one contaminant is involved in the risk calculation, and if the contaminants exhibit consistent modes of toxicity and effects on endpoints, then it is appropriate to sum the hazard quotients to compute a hazard index. The ecological hazard index for FTA4 is 0.14, which suggests that the likelihood of adverse ecological effects occurring at the site from the COECs is low. In summary, the screening of ecological risk at FTA4 indicates a low potential for adverse ecological effects. Further, this is a conservative estimation and significant uncertainties are inherent to this risk estimate.

Uncertainties and limitations are intrinsic to new tools such as ecological risk assessment, particularly when applied at the screening level such as this. This uncertainty represents a lack of adequate information about factors such as adverse effects of COECs on receptor organisms. We took precautions to make conservative assumptions whenever possible, so as to not underestimate risks. For purposes of the assessment, the maximum concentrations of COECs in soil were used rather than the 95% upper confidence level, which given the general distribution of concentrations and numbers of samples, is more conservative. We assumed that the only significant exposure pathway present at the site involves plants and animals that come directly in contact with the soil. Therefore, ingestion was the only exposure pathway considered in our estimate. Dermal and inhalation pathways were not included, as the potential significance of PNA or zinc uptake from these exposure routed is judged to be negligible. This assessment was limited to the chemicals analyzed, and through a screening procedure, risk was estimated for chemicals judged to present the greatest potential hazard. Further, the assessment focused on potential risk to the deer mouse, as the indicator species. It was judged that if the mice were not at risk, then other biota of concern at the site (e.g raptors), would not be at risk as long as the chemicals of concern did not bioaccumulate to higher trophic levels.

9.0 CONCLUSIONS AND RECOMMENDATIONS

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The objectives of the RFI were to sample potentially affected media and perform the necessary analyses on a sufficient number of samples collected at appropriate locations and/or intervals to:

- Delineate the vertical and lateral extent of contamination in each contaminated media;
- Identify all contaminants of concern;
- Determine the fate and transport characteristics of each contaminant of concern;
- Perform a human health and environmental risk assessment to determine if site conditions pose a risk to human health or the environment according to USEPA policy; and
- Support a decision for no further action or the selection of corrective measures/remedial alternatives and remedial design.

Principal conclusions relative to these objectives are outlined in the following paragraphs.

9.1 NATURE AND EXTENT OF CONTAMINATION

9.1.1 Volatile Organic Compounds

VOCs were detected above the MRLs only in boring SB01 located at the former fire training pit (SWMU No. 109). VOCs detected in SB01 included toluene, ethylbenzene, m&p-xylene, o-xylene, isopropylbenzene, n-propylbenzene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, sec-butylbenzene, p-isopropyltoluene, n-butylbenzene, 1,2-dibromo-3-chloropropane, naphthalene, and 2-butanone. Individual detections in boring SB01 were recorded at depths of 3 feet, 19 feet, 27 feet, 38 feet, 42 feet, 55 feet, and 65 feet. Where detected, concentrations of individual VOCs ranged as follows:

- toluene (17.4 - 4,370 μg/kg);
- ethylbenzene (34.6 - 7,230 μg/kg)
- m&p-xylene (166 - 34,100 μg/kg);
- o-xylene (81.1 - 18,900 μg/kg);
- isopropylbenzene (16.6 - 1,940 μg/kg);
- n-propylbenzene (29.3 - 4,450 μg/kg);
- 1,3,5-trimethylbenzene (92.6 - 15,500 μg/kg);
- 1,2,4-trimethylbenzene (11.2-41,800 μg/kg);
- sec-butylbenzene (15.6 μg/kg);
- p-isopropyltoluene (51.8 - 9,530 μg/kg);
- n-butylbenzene (26.2 - 4,620 μg/kg);
- naphthalene (10.7 - 8,580 μg/kg); and
- 2-butanone (89.8 μg/kg).

9.1.2 Semi-Volatile Organic Compounds

Semi-volatile organic compounds were detected above the MRLs only in soil boring SB01. Detection of naphthalene and 2-methylnaphthalene occurred in five instances, in soil boring SB01 at depths of 3 feet, 19 feet, 27 feet, 38 feet, and 42 feet. Detected concentrations in these samples ranged as follows: naphthalene (586 - 3,800 μg/kg) and 2-methylnaphthalene (3,500 - 11,700 μg/kg).

9.1.3 Total Recoverable Petroleum Hydrocarbons

Laboratory analytical data indicates that TRPH was detected in each of the nineteen (19) soil borings drilled in the RFI. The highest concentrations were detected in borings drilled near SWMU No. 109 (SB01, SB19, SB04, and SB11) and SWMU No. 111/112 (SB14). The highest concentrations were detected in boring SB01 at a depth of 19 feet (5,560 mg/kg), boring SB19 at a depth of 4 feet (1,530 mg/kg), boring SB04 in the surface sample (3,270 mg/kg), boring SB11 in the surface sample (14,400 mg/kg), and boring SB14 in the surface sample (1,040 mg/kg).

Detected TRPH concentrations generally decrease rapidly with depth, with the highest relative concentration in each boring detected in surficial or near-surface samples (within the upper 4 feet). This is seen in all borings with exception of boring SB01 where the highest detected concentration of TRPHs was detected at a depth of 19 feet and concentrations greater than 1,000 mg/kg were detected to a depth of 42 feet.

Field immunoassay screening data further indicates that detectable concentrations (greater than 10 ppm) were found in soil borings SB01 and SB12. In boring SB01, TRPH was detected to a depth of 65 feet. Samples collected from boring SB01 from depths of 65 feet and 73 feet indicated non-detectable concentrations (less than 10 ppm). In boring SB12, TRPH was detected at a depth of 10 feet. Samples collected from boring SB12 at a depth of 2 feet, 21 feet, and 31 feet indicated non-detectable concentrations. TRPHs were not detected in any other sample using field immunoassay screening methods. Comparison of the field immunoassay screening data with laboratory analytical data indicates a positive qualitative correlation.

9.1.4 Target Analyte List Metals

Analytical results indicated detectable concentrations of target analyte list metals in each of the nineteen (19) soil borings drilled in the RFI. Where detected, concentrations of individual compounds ranged as follows:

- aluminum (1,230 - 9,990 mg/kg);
- antimony (2.3 - 6.2 mg/kg);
- arsenic (0.6-3.3 mg/kg);
- barium (15.3 - 1,250 mg/kg);
- beryllium (0.15 - 0.74 mg/kg);
- calcium (1,680 - 253,000 mg/kg);

- chromium (2.2 - 20.9 mg/kg);
- cobalt (1.1 - 5.4 mg/kg);
- copper (1.1 - 8.4 mg/kg);
- iron (1,830 - 10,700 mg/kg);
- lead (0.91 - 21.5 mg/kg);
- magnesium (702 - 5,300 mg/kg);
- manganese (18.8 - 1,350 mg/kg);
- nickel (2.9 mg/kg - 10.7 mg/kg);
- potassium (285 - 2,360 mg/kg);
- selenium (0.067 - 0.69);
- sodium (51.3 - 860 mg/kg);
- thallium (0.12 mg/kg);
- vanadium (4.2 - 24.7 mg/kg); and
- zinc (4.5 - 27.6 mg/kg)

Concentrations generally decrease with increasing depth below the ground surface, noticeable for most of the metals analyzed (i.e. aluminum, beryllium, chromium, cobalt, copper, lead, manganese, vanadium, zinc) and especially evident in the deeper soil borings (i.e. SB01, SB17, SB18, SB19). Eleven (11) metals were detected at concentrations exceeding background concentration ranges at Cannon AFB. These included barium, beryllium, calcium, chromium, cobalt, iron, lead, manganese, nickel, silver, and zinc. For these metals, most of the elevated concentrations occur at the ground surface or within soils with a high silt/clay content. The trend of decreasing concentrations at depth below the ground surface appears to coincide with the presence of soils with increased silt and clay content. Additionally, comparison of the detected concentrations for each of these eleven metals with the background concentration ranges indicates that, in general, the detected concentrations only marginally exceed the background concentrations.

9.2 HUMAN HEALTH EVALUATION

A Human Health Risk Assessment was conducted to assess the potential adverse human health effects that could occur due to exposure to site contaminants at FTA4, in the event no action is taken to remove contaminants and/or prevents their migration. The assessment was prepared in accordance with the RAGS (USEPA, 1989). Five chemicals, barium, beryllium, manganese, benzo(a)pyrene, and benzo(b)fluorathene, were identified as COPCs and were evaluated in this risk assessment. Four categories of receptors, military personnel, visitors/trespassers, construction workers, and military personnel engaged in construction, were postulated and evaluated for exposure to the four chemicals. The result shows that the cancer or noncancer risks to any of the receptors are several orders of magnitude smaller than the regulated cancer risk of 10^{-6} or noncancer hazard quotient of 1, indicating that exposure the site contaminants is negligible. Moreover, to ensure the conservative nature of risk assessment, most of the parameters used in the risk assessment are generic, the true risks may be even less than the calculated risks. In conclusion, the site contaminants pose no significant risks to any of the populations.

9.3 ECOLOGICAL ASSESSMENT

An ecological risk assessment was performed as part of the overall RFI effort to evaluate the potential for biological resources in the vicinity of FTA4 to be adversely affected by site contaminants. Concentrations of chemicals found at FTA4 were evaluated specifically in terms of potential risks to the Deer mouse population, selected as the indicator species. The chemicals phenanthrene, fluoranthene, pyrene, beryllium, lead, and zinc were detected in site soils and were considered to be chemicals of ecological concern. Concentrations of these chemicals in soils were very low and were not considered to pose an ecological concern. The results of the ecological risk assessment are presented below.

Risk characterization is based on a hazard quotient approach (USACE 1996). This screening-level ecological risk assessment indicates a hazard quotient for pyrene of 0.004. Hazard quotients for other COECs are lower: 0.002 for fluoranthene, 0.002 for phenanthrene and 0.24 for lead. When more than one contaminant is involved in the risk calculation, and if the contaminants exhibit consistent modes of toxicity and effects on endpoints, then it is appropriate to sum the hazard quotients to compute a hazard index. The ecological hazard index for FTA4 is 0.2, which suggests that the likelihood of adverse ecological effects occuring at the site from the COECs is low. In summary, the screening of ecological risk at FTA4 indicates a low potential for adverse ecological effects. Moreover, this is a conservative estimation and the actual risks may be even less than those calculated.

9.4 RECOMMENDATIONS

Based on the results of the RFI and subsequent human health and ecological risk assessments, a "No Action" remedial alternative is recommended for FTA4, including the following SWMUs:

- SWMU No. 109 - Fire Training Pit
- SWMU No. 110 - Underground Waste Oil Tank #2336
- SWMU No. 111 - Unlined Pit; and
- SWMU No. 112 - Oil/Water Separator #2336

10.0 REFERENCES

10.0 REFERENCES

Atlas, Ronald M. and R. Bartha. 1993. Microbial Ecology: Fundamentals and Applications.

