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DEPARTMENT OF THE AIR FORCE

HEADQUARTERS 49TH FIGHTER WING (ACC)
HOLLOMAN AIR FORCE BASE, NEW MEXICO

RECEIVED
APR 2008
NMED Hazardous Waste Bureau

MEMORANDUM FOR NEW MEXICO ENVIRONMENT DEPARTMENT
Attn: Mr. James Bearzi
Hazardous Waste Bureau
2905 Rodeo Park Drive East
Santa Fe NM 87105-6303

APR 14 2008

FROM: 49 CES/CEV
550 Tabosa Ave
Holloman AFB NM 88330-8458

Subject: Final Accelerated Corrective Measures (ACM) Completion Report Sites SS-12 and OT 20, Holloman AFB, NM

1. The subject work plan is hereby submitted to NMED for review and approval.

2. I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

3. If you have any questions, please feel free to contact David Scruggs at (575) 572-5395.

A. DAVID BUDAK
Deputy Base Civil Engineer

Attachment:
Report Sites Binder (SS-12 and OT 20).

cc:

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FINAL

ACCELERATED CORRECTIVE MEASURES COMPLETION REPORT SITES SS-12 AND OT-20

HOLLOMAN AIR FORCE BASE, NEW MEXICO

Prepared for:

49 CES/CEV
Holloman Air Force Base
New Mexico

Under Contract To:

U.S. Army Corps of Engineers
Omaha, Nebraska
Contract No. DACA45-03-D-0023
Task Order No. 21

Prepared by:

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Bhate Project No. 9050361.03

April 2008
Revision No. 00

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FINAL

ACCELERATED CORRECTIVE MEASURES COMPLETION REPORT SITES SS-12 AND OT-20

HOLLOMAN AIR FORCE BASE, NEW MEXICO

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LIST OF ACRONYMS

AAF	Army Air Field
ACC	Air Combat Command
ACM	Accelerated Corrective Measures
amsl	Above mean sea level
AOC	Area of Concern
ASTM	American Society for Testing and Materials
atm-m^3/mol	Atmosphere-cubic meters per mole
bgs	Below ground surface
Bhate	Bhate Environmental Associates, Inc.
°C	Degrees Celsius
cm	Centimeters
cm/sec	Centimeters per second
COPCs	Chemicals of potential concern
DPT	Direct push technology
DQO	Data quality objectives
DRO	Diesel Range Organics
ERP	Environmental Restoration Program
EM	Exposure Model
°F	Degrees Fahrenheit
ft	Feet or foot
g/mole	Grams per mole
GPS	Global Positioning System
GRO	Gasoline Range Organics
H	Henry's law constant
HAFB	Holloman Air Force Base
HQ	Hazard Quotient
J	Laboratory Qualifier (denotes a lab estimated value)
J&E	Johnson and Ettinger
MCL	Maximum Contaminant Level
MCPA	2-Methyl-4-Chlorophenoxyacetic Acid
MDL	Method detection limit
µg/g	Micrograms per gram
µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter
mg/L	Milligrams per liter
mg/kg	Milligrams per kilogram
NFA	No Further Action
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department

LIST OF ACRONYMS (CONTINUED)

NMWQCC	New Mexico Water Quality Control Commission
ORO	Oil Range Organics
PCBs	Polychlorinated Biphenyls
PCS	Petroleum Contaminated Soil
PID	Photoionization detector
PVC	Polyvinyl chloride
QAPP	Quality Assurance Project Plan
RA	Risk Assessment
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RI	Remedial Investigation
SI	Site Investigation
SOP	Standard Operating Procedure
SSLs	Soil Screening Levels
STL	Severn Trent Laboratories
SVOC	Semi-volatile organic compound
SWMU	Solid Waste Management Unit
TDS	Total dissolved solids
TFH	Total Fuel Hydrocarbons
TPH	Total petroleum hydrocarbon
TRPH	Total recoverable petroleum hydrocarbons
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound
WRCC	Western Regional Climate Center
WSMR	White Sands Missile Range

1 INTRODUCTION

Bhate Environmental Associates, Inc., (Bhate) has been retained by the U.S. Army Corps of Engineers (USACE), Omaha District, under contract DACA45-03-D0023, Task Order No. 21 to conduct Accelerated Corrective Measures (ACM) at Environmental Restoration Program (ERP) Sites SS-12 (Northeast Fuel Line Spill Site) and OT-20 (Sewage Lagoons Disposal Trenches) at Holloman Air Force Base (HAFB), New Mexico.

This *Accelerated Corrective Measures Completion Report* documents the additional investigations at SS-12 and OT-20 that were designed to fill in the data gaps to identify and define the presumed petroleum contaminated soil (PCS) and/or hazardous constituent source areas. Groundwater conditions were also evaluated at each site. These Sites are listed as Area of Concern (AOC) K (SS-12) and Solid Waste Management Unit (SWMU) 113A (OT-20) in Appendix 4-A of the HAFB Resource Conservation and Recovery Act (RCRA) *Hazardous Waste Facility Permit No. NM6572124422* issued by the New Mexico Environment Department (NMED) on February 24, 2004.

1.1 Objectives

The primary objectives of the ACM conducted at Sites SS-12 and OT-20 were to review available historical information and collect additional soil and groundwater data to fill in the data gaps identified in the previous investigations to determine the location of hazardous waste source area(s). In the event that a hazardous waste source area(s) was identified (soil containing chemicals and/or metals above the current NMED soil screening levels or equivalent) the next objective was to remove, through excavation and properly dispose of the contaminated soil.

The objectives were stated in the *Final Accelerated Corrective Measures Work Plan Multiple Sites, Holloman, AFB, New Mexico* (Bhate, 2007). The Work Plan was revised to include deficiencies outlined by NMED in correspondence dated March 30, 2007 (see Attachment A of this report). Additionally, this report summarizes the previously known and current subsurface conditions, and impacts to groundwater. During this process, required data were collected to support the closure of the sites based on guidance from the NMED. The ultimate objective is to achieve No Further Action (NFA) approval for site closure from NMED.

This report presents the current nature and extent of the soil and groundwater contamination (if present), and the conclusions and recommendations for two of the nine sites requiring further investigation and/or source removal that were included in the *Final Accelerated Corrective Measures Work Plan, Holloman, AFB, New Mexico* (Bhate, 2007). The remaining seven sites (OT-03, SS-18, OT-32, OT-37, OT-38, RW-42, and OT-45) will be evaluated under separate completion reports.

1.2 Purpose of the ACM Investigation

The primary purpose of the ACM is to comply with the requirements of RCRA Permit number NM6572124422 by completing the sampling program identified in the Scope of Work and applying site-specific data quality objectives identified in the HAFB *Basewide Quality Assurance Project Plan* (Basewide QAPP) (Bhate, 2003). The data quality objectives include:

- Generate data to characterize contaminant sources; and
- Determine to the extent possible the nature and extent of contamination in the site media.

1.3 Scope of Work

The following summary of the work performed under this ACM is detailed in the *Final Accelerated Corrective Measures Work Plan, Multiple Sites, Holloman AFB, New Mexico* (Bhate, 2007) and included:

- Review existing information about the site;
- Conduct a site and environs reconnaissance;
- Collect additional soil and groundwater data;
- Identify potential receptors (for OT-20 risk based evaluation); and
- Evaluate all information collected.

An additional investigation was completed at SS-12 and OT-20 to meet the project objectives. The following activities were performed by Bhate from June through August 2007.

1.3.1 SS-12 Northeast Fuel Line Spill Site

The objectives of the additional investigation at Site SS-12 were to delineate a potential PCS source area and to evaluate the current groundwater conditions. These objectives were accomplished by subsurface soil sampling and sampling the existing groundwater monitoring well network. Twelve soil borings (SS12-DP01 through SS12-DP12) were drilled along the storm sewer drainage ditch and where the JP-4 fuel pipeline had been ruptured in 1979. Twelve subsurface soil samples (one per borehole) were collected for chemical analysis. Two additional boreholes (SS12-DP13 and SS12-DP14) were installed for collecting undisturbed soil samples for geotechnical analysis. Groundwater samples were collected from existing monitoring wells WL-12-01, WL-12-02, and WL-12-03. The samples were analyzed for the following parameters:

- Volatile Organic Compounds (VOCs) using United States Environmental Protection Agency (USEPA) Method 8260B (soil and groundwater);
- Semi-volatile organic compounds (SVOCs) using USEPA Method 8270C (soil and groundwater);
- Total Petroleum Hydrocarbons (TPH) Gasoline Range Organics (GRO)/Diesel Range

Organics (DRO)/Organic Range Organics (ORO), using USEPA method 8015B (soil only);
- RCRA Metals using USEPA Methods 6010B and 7471A/7470A (soil and groundwater); and
- Total Dissolved Solids (TDS) using USEPA Method 160.1 (groundwater only).

Two geotechnical samples were collected and analyzed for the following:

- Moisture Content using American Society for Testing and Materials (ASTM) Method 160.3M;
- Dry Bulk Density using ASTM Method D2937-94M;
- Specific Gravity using ASTM Method 1429; and
- Fractional Organic Carbon Content using ASTM Method D2974-87.

1.3.2 OT-20 Sewage Lagoons Disposal Trenches

The objectives of the additional investigation at Site OT-20 were to confirm the locations of the three sewage grit disposal trenches, characterize the sewage grit for source removal, and evaluate the current groundwater conditions at the site. These objectives were accomplished by subsurface soil sampling, permanent monitoring well installation, and groundwater sampling. Six soil borings (OT20-DP01 through OT20-DP06) were drilled; 3 subsurface soil samples were collected for chemical analysis (OT20-DP01, -DP02, and –DP03), and 2 undisturbed soil samples were collected for analyzing geotechnical parameters (OT20-DP05 and OT20-DP06). Boreholes (OT20-DP04 through OT20-DP06) were converted into monitoring wells (OT20-MW01 through OT20-MW-03). An additional downgradient monitoring well (OT20-MW04) was installed in August 2007. Groundwater samples were collected from monitoring wells OT20-MW01, OT20-MW02, OT20-MW03, and OT20-MW04.

Groundwater and soil samples collected at each site were analyzed for the following:

- VOCs using USEPA Method 8260B (soil and groundwater);
- SVOCs using USEPA Method 8270C (soil and groundwater);
- TPH GRO/DRO/ORO, using USEPA method 8015B (soil only);
- Pesticides using USEPA Method 8081A (soil and groundwater);
- Polychlorinated Biphenyls (PCBs) using USEPA Method 8082 (soil and groundwater);
- Herbicides using USEPA Method 8151A (soil and groundwater);
- RCRA Metals using USEPA Methods 6010B and 7471A/7470A (soil and groundwater); and
- TDS using USEPA Method 160.1 (groundwater only).

