Sandia National Laboratories / New Mexico

PROPOSAL FOR NO FURTHER ACTION ENVIRONMENTAL RESTORATION PROJECT SITE 28, MINESHAFTS OPERABLE UNIT 1332

FY 1995

August 1995

Environmental
Restoration
Project

United States Department of Energy
Albuquerque Operations Office

PROPOSAL FOR
NO FURTHER ACTION
Environmental Restoration Project

Site 28, Mineshafts
OU 1332

Prepared by
Sandia National Laboratories/New Mexico
Environmental Restoration Project
Albuquerque, New Mexico

Prepared for the
United States Department of Energy

TABLE OF CONTENTS

TABLE OF CONTENTS (Concluded)

LIST OF FIGURES

LIST OF ATTACHMENTS

Attachment

1. Introduction

1.1 ER Site 28, Mineshafts

Sandia National Laboratories/New Mexico (SNL/NM) is proposing an administrative no further action (NFA) decision for Environmental Restoration (ER) Site 28, Mineshafts, Operable Unit (OU) 1332. ER Site 28, formerly included in OU 1297, was identified in the Hazardous and Solid Waste Amendment (HSWA) Module IV (Ref. 1) of the SNL/NM Resource Conservation and Recovery Act (RCRA) Hazardous Waste Management Facility Permit (NM5890110518) (Ref. 2).

1.2 SNL/NM Administrative NFA Process

This proposal for a determination of an administrative NFA decision has been prepared using the criteria presented in Section 4.5.3 of the SNL/NM Program Implementation Plan (Ref. 3). Specifically, this proposal will "contain information demonstrating that there are no releases of hazardous waste (including hazardous constituents) from solid waste management units (SWMU) at the facility that may pose a threat to human health or the environment" (as proposed in the Code of Federal Regulations [CFR] Section 40 Part 264.51[a] [2]) (Ref. 4). The HSWA Module IV contains the same requirements for an NFA demonstration:

> Based on the results of the RFI [RCRA Facility Investigation] and other relevant information, the Permittee may submit an application to the Administrative Authority for a Class III permit modification under 40 CFR 270.42(c) to terminate the RFI/CMS [corrective measures study] process for a specific unit. This permit modification application must contain information demonstrating that there are no releases of hazardous waste including hazardous constituents from a particular SWMU at the facility that pose threats to human health and/or the environment, as well as additional information required in 40 CFR 270.42(c) (Ref. 1).

In requesting an administrative NFA decision for ER Site 28, Mineshafts, this proposal is using existing administrative/archival information to satisfy the permit requirements. A unit can be eligible for an administrative NFA proposal based on one or more of the following criteria taken from the RCRA Facility Assessment Guidance (Ref. 5):

- Criterion A: The unit has never contained constituents of concern (COCs).
- Criterion B: The unit has design and/or operating characteristics that effectively prevent releases to the environment.
- Criterion C: The unit clearly has not released hazardous waste or constituents into the environment.

Specifically, ER Site 28, which is comprised of ten individual mine sites, is being proposed for an administrative NFA decision because nine of the sites never contained hazardous waste

or constituents (Criterion A), and one of the sites has not released hazardous waste or constituents into the environment (Criterion C).

1.3 Local Setting

ER Site 28 is comprised of ten locations where past mining activity took place. The mines included as ER Site 28 have long since been abandoned, or were never used beyond some very limited prospecting. The individual mine locations vary considerably, ranging from small prospector pits to vertical and horizontal shafts that extend from 50 to over 600 feet into the subsurface. Most of the mines are situated in fractured granite and metamorphic Precambrian-age rocks (hard rock mines) comprising the Manzanita Mountains, although one location is in younger Pennsylvanian-age limestone (Madera Formation) that lies directly over the Precambrian granite and metamorphics.

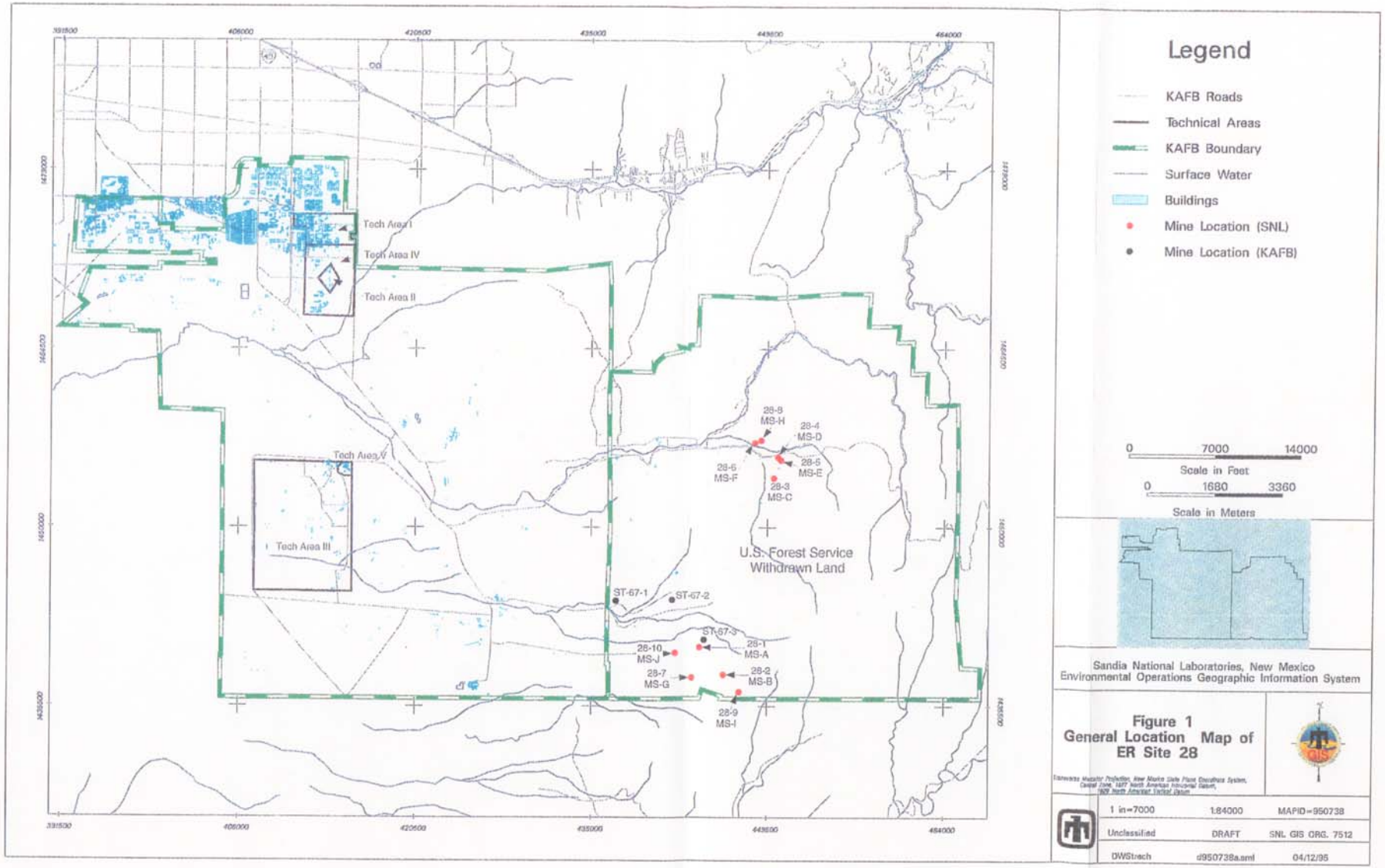
ER Site 28 (all ten locations, 28-1 through 28-10) is located in the south-central and central part of the United States Forest Service Withdrawn Area (withdrawn to Kirtland Air Force Base, here after referred to as the "Withdrawn Lands"). Figure 1 shows the general location of the ten sites within the Kirtland Air Force Base (KAFB) boundary. Figure 1a shows more precise locations of 28-1 through 28-10 and surface topography within the south-central part of the Withdrawn Lands. Figures 1 and 1a also show mine locations ST-67-1 through ST-67-3, which are KAFB mine sites that are being investigated under the KAFB Installation Restoration Program (IRP).

The southern portion of the Withdrawn Lands was used extensively by the military during World War II for ordnance testing (Ref. 6). Numerous shells, some of which may still be live, and pieces of shrapnel are scattered over much of the area. Personnel at KAFB determined that removal and/or disposal of the shells would be too costly. The shells are considered a United States Air Force (USAF) responsibility (Ref. 7).

2. History of the SWMU

2.1 Sources of Supporting Information

In preparation to request an administrative NFA decision for ER Site 28, a background study was conducted to collect available and relevant site information. Background information sources include records, reports, and investigative field notes/log books. Interviews were conducted with SNL/NM staff and contractors familiar with activities performed in the vicinity of these mines. Radiation surveys were conducted at all locations to determine if radioactive waste or materials were disposed of in the mines. The studies were documented and referenced in this report (Section 3.3 and 3.4).


391500
406000
420500
435000
449500
464000
1473000
1464500
1456000
1447500
1439000
Tech Area I
Tech Area IV
Tech Area II
Tech Area V
Tech Area III
U.S. Forest Service
Withdrawn Land
28-9
MS-H
28-4
MS-D
28-5
MS-E
28-6
MS-F
28-3
MS-C
ST-67-1
ST-67-2
ST-67-3
28-1
MS-A
28-10
MS-J
28-7
MS-G
28-2
MS-B
28-8
MS-I
Legend
KAFB Roads
Technical Areas
KAFB Boundary
Surface Water
Buildings
Mine Location (SNL)
Mine Location (KAFB)
0
7000
14000
Scale in Feet
0
1680
3360
Scale in Meters
Sandia National Laboratories, New Mexico
Environmental Operations Geographic Information System
Figure 1
General Location Map of
ER Site 28
1 in=7000
1:84000
MAPID=950738
Unclassified
DRAFT
SNL GIS ORG. 7512
DWStech
d950738a.aml
04/12/95

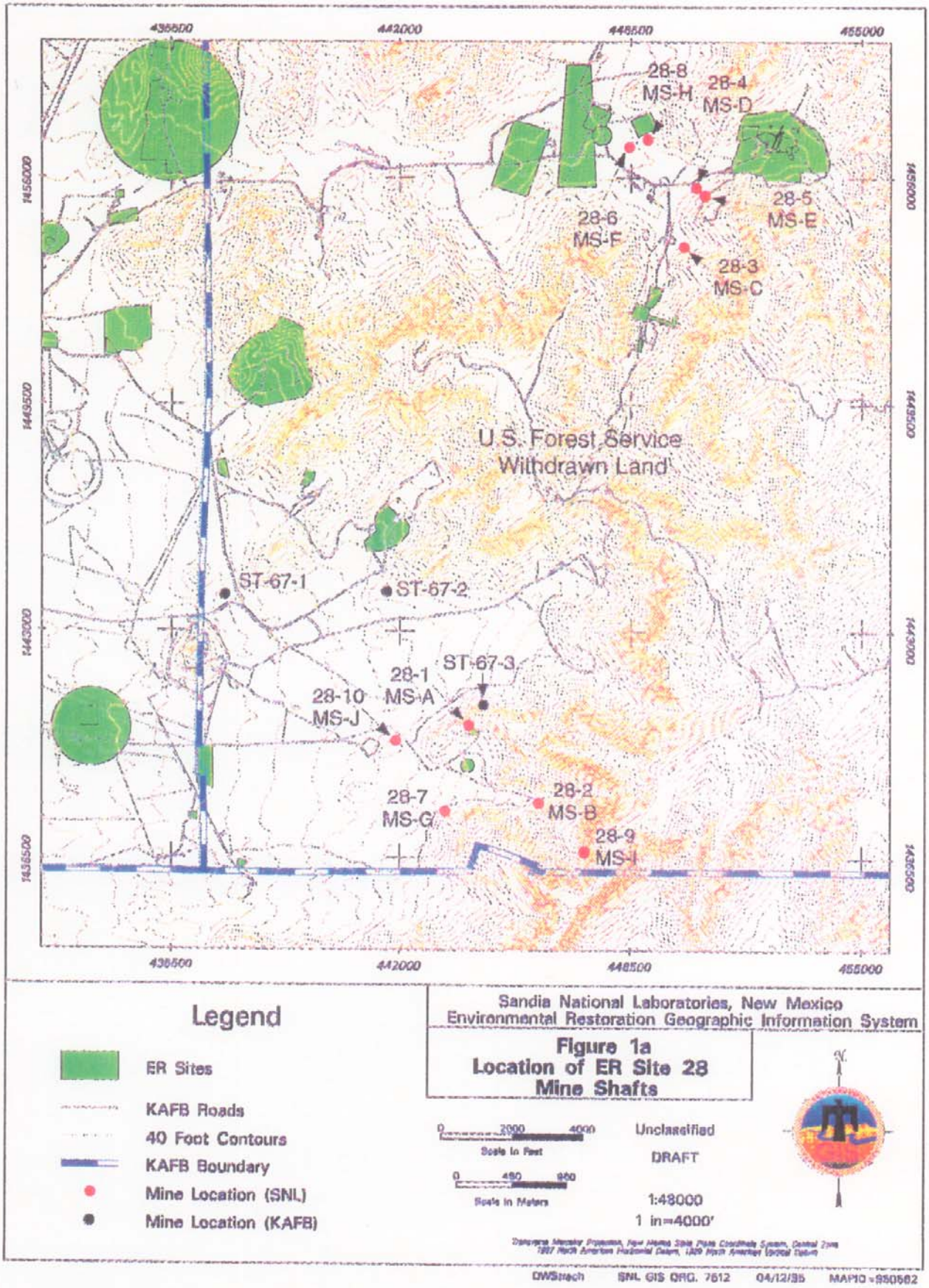


Figure 1a.
Location of ER Site 28 Mineshafts

The following information sources, listed in order of importance relative to this NFA proposal, were used in the evaluation of ER Site 28:

- Radiation survey report and field log book: document a detailed radiation survey of all of the ER Site 28 mine locations.

- Documented field inspections and mapping surveys of the mines:
  (1) SNL/NM Health Physics Division inspections associated with the radiation survey (1982-83)
  (2) KAFB inspections and mapping surveys (1993)
  (3) Three distinct SNL/NM ER Project inspection efforts (1989 - 1995), including some soil sampling and radiation survey work, and photography and land survey of all mine locations.

- Eight interviews with thirteen SNL/NM facility personnel (current and retired).

- Miscellaneous information sources including SNL/NM and KAFB correspondence (memorandums, letters, and field notes regarding ER Site 28).

- The Comprehensive Environmental Assessment and Response Program (CEARP) Phase I Report (Ref. 7) and CEARP records contained in the Environmental Operations Record Center.

Using this information, a brief history of ER Site 28 and a discussion of all relevant evidence regarding past waste practices and releases at the site have been prepared and are presented in this proposal for an administrative NFA decision.

