HWB 05

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July 20, 2005

Received
JUL 21 2005
District 1

Haz Waste Bureau
New Mexico Environment Department
550 San Antonio NE
Albuquerque, NM 87109

ATTN: Cornelius Amindyas

Subject: **Risked Based Evaluation**
**Officer's Club, Site SS-57**
Holloman Air Force Base, NM
Contract No.: DACA45-03-D-0023
Delivery Order No.: 02
Bhate Project Number: 9040002

Dear Mr. Amindyas:

Enclosed are two sets of drawings that were inadvertently left out of the above referenced report. Please inset them at the end of the tabbed section for Figures.

I apologize for any inconvenience. If you have any questions, please call me at 205-918-4000.

Sincerely,
**Bhate Environmental Associates, Inc.**

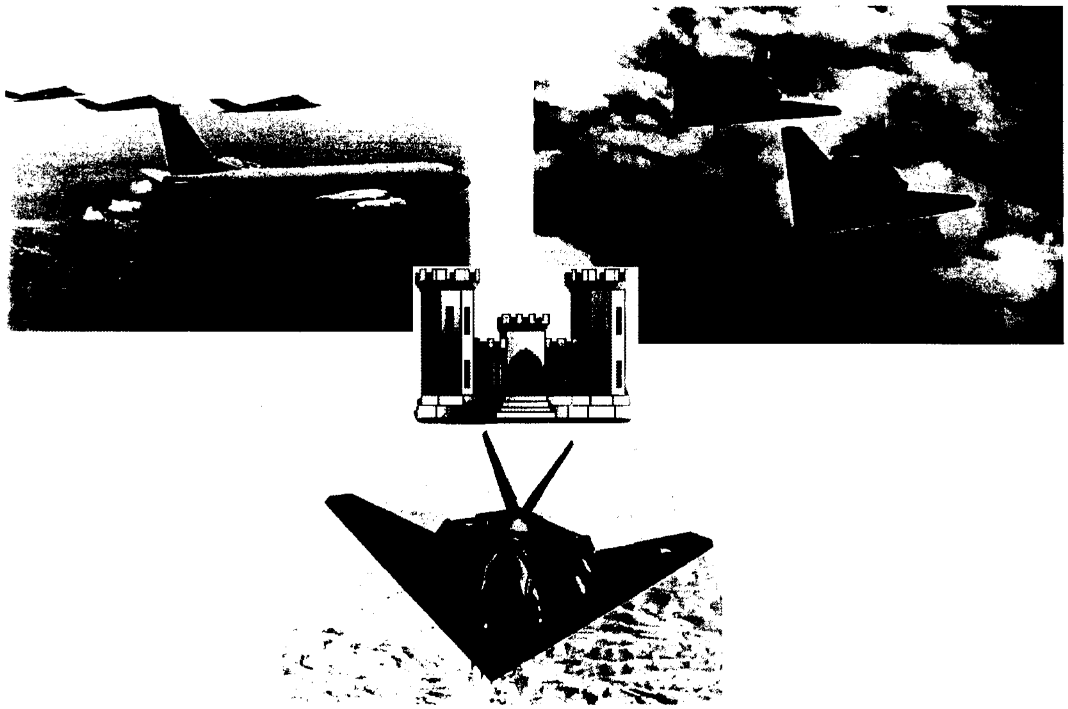
Karen J. Niebuhr, PE
Project Manager/Senior Engineer

Attachment (or Enclosures)

cc: Mr. Tom Zink (2 sets)
Mr. Chuck Schick (1 set)
Mr. Frank Gardner (1 set)
Mr. John Hymer (2 sets)

HAFB 05 7/1/05

# RISK-BASED EVALUATION
# OFFICER'S CLUB, SITE SS-57



**Holloman Air Force Base**
**New Mexico**

**July 2005**

**Contract No.: DACA45-03-D-0023**
**Delivery Order No.: 02**
**Bhate Project No.: 9040002**

**Headquarters, Air Combat Command**
**Langley Air Force Base, Virginia**

**49 CES/CEV**
**Holloman Air Force Base, New Mexico**

# RISK-BASED EVALUATION

Received
JUL 21 2005
District 1

# OFFICER'S CLUB, SITE SS-57
# HOLLOMAN AFB, NEW MEXICO

Prepared for:

**49CES/CEV**
**Holloman Air Force Base**
**New Mexico**

Under Contract To:

**U.S. Army Corps of Engineers**
**Omaha, Nebraska**
**Under Contract No. DACA45-03-D-0023**
**Delivery Order No. 02**

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**Bhate Project No. 9040002**

**July 2005**

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# RISK-BASED EVALUATION

## TABLE OF CONTENTS

**Figures**



**Tables**

## Appendices

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# LIST OF ACRONYMS

| | |
|---|---|
| AMSL | Above Mean Sea Level |
| AS/SVE | Air sparging/soil-vapor extraction |
| ASTM | American Society for Testing and Materials |
| BTEX | Benzene, toluene, ethylbenzene, and xylenes (total) |
| bgs | Below ground surface |
| C | Complete |
| °C | Degrees Celsius |
| CFA | California Fertilizer Association |
| cm | Centimeter |
| COPCs | Chemicals of potential concern |
| CSM | Conceptual Site Model |
| E | Exceed |
| EM | Exposure model |
| EPA | Environmental Protection Agency |
| ERP | Environmental Restoration Program |
| °F | Degrees Fahrenheit |
| J&E | Johnson and Ettinger |
| HA | Health Advisory |
| HAFB | Holloman Air Force Base |
| HI | Hazard Index |
| HQ | Hazard Quotient |
| MCL | Maximum contaminant level |
| mg/L | Milligrams per liter |
| NA | Not available, not analyzed, or not applicable |
| ND | Non-detect |
| NE | Not exceed |
| NIOSH | National Institute for Occupational Safety and Health |
| NMED | New Mexico Environmental Department |
| NMRBCA | New Mexico Risk-Based Corrective Action |
| NOC | Not of concern |
| PAHs | Polycyclic aromatic hydrocarbons |
| ROEs | Routes of exposure |
| SCS | Soil Conservation Service |
| SSLs | Soil Screening Levels |
| SSTLs | Site-Specific Target Levels |
| SVOC | Semi-volatile organic compound |
| TKN | Total Kjeldahl Nitrogen |
| TOC | Total Organic Carbon |
| TPH | Total petroleum hydrocarbon |
| TPHCWG | Total Petroleum Hydrocarbon Criteria Working Group |
| TPH-DRO | Total Petroleum Hydrocarbon-Diesel Range Organic |
| TPH-GRO | Total Petroleum Hydrocarbon-Gasoline Range Organic |
| TPH-ORO | Total Petroleum Hydrocarbon-Oil Range Organic |

| | |
|---|---|
| μg/kg | Micrograms per kilogram |
| μg/$m^3$ | Micrograms per cubic meter |
| μg/L | Micrograms per liter |
| USEPA | United States Environmental Protection Agency |
| UST | Underground storage tank |
| VOC | Volatile organic compound |
| WQCC | Water Quality Control Commission |

# EXECUTIVE SUMMARY

Environmental Restoration Program (ERP) Site SS-57 (The Officer's Club) is located at the corner of West 8th Street and West New Mexico Avenue, Holloman Air Force Base (HAFB), New Mexico. In response to hydrogen sulfide odors detected in the building in the fall of 1991, numerous investigations have been conducted at the site. These have resulted in the installation of several groundwater monitoring and soil-vapor wells, collection and analysis of groundwater samples, soil samples, and soil-vapor samples. Additionally, an air sparge/soil-vapor extraction system operated at the site from about 1996 to 2002.