Two geotechnical samples were collected and analyzed at each site for the following:

- Moisture Content using USEPA 160.3M
- Dry Bulk Density using ASTM Method D2937-94M;
- Specific Gravity using ASTM Method 1429; and
- Fractional Organic Carbon Content using ASTM Method D2974-87.

1.4 Document Organization

This ACM Report has been modeled after the format suggested in the RCRA Facility Investigation (RFI) Report Requirements found in the HAFB RCRA Permit NM6572124422 (Appendix 4-B of the Permit). The document contains the following 5 sections:

- Section 1 – Introduction
- Section 2 – Site Background and Historical Data Review
- Section 3 – Environmental Setting
- Section 4 – Site Specific Results, the Nature and Extent of Contamination, and the Site Specific Risk Based Evaluation (OT-20 only) as well as the Conclusions and Recommendations
- Section 5 – References

The tables and figures referenced throughout this ACM Completion Report are included following the text (after Section 5). Attachment A contains correspondence from the NMED regarding the ACM Work Plan.

This report also includes the following six Appendices:

- Appendix A – Historical Data from Previous Investigations
- Appendix B – Soil Boring Logs and Monitoring Well Construction Diagrams
- Appendix C – Field Sampling Documentation
- Appendix D – Analytical Data Packages
- Appendix E – Laboratory Analysis and Data Validation Summary with Data Validation Reports
- Appendix F – Geotechnical Data Package

2 SITE-SPECIFIC BACKGROUND AND HISTORICAL DATA REVIEW

Since 1983, the two sites addressed in this ACM Completion Report have been the subject of a series of environmental investigations related to evaluating the soil and groundwater conditions to determine the various site-specific sources of VOCs, SVOCs, petroleum hydrocarbons, pesticides, herbicides, PCBs, and metals contamination. This section provides the site background and overview of the previous investigations conducted at SS-12 and OT-20 from 1983 through 1996. Most of the site-specific information presented in this section was obtained from the following historical reports:

- *Installation Restoration Program Records Search for Holloman Air Force Base, New Mexico,* August 1983, CH_2M Hill.
- *Draft Final Remedial Investigation (RI) Report, Investigation, Study and Recommendation for 29 Waste Sites, Holloman Air Force Base, NM,* June 1992, Radian Corporation.
- *Draft Final Preliminary Assessment and Site Investigation Report, Investigation of Four Waste Sites, Holloman Air Force Base, NM,* November 1993, Radian Corporation.
- *Technical Memorandum Installation Restoration Sites SS-12, SD-27, and OT-45,* June 1996, Foster Wheeler Environmental Corporation and Radian International LLC.

The analytical results and sample locations for the surface soil, subsurface soil, and groundwater samples collected during the previous investigations for SS-12 and OT-20 are included in Appendix A of this report.

2.1 Holloman AFB Site Description

Holloman AFB is located in south central New Mexico, in the northwest central part of Otero County, approximately 75 miles north-northeast of El Paso, Texas (see Figure 2-1 of this report). HAFB has a population of 6,000 and occupies about 50,000 acres in the northeast quarter of Section 1, Township 17 South, and Range 8 East. The White Sands Missile Range testing facilities occupy additional land extending northward from the Base. Private and public owned lands border the remainder of HAFB. The major highway servicing HAFB is Highway 70, which runs southwest from the town of Alamogordo and separates HAFB from publicly owned lands to the south. Alamogordo is the county seat for Otero County, has a population of approximately 35,000 and is located approximately 7 miles east of the base. The economy of Alamogordo depends largely upon Holloman AFB and other military installations in the area.

HAFB was first established in 1942 as Alamogordo Army Air Field (AAF). From 1942 through 1945, Alamogordo AAF served as the training grounds for over 20 different flight groups, flying primarily B-17s, B-24s, and B-29s. After World War II, most operations had ceased at the base. In 1947, Air Material Command announced the air field would be its primary site for the testing and development of un-manned aircraft, guided missiles, and other research programs. On January 13, 1948, the Alamogordo installation was renamed Holloman Air Force Base, in honor of the late Col. George V. Holloman; a pioneer in guided missile research. The facility mission remained largely unchanged until 1971, although the facility identification changed several times during the 20-year span: Air Force Missile Test Center (1951-1952), Holloman Air Development Center (1952-1957), and Air Force Missile Development Center (1957-1971). The Tactical Air Command operated the facility form 1972 to 1992 and housed the 49th Tactical Fighter Wing, 479th Tactical Training Wing, 833rd Air Division, and 4449th Mobile Support Squadron. In 1992, Holloman AFB was realigned under the Air Combat Command (ACC) and also serves as the training center for the German Air Force's Tactical Training Center.

2.2 SS-12 Northeast Fuel Line Spill Site

2.2.1 Site Description and Background

This site is an Area of Concern and is listed on Table A of the HAFB RCRA Permit as Northeast Fuel Line Spill Site, AOC-K. Site SS-12, is located immediately east of the main housing area at HAFB (see Figure 2-2 of this report). In 1975, approximately 2,000 gallons of JP-4 were spilled at the site as a result of a rupture (due to excessive pressure) in the main pipeline that serves the HAFB POL area. The majority of fuel was reportedly collected in a pit and pumped into a truck shortly after the spill. In 1992, petroleum product was allegedly encountered while installing a utility trench west and upgradient of the pipeline.

2.2.2 Previous Investigations

A record search for Site SS-12 was conducted by CH_2M Hill in 1982 (CH_2M Hill, 1983). The site was not considered to present a significant concern for adverse effects on health or the environment. Since 1993, SS-12 has been the subject of two environmental investigations related to evaluating the soil and groundwater conditions. The initial investigation was a Site Investigation conducted by Radian in 1993. A follow-on soil sampling investigation was performed by Foster Wheeler in 1994. The chronology and findings of the previous investigations conducted at Northeast Fuel Line Spill Site are presented below. Soil boring and monitoring well locations for the previous investigations conducted at SS-12 are shown on Figure 2-3 of this report.

2.2.2.1 Site Investigation

The site was investigated in November 1992 and February 1993 during a Site Investigation (SI) conducted by Radian Corporation. The following information was obtained from the *Chemical Data Acquisition Plan (CDAP), Investigation of Four Waste Sites Holloman Air Force Base, NM*

(Radian, 1993a) and the *Draft Final Preliminary Assessment and Site Investigation Report, Investigation of Four Waste Sites, Holloman Air Force Base, NM* (Radian, 1993b). The SI focused on two principal areas of possible contamination: the segment of the JP-4 pipeline that ruptured in 1975 and an area where the alleged fuel product was encountered during the sewer installation. The scope of work for the SS-12 SI included the following field activities:

- A passive soil-gas survey was conducted at the site using a grid of 32 samplers. During the installation of the samplers, visibly contaminated soil was observed along the pipeline at a depth of 1 foot below ground surface (ft bgs). Twenty-four (24) of the passive soil gas samplers were misplaced and one was broken. The remaining seven samplers were analyzed for aromatic compounds and petroleum hydrocarbons (Radian, 1993a).

- A second, real-time soil-gas survey was conducted to obtain more information (Radian, 1993a).

- Six soil borings (BH-12-01 through BH-12-06) were installed to collect soil samples (one per borehole) for chemical analysis in the potentially contaminated areas along the storm sewer and pipeline. The six soil samples were analyzed for total fuel hydrocarbons (TFH) (Radian, 1993b).

- Three of the soil borings (BH-12-01, -02, and -03) were completed as monitoring wells (WL-12-01 through WL-12-03). The wells were installed in potential source areas to determine the local groundwater flow direction and whether there had been a release to groundwater. One round of groundwater samples were collected and analyzed for TFH (Radian, 1993b).

The soil-gas surveys at Site SS-12 indicated potential contamination along both the pipeline in the vicinity of the storm sewer drainage and the storm sewer between two houses in the Base housing area (Buildings 2461 and 2464). The passive and real-time soil gas sampling locations and results are included in Appendix A-1-1 of this report. Kerosene was detected (35 micrograms per gram [µg/g]) in the soil sample from BH-12-02 (0 to 2 ft bgs) located adjacent to the JP-4 pipeline and near a ditch that receives runoff from the storm sewer. This detection of kerosene is more likely a result of runoff from the storm sewer that accumulates in the ditch (Foster Wheeler, 1996). In addition, a very low level (3.1 µg/g) of an unidentified organic compound eluting in the diesel range was also detected in one soil sample from the 2-4 ft depth at BH-12-06. TFH was not detected in any of the other four soil samples collected at the site.

Benzene (0.49 micrograms per liter [µg/L]) and toluene (0.66 µg/L) were detected in the groundwater sample from WL-12-01. Benzene (0.4 µg/L) and ethylbenzene (3.6 µg/L) were detected in the sample from monitoring well WL-12-02. Both of these wells are located along the JP-4 pipeline. All of the concentrations for benzene, toluene, and ethylbenzene were well below their respective New Mexico Water Quality Control Commission (NMWQCC) standards (20.6.2.301 New Mexico Administrative Code [NMAC]) and the USEPA drinking water standards. No petroleum constituents were detected in the sample from monitoring well WL-12-03, located adjacent to the storm sewer.

The analytical results and sample locations for the soil-gas, subsurface soil, and groundwater samples collected during the SI are included in Appendix A-1-2 of this report. The *Draft Final Preliminary Assessment and Site Investigation Report, Investigation of Four Waste Sites, Holloman Air Force Base, NM* (Radian, 1993b) determined based on a qualitative risk assessment that detected concentrations did not pose a potential risk to human health and the environment and recommended site closure.

2.2.2.2 Additional Sampling

NMED reviewed the results of the SI and requested additional sampling. To address the NMED's concerns, additional sampling was performed by Foster Wheeler in 1994. The following information was obtained from the *Technical Memorandum, Installation Restoration Sites SS-12, SD-27, and OT-45* (Foster Wheeler and Radian, 1996). Two soil borings (94-12-01 and 94-12-02) were drilled and soil samples were collected from within and below a gray soil layer identified during the SI. Six additional soil samples were collected and analyzed for VOCs, SVOCs, and total recoverable petroleum hydrocarbons (TRPH).

Visible staining was noted from approximately 5.2 to 6.2 ft bgs in soil boring 94-12-01 and from 0 to 11.8 ft bgs in boring 94-12-02. Subsurface soil samples were collected within and below the gray layer in both boreholes. The only VOCs or SVOCs detected were low concentrations of acetone and methylene chloride which are common laboratory contaminants and are not indicative of petroleum contamination. The maximum concentration of TRPH (590 mg/kg) was detected in the sample from 94-12-01 from the 2 to 4 ft depth. This detection of TRPH is below the NMED TPH screening guideline for kerosene as jet fuel of 940 mg/kg (NMED, 2006a).

