Sandia National Laboratories/New Mexico

PROPOSALS FOR NO FURTHER ACTION ENVIRONMENTAL RESTORATION PROJECT SWMUs 98, 82, 60, 8IA, 81B, 81D, 81E, 81F, 9, AND 117

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Environmental
Restoration
Project

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Albuquerque Operations Office

EXECUTIVE SUMMARY

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a risk-based no further action (NFA) decision for Solid Waste Management Units (SWMUs) 98, 82, 60, 81A, 81B, 81D, 81E, 81F, 9, and 117. These SWMUs are proposed for an NFA decision based upon baseline and confirmatory sampling data demonstrating that constituents of concern (COCs) that could have been released from the SWMUs into the environment pose an acceptable level of risk under current and projected future land use, as set forth by the Criterion 5, which states, "The SWMU/AOC [area of concern] has been characterized or remediated in accordance with current applicable state or federal regulations, and the available data indicate that contaminants pose an acceptable level of risk under current and projected land use" (NMED March 1998). This executive summary briefly describes each SWMU and the basis for the NFA proposal.

- SWMU 98 (Building 863 TCA [trichloroethane] and Photochemical Release in Operable Unit [OU] 1302) was constructed in 1950 and in 1951 became the motion picture production and film processing division for SNL/NM. The site was listed as a SWMU because of silver recovery processes and for releases of TCA from a film-cleaning machine. SWMU 98 was characterized through a series of four investigations: 1) a Comprehensive Environmental Assessment and Response Program (CEARP) (1987), 2) an Environmental Restoration (ER) Preliminary Investigation in 1993, 3) a RCRA Facility Investigation (RFI) in 1995, and 4) an Additional RFI Field Investigation in 1999. The four investigations included a background review, a cultural resources survey, a sensitive species survey, and sampling data collection. The building was decontaminated, decommissioned, and demolished in 1999. Based upon field investigation data and the human health and ecological risk screening assessments, NFA is recommended for the site because no COCs (metals, volatile organic compounds [VOCs], semivolatile organic compounds [SVOCs]) were present in concentrations considered hazardous to human health or site ecological receptors for an industrial land-use scenario.

- SWMU 82 (Old Aerial Cable Site in OU 1332) was constructed in 1968 to study problems in an experimental Fuel-Air Explosive weapon. Phillips Laboratories currently uses the site as a High Energy Research Test Facility. SWMU 82 was characterized through a series of four investigations: 1) a CEARP in 1997, 2) an ER Preliminary Investigation in 1992, 3) an ER RFI between 1995 and 1999, and 4) a Voluntary Corrective Action (VCA) conducted in 1999. The four investigations included visual inspections of the site, a background review, radiological surveys, unexploded ordnance (UXO)/high explosives (HE) surveys, a cultural resources survey, and sampling data collection. Based upon field investigation data and the human health and ecological risk screening assessments, NFA is recommended for the site because no COCs (metals, VOCs, SVOCs, HE, or radionuclides) were present in concentrations or activity levels considered hazardous to human health or site ecological receptors for a recreational land use scenario.

- SWMU 60 (Bunker Area in OU 1333) was a supply bunker and control bunker. The control bunker was destroyed during explosive testing in 1979. During the explosive test two mock weapons containing HE, depleted uranium, and beryllium were detonated, and the control bunker was destroyed. SWMU 60 was characterized through three investigations: 1) a CEARP in 1985, 2) an ER Preliminary Investigation from 1989 to 1994, and 3) a VCA conducted in 1999. The site investigations included a Phase I site investigation, a background review, a UXO/HE survey, a radiation survey, a cultural resource survey, and a sensitive species survey. The VCA was conducted in 1999 and included radiological surveys to characterize depleted uranium contamination present on remaining structures and debris, demolition and removal of this material, and confirmatory sampling. Based upon field investigation data and the human health and ecological risk screening assessments, NFA is recommended for the site because no COCs (metals, HE, radionuclides) were present in concentrations or activity levels considered hazardous to human health or site ecological receptors for a recreational land use scenario.

- SWMU 81A (Catcher Box/Sled Track in OU 1333) was constructed in 1970 and is an active subunit of SWMU 81 (New Aerial Cable Facility). The site was constructed to support impact testing on weapons and other test units that could be subject to detonation at SWMU 81. SWMU 81A was characterized through three investigations: 1) a CEARP conducted in the mid-1980s, 2) an ER Preliminary Investigation in 1993, and 3) baseline sampling in 1998. The three investigations included a Phase I investigation, a background review of the site, a UXO/HE survey, a radiological survey, a cultural resource survey, a sensitive-species survey, and sampling data collection. Based upon field investigation data and the human health and ecological risk screening assessments, NFA is recommended for the site because no COCs (metals, VOCs, SVOCs, radionuclides) were present in concentrations or activity levels considered hazardous to human health or site ecological receptors for a recreational land use scenario.

- SWMU 81B (Impact Pad in OU 1333) was constructed in 1970 and is an active subunit of SWMU 81 (New Aerial Cable Facility). The pad was designed to provide an "unyielding surface" for testing the impact of weapons and transportation containers that are designed to house nuclear materials. SWMU 81B was characterized through three investigations: 1) a CEARP conducted in the mid-1980s, 2) an ER Preliminary Investigation in 1993, and 3) baseline sampling in 1998. The three investigations included a Phase I investigation, a background review of the site, a UXO/HE survey, a radiological survey, a cultural resource survey, a sensitive-species survey, and sampling data collection. Based upon field investigation data and the human health and ecological risk screening assessments, NFA is recommended for the site because no COCs (metals, VOCs, HE, radionuclides) were present in concentrations or activity levels considered hazardous to human health or site ecological receptors for a recreational land use scenario.

- SWMU 81D (Northern Cable Area in OU 1333) was constructed in 1984-1985 and is an active subunit of SWMU 81 (New Aerial Cable Facility). The site was constructed to provide a dedicated area for antiarmor tests. SWMU 81D was characterized through three investigations: 1) a CEARP conducted in the mid-1980s, 2) an ER Preliminary Investigation in 1993, and 3) baseline sampling in 1998. The three investigations included a Phase I investigation, a background review of the site, a UXO/HE survey, a radiological survey, a cultural resource survey, a sensitive-species survey, and sampling data collection. Based upon field investigation data and the human health and ecological risk screening assessments, NFA is recommended for the site because no COCs (metals, VOCs, radionuclides) were present in concentrations or activity levels considered hazardous to human health or site ecological receptors for a recreational land use scenario.

- SWMU 81E (Gun Impact Area in OU 1333) is an inactive subunit of SWMU 81 (New Aerial Cable Facility). The site is the area impacted from the projectiles shot from portable guns in SWMUs 81A and 81B. SWMU 81E was characterized through three investigations: 1) a CEARP conducted in the mid-1980s, 2) an ER Preliminary Investigation in 1993, and 3) baseline sampling in 1998. The three investigations included a Phase I investigation, a background review of the site, a UXO/HE survey, a radiological survey, a cultural resource survey, a sensitive-species survey, and sampling data collection. Based upon field investigation data and the human health and ecological risk screening assessments, NFA is recommended for the site because no COCs (metals, radionuclides) were present in concentrations or activity levels considered hazardous to human health or site ecological receptors for a recreational land use scenario.

- SWMU 81F (Scrap Yard in OU 1333) is an active subunit of SWMU 81 (New Aerial Cable Facility). The site was constructed in 1970 and has been used for storage of test equipment associated with SWMU 81 subunits. SWMU 81E was characterized through three investigations: 1) a CEARP conducted in the mid-1980s, 2) an ER Preliminary Investigation in 1993, and 3) baseline sampling in 1998. The three investigations included a Phase I investigation, a background review of the site, a UXO/HE survey, a radiological survey, a cultural resource survey, a sensitive-species survey, and sampling data collection. Based upon field investigation data and the human health and ecological risk screening assessments, NFA is recommended for the site because no COCs (metals, VOCs, SVOCs, HE, radionuclides) were present in concentrations or activity levels considered hazardous to human health or site ecological receptors for a recreational land use scenario.

- SWMU 9 (Burial Site/Open Dump [Schoolhouse Mesa] in OU 1334) is an inactive debris disposal area. SWMU 9 was characterized through a series of four investigations: 1) a CEARP in the mid-1980s, 2) an ER Preliminary Investigation in 1992, 3) preliminary RFI sampling in 1991, and 4) a radiological voluntary corrective measure (VCM) to excavate and remove buried materials between 1996 and 1998 followed by confirmatory sampling in 1999. The four investigations included a background review, a UXO/HE survey, radiological surveys and VCM excavations, a cultural resource survey, a sensitive species survey, and soil sampling data collection. Based on the field investigation data and the human health and ecological risk screening assessments, NFA is recommended for the site because no COCs (metals, VOCs, SVOCs, HE, radionuclides) were present in concentrations or activity levels considered hazardous to human health or site ecological receptors for an industrial land use scenario.

- SWMU 117 (Trenches [Building 9939] in OU 1335) were disposal trenches that were dug to receive water runoff and reaction products resulting from water sprayed on residual solidified sodium metal in concrete test crucibles. Some solid waste items were also disposed of in one of the trenches. SWMU 117 was characterized through a series of three investigative stages: 1) a CEARP conducted in 1987, 2) ER Preliminary Investigations in 1994, 1995, 1997, and 1998, and 3) a VCA Remediation in 1999/2000. The three investigation stages included a background review, a UXO/HE survey, a radiological survey, a cultural resource survey, a sensitive-species survey, a geophysical survey, and sampling data collection. Based upon field investigation data and the human health and ecological risk screening assessments, NFA is recommended for the site because no COCs (metals, SVOCs, radionuclides) were present in concentrations or activity levels considered hazardous to human health or the environment for an industrial land use scenario.

REFERENCES

New Mexico Environment Department (NMED), March 1998. "RPMP Document requirement Guide," Hazardous and Radioactive Materials Bureau, RCRA Permits Management Program, New Mexico Environment Department, Santa Fe, New Mexico.

1.0 INTRODUCTION

Sandia National Laboratories/New Mexico (SNL/NM) is proposing No Further Action (NFA) recommendations for ten Environmental Restoration Solid Waste Management Units (SWMU). The following SWMUs are listed in the Hazardous and Solid Waste Amendments Module IV of the SNL/NM Resource Conservation and Recovery Act Hazardous Waste Management Facility Permit (NM5890110518) (EPA August 1993). Proposals for each SWMU are located in this document as follows:

Operable Unit 1302

- SWMU 98, Building 863 TCA and Photochemical Release

Operable Unit 1332

- SWMU 82, Old Aerial Cable Site

Operable Unit 1333

- SWMU 60, Bunker Area
- SWMU 81A, Catcher Box/Sled Track
- SWMU 81B, Impact Pad
- SWMU 81D, Northern Cable Area
- SWMU 81E, Gun Impact Area
- SWMU 81F, Scrap Yard

Operable Unit 1334

- SWMU 9, Burial Site/Open Dump (Schoolhouse Mesa)

Operable Unit 1335

- SWMU 117, Trenches (Building 9939)

These proposals each provide a site description, history, summary of investigatory activities, and the rationale for the NFA decision, as determined from assessments predicting acceptable levels of risk under current and projected future land use.

REFERENCES

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

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4.0 SOLID WASTE MANAGEMENT UNIT 60: BUNKER AREA

4.1 Summary

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a risk-based No Further Action (NFA) decision for Environmental Restoration (ER) Solid Waste Management Unit (SWMU) 60 Bunker Area, Operable Unit 1333. SWMU 60 is located near the northeastern corner of Kirtland Air Force Base (KAFB) on federally owned land controlled by KAFB. Environmental concern for SWMU 60 is primarily based upon depleted uranium (DU) contamination of the concrete walls, corrugated metal roof, and other debris associated with a control bunker that was destroyed during explosives testing.

The blast radius associated with the explosion of two mock weapons containing DU and the soil mounds generated during salvage operations after the explosion was designated as SWMU 10. During a Voluntary Corrective Measure (VCM) conducted in 1996, DU-contaminated soil was removed from SWMU 10, and a Voluntary Corrective Action (VCA) was conducted in 1998 to remove a mound of noncontaminated vermiculite from the site (SNL/NM August 1998). The NFA proposal for SWMU 10 was submitted to the New Mexico Environment Department (NMED) in September 1998 and was approved in December 1999 (Moats 1999).

SWMU 60 consisted of a control bunker, supply bunker, control bunker roof, and other debris related to the Torch Activated Burn System (TABS) test explosion. During the SWMU 60 VCA conducted in 1999, all remaining structures and debris were demolished, segregated, and removed from the site. Confirmatory soil samples were collected from the site, and then the entire area encompassing SWMU 10/60 was graded to restore the natural contour.

Review and analysis of all relevant data for SWMU 60 indicate that concentrations of constituents of concern (COC) are less than applicable risk-assessment action levels. Thus, SWMU 60 is being proposed for an NFA decision based upon confirmatory sampling data. This NFA demonstrates that COCs released from this SWMU into the environment pose an acceptable level of risk under current and projected future land use as set forth by NFA Criterion 5, which states, "the SWMU/AOC [area of concern] has been characterized or remediated in accordance with current applicable state or federal regulations, and the available data indicated that contaminants pose an acceptable level of risk under current and projected future land use" (NMED March 1998).

4.2 Description and Operational History

This section describes SWMU 60 and discusses its operational history.

4.2.1 SWMU Description

SWMU 60 (Figure 4.2.1-1) is located near the northeastern corner of KAFB, on federally owned land controlled by KAFB (SNL/NM July 1994a). Access to the general area is by Coyote Springs Road to Pendulum Road and then approximately 1.5 miles north. The site lies on approximately 2.9 acres at a mean elevation of 6,175 feet above sea level (SNL/NM April 1995).

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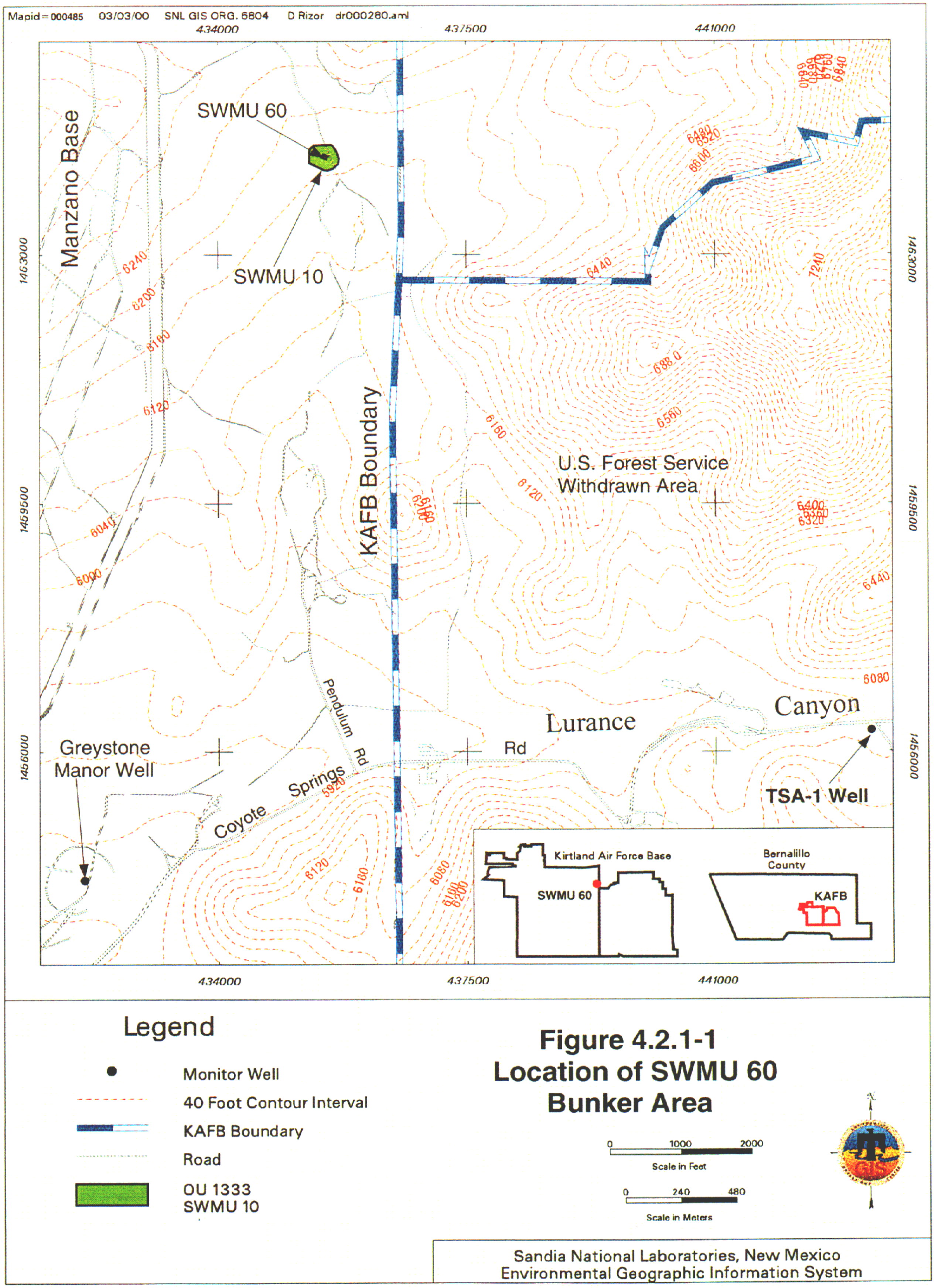

Figure 4.2.1-1
Location of SWMU 60
Bunker Area

The annual precipitation for the area, as measured at the Albuquerque International Sunport, is 8.1 inches (NOAA 1990). Due to the proximity of SWMU 60 to the Manzanita Mountains, precipitation is greater, however no meteorological stations exist close to the site. No springs or perennial surface-water bodies are located within 2 miles of the site. There is an arroyo, which drains towards the south, approximately 100 feet west of SWMU 60. During most rainfall events, rainfall quickly infiltrates the soil at SWMU 60. Due to the surface topography, there may also be some sheet flow to the arroyo during heavy downpours. However, virtually all of the moisture undergoes evapotranspiration and most of the moisture that infiltrates the soil evaporates due to the arid climate. Evapotranspiration estimates for the KAFB area range from 95 to 99 percent of the annual rainfall (SNL/NM February 1998).

SWMU 60 lies on Tesajo-Millett stony sandy loams that are underlain by igneous and metamorphic Precambrian rocks (USDA June 1977). The control bunker was set within granitic bedrock. Immediate topographic relief around the site is approximately 50 feet.

The nearest monitoring wells, the Graystone Manor and TSA-1 Wells, are located approximately 2.2 miles southwest and southeast of SWMU 10, respectively (Figure 4.2.1-1). Groundwater conditions at TSA-1 are probably more representative of conditions at SWMU 60 because SWMU 60 and TSA-1 are east of the Coyote Fault on thin alluvium deposits surrounded by Precambrian rocks (IT May 1994). At the TSA-1 well, semiconfined to confined groundwater is encountered in fractured Precambrian bedrock at a depth of 180 feet below ground surface (bgs) (IT May 1994). Local groundwater flow in the vicinity of SWMU 60 may be complicated because of abundant fractures and faults in the area.

Environmental concerns at SWMU 60 were primarily related to the control bunker, which was destroyed when two mock weapons containing DU detonated inside the bunker (Figure 4.2.1-2). It was noted during the VCM at SWMU 10 that the concrete walls of the bunker, the bunker roof, and some of the debris had radiological contamination associated with the DU released during the explosion. Fragments of DU were imbedded in the wood supports (telephone poles) and the concrete walls of the control bunker. The door and roof of the bunker also had fixed DU contamination on interior surfaces. Figure 4.2.1-3 presents a photograph of the area before the VCA.

4.2.2 Operational History

The history of SWMU 60 prior to the 1979 TABS test is not well documented. Archive records indicate that the bunkers were used as the control point and material storage area for SWMU 59, the Pendulum Site. SWMU 59 formerly housed a rocket-powered pendulum used to conduct instantaneous acceleration tests on weapons components. SWMU 59 was used in the early 1950s, and the SWMU 60 control bunker was used to house the instrumentation trailer for the tests. Possible materials stored at SWMU 60 for such tests include bazooka rockets and Honest John and Betty warhead shells (SNL/NM August 1995).