This report presents a site-specific risk assessment conducted at the site to determine whether the residual soil and groundwater concentrations of petroleum hydrocarbons result in an unacceptable risk. The risk assessment consisted of the following steps:

- Review of site history and compilation of relevant data
- Development of an exposure model (EM) for the identification of the complete routes of exposure (ROEs)
- Comparison of maximum soil, groundwater and soil-vapor concentrations with New Mexico Environmental Department (NMED) soil screening levels (SSLs), lowest groundwater standards (refer to Section 3.2), and air inhalation target levels (New Mexico Underground Storage Tank Bureau, 2000), respectively
- Application of the Johnson and Ettinger (J&E) model to estimate soil and groundwater target levels protective of indoor inhalation
- Speciation of total petroleum hydrocarbon-diesel range organics (TPH-DRO) data into aromatic and aliphatic fractions using the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) approach.
- Calculation of site-specific target levels (SSTLs) for each fraction for the primary ROEs

The results of the above tasks are summarized below:

1. The primary ROEs which have been quantitatively evaluated based on the site-specific receptors include:
   a. Commercial Worker
      i. Dermal contact with surficial soil
      ii. Ingestion of surficial soil
      iii. Outdoor inhalation from surficial soil
      iv. Indoor inhalation from subsurface soil
      v. Indoor inhalation from groundwater
   b. Resident
      i. Dermal contact with surficial soil
      ii. Ingestion of surficial soil
      iii. Outdoor inhalation from surficial soil
      iv. Indoor inhalation from subsurface soil

      v. Indoor inhalation from groundwater
   c. Construction Worker
      i. Dermal contact with surficial soil
      ii. Ingestion of surficial soil
      iii. Outdoor inhalation from surficial soil
      iv. Indoor inhalation from groundwater
      v. Dermal contact with groundwater
2. Review of site-specific data indicates that the residual concentrations are "very low". As an example, the maximum detected concentration of benzene in groundwater is 0.35 micrograms per liter (μg/L), which is significantly less than the federal groundwater standard of 5 μg/L.
3. None of the maximum soil and groundwater concentrations exceed NMED SSLs and groundwater standards respectively except for TPH-DRO.
4. None of the soil and groundwater concentrations exceed target levels protective of indoor inhalation using the J&E model. Note this step was necessary because the NMED SSLs do not consider indoor inhalation as a pathway.
5. SSTLs were calculated for TPH-DRO and its carbon fractions. Maximum detected concentrations did not exceed any of the SSTLs for the above identified primary ROEs for neither the TPH-DRO nor the carbon fractions.

Based on the above evaluation, the residual soil, groundwater, and soil-vapor concentrations are protective of current and reasonable future receptors at the site. These concentrations are anticipated to reduce in time due to natural attenuation processes which are expected to further reduce the risk.

# 1 INTRODUCTION

This Section presents the background data and site-specific information for a risk-based evaluation for the Environmental Restoration Program (ERP) Site SS-57 (The Officer's Club) at Holloman Air Force Base (HAFB), New Mexico.

## 1.1 Site Description

### 1.1.1 Location and Vicinity

HAFB is located directly west of Alamogordo, New Mexico. The Officer's Club (Building No. 531) is located at the corner of West 8$^{th}$ Street and West New Mexico Avenue, HAFB. Figures 1-1, 1-2, and 1-3 show the general locations of HAFB and the Officer's Club.

The grounds around the Officer's Club are landscaped along the southwestern and western sides of the building while the northern and eastern portions of the site are paved with asphaltic concrete.

### 1.1.2 Source Area

The site was identified in 1991 when hydrogen sulfide odors were detected in the Officer's Club building. These were assumed to result from the natural anaerobic organic degradation of diesel fuel hydrocarbons which leaked from an underground storage tank (UST) prior to 1991. This tank was located near the southwestern corner of the Officer's Club and has been removed.

## 1.2 Chronology of Events

The chronology of significant events at the site, based on reports reviewed is outlined below. Boring and sampling locations are shown on Figure 1-4.

Fall 1991 Hydrogen sulfide odors were detected in the Officer's Club building and the site was designated as SS-57.

Oct. 1991 Nine soil borings (B-1 to B-9) were advanced to depths ranging from approximately 1 to 29 feet below existing grade. Three monitoring wells (MW05, MW07, and MW09) were installed at three of the nine borings. The following samples were collected and submitted for laboratory analysis:

- Nine water samples from nine borings for standard water analysis and organic halogen analysis.
- Three water samples from B-1, B-2, and B-3 for volatile organic compound (VOC) analysis. The VOC method is not known and also not critical for risk assessment since this is pre-remediation and 13 year old data.
- Three air samples from B-1, B-2, and B-3 for sulfur compounds analysis and VOC analysis.

- One water sample from the seep in the basement access stairwell for diesel fuel.

Geotechnical parameters such as moisture content, grain-size analysis, Atterberg limits tests, and consolidation tests were performed on selected samples. A positive pressure air-handling system was installed at the Officer's Club to prevent nuisance odors from accumulating in the building.

Nov. 1992 Four vertical borings (VB-01 to VB-04) and two angle boring (AB-01 and AB-02) were drilled near the southern corner of the Officer's Club. Twenty five soil samples were collected and analyzed for total petroleum hydrocarbon (TPH) as diesel using Modified American Society for Testing and Materials (ASTM) Method D3328. Also, 13 soil samples were analyzed for a bacteria enumeration study and a biological screening.

Mar. 1996 One triple-nested air sparge well SP-01 screened from 18 to 20 feet, 28 to 30 feet, and 37.5 to 39.5 feet below ground surface (bgs) was installed. Three sparge monitor wells (SMP-01, SMP-02, and SMP-03) were installed. Each of these wells has three nested monitoring points screened at 18 to 20 feet, 28 to 30 feet, and 38 to 40 feet bgs (except 37 to 39 feet bgs for SMP-02).

Four groundwater monitoring wells (MW01 to MW04) were advanced to depths between 14 and 17 feet bgs. Fourteen soil samples were collected and analyzed for the following:

- TPH as Diesel fuel by Modified ASTM Method D3328
- Alkalinity by Modified Environmental Protection Agency (EPA) Method 310.1
- pH by EPA Method 9045A
- Sulfate by Modified EPA Method 375.4
- Total Kjeldahl Nitrogen (TKN) by Modified EPA Method 351.2
- Total Organic Carbon (TOC) by California Fertilizer Association (CFA) Method 18.0
- Phosphorous (total) by Modified EPA Method 365.4
- Moisture Content by ASTM Method D2216-80
- Iron (total) by EPA Method 6010A

Apr. 1996 Eleven groundwater samples were collected and analyzed for TPH as diesel by Modified ASTM Method D3328, dissolved iron by EPA Method 6010A, and sulfate by Modified EPA Method 375.4.

An air sparging/soil vapor extraction (AS/SVE) pilot test was performed for a horizontal vapor extraction trench (VET-01) and a triple-nested air sparge well (SP-01). Soil vapor samples were collected while venting on the vapor extraction trench and analyzed using EPA Method TO-14 and ASTM Method D-5504.

Oct. 1997 Soil samples were collected and analyzed for TPH using EPA Method 418.1.

Results of the soil samples are not available and also not necessary for risk assessment (refer to Section 1.5).

May 1998 Soil samples were collected and analyzed for TPH using EPA Method 418.1. Results of the soil samples are not available and also not necessary for risk assessment (refer to Section 1.5).

Apr. 1999 Soil samples were collected and analyzed for TPH using EPA Method 418.1. Results of the soil samples are not available and also not necessary for risk assessment (refer to Section 1.5).

May 2002 The AS/SVE which operated from April 1996 was turned off.

