**Department of Energy**
Los Alamos Area Office
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MAR 30 1994

Mr. William Honker, Chief
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Dear Mr. Honker:

Enclosed are two copies of the "RFI Phase Report, Operable Unit 1071, SWMU Aggregate 0-D, Ordnance Impact Areas, March 1994." This is the second Phase Report to be submitted for this operable unit.

If you have any questions regarding this submittal, please call me at (505) 665-7203.

Sincerely,

Theodore J. Taylor
Program Manager
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LESH:7TT-026

Enclosure (2)

cc:
See page 2

O-011 (a, c-e)
C-O-020

XXR1071

6741

MAR 30 1994



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## CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with 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 violation.

Document Title:

**"Resource Conservation And Recovery Act Facility Investigation (RFI) Phase Report - Operable Unit (OU) 1071, Solid Waste Management Unit (SWMU) Aggregate O-D Ordnance Impact Areas"**

Name: _____ Date: March 25, 1994

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# RFI Phase Report

# Operable Unit 1071, SWMU Aggregate 0-D

# Ordnance Impact Areas

Los Alamos National Laboratory
Los Alamos, NM

March 1994

Environmental Restoration Program
Los Alamos National Laboratory

**RFI Phase Report**

**Operable Unit 1071, SWMU Aggregate 0-D**
**Ordnance Impact Areas**

## Executive Summary

This report presents the results of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) field work conducted at Operable Unit (OU) 1071, Solid Waste Management Unit (SWMU) Aggregate 0D, ordnance impact areas. This aggregate contains five Potential Release Sites (PRSs): SWMUs 0-011(a), (c), (d), and (e); and Area of Concern (AOC) C-0-020. These areas were either known or possible ordnance impact sites used by the U.S. Army in the 1940s where potentially unexploded ordnance (UXOs) and ordnance explosive waste (OEW) could have been present. The goal of the RCRA process for this SWMU aggregate was to (1) ensure that all UXOs and OEW were located and removed and (2) determine if any chemical contaminants, derived from the degradation of the ordnance fragments or high explosives (HE) are present in concentrations above the screening action levels (SALs) for those contaminants.

### Field Program

OU 1071 RFI field activities at the five PRSs consisted of a search by a team of certified master explosive ordnance disposal (EOD) technicians. The sites were systematically scanned with ordnance detection equipment following standard military ordnance clearance procedures. Following the EOD team sweep, a team of geophysicists conducted a second survey of the PRSs using magnetic and/or electromagnetic survey instruments. The geophysical surveys provided a quality control measure to ensure that the areas were cleared of all UXOs and significant sized OEW fragments The EOD and geophysical surveys were conducted so as to ensure that every square foot of the PRSs were covered.

Geomorphic mapping of each PRS with OEW was completed to map the soils and extent of drainage channels within the site that would be likely pathways for the surficial transport of contaminants away from the impact zones. Sediment catchment sites along drainage channels were prioritized for sampling, because they represented areas with the highest probability of containing contaminants being removed from the site by surface runoff. All soil/sediment samples were screened for gross alpha, gross beta, and gross gamma activity. In addition, all samples were analyzed for target analyte list (TAL) metals and for HE. Metals results were evaluated with respect to background levels and screening action levels (SALs). HE results were analyzed with respect to SALs only.

### Results

#### SWMU 0-011(a)

SWMU 0-011(a) is located on Department of Energy (DOE) property about 0.4 miles east of the Sportsman's Club firing range in Rendija Canyon. Before the RFI site investigation began, the SWMU was thought to be delimited by a barbed-wired fence (and marked with warning signs) erected to keep individuals out of the site. However, the EOD surveys found that the impact area extended to the south, well beyond the fence, increasing the size of the SWMU from approximately 7 acres to approximately 28.5 acres. SWMU 0-011(a) was the only PRS where live HE mortar rounds with live fusings were found. Additionally, approximately 2400 pieces of ordnance fragments including tail fins and fuses, and approximately three-times as much scrap material were recovered. Following geomorphologic mapping, 19 soil samples were collected from sediment storage locations within the drainage channels that drained the areas of high fragment concentration. The data quality and screening assessments of the analytical results concluded that, despite some QA difficulties, there was no indication the HE was present in any of the samples. Concentration of all inorganics are comparable to regional background. Given the extremely thorough UXO and OEW search and retrieval operation and absence of any contaminants in the soil or sediments, if is recommended that the site be designated as a no further action (NFA) PRS and be approved for residential land use. Additionally, it is

recommended that DOE remove the fence.

**SWMU 0-011(c)**

SWMU 0-011(c) is an elongate-shaped area extending southeast to northwest, located on DOE and U.S. Forest Service property in Cabra Canyon, a tributary to Rendija Canyon. The sole indication that a SWMU might be present at this site was the presence of two deteriorating danger signs warning of explosives. The ordnance surveys of the SWMU did not locate any UXOs or even a single fragment EOW. The complete absence of these materials indicates that this site was never used as an ordnance impact area. It is therefore recommended that SWMU 0-011(c) be designated for no further action (NFA) and approved for residential land use.

**SWMU 0-011(d)**

SWMU 0-011(d) is in Bayo Canyon just northeast of the intersection of San Ildefonso Road and Diamond Drive. The area is well fenced and marked. Materials recovered from the SWMU were restricted to OEW fragments of 23.6-inch bazooka rounds. Following geomorphologic mapping, 20 soil/sediment samples were collected during two sampling events. The data quality and screening assessments of the analytical results show that there is no HE present at the site and the concentrations of all inorganics except lead are comparable to regional background. The lead levels are, however, far below the SAL of 500 ppm. Given the extremely thorough UXO and OEW search and removal operation and absence of any significant contaminants in the search and removal operation and absence of any significant contaminants in the soil or sediments, it is recommended that the site be designated as a NFA PRS and be approved for residential land use. Additionally, it is recommended that Los Alamos County take down the fence.

**SWMU 0-011(e)**

SWMU 0-011(e) is located on DOE and U.S. Forest Service land north-northeast of the Sportsman's Club in Thirty-Seven Millimeter Canyon, a tributary of Rendija Canyon. Materials recovered during the ordnance sweep of this SWMU included two 20 mm rounds, 102 armor-piercing (AP) rounds, and fragments of 37 mm HE rounds. Other materials found included 350 pieces of OEW fragments and expended bullets. Following geomorphologic mapping, nine soil samples were collected from sediment storage locations within the drainage channels that drained the areas of high fragment concentration and along the major channel that drained the site into Rendija Canyon. Analysis of the samples shows that HE is not present at the site and concentrations of all inorganics are comparable to regional background levels. Given the extremely thorough UXO and OEW search and removal operation and absence of any contaminants in the soil or sediments, it is recommended that the site be designated as a NFA PRS and approved for residential land use. Additionally, it is recommended that DOE and the U.S. Forest Service take down the fence.

**AOC C-0-020**

AOC C-0-020 is located in a tributary of Rendija Canyon west of the Guaje Pines Cemetery. It was thought that the U.S. Army fired mortar rounds from Barranca Mesa into this area, although it is poorly marked, and some doubt existed that it was ever an active site. An ordnance team from Fort Bliss did not encounter any ordnance in a preliminary site survey in 1991. The ordnance surveys of this AOC did not locate any UXOs or OEW. The complete absence of these materials indicates that this site was never used as an ordnance impact area. It is therefore recommended that AOC C-0-020 be designated for NFA and approved for residential land use.

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## 1.0 Introduction

### 1.1 SWMU Aggregate 0-D Description

This report presents the results of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) field work conducted at Operable Unit (OU) 1071, Solid Waste Management Unit (SWMU) Aggregate 0-D, ordnance impact areas. This aggregate, described in Section 5.3 of the OU 1071 RFI Work Plan (LANL 1992a), contains five Potential Release Sites (PRSs): SWMUs 0-011(a), (c), (d), and (e); and Area of Concern (AOC) C-0-020. Locations are shown in Figure 1. The archival search conducted for preparing the OU RFI work plan documented that SWMU 0-011 (b) and 0-011 (e) are the same site, so the 0-011 (b) designation was dropped. The Potential Release Sites (PRSs) are areas that were either known or possible ordnance impact sites used by the U.S. Army in the 1940s. All of them, therefore, were sites with potentially unexploded ordnance (UXOs) and ordnance explosive waste (OEW). Three of the sites [0-011(a), (d), and (e)] were fenced and posted with warning signs in the early 1960s.

### 1.2 RFI Objectives

The OU 1071 RFI Work Plan identifies four PRSs in Rendija Canyon and one in a tributary of Bayo Canyon as areas that could contain UXOs, OEW, and associated contamination due to the presence of high explosives and/or metals in the soil. The most likely and significant hazard to site visitors was the possible presence of UXOs. Decomposed ordnance could also spread contaminants through infiltration into the vadose zone or by water entrainment and dispersion into the environment downstream. Human receptors may be exposed to these contaminants through ingestion or dermal contact.

The goal of the RCRA process for this SWMU aggregate was to ensure that all UXOs and OEW were located and removed and determine if either or both metals and high explosive (HE) are present in the soil above the cleanup levels for these contaminants.

## 2.0 Investigation Program

### 2.1 Field Program

#### 2.1.1 Activities

OU 1071 RFI field activities at the five Potential Release Sites (PRSs) consisted of searching for and removing any UXOs and OEW, geomorphologic mapping, and collecting shallow surface soil samples. The ordnance search at SWMU 0-011(d), at the west end of Barranca Mesa, was conducted in September and October 1992. Activities at AOC C-0-020 and SWMUI 0-011 (c) were completed in the spring of 1993 and at SWMUs 0-011 (a) and 0-011 (d) by late September 1993.

A detailed surface and subsurface sweep for UXOs and OEW was conducted at each PRS by a team of certified master explosive ordnance disposal (EOD) technicians. The sites were systematically scanned with ordnance detection equipment following standard military ordnance clearance procedures. The number of pieces of OEW in each subarea/lane was recorded by the team to develop a data set on the distribution and density of OEW in the impact areas.

Following the EOD team sweep, a team of licensed land surveyors marked a 100 ft. square grid on the ground surface at each PRS. The grid provided location reference points for the geophysics team that conducted a follow on sweep of the PRS. This procedure reduced the time required by the geophysics team to conduct its surveys. The grid for the first PRS investigated, SWMU 0-011 (d), was not surveyed in for the geophysics team, requiring the team to devote a significant amount of time to accurately locate reference markers. The surveyors also mapped the boundaries of the PRSs.

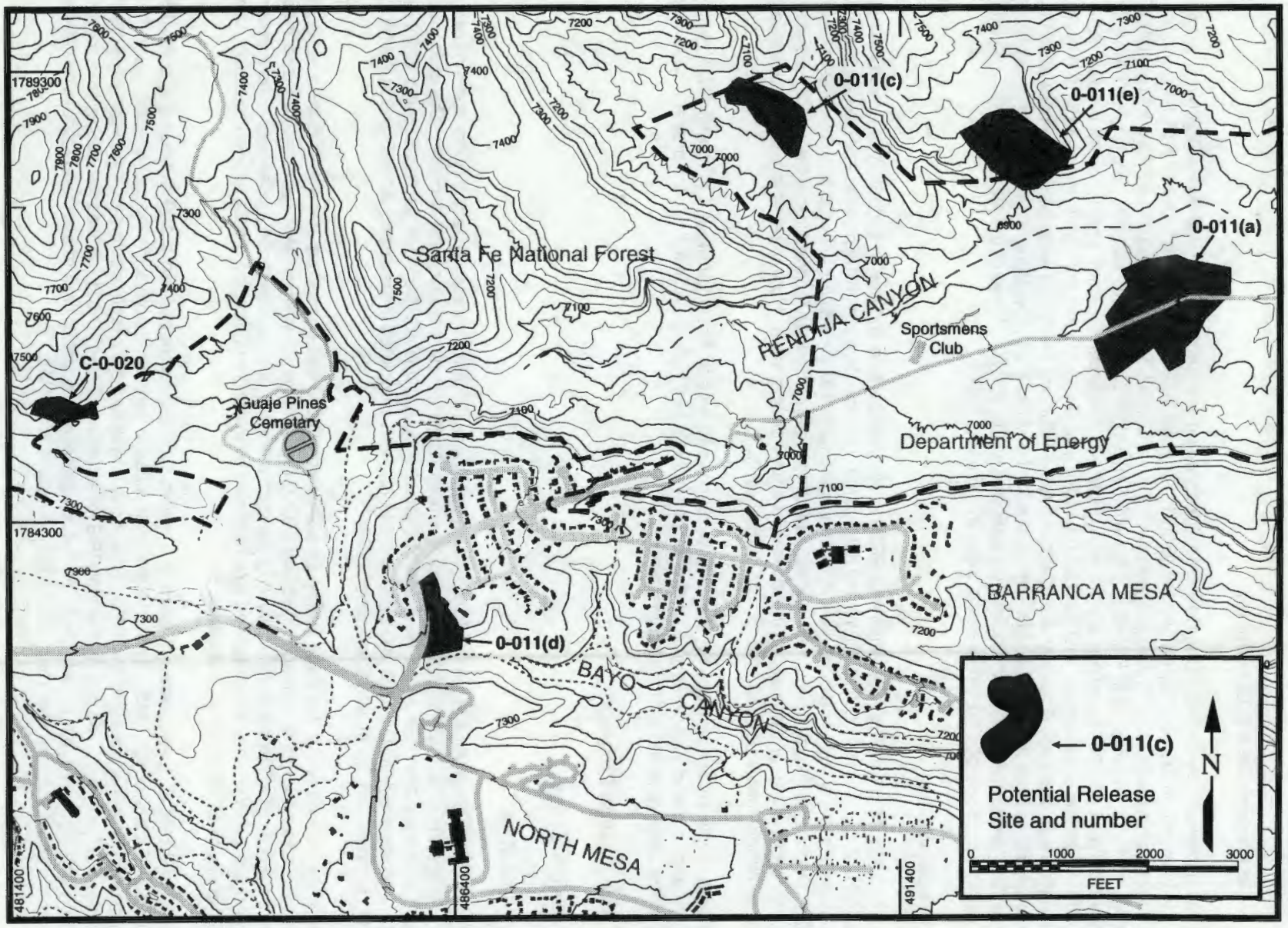


Figure 1. Map showing locations of possible and known ordnance impact areas in TA-0.

A team of geophysicists conducted a survey of the PRSs using magnetic and electromagnetic survey instruments. The geophysical surveys provided a quality control measure to ensure that the areas were cleared of all UXOs. Additionally, they identified OEW fragments missed by the EOD team. Each geophysical anomaly identified by the geophysics team was investigated by the EOD team.