The analytical results and sample locations for the subsurface soil samples collected during this additional investigation are included in Appendix A-1-3 of this report. The *Technical Memorandum, Installation Restoration Sites SS-12, SD-27, and OT-45* (Foster Wheeler, 1996) also recommended site closeout.

2.3 OT-20 Sewage Lagoons Disposal Trenches

2.3.1 Site Description and Background

This site is a SWMU and is listed on Table A of the HAFB RCRA Permit as the Sludge Disposal Trenches near Lagoons, SWMU 113A. From the beginning of Base operations to approximately 1984, all settled solids from the grit chamber located at the headworks of the wastewater treatment plant were buried in three distinct pits just east of Pond B in the southwest corner of HAFB (see Figure 2-2 of this report). The pits were reported to be approximately 2 feet wide, 5 feet deep, and 40 feet long and were dug perpendicular to the pond and reportedly covered an area approximately 200 to 300 feet north-south. The *Installation Restoration Program, Records Search for Holloman Air Force Base, New Mexico* (CH_2M Hill, 1983) indicated that small amounts of solvents and heavy metals may have been associated with the grit material. Additionally, PCBs have been identified at the adjacent sewage lagoons and in the grit disposal material.

2.3.2 Previous Investigations

The OT-20 record search concluded that the site was not considered to present any significant concern for adverse effects on health or the environment. The site was investigated in September 1991 during a Remedial Investigation (RI) conducted by Radian. The following information was obtained from the *Draft Final Remedial Investigation (RI) Report, Investigation, Study and Recommendation for 29 Waste Sites, Holloman Air Force Base, NM* (Radian, 1992). The scope of work for the OT-20 RI included the following field activities:

- Several trenches were excavated with a backhoe in order to locate the grit burial sites. Two trenches were dug approximately 40 ft apart in a north-south direction parallel to the fence, extending approximately 300 ft. Several smaller trenches were dug at the southern end of the site to investigate small mounds of soil and other signs of disturbance.

- One soil boring was drilled into each of the three identified waste disposal pits (SB-20-01 through SB-20-03). Two subsurface soil samples were collected (one discrete interval from within the grit waste and one composite sample of the native undisturbed soil below the waste) from each borehole. These soil samples were analyzed for VOCs, total metals, herbicides, pesticides, and PCBs. The locations of the trenches and soil borings installed during the RI conducted at OT-20 in 1991 are shown on Figure 2-4 of this report.

Identifiable grit waste was observed at three locations within the eastern 300 ft transect trench. The upper surfaces of the three identified grit disposal pits were all within 1.0 ft bgs. The southern most pit (containing SB-20-01) began at 0.4 ft and extended to 1.9 ft bgs, the middle pit (containing SB-20-02) began at 0.2 ft and extended to 1.3 ft bgs and the northern most pit began at 0.9 ft and extended to 8 ft bgs. The grit burial pits were all approximately 2 to 3 ft wide and less than 20 ft long, none of the grit disposal pits were identified within the western 300 ft transect trench.

Based on subsurface soil sample results, the grit waste placed into the disposal pits contained a variety of organic constituents. The organochlorine pesticides 4,4'-DDE, aldrin, endosulfan II, endrin aldehyde, heptachlor epoxide, and gamma-BHC were detected in the waste samples collected from SB-20-01 and SB-20-03. All of these pesticides were detected below their respective Soil Screening Levels (SSLs) (NMED, 2006) except for heptachlor. Heptachlor was detected above the SSL (1,080 micrograms per kilogram [µg/kg]) in soil boring SB-20-03 with a concentration of 5,000 µg/kg. The only herbicide that was detected was dicamba (220 µg/kg) which was also found in the SB-20-03 soil sample. The PCB aroclor 1254 was detected in the samples collected from each soil boring. The concentrations of aroclor 1254 exceeded the SSL (1,120 µg/kg) in the samples collected from SB-20-02 (2,200 µg/kg) and SB-20-03 (4,800 µg/kg). All other PCBs were not detected. Four VOCs (benzene, methylene chloride, toluene, and xylenes) were detected in each of the samples. Methylene chloride and toluene were both detected in the laboratory blank samples; therefore the presence of these constituents is suspect. Additionally, the detections of benzene and xylenes contained in the sample from SB-20-03 are estimated (concentrations are below the detection limit). All metals detected in the subsurface soil samples were below their respective SSLs.

The analytical results and sample locations for the subsurface soil samples collected during the OT-20 RI are included in Appendix A-2 of this report. The RI Report (Radian, 1992) recommended no further action for Site OT-20.

3 ENVIRONMENTAL SETTING

The following subsections present the environmental setting. This information was obtained primarily from the *Draft Final Remedial Investigation (RI) Report, Investigation, Study and Recommendation for 29 Waste Sites, Holloman Air Force Base, NM* (Radian, 1992), unless cited otherwise.

3.1 Physiography and Topography

Holloman AFB is located within the Sacramento Mountains Physiographic Province. HAFB is approximately 59,600 acres in area, and is located at a mean elevation of 4,093 feet above mean sea level (amsl). The region is characterized by high tablelands with rolling summit plains; cuesta-formed mountains dipping eastward and of west-facing escarpments with the wide bracketed basin forming the basin and range complex. The Base is located within the Tularosa Basin, which is part of a 170 mile long structural depression. The basin is bounded on the south by a low topographic divide near the Texas state line; on the west (about 30 miles) by the uplifted Organ, San Andes and Oscura Mountains; on the north by Chupadera Mesa; and on the east (about 10 miles) by the uplifted Jicarilla and Sacramento Mountains. The surrounding mountains rise abruptly to altitudes of 7,000 to 12,000 feet amsl. At its widest, the basin is about 60 miles east to west and stretches approximately 150 miles north to south.

The Tularosa Basin is a closed basin that contains all of the surface flow within its boundaries. Surface runoff from the surrounding mountains has deposited alluvial fans on the interior of the plain. Around the base, the ground surface is undulating comprised of alluvial fan deposits, eolian dunes, and flat bottomed playas (pan shaped depressions carved by wind erosion). To the west of the Base lie the gypsum sand dune fields of the White Sands National Monument. A topographic map of the base is provided in Figure 3-1 of this report.

3.2 Surface Water and Hydrology

Within the boundaries of the Base, surface water runoff is controlled by several arroyos that trend to the southwest (see Figure 3-2 of this report). The nearest inflow of surface waters to the Base comes from the Lost River, located in the north-central region of the Base. HAFB is dissected by several other southwest trending arroyos that control the surface drainage. Hay Draw arroyo is located in the far north. Malone and Rita's Draw, which drain into the Lost River, and Dillard Draw arroyos are located along the eastern perimeter of the Base. Approximately 10,000 years ago, indications are of a much wetter climate. The present day Lake Otero encompassed a much larger area, possibly upwards of several hundred square miles. Its remains are the Alkali Flat and Lake Lucero. Lake Lucero is a temporary feature of merely a few inches in depth during the rainy season.

Ancient lakes and streams deposited water bearing deposits over the older bedrock basement material. Fractures, cracks, and fissures in the Permian and Pennsylvanian bedrock yield small quantities of relatively good quality water in the deeper peripheral. Potable water is only found from a handful of wells near the edges of the basin with more saline water towards the center. Two of the principal sources of potable water are a long narrow north-south trending area east of Tularosa and Alamogordo and in the far southwestern part of the basin. Alamogordo's water, as well as the Base's, is supplied from Lake Bonito (which is in the Pecos River Basin).

3.3 Regional Geology and Soils

3.3.1 Geology

The Tularosa Basin is the easternmost extension of the Basin and Range Providence of the western United States. The Basin and Range was created by Cenozoic extensional (normal) faulting of Precambrian- through Tertiary-age sedimentary and igneous rocks. The basin is a graben, or downthrown block, bounded by the upthrown fault blocks of the San Andres and Sacramento Mountains.

During the Permian period of the Paleozoic era (approximately 270 million years ago), southern New Mexico was covered by a shallow sea. Limestone and sandstone were deposited, forming thick sedimentary units. Toward the end of the Mesozoic era (approximately 70 million years ago), the major mountain building activities that formed the Rocky Mountains took place. During these events, southern New Mexico emerged from the ocean as the earth's crust upwarped gently in this region. During the Cenozoic era (beginning approximately 70 million years ago), basin and rang formation was initiated in what is now the southwestern United States. Approximately 10 million years ago, Cenozoic faulting formed the graben structure known as the Tularosa Basin. During this process, arched portions of rock collapsed between large-scale, north-south trending faults. The Tularosa Basin is a central downthrown area, bounded on the east and west by fault block mountains. Bedded Permian strata can be seen along the faces of the Sacramento and San Andres Mountains. Permian limestones also occur west of HAFB in a low bedrock outcrop near Hurtz Spring. In the millions of years following, rainfall, snowmelt, and wind eroded the mountain sediments depositing them in the valley (i.e. Tularosa Basin). Water carrying eroded limestone, dolomite, gravel, and other matter continue to flow into the basin. A generalized cross-section of the Tularosa Basin is shown in Figure 3-3 of this report.

As the Tularosa Basin is a bolson, which is a basin with no surface drainage outlet, sediments carried by surface water into a closed basin are bolson deposits. The overlying alluvium generally consists of unconsolidated gravels, sands, and clays. The bolson sediments within the Tularosa Basin are derived from the adjacent ranges as erosional deposits of limestone, dolomite, and gypsum. Coarser material is deposited at the base of the mountains while finer material is carrier to the basin's interior. The bolson fill deposits thin out from Alamogordo to less than 100 feet near Hurtz Spring. Bolson fill deposits are 8,000 feet thick or more in the central portion of the Tularosa Basin.

Near-surface geologic conditions at HAFB have been established during this and numerous other ERP investigations. The near-surface bolsom deposits at HAFB consist of sediments that are alluvial, eolian, and lacustrine in origin. The alluvial fan deposits are laterally discontinuous units of interbedded sand, silt, and clay while the eolian deposits consist primarily of gypsum sands. The eolian and alluvial deposits are usually indistinguishable because the wind simultaneously reworks alluvial fan sediments and deposits gypsum sands resulting in an intermingling of the two sediment types. The playa, or lacustrine deposits, consist of medium to high plastic clay containing gypsum crystals and are contiguous with the alluvial fan and eolian deposits throughout HAFB. There has been the identification of stiff caliche layers, varying in thickness, at different areas of the Base. A generalized near surface cross-section for HAFB is shown in Figure 3-4 of this report.

3.3.2 Soils

The United States Department of Agriculture (USDA) Soil Conservation Service has identified two soil associations in the vicinity of Holloman AFB; the Holloman-Gypsum Land-Yesum complex, and the Mead silty clay loam. The permeability of these horizons ranges from $4x10^{-4}$ to $1 \; x10^{-3}$ centimeters per second (cm/sec). The distribution of soils in the vicinity of Holloman AFB is depicted on Figure 3-5 of this report (USDA, 1981).