Beyer, W. N. and C. Stafford. 1993. Survey and Evaluation of Contaminants in Earthworms and Soils Derived from Dredged Materials at Confined Disposal Facilities in the Great Lakes Region. Environmental Monitoring and Assessment 24: 151-165.

Bohn, H., B. McNeal and G. O'Connor. 1985. Soil Chemistry. John Wiley & Sons, New York.

Cannon AFB, 1996. Management Action Plan, January.

Cannon AFB, 1993. Commander's Long Range Facility Improvement Plan. September 8.

CH_2M Hill. 1983. Installation Restoration Program Records Search for Cannon Air Force Base, New Mexico. Prepared for the Air Force Engineering and Services Center and the Tactical Air Command. Contract No. FO8637-80-G0010-0018. August.

Flake, L. D. 1973. Food Habits of Four Species of Rodents on a Short-Grass Prairie in Colorado. J. Mammal. 54: 636-647.

Freeze, R.A., and J.A. Cherry. 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, N.J. p.29.

Gutentag, E.D., et al. 1984. Geohydrology of the High Plains Aquifer in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. USGS Professional Paper 1400-B.

Hale, Bruce. 1992. Personal communication between Bruce Hale and Woodward-Clyde Consultants. May 11.

Harza Environmental Services, Inc. 1996. RFI Work Plan, Phase II RCRA Facility Investigation, Fire Training Area No. 4, SWMU Nos. 109, 110, 111, 112, Cannon AFB, Clovis, New Mexico. September.

Harza Environmental Services, Inc. 1997. Quality Control Summary Report. Fire Training Area No. 4. SWMU Nos. 109, 110, 111, 112. Cannon Air Force Base, Clovis, New Mexico.

Hawley, J.W. et al, 1976. Quaternary Stratigraphy in the Basin and Range and Great Plains Provinces, New Mexico and Western Texas.

Kearney, A.T. 1987. Preliminary Review/VSI Report, RCRA Facility Assessment Cannon Air Force Base. U.S. Environmental Protection Agency, Region VI. A.T. Kearney, Inc., Chicago, Illinois.

Lee Wan & Associates, Inc. 1990. (And references contained therein). RCRA Facility Investigation Work Plan, Volume 1, II and III. Cannon AFB, New Mexico. Prepared for 27 CSG/DEV Cannon AFB, New Mexico.

Luckey, R.R., et al. 1981. Water-level and Saturated Thickness Changes, Predevelopment to 1980, in the High Plains Aquifer in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. Hydrologic Investigation Atlas HA-652. U.S. Geological Survey.

Lyman, W.L., W.F. Reehl, and D.H. Rosenblatt. 1990. Handbook of Chemical Property Estimation Methods.

New Mexico Department of Game and Fish (NMDGF), Conservation Services Division. 1997. Personal communication between NMDGF and Harza Environmental Services, Inc.

Opresko, D. M., B. E. Sample, and G. W. Suter II. 1994. Toxicological Benchmarks for Wildlife: 1994 Revision. ES/ER/TM-8686/R1. Oak Ridge National Laboratory, Oak Ridge, TN.

Radian Corporation. 1986. Final Installation Restoration Program Phase II Remedial Investigation.

SRC (Syracuse Research Corporation). 1985. Reference Values for Risk Assessment. Prepared for USEPA, Environmental Criteria and Assessment Office, Cincinnati, Ohio, by SRC, Syracuse, NY.

U.S. Air Force (USAF). 1990. Final Environmental Impact Statement, Realignment of Cannon AFB, Curry County, New Mexico. May.

U.S. Air Force (USAF). 1991. Draft Environmental Impact Statement Basing.

U.S. Army Corps of Engineers, Omaha District. 1995. General Chemistry Supplement to the Scope of Services.

U.S. Army Corps of Engineers, Omaha District. 1995. Scope of Services for RCRA Facility Investigation for Fire Training Area 4. Cannon Air Force Base, New Mexico.

U.S. Army Corps of Engineers (USACE). 1995. Risk Assessment Handbook, Volume I: Human Health Evaluation. EM 200-1-4. United States Army Corps of Engineers, Washington, DC.

U.S. Army Corps of Engineers (USACE). 1996. Risk Assessment Handbook. Volume II: Environmental Evaluation. EM 200-1-4. United States Army Corps of Engineers, Washington, DC.

U.S. Department of Agriculture (USDA) Soil Conservation Service. 1958. Soil Survey of Curry County, New Mexico. Soil Survey Series 1953, No. 4. U.S. Government Printing Office.

United States Fish and Wildlife Service (USFWS). 1987. Endangered and Threatened Species of Arizona and New Mexico.

U.S. Environmental Protection Agency. 1986. Superfund Public Health Evaluation Manual. October.

U. S. Environmental Protection Agency. 1987. RCRA Facility Investigation (RFI) Guidance. 4 volumes.

U.S. Environmental Protection Agency. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.

U.S. Environmental Protection Agency, 1989. Risk Assessment Guidance for Superfund. Volume 1. Human Health Evaluation Manual (Part A). OSWER. Washington, DC.

U.S. Environmental Protection Agency, 1991. Risk Assessment Guidance for Superfund. Volume 1. Human Health Evaluation Manual (Part B, Development of Pleliminary Remediation Goals). OSWER. Washington, DC.

U.S. Environmental Protection Agency, 1992. Guidance for Data Useability in Risk assessment (Part A). OSWER. Washington, DC.

U.S. Environmental Protection Agency, 1993. Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

U.S. Environmental Protection Agency. 1994a. Test Methods for Evaluating Solid Waste, SW-846.

U.S. Environmental Protection Agency. 1994b. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review.

U.S. Environmental Protection Agency. 1994c. USEPA Contract Laboratory Program, National Functional Guidelines for Organic Data Review.

U.S. Environmental Protection Agency. 1995. Land Use in the CERCLA Remedy Selection Process. OSWER Directive 9355.7-04.

U.S. Environmental Protection Agency. 1995. Great Lakes Water Quality Initiative Methodology for Development of Bioaccumulation Factors. Final Rule. Federal Register 60 (56). March 23.

U.S. Environmental Protection Agency. 1996. Soil Screening Guidance: Technical Background Document. May.

U.S. Environmental Protection Agency, Region III. 1995. BTAG Screening Levels. Draft, August, 1995. 27 pages.

U.S. Geological Survey (USGS). 1985. Potair Quadrangle, Oasis State Park Quadrangle; New Mexico.

Walk, Haydel & Associates, Inc. 1990. Final Installation Restoration Program Remedial Investigation. Cannon Air Force Base, New Mexico. Prepared under contract with Omaha District, Corps of Engineers, Omaha, Nebraska, for Headquarters, Tactical Air Command, HQ, TAC/DEEV, Langley Air Force Base, Virginia. 3 volumes.

Ward, Calvin et al.. 1995. Innovative Site Remediation Technology: Bioremediation.

Weeks, J.B., and E.D. Gutentag. 1981. Bedrock Geology, Altitude of Base and 1980 Saturated Thickness of the High Plains Aquifer in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, Wyoming: Hydrologic Investigation Atlas. HA-648, U.S. Geological Survey.

Will, M. E. and G. W. Suter II. 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1994 Revision. ES/ER/TM-85/R1. Oak Ridge National Laboratory, Oak Ridge, TN.

William Matotan and Associates Inc. 1985. Water Well Master Plan Survey. Prepared for Department of the Air Force, Cannon Air Force Base, New Mexico.

W.L. Gore & Associates, Inc. 1996. GORE-SORBER^{SM} Screening Survey Final Report, Fire Training Area No. 4, Cannon Air Force Base, Clovis, NM. November 26.

Woodward Clyde Consultants. 1992. Data Collection Quality Assurance Plan.

Woodward-Clyde Consultants. 1994. Concentrations of Selected Naturally Occurring Chemical Constituents in Soil and Groundwater at Cannon Air Force Base, Clovis, New Mexico. March.

Table 5-5
Summary of Soil Analytical Data
for Soil Boring SB01

Analytes	SB01-0103	SB01-0119	SB01-0127	SB01-0138	SB01-0142	SB01-0155	SB01-0165	SB01-0173	SB01-0180
VOAs (Method 8260A)	*Concentration (µg/kg)*								
Dichlorodifluoromethane	291U	301U	291U	288U	299U	2.4U	2.5U	2.3U	2.3U
Chloromethane	208U	215U	208U	206U	213U	1.7U	1.8U	1.6U	1.7U
Vinyl Chloride	180U	186U	180U	179U	185U	1.5U	1.5U	1.4U	1.4U
Bromomethane	109U	113U	109U	109U	112U	0.9U	0.93U	0.85U	0.87U
Chloroethane	208U	215U	208U	206U	213U	1.7U	1.8U	1.6U	1.7U
Trichlorofluoromethane	333U	344U	332U	330U	341U	2.7U	2.8U	2.6U	2.6U
1,1-Dichloroethene	180U	186U	180U	179U	185U	1.5U	1.5U	1.4U	1.4U
Methylene Chloride	346U	358U	346U	343U	356U	4.8 JB	5.2 JB	3.8 J	5.6 B
trans-1,2-Dichloroethene	90.1U	93.2U	90.0U	89.3U	92.4U	0.74U	0.76U	0.7U	0.72U
1,1-Dichloroethane	90.1U	93.2U	90.0U	89.3U	92.4U	0.74U	0.76U	0.7U	0.72U
Carbon Disulfide	208U	215U	208U	206U	213U	1.7U	1.8U	1.6U	1.7U
2,2-Dichloropropane	166U	172U	166U	165U	171U	1.4U	1.4U	1.3U	1.3U
cis-1,2-dichloroethene	97.0U	100U	96.9U	96.2U	99.5U	0.8U	0.82U	0.75U	0.77U
Bromochloromethane	114U	118U	114U	113U	117U	0.94U	0.96U	0.88U	0.9U
Chloroform	111U	115U	111U	110U	114U	0.92U	0.94U	0.86U	0.88U
1,1,1-Trichloroethane	70.7U	73.1U	70.6U	70.1U	72.5U	0.58U	0.60U	0.55U	0.56U
1,1-Dichloropropene	139U	143U	138U	137U	142U	1.1U	1.2U	1.1U	1.1U
Carbon Tetrachloride	136U	140U	136U	135U	139U	1.1U	1.2U	1.1U	1.1U
Benzene	72.1U	74.5U	72.0U	71.4U	73.9U	0.6U	0.61U	0.56U	0.57U
1,2-Dichloroethane	112U	116U	112U	111U	115U	0.93U	0.95U	0.87U	0.89U
Trichloroethene	152U	158U	152U	151U	156U	1.3U	1.3U	1.2U	1.2U
1,2-Dichloropropane	152U	158U	152U	151U	156U	1.3U	1.3U	1.2U	1.2U
Bromodichloromethane	91.5U	94.6U	91.4U	90.7U	93.9U	0.76U	0.78U	0.71U	0.73U
Dibromomethane	133U	138U	133U	132U	137U	1.1U	1.1U	1U	1.1U
cis-1,3-Dichloropropene	134U	139U	134U	133U	138U	1.1U	1.1U	1U	1.1U
Toluene	111U	4370	4190	298 J	2280	0.92U	17.4	0.86U	0.88U
trans-1,3-Dichloropropene	81.8U	84.6U	81.7U	81.0U	83.9U	0.68U	0.69U	0.63U	0.65U
1,1,2-Trichloroethane	112U	116U	112U	111U	115U	0.93U	0.95U	0.87U	0.89U
1,2-Dibromoethane	122U	126U	122U	121U	125U	1U	1U	0.94U	0.97U
Tetrachloroethene	108U	112U	108U	107U	111U	0.89U	0.92U	0.84U	0.86U
1,3-Dichloropropane	119U	123U	119U	118U	122U	0.99U	1U	0.92U	0.95U
Dibromochloromethane	80.4U	83.1U	80.3U	79.7U	82.5U	0.66U	0.68U	0.62U	0.64U
Chlorobenzene	79.0U	81.7U	78.9U	78.3U	81.1U	0.65U	0.67U	0.61U	0.63U
1,1,1,2-Tetrachloroethane	67.9U	70.2U	67.8U	67.3U	69.7U	0.56U	0.58U	0.53U	0.54U
Ethylbenzene	1780	7230	6450	893	2100	0.8U	24.6	0.75U	0.77U
m & p-Xylene	4130	24200	34100	14700	29900	1.1U	168	1.1U	1.1U
o-Xylene	367J	12800	18900	9780	17400	0.53U	81.1	0.49U	0.51U
Styrene	83.1U	86.0U	83.1U	82.4U	85.3U	0.69U	0.71U	0.64U	0.66U
2-Hexanone	596U	616U	595U	591U	611U	4.9U	5.1U	4.6U	4.7U
Bromoform	166U	172U	166U	165U	171U	1.4U	1.4U	1.3U	1.3U
Isopropylbenzene	1430	1780	1940	970	1800	0.76U	16.8	0.71U	0.73U
1,1,2,2-Tetrachloroethane	305U	315U	305U	302U	313U	2.5U	2.6U	2.4U	2.4U