Jul. 2002 Sixteen soil samples were collected from eight soil borings (DP01 to DP08). Samples were analyzed for VOCs by EPA Method 8260B, semi-volatile organic compounds (SVOCs) by EPA Method 8270C, TPH-diesel range organics (TPH-DRO) & TPH-oil range organics (TPH-ORO) by Modified EPA Method 8015D, and TPH-gasoline range organics (TPH-GRO) by Modified EPA Method 8015V. Data for 9 of the 16 samples are tabulated in Appendix A, the remaining were non-detects.

Feb. 2004 Five soil borings (SB01 to SB05) were drilled; 10 soil samples and 5 groundwater samples were collected. Three dual completion soil-vapor borings (SV01 to SV03) were drilled; six soil samples were collected for lab analysis as well as for analyzing geotechnical parameters. Boring GB-01 was drilled at a non-impacted area and also sampled for geotechnical data. Groundwater samples from MW01 to MW03, MW05, and MW07 were collected including a duplicate from MW07. The samples were analyzed for the following:

- VOCs (benzene, toluene, ethylbenzene, and xylenes [BTEX] only) using EPA Method 8260B
- Polycyclic aromatic hydrocarbons (PAHs) using EPA Method 8270C
- TPH using Texas Method 1005
- Carbon Fractions using Texas Method 1006

Apr. 2004 Six samples from dual completion soil-vapor borings (SV01 to SV03) were collected and sent for soil vapor analysis for the following:

- BTEX compounds using EPA Method TO-15
- TPH-DRO using National Institute for Occupational Safety and Health (NIOSH) Method 1550

Aug. 2004 Soil boring SB06 was drilled and two soil samples, including one duplicate sample, were collected and analyzed for the following:

- VOCs (BTEX only) using EPA Method 8260B
- PAHs using EPA Method 8270C
- TPH using Texas Method 1005

- Carbon Fractions using Texas Method 1006

A groundwater sample from MW04 was collected and analyzed for the following:

- VOCs (BTEX only) using EPA Method 8260B
- TPH using Texas Method 1005
- Carbon Fractions using Texas Method 1006

## 1.3 Data Used for Risk Analysis

Based on the chronology presented above, soil, groundwater, and soil-vapor analytical data have been collected at the site since 1991.

Data collected before June 2002 are not considered representative of current site conditions due to the natural biodegradation of petroleum hydrocarbons. Additionally, data collected during the operation of the AS/SVE system would be biased to the low end and not representative of static or current conditions. Although the pre June 2002 data was not used quantitatively, it was used qualitatively to develop the data acquisition plan for risk assessment (Bhate, 2004). The analytical data collected before June 2002 is presented in Appendix A. For risk assessment purposes, the soil, groundwater, and soil-vapor data collected between June 2002 and August 2004 are considered representative of the current site conditions and are presented in Tables 1-1, 1-2, and 1-3 respectively. Additionally, the data on these tables include values at ½ the method detection limit for all non detected analytes. Subsequent discussions refer only to these data collected after June 2002.

Duplicate samples were collected in borings SB02 at 2 feet bgs, SB06 at 3.5 feet bgs, and SV03 at 7 feet bgs for soil, in MW07 for groundwater and in SV03 at 8 feet bgs for soil-vapor. The duplicate samples were analyzed as follows:

- If both samples contained detectable concentrations, the average of the two were taken and considered as detected.
- If one of the sample contained detectable concentrations and the other was non-detect, the non-detect was replaced with ½ the detection limit and average of the two were taken and considered as detected.
- If both samples were non-detect, the non-detects were replaced with ½ the detection limit and average of the two were taken and considered as non-detect.
- If a chemical was analyzed in only one sample, the analyzed value is considered.

Based on the above conditions, the combined sample values were used for further analysis and are shown in Tables 1-1, 1-2, and 1-3.

The chemicals that were detected at least once in soil, groundwater, or soil-vapor samples are presented in Table 1-4.

## 1.4 Site Geology

Based on the soil boring logs (included in Appendix B), the soil underlying the site consists of the following units:

- 0-15 feet bgs silty sand
- 15-25 feet bgs varying layers of fine-grained, sandy clays and clay
- 25-40 feet bgs silt and silty sand

The site-specific soil geotechnical analytical results from boring SV01 to SV03 and GB-01 are tabulated in Table 1-5. Because all the data were collected in the unsaturated silty sand zone above the water table, the results for each geotechnical parameter were averaged for their use in the site-specific estimation of risk. Lab results from geotechnical analysis are included in Appendix C.

## 1.5 Site Hydrogeology

There are seven wells screened between 3 and 17 feet bgs. Tables 1-6 and 1-7 present the groundwater elevation data and monitoring well construction details, respectively. Historical depth to water ranges from approximately 8.5 to 12.5 feet bgs at the site. Hydraulic gradient ranges from approximately 0.013 to 0.025 feet per foot, and water flows south - southwest. The groundwater contours using the most recent water level data from October 19, 2004 are shown on Figure 1-5. Using a hydraulic conductivity of silty sand of 2.8 feet/day (Freeze and Cherry, 1979), the Darcy Velocity is estimated to be 0.0532 feet/day.

## 1.6 Distribution of COPCs in Soil

The soil samples collected have been analyzed for VOCs, SVOCs, TPH, and carbon fractions to identify chemicals of potential concern (COPCs). For risk assessment purposes, the vadose zone soil is divided into surficial soil and subsurface soil zones. The surficial soil zone is the zone of soil that a receptor can get exposed to by direct ingestion, dermal contact, and inhalation of vapors. The specific thickness of surficial soil is a policy choice. This is not defined in the Technical Background Document for Development of Soil Screening Levels (Revision 2) (NMED, 2002). However, based on Guidelines for Corrective Action (New Mexico Underground Storage Tank Bureau, 2000), the surficial soil zone was assigned a thickness of 1 foot.

Based on the review of soil data collected in July 2002, February 2004, and August 2004 (refer to Table 1-1) the following was observed:

**<u>Surficial Soil (0-1 feet bgs)</u>**

- Five surficial soil samples were collected from borings SB01 to SB05.
- TPH, acetone, carbon disulfide, hexane, and xylenes were detected in the surficial soil.

- Carbon disulfide was detected in SB02 at 3 µg/kg.
- Hexane was detected twice in SB02 and SB05. The higher concentration of 0.82 µg/kg of hexane was observed in SB05.
- Total xylenes were detected in all of the surficial soil samples and the highest total xylenes concentration was 3.3 µg/kg in SB03.
- TPH was detected in all of the five samples and the highest concentration was 685,000 µg/kg in SB02.

**Subsurface Soil (1 feet bgs to the water table)**

- Twenty subsurface soil samples were collected from borings DP-01 to DP-07, SB01 to SB05, and SV01 to SV03.
- Chrysene, ethylbenzene, diethylphthalate, fluoranthene, 2-methylnaphthalene, phenanthrene, TPH, hexane, indeno (1,2,3-c,d) pyrene, isopropylbenzene, xylenes, benzo (a) anthracene, benzo (b) fluoranthene, benzo (k) fluoranthene, benzo (g,h,i) perylene, benzo (a) pyrene, and pyrene were detected in the subsurface soil.
- The maximum depth of soil analysis was at 12 feet bgs for boring DP-04. TPH-DRO and TPH-ORO were detected.
- The maximum TPH-DRO concentration observed was 9,350,000 µg/kg at 2 feet bgs in SB02.

## 1.7 Distribution of COPCs in Groundwater

The groundwater samples collected have been analyzed for TPH and VOCs. Based on the review of groundwater data collected in February and August 2004, the following was observed:

- Eleven groundwater samples were collected from borings SB01 to SB05 and monitoring wells MW01 through MW05, and MW07.
- TPH-DRO, acetone, benzene, 2-butanone, carbon disulfide, chloroform, cyclohexane, 1,3-dichlorobenzene, 1,4-dichlorobenzene, dichlorodifluoromethane, ethylbenzene, isopropylbenzene, methylcyclohexane, trichloroethene, trichlorofluoromethane, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and xylenes were detected in groundwater samples.
- The maximum TPH-DRO concentration of 3,600 mg/L was observed in SB03.