Once all UXOs and OEW were removed, a site map was prepared showing the surficial deposits, the drainage channels within the site, and concentrations of OEW. These maps were then used to identify the most likely areas for contaminants from the ordnance to be concentrated and to select topographically biased sampling locations with a high likelihood of identifying the occurrence of contaminants, if present, at these sites. The surveyors precisely located these soil sample collection points.

Soil samples were collected following Los Alamos National Laboratory (the Laboratory) Environmental Restoration (ER) Program procedures for the collection of surface soil samples. Detailed information on the type and characteristics of the soil was also gathered.

### 2.1.2 Procedures

#### 2.1.2.1 Ordnance Search

The purpose of the EOD team's ordnance search was to detect, excavate, and remove all UXOs and, within the detection capability of their equipment, all OEW one inch in diameter or larger to a depth of 1 meter. This depth was selected, based on the types of ordnance and their maximum depths of penetration in sediments and soils in the impact areas and the surface geologic processes (burial and erosion) at these sites over the past 50 years. It was determined that 1 meter would be a highly conservative estimate of the maximum depth at which UXOs or OEW would be present. The fact that no ordnance fragments were found at any of the sites below a depth of about one helf meter lends credence to this determination.

The EOD team consisted of UXO-trained personnel, including personnel trained and certified as Master EOD Technicians under the requirements of the U.S. Army Corps of Engineers and the U.S. Army Toxic and Hazardous Materials Agency (USATHMA). The team members met all requirements for work at uncontrolled hazardous waste sites as described in 29 CFR 1920.120 and related regulations. On-site documentation for each member of the team included certification of 40-hour OSHA training, 8-hour refresher training (if applicable), a respirator fit test, proof of medical monitoring, and 8-hour supervisor training for the field team manager. All team members attended Laboratory health and safety and administrative training prior to the start of field work and complied with all applicable health and safety requirements.

For the ordnance surveys, lanes were set up on each site. The average lane width was eight feet, and the lanes were marked off with ropes which were laid out parallel to each other. After one lane was completed, the outside line was moved over to form the next lane (see Figure 2). This was continued until all of the lanes in each section were finished.

The orientation of the lanes was largely determined by the terrain. Lanes were oriented to allow the EOD team personnel to perform their work in the most efficient and safest manner. On steep slopes, for example, this meant orienting the lanes parallel to the slope direction. If this was not possible, then the last lane of a series of parallel lanes would be marked with flags so that no confusion would exist between the areas that were complete and areas that still needed to be completed. The lanes were swept up one side and down the other in 5 feet arcs that would overlap with the last pass (Figure 2). The lane

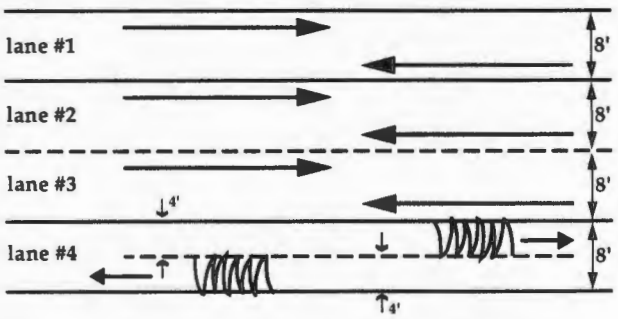


Figure 2. Explosive ordnance disposal team ordnance search pattern. Instrument movement shown by irregular lines in lane #4.

layout and instrument movement paths were designed to ensure that every square foot of each PRS was surveyed.

Magnetometers, which can readily locate mortar, bazooka, and 37 mm UXOs at the 1 meter target depth, and metal detectors were moved across the lanes so as to completely sweep the entire ground surface. Within each lane, the number of recovered pieces of OEW was recorded and notations made on the areas with the highest densities of OEW. No UXOs or OEW was found at any site below a depth of about 1/2 meter.

A complicating factor to the surveys was the unexpected finding that sizable parts of the Bandelier Tuff have significant magnetic properties. This increased the time of the surveys, because buried cobbles and boulders frequently gave false positive magnetic anomalies. Every anomaly was checked to verify the presence/ absence of ordnance, resulting in numerous rocks being excavated. Upon completion of the EOD sweep and clearance, the geophysical team performed a survey to verify that all buried UXOs and OEW had been found. The EOD team then investigated any anomalies identified by the geophysics team.

UXOs were detonated at the SWMUs where they were found. All OEW recovered at the sites was removed and flashed at TA-16 in a permitted open burn site to destroy any residual HE and then buried in the Area J administrative landfill at TA-54. Approximately seven cubic yards of OEW were removed from the sites.

#### 2.1.2.2 Geophysics — Quality Control Measure

Geophysical surveys were conducted over each PRS as a quality control (QC) measure to ensure that all UXOs and OEW one inch in diameter or larger had been located. This step in the investigation process is not done at Department of Defense facilities where ordnance impact areas have been cleaned up. By including the geophysical surveys, there is virtually a 100% confidence level that all UXOs were located.

At the first PRS to be investigated, SWMU 0-011 (d), state-of-the-art magnetometers and wide band electromagnetic instruments were employed in the investigation. Because the results for this site showed that the electromagnetic (EM) instrument did not detect any OEW not previously located by a magnetometer, EM surveys were not performed at the other four PRSs.

Magnetic geophysical surveys were conducted at all the sites. The surveys were conducted on a 5-ft spacing. The magnetic survey consisted of two parts: (1) collecting discrete data points on a 5-ft grid spacing, and (2) slowly sweeping an area continuously to locate smaller objects. The survey for the discrete data points resulted in a single gradient value recorded for each position and later contouring of the data for interpretation.

A land survey team defined a coordinate system marked on 100-ft increments. The markers placed in the field served as the registration points for the data collection. To ensure complete coverage of the sites, each 100-ft by 100-ft segment was subdivided into a series of 10-ft wide lanes marked by ropes. Each rope was 100 ft in length with flagging marking every 10 ft increment (see Figure 3). Two surveys were conducted simultaneously using this system of rope grids: (1) a continuous digital sweep designed to bring the sensor within 1 ft of all surface positions, and (2) digital data acquisition on a 5-ft interval. Working within a lane, the operator walked perpendicular to the long axis of the lane, sweeping the instrument back and forth. Additional digital data points were recorded at 5-ft intervals within the lane.

Areas of rock outcrop and cliff faces were not surveyed by the geophysics team. For areas where the rope grid could not be used the survey was visually controlled. These included ditches, steep terrain, and borders of sites. Upon detection of geophysical anomalies that could represent potential buried ordnance or OEW, the geophysics team flagged the anomalies for investigation by the EOD team.

Surveyors and geophysics team personnel met all requirements for work at uncontrolled hazardous waste sites as described in 29 CFR 1910.120 and related regulations. On-site documentation for each member of

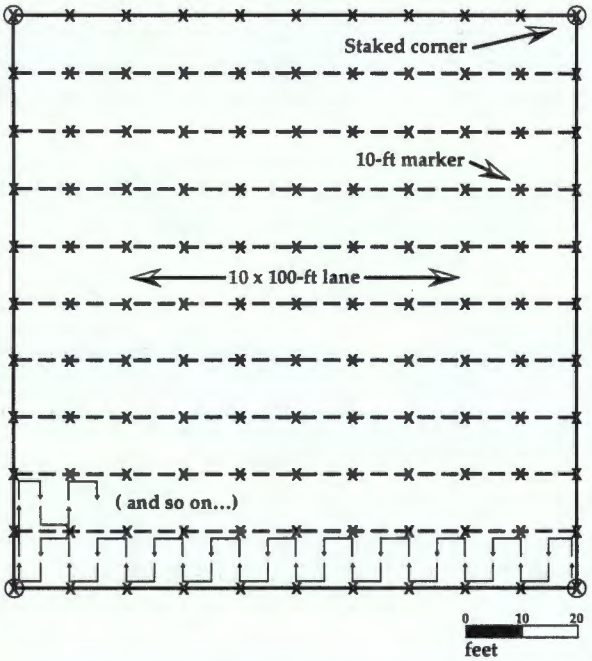


Figure 3. Geophysics team ordnance search pattern.

the team included certification of 40-hour OSHA training, 8-hour refresher training (if applicable), a respirator fit test, and proof of medical monitoring. All team members attended Laboratory health and safety and administrative training prior to the start of field work and complied with all applicable health and safety requirements.

#### 2.1.2.3 Geomorphology and Hydrology

Geomorphic mapping of the ordnance impact areas was completed in order to: (1) identify and map the extent and type of surficial, unconsolidated sediment in which the ordnance could be buried, or/and (2) map the extent of drainage channels within the site that would be likely pathways for the surficial transport of contaminants away from the impact zone. These drainage channels include both the small drainage channels that drain the hillslopes within the impact areas and any main (axial) drainage channel into which these small channels flow. Sediment catchment sites along these drainage channels were prioritized for sampling, because they were identified as sites with the highest probability of containing contaminants being removed from the site by surface runoff.

Rendija Canyon heads on the Pajarito Plateau just west of the townsite and is a tributary to Guaje Canyon approximately 2 miles east of SWMU 0-011(a). Rendija Canyon is an alluvium-floored drainage cut through the Tschicoma Formation, the Bandelier Tuff, and the Cerro Toledo Rhyolite. Thirty-Seven Millimeter Canyon and Cabra Canyon are small northern tributary canyons formed in Bandelier Tuff that join Rendija Canyon in its midreach. Surface flow in Rendija Canyon and its tributaries is intermittent and derived solely from storm runoff and spring snowmelt.

Bayo Canyon heads on the flanks of Barranca Mesa and North Mesa and flows east southeast approximately 11 miles before entering Los Alamos Canyon. Bayo Canyon is also an alluvium floored drainage cut through Bandelier Tuff into the underlying Puye Formation. Intermittent surface flow is generated in Bayo Canyon from spring snowmelt and storm runoff.

#### 2.1.2.4 Sampling

Only those PRSs in which ordnance or ordnance fragments were found were sampled because it was concluded that if no UXOs or OEW were present, then the PRS was not an impact area. At PRSs where ordnance fragments were found, the areas with highest densities of OEW were mapped. Additionally, the first-order drainages and surficial deposits were also included on this map. These maps provided the basis for selecting soil and sediment sample locations that would have the greatest possibility of containing contaminants from the ordnance, if they were present.

Samples were collected from the uppermost 6 inches of surface material at each sampling point, following procedures described in LANL-ER-SOP-06.09, Spade and Scoop Method for Collection of Soil Samples. Each sample was screened and analyzed.

### 2.2 Analytical Methodology

All soil samples were routinely screened for gross alpha and beta activity using a Berthold low-level counter and for gamma activity using a deep well counter before they were submitted with chain-of-custody

documentation to the sample coordination facility (SCF) for analysis. Soil samples were analyzed for target analyte list (TAL) metals by flame atomic absorption (FAA), electrothermal vaporization atomic absorption (ETVAA), cold vaporization atomic absorption (CVAA), and inductively coupled plasma emission spectroscopy (ICPES) (EPA 6010).

Soil samples were examined for high explosives (HE) using high performance liquid chromatography (HPLC), EPA approved, modified SW846 Method 8330 which uses a different calibration procedure.

### 2.3 Evaluation Methodology

Two assessment steps were followed for each set of analytical data from soil samples at the ordnance impact sites: 1) Data quality assessment; and 2) Screening assessment. Further data evaluation (e.g., risk assessment) would have been performed if the results of these preliminary assessments had identified contaminants at a site. This was not the case for any of the sites discussed in this report.

Analytical data assessment consists of either a tiered or a complete review of analytical results and includes completeness checks: the evaluation of blanks, matrix spikes, and other QA samples; and the verification that holding times were not exceeded. Where problems are noted, further evaluation of their impact on the useability of the data to make the proposed decisions is required.

Screening assessment is carried out to determine if any observation or group of observations suggests any cause for concern, in terms of risk to human health or the environment, about the site. As described in the Installation Work Plan (IWP) (LANL 1993, Rev. 3), screening assessment involves the comparison of individual observations to screening action levels (SALs) whose derivation is described in Appendix J of the IWP. For this purpose, results from analyses performed following EPA procedures (e.g. SW-846) are appropriate.

In this report, the observations of naturally occurring inorganic constituents are compared to background levels. Results obtained using the SW846 procedures are generally biased downward relative to published background values that are based on analytical procedures requiring no sample preparation (such as neutron activation) or on total sample dissolution methods incorporating hydrofluoric acid as well as nitric acid.

## 3.0 RFI Phase Investigations

### 3.1 SWMU 0-011(a)

#### 3.1.1 Background

##### 3.1.1.1 Description and History

SWMU 0-011(a) is located on DOE property about 0.4 miles east of the Sportsman's Club firing range in Rendija Canyon (Figure 1). Before the RFI site investigation began, the SWMU was thought to be delimited by a barbed-wire fence (and marked with warning signs) erected to keep individuals out of the site. However, the EOD surveys found that the impact area extended to the south, well beyond the fence (Figure 4). Because Rendija Canyon is open to the public, the unfenced part of the impact area has been used by visitors for a variety of activities.

##### 3.1.1.2 Geology and Hydrology

SWMU 0-011(a) is situated on an alluvial terrace. The underlying bedrock, which does not crop out within the site boundaries, is the volcanic Bandelier Tuff. The area has low relief with significant hillslope gradients only near the main drainage channel of Rendija Canyon. Because of the generally low relief and because much of the site area has been disturbed by human activity, the smaller channels that drain much of the site are neither prominent nor maturely developed.