Table 5-5 (continued)
Summary of Soil Analytical Data
for Soil Boring SB01

Analytes	SB01-0103	SB01-0119	SB01-0127	SB01-0138	SB01-0142	SB01-0155	SB01-0165	SB01-0173	SB01-0180
Bromobenzene	130U	135U	130U	129U	134U	1.1U	1.1U	1U	1U
1,2,3-Trichloropropane	277U	287U	277U	275U	284U	2.3U	2.4U	2.1U	2.2U
n-Propylbenzene	3320	3190	4450	2020	3640	0.66U	29.3	0.62U	0.64U
2-Chlorotoluene	108U	112U	108U	107U	111U	0.89U	0.92U	0.84U	0.86U
4-Chlorotoluene	111U	115U	111U	110U	114U	0.92U	0.94U	0.86U	0.88U
1,3,5-Trimethylbenzene	9250	11200	15500	7670	12700	2.8 J	92.6	0.54U	0.55U
tert-Butylbenzene	74.8U	77.4U	74.8U	74.2U	76.8U	0.62U	0.64U	0.58U	0.59U
1,2,4-Trimethylbenzene	22800	21000	41800	19500	35300	11.2	188	0.75U	0.77U
sec-Butylbenzene	87.3U	90.3U	87.2U	86.5U	89.6U	0.72U	15.6	0.68U	0.69U
p-Isopropyltoluene	7030	8280	9530	3330	5250	2.4 J	51.8	0.65U	0.67U
1,3-Dichlorobenzene	127U	132U	127U	126U	131U	1.1U	1.1U	0.99U	1U
1,4-Dichlorobenzene	139U	143U	138U	137U	142U	1.1U	1.2U	1.1U	1.1U
1,2-Dichlorobenzene	166U	172U	166U	165U	171U	1.4U	1.4U	1.3U	1.3U
n-Butylbenzene	4620	3630	138U	137U	142U	1.1U	26.2	1.1U	1.1U
1,2-Dibromo-3-Chloropropane	346U	358U	346U	343U	356U	2.9U	2.9U	2.7U	2.8U
1,2,4-Trichlorobenzene	152U	158U	152U	151U	156U	1.3U	1.3U	1.2U	1.2U
Hexachlorobutadiene	108U	112U	108U	107U	111U	0.89U	0.92U	0.84U	0.86U
Naphthalene	4830	3530	8590	3430	5510	10.7	28.0	1.8U	1.9U
1,2,3-Trichlorobenzene	180U	186U	180U	179U	185U	1.5U	1.5U	1.4U	1.4U
Acetone	1190U	2130 J	3150J	2210J	1520J	51.0 J	134	38.7 J	16.9 J
2-Butanone	1090U	1130U	1090U	1080U	1120U	9.0U	89.8	8.4U	8.7U
4-Methyl-2-Pentanone	499U	516U	498U	495U	512U	4.1U	4.2U	3.9U	4U
BNAs (Method 8270)	***Concentration (µg/kg)***								
Phenol	95.3U	247U	47.6U	47.3U	48.9U	49.3U	50.6U	46.1U	47.4U
Bis(-2-Chloroethyl)Ether	90.9U	235U	45.4U	45.1U	46.6U	47.0U	48.2U	44.0U	45.2U
2-Chlorophenol	93.1U	241U	46.5U	46.2U	47.8U	48.1U	49.4U	45.1U	46.3U
1,3-Dichlorobenzene	99.8U	258U	49.8U	49.5U	51.2U	51.5U	52.9U	48.3U	49.6U
1,4-Dichlorobenzene	93.1U	241U	46.5U	46.2U	47.8U	48.1U	49.4U	45.1U	46.3U
Benzyl Alcohol	88.7U	229U	44.3U	44.0U	45.5U	45.8U	47.1U	42.9U	44.1U
1,2-Dichlorobenzene	122U	315U	60.9U	60.4U	62.6U	63.0U	64.7U	59.0U	60.6U
2-Methylphenol	99.8U	258U	49.8U	49.5U	51.2U	51.5U	52.9U	48.3U	49.6U
Bis(2-Chloroisopropyl)Ether	109U	281U	54.3U	53.8U	55.7U	56.1U	57.6U	52.6U	54.0U
4-Methylphenol	95.3U	711 J	47.6U	47.3U	48.9U	49.3U	50.6U	46.1U	47.4U
N-Nitroso-Di-N-Propylamine	102U	264U	50.9U	50.5U	52.3U	52.7U	54.1U	49.4U	50.7U
Hexachloroethane	109U	281U	54.3U	53.8U	55.7U	56.1U	57.6U	52.6U	54.0U
Nitrobenzene	77.6U	201U	38.8U	38.5U	39.8U	40.1U	41.2U	37.6U	38.5U
Isophorone	62.1U	161U	31.0U	30.8U	31.9U	32.1U	32.9U	30.0U	30.8U
2-Nitrophenol	86.5U	224U	43.2U	42.9U	44.4U	44.7U	45.9U	41.8U	43.0U
2,4-Dimethylphenol	73.2U	189U	36.5U	36.3U	37.5U	37.8U	38.8U	35.4U	36.3U
Benzoic Acid	182U	470U	90.8U	90.1U	93.3U	214 J	96.5U	205 J	193 J
Bis(-2-Chloroethoxy)Methane	84.3U	218U	42.1U	41.8U	43.2U	43.5U	44.7U	40.8U	41.9U
2,4-Dichlorophenol	97.6U	252U	48.7U	48.4U	50.1U	50.4U	51.8U	47.2U	48.5U
1,2,4-Trichlorobenzene	84.3U	218U	42.1U	41.8U	43.2U	43.5U	44.7U	40.8U	41.9U

Table 5-5 (continued)
Summary of Soil Analytical Data
for Soil Boring SB01

Analytes	SB01-0103	SB01-0119	SB01-0127	SB01-0138	SB01-0142	SB01-0155	SB01-0165	SB01-0173	SB01-0180
Naphthalene	2200	3800	586	2400	2390	43.5U	44.7U	40.8U	41.9U
4-Chloroaniline	306U	791U	153U	152U	157U	158U	162U	148U	152U
Hexachlorobutadiene	90.9U	235U	45.4U	45.1U	46.6U	47.0U	48.2U	44.0U	45.2U
4-Chloro-3-Methylphenol	79.8U	206U	39.9U	39.6U	41.0U	41.2U	42.4U	38.6U	39.6U
2-Methylnaphthalene	4860	11700	2500	9650	8610	104 J	139 J	38.6U	39.6U
Hexachlorocyclopentadiene	75.4U	195U	37.7U	37.4U	38.7U	38.9U	40.0U	36.5U	37.4U
2,4,6-Trichlorophenol	73.2U	189U	36.5U	36.3U	37.5U	37.8U	38.8U	35.4U	36.3U
2,4,5-Trichlorophenol	82.0U	212U	41.0U	40.7U	42.1U	42.4U	43.5U	39.7U	40.7U
2-Chloronaphthalene	77.6U	201U	38.8U	38.5U	39.8U	40.1U	41.2U	37.6U	38.5U
2-Nitroaniline	57.6U	149U	28.8U	28.6U	29.6U	29.8U	30.6U	27.9U	28.6U
Dimethyl Phthalate	68.7U	178U	34.3U	34.1U	35.3U	35.5U	36.5U	33.3U	34.1U
Acenaphthylene	86.5U	224U	43.2U	42.9U	44.4U	44.7U	45.9U	41.8U	43.0U
2,6-Dinitrotoluene	71.0U	183U	35.4U	35.2U	36.4U	36.7U	37.6U	34.3U	35.2U
3-Nitroaniline	173U	447U	86.4U	85.7U	88.7U	89.3U	91.8U	83.7U	85.9U
Acenaphthene	71.0U	183U	35.4U	35.2U	36.4U	36.7U	37.6U	34.3U	35.2U
2,4-Dinitrophenol	66.5U	172U	33.2U	33.0U	34.1U	34.4U	35.3U	32.2U	33.0U
4-Nitrophenol	104U	269U	52.0U	51.6U	53.5U	53.8U	55.3U	50.4U	51.8U
Dibenzofuran	143 J	366 J	37.7U	37.4U	38.7U	38.9U	40.0U	36.5U	37.4U
2,4-Dinitrotoluene	66.5U	172U	33.2U	33.0U	34.1U	34.4U	35.3U	32.2U	33.0U
Diethylphthalate	79.8U	206U	39.9U	39.6U	41.0U	41.2U	42.4U	38.6U	39.6U
4-Chlorophenyl-Phenylether	75.4U	195U	37.7U	37.4U	38.7U	38.9U	40.0U	36.5U	37.4U
Fluorene	89.6 J	238 J	38.8U	38.5U	39.8U	40.1U	41.2U	37.6U	38.5U
4-Nitroaniline	131U	338U	65.3U	64.8U	67.1U	67.6U	69.4U	63.3U	65.0U
4,6-Dinitro-2-Methylphenol	102U	264U	50.9U	50.5U	52.3U	52.7U	54.1U	49.4U	50.7U
N-Nitrosodiphenylamine	86.5U	224U	43.2U	42.9U	44.4U	44.7U	45.9U	41.8U	43.0U
4-Bromophenyl-Phenylether	77.6U	201U	38.8U	38.5U	39.8U	40.1U	41.2U	37.6U	38.5U
Phenanthrene	138 J	172U	33.2U	33.0U	34.1U	34.4U	35.3U	32.2U	33.0U
Hexachlorobenzene	68.7U	178U	34.3U	34.1U	35.3U	35.5U	36.5U	33.3U	34.1U
Pentachlorophenol	124U	321U	62.0U	61.5U	63.7U	64.1U	65.9U	60.1U	61.7U
Anthracene	64.3U	166U	32.1U	31.9U	33.0U	33.2U	34.1U	31.1U	31.9U
Di-N-Butylphthalate	48.8U	126U	24.4U	24.2U	25.0U	25.2U	604	164 J	468
Fluoranthene	175 J	161U	31.0U	30.8U	31.9U	32.1U	32.9U	30.0U	30.8U
Pyrene	173 J	161U	31.0U	30.8U	31.9U	32.1U	32.9U	30.0U	30.8U
Butylbenzylphthalate	66.5U	172U	33.2U	33.0U	34.1U	34.4U	41.5 J	73.5 J	57.7 J
3,3'-Dichlorobenzidine	523U	1350U	261U	259U	268U	270U	278U	253U	260U
Benzo(a)Anthracene	59.9 J	138U	26.6U	26.4U	27.3U	27.5U	28.2U	25.8U	26.4U
Chrysene	66.0 J	143U	27.7U	27.5U	28.4U	28.6U	29.4U	26.8U	27.5U
Bis(2-Ethylhexyl)Phthalate	68.7U	274 J	57.6 J	56.5 J	60.3 J	35.5U	36.5U	33.3U	34.1U
Di-N-Octyl Phthalate	62.1U	161U	31.0U	30.8U	31.9U	32.1U	32.9U	30.0U	30.8U
Benzo(b)Fluoranthene	118U	304U	58.7U	58.2U	60.3U	60.7U	62.4U	56.9U	58.4U
Benzo(k)Fluoranthene	146U	378U	73.1U	72.5U	75.1U	75.6U	77.6U	70.8U	72.7U
Benzo(a)Pyrene	64.3U	166U	32.1U	31.9U	33.0U	33.2U	34.1U	31.9U	31.9U
Indeno(1,2,3-cd)Pyrene	73.2U	189U	36.5U	36.3U	37.5U	37.8U	38.8U	35.4U	36.3U