2.2 Previous Audits, Inspections, and Findings

The mines that comprise ER Site 28 became ER sites because of concerns that SNL/NM or KAFB may have disposed of radioactive waste, and/or hazardous waste in the mines. The cited sources for these concerns are two published reports:

- Defense Nuclear Agency (DNA), 1971, "Radioactive Waste Survey," performed by DNA, Headquarters Field Command, Kirtland Air Force Base, Albuquerque, New Mexico, August 16, 1971 (Ref. 8)

- Engineering Science, 1981, "Installation Restoration Program, Phase I: Kirtland Air Force Base," prepared for the USAF, AFESC/DEV, Tyndall AFB, Florida (Ref. 9)

In the early 1980s, citing the reports listed above, six mine locations were identified and named "MS-A through MS-F" (equivalent to 28-1 through 28-6). There was concern at this time, based on interviews with SNL/NM staff, that these mines (and some of the test areas/dirt mounds also investigated) may have had unacceptable levels of radioactivity from past disposal and/or testing.

CEARP findings related to ER Site 28 are based on interviews with SNL/NM personnel. These appear to be the same individuals that were interviewed in the early 1970s for the DNA inspection, which was cited as the source of information for the Engineering Science phase I records search report (for KAFB) (Ref. 9). Specific information cited in the CEARP Reports regarding ER Site 28 includes the following:

- Burning of aluminum-cased rocket motors in a horizontal mineshaft in the Frustration Mine area
- Solid wastes were disposed of in mineshafts near the New Aerial Cable Test Site
- Radioactive, mixed, and solid wastes may have been disposed of in some mineshafts and adits (no specific location referenced)

The CEARP information sources regarding Site 28 are limited to three interviews with three individuals (former SNL/NM staff). There are no other documented sources of information that indicate environmental concerns related to the mines, including the RFA and Hazardous Ranking System (HRS) information.

2.3 Historical Operations

ER Site 28 is comprised of ten locations where past mining activity took place (labeled 28-1 through 28-10 in Figures 1 and 1a. The previous labels, MS-A through MS-J, are also shown). The mines included as ER Site 28 have long since been abandoned, or were never worked beyond some very limited prospecting. The individual mine locations vary considerably, ranging from small prospecting pits to vertical and horizontal shafts that extend from 50 to over 600 feet into the subsurface. The old mine features, including adits, shafts, and prospecting pits, are the remnants of mineral mining activities conducted in the early- to mid-1900s. Fluorite was the most common target mineral, but barite, galena, and other sulfide minerals also were apparently mined based on examination of tailings piles. The Blackbird Mine (28-4) was one of the largest fluorite mining operations in the area and was active in the 1940s (Ref. 10). Most of the mines are the work of very small, independent prospector operations and were abandoned without ever producing significant amounts of ore. The exact times when these smaller mines may have been active are impossible to determine with existing records, and are not relevant to this proposal.

These mines are not ER sites because of the past mining activities, but rather speculation that SNL/NM personnel later used these remnant features to dispose of various wastes. According to CEARP interviews, various wastes may have been placed in a mine(s). Based on follow-up interviews, at least one rumor regarding the disposal of explosives in a mine is false. The disposal actually took place in a dry well, not in a mine (Ref. 11).

In addition, the CEARP findings state that a radiometric study was conducted by SNL/NM personnel and that although no radiation levels significantly above background were detected, "no entry was made into the mines." In fact, most of the mines were entered several times as part of this "radiometric study" in order to obtain accurate radiation readings (Ref. 12 and

13). The final report from this radiometric study (Ref. 12) and the field log book of the lead investigator (Ref. 13) document these entries. The information in these references provides critical descriptions of mines which are very dangerous to enter (28-2 and 28-9, in particular). The radiation survey is discussed further in Sections 3.3 and 3.4. Section 5 contains specific references from the ER Site 28 background files that provide more detailed historical background information.

ER Site 28 is somewhat confusing because it is comprised of 10 "mine sites", and many of these individual sites have more than one feature, such as multiple adits (horizontal) or shafts (vertical). In addition, there has been considerable confusion regarding who is actually investigating a given mine site, since KAFB and SNL/NM have both listed the same site (using different names) on their RCRA HSWA Permits. This duplication issue was cleared up between 1991 and 1993 through a series of letters between KAFB, SNL/NM, and Environmental Protection Agency (EPA) (Ref. 14, 15, 16, and 17). During an early radiation survey of these mines by SNL/NM personnel (described in Section 3.3 and 3.4), the locations were named "MS-A" through "MS-J" (this nomenclature may have been started by KAFB in the DNA report [Ref. 9]). Later, after the CEARP established the nomenclature of "ER Site 28", these locations were renamed 28-1 through 28-10.

Finally, there are a lot of small mines scattered throughout the KAFB "Withdrawn Lands" that are not included as ER Site 28. Many of these mines have been examined and contain insignificant features (small pits) or have no evidence of postmining activity, and therefore were not added to the site list. Any mines (or areas) directly referred to in the CEARP documentation have been included as part of ER Site 28, regardless of the significance of the mine features in those locations. The mines that are included as ER Site 28 are the most likely to have had something disposed of in them, based mainly on their accessibility, but also considering all of the information gathered to date.

2.4 Individual Mine Descriptions

The following site descriptions of ER Site 28-1 through 28-10 have been compiled based on numerous SNL/NM and KAFB site visits, mapping surveys and interviews with past field investigators. There have been five major, well-documented field inspection/investigation efforts: one conducted by KAFB (Ref. 18), and four conducted by various SNL/NM groups (Ref. 12, 13, 19, 20, 21, 22, and 23). These previous investigations, inspections, and mapping surveys are discussed in detail in Sections 3.3 and 3.4. Detailed descriptions based on mine entry and exploration of sites 28-1, 28-2, 28-7, 28-9, and 28-10 are present in the survey report completed by KAFB (Ref. 18). Terminology contained in these descriptions can be confusing and has been intentionally avoided in the descriptions presented below. Figures 1 and 1a show the locations of each mine site, and photographs of each mine entrance are included in Figures 2 through Figure 11. These figures should be consulted while reading the descriptions provided below to gain a clear picture of the features at each site.

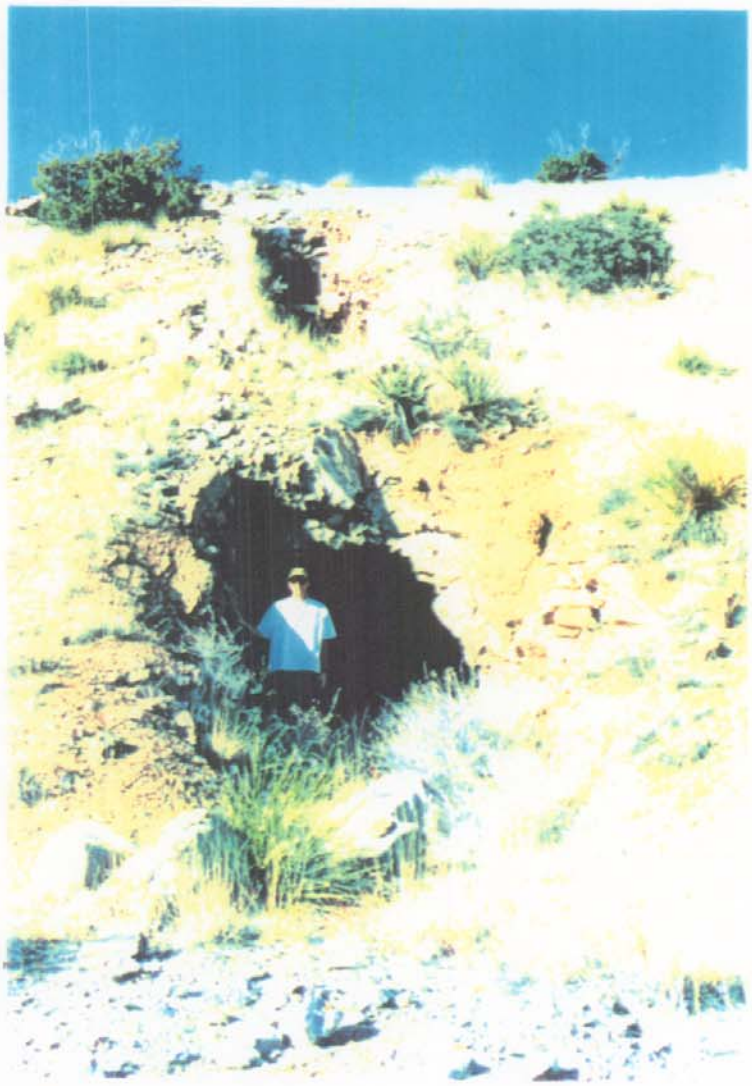


Figure 2a.
Site 28-1, Adit Behind Technician Connected/Continuous
With Excavated Trench in Background

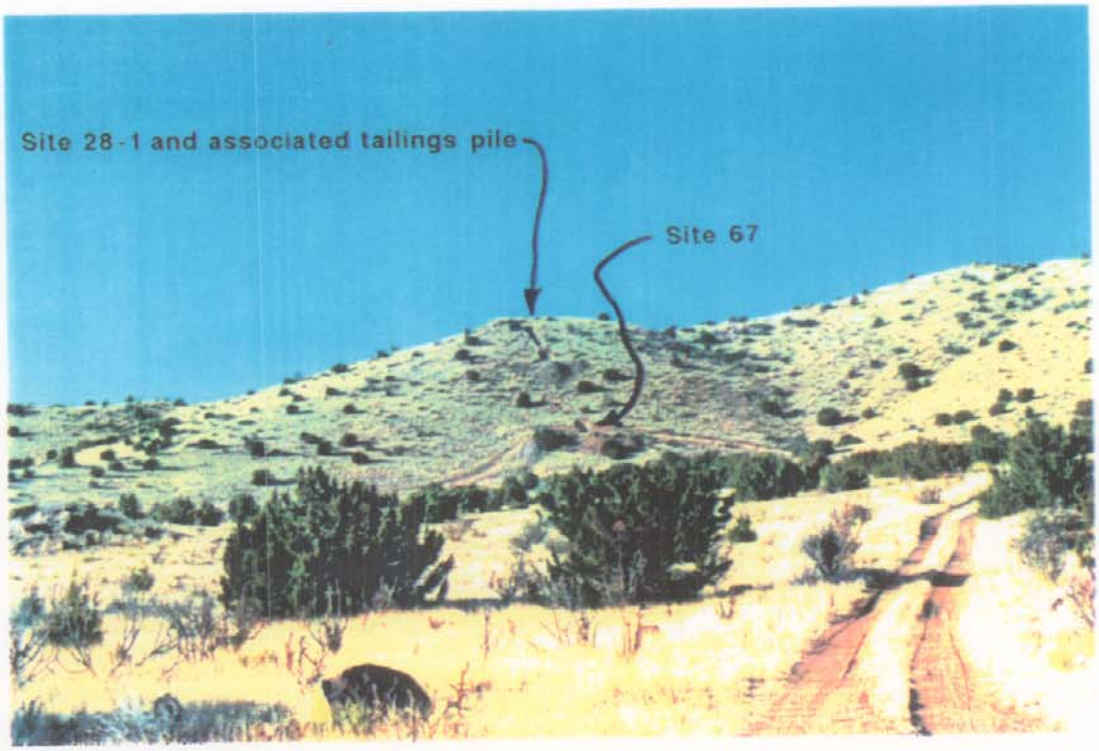


Figure 2b.
View Looking North at Site 67 and 28-1

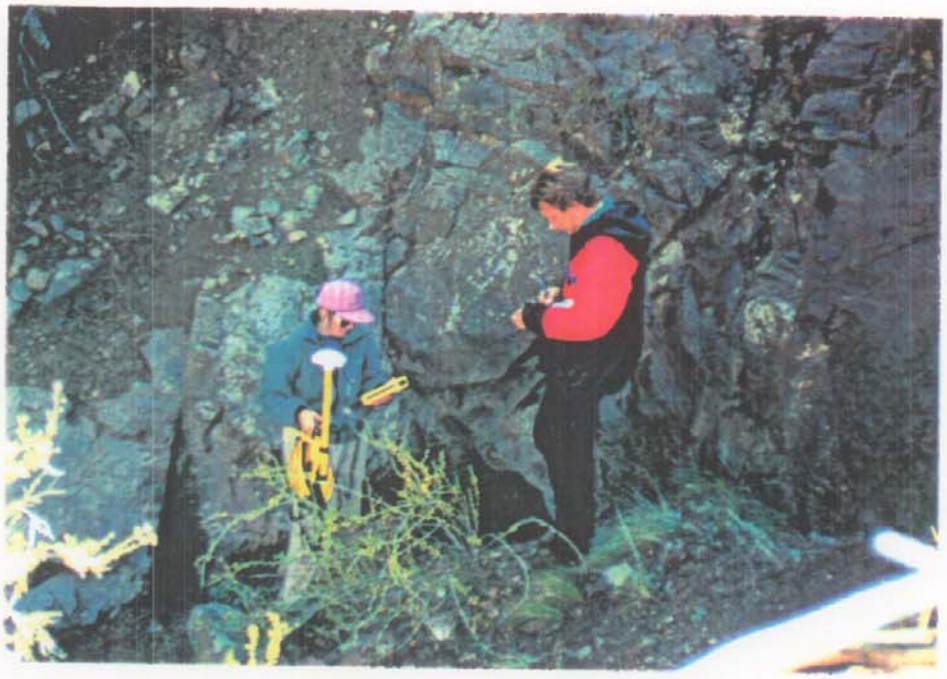


Figure 3a.
Site 28-2, lower caved-in adit located between the two ER personnel.
Yellow instrument is the Global Positioning System (GPS) instrument.

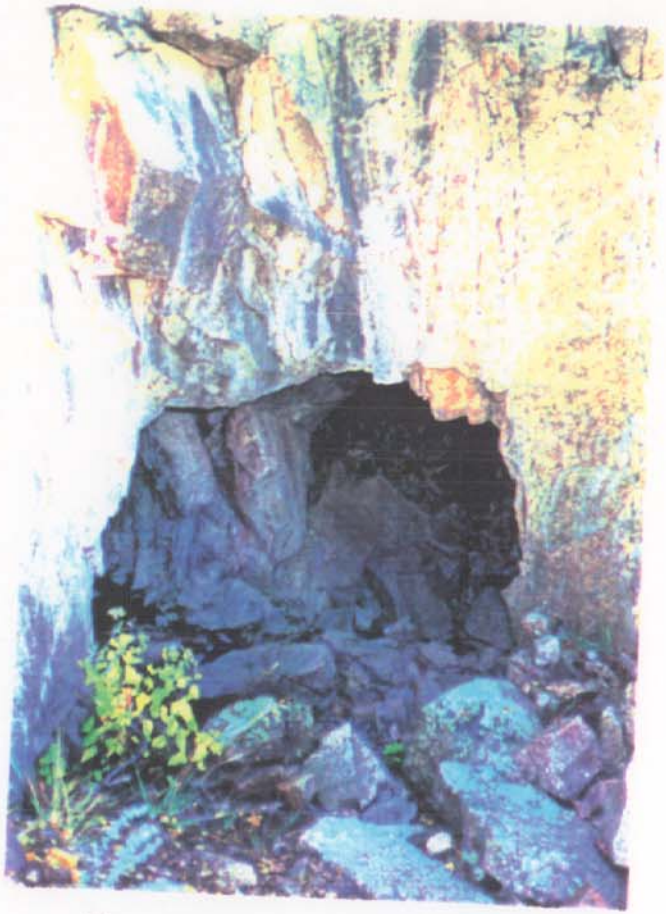


Figure 3b Site 28-2. Upper adit location. View of the opening.