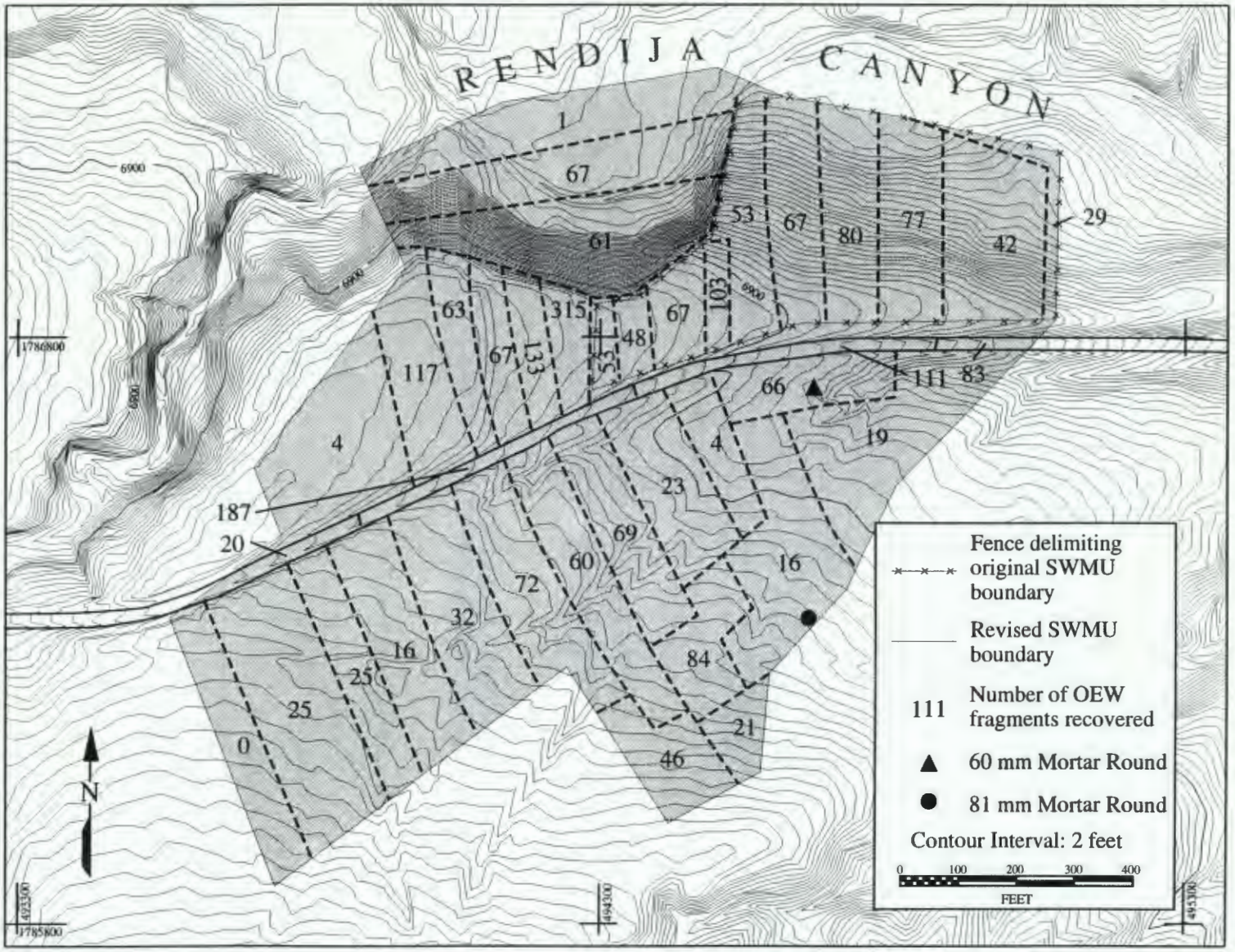


Figure 4. Map of SWMU 0-011(a) showing the original (fenced) boundary and final boundary after ordnance search was completed. Dashed lined delineate EOD team area subdivisions. The numbers in the subdivisions are the total number of pieces of OEW recovered within each area.

### 3.1.2 Site Investigation and Analytical Results

#### 3.1.2.1 Ordnance

Initially, the fenced area was swept for UXOs and OEW (see Figure 4 for area subdivisions). Because ordnance fragments were found up to the southwest corner of the fenced area and immediately outside it, the ordnance search was expanded. The procedure for determining the boundary of the SWMU involved adding new lanes until no ordnance was found in the outermost lane and no OEW was found within 50 feet in all directions of those OEW fragments farthest out. If no OEW was found then the inner-most edge of the land was considered the final boundary. If OEW/UXO was found during the EOD sweep or during the geophysical survey, the entire lane would be reswept and the boundaries adjusted, as necessary. By following this procedure to delineate the final boundary of the impact area, approximately 21 acres were added to the original 7 acres for a total of about 28.5 acres. The expanded boundary was surveyed in by the land survey crew to accurately determine its position (see Figure 4).

Two live HE mortar rounds were found and destroyed. An 81-mm mortar round was found (Figure 5) early on 16 June 1993 and detonated later that morning. The detonation was performed electrically so that the security of the area could be maintained. Representatives from the Laboratory's Emergency Management Office (EMO) and Environmental Safety and Health (ESH-5) were on-site, and officials with Los Alamos County's fire and police stations, the Department of Energy, and ERM/Golder were notified. The detonation followed EOD and Laboratory EMO-Hazardous Devices Team (HDT) standard procedures and occurred without incident. A second detonation took place on the morning of 23 July 1993. A 60-mm mortar round found (Figure 5) late the previous day was detonated in a manner similar to the first detonation. The same authorities were contacted, and the mortar round was discharged without incident. In both cases, the resulting OEW fragments were recovered and removed from the site.

Other materials recovered during the ordnance sweep of the SWMU included almost 2400 pieces of ordnance fragments such as tail fins and other OEW. Three times as much scrap material was found. The locations of recovered fragments indicate that there was more than one firing point and that these firing points were located on the south side of the canyon floor.

The geophysics survey identified 640 anomalies of which 132 were found to be related to OEW. All anomalies identified in the geophysics survey were investigated by the EOD team. Field work at the site was completed by September 1, 1993.

#### 3.1.2.2 Geomorphology and Sample Locations

Geomorphic mapping of SWMU 0-11 (a) included the mapping of all drainage channels that drained the area enclosed within the final boundaries of the site and the areas of high concentration of ordnance fragments. Because of the generally low relief of the site and because much of the site area has been disturbed by human activity, the drainage channels that drain the site are neither prominent nor maturely developed. Thus, detailed mapping of the drainage within the site was necessary prior to selection of surface sampling sites, including the larger drainage channels on or adjacent to the site, into which the smaller channels discharge. Sampling locations were selected from sediment storage locations within the drainage channels that drained the areas of high fragment concentration (Figure 5).

Soil investigations indicate that four major soil-geomorphic settings characterize areas where sampling activities have been conducted:
(1) Thin (<20 cm thick) pedogenically unmodified, very recent fine-grained sediment deposited in shallow swales or channels inset into young fluvial deposits or into an older gravelly to bouldery fluvial /debris flow deposit that underlies the terrace surface on which the site is located.
(2) Residual moderately to strongly developed soil on an older gravelly fill terrace surface, possibly partly modified by agricultural activity.

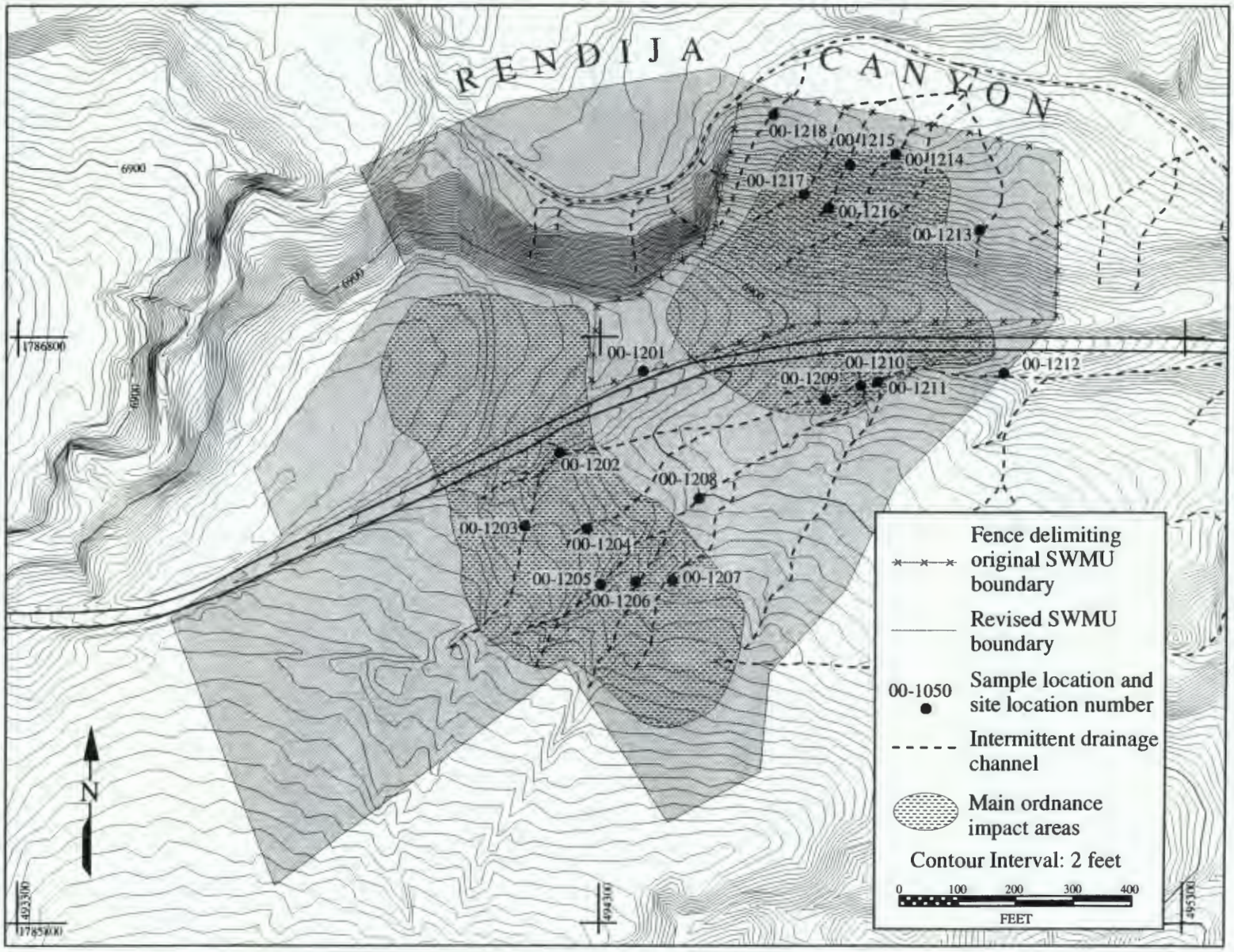


Figure 5. Map of SWMU 0-011(a) showing areas of greatest OEW concentrations, drainage pattern, and sample (site) locations.

(3) Thin (<10 cm) very recent pedogenically modified fine-grained sheetwash sediment derived from erosion of older deposits underlying the fill terrace that has accumulated in small drainages on hillslopes.
(4) Organic-rich, fine-grained sediment that has accumulated at the base of moderately steep hillslopes.

#### 3.1.2.3 Chemistry and Data Quality

Soil samples were analyzed for metals and HE. Radiation screening results (gross alpha, gross beta, and gross gamma) were uniformly below detection limits.

Nineteen soil samples were collected on 23 September, 1993 (AAA 6099, 6101, 6103, 6112-6113, 6115, 6118-6120, 6122-6123, 6125-6129, 6131, and 6133-6134). Inorganic measurements were made by group Chemical Science and Technology (CST-9) (formerly Environmental Management [EM-9]) following the SW846 procedures for ICPES (most elements), FAA (Ag), and ETVAA (As and Se). Results are shown in Table 1.

All of the quality control (QC) data for the metals were "under control" except for Fe and Sb. Fe is not an analyte of interest in the soil and therefore is not a concern. The Sb, however, is an analyte of interest. The analytical result for Sb in the QC sample was 0.029 mg/l, while the QC value was 0.04 mg/l. This makes the analytical result about 28% low. The result for Sb in all of the samples was <0.1 mg/kg while the SAL for Sb is 32 mg/kg. Therefore, the fact that the analytical result for Sb in the QC sample is 28% low does not affect the status of Sb being below SAL. This is because all reported Sb values for the samples are at least a factor of 320 below the SAL.

The organic compounds associated with HE were analyzed by the International Technology Analytical Services, St. Louis, MO using HPLC, a modified SW846 Method 8330. The compounds analyzed for were: 1,3-Dinitrobenzene; 2,4-Dinitrotoluene; 2,6-Dinitrotoluene; HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine); Nitrobenzene; m-Nitrotoluene; o-Nitrotoluene; p-Nitrotoluene; RDX (1,3,5-Trinitrohexahydro-1,3,5-triazine); Tetryl (Methy-2,4,5-trinitrophenylnitramine); 1,3,5-Trinitrobenzene; and 2,4,6-Trinitrotoluene. The results of these analyses were that no HE analytes were detected in the 19 samples, i.e. all analyses were below detection limits for all analytes. Therefore, the data are not presented in a table.

The contract analytical laboratory had two problems with the HE analyses. One was that the holding times for the analyses were missed by 2 days. The samples were extracted within 7 days but were not analyzed for 42 days (exceeding the 40 day limit). However, it was concluded that the data are still accurate because: (1) The report by the U. S. Army Environmental Center entitled "Experimental Assessment of Analytical Holding Times for Nitroaromatic and Nitramine Explosives in Soil" (special report 93-11, June 1993) shows that exceeding the holding times (up to 56 days after extraction) does not cause a loss of HE analytes, nitramines, and possibly nitroaromatics. (2) HE sample results were below detection limits for all analytes. (3) No peaks were detected that could have been degradation products from any HE that may have biodegraded (per analytical laboratory).

Another problem encountered by the analytical laboratory was surrogate and matrix spike/matrix spike duplicate (MS/MSD) recoveries. The surrogate recoveries ranged from 66% to 280%, while the MS/MSD recoveries ranged from 29% to 296% causing the CST-9 reviewer to qualify the data as "UJ" (undetected, estimated quantity). However, all analytes were below detection and no peaks from biodegradation products were present.