Table 5-5 (continued)
Summary of Soil Analytical Data
for Soil Boring SB01

Analytes	SB01-0103	SB01-0119	SB01-0127	SB01-0138	SB01-0142	SB01-0155	SB01-0165	SB01-0173	SB01-0180
Dibenzo(a,h)Anthracene	68.7U	178U	34.3U	34.1U	35.3U	35.5U	36.5U	33.3U	34.1U
Inorganics	***Concentrations (mg/kg)***								
Aluminum	6370	6510	4640	2840	3960	3470	2900	2310	1980
Antimony	6.6 J	4.8 J	4.7 J	3.6 J	3.4 J	3.7 J	3.6 J	2.4 J	2.2UJ
Arsenic	1.5	1.9	1.3	0.99	1.4	0.97	1	0.74	0.66
Barium	55.0	221	102	88.6	303	53.6	98.4	15.3	20.0
Beryllium	0.37	0.39	0.27	0.21	0.21	0.19	0.17	0.16	0.13
Cadmium	0.55U	0.57U	0.55U	0.55U	0.57U	0.57U	0.59U	0.54U	0.55U
Calcium	3540	169000	109000	113000	70300	46800	90100	21200	3330
Chromium	6.7	7.5	6.4	5.1	4.2	5	6.4	3.0	3.5
Cobalt	2.4	2.4	1.8	1.5	1.9	1.6	1.6	1.2	1.2
Copper	14.6 J	2.1 J	1.6 J	1.1UJ	1.1UJ	1.1UJ	1.2UJ	1.1UJ	1.1UJ
Iron	6260	4800	3530	2840	3300	3490	3120	2570	2500
Lead	6.2	4	2.5	1.9	2.5	2.4	1.9	2.1	1.9
Magnesium	888	5520	2760	4300	3290	3620	3810	2380	2310
Manganese	115 J	65.1 J	39.7 J	28.6 J	31.5 J	39.2 J	34.7 J	39.3 J	23.9 J
Mercury	0.089U	0.092U	0.089U	0.088U	0.091U	0.092U	0.094U	0.086U	0.088U
Nickel	28.3 J	5 J	3.4 J	2.8 J	3.3 J	2.3UJ	2.5 J	2.1UJ	2.2UJ
Potassium	968	1700	1010	587	758	768	509	434	383
Selenium	0.055U	0.057U	0.055U	0.055U	0.057U	0.057U	0.059U	0.054U	0.055U
Silver	0.55U	0.57U	0.55U	0.55U	0.57U	0.57U	0.59U	0.54U	0.55U
Sodium	163	269	150	151	132	162	140	73.1	81.7
Thallium	0.11U	0.11U	0.11U	0.11U	0.11U	0.11U	0.12U	0.11U	0.11U
Vanadium	11.4	12.4	9.3	15.8	14.1	9	10.2	8.5	7.6
Zinc	20.6	27.6	26.5	10.1	11.0	15.0	7.3	11.3	9.2
Cyanide, Total	0.56U	0.57U	0.56U	0.55U	0.57U	0.57U	0.58U	0.54U	0.55U
Petroleum Hydrocarbons	1940	5560	5120	1800	1990	83.2	141	16.1	17.6
	(%)								
Solids, Total	90.2	87.2	90.3	91.0	87.9	87.3	85	93.2	90.8

J - Indicates an estimated value above the method detection limit (MDL), but below the method reporting limit. May indicate spike recoveries outside specified quality control windows or values exceeding the instrument calibration range.

B - Analyte found in blank as well as in sample.

U - Not Detected at the Method Detection Limit shown.

Table 5-5
Summary of Soil Analytical Data
for Soil Boring SB01

Analytes	SB01-0103	SB01-0119	SB01-0127	SB01-0138	SB01-0142	SB01-0155	SB01-0165	SB01-0173	SB01-0180
VOAs (Method 8260A)	***Concentration (µg/kg)***								
Dichlorodifluoromethane	291U	301U	291U	288U	299U	2.4U	2.5U	2.3U	2.3U
Chloromethane	208U	215U	208U	206U	213U	1.7U	1.8U	1.6U	1.7U
Vinyl Chloride	180U	186U	180U	179U	185U	1.5U	1.5U	1.4U	1.4U
Bromomethane	109U	113U	109U	109U	112U	0.9U	0.93U	0.85U	0.87U
Chloroethane	208U	215U	208U	206U	213U	1.7U	1.8U	1.6U	1.7U
Trichlorofluoromethane	333U	344U	332U	330U	341U	2.7U	2.8U	2.6U	2.6U
1,1-Dichloroethene	180U	186U	180U	179U	185U	1.5U	1.5U	1.4U	1.4U
Methylene Chloride	346U	358U	346U	343U	356U	4.8 JB	5.2 JB	3.8 J	5.6 B
trans-1,2-Dichloroethene	90.1U	93.2U	90.0U	89.3U	92.4U	0.74U	0.76U	0.7U	0.72U
1,1-Dichloroethane	90.1U	93.2U	90.0U	89.3U	92.4U	0.74U	0.76U	0.7U	0.72U
Carbon Disulfide	208U	215U	208U	206U	213U	1.7U	1.8U	1.6U	1.7U
2,2-Dichloropropane	166U	172U	166U	165U	171U	1.4U	1.4U	1.3U	1.3U
cis-1,2-dichloroethene	97.0U	100U	96.9U	96.2U	99.5U	0.8U	0.82U	0.75U	0.77U
Bromochloromethane	114U	118U	114U	113U	117U	0.94U	0.96U	0.88U	0.9U
Chloroform	111U	115U	111U	110U	114U	0.92U	0.94U	0.86U	0.88U
1,1,1-Trichloroethane	70.7U	73.1U	70.6U	70.1U	72.5U	0.58U	0.60U	0.55U	0.56U
1,1-Dichloropropene	139U	143U	138U	137U	142U	1.1U	1.2U	1.1U	1.1U
Carbon Tetrachloride	136U	140U	136U	135U	139U	1.1U	1.2U	1.1U	1.1U
Benzene	72.1U	74.5U	72.0U	71.4U	73.9U	0.6U	0.61U	0.56U	0.57U
1,2-Dichloroethane	112U	116U	112U	111U	115U	0.93U	0.95U	0.87U	0.89U
Trichloroethene	152U	158U	152U	151U	156U	1.3U	1.3U	1.2U	1.2U
1,2-Dichloropropane	152U	158U	152U	151U	156U	1.3U	1.3U	1.2U	1.2U
Bromodichloromethane	91.5U	94.6U	91.4U	90.7U	93.9U	0.76U	0.78U	0.71U	0.73U
Dibromomethane	133U	138U	133U	132U	137U	1.1U	1.1U	1U	1.1U
cis-1,3-Dichloropropene	134U	139U	134U	133U	138U	1.1U	1.1U	1U	1.1U
Toluene	111U	4370	4190	298 J	2280	0.92U	17.4	0.86U	0.88U
trans-1,3-Dichloropropene	81.8U	84.6U	81.7U	81.0U	83.9U	0.68U	0.69U	0.63U	0.65U
1,1,2-Trichloroethane	112U	116U	112U	111U	115U	0.93U	0.95U	0.87U	0.89U
1,2-Dibromoethane	122U	126U	122U	121U	125U	1U	1U	0.94U	0.97U
Tetrachloroethene	108U	112U	108U	107U	111U	0.89U	0.92U	0.84U	0.86U
1,3-Dichloropropane	119U	123U	119U	118U	122U	0.99U	1U	0.92U	0.95U
Dibromochloromethane	80.4U	83.1U	80.3U	79.7U	82.5U	0.66U	0.68U	0.62U	0.64U
Chlorobenzene	79.0U	81.7U	78.9U	78.3U	81.1U	0.65U	0.67U	0.61U	0.63U
1,1,1,2-Tetrachloroethane	67.9U	70.2U	67.8U	67.3U	69.7U	0.56U	0.58U	0.53U	0.54U
Ethylbenzene	1780	7230	6450	993	2100	0.8U	34.6	0.75U	0.77U
m & p-Xylene	4130	24200	34100	14700	29900	1.1U	168	1.1U	1.1U
o-Xylene	367J	12800	18900	9780	17400	0.53U	81.1	0.49U	0.51U
Styrene	83.1U	86.0U	83.1U	82.4U	85.3U	0.69U	0.71U	0.64U	0.66U
2-Hexanone	596U	616U	595U	591U	611U	4.9U	5.1U	4.6U	4.7U
Bromoform	166U	172U	166U	165U	171U	1.4U	1.4U	1.3U	1.3U
Isopropylbenzene	1430	1780	1940	970	1800	0.76U	18.6	0.71U	0.73U
1,1,2,2-Tetrachloroethane	305U	315U	305U	302U	313U	2.5U	2.6U	2.4U	2.4U