The Holloman-Gypsum land-Yesum complex, 0 to 5 percent slopes soil consists of large areas of shallow and deep, well drained soils and areas of exposed gypsum. The Holloman soil makes up about 35 percent of the complex. Typically, the surface layer is light brown very fine sandy loam about 3 inches thick. The upper 13 inches of the substratum is pink very fine sandy loam that is very high in gypsum. Below that, the substratum is white gypsum to a depth of more than 60 inches. This soil is calcareous and mildly alkaline to moderately alkaline throughout. Permeability is moderate, and available water capacity is very low.

Gypsum land makes up about 30 percent of the Holloman-Gypsum land-Yesum complex, 0 to 5 percent slopes. Typically, less than 1 inch of very fine sandy loam overlies soft to hard, white gypsum. The deep Yesum very fine sandy loam makes up about 20 percent of the complex. Typically, the surface layer is light brown very fine sandy loam about 3 inches thick. The upper 9 inches of the substratum is light brown fine sandy loam that is very high in gypsum. Below that, the substratum is pink very fine sandy loam to a depth of more than 60 inches. The soil is calcareous throughout and is mildly alkaline. Permeability is moderate, and available water capacity is moderate. Many fine gypsum crystals are found throughout the profile.

The soil type located across the main drainage area for the installation is Mead silty clay loam, 0 to 1 percent slopes. This deep, poorly drained, nearly level soil is on outer fringes of alluvial fans. This soil formed in fine textured alluvium over lacustrine lake sediment. It is very high in salt content because of periodic flooding and poor drainage. Slopes are smooth and concave. Typically, the surface layer is reddish brown silty clay loam and clay loam about 5 inches thick. The substratum, to a depth of 48 inches, is light reddish brown clay that has a high content of salts. Below that, the substratum is lacustrine material of variable texture and color to a depth of more than 60 inches. Included with this soil are areas of Holloman soils and Gypsum land along the margins of the unit of steep, short gully sides and knolls. These inclusions make up about 15 percent of the map unit for this soil type. Individual areas are generally smaller than 10 acres. This soil is moderately calcareous throughout and is moderately to strongly alkaline. It has a layer of salt that is more soluble than gypsum. Permeability is very slow, and available water capacity is low.

3.4 Regional Hydrogeology

Groundwater occurs as an unconfined aquifer in the unconsolidated deposits of the central basin, with the primary source of recharge as rainfall percolation and minor amounts of stream run-off along the western edge of the Sacramento Mountains. Surface water/rainfall migrates downward into the alluvial sediments at the edge of the shallow aquifer near the ranges, and flows downgradient through progressively finer-grained sediments towards the central basin. Because the Tularosa Basin is a closed system, water that enters the area only leaves either through evaporation or percolation. This elevated amount of percolation results in a fairly high water table. Beneath HAFB, groundwater ranges from 5 to 50 feet bgs. Flow for the Base is generally towards the southwest with localized influences from the variations in the topography of the Base. In the northern and western portions of the Base, groundwater flows more to the west toward the Ritas Draw, Malone Draw, and Lost River drainages. Groundwater flow is affected by local topography in areas immediately adjacent to arroyos, where groundwater flows directly toward the drainages regardless of the regional flow pattern.

Figure 3-6 of this report shows the basewide groundwater flow direction obtained from water level measurements collected during the 2002 Long Term Monitoring groundwater sampling event. Groundwater quality in the Tularosa Basin is of potable quality at the recharge areas in close proximity to the Sacramento Mountains and becomes increasingly mineralized toward the central portion of the basin and discharge areas (Radian, 1992). The majority (over 70 %) of the ERP Sites/Solid Waste Management Units located across HAFB, have groundwater monitoring wells containing water with an average TDS concentration greater than 10,000 milligrams per liter (mg/L). This TDS data supports the hypothesis that TDS concentrations below 10,000 mg/L at HAFB are caused by dilution of natural groundwater from leaking water lines and surface irrigation from the domestic water supply. TDS concentrations greater than 10,000 mg/L exceed the NMWQCC limit as potable water and thus, the groundwater beneath HAFB has been designated as unfit for human consumption. Additionally, based on the USEPA document, *Guidelines for Groundwater Classification Under EPA Groundwater Protection Strategy* (USEPA, 1986), the groundwater can be classified as III B. Class III B groundwater is characterized by having a TDS concentration greater than 10,000 mg/L, and a low degree of interconnection to adjacent surface waters or groundwater of a higher class. Because the Tularosa is a closed basin, its groundwater does not discharge or connect to any adjacent aquifer. Adjacent surface waters include groundwater surfacing in Lake Holloman. TDS in Lake Holloman ranges from a winter low of 12,400 mg/L to a summer high of 17,000 mg/L (Cole, et al., 1981); therefore, groundwater at Holloman AFB is not interconnected with surface water of a higher class.

3.5 Site Specific Geology and Hydrogeology

This section presents the site specific geology and hydrogeology for Sites SS-12 and OT-20 that are included in this ACM Completion Report.

3.5.1 SS-12 Geology and Hydrogeology

The description of the Northeast Fuel Line Spill Site (SS-12) site geology is based upon the 20 soil borings completed between the 1993 Site Investigation (Radian, 1993b), an additional sampling event in 1994 (Foster Wheeler and Radian, 1996), and this ACM field investigation. These three investigations defined subsurface conditions at site SS-12 via direct sampling and observation of drilling operations. Drilling logs and monitoring well construction diagrams for the two previous investigations can be found in Appendices A-1-2 and A-1-3 of this report. Drilling logs for the ACM investigation can be found in Appendix B-1 of this report. The site SS-12 lithology consists primarily of silty sands and clayey silts. The first 2 to 3 feet are primarily clay and clayey silts. Fine grained, well rounded sand clasts are interspersed within the clays, with the sand becoming a larger constituent from 3 to 6 feet. From 6 feet down to 17 feet the site is primarily saturated very fine grained clayey sand. At approximately 14 to 17 feet a, dense, basal, silty clay begins.

Groundwater at SS-12 occurs in clayey sands in a shallow unconfined aquifer approximately 2.5 to 5 ft bgs. At SS-12, there are three monitoring wells (WL-12-01 through WL-12-03) that are screened from 2.5 to 5.2 feet below ground surface. In June 2007, depth to groundwater measurements ranged from 5.30 to 8.40 feet below the top of polyvinyl chloride (PVC) casing and groundwater elevations ranged from 4,061.09 to 4,060.80 feet amsl. Tables 3-1 and 3-2 of this report present the groundwater elevation data and monitoring well construction details respectively. A potentiometric surface map was prepared using the data collected in June 2007 (see Figure 3-7 of this report). Groundwater flows southeast toward Dillard Draw (similar to what Radian observed in March 1993) and the hydraulic gradient is approximately 2.15×10^{-3}. Dillard Draw is an arroyo that runs north to south along the eastern border of SS-12 and Holloman AFB. Dillard Draw influences groundwater flow at this site, away from the typical southwest flow direction seen elsewhere around the main base area.

3.5.2 OT-20 Geology and Hydrogeology

The description of the geology of Site OT-20 is based upon nine soil borings completed between September 1991 (Remedial Investigation) and this ACM field investigation. The drilling logs associated with the two investigations at OT-20 are included in Appendices A-2 and B-2. Based on these logs, the soils at OT-20 are primarily low plasticity sandy soils interbedded with very fine grained quartz clasts. These near surface sandy soils are well sorted and dry with increasing moisture towards the capillary fringe located at approximately 5 feet bgs. Below the capillary fringe, there is a saturated silty sand unit stretching across the site.

At OT-20, groundwater occurs in a very shallow sandy unconfined aquifer approximately 6.5 to 7.0 feet bgs. At OT-20 there are four monitoring wells (OT20-MW01 through OT20-MW04) that are screened from 4.2 and 14.7 feet bgs. The monitoring well construction diagrams for these wells are included in Appendix B-2 of this report. In August 2007, depth to groundwater measurements ranged from 5.81 to 7.10 feet below the top of PVC casing and groundwater elevations ranged from 4,037.56 to 4,038.12 feet above mean sea level. Tables 3-3 and 3-4 present the groundwater elevation data and monitoring well construction details respectively. A potentiometric surface map was prepared using the data collected in August 2007 (see Figure 3-8 of this report). Groundwater flows to the south toward a man made surface impoundment (Lagoon G) and the hydraulic gradient is approximately 2.5 x 10^{-3}. The man made surface impoundment (Lagoon G) influences groundwater flow direction at this site away from the typical southwest direction seen elsewhere around the main base area. It was also noted during development and purging that recharge rates were very slow at wells OT20-MW01, OT20-MW02, and OT20-MW04.

3.6 Climate

As a whole, New Mexico has a mild, arid to semi-arid continental climate characterized by light precipitation totals, abundant sunshine, relatively low humidity, and relatively large annual and diurnal temperature range (Western Regional Climate Center [WRCC], 2003). The climate of the Central Closed Basins varies with elevation. The Base is found in the low areas and is characterized by warm temperatures and dry air. Daytime temperatures often exceed 100 degrees Fahrenheit (°F) in the summer months and are in the middle 50s in the winter. A preponderance of clear skies and relatively low humidity permits rapid night time cooling resulting in average diurnal temperature ranges of 25 to 35°F. Potential evapotranspiration, at 67 inches per year, significantly exceeds annual precipitation, usually less than 10 inches. The very low rainfall amounts resulting in the arid conditions, which with the topographically induced wind patterns combining with the sparse vegetation, tend to cause localized "dust devils". The annual rainfall for Alamogordo is 12 inches per year[1]. Much of the precipitation falls during the mid-summer monsoonal period (July and August) as brief, yet frequent, intense thunderstorms culminating to 30 – 40% of the annual total rainfall.

3.7 Current and Future Land Use

The land surrounding Holloman AFB consists of residential areas to the east and northeast (City of Alamogordo), rangeland to the south, the White Sands National Monument to the west, and areas where military activities are conducted to the north. The desert terrain of the area immediately surrounding Holloman AFB has limited development, and there are no agricultural operations, residential communities, or large industrial operations located adjacent to the Base. Holloman AFB is an active military installation and is expected to remain active for the foreseeable future. No transfer of military property to the public is anticipated, and public access to the Base is restricted.

Residential development on the Base is limited by environmental and operational constraints imposed by the 100-year floodplain, historic sites, and areas identified under the Installation Restoration Program. Safety and noise zones also limit residential development on Holloman

[1] http://countrystudies.us/united-states/weather/new-mexico/

AFB. Future plans for residential development on the Base include renovation of existing structures, replacement of inefficient buildings, and expansion into open areas in the southeast corner of the Base (HAFB, 2000). Future land use is not expected to differ significantly from current land use practices.