The TABS test was conducted in the SWMU 60 control bunker to investigate the feasibility that remotely burning high explosives (HE) contained in nuclear weapons would not induce an explosion. However, during this test, two mock weapons containing HE, DU, and beryllium detonated, and the control bunker was destroyed. The blast radius associated with the explosion as evidenced by debris fragments including DU was designated as SWMU 10 (Kurowski January 1979). During a survey conducted by SNL/NM Industrial Hygiene and

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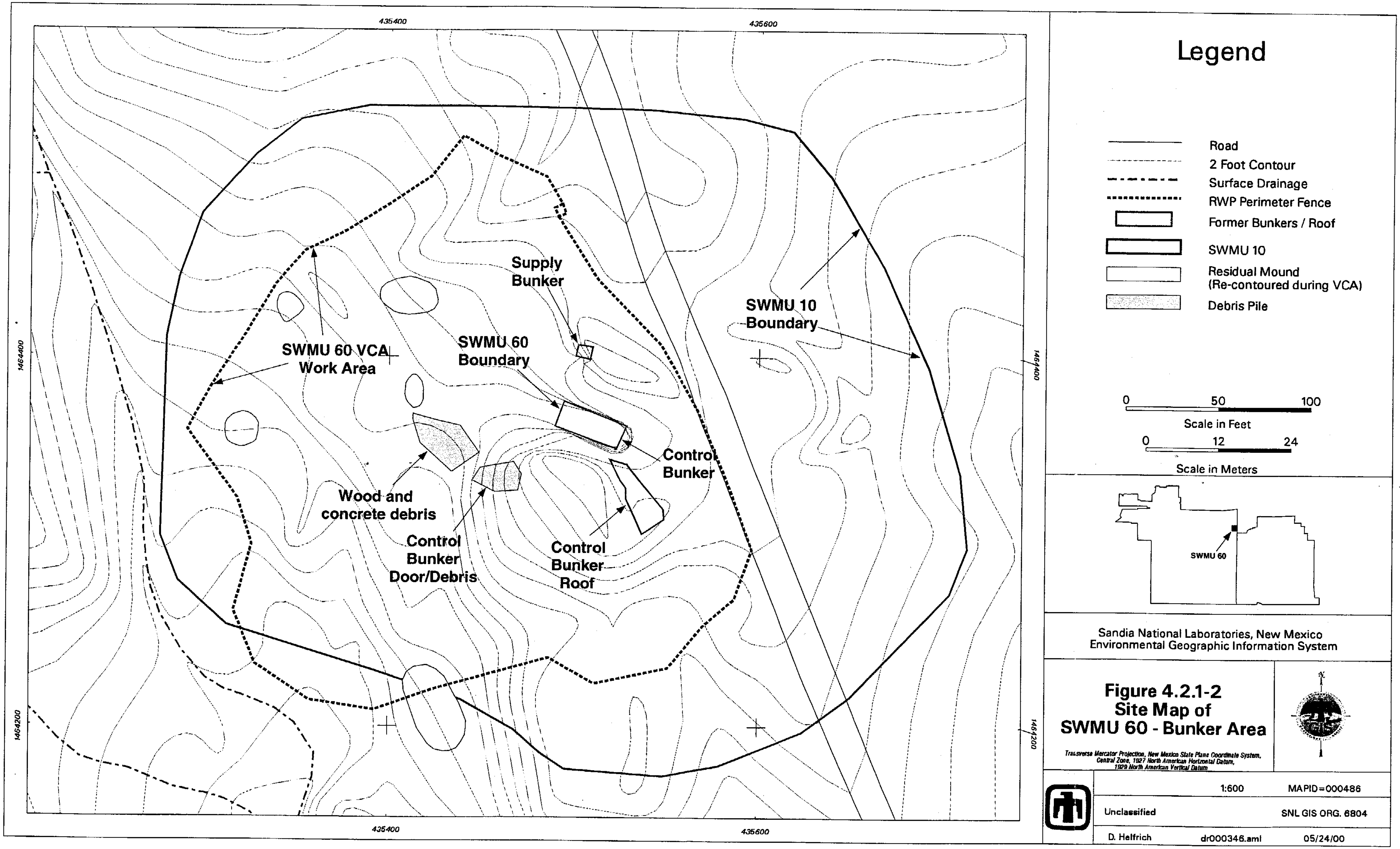

Figure 4.2.1-2
Site Map of SWMU 60 - Bunker Area

Figure 4.2.1-3
SWMU 60 Prior to VCA.

Radiation Protection Operations (RPO) personnel after the TABS test, DU fragments were removed and buried at the Mixed Waste Landfill in Technical Area III (Larson August 1994).

One interview record states that containment-type tests were conducted with short half-life radionuclides in the control bunker. Another interview record verifies that a test involving a radioactive osmium-191 tracer was conducted in the control bunker near the Pendulum Site. A test engineer involved in the radioactive tracer experiments stated that osmium tetra oxide was the tracer compound used, and that the test involved a vermiculite catch pit located about 100 feet southwest of the bunker (Wrightson September 1993). This implies that the tests were performed in the area of the vermiculite mound rather than in the bunkers. The test engineer also stated that the osmium-191 tracer had a half-life of about 16 days (half-life for osmium-191 is 15.4 days [GE 1989]). Precise details regarding the test setup and number of tests were not available.

A 1989 radiation survey of SWMUs 10 and 60 conducted by SNL/NM RPO identified an area of radioactively contaminated vermiculite. This vermiculite was removed in 1989 and disposed of as radioactive waste. The remaining vermiculite mound was free of radioactive contamination (Gaither January 1994, Minnema and Tucker August 1989, Larson August 1994). The noncontaminated vermiculite mound was removed in 1998 and was disposed of as solid waste.

4.3 Land Use

This section discusses the current and projected future land use for SWMU 60.

4.3.1 Current Land Use

SWMU 60 is located within the boundaries of KAFB and is currently an inactive site (Figure 4.3.1-1).

4.3.2 Future/Proposed Land Use

SWMU 60 has been recommended for industrial land use in the future (DOE and USAF March 1996). However, the risk associated with SWMU 60 has also been assessed for residential land use because the site is near private housing developments north and east of the base boundary.

4.4 Investigatory Activities

SWMU 60 has been characterized and remediated in a series of two investigations and a VCA. This section discusses the SWMU 60 investigatory activities.

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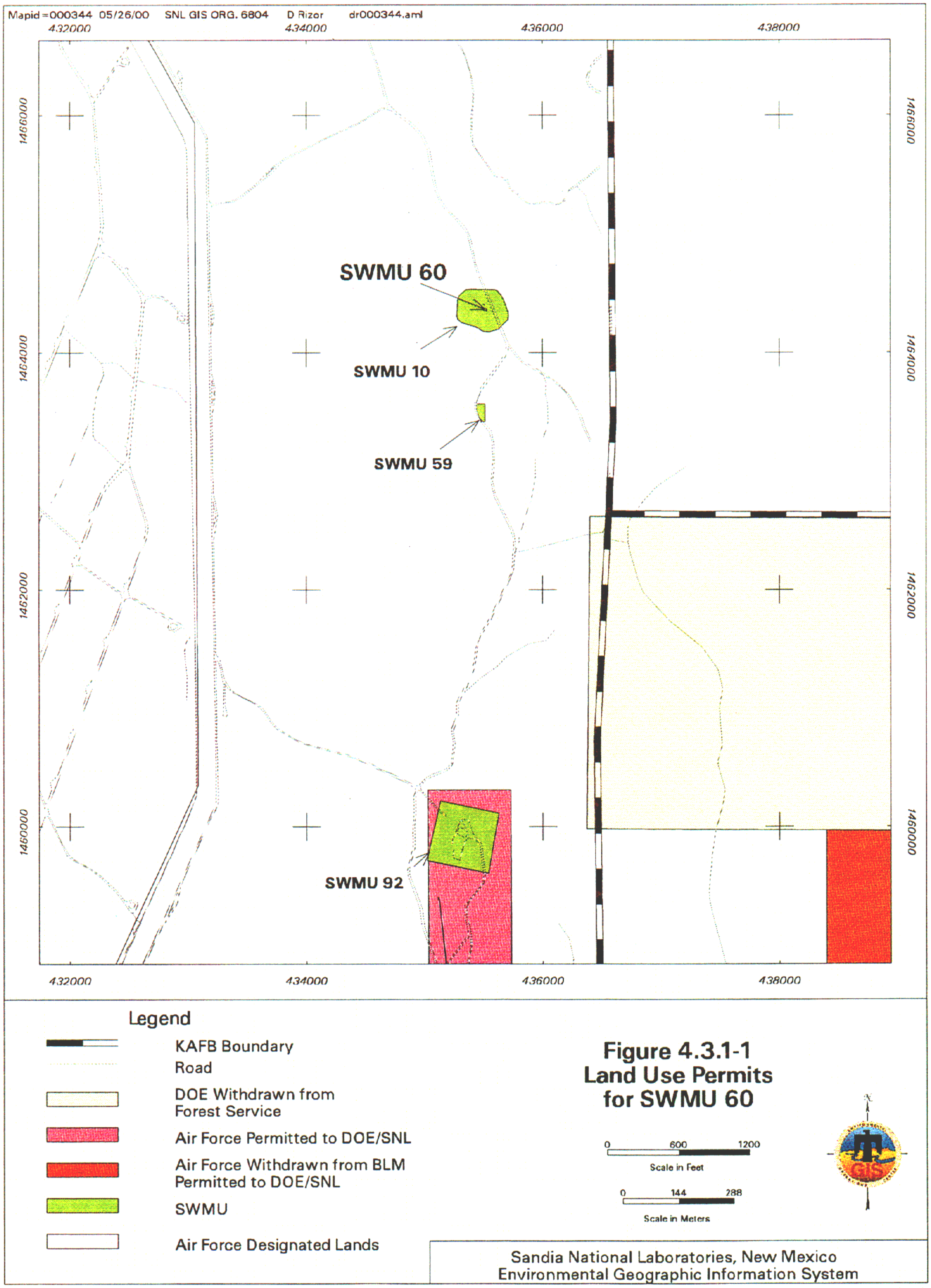

Figure 4.3.1-1
Land Use Permits for SWMU 60

4.4.1 Summary

SWMU 60 was investigated initially under the U.S. Department of Energy (DOE) Comprehensive Environmental Assessment and Response Program (CEARP) in the mid-1980s in conformance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The investigation included collecting nonsampling data and inspecting the site (Investigation #1). In 1989, preliminary investigations began that included unexploded ordnance (UXO)/HE, radiological, cultural resources, and sensitive-species surveys (Investigation #2). In 1999, a VCA was conducted and included additional site characterization activities, removal and disposal of the bunkers and associated debris, confirmatory sampling, and site restoration (Investigation #3).

4.4.2 Investigation #1—CEARP

4.4.2.1 Nonsampling Data Collection

SWMU 60 was first listed as a potential release site based upon the CEARP interviews in 1985. The CEARP Phase I draft report stated that the bunkers were used for a series of weapons tests and these weapons may have contained DU, beryllium, lead, and HE (DOE September 1987). The last test demolished the roof of the bunker. An SNL/NM radiometric survey showed some radioactive contamination at this site. The Resource Conservation and Recovery Act (RCRA) Facility Assessment Report stated that waste debris associated with weapons testing was buried in three soil mounds (EPA April 1987). The waste consisted of scrap metal, HE, beryllium, and lead.

4.4.2.2 Sampling Data Collection

No sampling activities were conducted at SWMU 60 as part of the CEARP or the RFA.

4.4.2.3 Data Gaps

No confirmation samples were obtained during the CEARP to confirm whether hazardous materials or wastes were stored or released to the surrounding environment. No Hazard Ranking System (HRS) or Modified HRS migration mode scores were calculated for SWMU 60.

4.4.2.4 Results and Conclusions

The CERCLA finding under the CEARP was positive for Federal Facility Site Discovery and identification findings, preliminary assessment, and preliminary site investigation, but insufficient information was available to calculate an HRS score for the SWMU.

4.4.3 Investigation #2—SNL/ER Preliminary Investigations

4.4.3.1 Nonsampling Data Collection

This section describes the nonsampling data collected at SWMU 60.

4.4.3.1.1 Background Review

A background review was conducted in order to collect available and relevant information regarding SWMU 60. Sources included interviews with SNL/NM staff and contractors familiar with the site's operational history and reviews of existing site records and reports. The study was documented completely and has provided traceable references that sustain the integrity of the NFA proposal. The following sources were used to assist in evaluating SWMU 60.

- Two SNL/NM technical reports on past site TABS testing activities (Kurowski January 1979, SNL/NM February 1979)
- Six historical aerial photographs spanning the years 1951 to 1992 (SNL/NM August 1994)
- Eight interviews with seven current and retired facility personnel (Martz October 1985, Larson and Palmieri September 1994, Larson August 1994, Brouillard June 1994, Larson and Palmieri August 1994a, Larson and Palmieri August 1994b, Palmieri November 1994, Wrightson September 1993)
- Photographs and field notes from numerous site inspections conducted by SNL/NM ER staff (Author [Unk] Date [Unk]a, Gaither January 1994, Gaither Date [Unk], Gaither November 1992, Author [Unk] Date [Unk]b, Author [Unk] Date [Unk]c, Gaither May 1992, Burton February 1987).

4.4.3.1.2 Unexploded Ordnance/High Explosives Survey

In September 1993, KAFB Explosive Ordnance Disposal personnel conducted a visual surface survey for UXO/HE on the ground surface of SWMUs 10 and 60. One live ground burst simulator was found and was removed in June 1994. The ordnance debris that were removed included twelve expended smoke grenades, two practice 40-millimeter (mm) grenades, three expended smoke pots, five empty White Star parachute containers, one empty homemade booby trap, one empty Molatov Cocktail, various pieces of unidentified rockets, and expended blank 7.6-mm and 5.6-mm ammunition (Young September 1994). It is believed that these materials were associated with KAFB war game operations.

4.4.3.1.3 Radiological Survey(s)

In addition to the DU removal activity after the TABS test in 1979, a 1989 radiation survey of SWMUs 10 and 60 conducted by SNL/NM RPO identified an area of radioactively-contaminated vermiculite. The radioactively-contaminated vermiculite was removed in 1989 and disposed of as radioactive waste. The remaining vermiculite mound was free of radioactive contamination (Gaither January 1994, Minnema and Tucker August 1989, Larson August 1994).

In May 1993, SNL/NM RPO conducted a radiation survey of the road leading to SWMU 60. Adhesive swipes that had been placed on the underside of the vehicle were analyzed and revealed no contamination, nor was airborne radioactivity detected in the dust kicked up by the vehicle (Oldewage May 1993).

In October 1993, RUST Geotech Inc. conducted a Phase I surface gamma radiation survey of SWMUs 10 and 60 (RUST Geotech December 1994). The survey was conducted on 6-foot centers and covered 100 percent of the site (Figure 4.4.3-1). The areas of gamma activity greater than 30 percent above natural background (10 to 16 microroentgens per hour [μR/hr]) included the following (SNL/NM September 1997):

- 21 fragment point source and small area source anomalies distributed in a circular pattern centered on the control bunker;
- 12 randomly located soil area source anomalies with no apparent pattern;
- 10 soil point-source anomalies in a circular distribution around the control bunker;
- 2 fragment area source anomalies located in the soil mound area within 100 feet of the control bunker;
- The control bunker floor and walls and a portion of the supply bunker; and
- 7 geologic outcrop anomalies concentrated near the northwestern corner of SWMU 60.

In February 1994, SNL/NM RPO personnel conducted a follow-up beta-gamma radiation survey at SWMUs 10 and 60 (SNL/NM September 1995). None of the measured swipe-sampled anomalies yielded removable contamination above the action levels detailed in DOE Order 5400.1, "General Environmental Protection Program," nor were radiation levels greater than 5 μR/hr at a distance of 1 foot. It is suspected that RUST Geotech anomalies of 60E+36, 60E+39, 60E+41, 60E+42, 60E+43, 60E+44, and 60E+45, identified in the Phase I survey, resulted from bedrock outcrops of granitic composition (Oldewage February 1994).

It should be noted that identified radiological anomalies, with the exception of the control bunker floor and walls, the supply bunker, and the geologic outcrops, were removed during the SWMU 10 radiological VCM conducted in April 1996.

4.4.3.1.4 Cultural Resources Survey

A cultural resources survey was conducted as part of the site assessment. One archeological site was identified north of SWMU 60, outside of the site boundary (Hoagland and Dello-Russo February 1995).

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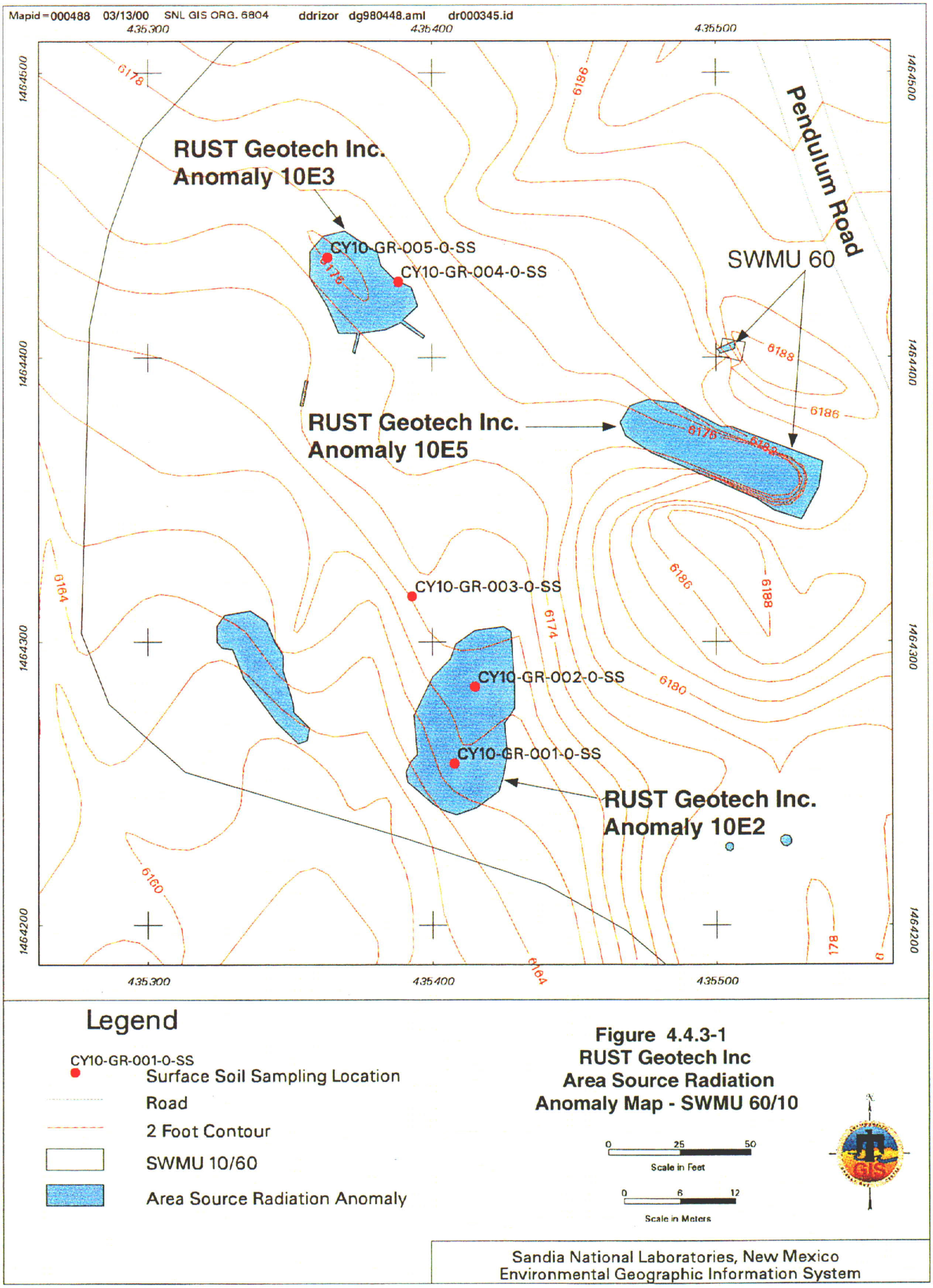


Figure 4.4.3-1
RUST Geotech Inc
Area Source Radiation
Anomaly Map - SWMU 60/10

4.4.3.1.5 *Sensitive-Species Survey*

The site was surveyed for sensitive species on April 26 and May 24, 1994, using parallel transects spaced 100 feet apart. The area is within piñon-juniper woodland vegetation, with an understory dominated by blue grama. The terrain is rolling, and the soil is coarse to rocky. A small but vigorous population of visnagita cacti was found on a low hill in the southeastern quarter of SWMU 10 near its outer boundary. A single Wright's pincushion cactus was found in the northeastern quarter of the survey area outside of the site boundary (IT February 1995).

4.4.3.2 *Sampling Data Collection*

No samples were collected at SWMU 60 during the preliminary investigations; however, preliminary radiological survey results indicated that the remaining structures and debris had some radiological contamination due to the explosion of two mock weapons containing DU. Activities at SWMU 10, particularly the radiological VCM conducted in April 1996 and the confirmatory sampling conducted after this VCM to support the NFA proposal, provided additional information useful in planning field activities at SWMU 60 (SNL/NM August 1998). Radiological anomalies were noted in the control bunker walls, roof, and some of the debris during this VCM. The results of this VCM/confirmatory sampling indicated DU to be the primary COC.

4.4.4 Investigation #3—SNL/NM ER VCA and Confirmatory Sampling

4.4.4.1 *Nonsampling Data Collection*

Investigation #3 consisted of the VCA remediation at SWMU 60. No nonsampling data collection activities were conducted as part of Investigation #3.

4.4.4.2 *VCA Activities*

The purpose of the SWMU 60 VCA was to remove all contaminated material from the site, rendering it suitable for future industrial or residential use. Before beginning the VCA, a project work plan was submitted to NMED Oversight Bureau for review and comment (SNL/NM February 1999).