Table 5-5 (continued)
Summary of Soil Analytical Data
for Soil Boring SB01

Analytes	SB01-0103	SB01-0119	SB01-0127	SB01-0138	SB01-0142	SB01-0155	SB01-0165	SB01-0173	SB01-0180
Bromobenzene	130U	135U	130U	129U	134U	1.1U	1.1U	1U	1U
1,2,3-Trichloropropane	277U	287U	277U	275U	284U	2.3U	2.4U	2.1U	2.2U
n-Propylbenzene	3320	3190	4450	2020	3640	0.66U	29.3	0.62U	0.64U
2-Chlorotoluene	108U	112U	108U	107U	111U	0.89U	0.92U	0.84U	0.86U
4-Chlorotoluene	111U	115U	111U	110U	114U	0.92U	0.94U	0.86U	0.88U
1,3,5-Trimethylbenzene	9250	11200	15500	7670	12700	2.9 J	92.8	0.54U	0.55U
tert-Butylbenzene	74.8U	77.4U	74.8U	74.2U	76.8U	0.62U	0.64U	0.58U	0.59U
1,2,4-Trimethylbenzene	22800	21000	41800	19500	35300	11.2	188	0.75U	0.77U
sec-Butylbenzene	87.3U	90.3U	87.2U	86.5U	89.6U	0.72U	15.8	0.68U	0.69U
p-Isopropyltoluene	7030	8280	9530	3330	5250	2.4 J	51.8	0.65U	0.67U
1,3-Dichlorobenzene	127U	132U	127U	126U	131U	1.1U	1.1U	0.99U	1U
1,4-Dichlorobenzene	139U	143U	138U	137U	142U	1.1U	1.2U	1.1U	1.1U
1,2-Dichlorobenzene	166U	172U	166U	165U	171U	1.4U	1.4U	1.3U	1.3U
n-Butylbenzene	4620	3530	138U	137U	142U	1.1U	26.2	1.1U	1.1U
1,2-Dibromo-3-Chloropropane	346U	358U	346U	343U	356U	2.9U	2.9U	2.7U	2.8U
1,2,4-Trichlorobenzene	152U	158U	152U	151U	156U	1.3U	1.3U	1.2U	1.2U
Hexachlorobutadiene	108U	112U	108U	107U	111U	0.89U	0.92U	0.84U	0.86U
Naphthalene	4830	3530	8580	3430	5510	10.7	28.0	1.8U	1.9U
1,2,3-Trichlorobenzene	180U	186U	180U	179U	185U	1.5U	1.5U	1.4U	1.4U
Acetone	1190U	2130 J	3150J	2210J	1820J	51.0 J	134	38.7 J	16.9 J
2-Butanone	1090U	1130U	1090U	1080U	1120U	9.0U	89.8	8.4U	8.7U
4-Methyl-2-Pentanone	499U	516U	498U	495U	512U	4.1U	4.2U	3.9U	4U
BNAs (Method 8270)	***Concentration (µg/kg)***								
Phenol	95.3U	247U	47.6U	47.3U	48.9U	49.3U	50.6U	46.1U	47.4U
Bis(-2-Chloroethyl)Ether	90.9U	235U	45.4U	45.1U	46.6U	47.0U	48.2U	44.0U	45.2U
2-Chlorophenol	93.1U	241U	46.5U	46.2U	47.8U	48.1U	49.4U	45.1U	46.3U
1,3-Dichlorobenzene	99.8U	258U	49.8U	49.5U	51.2U	51.5U	52.9U	48.3U	49.6U
1,4-Dichlorobenzene	93.1U	241U	46.5U	46.2U	47.8U	48.1U	49.4U	45.1U	46.3U
Benzyl Alcohol	88.7U	229U	44.3U	44.0U	45.5U	45.8U	47.1U	42.9U	44.1U
1,2-Dichlorobenzene	122U	315U	60.9U	60.4U	62.6U	63.0U	64.7U	59.0U	60.6U
2-Methylphenol	99.8U	258U	49.8U	49.5U	51.2U	51.5U	52.9U	48.3U	49.6U
Bis(2-Chloroisopropyl)Ether	109U	281U	54.3U	53.8U	55.7U	56.1U	57.6U	52.6U	54.0U
4-Methylphenol	95.3U	711 J	47.6U	47.3U	48.9U	49.3U	50.6U	46.1U	47.4U
N-Nitroso-Di-N-Propylamine	102U	264U	50.9U	50.5U	52.3U	52.7U	54.1U	49.4U	50.7U
Hexachloroethane	109U	281U	54.3U	53.8U	55.7U	56.1U	57.6U	52.6U	54.0U
Nitrobenzene	77.6U	201U	38.8U	38.5U	39.8U	40.1U	41.2U	37.6U	38.5U
Isophorone	62.1U	161U	31.0U	30.8U	31.9U	32.1U	32.9U	30.0U	30.8U
2-Nitrophenol	86.5U	224U	43.2U	42.9U	44.4U	44.7U	45.9U	41.8U	43.0U
2,4-Dimethylphenol	73.2U	189U	36.5U	36.3U	37.5U	37.8U	38.8U	35.4U	36.3U
Benzoic Acid	182U	470U	90.8U	90.1U	93.3U	214 J	96.5U	205 J	193 J
Bis(-2-Chloroethoxy)Methane	84.3U	218U	42.1U	41.8U	43.2U	43.5U	44.7U	40.8U	41.9U
2,4-Dichlorophenol	97.6U	252U	48.7U	48.4U	50.1U	50.4U	51.8U	47.2U	48.5U
1,2,4-Trichlorobenzene	84.3U	218U	42.1U	41.8U	43.2U	43.5U	44.7U	40.8U	41.9U

Table 5-5 (continued)
Summary of Soil Analytical Data
for Soil Boring SB01

Analytes	SB01-0103	SB01-0119	SB01-0127	SB01-0138	SB01-0142	SB01-0155	SB01-0165	SB01-0173	SB01-0180
Naphthalene	2200	3800	586	2400	2390	43.5U	44.7U	40.8U	41.9U
4-Chloroaniline	306U	791U	153U	152U	157U	158U	162U	148U	152U
Hexachlorobutadiene	90.9U	235U	45.4U	45.1U	46.6U	47.0U	48.2U	44.0U	45.2U
4-Chloro-3-Methylphenol	79.8U	206U	39.9U	39.6U	41.0U	41.2U	42.4U	38.6U	39.6U
2-Methylnaphthalene	4860	11700	3500	9650	8610	104 J	139 J	38.6U	39.6U
Hexachlorocyclopentadiene	75.4U	195U	37.7U	37.4U	38.7U	38.9U	40.0U	36.5U	37.4U
2,4,6-Trichlorophenol	73.2U	189U	36.5U	36.3U	37.5U	37.8U	38.8U	35.4U	36.3U
2,4,5-Trichlorophenol	82.0U	212U	41.0U	40.7U	42.1U	42.4U	43.5U	39.7U	40.7U
2-Chloronaphthalene	77.6U	201U	38.8U	38.5U	39.8U	40.1U	41.2U	37.6U	38.5U
2-Nitroaniline	57.6U	149U	28.8U	28.6U	29.6U	29.8U	30.6U	27.9U	28.6U
Dimethyl Phthalate	68.7U	178U	34.3U	34.1U	35.3U	35.5U	36.5U	33.3U	34.1U
Acenaphthylene	86.5U	224U	43.2U	42.9U	44.4U	44.7U	45.9U	41.8U	43.0U
2,6-Dinitrotoluene	71.0U	183U	35.4U	35.2U	36.4U	36.7U	37.6U	34.3U	35.2U
3-Nitroaniline	173U	447U	86.4U	85.7U	88.7U	89.3U	91.8U	83.7U	85.9U
Acenaphthene	71.0U	183U	35.4U	35.2U	36.4U	36.7U	37.6U	34.3U	35.2U
2,4-Dinitrophenol	66.5U	172U	33.2U	33.0U	34.1U	34.4U	35.3U	32.2U	33.0U
4-Nitrophenol	104U	269U	52.0U	51.6U	53.5U	53.8U	55.3U	50.4U	51.8U
Dibenzofuran	143 J	366 J	37.7U	37.4U	38.7U	38.9U	40.0U	36.5U	37.4U
2,4-Dinitrotoluene	66.5U	172U	33.2U	33.0U	34.1U	34.4U	35.3U	32.2U	33.0U
Diethylphthalate	79.8U	206U	39.9U	39.6U	41.0U	41.2U	42.4U	38.6U	39.6U
4-Chlorophenyl-Phenylether	75.4U	195U	37.7U	37.4U	38.7U	38.9U	40.0U	36.5U	37.4U
Fluorene	88.6 J	238 J	38.8U	38.5U	39.8U	40.1U	41.2U	37.6U	38.5U
4-Nitroaniline	131U	338U	65.3U	64.8U	67.1U	67.6U	69.4U	63.3U	65.0U
4,6-Dinitro-2-Methylphenol	102U	264U	50.9U	50.5U	52.3U	52.7U	54.1U	49.4U	50.7U
N-Nitrosodiphenylamine	86.5U	224U	43.2U	42.9U	44.4U	44.7U	45.9U	41.8U	43.0U
4-Bromophenyl-Phenylether	77.6U	201U	38.8U	38.5U	39.8U	40.1U	41.2U	37.6U	38.5U
Phenanthrene	128 J	172U	33.2U	33.0U	34.1U	34.4U	35.3U	32.2U	33.0U
Hexachlorobenzene	68.7U	178U	34.3U	34.1U	35.3U	35.5U	36.5U	33.3U	34.1U
Pentachlorophenol	124U	321U	62.0U	61.5U	63.7U	64.1U	65.9U	60.1U	61.7U
Anthracene	64.3U	166U	32.1U	31.9U	33.0U	33.2U	34.1U	31.1U	31.9U
Di-N-Butylphthalate	48.8U	126U	24.4U	24.2U	25.0U	25.2U	604	154 J	466
Fluoranthene	175 J	161U	31.0U	30.8U	31.9U	32.1U	32.9U	30.0U	30.8U
Pyrene	173 J	161U	31.0U	30.8U	31.9U	32.1U	32.9U	30.0U	30.8U
Butylbenzylphthalate	66.5U	172U	33.2U	33.0U	34.1U	34.4U	41.5 J	73.5 J	57.7 J
3,3'-Dichlorobenzidine	523U	1350U	261U	259U	268U	270U	278U	253U	260U
Benzo(a)Anthracene	59.9 J	138U	26.6U	26.4U	27.3U	27.5U	28.2U	25.8U	26.4U
Chrysene	68.0 J	143U	27.7U	27.5U	28.4U	28.6U	29.4U	26.8U	27.5U
Bis(2-Ethylhexyl)Phthalate	68.7U	274 J	57.6 J	56.8 J	80.1 J	35.5U	36.5U	33.3U	34.1U
Di-N-Octyl Phthalate	62.1U	161U	31.0U	30.8U	31.9U	32.1U	32.9U	30.0U	30.8U
Benzo(b)Fluoranthene	118U	304U	58.7U	58.2U	60.3U	60.7U	62.4U	56.9U	58.4U
Benzo(k)Fluoranthene	146U	378U	73.1U	72.5U	75.1U	75.6U	77.6U	70.8U	72.7U
Benzo(a)Pyrene	64.3U	166U	32.1U	31.9U	33.0U	33.2U	34.1U	31.9U	31.9U
Indeno(1,2,3-cd)Pyrene	73.2U	189U	36.5U	36.3U	37.5U	37.8U	38.8U	35.4U	36.3U