Figure 3c Site 28-2. View into the adit showing green vegetation, indicating the common presence of water.

Figure 3b and c.
Site 28-2

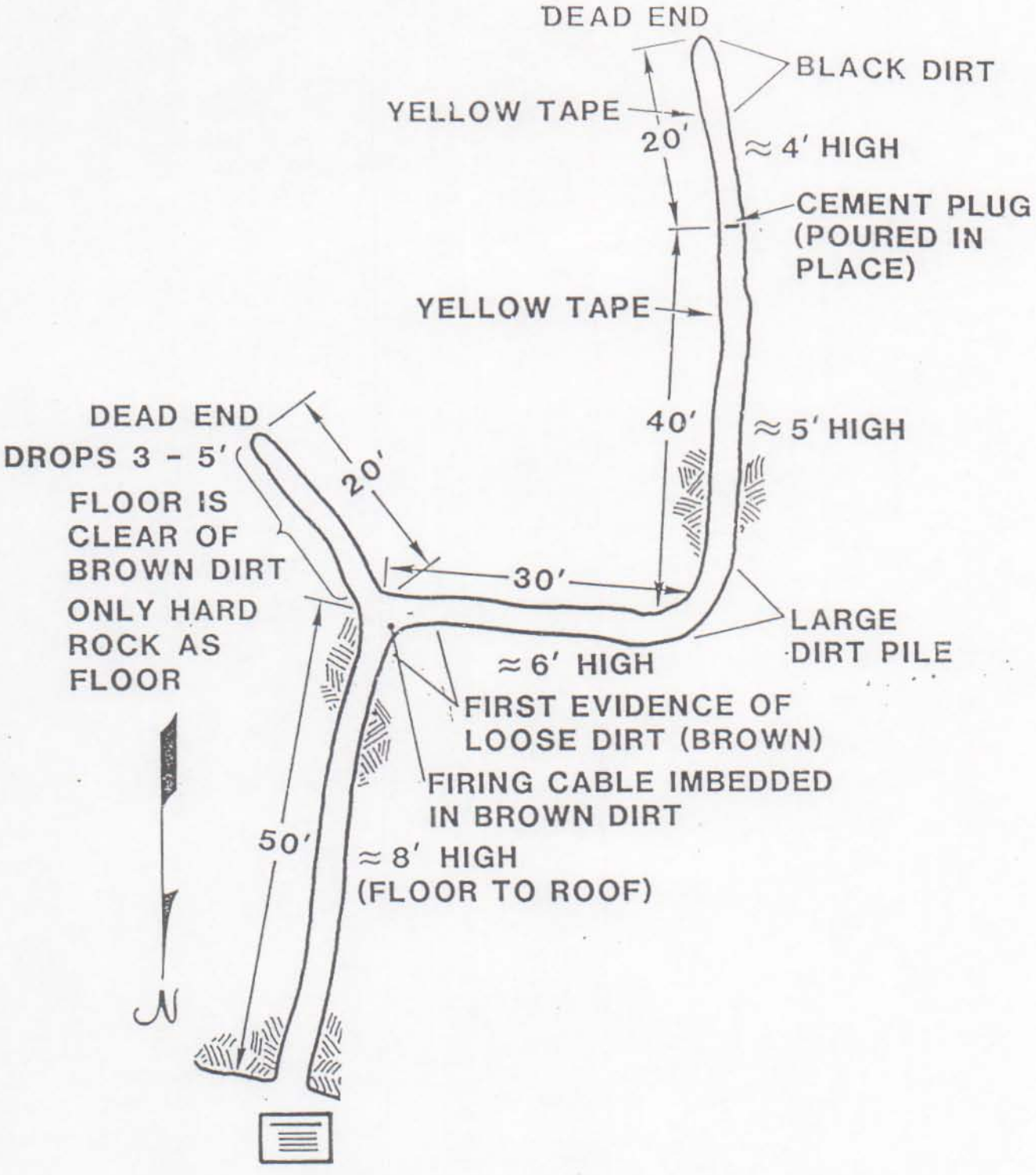


Figure 3d.
Site 28-2, Sketch Map of the Lower Adit

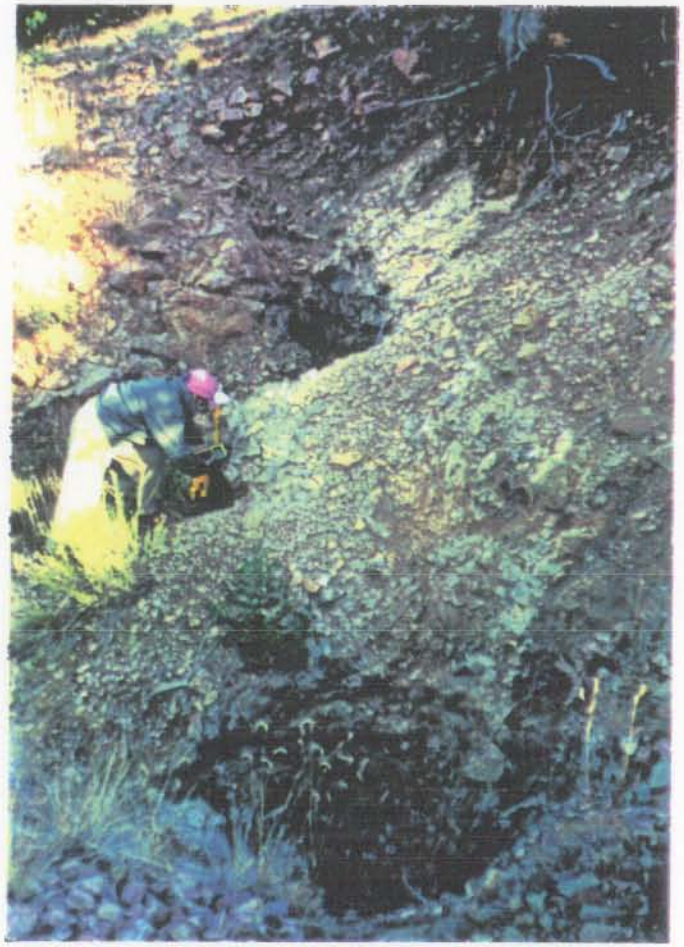


Figure 4a Site 28-3. Horizontal adit located above and vertical shaft located below ER GPS surveyor.

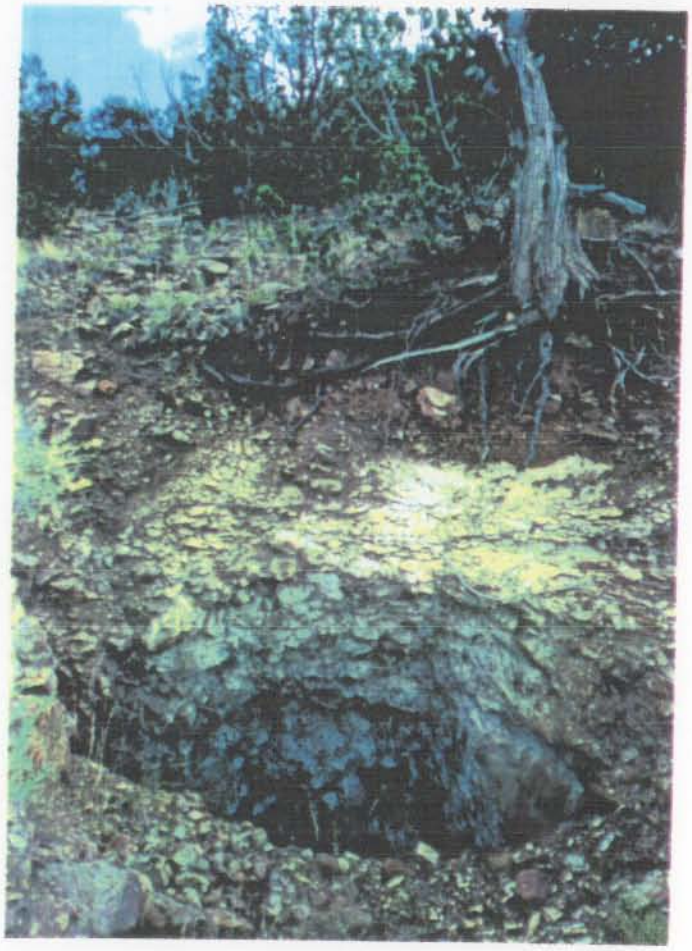


Figure 4b Site 28-3. Horizontal adit.

Figure 4a and b.
Site 28-3

Figure 4c.
Site 28-3, Vertical Adit With View Looking Down

Figure 5a Site 28-4. Blackbird Mine. View to the north of the main shaft and associated timbers.

Figure 5b Site 28-4. Closeup of the top of the main shaft.

Figure 5a and b.
Site 28-4

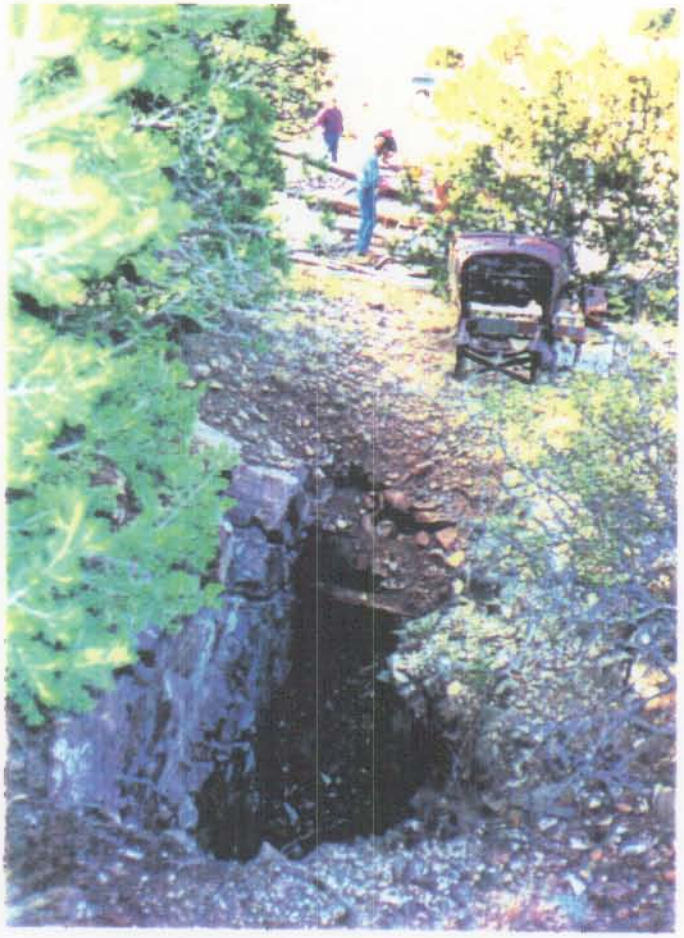


Figure 5c.
Site 28-4, One of Two Shallow Trenches Located
Just Southeast of the Main Shaft