<u>Permits</u>

A Topsoil Disturbance Permit was obtained from the City of Albuquerque because greater than three quarters of an acre would be disturbed during the VCA. A Hotwork Permit was also obtained from SNL/NM Facilities Engineering (No. 97-1193), and a Welding, Cutting, and Brazing Permit was obtained from the U.S. Air Force (No. 99-118). These permits were required because the galvanized metal roof of the bunker was going to be cut using an oxyacetylene torch. A Penetration/Dig Permit was obtained from SNL/NM Facilities Engineering. There were no buried utilities in the area.

Strategy

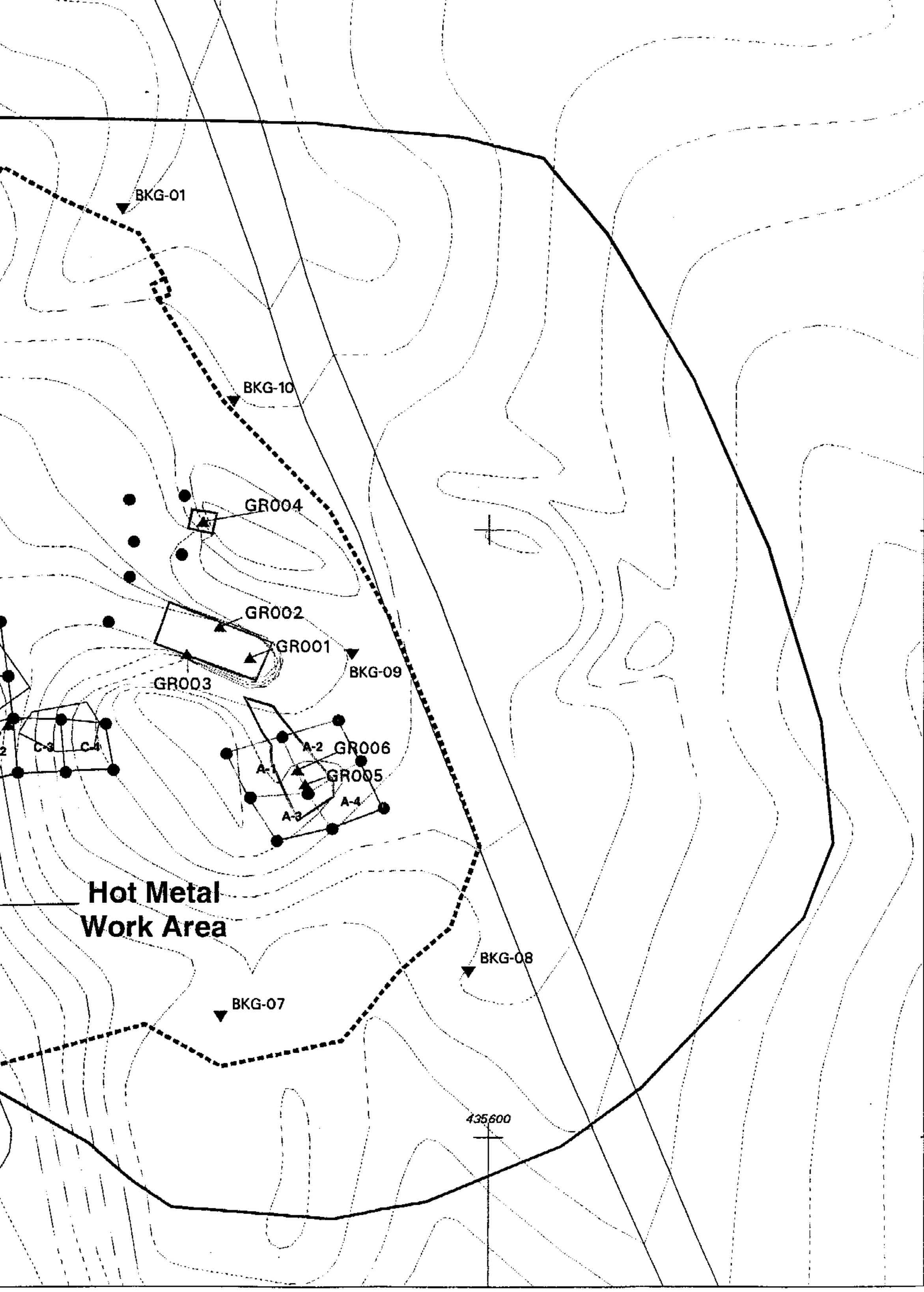
The overall strategy of the SWMU 60 VCA was to remove and properly dispose of all remaining structures, debris, and if encountered, any contaminated soil from the site. Specific elements of the VCA included:

- Characterization Sampling;
- Grading to clear a buffer zone around the hot metal work area and waste staging areas;
- A baseline radiological walkover survey of the proposed work area;
- A detailed radiological survey of the control bunker walls and floor;
- Cutting and segregation of metal debris;
- Removal and containerization of DU hotspots identified on the walls and floor of the control bunker;
- Removal of a small mercury anomaly identified during characterization sampling;
- Loading DU contaminated metal and debris into a transportainer for disposal;
- Beneficial reuse of noncontaminated concrete;
- A final radiological walkover survey;
- Confirmatory soil sampling; and
- Site restoration.

Chronology of Events

In January 1999, SNL/NM ER collected seven judgmental surface soil samples from areas most likely to be disturbed during the VCA (Figure 4.4.4-1). These samples were analyzed for HE, metals, and radionuclides at the Environmental Restoration Chemistry Laboratory (ERCL) and the Radiation Protection Sample Diagnostics (RPSD) Laboratory. The objective of this sampling activity was to determine whether there was contamination present in surface soil at levels that would be of concern for health and safety planning. The data was also evaluated to determine whether soil excavated to remove DU hotspots would have levels of HE or metals that might require handling as a mixed waste. Review of these data prior to start of the VCA showed that DU was the predominant COC.

SNL/NM ER mobilized to the site on February 3, 1999, with IT Corporation (IT) personnel contracted to perform the VCA. All surveys, contaminated debris loading, disposal of noncontaminated debris, and confirmatory sampling were completed by March 26, 1999. Site restoration activities were completed in July 1999. The transportainer of DU contaminated metal, soil, and



Characterization Sample Location
Grid Node
Background Radiological Survey Location
Road
2 Foot Contour
Surface Drainage
RWP Perimeter Fence
Former Bunkers/ Roof
SWMU 10
Residual Mound (Re-contoured during VCA)
Debris Pile
A-5 Sample Grid

0 50 100
Scale in Feet
0 12 24
Scale in Meters

SWMU 60

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

Figure 4.4.4-1
SWMU 60 - Radiological Survey Grids and Characterization Sample Locations

Transverse Mercator Projection, New Mexico State Plane Coordinate System, Central Zone, 1927 North American Horizontal Datum, 1929 North American Vertical Datum

1:600 MAPID=000489

Unclassified SNL GIS ORG. 6804

debris was transported to the Nevada Test Site (NTS) in September 1999. A summary of VCA activities by week is presented in Table 4.4.4-1.

Baseline Radiological Walkover Survey

To establish the background levels of radiation associated with the natural soil in the area, ten background monitoring points were established around the perimeter of the proposed work area (Figure 4.4.4-1). The background readings were measured utilizing a sodium-iodide detector and ranged from 1.36E+04 to 1.87E+04 counts per minute (cpm). The average background reading was 1.62E+04.

The waste staging areas were also surveyed to establish a baseline. The hot work area and the waste staging areas are identified in Figure 4.4.4-1. A five-meter grid was established over the proposed work areas, and a 100 percent radiological walkover survey was conducted using a sodium iodide detector. Readings were recorded at each corner and in the center of the grid, and the highest reading was recorded if encountered at a different location. Radiological survey data forms are included in Annex 4-A. No radiological anomalies were encountered during this baseline survey of the proposed work areas.

Detailed Radiological Survey of Control Bunker Walls and Floor

In order to facilitate surveying of the control bunker, it was necessary to remove excess soil that fell onto the control bunker floor after the roof was destroyed. This soil was removed using a backhoe and staged in a small soil pile. The floor and walls of the control bunker were divided into 4-foot by 4-foot grids and surveyed for radiological hotspots. The TABS test explosion visibly scarred the interior walls of the bunker and preliminary radiological surveys indicated DU was imbedded in the walls at several locations.

The walls of the bunker were surveyed using a Ludlum Model 2224 Gas Flow Detector, which detects both alpha and beta-gamma radiation and the floor of the bunker was surveyed using a sodium iodide probe (Figure 4.4.4-2). Several minor radiological hotspots were identified on the control bunker floor near the south wall and the former location of the front door. A number of hotspots were also identified on the concrete walls. DU contamination was discovered along most of the inner portion of the top of the walls after soil overburden was removed. Hotspots detected on the wall were marked with paint (Figure 4.4.4-3). Soil hotspot locations were marked with pin flags.

Surveying, Cutting, and Segregation of Metal Debris

Preliminary inspections of the control bunker roof (Figure 4.4.4-4) indicated that most of the interior side was contaminated with DU as a result of the TABS test explosion. An excavator was used to move the control bunker roof to the hot work area. The metal supply bunker was excavated and removed (Figures 4.4.4-5 and 4.4.4-6) and then staged in the hot work area with the roof and other metal debris. The hot work area was located near the southwest corner of the site in an area sheltered by the wind. The entire area had been graded previously using a dozer so that there was no combustible vegetation within a 30-foot radius of the area as

Table 4.4.4-1
Summary of SWMU 60 VCA Activities

Remediation Activity	Date of Activity
• Site mobilization and preparation • Baseline radiological surveys	02/22/99-02/26/99
• Move control bunker roof to hot metal cutting area • Transportainer delivery • Survey control bunker floor and walls • Survey and segregate metal debris • Sample and remove hotspots on control bunker floor • Excavate and remove supply bunker • Begin removal of hotspots on control bunker walls	03/01/99-03/05/99
• Obtain training for hot work permit • Cut metal roof and other debris • Continue surveys of debris for radiological contamination • Load transportainer with DU-contaminated metal and wood debris • Remove small mercury anomaly and collect confirmation samples • Start excavating around control bunker walls	03/08/99-03/12/99
• Remove additional hotspots identified on concrete walls during SNL/NM RCT free release survey • Arrange clean metal recycling • Collect confirmatory soil samples	03/15/99-03/19/99
• Free release surveys of concrete and metal debris completed • Concrete walls demolished • Clean concrete transported to KAFB LF-01 for use as fill material • Clean metal hauled off site by recycler • Containerize soil hotspots on floor of control bunker • Conduct final radiological walkover survey	03/22/99-03/26/99
• Collect waste characterization samples from drummed soil	04/03/99-04/09/99
• Regrade site, filling in control bunker and supply bunker excavations and leveling SWMU 10 soil mounds • Collect waste characterization samples of wood telephone poles • Broadcast native seed mix and water site	07/12/99-07/16/99
• Load transportainer for shipment to NTS	09/14/99

DU = Depleted uranium.
KAFB = Kirtland Air Force Base.
NTS = Nevada Test Site.
RCT = Radiation control technician.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid Waste Management Unit.
VCA = Voluntary Corrective Action.

Figure 4.4.4-2 Radiological Survey of Bunker Walls.

Figure 4.4.4-3 Radiological Survey of Bunker Walls. Hot Spots Marked with Paint.

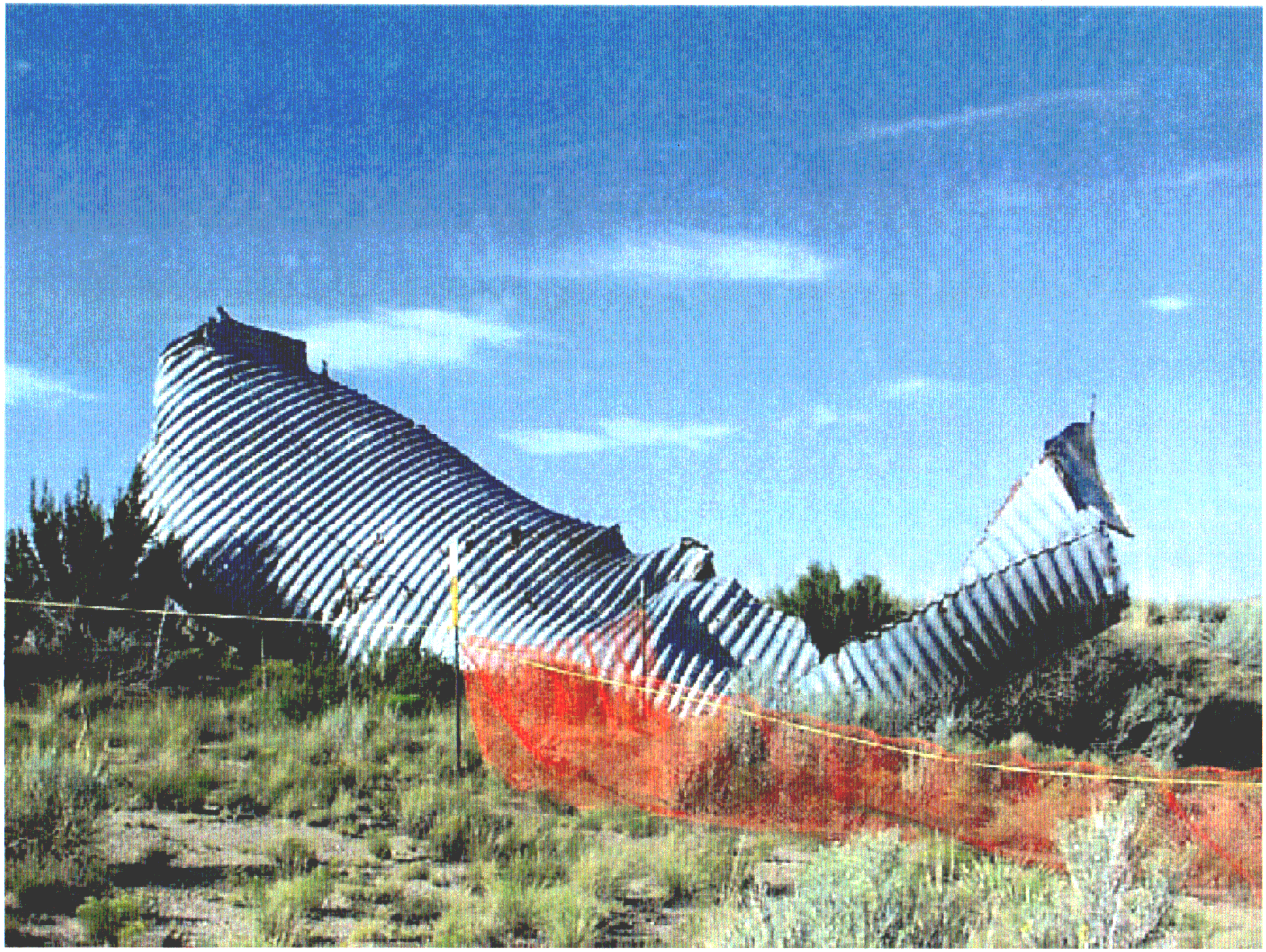


Figure 4.4.4-4
Control Bunker Roof.

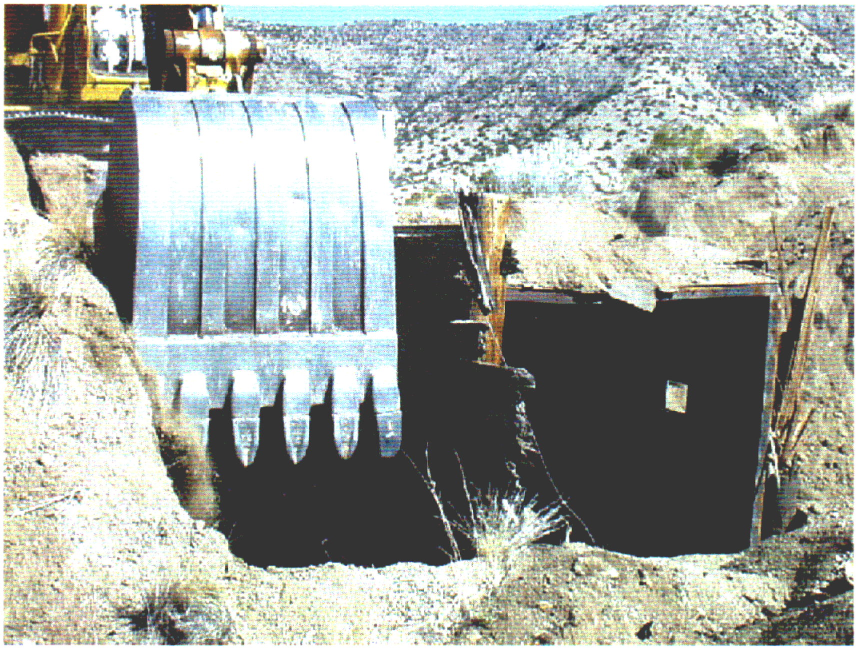


Figure 4.4.4-5 Excavating Supply Bunker.

Figure 4.4.4-6 Supply Bunker after Removal.

required by the hot work permit. The excavator was used to crush the roof flat with the interior side face up so that it could be surveyed for radiological contamination.

Radiological surveys were performed on all metal debris using a pancake probe (Figure 4.4.4-7). Almost the entire interior side of the roof of the bunker was contaminated with DU. Portions of the control bunker door and some of the other metal debris were also contaminated with DU. All pieces of metal surveyed and found to have contamination were given a letter/number designation and the activity of each piece of metal was recorded (Annex 4-A).

An oxyacetylene torch was used to cut the metal roof and other large sections of metal into smaller pieces that could be loaded into the transportainer. Galvanized metal releases zinc vapor when cut; therefore, the person using the cutting torch was in Level B (supplied air) and wore a fire resistant Nomex suit. A spotter assisted in monitoring the cutters hoses, air supply, and oxyacetylene tanks. A second person monitored the operation for sparks and fire hazards. During all cutting operations, a water truck was at the site with a fire hose staged next to the cutting area (Figure 4.4.4-8).

IT personnel conducted the initial radiological survey of metal and debris for contamination. Metal with DU contamination above background was staged in the hot work area before being loaded into the transportainer (Figure 4.4.4-9). After the contaminated metal was moved from the hot work area the metal slag associated with cutting the metal into manageable pieces was containerized in a drum. Metal identified as having no contamination was staged in the area immediately southwest of the transportainer. A second free release survey of all the metal staged for recycling was performed by SNL/NM RPO (SNL/NM March 1999a). After this survey was performed, the metal was staged just outside the perimeter fence by Pendulum Road. The metal was then loaded into a roll-off provided by the metal recycler and transported off site.

Removal of DU Hotspots from Control Bunker Walls and Floor

The removal of hotspots from the concrete walls of the control bunker was accomplished over a period of two weeks. A pneumatic hammer was used to chip away the areas of shallow DU contamination that had been marked with paint (Figure 4.4.4-10). Personnel operating the pneumatic hammer were in Level C personal protective equipment (PPE), wearing tyvek and a respirator. A sheet of heavy gauge plastic sheeting was laid out under the area where the concrete was chipped and the concrete chips were transferred from the plastic sheeting into 55-gallon drums. After an area was chipped, it was resurveyed by IT Radiation Technicians and, if any residual DU contamination was noted, the area was again marked with paint to identify areas requiring additional chipping. After all concrete hotspots were removed, SNL/NM radiation control technicians (RCT) performed a final free release survey of the concrete (SNL/NM March 1999b). A total of three 55-gallon drums of DU-contaminated concrete were generated.

The control bunker was installed below ground surface into weathered granitic bedrock. The bunker floor consists of weathered bedrock that is overlain by several inches of soil and loose bedrock. The radiological survey of the bunker floor is included in Annex 4-A. The granitic bedrock has a naturally higher level of activity, with readings ranging between 1.8 and 2.2E+04 cpm. After the radiological walkover survey was performed, three soil samples were collected from the floor

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Figure 4.4.4-7 Radiological Survey of Control Bunker Roof.

Figure 4.4.4-8 Cutting Control Bunker Roof.

Figure 4.4.4-9 Hot Metal Work Area.

Figure 4.4.4-10 Removing Hot Spots on Control Bunker Walls.

where the highest readings were measured. Gamma spectroscopy data from these locations verified anomalous levels of DU in the soil and these localized areas were subsequently excavated and containerized in drums. These data are discussed in Section 4.4.4.5.

Additional soil was removed along the south central portion of the wall and containerized in drums. There was more loose soil adjacent to the concrete wall in this area, which probably was related to over-excavation of the footer during installation of the wall. It was necessary to remove this soil in order to free release the bottom of the concrete wall. A total of four 55-gallon drums of soil were generated removing DU hotspots from the bunker floor. It should be noted that the volume of removable soil on the bunker floor was very small. Confirmation of hotspot removal was accomplished using direct read instruments, since all loose material was removed to bedrock.

Mercury Anomaly Removal

One of the initial characterization soil samples (CY60-GR-007) collected adjacent to the debris piles had a mercury detection of 92 milligrams per kilogram (mg/kg), which was significantly above the background concentration of 0.55 mg/kg. The soil in this area was not visibly stained, and there were no other metals detected above background. It is believed that this was a localized area of contamination related to a mercury switch or detonator. A 3-foot by 3-foot area was excavated to a depth of one foot, and this soil was containerized in a 55-gallon drum. Two soil samples were then collected for mercury analysis to confirm that all contaminated soil had been removed.