Table 5-5 (continued)
Summary of Soil Analytical Data
for Soil Boring SB01

Analytes	SB01-0103	SB01-0119	SB01-0127	SB01-0138	SB01-0142	SB01-0155	SB01-0165	SB01-0173	SB01-0180
Dibenzo(a,h)Anthracene	68.7U	178U	34.3U	34.1U	35.3U	35.5U	36.5U	33.3U	34.1U
Inorganics	***Concentrations (mg/kg)***								
Aluminum	6370	8510	4640	2840	3860	3470	2800	2310	1980
Antimony	5.6 J	4.8 J	4.7 J	3.6 J	3.4 J	3.7 J	3.6 J	2.4 J	2.2UJ
Arsenic	1.4	1.8	1.3	0.99	1.4	0.97	1	0.74	0.66
Barium	55.0	221	119	69.4	303	53.6	86.4	15.3	20.0
Beryllium	0.37	0.39	0.17	0.21	0.21	0.19	0.17	0.16	0.13
Cadmium	0.55U	0.57U	0.55U	0.55U	0.57U	0.57U	0.59U	0.54U	0.55U
Calcium	3540	169000	109000	119000	70300	46800	90100	21200	3330
Chromium	6.7	7.5	5.4	5.1	4.2	5	5.4	3.0	3.6
Cobalt	2.4	2.4	1.8	1.5	1.9	1.6	1.6	1.2	1.2
Copper	14.6 J	2.1 J	1.8 J	1.1UJ	1.1UJ	1.1UJ	1.2UJ	1.1UJ	1.1UJ
Iron	6260	4800	3530	2840	3300	3490	3120	2570	2500
Lead	6.2	4	2.5	1.9	2.5	2.4	1.9	2.1	1.9
Magnesium	888	5500	2750	4300	3290	3620	3810	2380	2310
Manganese	115 J	258 J	98.7 J	29.6 J	31.5 J	39.2 J	34.7 J	39.3 J	23.9 J
Mercury	0.089U	0.092U	0.089U	0.088U	0.091U	0.092U	0.094U	0.086U	0.088U
Nickel	28.8 J	31 J	3.4 J	2.9 J	3.3 J	2.3UJ	2.5 J	2.1UJ	2.2UJ
Potassium	968	1760	1010	587	758	768	509	434	383
Selenium	0.055U	0.057U	0.055U	0.055U	0.057U	0.057U	0.059U	0.054U	0.055U
Silver	0.55U	0.57U	0.55U	0.55U	0.57U	0.57U	0.59U	0.54U	0.55U
Sodium	163	289	150	151	132	162	140	73.1	81.7
Thallium	0.11U	0.11U	0.11U	0.11U	0.11U	0.11U	0.12U	0.11U	0.11U
Vanadium	11.4	12.4	9.3	15.8	14.1	9	10.2	8.5	7.8
Zinc	20.6	21.4	26.5	10.1	11.0	13.0	7.3	11.3	8.2
Cyanide, Total	0.56U	0.57U	0.56U	0.55U	0.57U	0.57U	0.58U	0.54U	0.55U
Petroleum Hydrocarbons	1940	5560	5120	1600	1990	63.2	141	16.1	17.8
	(%)								
Solids, Total	90.2	87.2	90.3	91.0	87.9	87.3	85	93.2	90.8

J - Indicates an estimated value above the method detection limit (MDL), but below the method reporting limit. May indicate spike recoveries outside specified quality control windows or values exceeding the instrument calibration range.
B - Analyte found in blank as well as in sample.
U - Not Detected at the Method Detection Limit shown.

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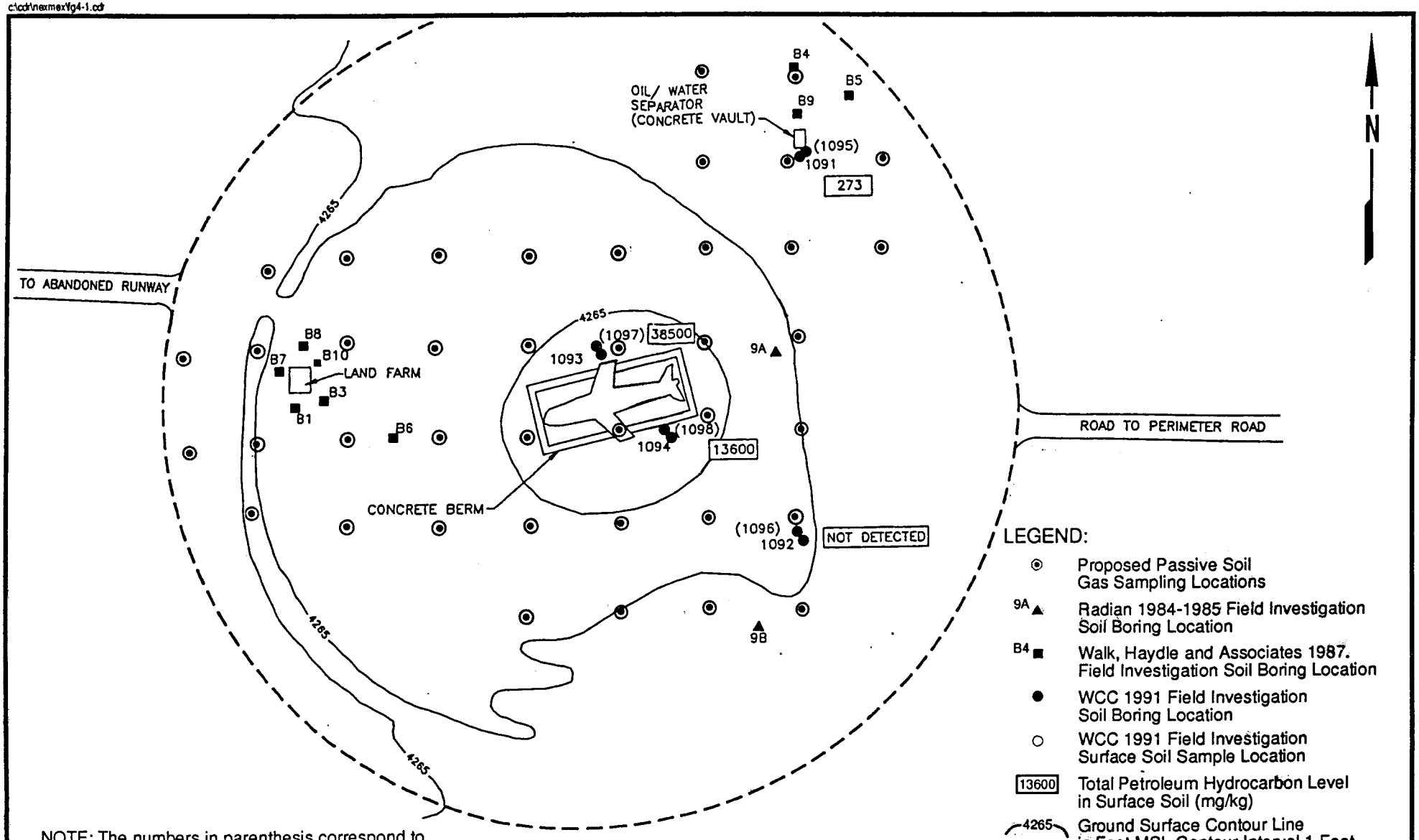

NOTE: The numbers in parenthesis correspond to redrills/resamples of the original boring/sample.

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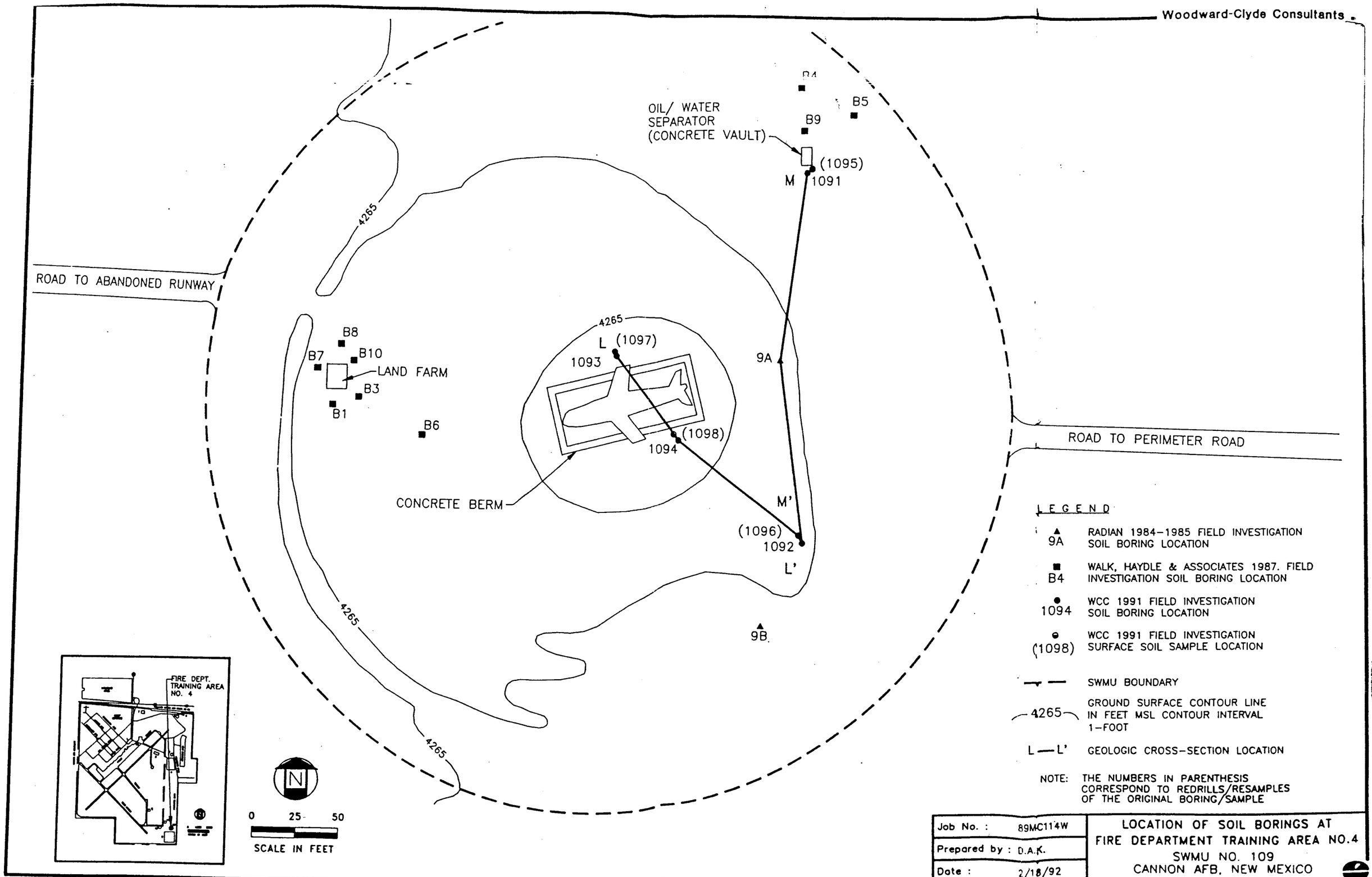
Figure 4-1