3.8 Current and Future Water Use

At present, the primary fresh water resource for the City of Alamogordo and Holloman AFB is Lake Bonita, 60 miles northeast of the Tularosa Basin. Currently, there are no potable supplies of groundwater or surface water located on the Base. Holloman AFB obtains its water supply from the City of Alamogordo and the Holloman AFB wells in the Boles, San Andres, and Douglas well fields at the base of the Sacramento Mountains. No water supply wells are located on or near the Base because of poor groundwater quality (TDS greater than 10,000 mg/L). The nearest production well downgradient from Holloman AFB is a livestock well located 11 miles southwest of Holloman AFB. There are no potable or irrigation wells near to or immediately downgradient of the Base. Storm water run-off at SS-12 is controlled by the ditch that flows to the east towards Dillard Draw. Within the boundaries of OT-20, storm water run-off is controlled by the minimal topographic relief as per the existing grade and minimal landscaping.

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4 SITE SPECIFIC RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

This section presents the Site Specific investigations, results, conclusions, and recommendations conducted during the ACM at SS-12 and OT-20.

4.1 SS-12 Northeast Fuel Line Spill Site

4.1.1 Site Investigation

The objectives of the additional investigation at site SS-12 were to delineate a potential PCS source area and to evaluate the current groundwater conditions of the site. To meet these objectives the following field activities at SS-12 were preformed during the ACM investigation in June 2007:

- Twelve soil borings (SS12-DP01 to SS12-DP12) were drilled and sampled, in order to delineate the potential PCS source area associated with the ruptured JP-4 fuel line (1975);
- A round of groundwater samples were collected from three previously installed monitoring wells (WL-12-01 through WL-12-03) to characterize the current groundwater quality at the site; and
- Two geotechnical samples were collected from upgradient borings SS12-DP13 and SS12-DP14, to provide geotechnical data of non-impacted soils at the site.

Prior to beginning field work a Base Dig Permit (AF Fm 103) with a utility clearance, was submitted and approved by the proper authority. All completed field and waste handling activities at SS-12 were performed in accordance with HAFB Standard Operating Procedures (SOPs), provided in the *Basewide Quality Assurance Project Plan* (Bhate, 2003) and *Bhate Standard Operating Procedures* (Bhate, 2002), as outlined in the *Final Accelerated Corrective Measures Work Plan, Multiple Sites, Holloman AFB, New Mexico* (Bhate, 2007).

4.1.1.1 Subsurface Soil Sampling

In early June 2007, twelve direct push technology (DPT) soil borings (SS12-DP01 through SS12-DP12) were advanced at Site SS-12 (see Figure 2-3 of this report). These soil borings were advanced using an AMS® Incorporated, truck mounted 9600 direct push drill rig, and a five foot Geoprobe® Dual Tube sampling system. Each boring was continuously sampled every 5 feet to a depth of 10-15 feet bgs. One soil sample for chemical analysis was collected from each boring at various intervals from 4 to 10 feet bgs.

Soils were visually classified in the field by a Geologist according to the Unified Soil Classification System. Soils were screened with a MiniRAE® 2000 VOC photoionization detector (PID) with soil-headspace screening techniques to assist in the selection of samples for laboratory analysis. Prior to soil-headspace screening, a sample aliquot was collected from each interval using an Encore™ sampler (for VOCs), to prevent volatilization of the sample. One soil sample was selected from each boring from the interval where the PID reading was the highest. Soil samples were placed in the appropriate containers, packed on ice at 4 degrees Celsius (°C), and delivered under chain-of-custody to Severn Trent Laboratories (STL) in Denver, Colorado. Soil boring logs for SS-12 are included in Appendix B-1 of this report.

In addition, two samples were collected for geotechnical analysis. The samples were collected from two additional upgradient borings (SS12-DP13 and SS12-DP14), to provide geotechnical data for non-impacted soils at the site (see Figure 2-3 of this report). Each sample was collected at approximately 2 feet bgs, above the water table where the lithology is representative of the site, and analyzed for dry bulk density, specific gravity, moisture content, and fractional organic carbon content. The geotechnical samples were collected in a thin-walled soil sampler to ensure a non disturbed sample, and shipped under chain-of-custody to Accutest Laboratories in Orlando, Florida.

4.1.1.2 Groundwater Sampling

In June 2007, groundwater samples were collected from the three existing monitoring wells (WL-12-01, WL-12-02, and WL-12-03) shown in Figure 2-3 of this report. Prior to sampling groundwater, water levels were taken at each monitoring well and each well was subsequently purged. The monitoring wells were purged utilizing low flow techniques. A peristaltic pump and disposable polyethylene tubing were placed at mid screen, in accordance with HAFB SOPs. Each well was pumped at an average of less than 1 liter per minute, and sampled for VOCs, SVOCs, TDS, and RCRA metals. All samples for RCRA metals analysis were filtered in-line through a disposable 0.45 micron filter. Appendix C of this report includes the Monitoring Well Sample Collection Forms. Groundwater samples were placed in the appropriate containers, packed on ice at 4° C, and delivered under chain-of-custody to STL in Denver, Colorado.

4.1.2 Nature and Extent of Contamination

This section presents the soil, geotechnical, and groundwater analytical results from the ACM field investigation completed at Site SS-12 by Bhate in June 2007. This section also presents the current nature and extent of contamination found in the soil and groundwater during this investigation. The soil and groundwater sampling locations from this investigation are shown on Figure 2-3.

The objectives of the ACM at Site SS-12 were to: 1) determine if any soil, and/or groundwater contamination currently exist at the site, 2) delineate the current horizontal and vertical extent of the contamination (if present), and 3) collect the proper data meeting the data quality objectives to support closure of the site based on guidance from the NMED. Soil, geotechnical, and groundwater analytical results are summarized in Tables 4-1, 4-2, and 4-3 of this report, respectively. Duplicate samples were collected in soil borings SS12-DP04-10 and SS12-DP08-5 and in monitoring well WL-12-01 for groundwater. The complete analytical data packages for this investigation as provided by Severn Trent Laboratories are presented in Appendix D of this report. The Laboratory Analysis and Data Validation Summary and Reports are included in Appendix E of this report.

4.1.2.1 Soil Analytical Results

The 12 soil samples collected from soil borings SS12-DP01 through SS12-DP12 during the ACM investigation were analyzed for VOCs, SVOCs, TPH (DRO, GRO, and ORO), and RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver). The subsurface soil samples collected during the SS-12 ACM investigation were collected from 4 to 10 feet bgs. The last digit of the sample identification number indicates the bottom of the sample interval; the SS-12 analytical results for soil are summarized in Table 4-1 of this report.

Seven VOCs were detected above the reporting limit in samples collected from five soil borings (DP05, DP06, DP08, DP11, and DP12). The maximum concentrations (detected at 5 feet bgs in DP08, DP11, and DP12) of acetone (56 µg/kg), benzene (10 µg/kg), n-butylbenzene (29 µg/kg), sec-butylbenzene (660 µg/kg), isopropylbenzene (470 µg/kg), n-propylbenezene (390 µg/kg), and tert-butylbenzene (25 µg/kg) were all below their respective SSLs (NMED, 2006a). Estimated concentrations of tetrachloroethene, 2-butanone, and naphthalene were detected above the method detection limit (MDL) but less than the reporting limit, and all other VOCs were not detected. With the exception of one estimated concentration of dibenzofuran (94 J µg/kg) and fluorene (65 J µg/kg) detected in the DP08 duplicate sample at 5 feet bgs, all SVOCs were not detected above the method detection limit.

TPHs were analyzed for GRO ($C_6 - C_{10}$), DRO ($C_{10} - C_{22}$), and ORO ($>C_{22} - C_{36}$). The TPH-GRO and DRO fractions were detected in the method blanks associated with each of the SS-12 soil samples, therefore all TPH-GRO and DRO results have been qualified by the laboratory (STL) with a "B". In turn, these samples have been qualified, per the USEPA National Functional Guidelines, by the validating chemist as estimated "J" (Appendix E). TPH-GRO ranged from 0.49 J milligrams per kilogram (mg/kg) to 220 J mg/kg and TPH-DRO ranged from 1.9 J mg/kg to 480 J mg/kg. TPH-ORO was not detected above the method detection limit in any of the SS-12 soil samples. The maximum concentrations of TPH-GRO (220 J mg/kg) and DRO (480 J mg/kg) were detected in the subsurface soil sample collected from DP08 at 5 feet bgs. The combined TPH-GRO and DRO concentration for this sample was 700 mg/kg which is below the NMED TPH screening guideline for kerosene and jet fuel of 940 mg/kg (NMED, 2006b).

Six of the eight RCRA metals were detected above the method detection limit. Maximum concentrations of these six metals were detected in samples collected from 10 feet bgs at DP04, 9 feet bgs at DP06, and 5 feet bgs at DP11. The maximum concentrations of barium (150 mg/kg), cadmium (0.32 J mg/kg), chromium (16 mg/kg), arsenic (2.6 J mg/kg), mercury (6.7 J mg/kg), and lead (8.6 mg/kg) were all detected below their respective SSLs (NMED, 2006a).

The two geotechnical samples collected from SS12-DP13 and DP14 were analyzed for bulk density, fractional organic carbon, moisture content, and specific gravity. The geotechnical analytical results are presented in Table 4-2 of this report. The geotechnical borehole locations are also shown on Figure 2-3 of this report. Lab results from the geotechnical analysis are included in Appendix F of this report.

4.1.2.2 Groundwater Analytical Results

The three groundwater samples collected from WL-12-01, WL-12-02, and WL-12-03 were analyzed for VOCs, SVOCs, RCRA metals, and TDS. The analytical results are presented in Table 4-3 of this report and the monitoring well locations are shown on Figure 2-3 of this report.

Low concentrations of several VOCs were detected above the method detection limit in monitoring wells WL-12-01 and WL-12-02. The maximum concentrations of 1,1-dichloroethane (0.20 J µg/L), tetrachloroethene (0.22 J µg/L), trichloroethene (0.20 J µg/L), sec-butylbenzene (6.1 µg/L), isopropylbenzene (2.2 µg/L), tert-butylbenzene (0.37 J µg/L), and naphthalene (0.44 J µg/L) were all detected below the NMWQCC standards (NMAC 20.6.2) and the USEPA Maximum Contaminant Levels (MCLs). An estimated concentration of bis(2-ethylhexyl)phthalate (5.0 J µg/L) was detected in monitoring well WL-12-02 and was the only SVOC detected during this sampling event. Two RCRA metals were detected above the method detection limit. The maximum concentrations of arsenic (8.8 J µg/L) and barium (30 µg/L) were each below their respective USEPA MCLs and the NMWQCC screening levels (NMAC 20.6.2). TDS concentrations ranged from 2,400 mg/L (WL-12-03) to 36,000 mg/L (WL-12-01) and exceeded the NMWQCC standard of 1,000 mg/L at each well.