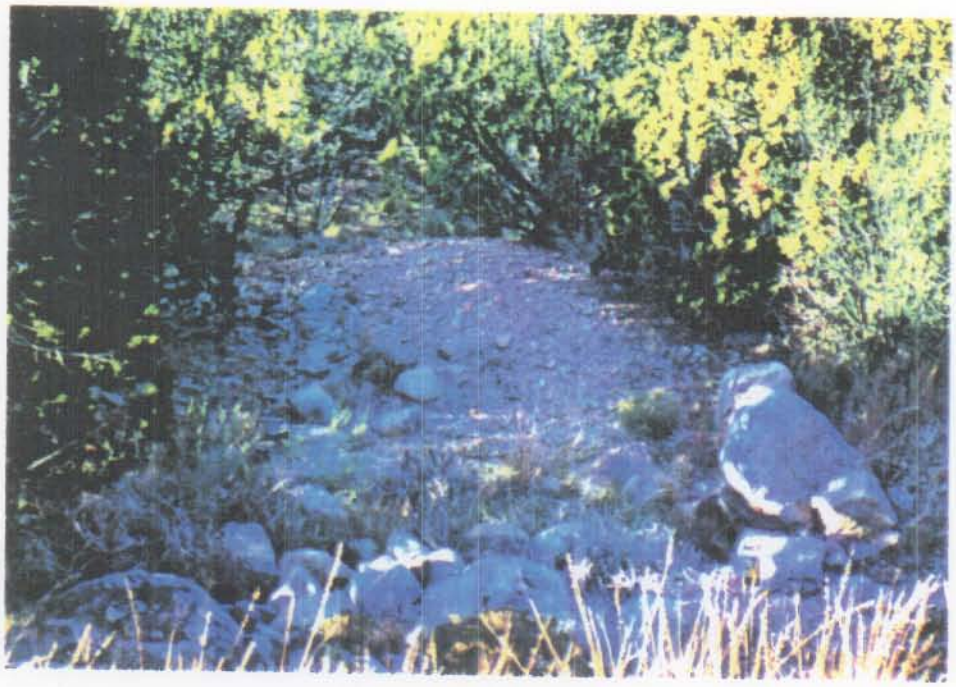


Figure 6.
Site 28-5, Small, Nondescript Tailings Pile

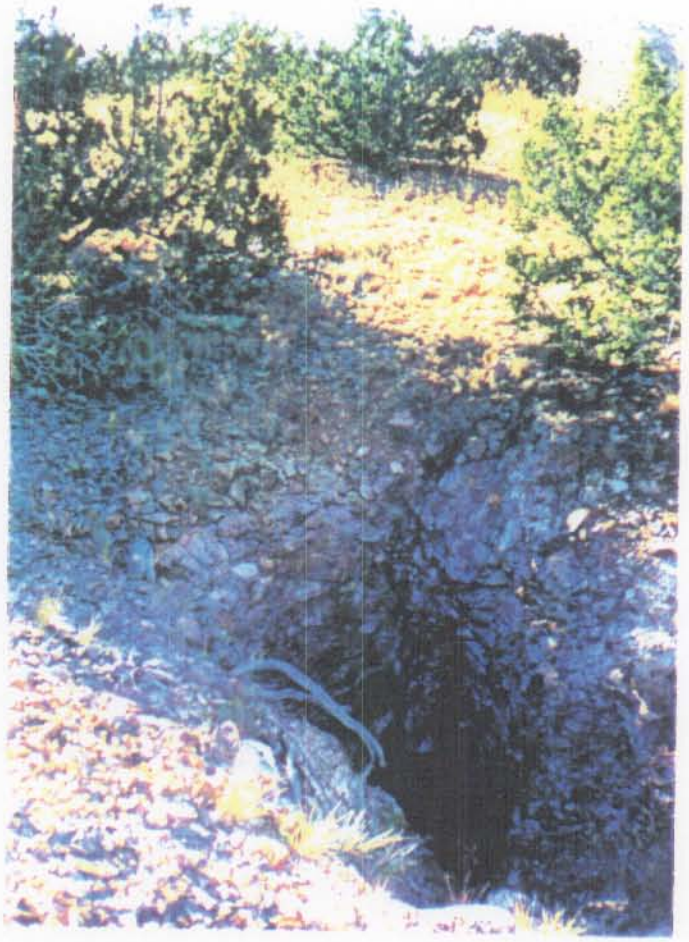


Figure 7.
Site 28-6, Vertical Shaft

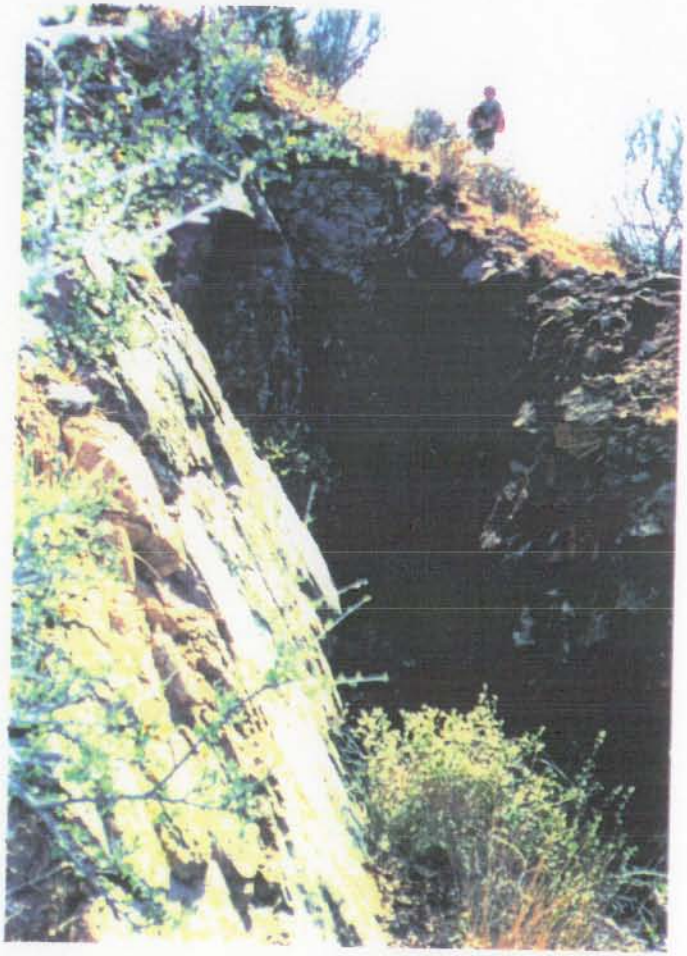


Figure 8a Site 28-7. View looking south of horizontal adit.

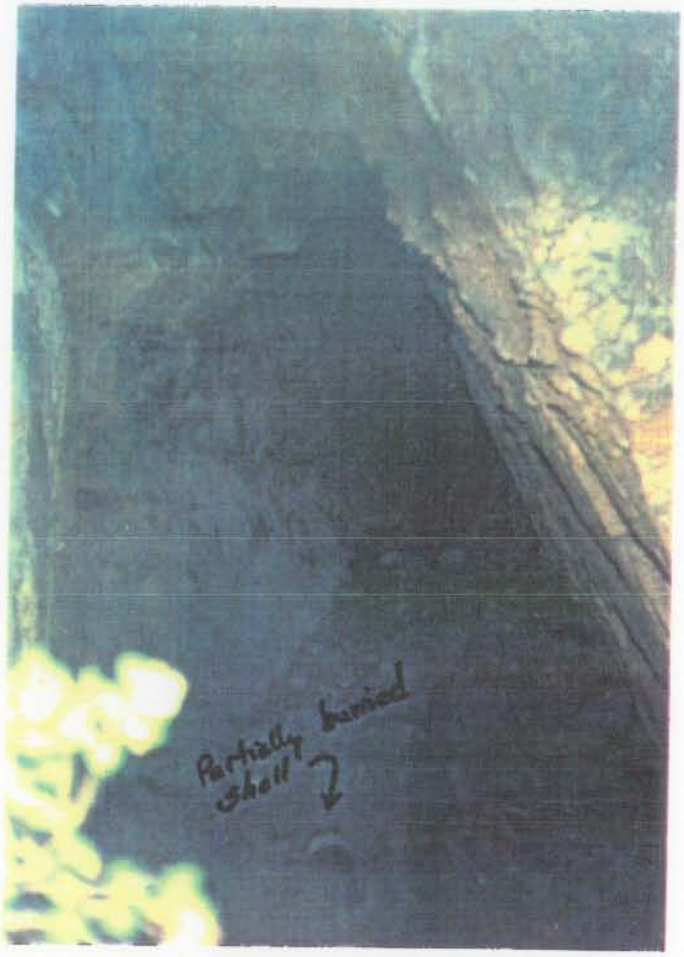


Figure 8b Site 28-7. Closeup of the inside of the adit.

Figure 8a and b.
Site 28-7

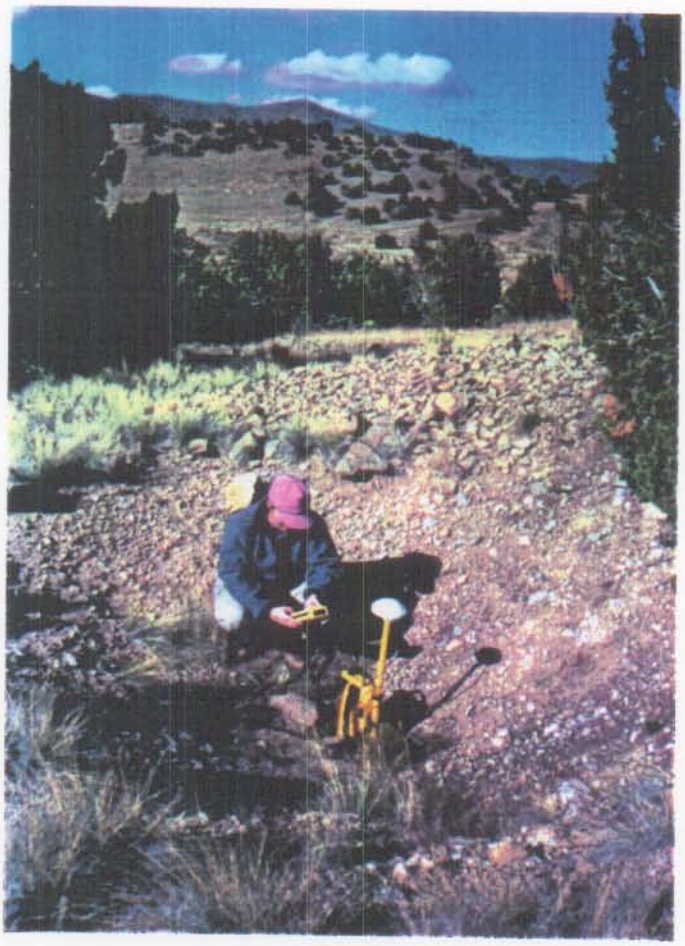


Figure 9 Site 28-8. View looking to the north. GPS technician surveying in location.

Figure 9.
Site 28-8, view is looking to the north.
GPS technician is surveying in location.

Figure 10a Site 28-9. Horizontal adit. View to the east.
GPS instrument antenae in foreground.

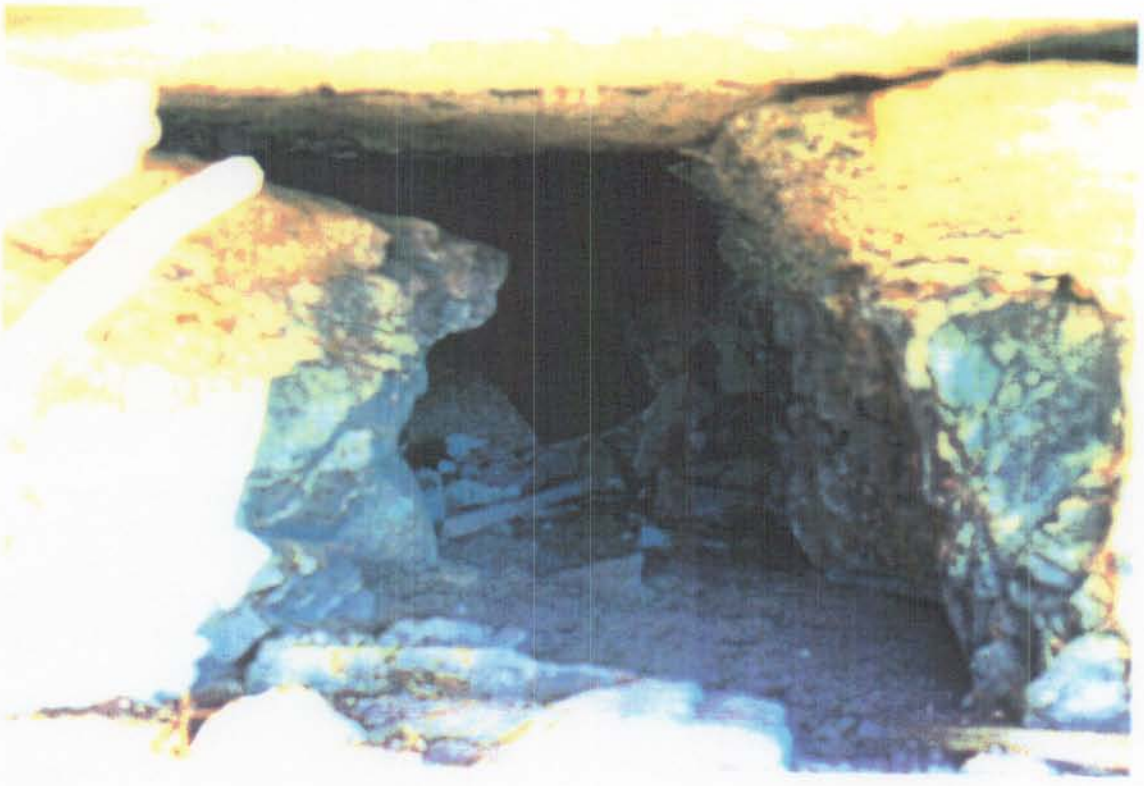


Figure 10b Site 28-9. Closeup of inside of adit.
Approximately 5 ft. from
ceiling to floor.

Figure 10a and b.
Site 28-9

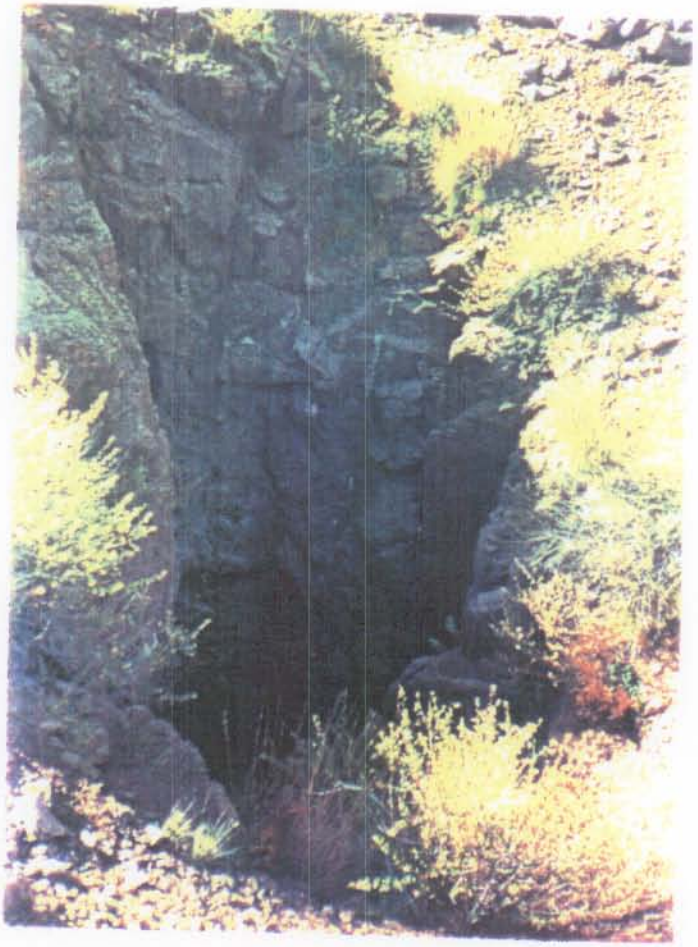


Figure 11.
Site 28-10, Vertical Shaft

2.4.1 ER Site 28-1 (MS-A)

This site is located in the southern portion of the Withdrawn Lands (Figures 1 and 1a) in the vicinity of the Frustration Mine (ER Site 67). The Frustration Mine is a horizontal adit approximately 50 feet deep used by SNL/NM to house an experimental seismic station during the 1960s and 1970s (see Figure 2b). The station was used to record seismic disturbances from various testing programs. ER Site 28-1 is defined as the mining features in the immediate vicinity, not including ER Site 67 (Frustration Mine). All of the excavations described below are on the south-facing slope of a narrow ridge which protrudes from the main escarpment of the Manzanita Mountains (Figures 1a and 2b). Just over the ridge to the northeast is a large vertical mineshaft that is part of the KAFB IRP (Site ST-67-3, see Figure 1a).

Figure 2a displays the 28-1 entrance, which is a large, narrow trench feature (~3 to 5 feet wide at the surface, 60 feet in length, and up to ~75 feet deep) cut into the south-sloping hillside. Figure 2b shows the location of this trench relative to the Frustration Mine (ER Site 67). Site 28-1 is approximately 75 vertical feet above the Frustration Mine. The depth of the trench is greatest in the center, and decreases to the south due to the downward slope of the surface relative to the trench (Figures 2a and 2b). The trench is continuous beneath the "roof" over the field technician's head in Figure 2a, and contains some original timbers used to support the opening (shoring). Moving down into the trench from the surface, the width increases to approximately 10 feet in some places. Significant collapse has occurred in the trench as indicated by rubble (rock) within the mine. The sidewalls appear very unstable, characterized by loose, fractured blocks.

At approximately the center point along the length of the trench there is a more vertical shaft that angles downward to the southeast at ~45 degrees from the floor of the trench. Although difficult to see from the surface, the shaft has been thoroughly inspected and described as extending approximately 25 feet downward from the trench floor (Ref. 18). It does not connect to the topographically lower Frustration Mine (Ref. 18). There is a section of radio tower located just behind the technician shown in Figure 2a that appears to have been used as a ladder to gain access to the bottom of the shaft. From the surface, the entire trench and upper part of the 45 degree shaft can be completely inspected.