Loading DU-Contaminated Metal and Debris into Transportainer

After the contaminated metal was surveyed and size reduced using a cutting torch, it was loaded into a transportainer staged on site. Segments of the metal roof and other larger debris were placed in the transportainer first (Figure 4.4.4-11). There was a significant amount of wood debris at the site as telephone poles were used as structural support around both the supply bunker and the control bunker and the outside of the supply bunker was lined with 2- by 8-foot boards. Due to the porous nature of the wood, it could not be free released by the SNL/NM RCTs. Some of the telephone poles were size reduced using a chain saw and were loaded into the transportainer. Tires, PPE, and plastic liners used for waste staging were also loaded into the transportainer. The drums of soil were loaded into the transportainer after waste characterization results were reviewed, and it was determined that no RCRA hazardous chemicals were associated with the soil. Waste characterization data is discussed in Section 4.4.4.3.

Removal and Disposal of Concrete

After the concrete walls of the bunker were free released by SNL/NM RCTs, they were demolished using the excavator (Figures 4.4.4-12 and 4.4.4-13). The concrete was broken into small enough sections to be loaded into trucks, and excess rebar in the concrete was cut away. KAFB was actively seeking concrete to fill in a depression near Landfill 01, so approximately 60 cubic yards of concrete rubble was transported to a location specified by KAFB Environmental Management Staff (Freshour March 1999).

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Figure 4.4.4-11
Waste Staging Area after Metal Loaded into Transportainer.

Figure 4.4.4-12 Demolition of Control Bunker.

Figure 4.4.4-13 Control Bunker Area after Demolition and Removal.

4.4.4.3 *Waste Management*

The SWMU 60 VCA generated several types of waste material that was disposed of or recycled. The transportainer was loaded with DU-contaminated metal and potentially contaminated wood debris. A total of eight drums of DU-contaminated soil and concrete were also loaded in the transportainer. An inventory was kept of each piece of material that was placed in the transportainer.

All waste characterization sampling was performed in conformance with the requirements set forth by the SNL/NM ER Waste Management group. Required sampling for material loaded into the transportainer included Toxicity Characteristic Leaching Procedure (TCLP) sampling of two of the drums of soil, TCLP sampling of one of the telephone poles, and gamma spectroscopy data associated with hotspot sampling. These data showed that there were no RCRA hazardous chemicals in any of the material loaded into the transportainer. An inventory of material loaded into the transportainer, including sampling data, is presented in SNL/NM ER Waste Management Memorandum 99-022 (SNL/NM 1999a).

The mercury anomaly detected at CY60-GR-007 was excavated, and the soil was containerized in a single 55-gallon drum. Existing analytical data was used for waste characterization, and the drum of soil was transported to the SNL/NM ER Hazardous Waste Management Facility for disposal. Details regarding this material are included in SNL/NM ER Waste Management Memorandum 99-020 (SNL/NM 1999b).

After DU hotspots were removed from the concrete walls of the control bunker, the walls were demolished, and the concrete rubble was transported by truck to a location specified by KAFB Environmental Management and used as fill material. Correspondence with KAFB Environmental Management regarding beneficial reuse of the concrete and the free-release survey for the concrete are included in SNL/NM ER Waste Management Memorandum 99-052 (SNL/NM 1999c).

4.4.4.4 *VCA Confirmatory Work*

To verify that SWMU 60 was adequately remediated during the VCA, confirmatory work consisted of a final radiological walkover survey performed by IT personnel; a radiological walkover survey performed by SNL/NM RCTs after site restoration activities were completed, and evaluation of characterization sampling data and confirmatory sampling data to assess the residual levels of COCs remaining in soil at the site.

Radiological Walkover Survey

After all the metal, concrete, and debris had been either removed from the site or containerized, IT Radiation Technicians performed a final radiological walkover survey of the hot work area, the waste staging area, the former debris piles, the bunker roof location, and the control bunker floor. No readings above background were noted at any of these locations. The survey results are presented in Annex 4-A.

Site Restoration

Site restoration activities included filling in the excavations associated with removal of the supply bunker and the control bunker, leveling the SWMU 10 soil mounds, and then recontouring the area to reduce the slope of the hillside towards the arroyo (Figures 4.4.4-14 and 4.4.4-15). After regrading was completed, the area was reseeded using a mix of blue grama, galleta, sideoats grama, and Indian ricegrass. The seed mix was broadcast over the graded site, and then the area was watered.

Final Radiological Walkover Survey

After site restoration activities were completed, SNL/NM RCTs performed a final radiological walkover survey of the entire regraded area. No readings above background were detected. The final radiological free-release survey is included as Annex 4-B.

Confirmatory Soil Sampling

Table 4.4.4-2 summarizes the environmental samples collected at SWMU 60. In January 1999, seven surface soil samples (0 to 6 inches) were collected to characterize COCs in soil prior to start of the VCA. These samples were analyzed for HE and RCRA metals plus beryllium at ERCL, and for gamma spectroscopy at RPSD Laboratory. Five of the seven samples were collected from locations that did not require remediation; hence, these data are appropriate for evaluating residual levels of COCs in soil after completion of the VCA. A number of samples were collected to assess contamination for waste characterization. The waste characterization samples not used in the risk screening assessment are highlighted on Table 4.4.4-2, as are the characterization sample locations that were subsequently remediated. After completing the debris segregation/removal phase of the project, ten confirmatory surface soil samples were collected from SWMU 60. These samples were analyzed for HE, RCRA metals plus beryllium, and uranium at an off-site laboratory. Four of the samples were also analyzed for gross alpha/beta and gamma spectroscopy. RPSD Laboratory also performed gamma spectroscopy analyses on a portion of these samples. Soil sampling locations are shown in Figure 4.4.4-16.

Table 4.4.4-3 summarizes the analytical methods used for the characterization and confirmation samples collected on this project. Characterization and confirmation samples were collected judgmentally from locations most likely to have residual soil contamination. The rationale for each sample location is noted in Table 4.4.4-2.

4.4.4.5 Data Gaps

Analytical data from the characterization and confirmatory sampling are sufficient to determine the nature and extent of residual COCs that remain following the VCA. There are no further data gaps regarding characterization of SWMU 60.

4.4.4.6 Results and Conclusions

In January 1999, seven surface soil samples (CY60-GR-001 – CY60-GR-007) were collected at SWMU 60 and were analyzed for metals, HE, and radionuclides in order to characterize levels

Figure 4.4.4-14
Regrading of SWMU 60 after VCA.

Figure 4.4.4-15
SWMU 60 after Site Restoration.

Table 4.4.4-2
SWMU 60—Voluntary Corrective Action
Index to Soil Samples

Sample ID	Laboratory: Analyses[a]	Rationale	Comments
CY60-GR-001	ERCL: HE, metals RPSD: gamma spectroscopy	Determine COCs present in soil prior to start of VCA.	Inside control bunker near back wall.
CY60-GR-002	ERCL: HE, metals RPSD: gamma spectroscopy	Determine COCs present in soil prior to start of VCA.	Inside control bunker near north wall central.
CY60-GR-003	ERCL: HE, metals RPSD: gamma spectroscopy	Determine COCs present in soil prior to start of VCA.	Inside control bunker near south wall next to bunker entrance. Area removed as hotspot.
CY60-GR-004	ERCL: HE, metals RPSD: gamma spectroscopy	Determine COCs present in soil prior to start of VCA.	Soil from inside supply bunker.
CY60-GR-005	ERCL: HE, metals RPSD: gamma spectroscopy	Determine COCs present in soil prior to start of VCA.	Under control bunker roof.
CY60-GR-006	ERCL: HE, metals RPSD: gamma spectroscopy	Determine COCs present in soil prior to start of VCA.	Under control bunker roof.
CY60-GR-007	ERCL: HE, metals RPSD: gamma spectroscopy	Determine COCs present in soil prior to start of VCA.	Large debris pile, under control bunker door. Mercury anomaly in soil (removed).
CY60-GR-008	RPSD: gamma spectroscopy	Correlate hot spots identified during rad survey with gamma spectroscopy results.	Waste Characterization. Depleted uranium hotspot containerized in drum.
CY60-GR-009	RPSD: gamma spectroscopy	Correlate hot spots identified during rad survey with gamma spectroscopy results.	Waste Characterization. Depleted uranium hotspot containerized in drum.
CY60-GR-010	RPSD: gamma spectroscopy	Correlate hot spots identified during rad survey with gamma spectroscopy results.	Waste Characterization. Depleted uranium hotspot containerized in drum.
CY60-GR-011	RPSD: gamma spectroscopy	Correlate background location in rad survey with gamma spectroscopy results	Background sample location from initial radiological survey grid in proposed waste staging area.
CY60-GR-012	ERCL: mercury RPSD: gamma spectroscopy	Verify that mercury hit (GR-007) has been removed.	Mercury analysis only.
CY60-GR-013	ERCL: mercury RPSD: gamma spectroscopy	Verify that mercury hit (GR-007) has been removed.	Mercury analysis only.
CY60-GR-014	RPSD: gamma spectroscopy	Determine whether soil in corners of bunker is rad.	Soil removed from corners of control bunker prior to radiological survey of walls. Soil pile spread on site after review of data.
CY60-GR-015	RPSD: gamma spectroscopy	Determine whether vermiculite found in supply bunker had radiological contamination.	Grab sample of vermiculite that was bagged during removal of supply bunker. Vermiculite placed in transportainer.
CY60-GR-016	GEL: HE, metals, gamma spectroscopy, gross alpha/beta RPSD: gamma spectroscopy	Confirmatory sample.	From east central portion of control bunker floor.
CY60-GR-017	GEL: HE, metals, gamma spectroscopy, gross alpha/beta RPSD: gamma spectroscopy	Confirmatory sample.	From west central portion of control bunker floor.
CY60-GR-018	GEL: HE, metals, gamma spectroscopy, gross alpha/beta RPSD: gamma spectroscopy	Confirmatory sample.	Former debris pile area.

Refer to footnotes at end of table.

Table 4.4.4-2
SWMU 60—Voluntary Corrective Action
Index to Soil Samples (Concluded)

Sample ID	Laboratory: Analyses[a]	Rationale	Comments
CY60-GR-019	GEL: HE, metals, gamma spectroscopy, gross alpha/beta RPSD: gamma spectroscopy	Confirmatory sample.	Former control bunker roof area.
CY60-GR-020	GEL: HE, metals RPSD: gamma spectroscopy	Confirmatory sample.	Former control bunker door area.
CY60-GR-021	GEL: HE, metals RPSD: gamma spectroscopy	Confirmatory sample.	Hot metal work area.
CY60-GR-022	GEL: HE, metals RPSD: gamma spectroscopy	Confirmatory sample.	Hot metal work area.
CY60-GR-023	GEL: HE, metals RPSD: gamma spectroscopy	Confirmatory sample.	Hot metal work area.
CY60-GR-024	GEL: HE, metals RPSD: gamma spectroscopy	Confirmatory sample.	Hot metal staging area next to transportainer.
CY60-GR-025	GEL: HE, metals RPSD: gamma spectroscopy	Confirmatory sample.	Under floor of supply bunker.
CY60-GR-026	GEL: TCLP-VOCs, SVOCs, metals, HE, gamma spectroscopy	Waste characterization sample of containerized soil.	No RCRA hazardous chemicals in soil. Results presented in SNL/NM ERwm 99-022.[b]
CY60-GR-027	GELT: CLP-VOCs, SVOCs, metals, HE, gamma spectroscopy	Waste characterization sample of containerized soil.	No RCRA hazardous chemicals in soil. Results presented in SNL/NM ERwm 99-022.[b]
CY60-GR-028	GEL: TCLP-VOCs, SVOCs, metals	Waste characterization sample of wood telephone pole.	No RCRA hazardous chemicals in soil. Results presented in SNL/NM ERwm 99-022.[b]
CY60-GR-028-DU	GEL: TCLP-VOCs, SVOCs, metals	Waste characterization sample of wood telephone pole (duplicate).	No RCRA hazardous chemicals in soil. Results presented in SNL/NM ERwm 99-022.[b]

Note: Shaded rows indicate either waste characterization samples or soil from a location removed during VCA not used in the Risk Screening Assessment.

[a]Metals analysis included RCRA metals plus beryllium (and uranium for confirmatory samples).

[b]SNL/NM 1991a.

COC = Constituent(s) of concern.
CY = Canyon.
DU = Duplicate.
ERCL = Environmental Restoration Chemistry Laboratory.
ERwm = Environmental Restoration Waste Management.
GEL = General Engineering Laboratory.
GR = Grab sample.
HE = High explosives.
ID = Identification.
Rad = Radiological.
RCRA = Resource Conservation and Recovery Act.
RPSD = Radiation Protection Sample Diagnostics.
SNL/NM = Sandia National Laboratories/New Mexico.
SVOC = Semivolatile organic compound.
SWMU = Solid Waste Management Unit.
TCLP = Toxicity characteristic leaching procedure.
VCA = Voluntary Corrective Action.
VOC = Volatile organic compound.

Figure 4.4.4-16
SWMU 60
Sample Locations

Transverse Mercator Projection, New Mexico State Plane Coordinate System, Central Zone, 1927 North American Horizontal Datum, 1929 North American Vertical Datum

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Table 4.4.4-3
Summary of Analytical Methods Used for SWMU 60
Characterization and Confirmatory Soil Samples

Analyte	Analytical Method	Analytical Laboratory
Radionuclides	EPA 901.1[a] (gamma spectroscopy)	GEL, RPSD
Gross alpha/beta	EPA 900.0[a]	GEL
RCRA metals	6010/7000 series[a]	ERCL, GEL
Total uranium	908.1[a]	GEL
HE compounds	MEKC, 8330[a]	ERCL, GEL

[a]EPA November 1986.
EPA = U.S. Environmental Protection Agency.
ERCL = Environmental Restoration Chemistry Laboratory.
GEL = General Engineering Laboratory.
HE = High explosives.
MEKC = Micellar electrokinetic chromatograph.
RCRA = Resource Conservation and Recovery Act.
RPSD = Radiation Protection Sample Diagnostics.
SWMU = Solid Waste Management Unit.

of COCs in soil prior to the VCA. Review of these data indicated that COCs were limited to DU and beryllium and some isolated detections of lead, silver, and cadmium, which were slightly above the naturally occurring background concentrations. There was an elevated mercury detection in sample CY60-GR-007.

During the VCA, eight soil samples (CY60-GR-008 through CY60-GR-015) were collected and analyzed using gamma spectroscopy at RPSD Laboratory. Surface soil samples (CY60-GR-008, CY60-GR-009, CY60-GR-010) were collected at three locations on the floor of the control bunker in order to correlate hotspots identified during the radiological survey with fixed-base gamma spectroscopy data from RPSD Laboratory. These hotspots were excavated and containerized in drums. One additional sample (CY60-GR-011) was collected for analysis at RPSD Laboratory from the proposed waste staging area, where radiological survey readings were within the background range.

The mercury anomaly identified during the characterization sampling was removed during the VCA, and two samples (CY60-GR-012 and CY60-GR-013) were collected for mercury analyses at ERCL. These samples were collected to verify that the mercury anomaly had been removed.

In order to conduct the detailed radiological survey of the control bunker floor and walls, it was necessary to remove soil that had fallen into the back corners of the bunker from above. This soil was removed using a backhoe and staged in a small soil pile (3-4 cubic yards) west of the bunker. One soil sample (CY60-GR-014) was collected from the pile for gamma spectroscopy analysis at RPSD Laboratory. After review of the data, this pile was leveled.

Several bags of vermiculite were present in the supply bunker under soil that partially filled the bottom of the bunker. Some of these bags were broken open during removal of the supply bunker. The vermiculite was shoveled into several bags. A sample (CY60-GR-015) of the vermiculite was sent to RPSD Laboratory for gamma spectroscopy analysis. The vermiculite did not have elevated levels of radiological activity; however, because there was room in the transportainer, the vermiculite was placed in it for disposal.

After completion of the VCA ten confirmatory surface soil samples (CY60-GR-016 through CY60-GR-025) were collected from locations at SWMU 60 most likely to have residual levels of COCs. These samples were analyzed for RCRA metals plus beryllium, uranium, and HE at an off-site laboratory. Four of the confirmatory samples were also analyzed for gross alpha/beta and gamma spectroscopy at the off-site laboratory. A portion of each confirmatory sample was analyzed using gamma spectroscopy at RPSD Laboratory in order to release the samples to the off-site laboratory.

Two surface soil samples (CY60-GR-016 and CY60-GR-017) were collected from the floor of the control bunker. One sample (CY60-GR-018) was collected from the former location of the debris pile that consisted mainly of wood and concrete. One sample was collected from the former location of the control bunker roof (CY60-GR-019) and one sample (CY60-GR-020) was collected from the former location of the control bunker door. Three samples (CY60-GR-021 through CY60-GR-023) were collected from the hot work area and one sample (CY60-GR-024) was collected from the area where hot metal was staged on a pallet prior to loading in the transportainer. Lastly, one sample (CY60-GR-025) was collected from the former location of the supply bunker.

Metals

Table 4.4.4-4 summarizes the metals analytical results for the seven characterization samples. Arsenic, barium, and selenium were not detected above the background concentration limit in any of the characterization samples. Beryllium was detected above the 0.75 mg/kg background concentration limit in all three samples (CY60-GR-001-SS, CY60-GR-002-SS, and CY60-GR-003-SS) collected on the floor of the control bunker and in the sample collected under the control bunker roof (CY60-GR-006-SS). Beryllium concentrations at these locations ranged between 0.82 and 12.0 mg/kg. The CY60-GR-003-SS sample location was removed during the VCA. Cadmium was detected slightly above the 0.64 mg/kg background concentration limit in one sample, CY60-GR-003-SS collected on the floor of the control bunker. Chromium was detected above the 18.8 mg/kg background concentration limit in two samples, CY60-GR-001-SS (32 mg/kg) collected on the floor of the bunker, and CY60-GR-004-SS (23 mg/kg). Lead was detected above the 18.9 mg/kg background concentration limit in one sample, CY60-GR-002-SS, collected on the bunker floor. Mercury was detected above the 0.055 background concentration limit in one sample, CY60-GR-007-SS, which was collected under the control bunker door debris pile. The concentration of mercury was 92 mg/kg, and this area of soil contamination was removed during the VCA. Silver was detected above the <0.5 mg/kg nonquantifiable background concentration limit in two samples, CY60-GR-001-SS and CY60-GR-003-SS.

Table 4.4.4-5 summarizes the metals analytical results for the ten confirmatory samples.

Arsenic, barium, lead, mercury, and selenium were not detected above the background concentration limits in any of the confirmatory soil samples. Beryllium was detected at slightly above the background limit of 0.75 mg/kg at one location (CY60-GR-017-SS) collected on the

Table 4.4.4-4
Summary of SWMU 60 Characterization Soil Sampling Metals Analytical Results
January 1999
(On-Site Laboratory)

Sample Attributes			Metals (EPA Methods 6010/7000)[a] (mg/kg)								
Record Number[b]	ER Sample ID (Figure 4.4.4-16)[c]	Sample Depth (ft)	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
601240	CY60-**GR-001**-SS	0.0–0.5	ND (0.66)	110	**12**	0.53	**32**	11.0	ND (0.044)	1.7	**0.63**
601240	CY60-**GR-002**-SS	0.0–0.5	0.86 J (2.8)	110	**0.82**	0.46	13	**22**	ND (0.047)	1.6	0.47
601240	CY60-**GR-003**-SS	0.0–0.5	0.74 J (2.8)	93	**1.6**	**0.66**	14	11	ND (0.044)	1.9	**0.59**
601240	CY60-**GR-004**-SS	0.0–0.5	1.2 J (2.8)	130	0.73	0.32	**23**	9.8	ND (0.044)	1.9	0.098
601240	CY60-**GR-005**-SS	0.0–0.5	1.2 J (2.8)	120	0.67	0.35	4.4	8.2	ND (0.043)	1.3	0.096 J (0.17)
601240	CY60-**GR-006**-SS	0.0–0.5	ND (0.62)	81	**0.93**	0.47	3.5	9.2	ND (0.041)	1.5	0.066 J (0.16)
601240	CY60-**GR-007**-SS	0.0–0.5	ND (0.64)	83	0.56	0.62	1.3	5.0	**92**	1.2 J (1.3)	0.063 J (0.17)
601653	GR-012[d]	NA	NA	NA	NA	NA	NA	NA	**0.056**	NA	NA
601653	GR-013[d]	NA	NA	NA	NA	NA	NA	NA	ND (0.042)	NA	NA
Background Soil Concentrations—Canyon Area[e]			9.8	246	0.75	0.64	18.8	18.9	0.055	2.7	<0.5

Note: Values in **bold** exceed background soil concentrations.
[a]EPA November 1986.
[b]Analysis request/chain-of-custody record.
[c]**Bold** portion of the Sample ID corresponds to location shown on Figure 4.4.4-16.
[d]GR-012 and GR-013 were collected to verify area of mercury-contaminated soil cleaned up.
[e]From Garcia November 1998.