## 1.8 Distribution of CPOCs in Soil-Vapor

Three dual completion soil-vapor borings (SV01 to SV03) were drilled and analyzed for TPH and VOCs (Table 1-3).

- Six soil-vapor samples were collected from the soil-vapor borings (two each from SV01 to SV03).

- 2-Propanol, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, acetone, chloroform, toluene, m/p-xylene, o-xylene, and naphthalene were detected in soil-vapor samples.
- A toluene concentration of 5.2 micrograms per cubic meter ($\mu g/m^3$) was detected at 3 feet in soil-vapor boring SV03.

## 1.9 Water Use

HAFB is located in the Tularosa Sub-basin. Potable water is available from municipal wells along the margins of the basin with more saline water towards the center. The principle sources of potable water are located in a long narrow north-south trending area east of Alamogordo and Tularosa and in the far southern part of the basin. HAFB is supplied potable water from Lake Bonito, which is in the Pecos River Basin.

Within the boundaries of SS-57, stormwater run-off is controlled by the minimal topographic relief as per the existing grade and landscaping. Appurtenances can be found along the perimeter for collection into the Base storm water drainage system.

The annual rainfall for Alamogordo is 12 inches per year (http://countrystudies.us/united-states/weather/new-mexico/).

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# 2 EXPOSURE MODEL

This Section presents the exposure model (EM) for the Officer's Club, Site SS-57. The EM identifies the potential receptors and the routes of exposure under current and anticipated future conditions.

## 2.1 Receptors

As per Sections 2.2 and 2.3 of the *Technical Background Document for Development of Soil Screening Levels* (Revision 2) (NMED, 2002), following are the definitions of the various receptors that should be considered:

- A residential receptor is assumed to be a long-term receptor occupying a dwelling within the site boundaries and thus is exposed to contaminants 24 hours per day, and is assumed to live at the site for 30 years, remaining on-site for 350 days per year.
- A commercial/industrial worker is assumed to be a long-term receptor exposed during the course of a work day as either (1) a full time employee of a company operating on-site who spends most of the workday conducting maintenance or manual labor activities outdoors or (2) a worker who is assumed to regularly perform grounds-keeping activities as a part of his/her daily responsibilities.
- A construction worker is assumed to be receptor that is exposed to contaminated soil during the work day for the duration of a single on-site construction project.

Based on the above definitions and the current land use in the vicinity of impacts, the commercial/industrial worker is considered as the current receptor for risk assessment. Assuming the future land use to be residential, the resident is considered as the future receptor for risk assessment. This is a very conservative assumption since it is highly unlikely that the site would become residential in the future. The construction worker is considered a receptor for both current and the future conditions. From the soil and groundwater analytical data, it appears that the impacts of the release were minimal and localized.

## 2.2 Conceptual Site Model

The conceptual site model (CSM) evaluates the various routes of exposure for each receptor. Table 2-1 presents the CSM for current conditions for the commercial/industrial worker. Table 2-2 presents the CSM for the future conditions for the residential receptor. Table 2-3 presents the CSM for both current and future conditions for the construction worker. Note that outdoor inhalation from surface and subsurface soil will not be quantified since indoor inhalation is being considered and is the more critical pathway.

## 2.3 Summary of Complete Exposure Pathways

The complete routes of exposure (refer to Tables 2-1, 2-2 and 2-3) that will be quantitatively evaluated are summarized below:

### Current Non-residential Worker

1. Dermal contact with surficial soil
2. Ingestion of surficial soil
3. Outdoor inhalation from surficial soil
4. Indoor inhalation from subsurface soil
5. Indoor inhalation from groundwater

### Future Resident

1. Dermal contact with surficial soil
2. Ingestion of surficial soil
3. Outdoor inhalation from surficial soil
4. Indoor inhalation from subsurface soil
5. Indoor inhalation from groundwater

### Current/Future Construction Worker

1. Dermal contact with surficial soil
2. Ingestion of surficial soil
3. Outdoor inhalation from surficial soil
4. Indoor inhalation from groundwater
5. Dermal contact with groundwater

# 3 COMPARISON OF CONCENTRATIONS

This Section presents the comparison of soil, groundwater, and soil-vapor data with generic standards. The standards selected and the results of the comparison are explained in detail below. However, the standards used do not consider the indoor inhalation pathway from soil or groundwater. A quantitative evaluation of this pathway is presented in Section 4.

## 3.1 Comparison of Soil Concentrations

The maximum detected concentration from the July 2002, February 2004, and August 2004 soil data was compared with New Mexico Environmental Department (NMED) soil screening levels (SSLs) for residential and industrial/occupational land use (NMED, 2002). For TPH-DRO and TPH-ORO, the SSLs are as per the NMED TPH Screening Guidelines (NMED, 2003). SSLs for TPH-GRO are not required since the primary constituents of TPH-GRO (i.e., BTEX) have been evaluated separately. The comparisons presented in Table 3-1 indicate that none of the parameters, except TPH-DRO, exceed the NMED SSLs.

Two chemicals (2-methylnaphthalene and benzo (g,h,i) perylene) did not have NMED SSLs. For these chemicals, the SSLs were calculated using the methodology included in the NMED soil screening guidance (NMED, 2002).

## 3.2 Comparison of Groundwater Concentrations

The maximum detected concentration from the February 2004 and August 2004 groundwater data was compared with groundwater standards. Conservatively, the groundwater standard used is the lowest of the following groundwater standards:

- New Mexico's Water Quality Control Commission (WQCC)
- EPA-promulgated maximum contamination levels (MCLs)
- EPA-promulgated health advisory (HA)

For chemicals without groundwater standards in the above mentioned resources, groundwater standards were calculated based on risk levels for domestic consumption of water. TPH groundwater standards were taken from NMED TPH screening guidelines.

Five chemicals (1,2,4-trimethylbenzene, acetone, carbon disulfide, cyclohexane, methylcyclohexane) did not have the first three above mentioned groundwater standards. For these chemicals, the groundwater standards were calculated using the risk-based approach as presented in the *Guidelines for Corrective Action Document* (New Mexico UST Bureau, 2000) and assuming direct ingestion of water by an adult.

The TPH-DRO groundwater standard was not calculated using the risk-based approach. Instead this standard is taken from the *TPH Screening Guidelines* (NMED, 2003).

The groundwater comparison tabulated in Table 3-2 indicates that the maximum concentrations for none of the chemicals, except TPH-DRO, exceeded the groundwater standards.

## 3.3 Comparison of Soil-Vapor Concentrations

The maximum detected concentration from the February 2004 soil-vapor data are compared with the allowable indoor inhalation levels for both the resident and the commercial worker included in the New Mexico *Underground Storage Tank Bureau Guidelines for Corrective Action.* Note that the allowable indoor inhalation levels are the allowable concentrations in the breathing zone. The comparison is very conservative since the soil-vapor concentrations will reduce as vapors migrate into the enclosed space, and mix with the air in the enclosed space resulting in significantly lower indoor air concentrations.

Four chemicals (1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, acetone, and chloroform) did not have allowable indoor inhalation standards. For these chemicals, the indoor inhalation standards were calculated using the risk-based approach.

The soil-vapor comparison is tabulated in Table 3-3 and indicates that none of the chemicals, except 1,2,4-trimethylbenzene for resident and 1,3,5-trimethylbenzene and chloroform for both resident and commercial worker, exceeded the indoor inhalation vapor levels.