There are two small prospect pits located 150 feet and 250 feet east of the main workings and a shallow shaft near the crest of the hill, 200 feet east of the trench adit described above. None of these other smaller mining features described above show any evidence of postmining activity.

With the exception of the near-vertical shaft extending downward from the central floor of the trench, the entire 28-1 mine can be easily inspected from the surface. The lower shaft was thoroughly inspected by KAFB personnel during several August 1993 mapping inspections (Ref. 18), and by SNL/NM personnel during 1982-83 (Ref. 12 and 13) and again in June 1989 (Ref. 23). Except for the section of radio tower, there is no evidence of postmining activity in the 28-1 mine.

2.4.2 ER Site 28-2 (MS-B)

ER Site 28-2 is located in the same general vicinity as 28-1, approximately 3000 feet to the southeast (Figures 1 and 1a). There are two adits at this site, a lower and an upper (Figures 3a and 3b). The lower adit is described in detail in other reports (Ref. 12, 13, 18, and 23) and was previously posted with a radiation warning sign. In addition, it is easily accessed by a high-clearance vehicle via an unmaintained gravel road (Figure 1a). In addition to the lower adit, there is an upper adit, the portal of which is located approximately 60 vertical feet above the lower adit.

Both mines were entered for a complete visual inspection. Both KAFB and SNL/NM personnel have entered and inspected both the lower and upper adits comprising ER Site 28-2 (see Section 3.3 for a detailed account of these inspections). Based on site background interviews conducted by SNL/NM ER personnel, SNL/NM staff used to detonate waste explosives in the lower mine adit at 28-2 (Figure 3a, Ref. 24, 25, 26, and 27). This has been confirmed based on the presence of the "concrete wall and detonation cord" inside the mine described below, as well as a follow-up visit to the site with a former SNL/NM staff member who participated in these activities (Ref. 24 and 25). The explosives were loaded into the drift (back of the mine) and detonated so that rock debris would not be thrown out the front of the mine (Ref. 24). There have been no reports of disposal or explosive activity in the upper adit. There has been some collapse in the drift and part of the main adit, probably as a result of these detonations. The main entrance is nearly closed off with rock and soil debris, and is currently unsafe to enter (Figure 3a).

The lower adit extends to the south-southwest to a point 50 feet from the opening before turning to the southeast for 20 feet. See Figure 3d for a detailed sketch map of the lower adit. At the turn in the adit, a drift (side tunnel or horizontal shaft) extends to the west for 30 feet and then turns to the south for a distance of 60 feet. There is a large concrete plug located 20 feet from the face of the drift. This plug nearly blocks the drift and appears to have been moved after it was placed. See Figure 3d for a detailed sketch map of the lower adit.

There are piles of brown soil located at the entrance to the first drift, at the turn in the drift, and in front of the concrete plug. The soil behind the plug at the very back of the drift is black. It appears the soil was brought into the mine in burlap or canvas bags that have since rotted away. The yellow tape used to seal the bags is all that remains. It is possible, however, that the bags were cut and the soil was dumped onto the piles.

Visual evidence suggests that some type of explosive ordnance test(s) was conducted in this mine. The concrete plug probably acted as a Klotz device to attenuate the gas pressure and shock waves from detonations, as did the piles of soil. Two-conductor black detonation cable is visible protruding from the first soil pile. The radiation hazard sign previously posted at the portal has been removed.

This upper adit extends to the south for 15 feet and then turns to the southeast for 15 feet. A short (< 2 feet) drift extends to the south 4 feet from the adit face. Another short drift extends to the southwest from just beyond the portal. There is a 1.5-inch-diameter pipe

protruding from the portal that was apparently used for draining water. Mud and green vegetation in the adit indicate that it is often saturated (Figure 3c). What remains of an abandoned road continues up the south side of the canyon to the east for a distance of approximately 1,800 feet, where it crosses to the north side, continuing up-slope for 400 feet. The road dead-ends at a leveled pad of unknown origin or use. Although a section of two-conductor black detonation wire was observed on the slope below this adit, there is no indication of any postmining activity.

2.4.3 ER Site 28-3 (MS-C)

This mine site is located in the north-central portion of the Withdrawn Lands (Figure 1 and 1a), in the same canyon as ER Site 81 (New Aerial Cable Site, which is represented in Figure 1a by the green polygons approximately 2,000 feet south of 28-3).

28-3 includes two distinct excavations (Figure 4a): one is basically horizontal and extends approximately 30 feet into the hill slope (Figure 4b), and the other is vertical and is approximately 30 feet deep (Figure 4c) (Ref. 20). Both features are small, with openings that are less than 10 feet in diameter. Below the surface the respective adits become thinner with depth and can be visually inspected from the surface. The vertical shaft has some remnant timbers toward the bottom of the hole, which shows signs of collapse. The horizontal adit angles downward for approximately 6 feet, then levels out and tapers in diameter until it comes to an end.

Special attention was paid to these adits because of the statement in the CEARP Report (Ref. 7) that indicated solid waste may have been put in mineshafts in the vicinity of the New Aerial Cable Site. These adits are the closest mines to the New Aerial Cable Site. Both adits can be easily inspected from the surface and show no evidence of postmining activity, including disposal of solid waste.

2.4.4 ER Site 28-4 (MS-D)

Site 28-4 is located in the north-central portion of the Withdrawn Lands (Figure 1 and 1a), approximately 200 feet north of 28-3. The mine is in Lurance Canyon just south of Coyote Springs Road (Figure 1a), and just west of ER Site 94 (Lurance Canyon Burn Site). The main part of this mine site is a shaft covered with broken wooden framing, which is the historic Blackbird Mine (Figures 5a and 5b). In addition to the shaft, there are two trenches at this site.

The main shaft is at least 49 feet deep, based on New Mexico Bureau of Mines and Mineral Resources report (Bulletin 21) dated 1946. It is not possible to determine the exact depth due to caving near the collar (now less than 10 feet deep and filled with broken rock). This report also describes a drift at a depth of 42 feet extending from the shaft toward the southeast for 87 feet with stopes to the surface. There is abundant timbering at the collar, indicating that there was once a headframe over the shaft. An old truck frame mounted near

the collar is all that remains of a makeshift hoisting winch (Figure 5c). There are also concrete pads and scrap lumber piles near the shaft.

The two trenches are located immediately southeast of the shaft (Figure 5c). The closest trench is up to 6 feet deep and was formed by the collapse of the stopes described in the 1946 report. The other trench is approximately 3 feet deep and 25 feet long. It was excavated to explore the mineralized zone at the surface. The trenches are minor features that show no evidence of postmining activity.

The main shaft and trenches can be easily inspected from the surface, with the exception of the collapsed area in the main shaft. There is no visible evidence in both the mine features and the general area of any postmining activity.

2.4.5 ER Site 28-5 (MS-E)

This location is in the same vicinity as 28-4 and 28-3 (north-central part of the Withdrawn Lands), approximately 400 feet southeast of 28-4 (Figures 1 and 1a). Site 28-5 is comprised of a very small pile of what appears to be tailings from a prospecting pit (Figure 6). The area was searched thoroughly for a shaft or adit feature, but nothing was found (Ref. 20). The SNL/NM Health Physicist who surveyed the locations for radioactivity verified that this was the same location he surveyed back in the early 1980s (Ref. 19). Besides the pile of tailings, there is no other evidence in the area of either mining or postmining activities.

2.4.6 ER Site 28-6 (MS-F)

This site is located in the north-central part of the Withdrawn Lands on the north side of Lurance Canyon, approximately 2,000 feet northwest of Site 28-4 on a small ridge (Figures 1 and 1a). The site is bounded to north by ER Site 236 and to the west by ER Sites 63A, 63B, and 236 (Figure 1a). Site 28-6 is comprised of a single vertical shaft that is approximately 15 feet deep and 5 feet in diameter (Figure 7). A small collar of tailings material surrounds the shaft.

This shaft can be easily inspected from the surface and there is no evidence of postmining activity.

2.4.7 ER Site 28-7 (MS-G)

Site 28-7 is located in the southwestern portion of the Withdrawn Lands, approximately 2,000 feet due west of 28-2 and 2,000 feet south of 28-1 (Figures 1 and 1a). This is an area of KAFB land where extensive military testing has been conducted. As a result of this testing, numerous "dummy" and expended 3- to 5-inch shells are scattered throughout the area. The shells are not related to activities directly associated with the mines (the mines just happen to be in the area where these shells were fired) and are considered a USAF responsibility (Ref. 7).

This mine site consists of an adit that extends approximately 30 feet into the hill slope towards the south (Figure 8a and 8b). The adit is approximately 6 feet high at the entrance and 3 feet wide, and is relatively uniform in dimension. There is evidence of minor caving at the entrance.

A fragment of a shell is visible at the entrance of the adit (Figure 8b). It is similar to the shells that are found throughout the area, and appears to have simply landed in the entrance area. The interior of the mine has been carefully inspected and no shells can be seen within the mine. It is possible that the caving at the entrance to the mine resulted in part from the impact of the shell. Another explanation is erosion, because the hill slopes in this area. The entire adit can be viewed from the entrance and there is no evidence of postmining activities or disposal in the adit.

2.4.8 ER Site 28-8 (MS-H)

This site is located in the north-central part of the Withdrawn Lands on the north side of Lurance Canyon, approximately 2,000 feet northwest of Site 28-4 on the same small hill/ridge as Site 28-6 (Figures 1 and 1a). This site is in the immediate vicinity of 28-6 and is a very small depression/excavation (Figure 9). It is probably a prospecting pit that was abandoned prior to significant excavation. This feature is insignificant and shows no evidence of postmining activity.

2.4.9 ER Site 28-9 (MS-I)

Site 28-9 is located in the southwestern portion of the Withdrawn Lands, approximately 2,000 feet southeast of 28-2 and 4,000 feet east-southeast of 28-7 (Figures 1 and 1a). This mine is comprised of a single adit located up the steep west-facing slope of the Manzanita Mountains at an elevation of approximately 7,340 feet (Figure 1a, 10a and 10b). This location is significantly more remote than the others, with no road in the near vicinity (the closest road is the unmaintained gravel road that leads to Site 28-2).

The adit extends into the mountain horizontally approximately 650 feet to the east, making this the most extensive underground mine in the area. Drifts, each 10 feet long, extend from the adit in opposite directions (north and south) along a fault. Most of the adit contains a plated, wooden skid-type track. There are two small prospect pits located on either side of the canyon leading to this adit, but no other mine features have been noted in the near vicinity.

Both KAFB and SNL/NM personnel have entered and inspected the mine (see Section 3.3 for a detailed account of these inspections). Based on these inspections, there is no evidence of postmining activity or disposal. This canyon and adjacent slopes contain scattered 5-inch and 3-inch shells, however no shells have been observed in the immediate vicinity of the mine entrance or within the mine.

2.4.10 ER Site 28-10 (MS-J)

Site 28-10 is located in the southwestern portion of the Withdrawn Lands, approximately 2,000 feet west of 28-1 (Figures 1 and 1a). This area is located on the north side of a small hill that houses a building and support structures used during laser tests at the Sandia Optical Range.

Site 28-10 is a vertical shaft on the north slope near the summit of the hill, and is approximately 50 feet deep (Figure 11). There is a concrete slab (approximately 4 feet by 6 feet) just north of the main shaft, which may have been used to anchor a hoist or some other type of mining equipment. The opening is surrounded by a rim of tailings, and the shaft itself may have caved in to some degree, although it is difficult to say how much.

The main shaft can be visually inspected from the surface. In the shaft itself there is no evidence of any postmining activity. There are numerous 4.2-inch-mortar-round shipping canisters on the ground in an area just south of this shaft on top of the hill. The canisters are related to military training conducted in the area and are considered a USAF responsibility (Ref. 7). A small amount of unidentified slag material was observed at the collar of the main shaft, but it is not abundant and appears to be related to mining activities (possibly some crude smelting was done).

Three other adits were excavated to explore a fluorite mineralized zone near the base of the northwest quadrant of this hill. All three adits are caved, but appear to have been less than 15 feet in length. There is a caved shaft and caved adit located on the east side of the hill. None of these other workings in the area are significant, nor show any signs of post mining activities.

2.4.11 Summary

Of the ten ER Site 28 mines, only three (28-1, 28-2 [both adits], and 28-9) would require physical entry into the mine to be fully inspected. The only vertical shaft that has significantly collapsed, obscuring deeper portions of the mine, is 28-4 (Blackbird Mine). Vertical shafts at 28-1 (in the bottom of the trench), 28-3, 28-4, 28-6, and 28-10 may have experienced some minor collapse, but probably not major collapse on the same scale as Site 28-4 (was ~50 feet deep, now only ~10 feet). This is partly based on the appearance of the shaft, as well as the size of the surrounding tailings piles relative to the shaft's depth. In any case, there is still uncertainty about the actual location of shafts and adits at these mines, which may yet be subject to collapse. The vicinity is still very hazardous.

As discussed in Section 2.2, these mines are not ER sites because of the past mining activities, but rather speculation that SNL/NM or KAFB later used these remnant features to dispose of various wastes. Some of this speculation may have resulted from the "Radiation Warning Sign" posted at Site 28-2. This sign was later removed after the mine was thoroughly surveyed and sampled for radiation, and found to have only background levels/concentrations (this mine was actually surveyed for radiation twice). None of the

speculation documented in the CEARP Report (Ref. 7) was based on visits to the mines or physical/visual evidence.

The individual site descriptions presented in this section are summarized from several significant investigative efforts conducted by both KAFB and SNL/NM personnel. These sources of information are further detailed in Sections 3.3 and 3.4.

It is also important to understand that many of the mines associated with ER Site 28 represent significant safety hazards. In particular, unprotected vertical shafts and horizontal adits are dangerous places where people, either due to curiosity or lack of awareness, can fall into and/or become trapped due to caving/collapse of wall and roof material. Several of the mine sites contain vertical shafts that are deep enough to cause a fatal fall. Further characterization efforts that require entry into the mines could be very dangerous, and would require significant support structures to be constructed, and elaborate health and safety precautions.

3. Evaluation of Relevant Evidence

3.1 Unit Characteristics

The characteristics of the mine sites are highly variable, as discussed in the previous section and shown in Figures 2 - 11. These mine features were not designed to hold waste, and are not appropriate for this purpose.

3.2 Operating Practices

Hazardous wastes were not managed or contained at ER Site 28.

3.3 Presence or Absence of Visual Evidence

There have been five major, well-documented field inspection/investigation efforts that have supplied most of the information contained in this NFA proposal: one conducted by KAFB and four conducted by various SNL/NM groups. All of the investigative efforts shared the same primary objective: to determine if the mines had been used for any activities that resulted in an environmental problem/concern. Secondary objectives included mapping the mines, surveying their locations, and documenting each location with photographs.

This section details the following information for each investigative effort: (1) who performed the investigation, a description of the investigation, and the specific objectives, including whether or not physical entry was made into the mines at Sites 28-1, 28-2 (both adits), and 28-9 (the only mine sites that require physical entry to fully inspect); (2) the number of site visits and the time-frame of those visits; and (3) the references that document these inspections/investigations. These investigations are summarized below in chronological order. After a summary of these efforts, conclusions specific to each location are presented.