### 3.1.3. Data Assessment

No TAL metals exceeded their SALs except for arsenic and beryllium, for which the SALs are below background concentrations (Table 2). Concentrations of all Table 2 elements are comparable to regional background values, allowing for the bias in methods discussed in Section 2.3. No high explosives (HE) or byproducts were detected in any sample. This is significant because even if all of the samples had the lowest recoveries and contaminants were present at a concentration equal to the highest detection limit within the sample set,

**TABLE 1. Results of Inorganic Analysis of Soils for 0-011a in ppm.**

| Location ID | Sample # | Al | Ag | As | Ba | Be | Ca | Cd | Co | Cr | Cu | Fe | Hg | K | Mg | Mn | Na | Ni | Pb | Sb | Se | Tl | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00-1201 | AAA6118 | 14000 | <1 | 3.9 | 120 | 1 | 2100 | <0.4 | 6 | 11 | 6.8 | 12000 | <0.1 | 1900 | 2400 | 340 | 87 | 10 | 17 | <0.1 | 0.3 | 0.3 | 22 | 34 |
| 00-1202 | AAA6119 | 10000 | <1 | 2.5 | 110 | 0.7 | 1400 | <0.4 | 6.3 | 7.9 | 4 | 9600 | <0.1 | 1500 | 1600 | 430 | 92 | 6 | 17 | <0.1 | 0.6 | 0.1 | 18 | 32 |
| 00-1203 | AAA6134 | 10000 | <1 | 2.7 | 96 | 0.75 | 1500 | <0.4 | 6 | 7.4 | 4.1 | 9800 | <0.1 | 1500 | 1600 | 350 | 98 | 5 | 14 | <0.1 | 0.5 | 0.1 | 17 | 30 |
| 00-1204 | AAA6123 | 12000 | <1 | 3.6 | 130 | 1 | 2200 | <0.4 | 6.6 | 10 | 5.6 | 13000 | <0.1 | 1600 | 2300 | 410 | 89 | 9 | 16 | <0.1 | 0.3 | 0.3 | 23 | 34 |
| 00-1205 | AAA6129 | 10000 | <1 | 3.3 | 120 | 0.91 | 1700 | <0.4 | 6.8 | 8 | 5.6 | 11000 | <0.1 | 1700 | 1800 | 410 | 74 | 6 | 16 | <0.1 | 0.4 | 0.3 | 18 | 30 |
| 00-1206 | AAA6131 | 9400 | <1 | 3 | 120 | 0.9 | 1800 | <0.4 | 5.3 | 7 | 6 | 9900 | <0.1 | 1700 | 1700 | 390 | 70 | 5 | 15 | <0.1 | 0.3 | 0.3 | 16 | 32 |
| 00-1207 | AAA6133 | 12000 | <1 | 3.2 | 120 | 0.88 | 1500 | <0.4 | 5.3 | 8.5 | 5.8 | 11000 | <0.1 | 1900 | 1900 | 400 | 82 | 7.6 | 17 | <0.1 | 0.4 | 0.1 | 20 | 33 |
| 00-1208 | AAA6101 | 16000 | <1 | 3.5 | 180 | 1.2 | 2200 | <0.4 | 8.8 | 11 | 7.9 | 14000 | <0.1 | 2500 | 2600 | 640 | 79 | 9 | 19 | <0.1 | 0.6 | 0.3 | 24 | 40 |
| 00-1208 | AAA6122 | 17000 | <1 | 3.7 | 150 | 1.2 | 2200 | <0.4 | 5.9 | 12 | 8.2 | 14000 | <0.1 | 2500 | 2600 | 430 | 80 | 8 | 18 | <0.1 | <0.2 | 0.3 | 24 | 41 |
| 00-1209 | AAA6125 | 10000 | <1 | 3.3 | 120 | 0.91 | 2000 | <0.4 | 5 | 8.2 | 6 | 10000 | <0.1 | 2100 | 1800 | 360 | 70 | 6 | 29 | <0.1 | 0.4 | 0.3 | 17 | 34 |
| 00-1210 | AAA6126 | 12000 | <1 | 3.4 | 110 | 0.97 | 1900 | <0.4 | 6 | 8.7 | 6.1 | 11000 | <0.1 | 1800 | 2000 | 330 | 74 | 9 | 17 | <0.1 | 0.3 | 0.3 | 17 | 32 |
| 00-1211 | AAA6120 | 11000 | <1 | 3.2 | 120 | 0.93 | 1900 | <0.4 | 8 | 9 | 6 | 11000 | <0.1 | 1700 | 1900 | 460 | 84 | 9 | 18 | <0.1 | 0.5 | 0.3 | 17 | 30 |
| 00-1212 | AAA6099 | 11000 | <1 | 2.8 | 110 | 0.93 | 2000 | <0.4 | 4.3 | 8.4 | 6.4 | 10000 | <0.1 | 1700 | 1900 | 300 | 77 | 7 | 18 | <0.1 | 0.8 | 0.3 | 17 | 30 |
| 00-1213 | AAA6127 | 5100 | <1 | 2 | 44 | 0.41 | 750 | <0.4 | 3 | 5 | 3.2 | 5800 | <0.1 | 620 | 840 | 200 | 98 | 4 | 7 | <0.1 | 0.6 | <0.1 | 10 | 17 |
| 00-1214 | AAA6115 | 5700 | <1 | 2 | 59 | 0.44 | 910 | <0.4 | 3.5 | 5.3 | 3.7 | 6300 | <0.1 | 930 | 990 | 220 | 100 | 5 | 9 | <0.1 | 0.5 | <0.1 | 11 | 17 |
| 00-1215 | AAA6103 | 9300 | <1 | 2.2 | 94 | 0.73 | 1400 | <0.4 | 5 | 8.7 | 4.2 | 9000 | <0.1 | 1300 | 1500 | 310 | 81 | 7.6 | 10 | <0.1 | 0.8 | 0.1 | 17 | 23 |
| 00-1216 | AAA6128 | 9300 | <1 | 3.3 | 110 | 0.82 | 1600 | <0.4 | 5.4 | 7.4 | 4.8 | 9300 | <0.1 | 1200 | 1600 | 340 | 70 | 6.4 | 14 | <0.1 | 0.4 | 0.1 | 18 | 23 |
| 00-1217 | AAA6113 | 6300 | <1 | 3.6 | 83 | 0.64 | 1000 | <0.4 | 6 | 5.3 | 4 | 8000 | <0.1 | 940 | 1200 | 470 | 77 | 5 | 18 | <0.1 | 0.8 | 0.1 | 17 | 18 |

**TABLE 2. Summary of Inorganic Results from 0-011(a)**

| | min | mean | median | max | SAL | background |
|---|---|---|---|---|---|---|
| Ag | <1 | | <1.0 | <1.0 | 400.0 | 1.16 |
| Al | 5100 | 10368 | 10000 | 17000 | — | 50,000-144,000 |
| As | 1.70 | 2.99 | 3.20 | 3.90 | 0.4 | 1.2-10.8 |
| Ba | 44 | 108.5 | 110 | 180 | 5600.0 | 125-830 |
| Be | 0.41 | 0.84 | 0.9 | 1.2 | 0.16 | 1.0-4.4 |
| Ca | 750 | 1645 | 1700 | 2200 | — | 1900-80,400 |
| Cd | <0.4 | | <0.4 | <0.4 | 80 | 1.2-1.7 |
| Co | 3.0 | 5.6 | 5.9 | 8.8 | — | 0.4-23 |
| Cr | 5.0 | 8.1 | 8.2 | 12.0 | 400 | 2-71 |
| Cu | 2.4 | 5.3 | 5.6 | 8.2 | 3000 | 2-18* |
| Fe | 5800 | 10094 | 10000 | 14000 | — | 10,000-48,600 |
| Hg | <0.1 | | | <0.1 | 24.0 | 0.007-0.029* |
| K | 620 | 1584 | 1700 | 2500 | — | 10,400-48,000 |
| Mg | 840 | 1754 | 1800 | 2600 | — | 1331-16,800 |
| Mn | 200 | 374 | 360 | 640 | 8000.0 | 190-1600 |
| Na | 70 | 83.3 | 81 | 100 | — | 2700-36,300 |
| Ni | 3.5 | 6.74 | 6.4 | 10.0 | 1600.0 | 1.6-19* |
| Pb | 7 | 15.7 | 17 | 29 | 500.0 | <14-44 22.3 |
| Sb | <0.1 | | <0.1 | <0.1 | 32.0 | 0.3-1.6 |
| Se | <0.2 | 0.47 | 0.5 | 0.8 | 400.0 | 0.26† |
| Tl | <0.1 | 0.18 | 0.3 | 0.3 | 6.4 | <0.2-0.9 |
| V | 10.0 | 17.5 | 17.0 | 24.0 | 560.0 | 12-113 |
| Zn | 17.0 | 29.2 | 30.0 | 41.0 | 24000.0 | 20-146 |

— No SAL for analyte.
All units in parts per million.
Background values are from Longmire et al. (1993) unless otherwise indicated.
* = Ferenbaugh et al. (1990).
† = Shacklette and Boerngen (1984)

the adjusted values would be well below SALs. At worst, the reported level of <0.31 mg/kg for 2-,6-dinitrotoluene (see Table 3) is lower than the SAL by a factor of more than 3200. Thus, for the compound to be even a potential problem, recovery would have to be 0.031%, far lower than indicated by any surrogate or MS measurement.

### 3.1.4 Conclusions and Recommendations

This site has been cleaned of all UXOs and OEW fragments to the smallest size possible using state-of-the-art instruments. In addition to a very careful search conducted by an EOD team, the site underwent an extremely thorough quality control check by a geophysics team to ensure that no UXOs of significant sized OEW fragments remained.

Judgementally selected soil and sediment samples, chosen to maximize the possibility of finding contaminants (metals or HE) from the ordnance, showed that all TAL metals at the site are in the range of background values and that HE is not present at the detection limits of analytical instruments. Therefore, the soils and sediment at the site do not contain HE above SALs.

Given the location and removal of all UXOs and significant sized OEW at the site and the absence of any significant contaminants in the soils and sediment, it is recommended that the fence be taken down from what was the original SWMU. Additionally, it is recommended that the site be designated as a no further action PRS and be approved for future residential use.

**Table 3. Comparison of Analytical Data and SALs for HE Sample Analyses for 0-011a**

| Analyte | SAL (mg/kg) | HV (mg/kg) | Factor | %Recovery |
|---|---|---|---|---|
| "1,3-Dinitrobenzene" | 8 | <0.0003 | 27000 | 33-165 |
| "2,4-Dinitrotoluene" | 1 | <0.0003 | 3000 | 33-296 |
| "2,6-Dinitrotoluene" | 1 | <0.00031 | 3000 | 55-165 |
| HMX | 4000 | <0.0026 | 1540000 | 32-153 |
| Nitrobenzene | 5.3 | <0.00031 | 17000 | 35-160 |
| m-Nitrotoluene | - | <0.0003 | - | 57-147 |
| o-Nitrotoluene | - | <0.0003 | - | 53-120 |
| p-Nitrotoluene | - | <0.0003 | - | 61-139 |
| RDX | 64 | <0.0012 | 53000 | 35-147 |
| Tetryl | 800 | <0.00078 | 1030000 | 44-172 |
| "1,3,5-Trinitrobenzene" | 4 | <0.0003 | 13000 | 31-175 |
| "2,4,6-Trinitrotoluene" | 40 | <0.0003 | 130000 | 29-183 |

HV = Highest Value from the analytical results for particular analyte.
"Factor = SAL/HV, the factor HV is below SAL."
·% Recovery - range in % recovery for MS/MSD.

## 3.2 SWMU 0-011(c)

### 3.2.1 Background

#### 3.2.1.1 Description and History

SWMU 0-011(c) is an elongated area extending southeast to northwest just north of the Sportsman's Club in Cabra Canyon, a tributary of Rendija Canyon (Figure 1). It is largely on DOE land but also is partly in the Santa Fe National Forest. The sole indication that a SWMU might be present at this site are two deteriorating signs warning of danger of explosives. They are both on trees at the locations shown on Figure 6. The final boundary of the SWMU and area to be searched was established by taking into consideration the positions of the two signs, the topography, and the location of a known ordnance impact area [0-011(d)] in a similar topographic setting. The boundary was marked with flagging and surveyed in by a geodetic crew.

#### 3.2.1.2 Geology and Hydrology

SWMU 0-011(c) lies athwart the drainage channel of a small tributary of Cabra Canyon, which in turn flows into Rendija Canyon. The relief of this area is moderate, consisting mostly of gentle to moderately steep hillslopes and the alluvial channels that drain the site. These drainage channels, although not deep, are well formed and their identification is not difficult. The bedrock of the area consists primarily of the Bandelier Tuff, but also includes some of the dacitic rocks of the Tschicoma Formation. The hillslopes are thinly mantled with unconsolidated colluvial material, and the alluvium fills the drainage channels within the site.

### 3.2.2 Site Investigation and Analytical Results

The ordnance sweep at SWMU 0-011(c) took approximately 14 days. Ordnance surveys at the site resulted in no findings except for scrap metal, such as bailing wire. Using a 100 feet grid surveyed and staked by the geodetic crew, a geophysics team conducted a follow-on QC sweep, and located 14 anomalies. The subsequent check by EOD personnel determined that the anomalies were rocks and some small pieces of

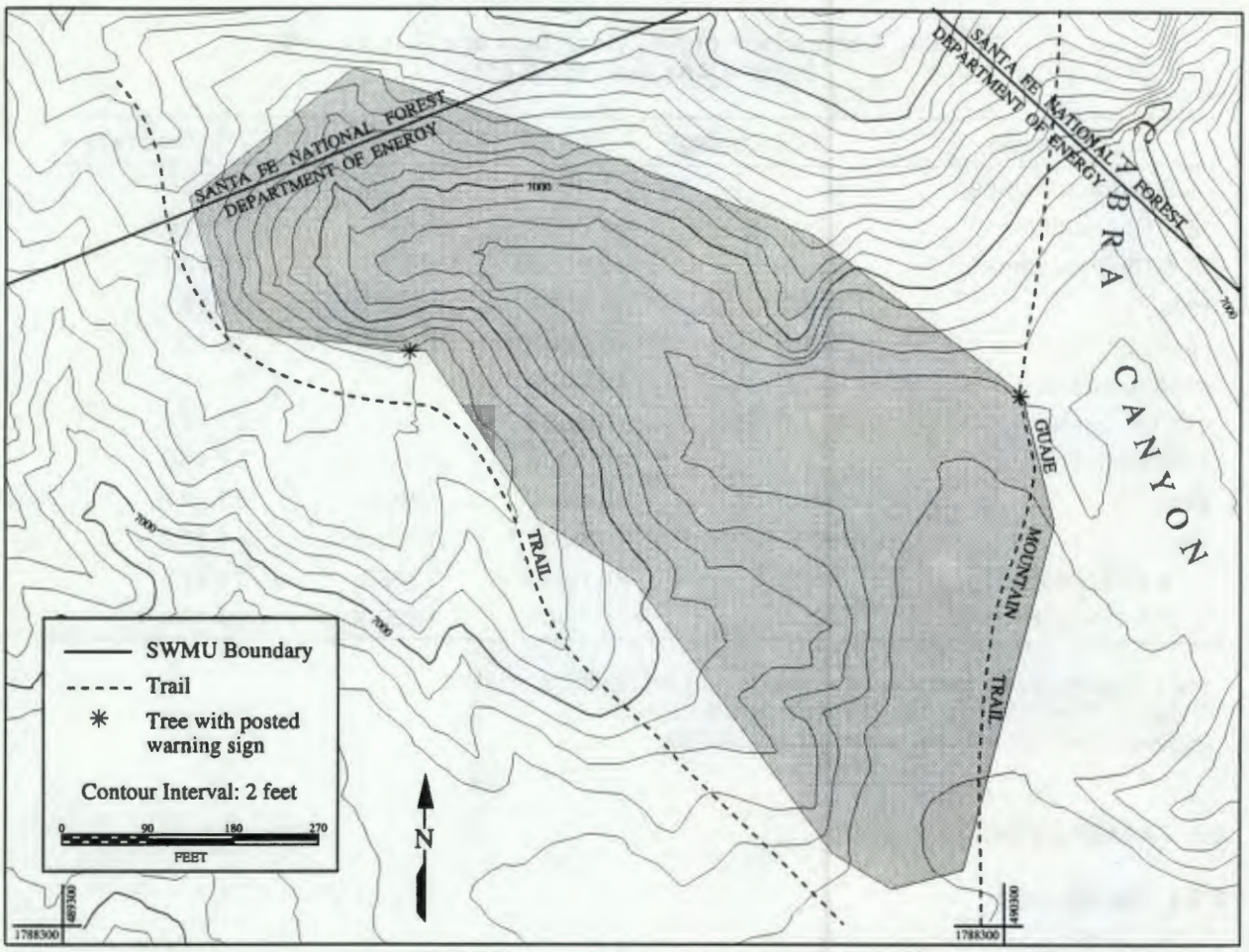


Figure 6. Map of SWMU 0-011(c).

wire and tin cans. Field work at the site was completed by 23 June 1993. No ordnance or ordnance fragments were found.