4.1.3 Conclusions and Recommendation

The analytical results from soil and groundwater samples collected at SS-12 during the Site Investigation (Radian, 1992), the additional sampling event (Foster Wheeler, 1994), and this ACM investigation did not contain any VOCs, SVOCs, TPH, or RCRA metals in excess of current SSLs, NMWQCC standards, or USEPA MCLs. Therefore, Holloman AFB will submit a Statement of Basis requesting No Further Action for Site SS-12 (AOC-K) based upon Criterion #5 listed in Appendix 4-B of the Holloman AFB Hazardous Waste Permit (NMED, 2004) which states:

> *"The site was characterized or remediated in accordance with applicable state and/or federal regulations, and the available data indicate that contaminants pose an acceptable level of risk under current and projected future land use."*

This criterion was accomplished by conducting additional characterization activities (soil and groundwater sampling) at SS-12. It was determined by the ACM investigation and the previous investigations that contaminated PCS source area(s) above the current NMED SSLs were not detected at the site. Therefore excavation of contaminated soil is not required for site closure.

4.2 OT-20 Sewage Lagoons Disposal Trenches

4.2.1 Site Investigation

The objectives of the additional investigation activities at this site were to confirm the locations of the three sewage grit disposal trenches, characterize the sewage grit for potential source removal, and evaluate the current groundwater conditions at the site. The following field activities were performed to meet these objectives from June through August of 2007:

- Three DPT boreholes (OT20-DP-01 to OT20-DP-03) were advanced to confirm the locations of the three sewage grit disposal pits;
- Four permanent monitoring wells (OT20-MW01 through OT20-MW04) were installed using DPT drilling techniques to determine and quantify groundwater quality at the site;
- Soil and groundwater samples were collected for chemical analysis; and
- Two geotechnical soil samples were collected from borings OT20-DP05 and OT20-DP06, to provide geotechnical data of non-impacted soils at the site.

Prior to beginning field work a Base Dig Permit (AF Fm 103) with a utility clearance was submitted and approved by the proper authority. All completed field and waste handling activities at OT-20 were performed in accordance with HAFB SOPs, provided in the *Basewide Quality Assurance Project Plan* (Bhate, 2003a) and the *Bhate Standard Operating Procedures* (Bhate, 2002), outlined in the *Final Accelerated Corrective Measures Work Plan, Multiple Sites, Holloman AFB, New Mexico* (Bhate, 2007).

4.2.1.1 Subsurface Soil Sampling

In June 2007, three DPT soil borings (OT20-DP01 through OT20-DP03) were advanced at Site OT-20. Based on Global Positioning System (GPS) northing and easting coordinates the three DPT soil borings were installed immediately east of the three soil borings (SB-20-01, SB-20-02 and SB-20-03) that were drilled during the 1991 Remedial Investigation. The locations of the three RI and three ACM boreholes are shown on Figure 2-4 of this report. The DPT borings were advanced using an AMS Incorporated®, truck mounted 9600 direct push drill rig and a five foot stainless steel core barrel with the associated tooling. Each of the six borings was sampled continuously to various depths ranging from 10 to 15 feet bgs.

Identifiable sewage grit waste (grayish black sludge containing fecal material) was not encountered in the three sewage grit source area DPT soil borings installed during the ACM investigation. As a result only one soil sample was collected from just above the capillary fringe (1 to 5 ft bgs) from each of the three DPT soil borings. It should be noted that the 0 to 1 foot interval was not sampled as it contained road base. Four additional borings (OT20-DP04 through OT20-DP07) were advanced for the installation of four permanent monitoring wells (one upgradient and three downgradient wells). Soil samples for chemical analysis were not collected from these soil borings. The locations of the four OT-20 monitoring wells are also shown on Figure 2-4 of this report.

Soils were visually classified and logged by a Geologist in the field according to the Unified Soil Classification System. The soil boring logs for these borings are included in Appendix B-2 of this report. Soils were screened using a MiniRAE® 2000 Volatile Organic Compound PID meter. Soil samples were placed in the appropriate containers, packed on ice at 4 °C, and delivered under chain-of-custody to STL in Denver, Colorado.

In addition two soil samples were collected for geotechnical analysis in soil borings OT20-DP05 and OT20-DP06. These two undisturbed samples were collected from 4 to 5 feet bgs, just above the water table in soil representative of the site. The samples were collected in a thin-walled soil sampler and analyzed by Accutest Laboratories in Orlando, Florida, for geotechnical properties (dry bulk density, specific gravity, moisture content, and fractional organic carbon content).

4.2.1.2 Groundwater Sampling

In June 2007, groundwater samples were collected from the three new monitoring wells (OT20-MW01, OT20-MW02, and OT20-MW03) shown on Figure 2-4 of this report. Prior to sampling, the monitoring wells were developed, in accordance with Bhate SOP No. 10 (*Subsurface Water Investigation*), Section 3, Well Development, to remove sediment and facilitate communication between the well and the surrounding formation, ensuring a representative water sample. During development a Horiba® U-22 (2-meter) water quality analyzer was used to collect water quality parameters. Wells were sampled using low flow purge techniques with a peristaltic pump (pumping at an average rate of less than 1 liter per minute) and disposable polyethylene tubing. All samples for RCRA metals analysis were filtered in-line through a disposable 0.45 micron filter. Prior to sampling groundwater, water levels were taken at each monitoring well and each well was subsequently purged. Monitoring Well Development and Sample Collection Logs can be found in Appendix C of this report.

In August of 2007 a fourth monitoring well, OT20-MW04, was installed further downgradient of the site. This monitoring well was also developed and sampled in August. All groundwater samples collected at OT-20 wells were placed in the appropriate containers, packed on ice at 4° C, and delivered under chain-of-custody to STL in Denver, Colorado.

4.2.2 Nature and Extent of Contamination

This section presents the soil, geotechnical, and groundwater analytical results from the ACM field investigation conducted at Site OT-20 from June to August 2007. This section also presents the current nature and extent of contamination found in the soil and groundwater during this investigation. The soil and groundwater sampling locations from this investigation are shown on Figure 2-4 of this report.

The objectives of the ACM at Site OT-20 were to: 1) confirm the locations of the sewage grit disposal trenches, 2) determine if any grit, soil, and/or groundwater contamination currently exist at the site, 3) delineate the current horizontal and vertical extent of the contamination (if present) and 4) collect the proper data meeting the data quality objectives to support closure of the site based on guidance from the NMED. Soil, geotechnical, and groundwater analytical results are summarized in Tables 4-4, 4-5, and 4-6 of this report, respectively. Duplicate samples were collected in soil boring OT20-DP02 and in monitoring well OT20-MW03 for groundwater. The complete analytical data packages for this investigation as provided by STL are presented in Appendix D of this report. The Laboratory Analysis and Data Validation Summary and Reports are included in Appendix E of this report.

4.2.2.1 Soil Analytical Results

The three soil samples collected from soil borings OT20-DP01 through OT20-DP03 during the ACM investigation were analyzed for VOCs, SVOCs, TPH (DRO, GRO, and ORO), pesticides, PCBs, herbicides, and RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver). The subsurface soil samples collected during the OT-20 ACM investigation were collected from 1 to 5 feet bgs (0 to 1 ft bgs contained road base). The last digit of the sample identification number indicates the bottom of the sample interval. The OT-20 analytical results for soil are summarized in Table 4-4 of this report.

Two VOCs were detected in the OT-20 soil boring samples. Tetrachloroethene (8.8 µg/kg) and naphthalene (1.0 J µg/kg) were detected soil samples collected from 1 to 5 feet bgs in soil borings DP03 and DP01, respectively. Both of these VOCs were detected below the current SSLs (NMED, 2006a).

TPHs were analyzed for GRO ($C_6 - C_{10}$), DRO ($C_{10} - C_{22}$), and ORO ($>C_{22} - C_{36}$). Estimated quantities of TPH-GRO and TPH-DRO were detected in each of the three soil boring samples. TPH-GRO ranged from not detected to 0.60 J mg/kg and TPH-DRO ranged from 2.1 J to 2.4 J mg/kg. TPH-ORO was not detected above the method detection limit in any of the OT-20 soil samples. The herbicide MCPA (2-Methyl-4-Chlorophenoxyacetic Acid) was detected in the duplicate sample collected from OT20-DP02 with an estimated concentration of 2,100 J µg/kg. Although there is not an NMED SSL for MCPA this estimated concentration is below the Region 6 Human Health Medium Specific Screening Level for MCPA (31,000 µg/kg). All other herbicides were not detected above their method detection limits. Additionally, all pesticides, PCBs, and SVOCs were also not detected above their method detection limits.

Five of the eight RCRA metals were detected above the method detection limits. The maximum concentrations of barium (96 mg/kg), cadmium (0.25 J mg/kg), chromium (10 mg/kg), arsenic (3.8 mg/kg), and lead (5.1 mg/kg) were all below their respective SSLs (NMED, 2006a). The two geotechnical samples collected from OT20-DP05 and DP06 were analyzed for bulk density, fractional organic carbon, moisture content, and specific gravity. The geotechnical analytical results are presented in Table 4-5 of this report. The geotechnical borehole locations are also shown on Figure 2-4 of this report. Because these samples were collected in the unsaturated zone above the water table, the results for each geotechnical parameter were averaged for their use in the site-specific estimation of risk presented in Section 4.2.3 of this report. Lab results from the geotechnical analysis are included in Appendix F of this report.

4.2.2.2 Groundwater Analytical Results

The groundwater samples collected from OT20-MW01, OT20-MW02, OT20-MW03, and OT20-MW04 were analyzed for VOCs, SVOCs, pesticides, PCBs, herbicides, RCRA metals, and TDS. The analytical results are presented in Table 4-6 of this report and the monitoring well locations are shown on Figure 2-4 of this report. Due to poor recharge conditions, monitoring wells OT20-MW01 and MW02 were sampled in June and again in July 2007 in order to obtain the full suite of analytical parameters in one sampling event. In August 2007 well OT20-MW04 was added to the Site OT-20 monitoring well network in order to define the downgradient extent of VOC (tetrachloroethene) contamination detected in monitoring wells MW02 and MW03.