CY = Canyon.
EPA = U.S. Environmental Protection Agency.
ER = Environmental Restoration.
ft = Foot (feet).
GR = Grab sample.
ID = Identification.
J ( ) = The reported value is greater than or equal to the MDL, but is less than the practical quantitation limit for on-site laboratory analyses or the reporting detection limit for off-site laboratory analyses, shown in parentheses.
MDL = Method detection limit.
mg/kg = Milligram(s) per kilogram.
NA = Not analyzed.
ND ( ) = Not detected above the MDL, shown in parentheses.
SS = Surface soil sample.
SWMU = Solid Waste Management Unit.

Table 4.4.4-5
Summary of SWMU 60 Confirmatory Soil Sampling Metals Analytical Results
March 1999
(Off-Site Laboratory)

Sample Attributes			Metals (EPA Methods 6010/7000)[a] (mg/kg)									
Record Number[b]	ER Sample ID[c] (Figure 4.4.4-16)	Sample Depth (ft)	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver	Uranium
601656	CY60-**GR-016**-SS	0.0–0.5	2.22	69.6	0.693	0.518	5.59	7.31	0.0165 J	0.866	**0.504** J	2.74 J
601656	CY60-**GR-017**-SS	0.0–0.5	3.42	103	**1.02**	**0.809**	**29.4**	7.71	0.0169 J	1.11	0.303 J	**13.0**
601656	CY60-**GR-018**-SS	0.0–0.5	2.78	75.2	**0.757**	0.568	9.46	10.8	0.0130 J	1.21	ND (0.031)	2.51
601656	CY60-**GR-019**-SS	0.0–0.5	3.15	97.2	0.607	0.489	6.5	6.71	0.0159 J	0.970	ND (0.031)	0.602
601656	CY60-**GR-020**-SS	0.0–0.5	2.89	82.3	**1.09**	0.550	7.38	6.38	0.0113 J	1.02	ND (0.031)	**4.07**
601656	CY60-**GR-021**-SS	0.0–0.5	2.65	74.3	0.652	0.447 J (0.476)	6.61	6.68	0.0177 J	1.01	ND (0.031)	2.07
601656	CY60-**GR-022**-SS	0.0–0.5	2.75	93.5	0.583	0.432 J (0.481)	13.2	7.16	0.00867 J	0.843	ND (0.031)	0.506
601656	CY60-**GR-023**-SS	0.0–0.5	2.83	86.1	0.628	0.542	15.5	6.54	0.0150 J	0.983	ND (0.031)	2.03
601656	CY60-**GR-024**-SS	0.0–0.5	2.50	99.7	0.534	0.433 J (0.481)	18.8	6.19	0.0128 J	1.10	ND (0.031)	**4.30**
601656	CY60-**GR-025**-SS	0.0–0.5	2.63	17.5	0.624	0.585	5.15	5.37	0.00296 J	1.18	ND (0.031)	1.45
Background Soil Concentrations—Canyon Area[d]			9.8	246	0.75	0.64	18.8	18.9	0.055	2.7	<0.5	3.42
Quality Assurance/Quality Control Sample (mg/L)												
601656	CY60-EB	NA	ND (0.00451)	ND (0.00051)	ND (0.00500)	ND (0.00026)	0.000607J	ND (0.00159)	ND (0.000035)	ND (0.00271)	ND (0.00073)	0.000294

Note: Values in **bold** exceed background soil concentrations.

[a]EPA November 1986.

[b]Analysis request/chain-of-custody record.

[c]**Bold** portion of the Sample ID corresponds to location shown on Figure 4.4.4-16.

[d]From Garcia November 1998.

CY = Canyon.
EB = Equipment blank.
ER = Environmental Restoration.
ft = Foot (feet).
GR = Grab sample.
ID = Identification.
J () = The reported value is greater than or equal to the MDL, but is less than the practical quantitation limit for on-site laboratory analyses or the reporting detection limit for off-site laboratory analyses, shown in parentheses.
J = Analytical result was qualified as an estimation during data validation.
MDL = Method detection limit.
mg/kg = Milligram(s) per kilogram.
mg/L = Milligram(s) per liter.
NA = Not analyzed.
ND () = Not detected above the MDL, shown in parentheses.
SS = Surface soil sample.
SWMU = Solid Waste Management Unit.

floor of the former control bunker and at two locations (CY60-GR-018-SS and CY60-GR-020-SS) where debris was removed. Beryllium detections greater than background ranged between 0.76 and 1.09 mg/kg. Cadmium was detected above the 0.64 mg/kg background concentration limit in one sample, CY60-GR-017-SS, at a concentration of 0.809 mg/kg. Chromium was detected above the 18.8 mg/kg background concentration limit in one sample, CY60-GR-017-SS, at a concentration of 29.4 mg/kg. Silver was detected slightly above the <0.5 mg/kg nonquantifiable background concentration limit in one sample, CY60-GR-016-SS. Uranium (as a metal) was detected above the 3.42 mg/kg background concentration limit at three of the ten sample locations (CY60-GR-017-SS, CY60-GR-020-SS, CY60-GR-024-SS) at concentrations ranging from 4.07 to 13.0 mg/kg. With the exception of the uranium detection in CY60-GR-024-SS, there were no metal detections above background at any of the sample locations collected in the hot metal work area or in the waste staging area.

HE

Because there are no background concentrations for HE compounds in soil, any detectable HE compounds in the samples collected at SWMU 60 would have been considered an indication of contamination. However, no HE compounds were detected in any of the soil samples collected at SWMU 60. Tables 4.4.4-6 and 4.4.4-7 summarize the detection limits for analysis of HE compounds by the on-site and off-site laboratories.

Radionuclides

Tables 4.4.4-8, 4.4.4-9, 4.4.4-10, 4.4.4-11, and 4.4.4-12 summarize the gamma spectroscopy data associated with the SWMU 60 VCA. Annex 4-C contains the complete analytical results for the gamma spectroscopy. Table 4.4.4-8 presents the RPSD Laboratory gamma spectroscopy results associated with the seven characterization samples. Uranium-238 was detected above the background level of 2.31 pCi/g in four of the seven samples (CY60-GR-001-SS, CY60-GR-003-SS, CY60-GR-006-SS, and CY60-GR-007-SS); however, at two of these locations (CY60-GR-003-SS and CY60-GR-007-SS), the soil was removed during the VCA. At the two remaining sample locations (CY60-GR-001-SS and CY60-GR-006-SS), uranium-238 values were 5.93 pCi/g and 3.29 pCi/g, respectively. Thorium-232 values were above the background level of 1.03 pCi/g at all locations, CY60-GR-001-SS through CY60-GR-007-SS. It should be noted that over half of all the soil samples collected at SWMU 60 and previously at SWMU 10 had anomalous levels of thorium-232. It is likely that background levels of thorium are elevated in this area due to the proximity of granitic bedrock to the ground surface. Uranium-235 was detected above the background level of 0.16 pCi/g at one location, CY60-GR-002-SS at a concentration of 0.207 pCi/g. The detection limit for uranium 235 was greater than background at two of the sample locations. Cesium-137 was not detected above the background limit of 0.515 pCi/g at any of the sample locations.

During the VCA, hotspots on the bunker floor were sampled (CY60-GR-008-SS through CY60-GR-010-SS) prior to removal. One sample (CY60-GR-011-SS) was also collected from a location where radiological survey results indicated background conditions. These samples were analyzed at RPSD Laboratory using gamma spectroscopy. The results are included as Table 4.4.4-9. Uranium-238 and uranium-235 levels were approximately an order of magnitude higher than background in the samples collected from the soil hotspots, CY60-GR-008-SS

Table 4.4.4-6
HE Analytical Detection Limits Used for SWMU 60
January 1999
(On-Site Laboratory)

Analyte	Soil Sample Method Detection Limit (mg/kg)
2-Amino-4,6-dinitrotoluene	0.12
4-Amino-2,6-dinitrotoluene	0.15
1,3-Dinitrobenzene	0.18
2,4-Dinitrotoluene	0.23–0.24
2,6-Dinitrotoluene	0.27–0.28
HMX	0.12
Nitrobenzene	0.16
2-Nitrotoluene	0.14
3-Nitrotoluene	0.14
4-Nitrotoluene	0.12
Pentaerythritol tetranitrate	0.32–0.33
RDX	0.25–0.26
1,3,5-Trinitrobenzene	0.13
2,4,6-Trinitrotoluene	0.27–0.28

HE = High explosive(s).
HMX = 1,3,5,7-Tetranitro-1,3,5,7-tetrazacyclooctane.
mg/kg = Milligram(s) per kilogram.
RDX = 1,3,5-Trinitro-1,3,5-triazacyclohexane.
SWMU = Solid Waste Management Unit.

Table 4.4.4-7
HE Analytical Detection Limits Used for SWMU 60
March 1999
(Off-Site Laboratory)

Analyte	Soil Sample Method Detection Limit (μg/kg)
2-Amino-4,6-dinitrotoluene	6.6
4-Amino-2,6-dinitrotoluene	5.5
1,3-Dinitrobenzene	4.1
2,4-Dinitrotoluene	6.2
2,6-Dinitrotoluene	6.5
HMX	5.3
Nitrobenzene	5.2
2-Nitrotoluene	7.8
3-Nitrotoluene	11
4-Nitrotoluene	11
RDX	9.7
Tetryl	7.5
1,3,5-Trinitrobenzene	6.6
2,4,6-Trinitrotoluene	5.7

HE = High explosive(s).
HMX = 1,3,5,7-Tetranitro-1,3,5,7-tetrazacyclooctane.
μg/kg = Microgram(s) per kilogram.
RDX = 1,3,5-Trinitro-1,3,5-triazacyclohexane.
SWMU = Solid Waste Management Unit.
Tetryl = 2,4,6-Trinitrophenylmethylnitramine.

Table 4.4.4-8
Summary of SWMU 60 Characterization Soil Sampling Gamma Spectroscopy Analytical Results
January 1999
(On-Site Laboratory)

Sample Attributes			Gamma Spectroscopy Activity (pCi/g)							
Record Number[a]	ER Sample ID (Figure 4.4.4-16)[b]	Sample Depth (ft)	Cesium-137		Thorium-232		Uranium-235		Uranium-238	
			Results	Error[c]	Results	Error[c]	Results	Error[c]	Results	Error[c]
601241	CY60-**GR-001**-SS	0.0–0.5	0.0204	0.0248	**1.48**	2.51	0.139	0.229	**5.93**	2.41
601241	CY60-**GR-002**-SS	0.0–0.5	0.0607	0.0418	**1.36**	0.668	**0.207**	0.205	2.04	0.813
601241	CY60-**GR-003**-SS	0.0–0.5	0.0438	0.0425	**1.40**	0.711	0.0964	0.119	**5.37**	1.30
601241	CY60-**GR-004**-SS	0.0–0.5	ND (0.0436)	--	**1.37**	0.629	ND (0.241)	--	ND (0.645)	--
601241	CY60-**GR-005**-SS	0.0–0.5	0.0354	0.0177	**1.38**	0.697	0.112	0.204	1.59	0.576
601241	CY60-**GR-006**-SS	0.0–0.5	ND (0.0433)	--	**1.43**	0.699	ND (0.157)	--	**3.29**	0.779
601241	CY60-**GR-007**-SS	0.0–0.5	0.0549	0.0410	**1.56**	0.716	ND (0.191)	--	**8.31**	1.63
Background Soil Activities—Upper Canyon Area[d]			0.515	NA	1.03	NA	0.16	NA	2.31	NA

Note: Values in **bold** exceed background soil activities.
[a]Analysis request/chain-of-custody record.
[b]**Bold** portion of the Sample ID corresponds to location shown on Figure 4.4.4-16.
[c]Two standard deviations about the mean detected activity.
[d]From Dinwiddie September 1997.
CY = Canyon.
ER = Environmental Restoration.
ft = Foot (feet).
GR = Grab sample.
ID = Identification.
NA = Not applicable.
ND = Not detected above the minimum detectable activity, shown in parentheses.
pCi/g = Picocurie(s) per gram.
SS = Surface soil sample.
SWMU = Solid Waste Management Unit.
-- = Error not calculated for nondetectable results.

Table 4.4.4-9
SWMU 60 Radiological Survey Hotspots, Bunker Floor, Gamma Spectroscopy Analytical Results
March 1999 (Hotspots Removed During VCA)
(On-Site Laboratory)

Sample Attributes			Activity (pCi/g)							
Record Number[a]	ER Sample ID[b] (Figure 4.4.4-16)	Sample Depth (ft)	Cesium-137		Thorium-232		Uranium-235		Uranium-238	
			Results	Error[c]	Results	Error[c]	Results	Error[c]	Results	Error[c]
601642	CY60-**GR-008**-SS	0.0–0.5	0.066	0.0320	**1.47**	0.839	**3.83**	2.53	**297**	43.0
601642	CY60-**GR-009**-SS	0.0–0.5	0.0831	0.0438	**1.26**	0.671	**1.04**	0.415	**84.1**	36.5
601642	CY60-**GR-010**-SS	0.0–0.5	ND (0.0618)	--	**1.69**	0.960	**2.39**	0.742	**203**	29.3
601642	CY60-**GR-011**-SS (Background)	0.0–0.5	0.175	0.0517	**1.27**	2.28	0.113	0.188	ND (0.674)	--
Background Soil Activities—Upper Canyon Area[d]			0.515	NA	1.03	NA	0.16	NA	2.31	NA

Note: Values in **bold** exceed background soil activities.
[a]Analysis request/chain-of-custody record.
[b]**Bold** portion of the Sample ID corresponds to the location shown in Figure 4.4.4-16.
[c]Two standard deviations about the mean detected activity.
[d]From Dinwiddie September 1997.

CY = Canyon.
ER = Environmental Restoration.
ft = Foot (feet).
GR = Grab sample.
ID = Identification.
NA = Not applicable.
ND = Not detected above the minimum detectable activity, shown in parentheses.
pCi/g = Picocurie(s) per gram.
SS = Surface soil sample.
SWMU = Solid Waste Management Unit.
VCA = Voluntary Corrective Action.
-- = Error not calculated for nondetectable results.

Table 4.4.4-10
Summary of SWMU 60 Waste Characterization Soil Sampling Gamma Spectroscopy Analytical Results
March 1999
(On-Site Laboratory)

Sample Attributes			Gamma Spectroscopy Activity (pCi/g)							
			Cesium-137		Thorium-232		Uranium-235		Uranium-238	
Record Number[a]	ER Sample ID[b] (Figure 4.4.4-16)	Sample Depth (ft)	Results	Error[c]	Results	Error[c]	Results	Error[c]	Results	Error[c]
601652	CY60-**GR-012**-SS	0.0–0.5	ND (0.0327)	--	**1.27**	0.612	ND (0.234)	--	ND (0.651)	--
601652	CY60-**GR-013**-SS	0.0–0.5	ND (0.0316)	--	**1.26**	0.610	ND (0.239)	--	ND (0.690)	--
601652	CY60-**GR-014**-SS	0.0–0.5	ND (0.0309)	--	**1.25**	0.625	ND (0.240)	--	2.19	0.676
601652	CY60-**GR-015**-SS	0.0–0.5	ND (0.0435)	--	0.836		ND (0.294)	--	ND (1.02)	--
Background Soil Activities—Upper Canyon Area[d]			0.515	NA	1.03	NA	0.16	NA	2.31	NA

Note: Values in **bold** exceed background soil activities.

[a]Analysis request/chain-of-custody record.

[b]**Bold** portion of the Sample ID corresponds to the location shown in Figure 4.4.4-16.

[c]Two standard deviations about the mean detected activity.

[d]From Dinwiddie September 1997.

CY = Canyon.
ER = Environmental Restoration.
ft = Foot (feet).
GR = Grab sample.
ID = Identification.
NA = Not applicable.
ND = Not detected above the minimum detectable activity, shown in parentheses.
pCi/g = Picocurie(s) per gram.
SS = Surface soil sample.
SWMU = Solid Waste Management Unit.
-- = Error not calculated for nondetectable results.

Table 4.4.4-11
Summary of SWMU 60 Confirmatory Soil Sampling Gamma Spectroscopy Analytical Results
March 1999
(On-Site Laboratory)

Sample Attributes			Activity (pCi/g)							
			Cesium-137		Thorium-232		Uranium-235		Uranium-238	
Record Number[a]	ER Sample ID[b] (Figure 4.4.4-16)	Sample Depth (ft)	Results	Error[c]	Results	Error[c]	Results	Error[c]	Results	Error[c]
601657	CY60-**GR-016**-SS	0.0–0.5	0.0374	0.0318	**1.07**	0.543	ND (0.224)	--	1.84	0.563
601657	CY60-**GR-017**-SS	0.0–0.5	ND (0.0245)	--	**1.43**	0.706	ND (0.254)	--	**5.60**	1.26
601657	CY60-**GR-018**-SS	0.0–0.5	0.0337	0.0349	1.03	0.519	**0.190**	0.192	2.27	0.619
601657	CY60-**GR-019**-SS	0.0–0.5	0.0421	0.0447	**1.05**	0.552	0.134	0.195	ND (0.643)	--
601657	CY60-**GR-020**-SS	0.0–0.5	0.0602	0.0359	**1.12**	1.70	**0.201**	0.194	1.17	0.523
601657	CY60-**GR-021**-SS	0.0–0.5	0.0354	0.0231	**1.14**	0.575	ND (0.232)	--	1.21	0.626
601657	CY60-**GR-022**-SS	0.0–0.5	0.0502	0.0444	0.953	0.505	ND (0.216)	--	ND (0.0562)	--
601657	CY60-**GR-023**-SS	0.0–0.5	0.0332	0.0368	0.973	0.506	**0.208**	0.186	1.39	0.526
601657	CY60-**GR-024**-SS	0.0–0.5	ND (0.0441)	--	**1.05**	0.580	ND (0.236)	--	2.26	0.901
601657	CY60-**GR-025**-SS	0.0–0.5	ND (0.0414)	--	**1.34**	0.674	ND (0.242)	--	ND (0.635)	--
Background Soil Activities—Upper Canyon Area[d]			0.515	NA	1.03	NA	0.16	NA	2.31	NA

Note: Values in **bold** exceed background soil activities.
[a]Analysis request/chain-of-custody record.
[b]**Bold** portion of the Sample ID corresponds to the location shown in Figure 4.4.4-16.
[c]Two standard deviations about the mean detected activity.
[d]From Dinwiddie September 1997.
CY = Canyon.
ER = Environmental Restoration.
ft = Foot (feet).
GR = Grab sample.
ID = Identification.
NA = Not applicable.
ND = Not detected above the minimum detectable activity, shown in parentheses.
pCi/g = Picocurie(s) per gram.
SS = Surface soil sample.
SWMU = Solid Waste Management Unit.
-- = Error not calculated for nondetectable results.

Table 4.4.4-12
Summary of SWMU 60 Confirmatory Soil Sampling Gamma Spectroscopy Analytical Results
March 1999
(Off-Site Laboratory)

Sample Attributes			Gamma Spectroscopy Activity (pCi/g)							
			Cesium-137		Thorium-232		Uranium-235		Uranium-238	
Record Number[a]	ER Sample ID[b] (Figure 4.4.4-16)	Sample Depth (ft)	Results	Error[c]	Results	Error[c]	Results	Error[c]	Results	Error[c]
601656	CY60-**GR-016**-SS	0.0–0.5	ND (0.00806)	0.0161	0.868	0.104	ND (0.00705)	0.125	1.21	0.808
601656	CY60-**GR-017**-SS	0.0–0.5	0.0402	0.0334	**1.38**	0.167	0.142	0.19	**4.65**	1.93
601656	CY60-**GR-018**-SS	0.0–0.5	0.0828	0.0326	**1.13**	0.146	**0.224**	0.18	**2.33**	1.58
601656	CY60-**GR-019**-SS	0.0–0.5	0.0533	0.0341	**1.23**	0.147	0.0843	0.174	0.919	1.07
Background Soil Activities—Upper Canyon Area[d]			0.515	NA	1.03	NA	0.16	NA	2.31	NA

Note: Values in **bold** exceed background soil activities.

[a]Analysis request/chain-of-custody record.

[b]**Bold** portion of the Sample ID corresponds to the location shown in Figure 4.4.4-16.

[c]Two standard deviations about the mean detected activity.

[d]From Dinwiddie September 1997.

CY = Canyon.
ER = Environmental Restoration.
ft = Foot (feet).
GR = Grab sample.
ID = Identification.
NA = Not applicable.
ND = Not detected above the minimum detectable activity, shown in parentheses.
pCi/g = Picocurie(s) per gram.
SS = Surface soil sample.
SWMU = Solid Waste Management Unit.
-- = Error not calculated for nondetectable results.

through CY-GR-010-SS. Thorium concentrations were greater than background at all sample locations.

Cesium-137 was not detected above the background level at any of the sample locations. These data were used to characterize the containerized soil that was shipped to the NTS for disposal.