Calculation of risk based standards used the exposure factors in Table 3-4, physical and chemical parameters in Table 3-5 and toxicity parameters Table 3-6.

## 3.4 Summary of Comparison with Target Levels

The above comparisons are summarized as follows:

1. The maximum detected TPH-DRO concentration in soil exceeded the NMED TPH target level. Therefore, site-specific levels for TPH-DRO were developed using the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) approach for the complete pathways as per the CSM (Section 2). This is further discussed in Section 5.
2. The maximum detected TPH-DRO concentration in groundwater exceeded the NMED TPH target level. Therefore, site-specific levels for TPH-DRO were developed using the TPHCWG approach for the complete pathways as per the CSM (Section 2). This is further discussed in Section 5.
3. The maximum detected soil-vapor concentrations for 1,2,4-trimethylbenzene for resident and 1,3,5-trimethylbenzene and chloroform for both resident and commercial worker exceeded the inhalation vapor target levels. As discussed in Section 3.3, this is a very conservative comparison.
4. Since the NMED target levels do not account for soil and groundwater concentrations protective of indoor inhalation, this pathway is evaluated in Section 4.

# 4 INDOOR INHALATION

This Section describes the procedure used to calculate the site-specific risk-based target levels for the indoor inhalation pathway. Note this indoor inhalation pathway is not accounted for by NMED SSLs and groundwater standards. The Johnson and Ettinger (J&E) model (USEPA, 2003) is used for estimating screening levels for vapor intrusion pathways. USEPA used the J&E model as the basis to develop a spreadsheet to estimate the incremental risk level, hazard index (HI), or target soil and groundwater cleanup concentrations for prescribed risk and HI.

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

- Toxicity parameters
- Physical and chemical parameters
- Exposure factors
- Fate and transport parameters
- Soil and building characteristics

Each of these is discussed below.

## 4.1 Inputs Used to Calculate Target Levels

### 4.1.1 Toxicity Parameters

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 4-1(a).

### 4.1.2 Physical and Chemical Parameters

The development of risk-based soil screening levels requires selected 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 4-1(a).

### 4.1.3 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 soil and groundwater screening levels are presented in Table 3-4. The exposure factors were obtained from the *Technical Background Document for Development of Soil Screening Levels* (Revision

2) (NMED, 2002). For the Officer's Club, the site-specific receptor considered for the indoor inhalation pathway is a non-resident.

### 4.1.4 Fate and Transport Parameters

Fate and transport parameters are necessary to estimate the target levels for the indirect routes of exposure. These factors characterize the physical properties of vadose zone, saturated zone, building, and ambient air. Table 4-1(b) provides these values that were obtained from a combination of *Technical Background Document for Development of Soil Screening Levels* (Revision 2) (NMED, 2002) and site-specific values.

### 4.1.5 Soil and Building Characteristics

The site-specific soil and building parameters considered are as follows:

1. Depth below grade to bottom of enclosed space floor - For the Officer's club, due the presence of a basement, the default value of 200 centimeter (cm) is considered (USEPA, 2003). For residential land use, the default value of 15 cm (slab-on-grade construction) is considered (USEPA, 2003).
2. Average soil temperature - For New Mexico, the range of groundwater temperature is 52 to 62 degrees Fahrenheit (°F)(USEPA, 2003). The groundwater temperature of 62 °F (17 degrees Celsius [°C]) has been considered as the approximate average soil temperature.
3. Vadose zone Soil Conservation Service (SCS) soil type – For the Officer's Club, the vadose zone soil type is silty sand (Section 1.4). However, the most similar soil type to silty sand from the default SCS soil type listed in the USEPA spreadsheet is loamy sand.

## 4.2 Risk Assessment

The above input parameters are used in the USEPA spreadsheet implementation of the J&E model to evaluate the target levels. The risk value of 1E-05 and hazard quotient (HQ) value of 1 (NMED, 2002) are used to evaluate the target soil and groundwater cleanup concentrations.

However, the USEPA spreadsheet does not include several of the PAHs because PAHs have low Henry's law constant and vapor pressure and hence are not considered volatile. Additionally, the USEPA spreadsheet does not include TPH-DRO. To evaluate TPH-DRO, an alternative version of the J&E model, similar to the program incorporated into the New-Mexico Risk-Based Corrective Action (NMRBCA) program, was used. TPH-DRO was broken down into six individual carbon fraction ranges and the target levels for each fraction was calculated.

The target levels were compared with the maximum and average concentrations. To calculate the average concentrations, the non-detect values were replaced with ½ of the detection limits. The average concentrations were considered because the mass flux of volatile chemicals that enters the enclosed space is proportional to the average and not the maximum concentration. For calculating average soil concentrations, data from borings SB02, SB04, SB05, and SB06 were conservatively considered even though these borings are outside the Officer's Club property boundary since they have detected concentrations and it is more conservative to include them.

For calculating the groundwater average concentration, data from SB05 was not considered since all the chemicals were non-detect. Groundwater data from MW07 was conservatively included in calculating the average concentration because, even though it is a periphery well, it had the highest chloroform concentration and detectable concentrations of of 1,3-dichlorobenzene and xylenes. Tables 4-2 through 4-5 present the comparison of the soil and groundwater concentrations with the indoor inhalation target levels. The comparison indicates that neither the maximum nor average concentrations for any of the volatile chemicals exceeded the target levels.

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# 5 EVALUATING COPCS FOR COMPLETE ROUTES OF EXPOSURE

As mentioned in Section 3.4, the maximum detected TPH-DRO concentration exceeded the generic screening levels in both soil and groundwater (Tables 3-1 and 3-2). This Section presents the calculation of site-specific target levels for TPH-DRO.

## 5.1 Methodology

The site-specific target levels (SSTLs) for all the complete routes of exposure presented in Section 2.3 for resident, commercial worker, and construction worker were developed using the methodology discussed in *Guidelines for Corrective Action* (New Mexico Underground Storage Tank Bureau, 2000) and *Risk Assessment Guidance for Superfund - Volume I, Human Health Evaluation Manual* (USEPA, 1989).

TPH-DRO was composed of three aliphatic (i.e., C10-C12, C12-16, C16-C21) and three aromatic (i.e., C10-C12, C12-16, C16-C21) carbon fractions. Target levels for each of these fractions were calculated. The sum of the target levels for each fraction was used to yield a target level for TPH-DRO. For additional details of this approach refer to TPHCWG Series (Volumes 1 through 5).

The physical, chemical, and toxicological parameters for TPH-DRO and the carbon fractions are taken from the TPHCWG. The exposure factors, physical and chemical parameters, and toxicological parameters for calculating the standards are presented in Tables 3-4 through 3-6.

## 5.2 Comparison with SSTLs

The comparison of the maximum detected TPH-DRO and the carbon fractions are presented in Tables 5-1 to 5-4. None of the concentrations exceeded the SSTLs for any of the complete routes of exposures (ROEs).

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# 6 RESULTS AND CONCLUSIONS

This Section summarizes the results and the conclusions of this risk-based evaluation.

The review of site history identified non-residential workers and commercial workers as the site-specific receptors. The primary ROEs which have been quantitatively evaluated include:

- Commercial Worker
  - Dermal contact with surficial soil
  - Ingestion of surficial soil
  - Outdoor inhalation from surficial soil
  - Indoor inhalation from subsurface soil
  - Indoor inhalation from groundwater
- Resident
  - Dermal contact with surficial soil
  - Ingestion of surficial soil
  - Outdoor inhalation from surficial soil
  - Indoor inhalation from subsurface soil
  - Indoor inhalation from groundwater
- Construction Worker
  - Dermal contact with surficial soil
  - Ingestion of surficial soil
  - Outdoor inhalation from surficial soil
  - Indoor inhalation from groundwater
  - Dermal contact with groundwater

The maximum soil, groundwater, and soil-vapor concentrations were compared with NMED SSLs, NMWQCC standards, and air inhalation target levels (New Mexico Underground Storage Tank Bureau, 2000), respectively. None of the concentrations exceeded the standards. However, NMED target levels do not account for indoor inhalation of vapors from soil or groundwater.