### 3.2.3 Conclusions and Recommendations

This site, identified as a possible former ordnance impact area, was thoroughly surveyed for OEW. Not a single piece of OEW was found during the EOD or geophysical surveys. This procedure, of having a follow-on geophysical survey, ensured that a careful quality control check was made of each square foot of the area. The complete absence of OEW shows that this site was never used as an ordnance impact area. The two signs on the perimeter of the site (see Figure 6) may have been placed there by the U.S. Army personnel at Los Alamos in the early 1940s with the expectation of using the site as an ordnance impact area, an expectation that never materialized.

Given that the extremely detailed and careful search for OEW at this SWMU did not result in even a single fragment of OEW being found, demonstrating that the site is not a former ordnance impact area, it is recommended that the site be designated for NFA.

### 3.3 SWMU 0-011(d)

### 3.3.1 Background

#### 3.3.1.1 Description and History

SWMU 0-011(d) is in a small north-trending tributary of Bayo Canyon northeast of the intersection of San Ildefonso Road and Diamond Drive (Figure 1). The eastern side of this tributary is a cliff, while the west side is a moderately steep slope of fill that resulted from the construction of San Ildefonso Road (Figure 7). The area is fenced and marked by warning signs. It is almost entirely on Los Alamos County land, but a very small part of the fenced area includes private property.

#### 3.3.1.2 Geology and Hydrology

SWMU 0-011(d) occupies a small canyon along the southern flank of Barranca Mesa. The site is rimmed on the north and eastern edges by cliffs formed in the Bandelier Tuff, the bedrock unit that underlies this site. The lower cliff slopes, down to the axial drainage, are veneered by colluvium, and the drainage channels contain small quantities of alluvial material. The only well-established drainage channel on the site is the axial channel of this small canyon that flows into the axial channel of Bayo Canyon just downstream of the site boundary.

### 3.3.2 Site Investigation and Analytical Results

#### 3.3.2.1 Ordnance

The entire area bounded by the fence at SWMU 0-011(d) was surveyed for UXOs and OEW. The SWMU was subdivided into six subareas by the EOD team to facilitate their survey. The subareas were delineated solely on the basis of topography (see Figure 7). Lanes were layed out by the EOD team in each of these subareas to guide their survey, except for the cliff where complete coverage was visually controlled by features on the cliff's surface. Access to the cliff was by a combination of climbing and repelling.

All of the OEW recovered from the site was found in an area about 160 feet by 80 feet along the base of the cliff (see Figure 7). The OEW was entirely 23.6 inch bazooka fragments except for one partly intact round. The material included tail fin assemblies, motors, bullets, and other fragments. The OEW was all found in the subsurface. Approximately one-half cubic meter of ordnance fragments were recovered. The geophysical survey identified over 100 ferrous objects. All objects identified in the geophysics survey were investigated by the EOD team. The field work at this site was completed in September, 1992.

#### 3.3.2.2 Geomorphology and Sample Locations

Geomorphic mapping of the ordnance impact area included: (1) mapping the surficial, unconsolidated sediment at the site, and (2) mapping the drainage channels that would be likely pathways for the surficial transport of contaminants away from the impact zone. These drainage channels include both the small drainage channels that drain the hillslopes within the impact area and the main (axial) drainage channel into which the small channels flow (Figure 8). Sediments in the channels have a thin upper coarse sand to pebble layer ranging in thickness from about one to several centimeters which overlies a clay-rich layer.

Sampling in the fall of 1992 involved the collection of soil from the surface and selected sediment trap locations for evaluation of HE and TAL metals. Sediment catchment sites along both the drainage channels on the hillslope below the cliff and along the axial drainage channel were selected for sampling, because they are sites with the highest probability of containing contaminants that are being removed from the impact zone by surface runoff (Figure 8). Additional sampling was conducted on 14 June 1993 for metals and HE.

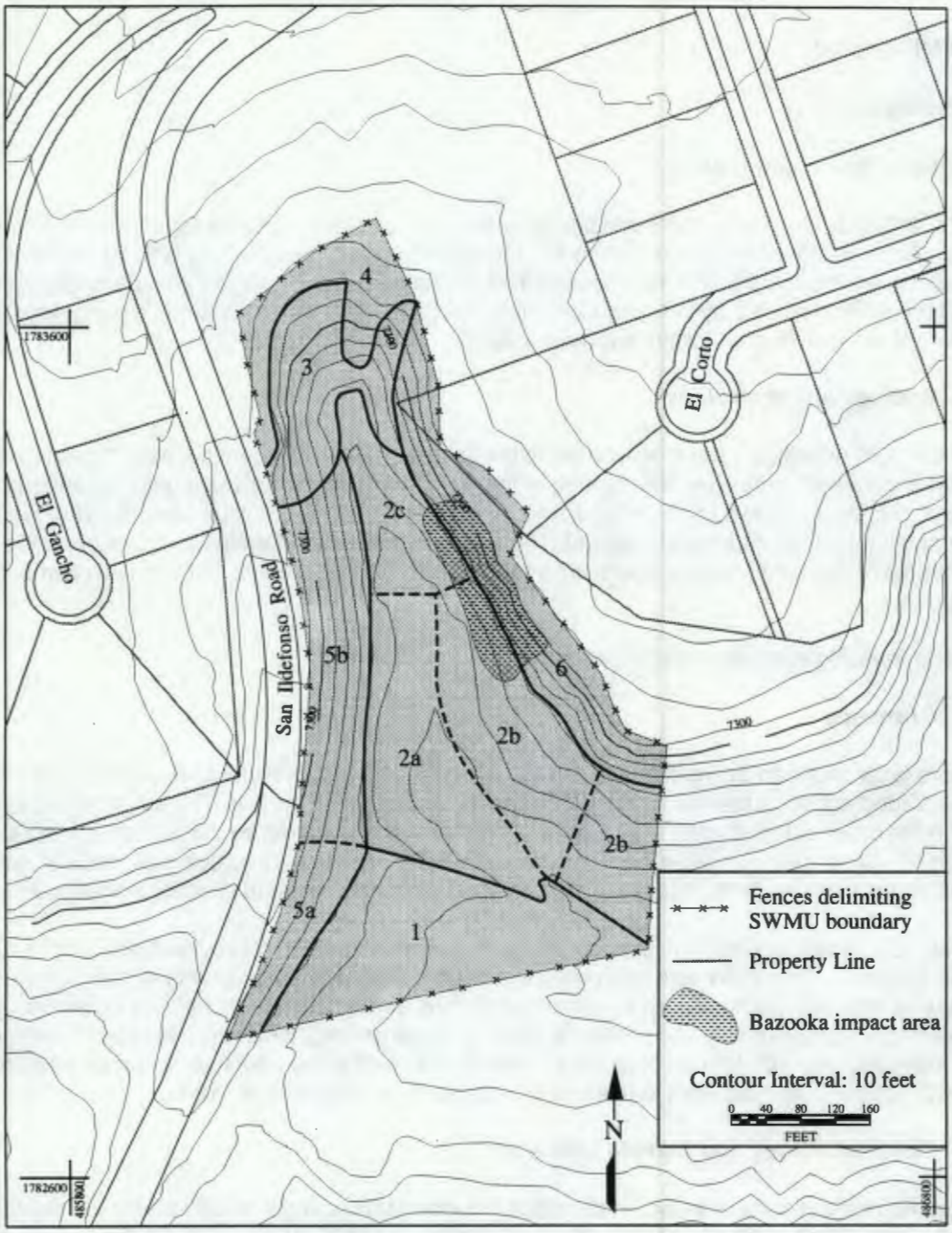


Figure 7. Map of SWMU 0-011(d) showing the fenced boundary, the area of subdivisions of the EOD team, and the bazooka impact area where all of the OEW was recovered.

Altogether, a total of 20 samples were collected: 9 samples were analyzed for HE, and 8 were analyzed for TAL metals (4 samples collected from the sediment traps were analyzed for both).

### 3.3.2.3 Chemistry and Data Quality

Soil samples were analyzed for metals and HE. Radiation screening results (gross alpha, gross beta, and gross gamma) were uniformly below detection limits. Following the RFI sampling plan, seven soil samples were collected on 10 October, 1992 (samples AAA 1727-1733):

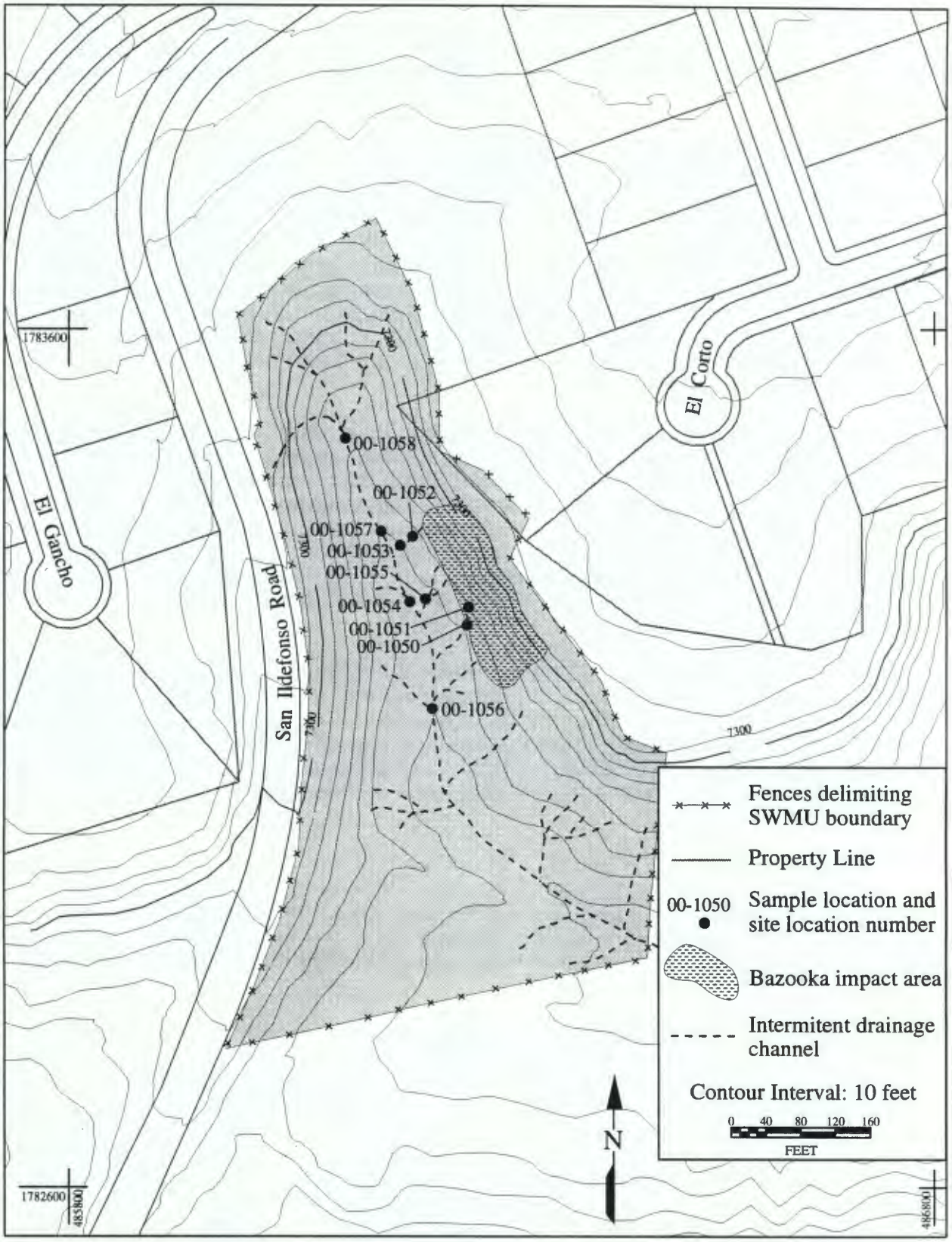


Figure 8. Map of SWMU 0-011(d) showing bazooka impact area, drainage pattern, and sample (site) locations.

Inorganic measurements were made following the SW846 procedures for ICPES (most elements), FAA (Ag), and ETVAA (As and Se). The results show three samples with Pb above background levels but well below the SAL (see Table 4). The holding times for HE was missed by several months so the data could not be used.

Thirteen additonal soil and sediment samples (AAA 2961-2964, 2966-2974) were collected on 14 June 1993. The primary purpose of these samples was to obtain good HE data, but they were also collected to answer a question concerning Pb levels in some of the initial seven samples. Although the Pb levels were low and of no health concern, the question remained whether the elevated Pb reflected contributions from the OEW or a sedimentary layer with higher than normal background. Thus, when sampling at the two locations with the higher levels, separate samples were taken of the upper granular layer and underlying clay-rich layer. Additionally, two samples of each layer were taken at two new locations upstream from the impact zone. Thus, a total of 8 samples were taken at four locations to assess the source of the elevated Pb (locations 00-1056, 00-1054, 00-1057, and 00-1058 on Figure 8). Nine samples were analyzed for HE from the original 7 locations, 5 from the hillslope and four from locations 00-1054 and 00-1056. The holding times were met in the second group of samples.

Two different methods were used to extract the soil samples listed in Table 4 for inorganic analyses. A total dissolution procedure including the addition of hydrofluoric acid was used on the October 1992 samples, while the June 1993 samples were extracted using nitric acid, which results in only partial dissolution of the sample. Consequently, the two sets of results are not readily comparable to each other, nor is either set of results necessarily comparable to background as reported by Longmire et al. (1993) although the hydrofluoric dissolution process generally provides more nearly comparable results. Results obtained using the nitric acid procedure, which is the procedure generally prescribed for site contamination assessment (SW 846), are generally biased downward relative to the traditional total measurements, although for most minor and trace elements this bias is quite small (less than 30-50%).