Four additional samples were collected during the VCA for gamma spectroscopy analysis at RPSD Laboratory in order to make field decisions regarding waste characterization. The results are included as Table 4.4.4-10. After removal of the mercury anomaly, two confirmatory soil samples (CY60-GR-012-SS and CY60-GR-013-SS) were collected to verify that this area had no radiological contamination. One soil sample (CY60-GR-014-SS) was collected from a soil pile associated with removal of dirt from the corners of the control bunker and one sample (CY60-GR-015-SS) of vermiculite found in the supply bunker was collected. Uranium-238, uranium-235, and cesium-137 were not detected above background limits in any of these samples. Thorium was detected above background in all three soil samples, but not in the vermiculite sample.

After the VCA was completed, ten confirmatory samples were collected. All of these samples were analyzed using gamma spectroscopy at RPSD Laboratory as required to release samples for off-site analyses. Four of the confirmatory samples were also analyzed using gamma spectroscopy and gross alpha/beta at an off-site laboratory. These data are summarized in Tables 4.4.4-11 and 4.4.4-12, respectively. Uranium-238 was detected above the background level of 2.31 pCi/g in one (CY60-GR-017-SS) of the ten samples analyzed at RPSD Laboratory at an activity of 5.60 pCi/g. Thorium was detected slightly above the background level of 1.03 pCi/g in seven of the ten soil samples; the other three samples were at or only slightly below background. Uranium-235 was detected slightly above the background level of 0.16 pCi/g at three locations (CY60-GR-018-SS, CY60-GR-020-SS, and CY60-GR-023-SS. The minimum detectable activity (MDA) for uranium-235 was greater than the background level for six of the ten samples that were analyzed at RPSD Laboratory. Cesium-137 was not detected above background at any of the sample locations.

The four samples collected for off-site gamma spectroscopy were collected from the areas most likely to have residual DU contamination. Two samples (CY60-GR-016-SS and CY60-GR-017-SS) were collected from the floor of the control bunker, one sample (CY60-GR-018-SS) was collected from the former debris pile area, and one sample (CY60-GR-019-SS) was collected from surface soil at the former location of the control bunker roof. Uranium-238 was detected above the background level of 2.31 pCi/g in two samples, CY60-GR-017-SS and CY60-GR-018-SS, at activities of 4.65 pCi/g and 2.33 pCi/g, respectively. Three of the four samples had thorium-232 activities slightly greater than the background level of 1.03 pCi/g. Uranium-235 was detected above the background level of 0.16 pCi/g in one sample, CY60-GR-018-SS. Cesium-137 was not detected above the background level at any of the sample locations.

Gross Alpha and Gross Beta

Four of the confirmatory soil samples sent to the off-site laboratory were analyzed for gross alpha and gross beta. The results are summarized in Table 4.4.4-13. Gross alpha activities were slightly above the background level of 18.3 pCi/g in samples CY60-GR-017-SS

Table 4.4.4-13
Summary of SWMU 60 Confirmatory Soil Sampling
Gross Alpha and Gross Beta Analytical Results
March 1999
(Off-Site Laboratory)

Sample Attributes			Activity (pCi/g)			
			Gross Alpha		Gross Beta	
Record Number[a]	ER Sample ID[b] (Figure 4.4.4-16)	Sample Depth (ft)	Results	Error[c]	Results	Error[c]
Inside Bunker						
601656	CY60-**GR-016**-SS	0.0–0.05	13.7	3.54	30.7	3.89
601656	CY60-**GR-017**-SS	0.0–0.05	**20.1**	4.25	42.5	4.06
601656	CY60-**GR-018**-SS	0.0–0.05	**20.3**	4.25	37.9	4.05
601656	CY60-**GR-019**-SS	0.0–0.05	16.9	4.01	30.2	3.8
Background Soil Activities—Canyon Area[d]			18.3	NA	52.7	NA

Note: Values in **bold** exceed background soil activities.
[a]Analysis request/chain-of-custody record.
[b]**Bold** portion of the Sample ID corresponds to the location shown in Figure 4.4.4-16.
[c]Two standard deviations about the mean detected activity.
[d]From Dinwiddie September 1997.
CY = Canyon.
ER = Environmental Restoration.
ft = Foot (feet).
GEL = General Engineering Laboratory.
GR = Grab sample.
ID = Identification.
NA = Not applicable.
pCi/g = Picocurie(s) per gram.
SS = Surface soil sample.
SWMU = Solid Waste Management Unit.

and CY60-GR-018-SS. Gross alpha activities were 20.1 and 20.3 pCi/g, respectively. Gross beta activities were within the background limit of 52.7 pCi/g.

Data Quality

Table 4.4.4-5 presents the results of the analysis of the metals QA/QC sample collected during the confirmatory sampling program at SWMU 60. One equipment rinsate sample (CY60-EB) was collected with the confirmatory soil samples. No HE was detected in the equipment rinsate sample. Metals concentrations in the equipment rinsate were all nondetect with the exception of chromium, which was detected at a concentration of 0.000607 J mg/L, and uranium, which was detected at a concentration of 0.000294 mg/L. The concentration of chromium was below the practical quantitation limit and was qualified J (estimated value). No QA/QC samples were collected for radionuclide analyses. No duplicate samples were collected.

Data Validation

All on-site laboratory results were reviewed and verified/validated according to "Verification and Validation of Chemical and Radiochemical Data," TOP 94-03 (SNL/NM July 1994b). All off-site laboratory results were reviewed and verified/validated according to "Data Validation Procedure for Chemical and Radiochemical Data," AOP 00-03, Rev. 0 (SNL/NM December 1999). All gamma spectroscopy data were reviewed by SNL/NM Department 7713 RPSD Laboratory according to "Laboratory Data Review Guidelines," Procedure No. RPSD-02-11, Issue No: 02 (SNL/NM July 1996). Annex 4-D contains the off-site data validation reports. The verification/validation process confirmed that the data are acceptable for use in this NFA proposal for SWMU 60.

During data validation, qualifications were applied to metals data due to blank contamination. Chromium was detected in the initial calibration blank, affecting one sample. Silver was detected in the continuing calibration blank, affecting two samples. Mercury was detected in the method blank, affecting ten samples. All blank contamination resulted in estimated concentrations of the analytes.

4.5 Site Conceptual Model

The site conceptual model for SWMU 60 is based upon the residual COCs identified in surface soil samples following the VCA activities. This section summarizes the nature and extent of contamination and the environmental fate of COCs.

4.5.1 Nature and Extent of Contamination

The COCs at SWMU 60 are metals and radionuclides associated with the TABS test explosion, which destroyed the control bunker in 1979. No HE compounds were detected in any of the soil samples. The HE apparently was consumed in the initial explosion.

Metal and radionuclide COCs were determined by comparing sample results to background concentrations and activities that had been established in the Canyons Area (Dinwiddie

September 1997, Garcia November 1998). Any metal or radionuclide found to exceed background in any sample was considered a potential COC for the site. Consequently, metal COCs included beryllium, cadmium, chromium, lead, mercury, silver, and uranium. The radiological COCs include uranium-235, uranium-238, and thorium-232. Because the MDAs for uranium-235 analyses exceed background activity limits, nondetect sample results are also considered in identifying potential COCs. Table 4.5.1-1 summarizes the COCs for SWMU 60. Refer to Table 4.4.4-2 for sample locations that were removed during the VCA and are not included as COC locations.

Radionuclide and metal COCs did exceed background activities or concentrations in a few of the surface soil samples collected in areas where contaminated structures or debris were removed. The samples collected in the waste staging areas had only isolated detections of radionuclide and metal COCs exceeding background.

As stated previously, most samples had thorium-232 activities slightly above the background level established from samples collected around the Lurance Canyon Burn Site. Presumably, the elevated thorium-232 activity at SWMU 60/10 is related to the soil being comprised of weathered granitic bedrock. Uranium-238 was the primary radionuclide detected above background as a result of past explosives testing using DU. Beryllium was the primary metal COC detected above background.

The confirmatory surface soil samples are considered to be representative of the soil potentially contaminated with COCs and sufficient to determine the vertical extent, if any, of COCs due to the following. The TABS test explosion released COCs to surface soil. Also, there was no information suggesting that materials had been buried at the site and the depth to bedrock ranged from 0, on the control bunker floor, to less than 2 feet. Additionally, the vertical rate of contamination migration was expected to be extremely low for SWMU 60 because of the low precipitation, high evapotranspiration, impermeable vadose zone soils, and the relatively low solubility of DU and metals.

4.5.2 Environmental Fate

The primary source of COCs at SWMU 60 was the TABS test explosion in 1979, when two mock weapons containing DU and beryllium detonated inside the control bunker. The explosion destroyed the control bunker, contaminating the roof of the bunker, the walls of the bunker, and surrounding surface soil with DU. The primary release mechanism of COCs occurred during this event. The SWMU 10 VCM removed most of the DU from the blast radius, with the exception of surface soil underlying the debris piles, the control bunker roof, and the control bunker floor. This remaining contaminated debris may have released COCs to the underlying surface soil over time. SWMU 60 lies immediately east of a small surface drainage. During the VCA, the site was recontoured to minimize erosion into a nearby surface drainage and contaminated debris and soil were removed during the SWMU 60 VCA. During intense rainfall events surface runoff can actively erode the site and could be considered a release mechanism.

Possible secondary release mechanisms include suspension and/or dissolution of trace levels of residual COCs in surface-water runoff and in percolation to the vadose zone, direct contact or receptors with soil (radionuclides only), dust emissions, and uptake of COCs in the soil by biota (Figure 4.5.2-1). The depth to groundwater at the site (approximately 220 feet bgs) precludes

Table 4.5.1-1
Summary of Residual COCs for SWMU 60

COC Type	Number of Samples	COCs Greater Than Background	Maximum Background Limit/Canyon Area[a] (mg/kg, except where noted)	Maximum Concentration (mg/kg, except where noted)	Average Concentration[b] (mg/kg, except where noted)	Sampling Locations Where Background Concentration Exceeded[c]
Metals	15 environmental	Arsenic	9.8	3.42	2.16	None
		Beryllium	0.75	12	1.489	CY60-GR-001-SS CY60-GR-002-SS CY60-GR-006-SS CY60-GR-017-SS CY60-GR-018-SS CY60-GR-020-SS
	15 environmental	Barium	246	130	90	None
	15 environmental	Cadmium	0.64	0.809	0.500	CY60-GR-017-SS
	15 environmental	Chromium	18.8	32	12.9	CY60-GR-001-SS CY60-GR-004-SS CY60-GR-017-SS
	15 environmental	Lead	18.9	22	8.74	CY60-GR-002-SS
	17 environmental	Mercury	0.055	0.056	0.026	CY60-GR-012-SS
	15 environmental	Selenium	3.0	1.7	1.22	None
	15 environmental	Silver	<0.5	0.63	0.152	CY60-GR-001-SS
	10 environmental	Uranium	3.42	13	3.32	CY60-GR-017-SS CY60-GR-020-SS CY60-GR-024-SS
Radionuclides	20 environmental	Cesium-137	0.515 pCi/g	0.175 pCi/g	Not calculated[d]	None
		Thorium-232	1.03 pCi/g	1.48 pCi/g	Not calculated[d]	16 of 20 samples above background
		Uranium-235	0.16 pCi/g	0.254 pCi/g	Not calculated[d]	CY60-GR-002-SS CY60-GR-018-SS CY60-GR-020-SS MDA greater than background in 10 samples
		Uranium-238	2.31	5.93	Not calculated[d]	CY60-GR-001-SS CY60-GR-006-SS CY60-GR-017-SS CY60-GR-018-SS

Refer to footnotes at end of table.

Table 4.5.1-1
Summary of Residual COCs for SWMU 60 (Concluded)

[a]From Dinwiddie September 1997 (radionuclides) and Garcia November 1998 (metals).
[b]Average concentration includes all samples. For nondetectable results, the detection limit is used to calculate the average.
[c]Includes all samples with nondetectable results where the MDA exceeds background (radionuclides).
[d]An average MDA is not calculated because of the variability in instrument counting error and the number of reported nondetectable activities.

COC = Constituent of concern.
CY = Canyon.
GR = Grab sample.
J = The reported value is greater than or equal to the method detection limit, but is less than the practical quantitation limit.
MDA = Minimum detectable activity.
mg/kg = Milligram(s) per kilogram.
pCi/g = Picocurie(s) per gram.
SS = Soil sample.
SWMU = Solid Waste Management Unit.

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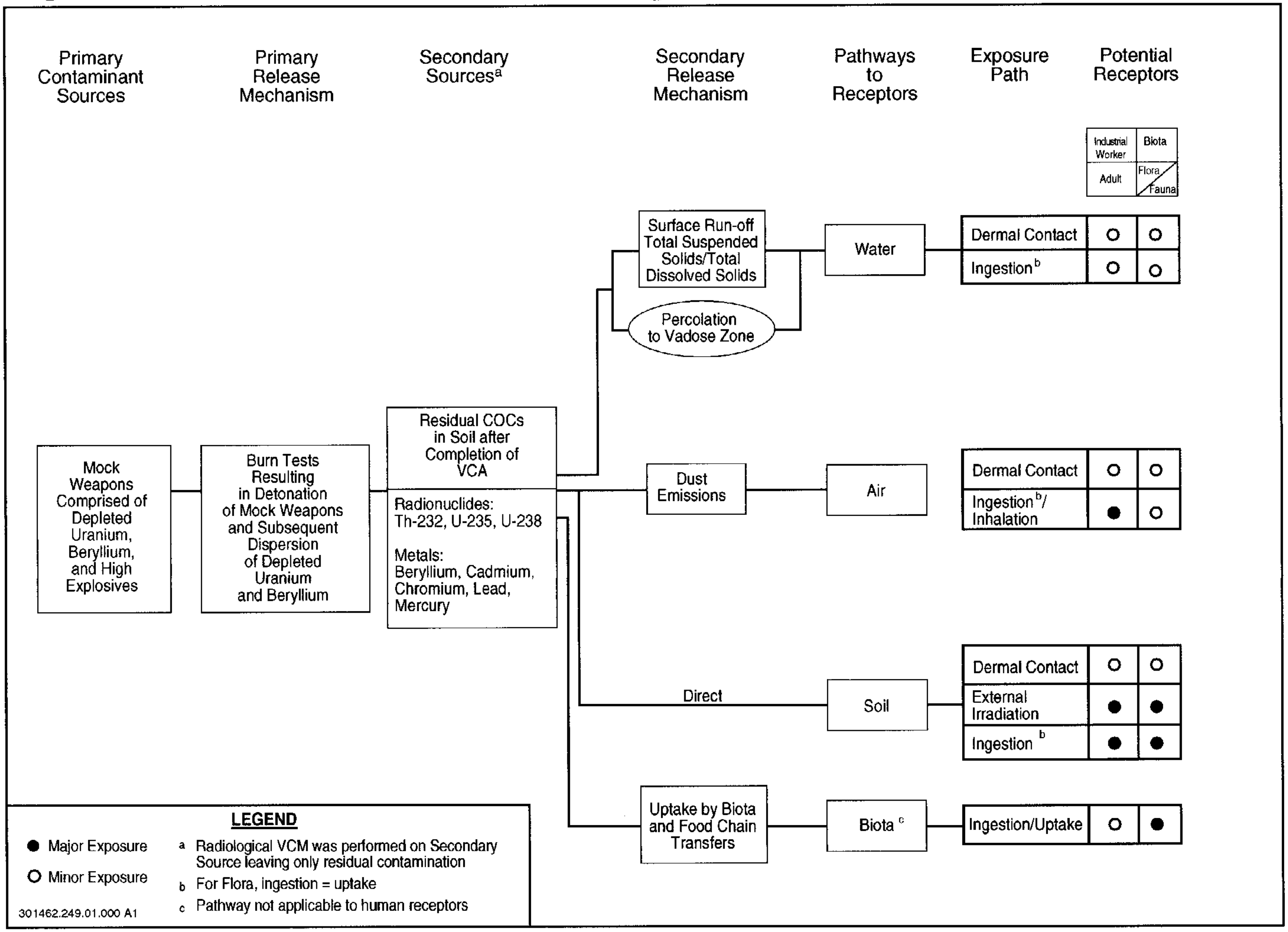

* Source: SWMU 10 NFA AL/7-98/SNL:R4400-3.doc 301462.183.03 08/06/98

Figure 4.5.2-1

Conceptual Model Flow Diagram for SWMU 60

migration of residual COCs to the shallow groundwater system. The pathways to receptors are soil ingestion, inhalation, and direct exposure (to radionuclides). Plant uptake was also considered as a pathway for the residential scenario only. Annex 4-E provides additional discussion of the fate and transport of COCs at SWMU 60.

The current and future land use for SWMU 60 is industrial (DOE and USAF March 1996). However, because the site is close to private housing developments, a residential land use is also considered. For all applicable pathways, the exposure route for the receptor is dermal contact and ingestion/inhalation. In addition, the receptor could be exposed by external irradiation from radionuclides in soil. Only external irradiation and ingestion of soil are considered major exposure routes for the receptor. Potential biota receptors include flora and fauna at the site. Similar to the human receptor, external irradiation and ingestion of soil are considered major exposure routes for biota, in addition to ingesting COCs through food chain transfers or indirect uptake. Annex 4-E provides additional discussion of the exposure routes and receptors at SWMU 60.

4.6 Site Assessments

The site assessment at SWMU 60 includes risk screening assessments followed by risk baseline assessments (as required) for both human health and ecological risk. The following sections summarize the site assessment results. Annex 4-E provides details of the site assessment.

4.6.1 Summary

After considering the uncertainties associated with the available data and modeling assumptions, ecological risks associated with SWMU 60 were found to be very low, and the site assessment concludes that SWMU 60 has no significant potential to affect human health under a residential or industrial land use scenario. Section 4.6.2 briefly describes and Annex 4-E provides details of the site screening assessments.

4.6.2 Screening Assessments

Risk screening assessments were performed for both human health risk and ecological risk for SWMU 60. This section briefly summarizes the risk screening assessments.

4.6.2.1 Human Health

SWMU 60 has been recommended for industrial land use (DOE et al. October 1995); due to the proximity of the area to private housing developments located north and east of the base boundary, a residential land use scenario was also evaluated. Annex 4-E provides a complete discussion of the risk assessment process, results, and uncertainties.

Because COCs are present in concentrations or activities greater than background levels at the site, it was necessary to perform a human health risk assessment analysis, which provides a quantitative evaluation of the potential adverse human health effects caused by constituents in the site's soil. This assessment included any metals and radionuclides detected either above background levels and/or above MDAs. The Risk Assessment Report calculated the hazard index (HI) and excess cancer risk for a recreational land use setting. The excess cancer risk from nonradiological COCs and the radiological COCs is not additive (EPA 1989).

In summary, the HI calculated for SWMU 60 for nonradiological COCs is 0.02 for an industrial land use setting and 0.9 for a residential land use setting, which are less than the numerical standard of 1.0 suggested by risk assessment guidance (EPA 1989). Incremental risk is determined by subtracting risk associated with background from potential nonradiological COC risk. The incremental HI is 0.02 for the industrial land-use setting and 0.25 for a residential land-use setting. The excess cancer risk for SWMU 60 for nonradiological COCs is 8E-08 for an industrial land use setting and 1E-07 for a residential land-use setting. Guidance from NMED indicates that excess lifetime risk of developing cancer by an individual must be less than 1E-06 for Class A and B carcinogens and less than 1E-05 for Class C carcinogens (NMED March 1998). Thus, the excess cancer risk for this site is below the suggested acceptable risk value (1E-06). The incremental excess cancer risk is 7.48E-08 for an industrial land-use setting and 1.09E-07 for a residential land-use setting.

The incremental total effective dose equivalent (TEDE) for radionuclides for an industrial land use setting for SWMU 60 is 1.4 millirems (mrem)/year (yr), and the TEDE for a residential land use setting is 2.6 mrem/yr. Both these values are below the recommended dose limit of 15 mrem/yr, found in EPA's OSWER Directive No. 9200.4-18 (EPA 1997a) and reflected in a document entitled, "Sandia National Laboratories/New Mexico Environmental Restoration Project—RESRAD Input Parameter Assumptions and Justification" (SNL/NM February 1998). The incremental excess cancer risk for the radionuclides is 1.9E-05 for an industrial land-use scenario and 3.4E-05 for the residential land-use setting.

4.6.2.2 Ecological

An ecological screening assessment that corresponds with the screening procedures in the EPA's Ecological Risk Assessment Guidance for Superfund (EPA 1997b) was performed as set forth by the NMED Risk-Based Decision Tree (NMED March 1998). An early step in the evaluation compared COC concentrations and identified potentially bioaccumulative constituents (see Annex 4-E, Sections III, VI, VII.2, and VII.3). This methodology also required developing a site conceptual model and a food web model, as well as selecting ecological receptors. Each of these items was presented in the "Predictive Ecological Risk Assessment Methodology for SNL/NM ER Program, Sandia National Laboratories/New Mexico" (IT July 1998) and will not be duplicated here. The screening also included the estimation of exposure and ecological risk.

Tables 15, 16, 17, and 18 of Annex 4-E present the results of the ecological risk assessment screen. Site-specific information was incorporated into the screening assessment when such data were available. Hazard quotients greater than unity were originally predicted; however, closer examination of the exposure assumptions revealed an overestimation of risk primarily attributed to exposure concentration (maximum COC concentration was used in estimating risk), exposure setting (area use factors of one were assumed), and background risk. Based upon an evaluation of these uncertainties, ecological risks associated with this site are expected to be very low.