Therefore, the J&E model was used to estimate soil and groundwater target levels protective of indoor inhalation. None of the site soil and groundwater maximum concentrations exceed these target levels.

Speciation of TPH-DRO data into aromatic and aliphatic fractions was based on the TPHCWG approach. SSTLs were calculated for each fraction for the each complete ROE. Neither TPH-DRO nor the carbon fraction exceeded the SSTLs for the ROEs.

Based on the above evaluation, the residual soil, groundwater, and soil-vapor concentrations are protective of current and reasonable future receptors at the site. These concentrations are anticipated to reduce in time due to natural attenuation processes further reducing the risk.

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# 7 REFERENCES

## 7.1 Site-Specific References

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Wilson & Company, 1991. *Engineering Report for Study to Determine Source of Odor at the Officer's Club SVS 91-0206.*

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## 7.2 General References

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New Mexico Environment Department, 2002. *Technical Background Document for Development of Soil Screening Levels* (Revision 2).

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Volume No. 2, Composition of Petroleum Mixtures

Volume No. 3, Selection of Representative TPH Fractions Based on Fate and Transport Considerations

Volume No. 4, Development of Fraction Specific Reference Doses (RfDs) and Reference Concentrations (RfCs) for Total Petroleum Hydrocarbons (TPH)

Volume No. 5, Human Health Risk-Based Evaluation of Petroleum Release Sites: Implementing the Working Group Approach

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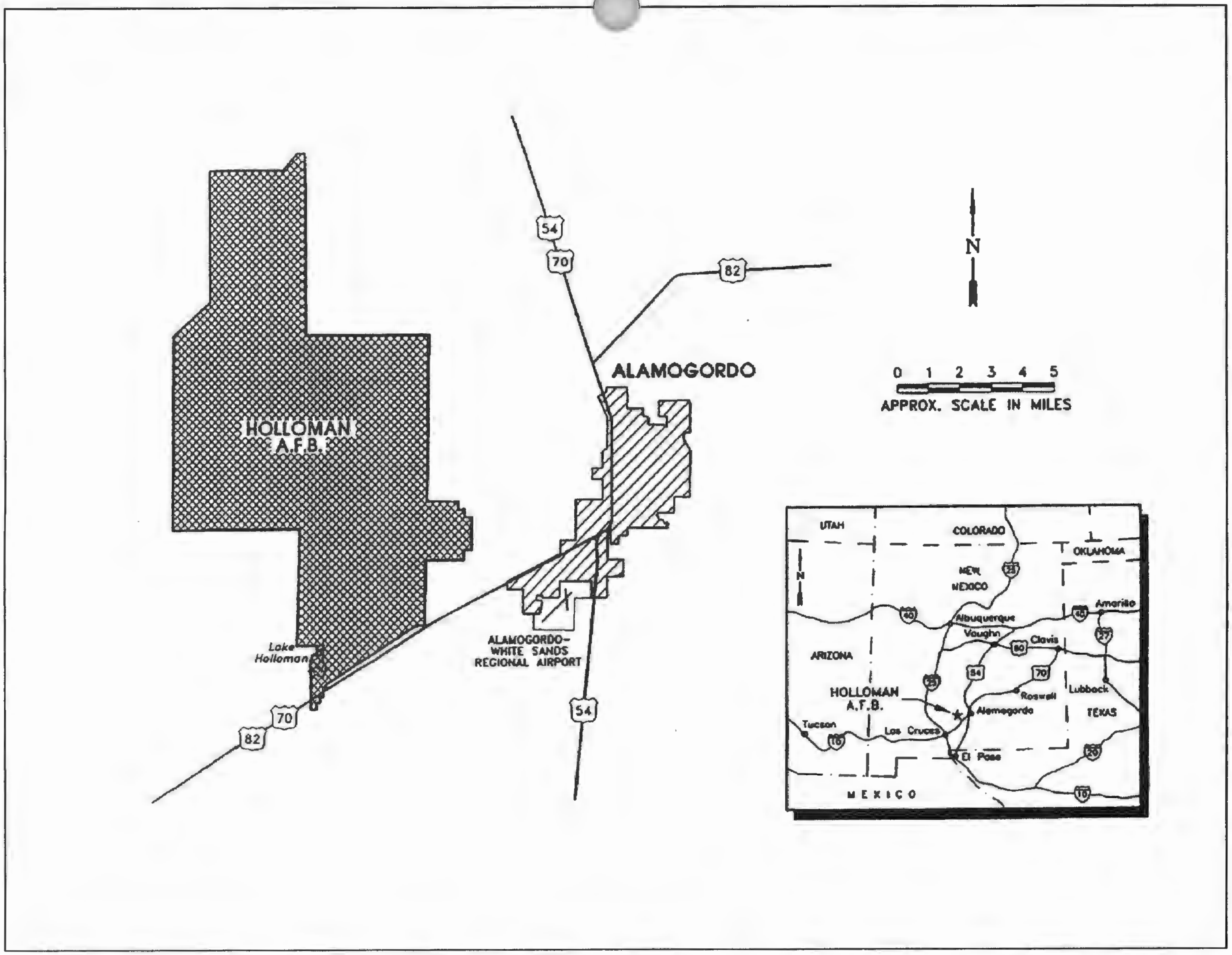
US EPA, 2003. *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings.*

# FIGURES

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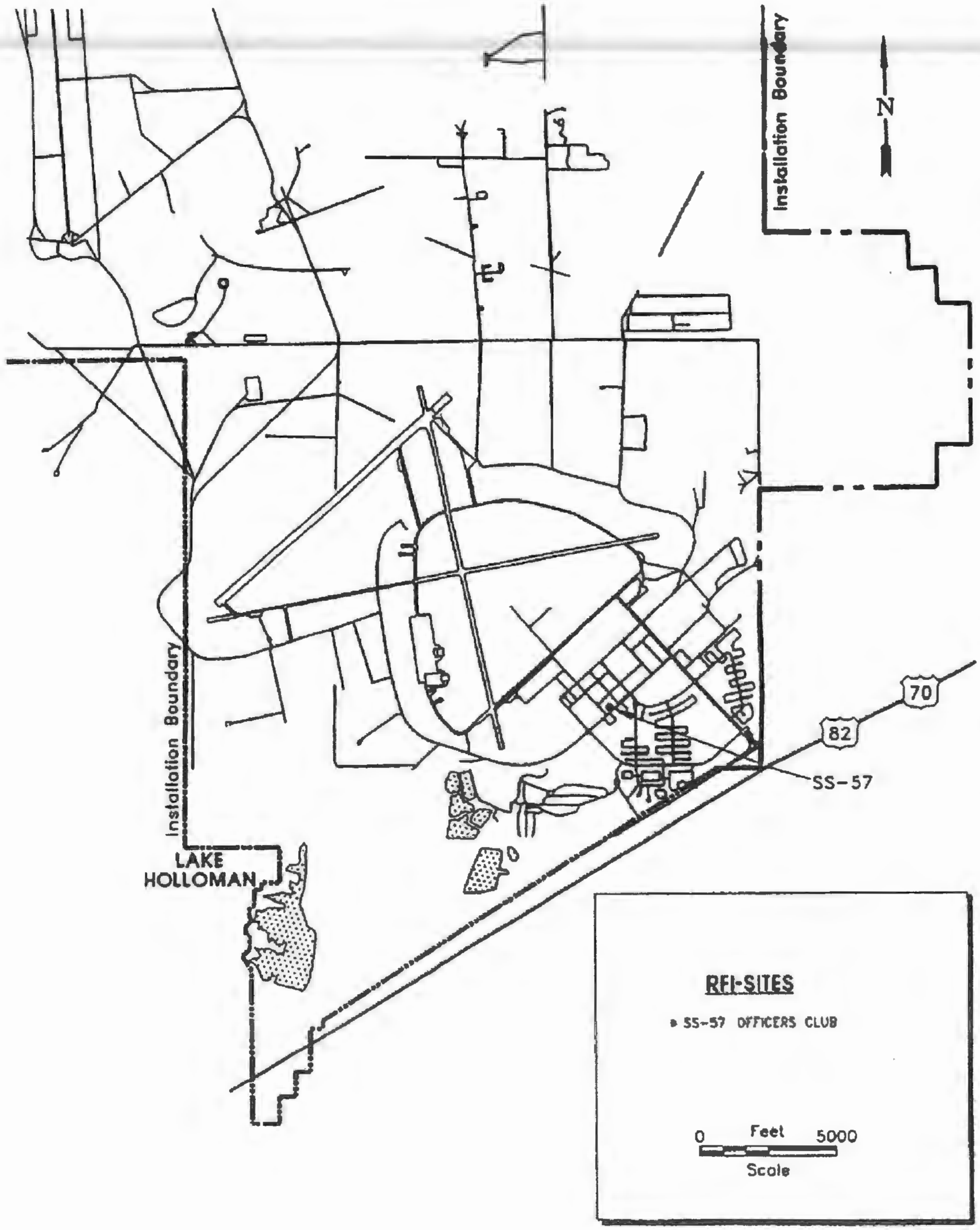
LOCATION MAP