The organic compounds associated with HE were sampled by CST-9 and analyzed by the Environmental Science & Engineering Laboratory, Gainesville, Florida, using HPLC, a modified SW846 Method 8330. The compounds analyzed for were: 4-Amino-2,6-dinitrotoluene; 2-Amino-4,6-dinitrotoluene; 1,3-Dinitrobenzene; 2,4-Dinitrotoluene; 2,6-Dinitrotoluene; HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine); Nitrobenzene; m-Nitrotoluene; o-Nitrotoluene; p-Nitrotoluene; RDX (1,3,5-Trinitrohexahydro-1,3,5-triazine); Tetryl (Methy-2,4,5-trinitrophenylnitramine); 1,3,5-Trinitrobenzene; and 2,4,6-Trinitrotoluene. All analyses were below detection limits for all analytes.

### 3.3.3 Data Assessment

No high explosives (HE) or byproducts were detected in any sample. No inorganic constituents exceeded their SALs except for arsenic and beryllium, for which the SALs are below background concentrations. In these cases, we compared the observations to background (see Table 5). Concentrations of arsenic and beryllium were within background ranges.

Two samples (one from each sampling event) had slightly elevated concentrations of lead, in the range of 110 to 160 ppm. For the purposes of comparing these observations with background figures, we note that for lead, nitric acid sample dissolution introduces only a small bias (5-10%) relative to dissolution using hydrofluoric acid. These isolated lead observations are thus well below levels of concern (500 to 1000 ppm). There were also several observations in the range of 50 to 70 ppm, which is somewhat high compared to the developed soils analyzed by Longmire et al. (1993) (see Table 6), but more comparable to observations from tuff in that same study. As many of the samples from SWMU 0-011(d) were comprised of coarse, granular material derived from tuff rather than well-developed soils, these results are not surprising. There was one above-background copper measurement, at 300 ppm. This is 10% of the SAL for copper. Concentrations of remaining elements appear to be comparable to regional background values, allowing for the bias in methods.

**TABLE 4. Results of Inorganic Analysis of Soils for 0-011d in ppm.**

| Location ID | Sample # | Al | Ag | As | Ba | Be | Ca | Cd | Co | Cr | Cu | Fe | Hg | K |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00-1050 | AAA1727 | 68414 | <1 | 0.9 | 155 | 3 | 2735 | <1 | 4 | 3 | <5 | 15562 | nd | 38230 |
| 00-1051 | AAA1728 | 68468 | <1 | 0.9 | 135 | 3 | 2829 | <1 | 4 | 3 | 14 | 16618 | nd | 38045 |
| 00-1052 | AAA1729 | 61358 | <1 | 0.4 | 142 | 2 | 2147 | <1 | 3 | 2 | <5 | 10424 | nd | 34992 |
| 00-1053 | AAA1730 | 68550 | <1 | 0.8 | 175 | 3 | 2217 | <1 | 3 | 3 | 13 | 10828 | nd | 37989 |
| 00-1054 | AAA1731 | 55421 | <1 | 1.1 | 482 | 2 | 5471 | <1 | 8 | 16 | <5 | 14165 | nd | 26016 |
| 00-1054 | AAA2962 | 4700 | <1 | 0.2 | 51 | 0.41 | 2200 | <0.4 | 5.1 | 9.5 | 5.7 | 8700 | <0.1 | 790 |
| 00-1054 | AAA2964 | 8000 | <1 | 2.6 | 69 | 0.67 | 1400 | <0.4 | 4.3 | 7 | 2.8 | 11000 | <0.1 | 1000 |
| 00-1055 | AAA1732 | 61310 | 2.6 | 0.8 | 174 | 2 | 2597 | <1 | 3 | 4 | <5 | 11824 | nd | 33450 |
| 00-1056 | AAA1733 | 62371 | <1 | 3.4 | 515 | 2 | 4878 | <1 | 18 | 21 | <5 | 19132 | nd | 24969 |
| 00-1056 | AAA2961 | 12000 | <1 | 3.4 | 160 | 0.91 | 4100 | <0.4 | 9.1 | 13 | 8.5 | 12000 | <0.1 | 1700 |
| 00-1056 | AAA2963 | 16000 | <1 | 3.4 | 150 | 1 | 2600 | <0.4 | 5.4 | 13 | 300 | 14000 | <0.1 | 2000 |
| 00-1059 | AAA2971 | 6100 | <1 | 2.2 | 49 | 0.78 | 1400 | <0.4 | 7.3 | 7.7 | 2.7 | 11000 | <0.1 | 950 |
| 00-1059 | AAA2972 | 4300 | <1 | 1.6 | 44 | 0.4 | 1400 | <0.4 | 3.7 | 9.5 | 3.6 | 7800 | <0.1 | 750 |
| 00-1059 | AAA2973 | 14000 | <1 | 4.7 | 150 | 0.96 | 2300 | <0.4 | 12 | 12 | | 14000 | <0.1 | 1700 |
| 00-1059 | AAA2974 | 2900 | <1 | 1.3 | 34 | 0.37 | 2100 | <0.4 | 4.8 | 14 | 5.2 | 12000 | <0.1 | 570 |

| Location ID | Sample # | Li | Mg | Mn | Mo | Na | Ni | Pb | Sb | Se | Sr | Tl | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00-1050 | AAA1727 | 29 | 765 | 538 | 4 | 31445 | <2 | 33 | <10 | <0.2 | 37 | <5 | 7 | 88 |
| 00-1051 | AAA1728 | 29 | 835 | 501 | 3 | 30888 | <2 | 34 | <10 | <0.2 | 30 | <5 | 7 | 86 |
| 00-1052 | AAA1729 | 24 | 484 | 407 | 2 | 28537 | <2 | 31 | <10 | <0.2 | 32 | <5 | 4 | 58 |
| 00-1053 | AAA1730 | 28 | 715 | 432 | 2 | 30894 | <2 | 44 | <10 | <0.2 | 39 | <5 | 7 | 61 |
| 00-1054 | AAA1731 | 21 | 2325 | 444 | <1 | 18128 | 8 | 156 | <10 | <0.2 | 123 | <5 | 28 | 79 |
| 00-1054 | AAA2962 | 4.7 | 1700 | 250 | 2.3 | 290 | 11 | 73 | <0.07 | 0.3 | 8.8 | <0.04 | 16 | 83 |
| 00-1054 | AAA2964 | 8.6 | 1100 | 330 | 1.4 | 180 | 6 | 26 | <0.07 | 0.3 | 11 | 0.08 | 14 | 40 |
| 00-1055 | AAA1732 | 26 | 947 | 395 | 2 | 27004 | <2 | 32 | <10 | <0.2 | 39 | <5 | 8 | 60 |
| 00-1056 | AAA1733 | 27 | 3441 | 867 | <1 | 16259 | 12 | 68 | <10 | <0.2 | 110 | <5 | 45 | 60 |
| 00-1056 | AAA2961 | 11 | 2200 | 630 | 1.7 | 160 | 10 | 110 | <0.07 | <0.2 | 20 | 0.07 | 23 | 72 |
| 00-1056 | AAA2963 | 12 | 2600 | 300 | 1 | 130 | 9 | 30 | <0.07 | <0.2 | 26 | 0.08 | 28 | 38 |
| 00-1059 | AAA2971 | 6 | 920 | 330 | 2 | 250 | 3.9 | 68 | <0.07 | <0.2 | 7.7 | <0.04 | 12 | 59 |
| 00-1059 | AAA2972 | nd | 950 | 230 | nd | 280 | 4 | 68 | <0.07 | <0.2 | nd | <0.04 | 12 | 65 |
| 00-1059 | AAA2973 | 11 | 2300 | nd | <1 | 330 | 8.9 | 33 | <0.07 | <0.2 | 11 | 0.1 | 29 | 37 |
| 00-1059 | AAA2974 | nd | 1100 | 210 | nd | 180 | 6.1 | 58 | <0.07 | <0.2 | nd | <0.04 | 24 | 68 |

nd = not determined
Samples 1727-1733 were analyzed after HF extraction
Samples 2961-2974 were analyzed after HNO3 extraction

**TABLE 5. Summary of Inorganic Results from 0-011(d)**

| | October, 1992 | | | | June, 1993 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | min | mean | median | max | min | mean | median | max | SAL | background |
| Ag | <1 | | <1 | 2.6 | <1 | | | <1 | 400.0 | 1.16 |
| Al | 55421 | 63699 | 62371 | 68550 | 2900 | 8500 | 7050 | 16000 | — | 50,000-144,000 |
| As | 0.4 | 1.19 | 0.9 | 3.4 | 0.2 | 2.43 | 2.4 | 4.7 | 0.4 | 1.2-10.8 |
| Ba | 135 | 254 | 174 | 515 | 34 | 88.4 | 60 | 160 | 5600.0 | 125-830 |
| Be | 2.0 | 2.43 | 2.0 | 3.0 | 0.37 | 0.69 | 0.73 | 1.0 | 0.16 | 1.0-4.4 |
| Ca | 2147 | 3268 | 2735 | 5471 | 1400 | 2188 | 2150 | 4100 | — | 1900-80,400 |
| Cd | <1 | | | <1 | <0.4 | | | <0.4 | 80 | 1.2-1.7 |
| CN | | | | | <0.05 | | <0.05 | 0.15 | 1600.0 | |
| Co | 3.0 | 6.14 | 4.0 | 18.0 | 3.70 | 6.46 | 5.25 | 12.0 | — | 0.4-23 |
| Cr | 2.0 | 7.43 | 3.0 | 21.0 | 7.00 | 10.71 | 10.75 | 14.0 | 400.0 | 2-71 |
| Cu | -5.0 | | -5.0 | 14.0 | 2.70 | 46.9 | 5.2 | 300 | 3000.0 | 2-18* |
| Fe | 10424 | 14079 | 14165 | 19132 | 7800 | 11313 | 11500 | 14000 | — | 10,000-48,600 |
| Hg | | | | | <0.1 | | | <0.1 | 24.0 | 0.007-0.029* |
| K | 24969 | 33384 | 34992 | 38230 | 570. | 1183 | 975 | 2000 | — | 10,400-48,000 |
| Li | 21.0 | 26.29 | 27.0 | 29.0 | 4.7 | 8.9 | 9.8 | 12.0 | — | |
| Mg | 484. | 1359 | 835 | 3441 | 920 | 1609 | 1400 | 2600 | — | 1331-16,800 |
| Mn | 395 | 512 | 444 | 867 | 210 | 326 | 300 | 630 | 8000.0 | 190-1600 |
| Mo | <1.0 | | 2.0 | 4.0 | <1.0 | | 1.55 | 2.3 | — | |
| Na | 16259 | 26165 | 28537 | 31445 | 130 | 225 | 215 | 330 | — | 2700-36,300 |
| Ni | <2.0 | | <2.0 | 12.0 | 3.90 | 7.36 | 7.50 | 11.0 | 1600.0 | 1.6-19* |
| Pb | 31.0 | 56.86 | 34.0 | 156.0 | 26.0 | 58.3 | 63.0 | 110 | 500.0 | <14-44 |
| Sb | <10 | | | <10 | <0.07 | | | <0.07 | 32.0 | 0.3-1.6 |
| Se | <0.2 | | | <0.2 | <0.2 | | <0.2 | 0.3 | 400.0 | 0.26† |
| Sr | 30.0 | 58.6 | 39.0 | 123.0 | 7.7 | 14.1 | 11.0 | 26.0 | — | 170-242 |
| Tl | <5 | | | <5 | <0.04 | | 0.015 | 0.1 | 6.4 | <0.2-0.9 |
| V | 4.0 | 15.1 | 7.0 | 45.0 | 12.0 | 19.8 | 19.5 | 29.0 | 560.0 | 12-113 |
| Zn | 58.0 | 70.3 | 61.0 | 88.0 | 37.0 | 57.8 | 62.0 | 83.0 | 24000.0 | 20-146 |

— No SAL for analyte.
All units in parts per million.
Background values are from Longmire et al. (1993) unless otherwise indicated.
* = Ferenbaugh et al. (1990).
† = Shacklette and Beorngen (1984).

### 3.3.4 Conclusions and Recommendations

This site has been cleaned of all UXOs and OEW fragments to the smallest size possible using state-of-the-art instruments. In addition to a very careful search conducted by an EOD team, the site underwent an extremely thorough quality control check by a geophysics team to ensure that no UXOs or significant sized OEW fragments remained. It is important to emphasize that the EOD search of the cliffs included a complete visual search supported by magnetometers to check holes and cracks, and the mesa top above the cliff to the fence that defines the SWMU boundary.

Judgementally selected soil and sediment samples, chosen to maximize the possibility of finding contaminants (metals or HE) from the bazooka rounds showed that all TAL metals are within the range of background except for lead in several samples, and they were far below the 500 ppm SAL. HE was not detected in any of the samples.

**TABLE 6. Results of Inorganic Analysis of Soils for 0-011e in ppm.**

| Location ID | Sample # | Al | Ag | As | Ba | Be | Ca | Cd | Co | Cr | Cu | Fe | Hg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00-1219 | AAA6121 | 3100 | <1 | 0.4 | 21 | 0.24 | 1100 | <0.4 | <0.5 | 1.7 | 2.7 | 3000 | <0.1 |
| 00-1220 | AAA6114 | 610 | <1 | 0.4 | 8.5 | 0.23 | 290 | <0.4 | <0.5 | 0.7 | 0.5 | 2200 | <0.1 |
| 00-1221 | AAA6109 | 1100 | <1 | 0.6 | 17 | 0.39 | 700 | <0.4 | <0.5 | <0.5 | 4.3 | 2700 | <0.1 |
| 00-1221 | AAA6108 | 1500 | <1 | 0.7 | 18 | 0.45 | 800 | <0.4 | <0.5 | 0.9 | 4.6 | 4200 | <0.1 |
| 00-1222 | AAA6116 | 2600 | <1 | 1.1 | 23 | 0.41 | 1000 | <0.4 | <0.5 | 1.8 | 2.4 | 3900 | <0.1 |
| 00-1223 | AAA6117 | 2500 | <1 | 0.5 | 24 | 0.2 | 2200 | <0.4 | 0.7 | 2.5 | 1.7 | 2600 | <0.1 |
| 00-1224 | AAA6100 | 860 | <1 | <0.2 | 9.5 | 0.13 | 580 | <0.4 | <0.5 | 1.1 | <0.5 | 2500 | <0.1 |
| 00-1225 | AAA6130 | 840 | <1 | <0.2 | 7.3 | 0.09 | 610 | <0.4 | <0.5 | 1.5 | <0.5 | 3800 | <0.1 |
| 00-1226 | AAA6124 | 1500 | <1 | <0.2 | 14 | 0.2 | 530 | <0.4 | <0.5 | 1.7 | 1.3 | 2400 | <0.1 |

| Location ID | Sample # | K | Mg | Mn | Na | Ni | Pb | Sb | Se | Tl | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00-1219 | AAA6121 | 550 | 710 | 90 | 430 | <2 | 3.6 | <0.2 | <0.2 | <0.2 | 4 | 80 |
| 00-1220 | AAA6114 | 320 | 160 | 100 | 58 | <2 | 3.1 | <0.2 | <0.2 | <0.2 | <0.5 | 22 |
| 00-1221 | AAA6109 | 490 | 310 | 140 | 76 | <2 | 6.4 | <0.2 | <0.2 | <0.2 | 2.3 | 33 |
| 00-1221 | AAA6108 | 430 | 370 | 200 | 100 | <2 | 7 | <0.2 | <0.2 | <0.2 | 3 | 28 |
| 00-1222 | AAA6116 | 610 | 570 | 160 | 98 | <2 | 6 | <0.2 | <0.2 | <0.2 | 4.5 | 32 |
| 00-1223 | AAA6117 | 330 | 1000 | 67 | 430 | <2 | 1.6 | <0.2 | <0.2 | <0.2 | 4.1 | 18 |
| 00-1224 | AAA6100 | <70 | 360 | 73 | 120 | <2 | 1.7 | <0.2 | <0.2 | <0.2 | 2.3 | 30 |
| 00-1225 | AAA6130 | <70 | 440 | 130 | 67 | <2 | 1.2 | <0.2 | <0.2 | <0.2 | 2.5 | 41 |
| 00-1226 | AAA6124 | 360 | 390 | 81 | 100 | <2 | 3.2 | <0.2 | <0.2 | <0.2 | 3.4 | 22 |

Given the identification and removal of all UXOs and OEW and the absence of any significant contaminants in the soil and sediment, it is recommended that the site be approved for residential use and designated for NFA. Additionally, it is recommended that Los Alamos County remove the fence from the site and open the area to the public.