3.3.1 SNL/NM Radiation Survey of the Mines

Description: In the early 1980s, citing the reports listed below, SNL/NM identified six mine locations and named them "MS-A through MS-F" (equivalent to 28-1 through 28-6).

- Defense Nuclear Agency (DNA), 1971, "Radioactive Waste Survey," performed by DNA, Headquarters Field Command, Kirtland Air Force Base, August 16, 1971.

- Engineering Science, 1981, "Installation Restoration Program, Phase I: Kirtland Air Force Base," prepared for USAF, AFESC/DEV Tyndall AFB, Florida.

There was concern at this time, based on interviews with SNL/NM staff and the reports cited above, that these mines (and some of the test areas/dirt mounds also investigated) may have unacceptable levels of radioactivity from past disposal and/or testing. SNL/NM Reactor Applications and Health Physics Divisions conducted this radiation survey designed to address these areas of potential radioactive contamination, including the mineshaft sites MS-A through MS-F (28-1 through 28-6). During this survey, four other mine sites were identified and named MS-G through MS-J (equivalent to 28-7 through 28-10). All of the sites were surveyed using SNL/NM's mobile radiation measurement laboratory, consisting of a computerized multichannel analyzer, a portable intrinsic germanium gamma spectrometer, and various other portable instruments. The results of the radiation survey are covered in Section 3.4. The radiation survey work involved detailed visual inspection of each ER Site 28 location (the same mine sites addressed in this survey [MS-A through MS-J] later became ER Site 28-1 through 28-10). Physical entry was made into 28-1, 28-2 (both adits), and 28-9. All other locations were either entered or inspected and surveyed from the surface.

Objective: The radiation survey had two main objectives: (1) identify and visually inspect the suspect mine locations, and (2) survey each location (including soil samples) for radiation to determine whether an environmental problem exists.

Timeframe: Field work was conducted in 1982-1983 and involved multiple visits to several of the locations, including 28-1 and 28-2.

References: Final Report (Ref. 12). Field log book (Ref. 13).

3.3.2 SNL/NM ER Investigation of Mines in the Frustration Site Area

Description: SNL/NM ER Project personnel conducted an investigation of ER Site 67 (Frustration Mine), 28-1, and 28-2 (both adits) in response to KAFB's request to move their M-60 Gun Range into that general area. These mines were entered and physically inspected, as well as sampled (for radiation measurements). Detailed descriptions of the mines were documented and a map of 28-2 (lower adit), was made (Figure 3d).

Objective: Determine if any significant contamination hazards are present in the mines, with the primary emphasis on radiation.

Timeframe: Field work was conducted on June 20, 1989.

References: Investigation Report (Ref. 23). Analytical results are also included (Ref. 23).

3.3.3 KAFB 377th ABW EMR Inspection and Detailed Mapping Survey

Description: KAFB 377th Air Base Wing Environmental Management and Restoration (377th ABW EMR) personnel conducted detailed mapping and inspection surveys of ER Site 67, 28-1, 28-2 (both adits), 28-4, 28-7, 28-9, and 28-10. This was part of the overall effort aimed at defining ownership of the mines (between KAFB and SNL/NM), as well as providing sound documentation of the condition and status of the mines. Sites 28-1, 28-2 (both adits), 28-7, and 28-9 were entered and thoroughly inspected. Inspections focused on looking for evidence of postmining activity.

Objective: Clearly document individual mine sites and their features, their condition, their location (mapping) on detailed topographic maps, and any evidence of postmining activity. Use this information to sort out ownership (between SNL/NM and KAFB) of the mines.

Timeframe: Field work conducted on August 2, 4, 6, 10, and 13, 1993.

Reference: Memorandum documenting results of field work (Ref. 18) (maps included).

3.3.4 SNL/NM ER Field Trip With Radiation Survey Lead Investigator

Description: ER field trip with the lead investigator of the 1982-1983 SNL/NM Radiation Survey conducted in 1982-1983. Purpose was to revisit and confirm locations that were surveyed in 1982-1983. Physically confirmed all locations except 28-9. Based on its unique location and features, 28-9 did not need to be revisited.

Objective: Make sure that the ER Site 28 locations are correct and complete, i.e., correspond to all of the locations previously surveyed. Site 28 was defined based on the locations originally identified and surveyed as part of the 1982-1983 investigation.

Timeframe: Field trip conducted on August 26, 1993.

Reference: Memo documenting trip (Ref. 19).

3.3.5 SNL/NM ER Field Inspection and Surveying/Photographing of Each Location

Description: Various field inspection trips conducted by SNL/NM personnel that included visits to all mine locations. Physical entry was made into 28-1, but not 28-2 (both adits) and 28-9 due to safety concerns related to the rather unstable condition of these old mines. All locations were visited at least twice, and thoroughly inspected from the surface. KAFB personnel most familiar with the mine sites were present for one of the field trips.

Objective: Photograph and survey with a Global Positioning System (GPS) instrument all locations (the GPS instrument is shown in Figures 3a, 4a, 9, and 10a). Document the current condition of the mines and look for any evidence of any type of postmining activity.

Timeframe: Four main inspection visits conducted November 4, 1994; February 3 and 11, 1995; and March 22, 1995.

References: Inspections documented in field log book. Pages of the log book have been copied for the site file and are included (Ref. 13, 20, and 22).

3.3.6 Summary of Findings From the Field Investigations

The mine sites comprising ER Site 28 are highly variable with regard to their physical characteristics. Because this is an important factor in visually inspecting the mines and evaluating whether or not individual sites may have been used in the past for waste disposal, the mine sites are broken into two groups below based on their physical characteristics.

- Group 1: Small- to moderate-size mine features (shaft, adit, pit/excavation) that can be completely visually inspected from the surface at the mine opening (internal portion of the mine can be completely viewed): 28-3, 28-4, 28-5, 28-6, 28-7, 28-8, and 28-10.

- Group 2: Larger mines that must be entered to be completely inspected: 28-1, 28-2 and 28-9.

Group 1

All of the Group 1 sites can be completely inspected from the surface, and have been visually inspected at least twice. Sites 28-3, 28-4, 28-5, 28-6, and 28-8 show no signs of any postmining activity, including disposal of any type of waste. According to the CEARP Report, solid waste was placed in a mine(s) near the New Aerial Cable Site (ER Site 81). The only mine site in the immediate vicinity is 28-3, and both adits at this location are free of solid waste. Sites 28-4, 28-5, 28-6, and 28-8 are in the general vicinity of the New Aerial Cable Site, and are also free of any signs of waste disposal.

Group 1, Site 28-7 is free of any signs of purposeful waste disposal; however, a 5-inch expended shell is visible at the entrance of the Site 28-7 adit (Figure 8b). It is similar to the shells that are found throughout the area that were part of military testing conducted in the 1940s (Ref. 6), and appears to have simply landed in the entrance area. The interior of the mine has been carefully inspected and no shells can be seen within the mine, nor is there any indication that shells have been buried within the adit. The shallow depth of material on the floor implies that nothing is buried there. Therefore, SNL/NM will request the shell at the entrance be removed by KAFB Explosive Ordnance Disposal personnel.

During inspections of the Site 28-10 vertical shaft, a small amount of "slag material" has been noted in the tailings pile surrounding the top of the shaft. This material is very porous (lots of small air holes) and looks like material from a furnace (clinker or furnace slag). During recent archaeology surveys at similar mine sites, fire hearths (pits) were identified that may have been used for smelting. Based on the small volume of this material (less than 55 gallons) and the lack of any other indications of nonmining debris such as detonation cord, tape, hazard flagging, old signs, etc., that are commonly associated with explosive testing or burn testing, this "slag material" is interpreted to be related to the original mining activities.

In summary, all Group 1 mine sites do not show any evidence of postmining use for waste disposal or other activities that would result in a significant release of hazardous or radioactive materials to the environment. The only direct evidence of postmining activity associated with a site, the shell in the entrance of Site 28-7, is due to the mine being located in the target zone for military testing.

Group 2

Group 2 sites are more significant, and more difficult to inspect visually because of their size and the safety hazards associated with entering these old mine features. Sites 28-1 and 28-9 were entered and do not have any visual evidence of postmining activity. Of the three Group 2 sites, only Site 28-2 shows any evidence of postmining activity. Site 28-1 does have a small portion of an old radio tower in it, which appears to have been used as a ladder to access the lower shaft inside the mine. Other than this ladder, there is no debris, no unusual staining (including burn or explosive markings), or any other physical indication of postmining activity. Site 28-9 is the most remote mine location (requires a significant hike up a steep canyon to access, over 2,000 feet from the nearest road and an elevation gain of over 800 feet, (Figure 1a) and shows no evidence of any activity since the mine was abandoned. Site 28-2 is the only notable exception with regard to visible evidence of postmining activities. One of the main reasons that ER Site 28 was identified during the CEARP appears to be related to activities conducted by SNL/NM personnel at 28-2. Visual inspections by SNL/NM Health Physics personnel (1982-1983) and KAFB personnel (August 1993) reported that a radiation warning sign, yellow tape associated with SNL/NM testing activities, and burlap bags of black soil were all present inside the lower adit location of 28-2 (Ref. 13 and 20). The upper adit was inspected in the meanwhile, and showed no signs of postmining activity. Follow-up interviews and a field visit to the 28-2 site with SNL/NM personnel familiar with activities related to this mine revealed that explosives

(hexahydro-1,3,5-trinitro-1,3,5,-triazine [RDX]; Composition 4 [C-4]; and detcord) were periodically open-detonated in a side shaft of 28-2, which contained a concrete wall just inside the main adit (Ref. 24, 25, and 27, Figure 3d). The detonations in the side shaft reportedly resulted in total collapse of the side shaft, but the main adit is currently largely open and the concrete wall is still visible (last detailed inspection was in August 1993). However, the entrance to the main adit is largely collapsed (Figure 3a) and the mine is not in a safe condition for entry.

Interviews conducted as part of the CEARP indicated a horizontal mine in the Frustration Site area was used to burn aluminum-cased rocket motors (Ref. 28). ER personnel conducted follow-up interviews to try to determine which mine was used for this burning activity (Ref. 24). The results of this follow-up interview indicated the burning occurred either in the Frustration Mine (ER Site 67) or in the horizontal trench adit (28-1). Site 28-1 has been thoroughly inspected (Ref. 12, 18, 20, 21, and 22) and there is no visual evidence of either the remaining aluminum casings of the rockets, nor of any areas where burning may have taken place (black burn marks or burn residues). A recent inspection of ER Site 67 (Frustration Mine) revealed no evidence that the burning activities took place in this mine.

3.4 Results of Previous Sampling/Surveys

3.4.1 Basewide Radiation Survey

In the 1982-1983 timeframe, SNL/NM Reactor Applications Division and Health Physics Division conducted a base-wide radiation survey designed to address six mine locations (MS-A through MS-F) identified as part of the DNA inspection, (Ref. 8) U.S. Air Force phase I records search report (Ref. 9). During this survey, four other mine sites were identified (named MS-G through MS-J) and included in the study (Ref. 12). These mines sites are equivalent to 28-1 through 28-10, which represent all of the ER Site 28 locations (the visual evidence obtained by this field investigation of the mine sites is also summarized in Section 3.3).

All of the sites were surveyed using SNL/NM's mobile radiation measurement laboratory, consisting of a computerized multichannel analyzer, a portable intrinsic germanium gamma spectrometer, and various other portable instruments. Both in situ readings were taken, as well as soil samples. The purpose of this study was to first determine whether radiation levels above background were present, and if so, then to determine what radionuclides were responsible for the elevated readings. Important references for this survey include Ref. 12 (Radiation Survey of KAFB/DOE Controlled Areas, Kirtland Air Force Base, Albuquerque, NM), and Ref. 13 (the field log book notes for this survey written by the Lead Investigator from SNL/NM Reactor Applications Division).

The results of the survey, as recorded in the final report (Ref. 12), conclude that the mine sites 28-1 through 28-10 show no signs of having been used for radioactive waste disposal or testing with radioactive materials. The radiation spectra from in situ instrument readings and soil sample analytical results showed nothing more than slight variations in background levels due to the types of rocks found at each location. Visual inspections performed during the

project revealed nothing that conflicts with this conclusion, with one notable exception. Site 28-2 was posted with a radiation warning sign, which the study concluded was unwarranted based on several readings and soil samples collected in this mine. It is unknown who placed the sign; investigators speculated it was simply used in an effort to keep out trespassers. The sign was subsequently removed in 1989 by SNL/NM personnel. The report also noted that all of these mines are in poor repair and represent conventional safety hazards that should be appropriately fenced and posted to prevent an accident.

3.4.2 SNL ER Project Radiation Survey of 28-2 and ER Site 67

Another field investigation/sampling effort was conducted at ER Site 67 (Frustration Mine) and Site 28-2 (lower adit) on June 20, 1989. The effort was led by SNL/NM ER Project personnel and conducted to determine if any radiation hazards existed in the mines. The investigation was requested prior to KAFB moving an M-60 Gun Range into the vicinity to make sure the area was free of radiation hazards. The primary concern was the 28-2 location (referred to in the investigation report as "the unnamed adit"), which was still posted at this time with the radiation warning sign.

A radiation survey was performed throughout the 28-2 (lower adit) mine with a TMB-3 radiation meter. No readings above background were recorded, and the readings ranged from 0.03 to 0.05 milliroentgens per hour. Two soil samples (black and brown dirt) were collected for gamma spectroscopy analysis at the SNL/NM Division 3313 Radiation Diagnostic Laboratory. Results indicate background conditions (no radionuclides present above background concentrations) and are consistent with the TMB-3 radiation readings in the mine. Analytical results are included (Ref. 23).

The investigation report concluded that no radiation hazards were detected at the Frustration Mine (ER Site 67) and the "unnamed adit" (Site 28-2). The radiation warning sign at Site 28-2 was removed on July 19, 1989, by SNL/NM personnel. It is possible that the radiation sign was used to keep curious visitors from entering the mine, and did not indicate a real radiation hazard.

3.5 Assessment of Gaps in Information

The main information gap for ER Site 28 relates to the lack of chemical data for the mine sites. Up to this point, the mine sites have been visually inspected and surveyed for radiological contaminants. Radiological concerns have been addressed by direct sampling of material from the mines or by taking various radiation measurements. The main reason for this apparent data gap is the fact that visual inspections have not revealed anything out of the ordinary at nine of ten mines to target for sampling with regard to hazardous chemicals or constituents. Therefore, the only mine site with a real hazardous chemical data gap is Site 28-2 (lower adit). The only location where postmining activities appear to have taken place inside a mine is at Site 28-2; therefore it is the only mine for which there is any concern.