| PROJECT NO. | SCALE | DATE | DRAWN BY: MRM / DRAWING NO: 9040002-01 |
|---|---|---|---|
| 9040002 | SHOWN | 10/20/04 | |

SITE SS-57
HOLLOMAN AFB
NEW MEXICO

Figure 1-1

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FACILITY MAP

| PROJECT NO. | SCALE | DATE | DRAWN BY: MRM |
|---|---|---|---|
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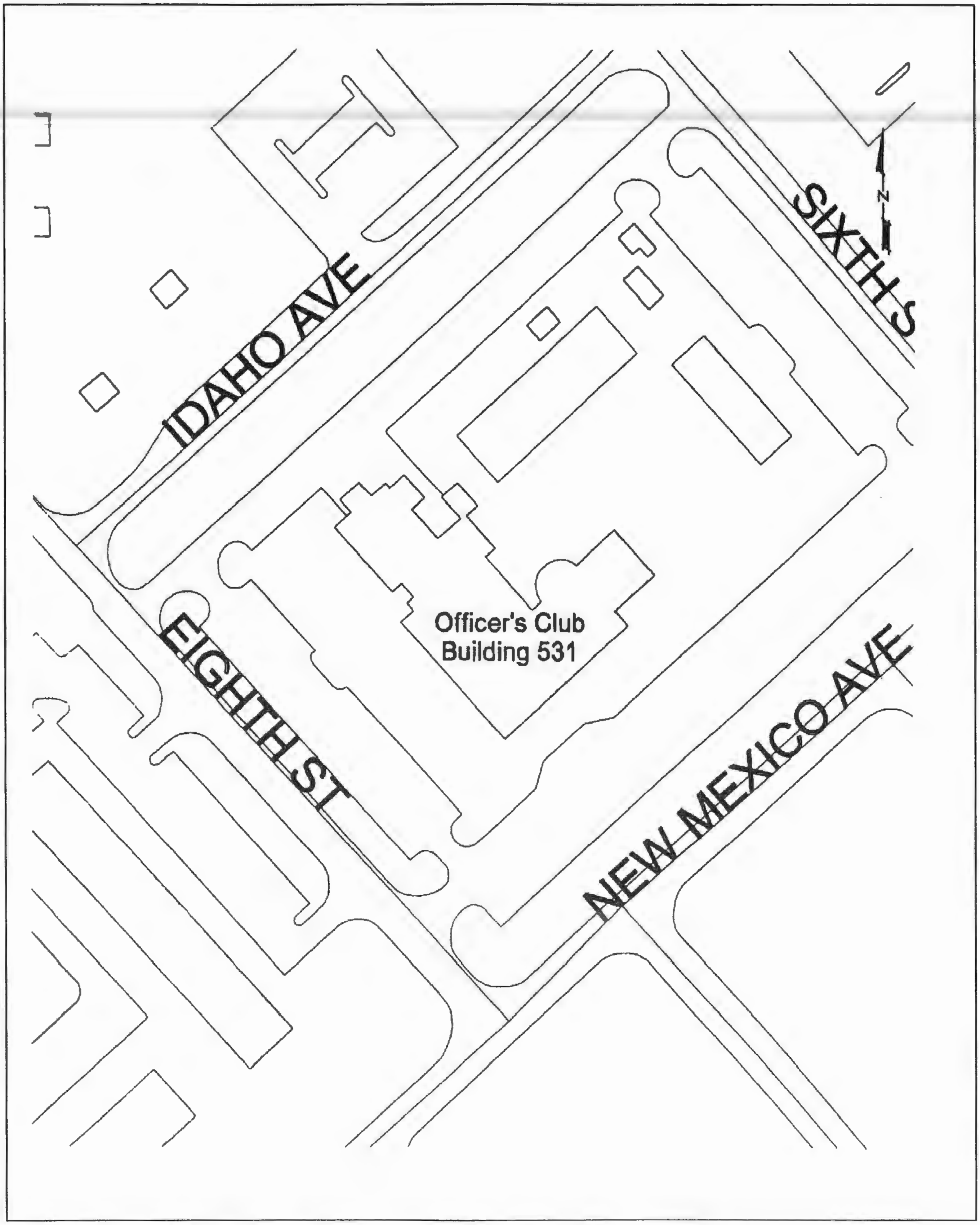
SITE SS-57
HOLLOMAN AFB
NEW MEXICO