### 3.4 SWMU 0-011(e)

#### 3.4.1 Background

##### 3.4.1.1 Description and History

SWMU 0-11(e) is an area that extends north along a tributary of Rendija Canyon to the top of the cliff face that is the head waters of the tributary drainage and is the north drainage divide of Rendija Canyon. The designators for this SWMU [0-011(b) and (e)] were originally thought to designate two separate units. SWMU 0-011(b), north-northeast of the Sportsman's Club, is fenced and labeled Thirty-Seven Millimeter Canyon on a 1962 range clearance map (LASL 1962) (Figure 1). This is the same SWMU that is referred to as "e" in the SWMU report (LANL 1990). The designator 0-11(e) was retained for this SWMU location. The SWMU 0-11(e) is largely on Santa Fe National Forest land except for a small segment at the southern boundary which is on DOE land.

U.S. Army personnel, operating tanks firing 37-mm rounds, used the canyon for training in the mid- to late 1940s (IT Corporation 1991). Not all of the area designated on the range clearance map was fenced, so the exact size of the SWMU was not known before field activities began. The northern unfenced boundary of the SWMU was established as the top of the cliff face (Figure 9).

##### 3.4.1.2 Geology and Hydrology

Thirty-Seven Millimeter Canyon is a northern tributary to Rendija Canyon. The area includes the headwaters of the tributary drainage as well as extensive near vertical cliffs formed on the Bandelier Tuff, which comprises the bedrock of this site. Hillslope colluvium and alluvial materials along drainage channels comprise the relatively thin surficial materials of the area. The axial channel of Thirty-Seven Millimeter Canyon is the principal drainage channel of the site and collects all surficial drainage of the site before its discharge into Rendija Canyon.

#### 3.4.2 Site Investigation and Analytical Results

##### 3.4.2.1 Ordnance

The area within the fence, the cliff, and the mesa top to a line about 100 meters back from the cliff were surveyed for UXOs and OEW. The SWMU was subdivided (see Figure 9) by the EOD team to facilitate their survey. Within each subdivision lanes were layed out to guide the surveys, except for the cliff face where complete coverage was visually controlled by features on the cliff face. Because the terrain was particularly rough, the EOD team was required to rappel down the cliff face. This activity took about four days and resulted in locating only one round. The team used civilian climbing equipment, including safety lines, and performed the work in accordance with applicable regulations and general practices of mountaineering safety.

The ordnance sweep at SWMU 0-011(e) took approximately 5 weeks. Materials recovered were primarily 37 mm rounds and fragments. Because of the uncertainty of whether each of these rounds were HE or armor-piercing (AP) they were placed in shallow pits and explosives then packed over them and detonated, a practice referred to as "shots." These detonations/shots were performed for several reasons: (1) to ensure positive identification of the rounds (deterioration of the rounds could result in mistakes in identification), (2) to ensure the materials were inert (EOD procedures prohibit bringing live rounds out of the survey area),

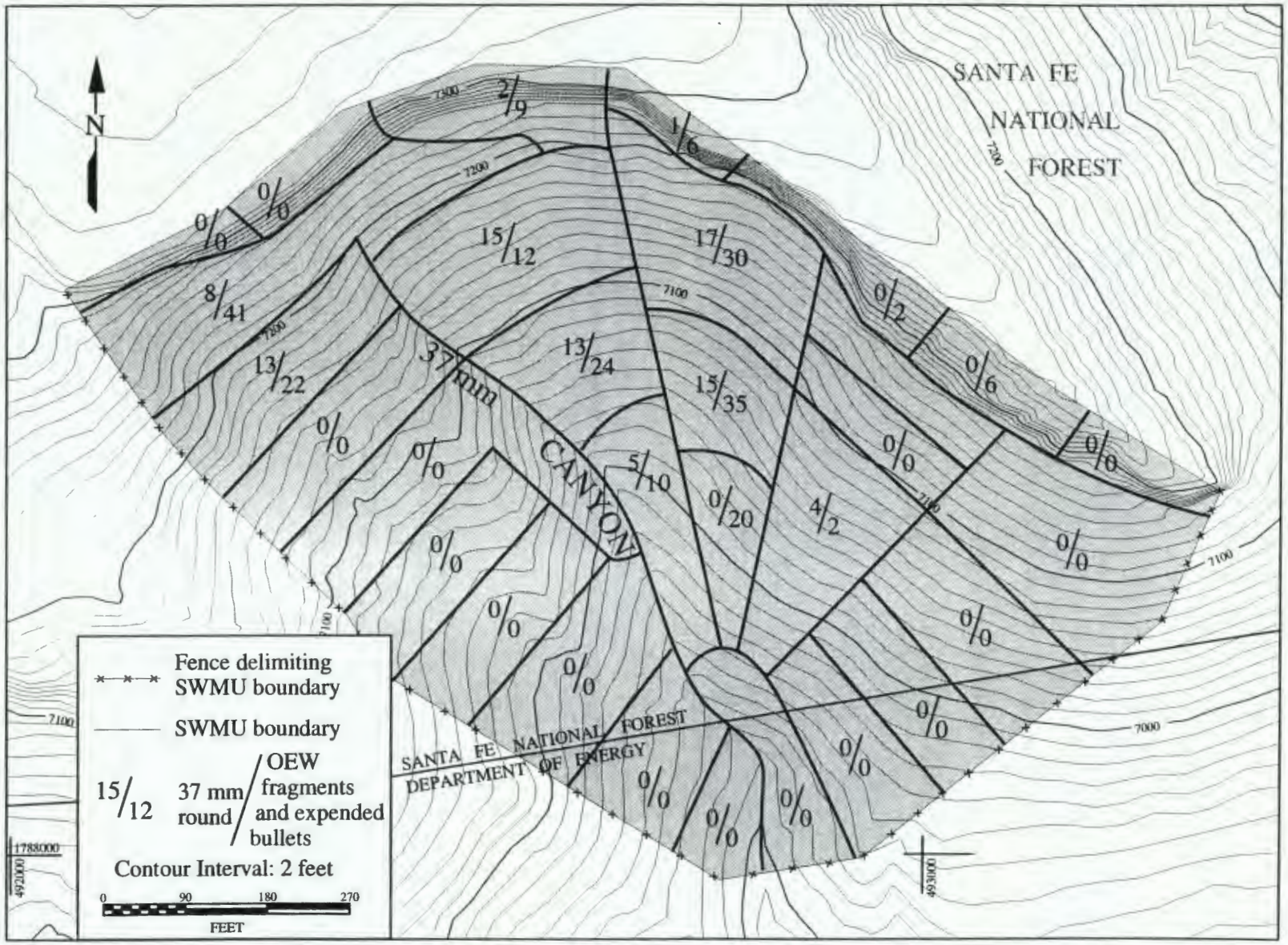


Figure 9. Map of SWMU 0-011(e) showing the fence on the southern boundary of the area. Dashed lines delineate EOD team area subdivisions, with the number of 37 mm rounds and number of OEW fragments found in each subdivision.

and (3) to facilitate safe disposal. The shots were fired non-electrically because of the difficulty of access to the area and the inability to visually maintain site security. Seven separate shots involving a total of 102 37 mm rounds were fired on 13 July 1993, 30 July 1993, and 23 August 1993. They were all fired within the main ordnance impact area of the site. After each of the detonations, the resulting EOW was recovered. All of the 37 mm rounds were confirmed to be AP.

Materials found in the ordnance sweep included two 20-mm rounds, 102 AP rounds, and fragments of an indeterminate number of 37-mm HE rounds (nose cones and fusing). All 350 pieces of EOW fragments and expended bullets (small caliber, both military and civilian) were found. The geophysics survey flagged 48 anomalies of which 27 were found to be ordanance related. The EOD team investigated all geophysical anomalies. Field work at the site was completed on September 24, 1993.

#### 3.4.2.2 Geomorphology and Sample Locations

Geomorphic mapping of SWMU 0-11 (e) included the mapping of all drainage channels that drained the area enclosed within the final boundaries of the site and (2) the areas of high concentration of ordnance fragments. Detailed mapping of the drainage within the site was necessary prior to selection of surface sampling sites, because of the generally high relief of the site and the concentration of ordnance in a relatively small segment of the site. Mapping included the larger drainage channels on or adjacent to the site, into which the smaller channels discharge (Figure 10). Soil investigations indicate two major soil-geomorphic settings characterize areas where sampling activities have been conducted: 1) Larger channels in which pedogenically unmodified , gravelly, sandy sediment has recently accumulated, and 2) recently deposited, pedogenically modified angular gravelly to sandy colluvium deposited in swales on steep hillslopes below steep cliffs formed in the Bandelier Tuff.

Sampling in fall of 1993 involved the collection of soil from the surface and selected sediment traps for evaluation of HE and TAL metals. Sediment catchment sites along the drainage channels of the hollslope below the cliff and within and directly below the main impact zone were selected for sampling because they are sites with the highest probability of the containing contaminants that are being removed from the SWMU (Figure 10).

#### 3.4.2.3 Chemistry and Data Quality

Following the RFI sampling plan, nine soil samples were collected on 24 September, 1993 (samples AA 6100, 6108-6109, 6114, 6116-6117, 6121, 6124 and 6130). Soil samples were analyzed for metals and HE. Radiation screening results (gross alpha, gross beta, and gross gamma) were uniformly below detection limits. Analyses of metals were made by group CTS-9 following the SW846 procedures for ICPES (most elements), FAA (Ag), and ETVAA (As and Se). Results for inorganics (Table 6) were obtained using the nitric acid sample dissolution procedures prescribed by EPA (SW 846) together with ICPES, ICPMS and AA instrumental techniques.

Be and As are above SALs, but fall well within the background range. All of the QC data for the metals were "under control" except for Hg which was "out of control." The analytical result for Hg in the QC sample was 2 μg/g while the QC value was 5 μg/g. This makes the analytical result about 60% low. The result for Hg in all of the samples was <0.1 mg/kg while the SAL for Hg is 24 mg/kg. Therefore, the fact that the analytical result for Hg in the QC sample is 60% low does not affect the status of Hg being below SAL. This is because all reported Hg values for the samples are at least a factor of 240 below the SAL.

The organic compounds associated with HE were analyzed by the International Technology Analytical Services, St. Louis, MO using HPLC, a modified SW846 Method 8330. The compounds analyzed for were: 1,3-Dinitrobenzene; 2,4-Dinitrotoluene; 2,6-Dinitrotoluene; HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine); Nitrobenzene; m-Nitrotoluene; o-Nitrotoluene; p-Nitrotoluene; RDX (1,3,5-Trinitrohexahydro-1,3,5-triazine); Tetryl (Methy-2,4,5-trinitrophenylnitramine); 1,3,5-Trinitrobenzene; and 2,4,6-Trinitrotoluene. All analyses were below detection limits for all analytes.

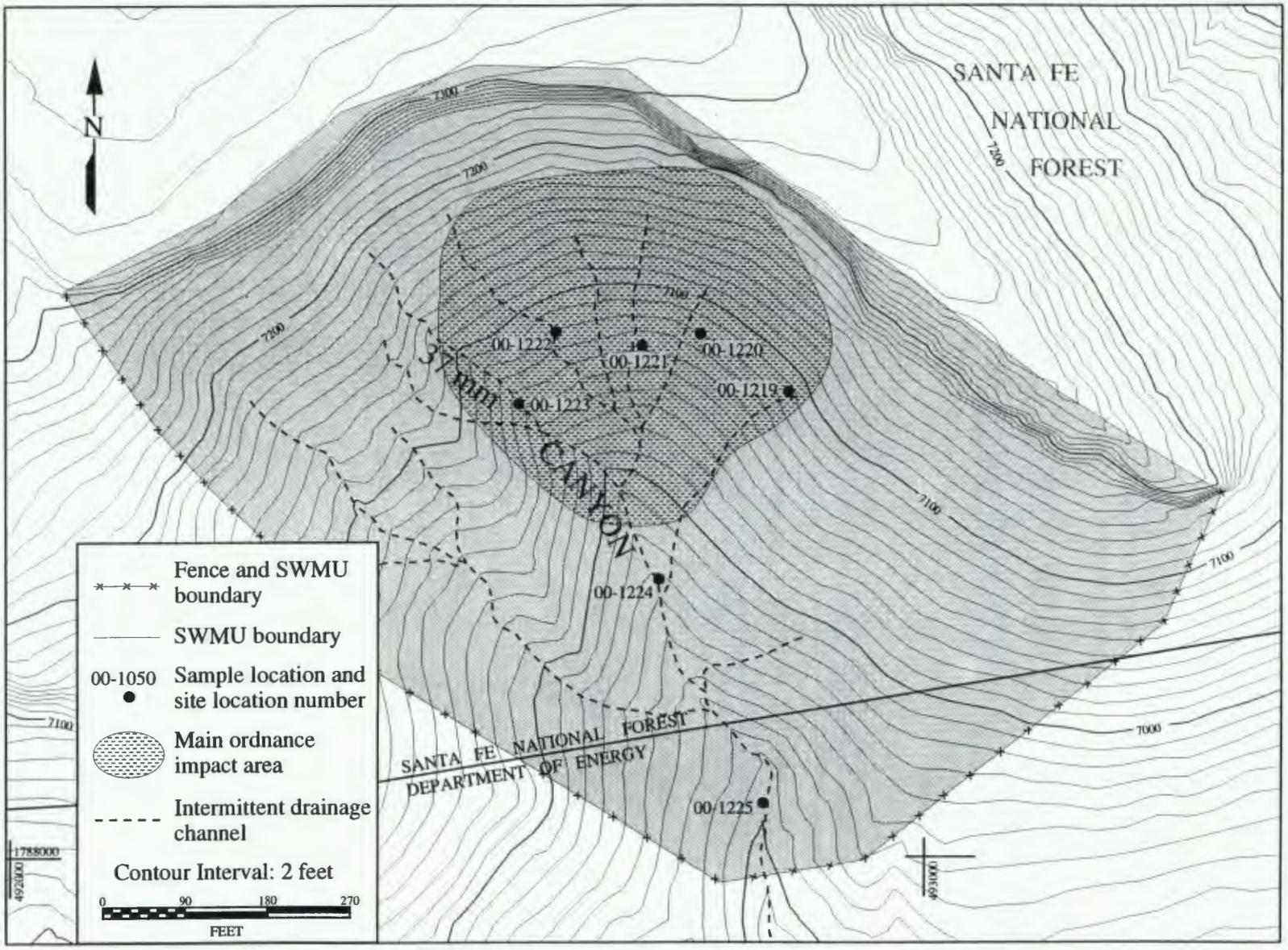


Figure 10. Map of SWMU 0-011(e) showing the main ordnance impact area, drainage pattern, and sample (site) locations.