Even at 28-2, where waste explosives have been open-detonated, obtaining soil samples to determine any adverse environmental impact is virtually impossible due to the fact that the side shaft where the detonations took place is reported as being collapsed. In addition, the information collected to date simply does not indicate nor suggest the presence of hazardous material (explosive residuals) in sufficient quantities to present a significant release source. Based on a recent study of open detonation of explosives performed by the U.S. Army Armament, Munitions, and Chemical Command (Ref. 29) and risk calculations using the results of this study, the residual explosive material, if any remained after the detonations, will not pose a significant threat to human health and the environment. Attachment 1 is a summary of the U.S. Army study and Attachment 2 includes risk calculations using the results of the study.

Since collecting a soil sample from many of these locations could put the personnel conducting the sampling at significant risk, there should be a clearly defined sampling target and benefit to the sampling event. Based on what has been seen in the mines during five major field investigations, there is not sufficient justification to put sampling personnel at risk.

3.6 Rationale for Pursuing an Administrative NFA Decision

ER Site 28 was defined as an SWMU as a result of second-hand information obtained through interviews with SNL/NM personnel. Follow-up interviews conducted by ER Project personnel and visual inspections of the sites by SNL/NM and KAFB personnel have determined that only two of the ten mines listed as ER Site 28, 28-2 and 28-7, actually show any signs of postmining activity. All mines in the vicinity of the New Aerial Cable Site (ER Site 81) have been inspected and do not contain any type of wastes (CEARP information indicated mines in the vicinity of Site 81 had been used for solid waste disposal, see Section 2.2). All of the locations, including 28-2 and 28-7, have been surveyed for elevated (relative to background) radiation, and all locations showed only background levels (Ref. 12 and 23).

Based on both interviews and site inspections, Site 28-2 was used prior to 1982 for detonating small quantities of waste explosives (Ref. 24 and 25). The main issue regarding this particular site is whether these detonations, which resulted in the collapse of a side shaft in the mine, constitute a concern relative to a potential release to the environment. Based on a recent study of open detonation of explosives performed by the U.S. Army Armament, Munitions, and Chemical Command (Ref. 29) and risk calculations using the results of this study, the residual explosive material, if any remained after the detonations, will not pose a significant threat to human health and the environment (see Attachments 1 and 2).

The only other mine site that has been affected by postmining activity, based on several visual inspections, is 28-7. This site occurs in an area where extensive military testing occurred in the 1940s. As a result, this mine has a 5-inch shell (expended) positioned at the entrance. This mine was not used for disposal of these shells, as evidenced by the numerous shells lying on the ground in the immediate vicinity (if the mine had been used for disposal, the shells in the immediate vicinity would have been gathered up and placed in the mine; it

could not have been used due to the shallow amount of soil on the floor). The shells present in this military range are not SNL/NM's responsibility.

As part of the ER Project follow up, eight SNL/NM staff members (several now retired) were interviewed specifically about the CEARP statements summarized in Section 2.2 (Ref. 11, 19, 26, 27, 28, and 30). Out of this interview process, SNL/NM ER personnel were able to verify that waste explosives were detonated in the 28-2 (lower adit) site. However, no individuals had any direct knowledge of disposal of other wastes in any of the mines, including 28-2. One interviewee clarified that explosives rumored to have been disposed of in a mine were actually disposed of in a dry well (Ref. 11).

Based on the information gathered to date, including documented detailed inspections of the mines, interviews, and the results of the radiation survey conducted in 1982-1983, there is no significant threat of a release from this SWMU that would pose a threat to human health and the environment. Eight of the ten ER Site 28 locations show no evidence of any postmining activity, and thereby do not pose a threat of a release.

The NFA criteria that apply to ER Site 28 are as follows:

- Criterion 1 (unit has never contained constituent of concern): Sites 28-1, 28-3, 28-4, 28-5, 28-6, 28-7, 28-8, 28-9, and 28-10.
- Criterion 3 (unit clearly has not released hazardous waste or constituents into the environment): Site 28-2.

4. Conclusion

Based upon the evidence cited above, no potential remains for a release of hazardous constituents which may pose a threat to human health or the environment. Therefore all ten ER Site 28 mine locations are recommended for an NFA determination.

5. References

5.1 ER Site References

Section 5.1 contains a comprehensive bibliographical list of the documents relating to ER Site 28. This list is arranged numerically by reference citation in the text.

1. U.S. Environmental Protection Agency (EPA), August 1993. Module IV of RCRA Permit No. NM5890110518, EPA Region 6, issued to Sandia National Laboratories, Albuquerque, New Mexico.

2. U.S. Environmental Protection Agency (EPA), August 1992. Hazardous Waste Management Facility Permit No. NM5890110518, EPA Region 6, issued to Sandia National Laboratories, Albuquerque, New Mexico.

3. Sandia National Laboratories/New Mexico (SNL/NM), February 1995. "Program Implementation Plan for Albuquerque Potential Release Sites," Sandia National Laboratories, Albuquerque, New Mexico.

4. U.S. Environmental Protection Agency (EPA), July 1990. "Corrective Action for Solid Waste Management Units (SWMU) at Hazardous Waste Management Facilities Proposed Rule," *Federal Register,* Vol. 55, Title 40, Parts 264, 265, 270, and 271.

5. U.S. Environmental Protection Agency (EPA), October 1986. "RCRA Facility Assessment Guidance," EPA/530-86-053, pb87-107769, Environmental Protection Agency, Washington, DC.

6. Sandia National Laboratories/New Mexico (SNL/NM), 1995. Environmental Operations Records Center Reference Number ER/1334/057/95-001, Sandia National Laboratories, Albuquerque, New Mexico.*

7. Department of Energy (DOE), Albuquerque Operations Office, Environmental Safety and Health Division, Environmental Program Branch, September 1987, draft. "Comprehensive Environmental Assessment and Response Program (CEARP) Phase I: Installation Assessment, Sandia National Laboratories, Albuquerque," Department of Energy, Albuquerque Operations Office, Albuquerque, New Mexico.

8. Defense Nuclear Agency (DNA), August 1971. "Radioactive Waste Survey," performed by the Defense Nuclear Agency, Headquarters Field Command, Kirtland Air Force Base, New Mexico, August 16, 1971.

9. Engineering Science (ES), 1981. "Installation Restoration Program, Phase I: Kirtland Air Force Base," prepared for the U.S. Air Force, AFESC/DEV, Tyndall AFB, Florida.

10. New Mexico Bureau of Mines and Mineral Resources, 1946, Bulletin 21, "Fluorspar Resource of New Mexico."

11. Sandia National Laboratories/New Mexico (SNL/NM), 1994. Environmental Operations Records Center Reference Number ER/7585/1332/82/Int/94-121, Sandia National Laboratories, Albuquerque, New Mexico.*

12. Minnema, D. M., and G. E. Tucker, August 1989. "Radiation Survey of KAFB/DOE Controlled Areas Kirtland AFB, Albuquerque, New Mexico," August 18, 1989.

13. Mitchell, Mike, November 1994. Field Notes. "Site 28 Field Trip," November 4, 1994.

*The SNL/NM reference numbers refer to a SNL/NM Records Center coding system intended to maintain the confidentiality of SNL/NM employees.

14. Mr. Davidson, HQ, 1606th Air Base Wing, Memorandum to HQ/MAC/LEEV (Ms. Hopper), Subject: Installation Restoration Program (IRP) Site Closeout Decision Documents, September 18, 1991.

15. Denise Bleakly, Memorandum to Warren Cox, Subject: Review of KAFB IRP/SNL ER Site Transfer Information, December 15, 1992.

16. Decision Paper, 02/92, Installation Restoration Program (IRP), 542d Crew Training Wing (CTW), Kirtland AFB, New Mexico.

17. Denise Bleakly, Memorandum to Warren Cox, Subject: Body of Text for EPA Request Concerning ER/IRP ER Site Exchange and ER Site 28, July 28, 1993.

18. Sandia National Laboratories/New Mexico (SNL/NM), 1992. Environmental Operations Records Center Reference Number ER/7585/1332/Int/92-023, Sandia National Laboratories, Albuquerque, New Mexico.*

19. Sandia National Laboratories/New Mexico (SNL/NM), 1993. Environmental Operations Records Center Reference Number ER/7585/1332/67/Int/93-199, Sandia National Laboratories, Albuquerque, New Mexico.*

20. Mitchell, Mike, March 1995. Mine Site Tour, (ER Site 28) Field Notes, March 22, 1995.

21. Jeff Havlena, Memorandum to Kathy Gaither, August 21, 1991.

22. Mitchell, Mike, February 1995. Field Logbook Notes - Surveying GPS and Photos of Mine Sites, February 24, 1995.

23. Sandia National Laboratories/New Mexico (SNL/NM), 1993. Environmental Operations Records Center Reference Number ER/7585/1332/Int/93-013, Sandia National Laboratories, Albuquerque, New Mexico.*

24. Skip Wrightson, Memorandum to Kathy Gaither, Subject: Notes of Field Activities 8/26/93 Mineshaft (Site 28) Locations, August 30, 1993.

25. Norris, Thomas A., Letter to Warren Cox, Subject: Letter to Mrs. Nancy R. Morlock (EPA Region 6), August 19, 1993.

26. Wrightson, Skip, to: Kathy Gaither, Caroline Byrd, Subject: Notes of Field Activities, 8/26/93 Mineshaft (Site 28) Locations, August 30, 1993.

*The SNL/NM reference numbers refer to a SNL/NM Records Center coding system intended to maintain the confidentiality of SNL/NM employees.

27. Minnema, Doug, November 1982. Doug Minnema's Logbook from 1982-1983, Radiation Survey Fieldwork, November 8, 1982.

28. Sandia National Laboratories/New Mexico (SNL/NM), 1994. Environmental Operations Records Center Reference Number ER/7585/1332/27/Int/94-005, Sandia National Laboratories, Albuquerque, New Mexico.*

29. U.S. Army Armament Headquarters, January 1992. "Development of Methodology and Technology for Identifying and Quantifying Emission Open Burning and Open Detonation Thermal Treatment Methods, Bang Box Test Series," Vols. 1, 2, and 3, Test Summary, U.S. Army, Sandia National Laboratories, Albuquerque, New Mexico.

30. Sandia National Laboratories/New Mexico (SNL/NM), 1993. Environmental Operations Records Center Reference Number ER/7585/1332/82/Int/93-019, Sandia National Laboratories, Albuquerque, New Mexico.*

5.2 Reference Documents

Sandia National Laboratories/New Mexico (SNL/NM), 1993. Environmental Operations Records Center Reference Number ER/7585/1332/Int/93-034, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico, September 1993, Environmental Operations Record Center Record Number ER/1334 057/94-001.

Sandia National Laboratories/New Mexico (SNL/NM), February 1994, draft. "Program Implementation Plan for Albuquerque Potential Release Sites," Sandia National Laboratories, Albuquerque, New Mexico.

5.3 Aerial Photographs

Aerial photographs were not used to gather information on ER Site 28.

*The SNL/NM reference numbers refer to a SNL/NM Records Center coding system intended to maintain the confidentiality of SNL/NM employees.

ATTACHMENT 1

OU 1332, ER Site 28

Open Burning/Open Detonation of Explosives

Open Burning/Open Detonation of Explosives

Site 28 contains a mine where explosives may have been detonated or open burned. The degree to which explosives were destroyed in open detonation events had not been conclusively documented until recently. The U.S. Army Armament, Munitions, and Chemical Command sponsored a study from 1988 to 1992 to document the combustion by-products of open burning/open detonation of rocket propellant and explosives. This study was conducted to meet regulatory needs for treatment permitting under the RCRA and for site investigation work under the RCRA and the CERCLA (603). The remainder of this section discusses the results of this study and how it relates to the approach in this NFA Proposal.

The technical steering committee that developed the study was formed from experts in field sampling, instrumentation, field and laboratory analysis, environmental documentation, atmospheric dispersion, data processing, combustion and explosive phenomenology, and quality assurance (QA)/quality control (QC). The EPA Headquarters and Research Triangle Park provided technical guidance and support during the test planning and execution phases of the test as well as review of both data collection and analytical procedures and assurance of instrument accuracy. During the study, the EPA Atmospheric Research and Exposure Assessment Laboratory, Quality Assurance Division, Research and Monitoring Evaluation Branch performed a technical audit with excellent results.

The study consisted of detonating or open burning explosives or rocket propellant within a building (referred to as the bangbox). This building contained the combustion by-products that allowed for a quantitative determination of the emissions. Various types of monitoring equipment were used to provide the best information on the tests.

Results of the study indicate that after open detonation/open burning, the explosives and rocket propellant are consumed to less than 4 ppm (measured by the weight of total explosive). Table 4-3 shows the carbon emissions resulting from the combustion of TNT.

Table 4-3
Carbon Emissions Produced by Combustion of TNT

Species	Percent Produced by Combustion of TNT
Carbon dioxide	97.20
Carbon monoxide	0.50
C_1 to C_{10} volatile hydrocarbons and other organics	0.57
Elemental carbon (soot)	1.71

TNT was used in the test because it contains less oxygen than other commonly used military explosives. Oxygen-deficient explosives are less likely to burn as completely as other explosives and thus provide a worst-case result for incomplete combustion by-product production. The amount of TNT surviving the detonation was 3.38 parts per million by weight (ppmw). Most of the explosives used on OU 1332 sites contained TNT.

The two most commonly used types of solid rocket propellant (double-based and composite) were also tested. Solid rocket propellant is a mixture of chemicals held together by carbon-based binders (mostly rubber or plastic). The fate of the carbon-based binders is indicative of the fate of the rocket propellant. Table 4-4 presents the measured results of carbon-containing species.

Table 4-4
Carbon Emissions Produced by Combustion of
Double-Based/Composite Rocket Propellant

Species	Percent Produced by Combustion of Double-Based/Composite Rocket Propellant
Carbon dioxide	99.64/99.88
Carbon monoxide	0.15/0.11
Organic carbon	0.21/0.00
Elemental carbon	0.00/0.01

Table 4-4 shows the complete combustion (to greater than 99.64 percent carbon dioxide) of the carbon-containing materials in both types of rocket propellant. The tests clearly indicate that no significant amount of explosives or rocket propellant can survive an open detonation/open burning event.

Dugway Proving Ground in Utah conducted additional testing. To collect emissions samples, various sampling devices were installed in airplanes and under the wings of airplanes that flew through the plumes produced by the open burning/open detonation of rocket propellant and explosives. Soil samples were also taken to improve the definition of the deposition of the combustion by-products in the environment. The tests involved large detonations (approximately 2,000 lb) of HE and large open-burning events with rocket propellants (of up to 7,000 lb).

The results were generally consistent with the smaller-scale bangbox study described above. The data evaluation was complicated by the use of reclaimed (and therefore slightly

contaminated) explosives. Compounds not used in the explosive tests were detected as residues in some soils after these tests, indicating that the site may have been contaminated previously by other unrelated activities.

Even with these complications, the soil deposition from these large open-burning/open-detonation events was very low. The highest value of deposition in soil resulting from the detonation of 2,000 lb of TNT was 0.36 ppm of TNT. The detonation of approximately 2,000 lb of RDX resulted in a maximum soil concentration of 15 ppb of RDX. Other combustion by-products were detected in soils in even smaller quantities. The Dugway report lists these.