SAMPLING GRID FOR PASSIVE SOIL GAS SURVEY

CANNON AIR FORCE BASE
Clovis, New Mexico

Woodward-Clyde Consultants



Job No. : 89MC114W	LOCATION OF SOIL BORINGS AT FIRE DEPARTMENT TRAINING AREA NO.4 SWMU NO. 109 CANNON AFB, NEW MEXICO
Prepared by : D.A.K.	
Date : 2/18/92	

C1140009

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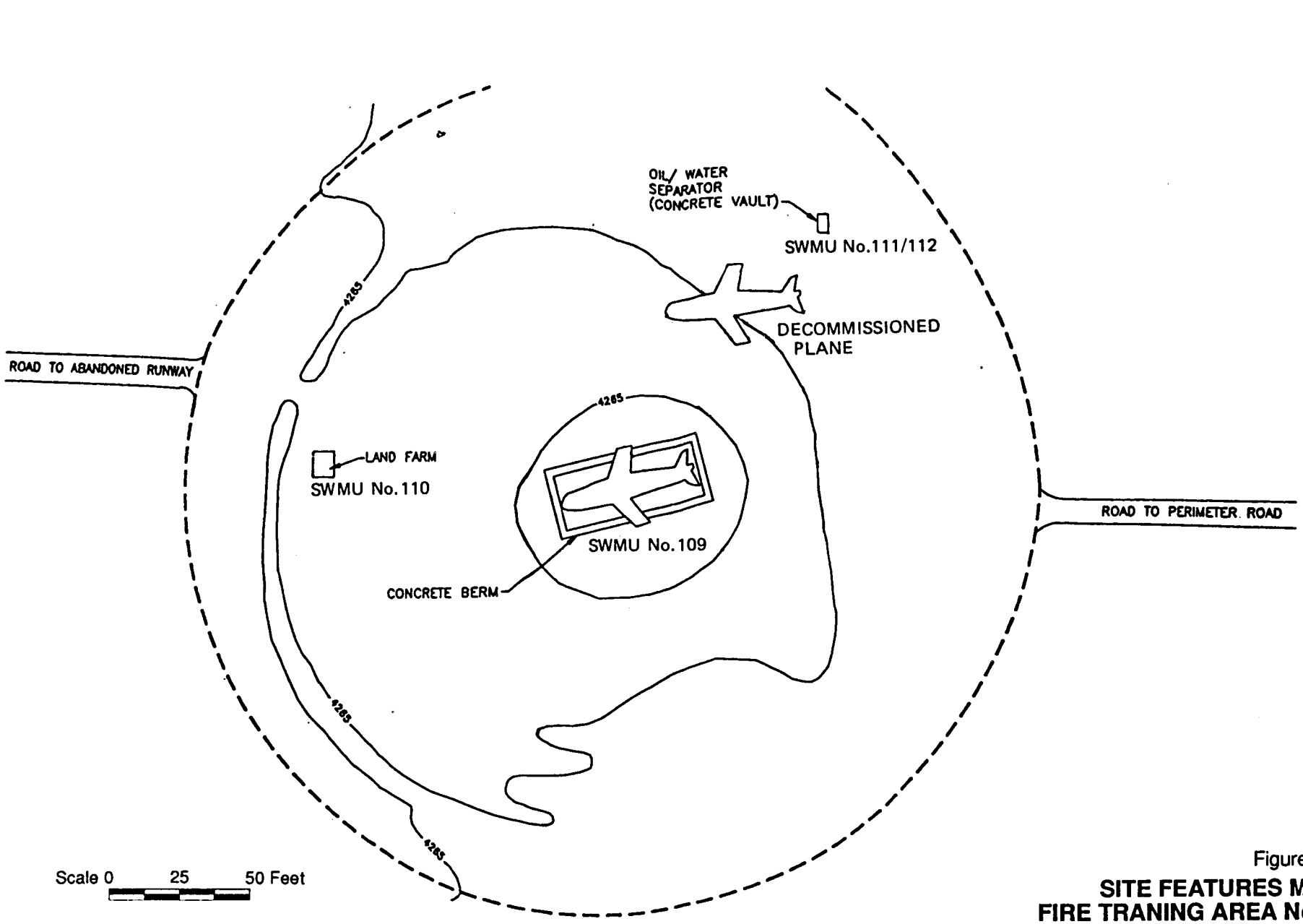

Figure 1-4

SITE FEATURES MAP
FIRE TRANING AREA No. 4
CANNON AIR FORCE BASE
Clovis, New Mexico

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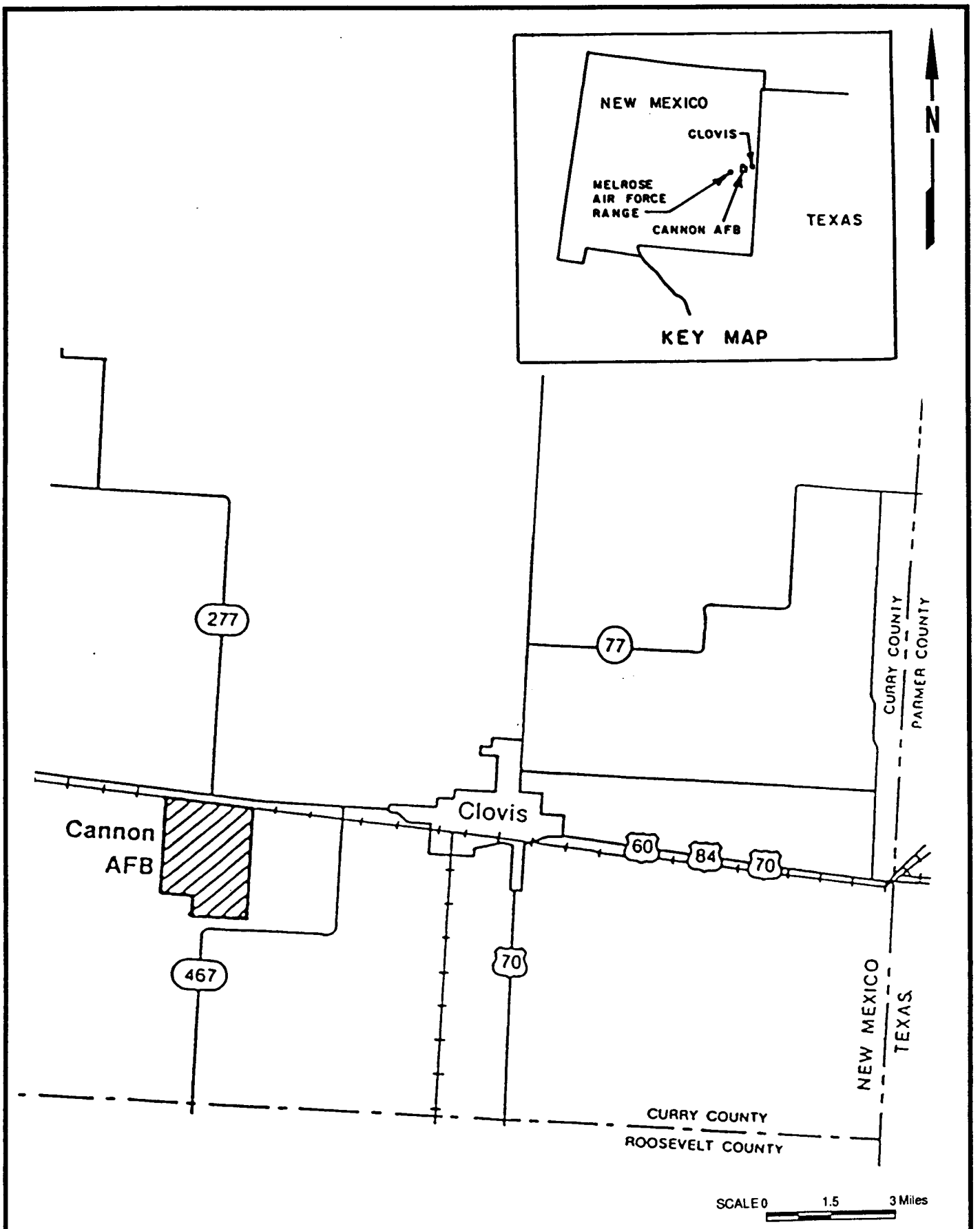

Figure 1-3
SITE LOCATION MAP
CANNON AIR FORCE BASE
Clovis, New Mexico

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State of New Mexico
ENVIRONMENT DEPARTMENT
Hazardous & Radioactive Materials Bureau
2044 Galisteo
P.O. Box 26110
Santa Fe, New Mexico 87502
(505) 827-1557
Fax (505) 827-1544

GARY E. JOHNSON
GOVERNOR

MARK E. WEIDLER
SECRETARY

EDGAR T. THORNTON, III
DEPUTY SECRETARY

APPROVAL
RFI RPT
FTA-4
SWMUS 109-112
CMS
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Certified Mail
Return Receipt Requested

June 18, 1998

David E. Clary, Colonel, USAF
Commander
100 S DL Ingram Blvd., Suite 200
Cannon Air Force Base, NM 88103-5214

Subject: Cannon Air Force Base Phase I RCRA Facility Investigation Report
Fire Training Area No. 4 (SWMU Nos. 109, 110, 111, 112)
EPA ID No. NM7572124454

Dear Colonel Clary:

The RCRA Permits Management Program (RPMP) of the New Mexico Environment Department (NMED) has reviewed for technical adequacy the above-referenced Report, as required under the New Mexico Hazardous Waste Management Regulations. The Report is dated May, 1998.