Nine VOCs (acetone, benzene, 2-butanone, chloromethane, methylene chloride, 4-methyl-2-pentanone, tetrachloroethene, trichloroethene, and naphthalene) were detected above the method detection limit. Tetrachloroethene was the only VOC detected above the USEPA MCL (5 µg/L) and/or the NMWQCC screening level (20 µg/L). Monitoring wells OT20-MW02 and MW03 had tetrachloroethene concentrations of 56 µg/L and 5.3 µg/L, respectively. In order to determine the extent of the tetrachloroethene groundwater contamination detected in wells OT20-MW02 and MW03, an additional well (OT20-MW04) was installed approximately 85 feet downgradient (south) of MW03 as show on Figure 2-4 of this report. Monitoring well OT-20-MW04 (sampled in late August 2007) had a tetrachloroethene concentration of 4.7 µg/L and estimated concentrations of trichloroethene (0.21 J µg/L) and naphthalene (0.24 µg/L), all other VOCs were not detected in this well. Figure 4-1 of this report presents the distribution of tetrachloroethene detected in the groundwater during the OT-20 ACM investigation. Due to the concentrations of tetrachloroethene that were detected in OT20-MW02 and MW03 above the USEPA MCL, a site- specific risk based evaluation was performed and is presented in Section 4.2.3 of this report.

Two SVOCs (Di-n-butyl phthalate and bis(2-Ethylhexyl)phthalate) were detected in monitoring wells OT20-MW04 and OT20-MW01 with concentrations of 1.6 J µg/L and 1.2 J µg/L, respectively. No other SVOCs were detected during this sampling event. Four herbicides were detected above the method detection limit. The maximum concentrations of dalapon (6.2 µg/L), dichlorprop (0.56 J µg/L), MCPP (120 J µg/L), and 2,4-DB (0.34 J µg/L) were all below applicable USEPA MCLs or NMWQCC (NMAC 20.6.2) groundwater screening levels. In addition, all pesticides and PCBs were not detected.

Four RCRA metals were detected above the method detection limits. The maximum concentrations of selenium (8.0 J µg/L), barium (59 J µg/L), cadmium (2.0 J µg/L) and chromium (3.2 J µg/L) were all below their respective EPA MCLs and NMWQCC screening levels (NMAC 20.6.2). TDS concentrations ranged from 30,000 mg/L (OT20-MW01) to 64,000 mg/L (OT20-MW02) and exceeded the NMWQCC standard of 1,000 mg/L at each well.

4.2.3 OT-20 Risk Based Evaluation

This section presents the methodology used for risk evaluation at Site OT-20. The methodology consists of the following:

1. Compilation of data (refer to Section 4.2.3.1);
2. Identification of chemicals of potential concern (COPCs) (refer to Section 4.2.3.2);
3. Development of exposure model (EM) (refer to Section 4.2.3.3);
4. Identification of target levels (refer to Section 4.2.3.4);
5. Calculation of representative concentrations (refer to Section 4.2.3.8); and
6. Comparison of representative concentrations with target levels (refer to Section 4.2.3.9).

Each of the above steps is presented below.

4.2.3.1 Compilation of Data

Following is the soil data available for Site OT-20:

Date	Borings	No. of Borings	No. of Samples
July 1991	SB-20-01, SB-20-02, and SB-20-03	3	5
June 2007	OT20-DP01, OT20-DP02, and OT20-DP03	3	3*
June 2007	OT20-DP05 and OT20-DP06	2	2**

Notes:
* One duplicate sample was collected from soil boring OT20-DP02.
** Samples were collected and analyzed for geotechnical parameters. The results for geotechnical parameters are presented in Table 4-5 of this report.

Following is the groundwater data available for Site OT-20:

Monitoring Well	No. of Sampling Events	Sampling Dates
OT20-MW01	2	June and July 2007
OT20-MW02	2	June and July 2007
OT20-MW03	1	June 2007*
OT20-MW04	1	August 2007

Note:
* One duplicate sample was collected from OT20-MW03.

The soil and groundwater data complied above were evaluated for use in this risk assessment (RA) as follows:

- Soil samples collected in July 1991 were not used since (i) samples collected in June 2007 are more representative of current conditions; and (ii) the locations of soil borings installed in June 2007 are very close to the soil borings drilled in July 1991.
- Conservatively, data with laboratory qualifier "J" are considered as detected concentrations.
- A duplicate soil sample (OT20-DP02-5A) and a duplicate groundwater sample (OT20-MW03-A) were collected. The original sample and the duplicate sample were averaged as follows:
    - If both samples contained detectable concentrations, the average of the two were taken and considered as detected;
    - If one of the samples contained a detectable concentration and the other was non-detect, the non-detect was replaced with ½ the reporting limit and average of the two were taken and considered as detected; and
    - If both of the samples had concentrations below the reporting limits, the average of the two reporting limits was taken and the sample was considered as non-detect.
- Chemicals with at least one detected concentration were considered for the RA.

Based on the above considerations, Tables 4-7(a) and 4-7(b) present the soil and groundwater data used for the RA, respectively.

4.2.3.2 Identification of Chemicals of Potential Concern

The chemicals that were detected in soil or groundwater sample were considered as COPCs and are included in this RA. The COPCs are presented in Table 4-8. In all, 10 chemicals in soil and 19 chemicals in groundwater are included.

4.2.3.3 Development of Exposure Model

This section presents the EM for the Site OT-20. The EM identifies the potential receptors and the exposure pathways under current and anticipated future conditions.

Receptors

Currently, the site is vacant and there is no building on it. Therefore, there are no receptors for the current land use.

As discussed in Section 3.7 of this report, residential development at the Site OT-20 is limited and future land use is expected to be commercial/industrial. Therefore, the commercial/industrial worker is considered a receptor of concern under future conditions. Additionally, in the future construction activities may occur, hence potential future construction worker is also considered a receptor of concern.

Exposure Pathways

Tables 4-9(a) and 4-9(b) present the EMs for the potential future commercial/industrial worker and construction worker, respectively. Of the various complete exposure pathways, outdoor inhalation from subsurface soil and from groundwater for commercial/industrial worker was not quantified since indoor inhalation is being considered and is the more critical pathway.

As per the NMED regulations (NMAC 20.6.2.3103), groundwater zones where TDS concentrations exceed 10,000 mg/L are considered non-potable and are not required to meet the NMWQCC standards. Groundwater zones where the TDS concentrations are less than 10,000 mg/L are required to meet the NMWQCC standards.

TDS data collected from monitoring wells at Site OT-20 are above 10,000 mg/L (see Table 4-6 of this report). Therefore, the shallow groundwater is not considered potable and the groundwater pathway is considered incomplete.

The complete exposure pathways that were quantitatively evaluated are summarized below. For future commercial/industrial worker:

- Indoor inhalation of vapors from subsurface soil; and
- Indoor inhalation of vapors from groundwater.

For future construction worker:

- Dermal contact with soil to depth of construction;
- Ingestion of soil to depth of construction;
- Outdoor inhalation of vapors or particulates from soil to depth of construction;
- Dermal contact with groundwater; and
- Outdoor inhalation of vapors from groundwater.

For the exposure pathways from soil, dermal contact with, ingestion of, and outdoor inhalation of vapors or particulates from soil were evaluated as the combined pathways from soil.

4.2.3.4 Identification of Target Levels

This section discusses the target levels for the complete exposure pathways identified in Section 4.2.3.3 of this report. For the following exposure pathway and receptor combinations, target levels for soil and groundwater were obtained from the following sources. Table 4-10 presents the target levels for soil and groundwater for each of the exposure pathway and receptor combinations.

- **Indoor inhalation of vapors from subsurface soil for commercial/industrial worker:** The Johnson & Ettinger (J&E) model (USEPA, 2004a) was used to develop the target levels for indoor inhalation of vapors from subsurface soil for commercial/industrial worker. The use of J&E model was necessary because the NMED SSLs document (NMED, 2006a) does not have the indoor inhalation pathway. The details of development of target levels for this pathway and receptor combination are discussed in Section 4.2.3.5 of this report.

- **Indoor inhalation of vapors from groundwater for commercial/industrial worker:** The J&E model (USEPA, 2004a) was used to develop the target levels for indoor inhalation of vapors from groundwater for commercial/industrial worker. The use of J&E model was necessary because the NMED SSLs (NMED, 2006a) document does not have the indoor inhalation pathway. The details of development of target levels for this pathway and receptor combination are discussed in Section 4.2.3.5 of this report.

- **Combined pathways from soil for construction worker:** The NMED SSLs for construction worker were used (NMED, 2006a). For TPH-DRO, the SSL is as per the NMED TPH Screening Guidelines (NMED, 2006b). One chemical (MCPA) did not have NMED SSL; therefore, the SSL was calculated using the methodology included in the NMED SSLs document (NMED, 2006a) for construction worker. Toxicity values and physical/chemical properties used to develop the target level for MCPA are presented in Table 4-11.

- **Dermal contact with groundwater for construction worker:** The target levels for dermal contact with groundwater for construction worker were developed as per the *Risk Assessment Guidance for Superfund (RAGS) Volume I, Part E Supplemental Guidance for Dermal Risk Assessment* (USEPA, 2004b). The details of development of target levels for this pathway and receptor combination are discussed in Section 4.2.3.6 of this report.

- **Outdoor inhalation of vapors from groundwater for construction worker:** The target levels for outdoor inhalation of vapors from groundwater for construction worker were developed as per the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM, 1995). The details of development of target levels for this pathway and receptor combination are discussed in Section 4.2.3.7.

4.2.3.5 Target Levels for Indoor Inhalation Pathways

This section describes the procedure used to calculate the risk-based target levels for the indoor inhalation of vapors from subsurface soil and groundwater for a commercial/industrial worker using the J&E model (USEPA, 2004a). The target levels for this pathway and receptor combination were developed only for the volatile chemicals. As per the USEPA (2004a), a chemical was considered volatile if it's Henry's law constant (H) is 1 $\times 10^{-5}$ atmosphere-cubic meters per mole (atm-m^3/mol) (unitless H of 4.2×10^{-4}) or greater and it's molecular weight is 200 grams per mole (g/mole) or less.

Specifically, the calculation of risk-based target levels requires the following:

- Toxicity parameters;
- Physical and chemical parameters;
- Exposure factors;
- Source parameters;
- Geotechnical parameters;
- Building parameters; and
- Target risk levels.

Each of these is discussed below.

Toxicity Values

The toxicity of chemicals with carcinogenic adverse health effects associated with inhalation exposure is quantified using unit risk. For chemicals that cause non-carcinogenic adverse health effects, toxicity associated with inhalation exposure is typically quantified by reference concentration. The chemical-specific toxicity parameters for the COPCs used are the default values from the USEPA spreadsheet implementation of the J&E model and are presented in Table 4-12(a).

Physical and Chemical Properties

The development of risk-based target levels requires physical and chemical properties of the COPCs. The chemical-specific physical and chemical parameters for the COPCs used are the default values from the USEPA spreadsheet implementation of the J&E model and are presented in Table 4-12(a).

Exposure Factors

Exposure factors describe the physiological and behavioral characteristics of the receptors. The receptor-specific exposure factors and their values used to evaluate the risk-based target levels are presented in Table 4-12(b). The exposure factors were obtained from the *Technical Background Document for Development of Soil Screening Levels, Revision 4.0* (NMED, 2006a). For the Site OT-20, the site-specific receptor considered for the indoor inhalation pathway is a commercial/industrial worker.