The analytical laboratory had several problems with the HE analyses. One was that the holding times for the analyses were missed by 6 days. The samples were extracted within 7 days but were not analyzed for 46 days (exceeding the 40 day limit required by the SW 846 Method 8330). However, it was concluded that the data are still accurate because: (1) a recent report by the U. S. Army Environmental Center entitled "Experimental Assessment of Analytical Holding Times for Nitroaromatic and Nitramine Explosives in Soil" (special report 93-11, June 1993) indicates that exceeding holding times (up to 56 days after extraction) does not cause a loss of HE analytes, nitramines, and possibly nitromatics, (2) HE sample results were below detection limits for all analytes, and (3) No peaks were detected that could have been degradation products from any HE that may have biodegraded (per analytical laboratory).

Another problem encountered by the analytical laboratory was surrogate and MS/MSD recoveries. The surrogate recoveries ranged from 66% to 280% while the MS/MSD recoveries ranged from 29% to 296%, causing the CST-9 reviewer to qualify the data as "UJ" (undetected, estimated quantity). However, all analytes were below detection and no peaks from biodegradation products were present.

### 3.4.3 Data Assessment

No TAL metals exceeding their SALs except for arsenic and beryllium, for which the SALs are comparable to background concentrations (Table 7). Concentrations of all elements appear to be comparable to regional

**TABLE 7. Summary of Inorganic Results from 0-011(e)**

| | min | mean | median | max | SAL | background |
|---|---|---|---|---|---|---|
| Ag | <1 | | | <1 | 400.o | 1.16 |
| Al | 610 | 1623 | 1500 | 3100 | — | 50,000-144,000 |
| As | <0.20 | 0.34 | 0.40 | 1.10 | 0.4 | 1.2-10.8 |
| Ba | 7.3 | 15.8 | 17.0 | 24.0 | 5600.0 | 125-830 |
| Be | 0.09 | 0.26 | 0.23 | 0.45 | 0.16 | 1.0-4.4 |
| Ca | 290 | 868 | 700 | 2200 | — | 1900-80,400 |
| Cd | <0.4 | | | <0.4 | 80.0 | 1.2-1.7 |
| Co | <0.5 | | <0.5 | 0.70 | — | 0.4-23 |
| Cr | <0.5 | 1.27 | 1.50 | 2.50 | 400.0 | 2-71 |
| Cu | <0.5 | 1.83 | 1.70 | 4.60 | 3000.0 | 2-18* |
| Fe | 2200 | 3033 | 2700 | 4200 | — | 10,000-48,600 |
| Hg | <0.1 | | | <0.1 | 24.0 | 0.007-0.029* |
| K | <70 | 328 | 360 | 610 | — | 10,400-48,000 |
| Mg | 160.00 | 478.89 | 390.00 | 1000.00 | — | 1331-16,800 |
| Mn | 67.00 | 115.67 | 100.00 | 200.00 | 8000.0 | 190-1600 |
| Na | 58.00 | 164.33 | 100.00 | 430.00 | — | 2700-36,300 |
| Ni | <2 | | | <2 | 1600.0 | 1.6-19* |
| Pb | 1.20 | 3.76 | 3.20 | 7.00 | 500.0 | <14-44 |
| Sb | <0.2 | | | <0.2 | 32.0 | 0.3-1.6 |
| Se | <0.2 | | | <0.2 | 400.0 | 0.26† |
| Tl | <0.2 | | | <0.2 | 6.4 | <0.2-0.9 |
| V | <0.5 | | 3.00 | 4.50 | 560.0 | 12-113 |
| Zn | 18.0 | 34.0 | 30.0 | 80.0 | 24000.0 | 20-146 |

— No SAL for analyte.
All units in parts per million.
Background values are from Longmire et al. (1993) unless otherwise indicated.
* = Ferenbaugh et al. (1990).
† = Shacklette and Beorngen (1984).

background values, allowing for the bias in methods discussed in Section 2.3. No high explosives (HE) or byproducts were detected in any sample. This is significant because even if all of the samples had the lowest recoveries and contaminants were present at a concentration equal to the highest detection limit within the sample set, the adjusted values would still be well below SALs (see Table 8 and discussion in Section 3.1.3)

### 3.4.4 Conclusions and Recommendations

This site has been cleaned of all UXOs and OEW fragments to the smallest size possible using state-of-the-art instruments. In addition to a very careful search conducted by an EOD team, the site underwent an extremely thorough quality control check by a geophysics team to ensure that no UXOs or significant sized OEW fragments remained. It is important to emphasize that the EOD search of the high cliff, which formed a backstop for the 37 mm rounds that were fired into the amphitheater, included a complete visual search supported by magnetometers to check holes and cracks. The mesa top above the cliff, to about 100 meters back from the rim, underwent the same careful search.

Judgementally selected soil and sediment samples, chosen to maximize the possibility of finding contaminants (metals or HE) from the 37 mm rounds, showed that all of the TAL metals at the site are within background values and that HE is not present at the detection limits of the analytical instruments. Therefore the soils and sediment at the site do not contain HE above SALs.

Given the location and removal of all UXOs and significant OEW fragments at the site and the absence of any significant contaminants in the soils and sediment, it is recommended that the site be approved for residential use and designated for NFA. Additionally, it is recommended that the DOE and US Forest Service remove the fence that delineates the southern boundary of the SWMU.

**TABLE 8. Comparison of Analytical Data and SALs for HE Sample Analyses for 0-011e**

| Analyte | SAL (mg/kg) | HV (mg/kg) | Factor | %Recovery |
|---|---|---|---|---|
| "1,3-Dinitrobenzene" | 8 | <0.0003 | 27000 | 33-165 |
| "2,4-Dinitrotoluene" | 1 | <0.0003 | 3000 | 33-296 |
| "2,6-Dinitrotoluene" | 1 | <0.00031 | 3000 | 55-165 |
| HMX | 4000 | <0.0026 | 1540000 | 32-153 |
| Nitrobenzene | 5.3 | <0.00031 | 17000 | 35-160 |
| m-Nitrotoluene | - | <0.0003 | - | 57-147 |
| o-Nitrotoluene | - | <0.0003 | - | 53-120 |
| p-Nitrotoluene | - | <0.0003 | - | 61-139 |
| RDX | 64 | <0.0012 | 53000 | 35-147 |
| Tetryl | 800 | <0.00077 | 1030000 | 44-172 |
| "1,3,5-Trinitrobenzene" | 4 | <0.0003 | 13000 | 31-175 |
| "2,4,6-Trinitrotoluene" | 40 | <0.0003 | 130000 | 29-183 |

HV = Highest Value from the analytical results for particular analyte.
"Factor = SAL/HV, the factor HV is below SAL."
% Recovery = range in % recovery for MS/MSD.

### 3.5 AOC C-0-020

### 3.5.1 Background

#### 3.5.1.1 Description and History

AOC C-0-020 is located in a tributary of Rendija Canyon west of the Guaje Pines Cemetery (**Figure 11**). Most of the site lies within the national forest except for a small area on the south eastern edge which is private property. Before the RFI site investigation began, it was thought that the U.S. Army fired mortar rounds from Barranca Mesa into this area (IT Corporation 1991). An ordnance team from Fort Bliss found no ordnance in a preliminary survey in 1991, thereby casting doubt that it was ever an active site.

#### 3.5.1.2 Geology and Hydrology

AOC C-0-020 lies along the north valley wall of Rendija Canyon into which all the drainage from this site discharges. The site also includes a small northern tributary of Rendija Canyon. The bedrock of the site consists primarily of dacitic rocks of the Tschicoma Formation with minor outcrops of the Bandelier Tuff. Additionally, the hillslopes are thinly veneered with hillslope colluvium and the valleys floors are covered with alluvial materials. Drainage channels on the hillslopes within the site are small channels that drain into the tributary of, or directly into, Rendija Canyon.

### 3.5.2 Site Investigation and Analytical Results

The ordnance sweep at AOC C-0-020 took about one week during the first part of May 1993. The area was designated an AOC based on deteriorated signs found at what was defined as the west corner and along the southern boundary of the AOC. The northern boundary was delimited on the basis of topography, so as to match the elevation of the ridge forming the southern boundary. As a result, the site was approximately 30 acres in size. The land surveyors set boundary angle points and staked a 100-foot grid (400 feet by 900 feet). The ordnance sweep of the portion of the SWMU thought most likely to have been an ordnance impact area resulted in findings of a few pieces of debris and scrap metal; no ordnance, OEW, or UXOs were located.

The geophysics team's survey found 11 anomalies. The subsequent QA investigation found that these anomalies were rocks and some pieces of tin. Field work at the site was completed by 05 June 1993.

### 3.5.3 Conclusions and Recommendations

This site, identified as a possible former ordnance impact area, was thoroughly surveyed for OEW. Not a single piece of OEW was found during the EOD or geophysical surveys. This procedure, of having a follow-on geophysical survey, ensured that a careful quality control check was made of each square foot of the area. The complete absence of OEW shows that this site was never used as an ordnance impact area. The three signs on the perimeter of the site (**see Figure 11**) may have been placed there to keep people away from the down-range side of the former small arms range located on the east.

Given that the extremely detailed and careful search for OEW at this AOC did not result in even a single fragment of OEW being found, demonstrating that the site is not a former ordnance impact area, it is recommended that the site be designated for NFA and approved for residential land use.

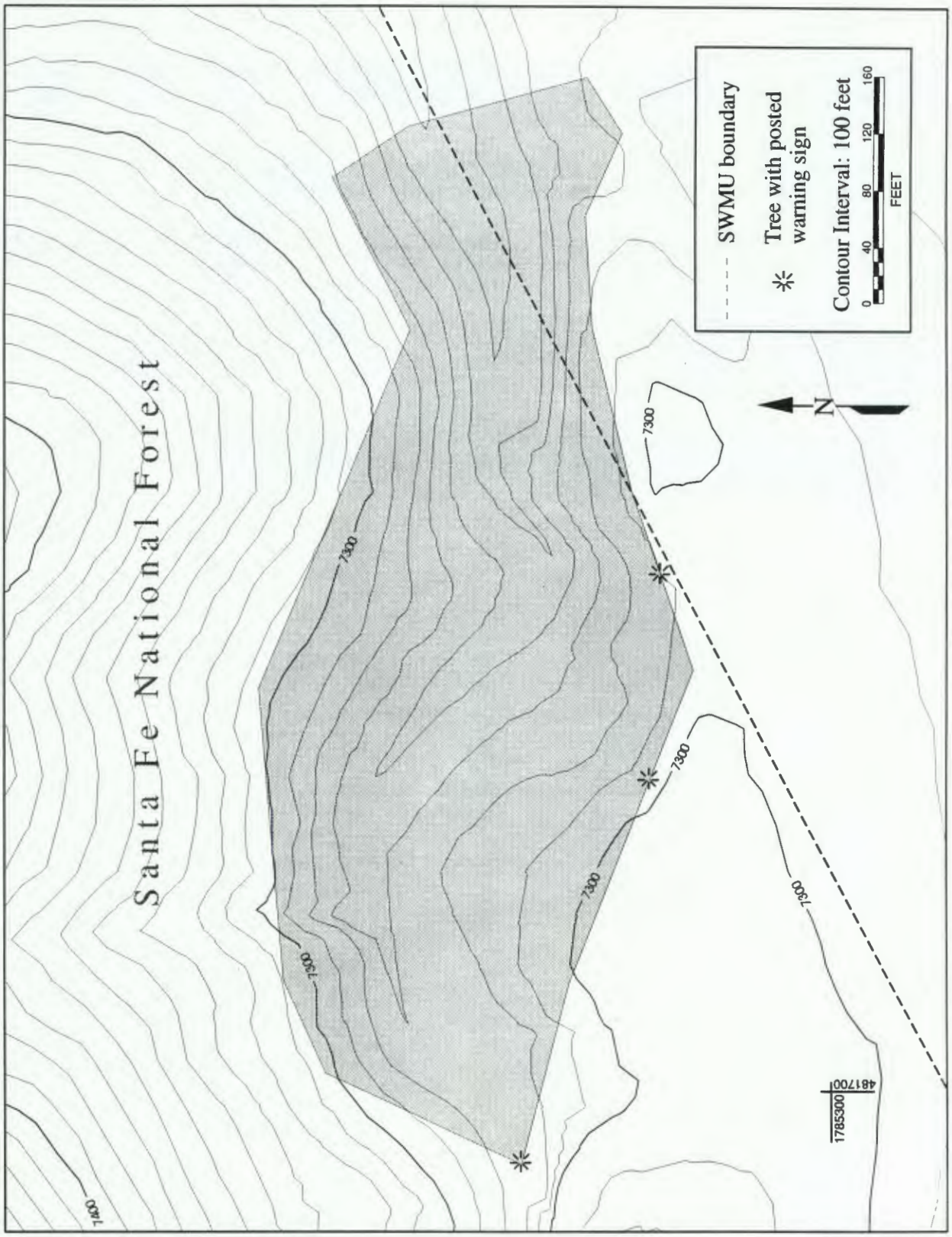


Figure 11. Map of AOC C-0-020.

### 3.6 References

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