4.6.3 Baseline Risk Assessments

This section discusses the baseline risk assessments for human health and ecological risk.

4.6.3.1 Human Health

Based upon the fact that human health results of the screening assessment summarized in Section 4.6.2.1 indicate that SWMU 60 does not have potential to affect human health under either an industrial or a residential land-use setting, a baseline human health risk assessment is not required for SWMU 60.

4.6.3.2 Ecological

Based upon the fact that ecological results of the screening assessment summarized in Section 4.6.2.2 indicate that SWMU 60 has very low ecological risk, a baseline ecological risk assessment is not required for SWMU 60.

4.6.4 Other Applicable Assessments

A Surface Water Site Assessment was conducted at SWMU 10/60 in November 1998 (SNL/NM November 1998). The surface water assessment guidance was developed jointly by Los Alamos National Laboratory and the NMED Surface Water Quality Bureau to evaluate the potential for erosion from SWMU 10/60. SWMU 10/60 received a score of 68, indicating that it has high erosion potential. The high erosion potential is primarily due to its relatively steep topography and its proximity to an arroyo. The site was regraded and then planted with native vegetation, which will reduce any future erosion potential at the site. The few COCs detected at the site were at scattered locations (Table 4.5.1-1) indicating that surface water runoff is not causing contaminant migration at SWMU 60. Additionally, as discussed under the Results and Conclusions (Section 4.4.4.6) and Screening Assessments (Section 4.6) sections, COCs detected are not at levels that pose a threat to human health or the environment or could adversely affect surface water quality.

4.7 No Further Action Proposal

4.7.1 Rationale

Based upon field investigation data and the human health risk assessment analysis, an NFA is recommended for SWMU 60 because no COCs (particularly VOCs or radionuclides) were present in concentrations considered hazardous to human health for a recreational land-use scenario.

4.7.2 Criterion

Based upon the evidence provided above, SWMU 60 is proposed for an NFA decision in conformance with Criterion 5 (NMED March 1998), which states, "The SWMU/AOC has been characterized or remediated in accordance with current applicable state or federal regulations, and that available data indicate that contaminants pose an acceptable level of risk under current and projected future land use."

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ANNEX 4-E
Risk Screening Assessment

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SWMU 60: RISK SCREENING ASSESSMENT REPORT

I. Site Description and History

Solid Waste Management Unit (SWMU) 60 is identified as the Bunker Area on the Resource Conservation and Recovery Act (RCRA) Hazardous and Solid Waste Amendment permit. SWMU 60 is located near the northeastern corner of Kirtland Air Force Base (AFB) on federally owned land controlled by Kirtland AFB. Access to the general area is by Coyote Springs Road to Pendulum Road and then approximately 1.5 miles north. The site lies on approximately 2 acres at a mean elevation of 6,175 feet above sea level (SNL/NM April 1995). SWMU 60 was initially used for materials storage and as the instrumentation control point during testing at SWMU 59, Pendulum Site, in the early 1950s. Afterwards the area was used for several tests using short half-life radioactive isotopes. A Torch Activated Burn System (TABS) Test was conducted in the SWMU 60 control bunker in 1979. During this test, two mock weapons containing depleted uranium (DU) exploded, destroying the bunker and releasing DU to the surrounding environment. The blast radius and soil mounds associated with the area were designated SWMU 10 and the bunkers and debris present on site were designated SWMU 60. Both areas were remediated and confirmatory soil samples were collected.

The annual precipitation for the area, as measured at the Albuquerque International Sunport, is 8.1 inches (NOAA 1990). Its proximity to the Manzanita Mountains subjects SWMU 60 to more precipitation, however no meteorological stations exist. No springs or perennial surface-water bodies are located within 2 miles of the site. There is an arroyo approximately 100 feet west of SWMU 60 that drains toward the south. During most rainfall events, rainfall quickly infiltrates the soil at SWMU 60. Because of the surface topography, there may also be some sheet flow to the arroyo during heavy downpours.

SWMU 60 lies on Tesajo-Millett stony sandy loams that are underlain by igneous and metamorphic Precambrian rocks (USDA June 1977). The control bunker is set within granitic bedrock. Immediate topographic relief around the site is approximately 50 feet. The nearest monitoring wells, the Graystone Manor and TSA-1 Wells, are located approximately 2.2 miles southwest and southeast of SWMU 60, respectively. Groundwater conditions at TSA-1 are probably more representative of conditions at SWMU 60, because SWMU 60 and TSA-1 are east of the Coyote Fault on thin alluvium deposits surrounded by Precambrian rocks (IT May 1994). At TSA-1 Well, semiconfined to confined groundwater is encountered in fractured Precambrian bedrock at a depth of 180 feet below ground surface (bgs) (IT May 1994). Local groundwater flow in the vicinity of SWMU 60 may be complicated because of abundant fractures and faults in the area. For a detailed discussion regarding the local setting at SWMU 60, refer to the "RCRA Facility Investigation Work Plan for Operable Unit [OU] 1333, Canyons Test Area" (SNL/NM September 1995).

The history of SWMU 60 prior to the 1979 TABS test is not well documented. Archive records indicate that the bunkers were used as the control point and material storage area for SWMU 59, the Pendulum Site. SWMU 59 formerly housed a rocket-powered pendulum, which was used to conduct instantaneous acceleration tests on weapons components. SWMU 59 was used in the early 1950s, and the SWMU 60 control bunker was used to house the instrumentation trailer for the tests. Possible materials stored at SWMU 60 for such tests include bazooka rockets and Honest John and Betty warhead shells (SNL/NM, August 1995).

The TABS test was conducted in the SWMU 60 control bunker to investigate the feasibility that remotely burning high explosive (HE) contained in nuclear weapons would not induce an explosion. However, when the two mock weapons containing HE, DU, and beryllium were detonated, the control bunker was destroyed and debris was scattered around SWMU 10 (Kurowski January 1979). During a survey conducted by Sandia National Laboratories/New Mexico (SNL/NM) Industrial Hygiene and Radiation Protection Operation personnel after the TABS test, DU fragments were removed and buried at the mixed waste landfill in Technical Area III (Larson August 1994). Interview records also indicated that some testing was conducted with short half-life radionuclides in a vermiculite catch pit (Wrightson, September 1993). The radioactively contaminated vermiculite was removed in 1989 and disposed of as radioactive waste. The remaining vermiculite mound was free of radioactive contamination (Gaither January 1994, Minnema and Tucker August 1989, Larson August 1994).

In 1996 SNL/NM Environmental Restoration (ER) conducted a Voluntary Corrective Measure (VCM) at SWMU 10 during which residual DU within the blast radius of the TABS explosion and in the soil mounds associated with the initial clean-up of the control bunker was removed. In 1998 a Voluntary Corrective Action (VCA) was conducted at SWMU 10 to remove the remaining uncontaminated vermiculite pile and dispose of it as solid waste (SNL/NM August 1998).

In 1999 a VCA was conducted at SWMU 60. The supply bunker was removed and demolished as was the damaged control bunker. A 100-percent radiological survey was performed on these structures and on the debris piles and the surface soil in the area. Materials or soil with elevated radiological activity were segregated and disposed of at the Nevada Test Site. The primary scope of the VCA was demolition and debris removal. Several soil hot spots were removed from the floor of the control bunker and one small mercury soil hot spot was removed from an area under the debris piles. Noncontaminated metal was recycled. After confirmatory soil samples were collected, the area was regraded and then planted with a native grass mix.

II. Data Quality Objectives

The confirmatory sampling conducted at SWMU 60 was designed to collect adequate samples to:

- Verify that VCA activities successfully remediated the site
- Characterize the nature and extent of and residual constituents of concern (COCs)
- Provide sufficient definitive analytical data to support screening risk assessments.

Tables 1 and 2 summarize the sampling performed at SWMU 60. The source of potential COCs was the TABS explosion which released DU, metals, and possibly HE to surrounding structures and the environment. Seven characterization samples were collected initially to

Table 1
Summary of Sampling Performed to Meet Data Quality Objectives (Characterization and Confirmation)

SWMU 60 Sampling Areas	Potential COC Source	Number of Sampling Locations	Sample Density	Sampling Location Rationale
Control bunker floor	DU, metals, HE related to TABS test explosion	3	1 sample/175 square feet	Characterize levels of COCs in surface soils of bunker floor
Control bunker floor	DU, metals, HE related to TABS test explosion	2	1 sample/263 square feet	Confirm residual levels of COCs after VCA completed
Supply bunker floor	DU, metals, HE related to TABS test explosion	1	1 sample/100 square feet	Characterize levels of COCs in surface soils inside bunker
Under supply bunker floor	DU, metals, HE related to TABS test explosion	1	1 sample/100 square feet	Confirm levels of COCs in soil after removal of bunker
Under roof of control bunker	DU, metals, HE related to TABS test explosion	2	1 sample/200 square feet	Characterize levels of COCs in soil under roof
Under roof of control bunker	DU, metals, HE related to TABS test explosion	1	1 sample/400 square feet	Confirm levels of COCs in soil after removal of roof
Hot metal cutting area	DU, metals from cutting galvanized metal roof	3	1 sample/300 square feet	Verify that no COCs released during torching and staging of DU contaminated metal
Waste staging area	DU, metals associated with galvanized metal roof	1	1 sample /500 square feet	Verify that no COCs released in area where hot metal staged prior to loading in transportainer

COC = Constituent of concern.
DU = Depleted uranium.
HE = High explosive(s).
SWMU = Solid Waste Management Unit.
TABS = Torch-Activated Burn System.
VCA = Voluntary Corrective Action.

Table 2
Number of Characterization and Confirmatory Soil Samples Collected at SWMU 60

Sample Type	Number of Samples	Radionuclides	Radionuclides	RCRA Metals	RCRA Metals	HE	HE
Characterization/ confirmatory	5/10	5/10	0/4	5/0	0/10	5/0	0/10
Duplicates	0/0	0/0	0/0	0/0	0/0	0/0	0/0
Equipment blanks	0/1	0/0	0/0	0/0	0/1	0/0	0/1
Total samples	16	15	4	5	11	5	11
Analytical laboratory	–	RPSD	GEL	ERCL	GEL	ERCL	GEL

Sampling date: 9/8/98.
ERCL = Environmental Restoration Chemistry Laboratory.
GEL = General Engineering Laboratories Inc.
HE = High explosive(s).
RCRA = Resource Conservation and Recovery Act.
RPSD = Radiation Protection Sample Diagnostic Laboratory.
SWMU = Solid Waste Management Unit.
– = Information not available.

determine whether surface soil contamination was present on the floor of either bunker, under the roof of the control bunker, or under any of the debris piles. These samples were analyzed for HE and RCRA metals plus beryllium at ERCL. Because the site was a Radiological Materials Management Area, a portion of each sample was sent to Radiation Protection Sample Diagnostic (RPSD) for gamma spectroscopy analyses. In addition, because soil was not removed from the areas where some of the characterization samples were collected during the VCA, these data can be used to characterize the nature and extent of residual COCs.

After the VCA was completed, 10 confirmatory surface soil samples were collected to verify that clean-up objectives had been met. All of these samples were analyzed for HE, RCRA metals plus beryllium and uranium at General Engineering Laboratory in Charleston, South Carolina. Four of the confirmatory samples were also analyzed for gross alpha/beta and gamma spectroscopy. Table 3 summarizes the analytical methods and data quality requirements necessary (1) to assess residual levels of COCs in surface soil after completion of the VCA and (2) to support screening risk assessments.

All on-site laboratory results were reviewed and verified/validated according to "Verification and Validation of Chemical and Radiochemical Data" TOP 94-03 (SNL/NM July 1994). All off-site laboratory results were reviewed and verified/validated according to "Data Validation Procedure for Chemical and Radiochemical Data" AOP 00-03 (SNL/NM December 1999). All gamma spectroscopy data were reviewed by SNL/NM Department 7713 RPSD Laboratory according to "Laboratory Data Review Guidelines," Procedure No. RPSD-02-11, Issue No. 02 (SNL/NM July 1996). These reviews confirmed that the data are acceptable for use in the no further action (NFA) proposal for SWMU 60. The data quality objectives (DQOs) for SWMU 60 have been met.

III. Determination of Nature, Rate, and Extent of Contamination

III.1 Introduction

The determination of the nature, migration rate, and extent of contamination at SWMU 60 was based upon an initial conceptual model validated with confirmatory sampling at the site. The initial conceptual model was developed from archival research, soil sampling, and radiological surveys. The SWMU 10 VCM, which included radiological surveys, waste characterization, and confirmatory sampling data also provided supporting data for the SWMU 60 initial conceptual model. The sampling data from the SWMU 60 VCA were subsequently used to develop the final conceptual model which is presented in Section 4.5 of the associated NFA proposal. This section describes the quality of the data specifically used to determine the nature, migration rate, and extent of contamination.

III.2 Nature of Contamination

The nature of contamination was evaluated using laboratory analyses of the soil samples (see Section V). The analytical requirements included analyses for DU-related radionuclides, RCRA metals plus beryllium and uranium, and HE compounds. Residual COCs present in surface soil

Table 3
Summary of Data Quality Requirements

Analytical Requirement	Data Quality Level	ERCL	GEL	RPSD
RCRA metals plus Be and U EPA Methods 6010/7000[a]	Definitive	7 Samples	Not analyzed	Not analyzed
RCRA metals plus Be and U EPA Methods 6010/7000[a]	Definitive	Not analyzed	10 Samples	Not analyzed
HE Compounds EPA Method 8330[a]	Definitive	7 Samples	Not analyzed	Not analyzed
HE Compounds EPA Method 8330[a]	Definitive	Not analyzed	10 Samples	Not analyzed
Gross alpha/gross beta EPA Method 900.0[a]	Definitive	Not analyzed	4 Samples	Not analyzed
Gamma spectroscopy EPA Method 901.1[a]	Definitive	Not analyzed	4 Samples	Not analyzed
Gamma spectroscopy EPA Method 901.1[a]	Definitive	Not analyzed	Not analyzed	16 samples

[a]EPA (November 1986).
BE = Beryllium.
EPA = U.S. Environmental Protection Agency.
ERCL = Environmental Restoration Chemistry Laboratory.
GEL = General Engineering Laboratory.
HE = High explosive(s).
RCRA = Resource Conservation and Recovery Act.
RPSD = Radiation Protection Sample Diagnostics.
U = Uranium.

after completion of the VCA are limited to DU-related radionuclides and metals. The analyses characterized any potential contaminants remaining after the VCA was completed. The analytes and methods listed in Table 2 are appropriate to characterize the COCs at SWMU 60.

III.3 Rate of Contaminant Migration

SWMU 60 is an inactive site that has recently been remediated; and therefore, all primary sources of COCs have been eliminated. As a result, only secondary sources of COCs potentially remain in soil in the form of adsorbed COCs (DU, RCRA metals). The rate of COC migration from surficial soil is, therefore, dependent predominantly upon precipitation and occasional surface-water flow as described in Section V. Data available from the Site-Wide Hydrogeologic Characterization Project (published annually); numerous SNL/NM monitoring programs for air, water, and radionuclides; various biological surveys; and meteorological monitoring are adequate to characterize the rate of COC migration at SWMU 60.

III.4 Extent of Contamination

Surface confirmatory soil samples were collected from all remediated areas, including from the control bunker floor under the supply bunker (after removal), under the control bunker roof (after removal), and under the debris piles (after removal), as well as from areas were contaminated debris was staged. The data gathered from these samples are adequate to assess the effectiveness of the VCA remediation. The confirmatory soil samples were collected using the sampling densities listed in Table 1 after all debris was removed from the site and a radiological walkover survey had been conducted.

The confirmatory soil samples were collected from the ground surface (0 to 6 inches). Sampling at a more extensive variety of depths was not a significant concern at SWMU 60 because there were no data to suggest that contaminated material had been buried below grade. Furthermore, the vertical rate of contamination migration was expected to be extremely low for SWMU 60 because of the low precipitation, high evapotranspiration, impermeable vadose zone soils, and the relatively low solubility of DU. Therefore, the confirmatory soil samples were considered to be representative of the soil potentially contaminated with the COCs and sufficient to determine the vertical extent, if any, of COCs.

In summary, the design of the confirmatory sampling was appropriate and adequate to determine the nature, migration rate, and extent of residual COCs in surface soil at SWMU 60.

IV. Comparison of COCs to Background Screening Levels

Site history and characterization activities are used to identify potential COCs. The SWMU 60 NFA proposal describes the identification of COCs and the sampling that was conducted in order to determine the concentration levels of those COCs across the site. Generally, COCs evaluated in this risk assessment include all detected explosives and all inorganic and radiological COCs for which samples were analyzed. If the detection limit of an explosive compound was too high (i.e., could possibly cause an adverse effect to human health or the environment), the compound was retained. Nondetect explosives not included in this assessment were determined to have sufficiently low detection limits to ensure protection of human health and the environment. In order to provide conservatism in this risk assessment, the calculation used only the maximum concentration value of each COC found for the entire site. The SNL/NM maximum background concentration (Dinwiddie September 1997, Garcia 1998) was selected to provide the background screen listed in Tables 4 and 5. Human health nonradiological COCs were also compared to SNL/NM proposed Subpart S action levels (Table 4) (IT July 1994).

Nonradiological inorganics that are essential nutrients such as iron, magnesium, calcium, potassium, and sodium were not included in this risk assessment (EPA 1989). Both radiological and nonradiological COCs were evaluated. The nonradiological COCs evaluated were limited to inorganic compounds because all explosive compounds were nondetect.

Table 4 lists nonradiological COCs for the human health and ecological risk assessment at SWMU 60. Table 5 lists radiological COCs for the human health and ecological risk assessment. All tables show the associated SNL/NM maximum background concentration values (Dinwiddie September 1997, Garcia 1998). Sections VI.4, VII.2 and VII.3 discuss Tables 4 and 5.

V. Fate and Transport

The primary releases of COCs at SWMU 60 were to the surface soil. Wind, water, and biota are natural mechanisms of COC transport from the primary release point. Winds at this site, however, are moderated by the locally mountainous topography and by the woodland vegetation. Therefore, wind erosion is probably not significant as a transport mechanism at this site.

Water at SWMU 60 is received as precipitation (rain or occasional snow). Precipitation will evaporate at or near the point of contact, infiltrate into the soil, or form runoff. Infiltration at the site is enhanced by the coarse nature of the soil (the soil in the area of the site is primarily Tesajo-Millett stony sandy loam [USDA June 1977]); however, surface runoff may be produced during intense rainfall events and during extended rainfall periods. Surface-water runoff from SWMU 60 will flow into the unnamed arroyo channel (described in Section I.1) that flows southward to Arroyo del Coyote. Runoff may carry surface soil particles with adsorbed COCs. The distance of transport will depend upon the size of the particle and the velocity of the water.

Water that infiltrates into the soil will continue to percolate through the soil until field capacity is reached. COCs desorbed from the soil particles into the soil solution may be leached into the subsurface soil with this percolation. The effective rooting depths of the soil at SWMU 60 is about 60 inches (USDA June 1977). This indicates the depth of the system's transient water cycling zone (the dynamic balance between percolation/infiltration and evapotranspiration). Because groundwater at this site is over 200 feet bgs, the potential for COCs to reach groundwater through the unsaturated zone above the watertable is very small. As water from the surface evaporates, the direction of COC movement may be reversed with capillary rise of the soil water.

Table 4
Nonradiological COCs for Human Health and Ecological Risk Assessment at SWMU 60 with Comparison to the Associated SNL/NM Background Screening Value, BCF, Log K_{ow}, and Subpart S Screening Value

COC Name	Maximum Concentration (mg/kg)	SNL/NM Background Concentration (mg/kg)[a]	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Log K_{ow} (for organic COCs)	Bioaccumulator?[b] (BCF >40, Log K_{ow}>4)	Subpart S Screening Value[c]	Is Individual COC less than 1/10 of the Action Level?
Arsenic	3.42	9.8	Yes	44[d]	NA	**Yes**	0.5	**No**
Barium	130	246	Yes	170[e]	NA	**Yes**	6000	Yes
Beryllium	12	0.75	**No**	19[d]	NA	No	0.2	**No**
Cadmium	0.809	0.64	**No**	64[d]	NA	**Yes**	80	Yes
Chromium, total[f]	32	18.8	**No**	16[d]	NA	No	400	Yes
Lead	22	18.9	**No**	49[d]	NA	**Yes**	–	–
Mercury	0.056	0.055	**No**	5500[d]	NA	**Yes**	20	Yes
Selenium	1.7	2.7	Yes	800[g]	NA	**Yes**	400	Yes
Silver	0.63	<0.5	**No**	0.5[d]	NA	No	400	Yes
Uranium	13	3.42[h]	**No**	20[e]	NA	No	NC	NA

Note: **Bold** indicates the COCs that failed the background and/or Subpart S screening procedures and/or are bioaccumulators.
[a]From Garcia (1998) Canyon Area Soils.
[b]NMED (March 1998).
[c]IT Corporation (July 1994).
[d]Yanicak (March 1997).
[e]Neumann (1976).
[f]Assumed to be chromium VI for Subpart S screening procedure.
[g]Callahan et al. (1979).
[h]Uranium background taken from noncanyon supergroups. Uranium background concentration for canyons area not calculated.