After reviewing the Report, the RPMP has found the Report to be technically adequate and approves the Report. However, the RPMP has determined that a Corrective Measures Study must be submitted to determine the most effective means of reducing TPH levels in soil to under 1,000 mg/kg, the RPMP cleanup level for TPH. TPH was detected at the site at up to 14,400 mg/kg.

If you have any questions please contact Carl Will of my staff at 505-827-1561.

Sincerely,

for

Robert S. ("Stu") Dinwiddie, Ph.D., Manager
RCRA Permits Management Program

cc: Col. James A. Thomas III, CAFB
Daniel A. Barnett, CAFB
Benito Garcia, HRMB
Bob Sturdivant, EPA Region 6

file: HSWA/CAFB/FTA-4
track: CAFB/6-18-98/Clary/Dinwiddie/FTA-4 RFI Report Approval

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS 27th FIGHTER WING (ACC)
CANNON AIR FORCE BASE NEW MEXICO

2 5 FEB 1998

ENTERED

FEB 1998

Colonel James A. Thomas III
Commander, 27th Support Group
110 E Sextant Avenue Suite 1098
Cannon AFB NM 88103-5323

Mr. Benito J. Garcia, Chief
Hazardous and Radioactive Materials Bureau
New Mexico Environment Department
2044 Galisteo Street
PO Box 26110
Santa Fe NM 87502

Dear Mr. Garcia

Enclosed is our response to your 23 Dec 97 Request for Supplemental Information on the Phase II RFI Report for Fire Training Area Number 4, (SWMUs 109-112).

If you have any questions, please contact Mr. Sanford Hutsell at (505) 784-6378 or Mr. John Pike at (505) 784-1092.

Sincerely

JAMES A. THOMAS III, Colonel, USAF

Attachment:
Response to Request for Supplemental Information

cc:
NMED (C. Will)
NMED GW Bureau (J. Jacobs)
EPA Region VI (D. Neleigh)
HQ ACC/CEVC (R. Shannon)

CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

RESPONSE TO COMMENTS BY
STATE OF NEW MEXICO ENVIRONMENT DEPARTMENT
HAZARDOUS & RADIOACTIVE MATERIALS BUREAU
PHASE II RCRA FACILITY INVESTIGATION REPORT
FIRE TRAINING AREA NO. 4 (FTA-4)
Dated December 23, 1997

1. **Comment. Section 4.0. Applicable or Relevant and Appropriate Requirements.** Table 4-1 lists the New Mexico Underground Storage Tank regulations as an Applicable or Relevant and Appropriate Requirement (ARAR) regarding soils contaminated with petroleum hydrocarbons. Specify how this ARAR will be adhered to.

   Response. The UST regulations are ARARs based on the levels of Total Petroleum Hydrocarbons (TPH) detected at the site. The text will be modified to reflect that an ARAR has been exceeded. A CMS to reduce TPH at the site would describe how the ARAR would be adhered to. See response to comment number 4.

2. **Comment. Section 5.4. Nature and Extent of Contamination.** It is HRMB policy to require two consecutive non-detects to delineate contamination in the vertical direction. Because there are SVOC and TPH detections at the deepest sampling points of several borings, the vertical extent of contamination has not been determined with certainty. For this reason, HRMB would like to be sure that groundwater monitoring exists that will detect releases to groundwater if such releases occur. Submit information on groundwater flow that indicates whether existing monitor wells for Landfill No. 5 will detect releases to groundwater from Fire Training Area No. 4. The probability of releases to groundwater is low enough that it may not be necessary to install an additional well for FTA-4 only. However, if existing monitor wells are not adequate, HRMB would like to discuss the possibility of installing an additional well in a location that might detect releases from both FTA-4 and Landfill No. 5. This could possibly be done when new monitor wells are required for Landfill No. 5 because of dropping water tables.

   Response. Most, if not all, of the monitoring wells for Landfill No. 5 are located in the downgradient flow direction from FTA-4. The closest monitoring wells (MW-A and MW-Q) are upgradient monitoring wells for Landfill No. 5. They are located in relatively close proximity to FTA-4. Additional information will be added to the text of the report discussing groundwater flow direction at the base and monitoring wells that would provide information in the unlikely event that a

release occurred at FTA-4. We concur that an additional well to solely monitor FTA-4 is not needed.

3. **Comment. Sections 5.4.2.1 and 5.4.2.2. Volatile Organic Compounds and Semi-Volatile Organic Compounds.** The text states that only SB01 contained detectable VOC's. Table 5-5 indicates unqualified detections of acetone and methylene chloride as well. The text states that only two SVOC's were detected, while Table 5-5 indicates that there were several unqualified detections of a third SVOC, di-n-butylphthalate. Explain the discrepancy or revise the text to accurately describe all detections above method reporting limits (MRL's) and background levels.

   Response. Methylene chloride, acetone, and di-n-butylphthalate were detected in many of the samples and in many, but not all, laboratory blanks. Concentrations in the samples and blanks, where detected, were similar. These also are common laboratory contaminants. Although not always flagged "B", their occurrence is judged to be attributable to laboratory contamination. Text will be added to these sections providing additional explanation.

   MRL's are sample-specific. A table providing all MRL's would have to include each sample and each constituent analyzed. MRL's are provided on the appended laboratory data sheets and a table of typical MRLs for the soil VOC and SVOC could be generated. A specific reference to the locations of documents for MRL's will be provided.

4. **Comment. Section 5.4.2.4. Total Recoverable Petroleum Hydrocarbons.** Submit a Corrective Measures Study (CMS) workplan for reduction of Total Petroleum Hydrocarbons (TPH) to below HRMB's cleanup level of 1,000 mg/kg. TPH was detected at the site at up to 14,400 mg/kg.

   Response. Funding is not available to conduct a CMS at FTA-4 at this time. Funding will be requested from Air Combat Command (ACC).

5. **Comment. Table 5-5.** Include an explanation of the "J" flag or code used in the table, i.e., why the values are estimated. Values can be estimated for various reasons with differing impacts on the reliability of the data.

   Response. "J" flags are used as defined by USEPA for data qualifiers, and an explanation is provided in the QCSR. Essentially, the "J" flag is used to indicate detections above the equipment detection limit, but below the quantitation limit and thus estimated. It is also used when spike recoveries are outside specified quality control windows and when values present exceed the instrument calibration range. The note on the table will be expanded.

6. **Comment. Section 7.2.1. Data Evaluation and Treatment.** Page 7-1, line 27 references a Quality Control Summary Report (Harza, June 30, 1997). Submit a copy of this report to HRMB.

Response. A copy of the QCSR was sent to HRMB after receipt of the original HRMB supplemental information request (comments).

7. **Comment. Section 7.3.1. Characterization of Exposure Setting.** Because the human health risk assessment is not based on the most conservative exposure scenario (i.e., residential), approval of the human health risk assessment is pending HRMB review of Department of Defense (DoD) base closure procedures that provide notice to future property owners that risk has not been assessed for residential use. HRMB is reviewing CAFB's November 21, 1997 response to HRMB's comment regarding this issue contained in the September 19 1997 Notice of Deficiency for Appendix II and III SWMU's.

Response. Additional text will be included to explain in more detail why a residential scenario was not addressed in this risk assessment. The explanation will include a discussion of Cannon AFB's Base Comprehensive Plan (BCP) which has present and future land use specifications for Fire Training Area No. 4. The Base's Real Estate Division and Planning Department area also aware of what is included in the BCP as long as the base continues to operate as a military facility. In the unlikely event that Cannon AFB should close, the Base Realignment and Closure (BRAC) will re-evaluate the land-use scenarios before the property is released for sale.

8. **Comment. Section 7.3.2. Identification of Potential Exposure Pathways.** At page 7-6, the report states that military personnel spend 15.6 days per year at the site, construction workers will work at the site 45 days per year, and visitors and trespassers visit the site 50 days a year for 30 years. What is the source of these exposure figures and are these numbers being used consistently throughout the Air Force or DoD?

Response. The Department of Defense and the Air Force do not have any policy concerning standard default exposure factors for military personnel. The exposure scenarios were based on professional judgement considering site conditions, foreseeable land use at FTA-4 and the continuing active operations at CAFB. Further explanation will be provided in the text as to how these exposure factors were derived and the text will be sent to NMED for approval prior to incorporation into the revised final report.

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1	1	98/02/25

6. REQUISITION NUMBER

7. DATE MATERIAL REQUIRED *(YYMMDD)*
98/02/26

8. PRIORITY

2. TO: *(Include ZIP Code)*
New Mexico Environment Department Hazardous & Radioactive Management Bureau
Administrative & Special Programs
2044 Galisteo Santa Fe, New Mexico 87505

9. AUTHORITY OR PURPOSE
See Attached Letter

10. SIGNATURE
Christine Shifflett

11a. VOUCHER NUMBER & DATE *(YYMMDD)*
C. Shifflett

3. SHIP TO - MARK FOR
ATTN: Mr. Benito Garcia
(505)827-1557

12. DATE SHIPPED *(YYMMDD)*

b.
27 CE/CEV x6022

13. MODE OF SHIPMENT
Federal Express JP-1

14. BILL OF LADING NUMBER

15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NO.

4. APPROPRIATIONS SYMBOL AND SUBHEAD	OBJECT CLASS	EXPENDITURE ACCOUNT *(From)*	*(To)*	CHARGEABLE ACTIVITY	BUREAU CONTROL ACTIVITY NO.	BUREAU CONTROL NO.	AMOUNT

ITEM NO. (a)	FEDERAL STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIAL AND / OR SERVICES (b)	UNIT OF ISSUE (c)	QUANTITY REQUESTED (d)	SUPPLY ACTION (e)	TYPE CON-TAINER (f)	CON-TAINER NOS. (g)	UNIT PRICE (h)	TOTAL COST (i)
01	Response to Request for Supplemental Information on FTA-4 package. I certify that this shipment does not contain any hazardou or classifiedmaterial. CS							

16. TRANSPORTATION VIA MATS OR MSTS CHARGEABLE TO

17. SPECIAL HANDLING

18. RECAPITULATION OF SHIPMENT	ISSUED BY	TOTAL CON-TAINERS	TYPE CON-TAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE
	C Shifflett					
	CHECKED BY					
	PACKED BY					
				← TOTAL →		

19. RECEIPT		DATE *(YYMMDD)*	BY	SHEET TOTAL
	CONTAINERS RECEIVED EXCEPT AS NOTED			
	QUANTITIES RECEIVED EXCEPT AS NOTED	DATE *(YYMMDD)*	BY	GRAND TOTAL
	POSTED	DATE *(YYMMDD)*	BY	20. RECEIVER'S VOUCHER NO.

DD Form 1149, DEC 93
(EF-V1) *(PerFORM*

51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

PREVIOUS EDITIO[illegible] BE USED.