Figure 1–2

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SITE LOCATION MAP

| PROJECT NO. | SCALE | DATE | DRAWN BY: MRM |
|---|---|---|---|
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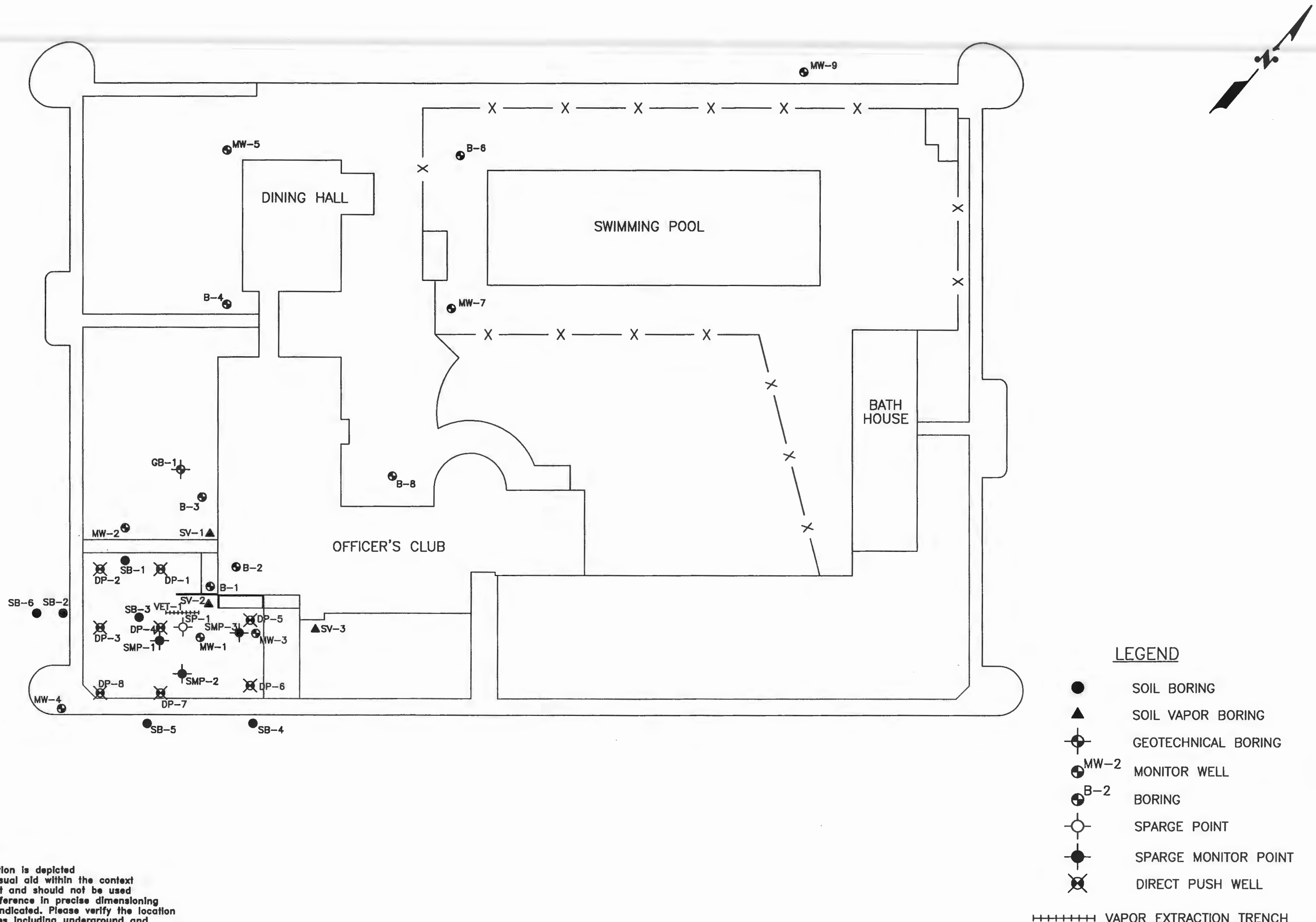
SITE SS-57
HOLLOMAN AFB
NEW MEXICO

Figure 1-3




NOTES:
This information is depicted to provide visual aid within the context of this report and should not be used as a sole reference in precise dimensioning of features indicated. Please verify the location of all features including underground and aboveground utilities prior to conducting any subsurface exploration or site assessment.

Drawing source: RAM GROUP INC.

SITE SS-57
HOLLOMAN AFB
NEW MEXICO

Figure 1-4

SAMPLE LOCATION MAP

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| DATE | 8/17/04 |
| SCALE | NTS |
| PROJECT NO. | 9040002 |

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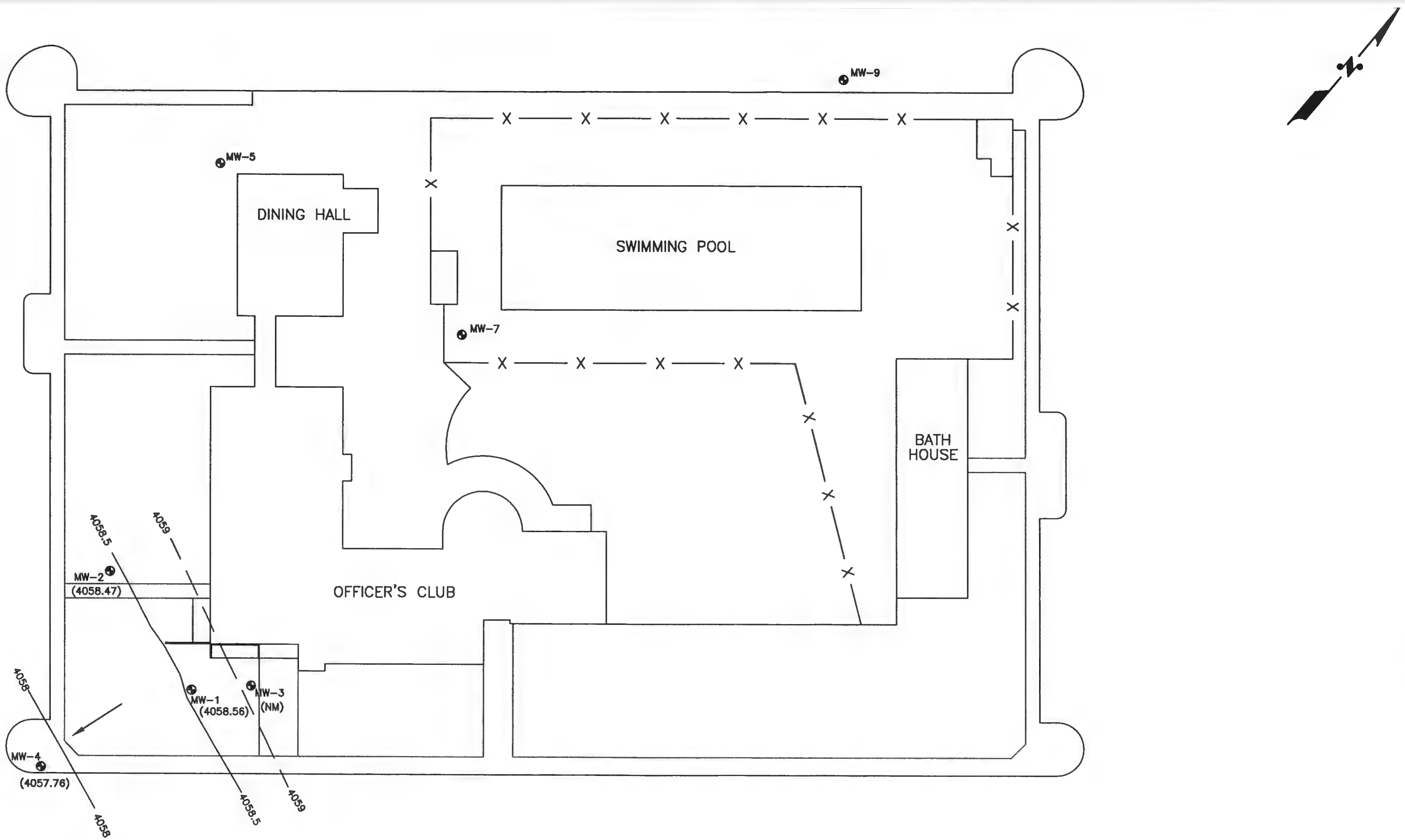


NOTES:
This information is depicted to provide visual aid within the context of this report and should not be used as a sole reference in precise dimensioning of features indicated. Please verify the location of all features including underground and aboveground utilities prior to conducting any subsurface exploration or site assessment.

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LEGEND

| | |
|---|---|
| MW-2 | MONITOR WELL |
| | GROUNDWATER CONTOUR LINES |
| 4057.80 | GROUNDWATER ELEVATION (APRIL 9, 1996) |
| | GROUNDWATER FLOW DIRECTION |

SITE SS-57
HOLLOMAN AFB
NEW MEXICO

Figure 1-5

GROUNDWATER CONTOUR MAP

| PROJECT NO. | SCALE | DATE | DRAWN BY: | DRAWING NO: |
|---|---|---|---|---|
| 9040002 | NTS | 8/17/04 | TES | 9040002-05 |

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