Source Parameters

The following source parameters are required to evaluate indoor inhalation of vapors.

- **Average soil temperature:** For New Mexico, the range of groundwater temperature is 52 to 62 °F (USEPA, 2004a). The groundwater temperature of 62 °F (17 °C) was considered as the approximate soil temperature.
- **Depth below grade to top of contamination:** For volatile COPCs, the detected concentrations were observed from the soil samples collected from 1 to 5 ft bgs. Therefore, an average depth of 3 ft (91.44 cm) was used for the depth below grade to top of contamination.
- **Depth below grade to water table:** A depth to water table of 6.5 ft (198.12 cm) was used for the depth below grade to top of contamination.

These parameters are presented in Table 4-12(c).

Geotechnical Parameters

The following geotechnical parameters are required to evaluate indoor inhalation of vapors.

1. Soil dry bulk density;
2. Soil total porosity;
3. Soil water-filled porosity; and
4. Soil organic carbon fraction.

For Site OT-20, the site-specific geotechnical parameters were analyzed for the vadose zone soil (see Table 4-5 of this report). However, these site-specific geotechnical data do not seem appropriate for use in the RA for the following two reasons:

1. As per Table 4-5, the average fractional organic carbon value is 0.1265 which is too high for typical soils. As per the Soil Survey Laboratory Soil Characterization Database from Natural Resources Conservation Service, the typical fractional organic carbon value has a range of 0.001 to 0.01. However, this high fractional organic carbon value may be due to the sewage grit disposed at the site. Despite this possibility, conservatively the NMED's default value of 0.0015 was used for organic carbon fraction (NMED, 2006a).
2. The estimated volumetric water-filled porosity of 0.279 exceeds the estimated total porosity of 0.222 as per the calculation below:

$$n = 1 - \frac{\rho_b}{\rho_s} = 1 - \frac{1.4}{1.8} = 0.222$$

$$\theta_{wv} = \theta_{wg} \times \frac{\rho_b}{\rho_l} = 0.199 \times \frac{1.4}{1} = 0.279$$

where,

n	=	Total porosity (cm^3/cm^3),
ρ_b	=	Soil dry bulk density (g/cm^3),
ρ_s	=	Soil specific gravity (unitless),
ρ_l	=	Water density (g/cm^3),
θ_{wv}	=	Volumetric water-filled porosity (cm^3/cm^3), and
θ_{wg}	=	Gravimetric water-filled porosity (g/g).

These types of discrepancies can occur at such sites due to significant variability in the geotechnical parameters and field sampling techniques. Therefore, default dry bulk density, total porosity, and water-filled porosity values for sandy soil type as per the USEPA (2004a) were used. As per Section 3.5.2 of this report, the vadose zone soil type for Site OT-20 is sandy.

The geotechnical parameter values used to evaluate indoor inhalation of vapors are presented in Table 4-12(c).

Building Parameters

The following building parameters are required to evaluate indoor inhalation of vapors:

- Depth below grade to bottom of enclosed space floor;
- Enclosed space floor thickness;
- Enclosed space floor length;
- Enclosed space floor width;
- Enclosed space height;
- Floor-wall seam crack width;
- Indoor air exchange rate; and
- Average vapor flow rate into building.

For depth below grade to bottom of enclosed space floor, the default value of 15 cm for slab-on-grade construction was considered (USEPA, 2004a). For other building parameters, default values in the USEPA spreadsheet were used. These values are presented in Table 4-12(c).

Target Risk Levels

The target risk for carcinogenic of 1 $\times 10^{-5}$ and target hazard quotient (HQ) of 1.0 (NMED, 2006a) were used to develop the risk-based target levels for indoor inhalation pathways.

The above input parameters were used to calculate the target levels for indoor inhalation of vapors from subsurface soil and groundwater by commercial/industrial worker. Those values are presented in Table 4-10.

4.2.3.6 Target Levels for Dermal Contact with Groundwater

This section describes the procedure used to calculate the risk-based target levels for the dermal contact with groundwater for a construction worker as per the *Risk Assessment Guidance for Superfund - Volume I, Human Health Evaluation Manual, Part E: Supplemental Guidance for Dermal Risk Assessment* (USEPA, 2004b).

Specifically, the calculation of risk-based target levels requires the following:

- Toxicity parameters;
- Chemical-specific parameters for dermal contact with water;
- Exposure factors; and
- Target risk levels.

Each of these is discussed below.

Toxicity Values

Dermal toxicity values are not readily available and in the absence of direct measurement of dermal toxicity, use of oral toxicity values is considered an acceptable alternative by the USEPA. Therefore, the oral toxicity values were used and are presented in Table 4-13(a).

Chemical-Specific Parameters for Dermal Contact with Water

The development of risk-based target levels requires parameters for dermal contact pathways. The chemical-specific parameters for dermal contact pathways are presented in Table 4-13(a).

Exposure Factors

The exposure factors for dermal contact with groundwater for a construction worker are presented in Table 4-13(b).

Target Risk Levels

The target risk for carcinogenic of 1×10^{-5} and target HQ of 1.0 (NMED, 2006a) were used to develop the risk-based target levels for dermal contact with groundwater.

The above input parameters were used to calculate the target levels for dermal contact with groundwater by construction worker. Those values are presented in Table 4-10.

4.2.3.7 Target Levels for Outdoor Inhalation of Vapors from Groundwater

This section describes the procedure used to calculate the risk-based target levels for the outdoor inhalation of vapors from groundwater for a construction worker as per the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM, 1995).

Specifically, the calculation of risk-based target levels requires the following:

- Toxicity parameters;
- Physical and chemical properties;
- Exposure factors;
- Fate and transport parameters; and
- Target risk levels.

Each of these is discussed below.

Toxicity Values

The inhalation toxicity values for COPCs are presented in Table 4-14(a).

Physical and Chemical Properties

The physical and chemical properties for COPCs are presented in Table 4-14(a).

Exposure Factors

The exposure factors for outdoor inhalation of vapors from groundwater for a construction worker are presented in Table 4-14(b).

Fate and Transport Parameters

The fate and transport parameters for outdoor inhalation of vapors from groundwater for a construction worker are presented in Table 4-14(c).

Target Risk Levels

The target risk for carcinogenic of 1×10^{-5} and target HQ of 1.0 (NMED, 2006a) were used to develop the risk-based target levels for dermal contact with groundwater.

The above input parameters were used to calculate the target levels for outdoor inhalation of vapors from groundwater by construction worker. Those values are presented in Table 4-10.

4.2.3.8 Calculation of Representative Concentration

The maximum detected soil concentrations were obtained from the data used for the RA (Table 4-7(a)). These maximum detected soil concentrations were compared with the soil target levels in Table 4-15(a).

The maximum detected groundwater concentrations were obtained from the data used for RA in Table 4-7(b). These maximum detected groundwater concentrations were compared with the groundwater target levels in Table 4-15(b).

The use of maximum concentration is very conservative because (i) the calculation of SSLs assumes long-term exposures; and (ii) the models used to develop SSLs assume average concentration over the exposure domain and not a single point concentration.

For the chemicals whose maximum detected concentration exceeded the target levels, the average concentrations were compared with the target levels. The average concentrations are more representative of the concentrations and consistent with the assumptions inherent in the models. To calculate the average concentrations, the non-detect values were replaced with ½ the detection limits.

4.2.3.9 Comparison of Representative Concentrations with Target Levels

The comparison of maximum soil detected concentrations with soil target levels is presented in Table 4-15(a). The maximum detected soil concentrations did not exceed the soil target levels for any of the COPCs. Therefore, the current soil concentration is protective of future on-site commercial/industrial workers and future on-site construction workers.

The comparison of maximum groundwater detected concentrations with groundwater target levels is presented in Table 4-15(b). The maximum detected tetrachloroethene concentration in groundwater exceeded the target level for indoor inhalation of vapors from groundwater for future commercial/industrial workers. For all other COPCs, the maximum detected groundwater concentrations did not exceed the target levels for groundwater.

For tetrachloroethene which the maximum groundwater concentration exceeded the target level, the average concentration was calculated as shown in Table 4-16(a). The average concentration was compared with target levels and these comparisons are presented in Table 4-16(b). The table shows that the average groundwater concentration of tetrachloroethene did not exceed the target levels for indoor inhalation pathway from groundwater for commercial/industrial worker. Therefore, the current groundwater concentration is protective of future on-site commercial/industrial workers and future on-site construction workers.

4.2.4 Conclusions and Recommendations

The analytical results from soil samples collected at Site OT-20 during the ACM investigation did not contain any VOCs, SVOCs, TPH, PCBs, herbicides, pesticides ,or RCRA metals in excess of the current SSLs. With the exception of tetrachloroethene detected above the USEPA MCL (5 µg/L) in monitoring wells OT20-MW02 (56 µg/L) and OT20-MW03 (5.3 µg/L) there were other no exceedences (VOCs, SVOCs PCBs, herbicides, pesticides, or RCRA metals) detected above the USEPA MCLs or NMWQCC standards in the groundwater samples collected at Site OT-20. As a result of the two tetrachloroethene exceedences detected in groundwater, a risk assessment was performed for potential future commercial/industrial workers and construction workers.

The TDS data collected from the four OT-20 monitoring wells are above 10,000 mg/L for each well, therefore as per NMED regulations the shallow groundwater is not considered potable and the groundwater pathway is considered incomplete.

The maximum detected soil and groundwater concentrations were compared with the soil target levels and groundwater target levels respectively. The maximum detected soil concentrations did not exceed the soil target levels for any of the COPCs. The maximum detected tetrachloroethene concentration in groundwater exceeded the target level for indoor inhalation of vapors from groundwater for future commercial/industrial workers. However, the average concentration of tetrachloroethene did not exceed the target levels for the indoor inhalation pathway from groundwater for commercial/industrial workers. Therefore, the current groundwater concentration is protective of future on-site commercial/industrial workers and future on-site construction workers.

Therefore, HAFB will submit a Statement of Basis requesting No Further Action for Site OT-20 (SWMU 113A) based upon Criterion #5 listed in Appendix 4-B of the Holloman AFB Hazardous Waste Permit (NMED, 2004) which states:

> *"The site was characterized or remediated in accordance with applicable state and/or federal regulations, and the available data indicate that contaminants pose an acceptable level of risk under current and projected future land use."*

This criterion was accomplished by conducting additional characterization activities (soil and groundwater sampling) and a risk assessment at Site OT-20. It was determined by the ACM investigation that a source area above the current NMED SSLs was not detected at the site. Therefore, excavation of contaminated soil is not required for site closure.

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FIGURES