The combustion by-products from these large explosive tests included some volatile and semivolatile compounds. A risk assessment for both toxicity and carcinogenicity was performed on all of the combustion by-products deposited in the soils from the tests. Based on the risk scenario and the constituent values given in the Dugway report, risks were calculated using the soil concentrations of COCs immediately following completion of the Dugway test. The risk assessment evaluated the risk level for the entire mixture of compound present. Risks for each compound were assumed to be cumulative--a conservative assumption resulting in higher calculated risk level.

The EPA has not yet published the health effects data that are necessary to assess toxicity or carcinogenicity of several of the combustion by-products produced in the Dugway tests. Health effects data for similar compounds were substituted in the risk calculation for those particular compounds. Care was taken to select substitute compounds that would have conservative risk values (i.e., higher risk levels). Attachment 2 includes a more detailed discussion of the methods used and the results of the risk assessment.

Even with the higher risk levels of the substitute compounds, the calculated risk levels for both toxicity and carcinogenicity were acceptable. A toxicity level of less than one (expressed as the Hazard Index) is the criterion defined by the EPA as acceptable. The Hazard Index calculated for the Dugway tests was 0.19. A carcinogenicity risk level of 10^{-6} or less is an acceptable risk level for residential land use -- the most stringent future land use scenario. The carcinogenic risk levels calculated for the Dugway test were less than 10^{-6}.

Explosives experts consulted by SNL/ER interpret the Dugway report as evidence that soil residues from open burning/open detonation conducted at most OU 1332 ER Sites would also have been in the similar parts-per-million range at the time of the testing. The detonations and open burning at one mine in site 28 were significantly smaller than the 2,000 lb of explosives used in the Dugway tests. Negligible quantities of residue would have been dispersed in the air at the time of testing. The combustion by-products deposited at the time of testing onto surface soils would be degraded by natural processes. Up to 44 years have passed since the open burn open/detonation testing in the site 28 mine occurred. Experts believe it highly unlikely that these materials could still be detected on the soil surface of the sites.

The acceptable toxicity and carcinogenic risks discussed above were calculated assuming a residential risk scenario and using deposition values measured immediately after the Dugway test ended. Because of the smaller quantities of explosives used, any residues that may have been deposited at site 28 would have been less significant than those from the Dugway tests. Those residues would have degraded over a period of many years. It can be assumed, then, that the toxicity and carcinogenic risks from the combustion by-products of the open burning/open detonations site 28 will thus be even less than those calculated for the Dugway tests. The site is proposed for future recreational land use. The risk levels allowed for these land-use scenarios are generally higher than the 10^{-5} level allowed for residential land use.

SNL/NM does not believe it is necessary to sample for explosives or rocket propellant at the site based on the study discussed above. Sampling of selected sites will be conducted at SNL/NM to verify the Dugway study results are applicable to the SNL sites. Due to the mine safety concerns, this site is not proposed for sampling.

ATTACHMENT 2

OU 1332, ER Site 28

Calculation of Hazard Indices and Risks From HE Detonation Test Soil Concentration Data

CALCULATION OF HAZARD INDICES AND RISKS FROM HE DETONATION TEST SOIL CONCENTRATION DATA

Scope and Purpose

A series of toxicity and cancer risk calculations were made using reported concentrations of soil residues left by HE detonation tests conducted by the U.S. DoD (U.S. Army, 1992). The purpose of this study was to preliminarily assess the potential for detonation sites at Sandia National Laboratories to pose health hazards. The calculation procedure was designed to produce conservatively large estimates of hazard index and cancer risk so that the effects of any uncertainties in the DoD soil data could be minimized. Such an approach facilitated the following reasoning regarding future assessment of the Sandia sites:

- If the conservative estimates based on the DoD data result in unacceptable risks and hazard indices, further, detailed investigations of the Sandia sites are necessary; or

- If the risk and hazard index estimates fall below recommended EPA levels, the potential for health hazards at the Sandia sites is extremely low, and only limited investigation of the sites, if any, is necessary.

Methodology and Results

Hazard indices and cancer incidences (i.e., cancer risk) were computed using methods and equations promulgated in proposed RCRA Subpart S, Appendices D and E. Accordingly, all calculations were based on the assumption that receptor doses from both toxic and carcinogenic chemicals result from ingestion of contaminated soil. The combined effects of all chemicals potentially in the soils at a detonation site were taken into account. For toxic chemicals, this was accomplished by summing the individual hazard quotients for each chemical into a total hazard index. In the case of carcinogens, individual risks were summed.

Calculation of hazard indices required values of oral reference doses (oral RfDs) for each of the chemicals that was being assessed. Although RfDs are published for many of the chemicals observed in the HE detonation test soil residues, toxicity information for the remaining chemicals is either provisional or not readily available. To include chemicals falling into this latter category in the hazard index calculations, the Sandia ER Program asked EPA Region 6 personnel to provide appropriate RfD values. As of this writing, such data had not yet been made available. Consequently, many of the chemicals were assigned RfDs using various types of reasoning. In some cases, the assigned values were taken from published RfD data for chemicals that are similar to those for which no data is available. In other instances, an assigned RfDs was set to an arbitrarily low value, which produced a conservatively large hazard quotient.

Similarly, calculation of cancer risks required values of ingestion cancer slope factors, many of which have not been published for the chemicals observed in the HE detonation test data. Thus slope factors were also assigned to many of the chemicals, again using either published data for similar chemicals or values that led to conservatively large estimates of risk.

In addition to the above-described conservative assumptions regarding reference doses and cancer slope factors, the following steps were taken to assure that conservatism was built into the calculations:

- Several different concentrations were reported for each chemical included in the list of soil residue constituents resulting from the HE detonation tests (U.S. Army, 1992). The concentrations varied depending on the test site, the type of explosive, and distance away from the detonation center. In all risk and hazard index calculations, only the maximum observed concentration of each chemical was employed.

- Some of the chemicals occurred in soil residue at certain test sites and not at others. For the purposes of risk and hazard index calculation, it was assumed that all of the soil residue chemicals reported at some point or another in the HE detonation test results exist simultaneously in the soil. Therefore, the effects of all chemicals were added, despite the unlikelihood that an actual testing site would contain all chemicals.

- For most of the chemicals for which published RfD and slope factor values were unavailable, it was unclear as to whether each chemical was toxic, carcinogenic, or both. In the calculations, each of the chemicals falling under this category was assumed to be both toxic and carcinogenic, despite the likelihood that many of the chemicals may be neither, one or the other, but not both.

- Some of the chemicals included in the cancer risk analysis are categorized as Class C carcinogens, which, according to EPA guidelines, means that their combined risk need only meet a 1×10^{-5} prescribed risk limit. The calculations were based on the assumption that all chemicals included in the cancer risk assessment were either Class A or Class B carcinogens, which meant that all chemicals would be required to meet the more restrictive limit of 1×10^{-6}.

A list of all of the chemicals included in the hazard index and risk computations, along with their assumed soil concentrations, is presented in Table 1.

Hazard Index Calculations

Following proposed Subpart S methodology, the equation and parameter values used to calculate the summed hazard index for toxic chemicals was:

$$HI = \sum_{i} [HSR(i) \times S(i)] \quad (1)$$

where

HI	=	hazard index (dimensionless),
HSR(i)	=	hazard index-to-soil concentration ratio for the ith chemical $(\mu g/kg)^{-1}$
	=	$\frac{I \times A}{RfD(i) \times W} \times \frac{0.000001\ kg}{\mu g}$
S(i)	=	soil concentration of the ith chemical (μg/kg),
I	=	soil ingestion rate = 0.2g/day,
A	=	absorption factor (dimensionless) = 1,
W	=	body weight = 16 kg, and
RfD(i)	=	oral reference dose for the ith chemical (mg/kg-day).

Table 2 presents a list of the chemicals that were included in the hazard index calculations along with their RfD values, computed hazard quotients for each chemical, and the total estimated hazard index. Chemicals for which RfD data was unavailable, are distinguished from the chemicals that have published RfD values. The "RfD source data" column lists either the published source of the RfD values or the assumption upon which assigned values were made.

As Table 2 shows the total computed hazard index was 0.1887. This value falls far short of the maximum allowable hazard index of 1 (EPA, 1989).

Cancer Risk Calculations

Following proposed Subpart S methodology, the equation and parameter values used to calculate the summed risk for carcinogenic chemicals was:

$$RISK = \sum_{i} [RSR(i) \times S(i)] \quad (2)$$

where

RISK	=	excess cancer incidence (dimensionless),
RSR(i)	=	risk-to-soil concentration ratio for the ith chemical $(\mu g/kg)^{-1}$
	=	$\frac{I \times A \times CSF(i) \times ED}{W \times LT} \times \frac{0.000001\ kg}{\mu g}$,
S(i)	=	soil concentration of the ith chemical (μg/kg),
I	=	soil ingestion rate = 0.1 g/day,
A	=	absorption factor (dimensionless) = 1,
CSF(i)	=	cancer slope factor for the ith chemical $(mg/kg\text{-}day)^{-1}$,
ED	=	exposure duration = 70 years,
W	=	body weight = 70 kg, and
LT	=	assumed lifetime = 70 years.

The chemicals included in the cancer risk calculations, the associated slope factors, individual chemical computed risks, and the total computed risk are presented in Table 3. As in the toxic chemical assessment, chemicals having published slope factors are distinguished from the chemicals for which slope factors were assumed. Again the reasoning that went into the assignment of slope factors is summarized. As this table indicates, the total computed cancer risk was 9.924×10^{-7}. This value is less than the assumed risk limit of 1×10^{-6} (EPA, 1989).

Conclusions

Hazard index and cancer risk calculations have been conducted using soil residue chemical concentrations resulting from HE detonation tests conducted by the U.S. DoD. The computations were designed to produce conservatively large estimates of combined hazard index and risk for the purpose of screening Sandia test sites. The conservative procedures employed resulted in a total computed hazard index of 0.1887, and the calculated total risk was 9.924×10^{-7}. The EPA prescribed limits on these two indexes are, respectively, 1 and 1×10^{-6}. Thus, this preliminary assessment indicates that the soil concentrations produced during the open burning/open detonation testing at Dugway Proving Grounds pose no unacceptable risk to human health. This is based on the detonation of up to 2,000 lbs of HE and open burning up to 7,000 lbs of rocket propellant. Sandia sites that open burned or open detonated these quantities or less, under comparable conditions, would likewise be expected to pose no unacceptable risk to human health.

References

U.S. Environmental Protection Agency (EPA), 1989. Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response, Washington, D.C. 20460.

Headquarters, U.S. Army Armament, Munitions and Chemical Command (U.S. Army), 1992. Development of Methodology and Technology for Identifying and Quantifying Emission Products from Open Burning and Open Detonation Thermal Treatment Methods, Field Test Series A, B, C, Volume 1, Test Summary. Maintenance Management Division, Demilitarization and Technology Branch , Rock Island, Illinois.

Table 1 - List of Chemicals Included in Risk Calculations and Maximum Observed Soil Concentrations for the DOD Tests

Chemical	Soil Concentration (ug/kg)
BENZ[A]ANTHRACENE	11
BENZO[A]PYRENE	0.67
DIBENZOFURAN	29
DINITROTOLUENE, 2,4-	35
DINITROTOLUENE, 2,6-	21
DIPHENYLAMINE	97
NAPHTHALENE	510
NITRODIPHENYLAMINE, 2-	1.7
NITRONAPTHALENE, 2-	47
NITROPYRENE, 1-	1.2
NITROSODIPHENYLAMINE, N-	1.7
PHENOL	69
PYRENE	53
RDX (CYCLONITE)	15
TRINITROBENZENE, 1,3,5-	39
TRINITROTOLUENE, 2,4,6-	680

Table 2 - Reference Doses and Hazard Index Calculations

Chemical	RfD, oral chronic [mg/kg/day]	Hazard Quotient	RfD Source Data
	Data Available		
DINITROTOLUENE, 2,4-	2.00E-03	2.275E-04	IRIS
DINITROTOLUENE, 2,6-	1.00E-03	2.730E-04	IRIS
DIPHENYLAMINE	2.52E-04	5.004E-03	HEAST
PHENOL	6.00E-01	1.495E-06	IRIS
PYRENE	3.00E-02	2.297E-05	IRIS
RDX (CYCLONITE)	3.00E-03	6.500E-05	IRIS
TRINITROBENZENE, 1,3,5-	5.00E-05	1.014E-02	IRIS
TRINITROTOLUENE, 2,4,6-	5.00E-04	1.768E-02	IRIS
	Data not Available		
BENZ[A]ANTHRACENE	5.00E-05	2.860E-03	RFD LOWEST OF AVAILABLE VALUES
DIBENZOFURAN	5.00E-05	7.540E-03	RFD LOWEST OF AVAILABLE VALUES
NAPTHALENE	5.00E-05	1.326E-01	RFD LOWEST OF AVAILABLE VALUES
NITRODIPHENYLAMINE, 2-	2.52E-04	8.770E-05	RFD FROM DIPHENYLAMINE
NITRONAPTHALENE, 2-	5.00E-05	1.222E-02	RFD LOWEST OF AVAILABLE VALUES
NITROPYRENE, 1-	3.00E-02	5.200E-07	RFD FROM PYRENE
Total Hazard Index	**=**	**1.887E-01**	

HEAST= Health Affects Assessment Summary Tables (1994)
IRIS = Integrated Risk Information System

Table 3 - Cancer Slope Factors and Computed Risks

Chemical	Slope Factor, oral [mg/kg/day]-1	Cancer Class	Computed Risk	Cancer Slope Factor Source Data
	Data Available			
BENZO[A]PYRENE	7.30E+00	B2	6.847E-09	IRIS
DINITROTOLUENE, 2,4-	6.80E-01	B2	3.332E-08	IRIS
DINITROTOLUENE, 2,6-	6.80E-01	B2	1.999E-08	IRIS
NITROSODIPHENYLAMINE, N-	4.90E-03	B2	1.166E-11	IRIS
TRINITROTOLUENE, 2,4,6-	3.00E-02	C	2.310E-09	IRIS
RDX (CYCLONITE)	1.10E-01	C	2.856E-08	IRIS
	Data not Available			
BENZ[A]ANTHRACENE	7.30E+00	A/B*	1.124E-07	SLOPE FACTOR LARGEST OF AVAILABLE VALUES
DIBENZOFURAN	7.30E+00	A/B*	2.964E-07	SLOPE FACTOR LARGEST OF AVAILABLE VALUES
NITRODIPHENYLAMINE, 2-	4.90E-03	A/B*	1.166E-11	SLOPE FACTOR FROM NITROSODIPHENYLAMINE, N-
NITRONAPTHALENE, 2-	7.30E+00	A/B*	4.803E-07	SLOPE FACTOR LARGEST OF AVAILABLE VALUES
NITROPYRENE, 2-	7.30E+00	A/B*	1.226E-08	SLOPE FACTOR LARGEST OF AVAILABLE VALUES
		Total Risk =	**9.924E-07**	

IRIS = Integrated Risk Information System

* = assumed carcinogen group