BCF = Bioconcentration factor.
COC = Constituent of concern.
K_{ow} = Octanol-water partition coefficient.
Log = Logarithm (base 10).
mg/kg = Milligram(s) per kilogram.
NA = Not applicable.
NC = Not calculated.
NMED = New Mexico Environment Department.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid Waste Management Unit.
– = Information not available.

Table 5
Radiological COCs for Human Health and Ecological Risk Assessment at SWMU 60 with Comparison to the Associated SNL/NM Background Screening Value and BCF

COC Name	Maximum Concentration (pCi/g)	SNL/NM Background Concentration (pCi/g)[a]	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Is COC a Bioaccumulator?[b] (BCF >40)
Th-232	**1.48**	1.03	**No**	3000[c]	No[d]
U-238	**5.93**	2.31	**No**	900[c]	**Yes**
U-235	**0.254**	0.16	**No**	900[c]	**Yes**
U-234	0.13[e]	2.31	Yes	900[c]	**Yes**
Cs-137	0.06	0.515	Yes	3000[f]	**Yes**

Note: **Bold** indicates COCs that exceed background screening values and/or are bioaccumulators.
[a]From Dinwiddie (September 1997), Canyons Area Soils.
[b]NMED (March 1998).
[c]Baker and Soldat (1992).
[d]Yanicak (March 1997).
[e]U-234 values were calculated using the U-238 concentration and assuming that the U-238 to U-234 ratio was equal to that detected during waste characterization of DU-contaminated soils generated during the radiological voluntary corrective measures project, where U-234=U-238/8 (Miller June 1998).
[f]BCF from Whicker and Schultz (1982).
BCF = Bioconcentration factor.
COC = Constituent of concern.
DU = Depleted uranium.
NMED = New Mexico Environment Department.
pCi/g = Picocurie(s) per gram.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid Waste Management Unit.

Plant roots can take up COCs that are in the soil. These COCs can then be transported to the above-ground tissues with the xylem stream. Above-ground tissues can also take up constituents from direct contact with dust particles. These tissues and the COCs in them can be consumed by herbivores or eventually be returned to the soil as litter. Above-ground litter can be transported by wind and water until it is decomposed. Constituents in plant tissues that are consumed by herbivores can be absorbed or be returned to the soil in feces (at the site or possibly transported from the site in the herbivore). COCs that are absorbed can be held in tissues or later excreted. The herbivore can be eaten by a primary carnivore or scavenger and the constituents still held in the tissues will repeat the potential fates of excretion or eventual consumption by higher predators, scavengers, and decomposers. The potential for transport of the constituents within the food chain depends upon the mobility of the species that comprise the food chain and the potential for the constituent to be transferred across the links in the food chain.

All of the COCs at SWMU 60 are inorganic and elemental in form. These are generally not considered to be degradable. Radiological COCs, however, undergo decay to stable isotopes or radioactive daughter elements. Other transformations of inorganics can include changes in valence (oxidation/reduction reactions) or incorporation into organic forms (e.g., the conversion of selenite or selenate from soil to seleno-amino acids in plants). The rate of such processes will be limited by the aridity of the environment at this site.

Table 6 summarizes the fate and transport processes that can occur at SWMU 60. COCs at this site include both inorganics (metals) and radionuclides in surface soil. Because of the local mountainous topography and woodland vegetation, the potential for transport of COCs by wind is low. The potential for transport by surface-water runoff is moderate for COCs currently at or near the soil surface. Significant leaching of COCs into the subsurface soil is unlikely and leaching to the groundwater at this site is highly unlikely. The potential for degradation is low and the potential for uptake into the food chain is considered moderate to low because of the terrestrial nature of the habitat and the arid climate. Decay of radiological COCs is insignificant because of their long half lives.

Table 6
Summary of Fate and Transport at SWMU 60

Transport and Fate Mechanism	Existence at Site	Significance
Wind	Yes	Low
Surface runoff	Yes	Moderate
Migration to groundwater	No	None
Food chain uptake	Yes	Moderate to low
Transformation/degradation	Yes	Low

SWMU = Solid Waste Management Unit.

VI. Human Health Risk Screening Assessment

VI.1 Introduction

Human health risk screening assessment of this site includes a number of steps that culminate in a quantitative evaluation of the potential adverse human health effects caused by constituents located at the site. The steps to be discussed include the following:

Step 1.	Site data are described that provide information on the potential COCs, as well as the relevant physical characteristics and properties of the site.
Step 2.	Potential pathways are identified by which a representative population might be exposed to the COCs.
Step 3.	The potential intake of these COCs by the representative population is calculated using a tiered approach. The first component of the tiered approach includes two screening procedures. One screening procedure compares the maximum concentration of the COC to an SNL/NM maximum background screening value. COCs that are not eliminated during the first screening procedure are subjected to a second screening procedure that compares the maximum concentration of the COC to the SNL/NM proposed Subpart S action level.
Step 4.	Toxicological parameters are identified and referenced for COCs that were not eliminated during the screening steps.
Step 5.	Potential toxicity effects (specified as a hazard index [HI]) and estimated excess cancer risks are calculated for nonradiological COCs and background. For radiological COCs, the incremental total effective dose equivalent (TEDE) and incremental estimated cancer risk are calculated by subtracting applicable background concentrations directly from maximum on-site contaminant values. This background subtraction only occurs when a radiological COC occurs as contamination and exists as a natural background radionuclide.
Step 6.	These values are compared with guidelines established by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) to determine whether further evaluation, and potential site cleanup, is required. Nonradiological COC risk values are also compared to background risk so that an incremental risk can be calculated.
Step 7.	Uncertainties of the above steps are also discussed.

VI.2 Step 1. Site Data

Section I provides the description and history for SWMU 60. Section II presents comparison of results to DQOs. Section III discusses the determination of the nature, rate, and extent of contamination.

VI.3 Step 2. Pathway Identification

SWMU 60 has been designated a future land use scenario of industrial (DOE and USAF March 1996) (see Appendix 1 for default exposure pathways and parameters). Because of the location and the characteristics of the potential contaminants, the primary pathway for human exposure is considered to be soil ingestion for the nonradiological COCs and direct gamma exposure for the radiological COCs. The inhalation pathway for both nonradiological and radiological COCs is included because of the potential to inhale dust. Soil ingestion is included for the radiological COCs as well. No water pathways to the groundwater are considered. Depth to groundwater at SWMU 60 is in excess of 200 feet bgs. Because of the lack of surface water or other significant mechanisms for dermal contact, the dermal exposure pathway is considered not to be significant. No intake routes through plant, meat, or milk ingestion are considered appropriate for the industrial land use scenario. However, plant uptake is considered for the residential land use scenario.

Pathway Identification

Nonradiological Constituents	Radiological Constituents
Soil ingestion	Soil ingestion
Inhalation (dust)	Inhalation (dust)
Plant uptake (residential only)	Plant uptake (residential only)
	Direct gamma

VI.4 Step 3. COC Screening Procedures

Step 3 is discussed in this section and includes two screening procedures. The first screening procedure compares the maximum COC concentration to the background screening level. The second screening procedure compares maximum COC concentrations to SNL/NM proposed Subpart S action levels. This second procedure is applied only to COCs that were not eliminated during the first screening procedure.

VI.4.1 Background Screening Procedure

VI.4.1.1 Methodology

Maximum concentrations of nonradiological COCs were compared to the approved SNL/NM maximum screening level for this area. The SNL/NM maximum background concentration was selected to provide the background screen in Table 4 and was used to calculate risk attributable to background in Table 10. Only the COCs that were detected above their respective SNL/NM maximum background screening levels or did not have either a quantifiable or calculated background screening level were considered in further risk assessment analyses.

For radiological COCs that exceeded the SNL/NM background screening levels, background values were subtracted from the individual maximum radionuclide concentrations. Those that did not exceed these background levels were not carried any further in the risk assessment. This approach is consistent with DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (DOE 1993). Radiological COCs that did not have a background value and were detected above the analytical minimum detectable activity were carried through the risk assessment at their maximum levels. The resultant radiological COCs remaining after this step are referred to as background-adjusted radiological COCs.

VI.4.1.2 Results

Tables 4 and 5 present SWMU 60 maximum COC concentrations that were compared to the SNL/NM maximum background values (Dinwiddie September 1997, Garcia 1998) for the human health risk assessment. For the nonradiological COCs, seven constituents were measured at concentrations greater than their respective background.

The maximum concentration value for lead is 22 milligrams (mg) per kilogram (/kg). The EPA intentionally does not provide any human health toxicological data on lead; therefore, no risk parameter values could be calculated. However, EPA Region 6 guidance for the screening value for lead for the industrial land use scenario is 2,000 mg/kg (EPA 1996a); for the residential land use scenario, the EPA screening guidance value is 400 mg/kg (EPA July 1994). The maximum concentration value for lead at this site is less than both screening values; therefore, lead is eliminated from further consideration in the human health risk assessment.

For the radiological COCs, three constituents had measured activity concentration slightly greater than their respective backgrounds (Th-232, U-238, and U-235).

VI.4.2 Subpart S Screening Procedure

VI.4.2.1 Methodology

The maximum concentrations of nonradiological COCs not eliminated during the background screening process were compared with action levels (IT July 1994) calculated using methods and equations promulgated in the proposed RCRA Subpart S (EPA 1990) and Risk Assessment Guidance for Superfund (RAGS) (EPA 1989) documentation. Accordingly, all calculations were based upon the assumption that receptor doses from both toxic and potentially carcinogenic compounds result most significantly from ingestion of contaminated soil. Because the samples were all taken from the surface and near surface, this assumption is considered valid. If there were ten or fewer COCs and each had a maximum concentration of less than 1/10 the action level, then the site was judged to pose no significant health hazard to humans. If there were more than ten COCs, then the Subpart S screening procedure was not performed.

VI.4.2.2 Results

Table 4 shows the COCs and the associated proposed Subpart S action level. The table compares the maximum concentration values to 1/10 the proposed Subpart S action level. This methodology was guidance given to SNL/NM from the EPA (EPA 1996a). One COC (beryllium) that failed the background screen is above 1/10 the Subpart S action level. Therefore, all constituents with maximum concentrations above background were carried forward in the risk assessment process, and an individual COC hazard quotient (HQ), cumulative HI, and an excess cancer risk value were calculated.

Radiological COCs have no predetermined action levels analogous to proposed Subpart S levels; therefore, this step in the screening process was not performed for radiological COCs.

VI.5 Step 4. Identification of Toxicological Parameters

Tables 7 (nonradiological) and 8 (radiological) list the COCs retained in the risk assessment and the values for the available toxicological information. The toxicological values used for nonradiological COCs in Table 7 were from the Integrated Risk Information System (IRIS) (EPA 1998a), the Health Effects Assessment Summary Tables (HEAST) (EPA 1997a), and the Region 3 (EPA 1997c) and Region 9 (EPA 1996c) electronic databases. Dose conversion factors (DCF) used in determining the excess TEDE values for radiological COCs for the individual pathways were the default values provided in the RESRAD computer code (Yu et al. 1993a) as developed in the following documents:

- DCFs for ingestion and inhalation are taken from "Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion" (EPA 1988).

- DCFs for surface contamination (contamination on the surface of the site) were taken from DOE/EH-0070, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public" (DOE 1988).

- DCFs for volume contamination (exposure to contamination deeper than the immediate surface of the site) were calculated using the methods discussed in "Dose-Rate Conversion Factors for External Exposure to Photon Emitters in Soil" (Kocher 1983) and in ANL/EAIS-8, *Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil* (Yu et al. 1993b).

VI.6 Step 5. Exposure Assessment and Risk Characterization

Section VI.6.1 describes the exposure assessment for this risk assessment. Section VI.6.2 provides the risk characterization, including the HI and the excess cancer risk for both the potential nonradiological COCs and associated background for industrial and residential land uses. The incremental TEDE and incremental estimated cancer risk are provided for the background-adjusted radiological COCs for both industrial and residential land uses.

VI.6.1 Exposure Assessment

Appendix 1 shows the equations and parameter input values used in calculating intake values and subsequent HI and excess cancer risk values for the individual exposure pathways. The appendix shows parameters for both industrial and residential land use scenarios. The equations for nonradiological COCs are based upon the RAGS (EPA 1989). Parameters are based upon information from the RAGS (EPA 1989) and other EPA guidance documents and reflect the reasonable maximum exposure (RME) approach advocated by the RAGS (EPA 1989). For radiological COCs, the coded equations provided in RESRAD computer code are used to estimate the incremental TEDE and cancer risk for individual exposure pathways. Further discussion of this process is provided in the *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD* (Yu et al. 1993a).

Table 7
Toxicological Parameter Values for SWMU 60 Nonradiological COCs

COC Name	RfD_o (mg/kg-d)	Confidence[a]	RfD_{inh} (mg/kg-d)	Confidence[a]	SF_o $(mg/kg-day)^{-1}$	SF_{inh} $(mg/kg-day)^{-1}$	Cancer Class[b]
Beryllium	2E-3[c]	L to M	5.7E-6[c]	M	–	8.4E+0[c]	B1
Cadmium	5E-4[c]	H	5.7E-5[d]	–	–	6.3E+0[c]	B1
Chromium III	1E+0[c]	L	5.7E-7[e]	–	–	–	–
Chromium VI	5E-3[c]	L	–	–	–	4.2E+1[c]	A
Mercury	3E-4[f]	–	8.6E-5[c]	M	–	–	D
Silver	5E-3[c]	L	–	–	–	–	D
Uranium	3E-3[c]	M	–	–	–	–	–

[a]Confidence associated with IRIS (EPA 1998a) database values. Confidence: L = low, M = medium, H = High.
[b]EPA weight-of-evidence classification system for carcinogenicity (EPA 1989) taken from IRIS (EPA 1998a):
A = Human carcinogen.
B1 = Probable human carcinogen. Limited human data available.
D = Not classifiable as to human carcinogenicity.
[c]Toxicological parameter values from IRIS electronic database (EPA 1998a).
[d]Toxicological parameter values from EPA Region 9 electronic database (EPA 1996c).
[e]Toxicological parameter values from EPA Region 3 electronic database (EPA 1997c).
[f]Toxicological parameter values from HEAST database (EPA 1997a).
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
HEAST = Health Effects Assessment Summary Tables.
IRIS = Integrated Risk Information System.
mg/kg-d = Milligram(s) per kilogram day.
$(mg/kg-day)^{-1}$ = Per milligram per kilogram day.
RfD_{inh} = Inhalation chronic reference dose.
RfD_o = Oral chronic reference dose.
SF_{inh} = Inhalation slope factor.
SF_o = Oral slope factor.
SWMU = Solid Waste Management Unit.
– = Information not available.

Table 8
Radiological Toxicological Parameter Values for SWMU 60 COCs Obtained from RESRAD Risk Coefficients[a]

COC Name	SF_o (1/pCi)	SF_{inh} (1/pCi)	SF_{ev} (g/pCi-yr)	Cancer Class[b]
U-235	4.70E-11	1.30E-08	2.70E-07	A
U-238	6.20E-11	1.20E-08	6.60E-08	A
Th-232	3.30E-11	1.90E-08	2.00E-11	A

[a]From Yu et al. (1993a).
[b]EPA weight-of-evidence classification system for carcinogenicity (EPA 1989): A = Human carcinogen for high dose and high dose rate (i.e., greater than 50 rem per year). For low-level environmental exposures, the carcinogenic effect has not been observed and documented.
1/pCi = One per picocurie.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
g/pCi-yr = Gram(s) per picocurie-year.
SF_{ev} = External volume exposure slope factor.
SF_{inh} = Inhalation slope factor.
SF_o = Oral (ingestion) slope factor.
SWMU = Solid Waste Management Unit.

Although the land use scenario is industrial for this site, the risk and TEDE values for a residential land use scenario are presented as recommended by the Citizen's Advisory Board.

VI.6.2 Risk Characterization

Table 9 shows a HI of 0.02 for the SWMU 60 nonradiological COCs and an estimated excess cancer risk of 8E-8 for the designated industrial land use scenario. The numbers presented included exposure from soil ingestion and dust inhalation for nonradiological COCs. Table 10 shows a HI of 0.00 and an excess cancer risk of 5E-10 assuming the maximum background concentrations of the SWMU 60 associated background constituents for the designated industrial land use scenario.

For the radiological COCs, contribution from the direct gamma exposure pathway is included. For the industrial land use scenario, a TEDE was calculated for an individual who spends 4 hours per week on the site. This resulted in an incremental TEDE of 1.4 millirems (mrem)/year (yr). In accordance with EPA guidance found in Office of Solid Waste and Emergency Response Directive No. 9200.4-18 (EPA 1997b), an incremental TEDE of 15 mrem/yr is used for the probable land use scenario (industrial in this case); the calculated dose value for SWMU 60 for the industrial land use is well below this guideline. The estimated excess cancer risk is 1.9E-5.

For the residential land use scenario nonradioactive COCs, the HI is 0.9, and the excess cancer risk is 1E-7 (Table 9). The numbers in the table included exposure from soil ingestion, dust inhalation, and plant uptake. Although the EPA (1991) generally recommends that inhalation not be included in a residential land use scenario, this pathway is included because of the

Table 9
Risk Assessment Values for SWMU 60 Nonradiological COCs

COC Name	Maximum Concentration (mg/kg)	Industrial Land-Use Scenario[a]		Residential Land-Use Scenario[a]	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Beryllium	12	0.01	5E-9	0.03	9E-9
Cadmium	0.809	0.00	3E-10	0.66	5E-10
Chromium, total[b]	32	0.01	7E-8	0.03	1E-7
Mercury	0.056	0.00	–	0.10	–
Silver	0.63	0.00	–	0.03	–
Uranium	13	0.00	–	0.03	–
Total		**0.02**	**8E-8**	**0.9**	**1E-7**

[a]From EPA (1989).
[b]Chromium, total assumed to be chromium VI (most conservative).
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
mg/kg = Milligram(s) per kilogram.
SWMU = Solid Waste Management Unit.
– = Information not available.

Table 10
Risk Assessment Values for SWMU 60 Nonradiological Background Constituents

COC Name	Background Concentration[a] (mg/kg)	Industrial Land-Use Scenario[b]		Residential Land-Use Scenario[b]	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Beryllium	0.75	0.00	3E-10	0.00	6E-10
Cadmium	0.64	0.00	2E-10	0.52	4E-10
Chromium, total[c]	18.8	0.00	–	0.01	–
Mercury	0.055	0.00	–	0.09	–
Silver	<0.5	–	–	–	–
Uranium	3.42	0.00	–	0.01	–
Total		**0.00**	**5E-10**	**0.6**	**1E-9**

[a]From Garcia (1998), Canyons Area.
[b]From EPA (1989).
[c]Chromium, total, assumed to be chromium III (most conservative).
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
mg/kg = Milligram(s) per kilogram.
SWMU = Solid Waste Management Unit.
– = Information not available.

potential for soil in Albuquerque, New Mexico, to be eroded and, subsequently, for dust to be present in predominantly residential areas. Because of the nature of the local soil, other exposure pathways are not considered (see Appendix 1). Table 10 shows that for the SWMU 60 associated background constituents, the HI is 0.6 and the excess cancer risk is 1E-9.

For the radiological COCs, the incremental TEDE for the residential land use scenario is 2.6 mrem/yr. The guideline being used is an excess TEDE of 75 mrem/yr (SNL/NM February 1998) for a complete loss of institutional controls (residential land use in this case); the calculated dose value for SWMU 60 for the residential land use scenario is well below this guideline. Consequently, SWMU 60 is eligible for unrestricted radiological release as the residential land use scenario resulted in an incremental TEDE of less than 75 mrem/yr to the on-site receptor. The estimated excess cancer risk is 3.4E-5. The excess cancer risk from the nonradiological COCs and the radiological COCs is not additive, as noted in the RAGS (EPA 1989).

VI.7 Step 6. Comparison of Risk Values to Numerical Guidelines.

The human health risk assessment analysis evaluated the potential for adverse health effects for both the industrial land use scenario (the designated land use scenario for this site) and the residential land use scenario.

For the industrial land use scenario nonradiological COCs, the HI is 0.02 (less than the numerical guideline of 1 suggested in the RAGS [EPA 1989]). Excess cancer risk is estimated at 8E-8. Guidance from the NMED indicates that excess lifetime risk of developing cancer by an individual must be less than 1E-6 for Class A and B carcinogens and less than 1E-5 for Class C carcinogens (NMED March 1998). The excess cancer risk is driven by chromium, total. Chromium, total, is conservatively assumed to be chromium VI. Chromium VI is a Class A carcinogen. Thus, the excess cancer risk for this site is below the suggested acceptable risk value (1E-6). This assessment also determined risks considering background concentrations of the potential nonradiological COCs for both the industrial and residential land use scenarios. Assuming the industrial land use scenario, for nonradiological COCs the HI is 0.00 and the excess cancer risk is 5E-10. Incremental risk is determined by subtracting risk associated with background from potential COC risk. These numbers are not rounded before the difference is determined and, therefore, may appear to be inconsistent with numbers presented in tables and within the text. For conservatism, the background constituent (silver) that does not have a quantified background concentration is assumed to have an HQ of 0.00. Incremental HI is 0.02 and estimated incremental cancer risk is 7.48E-8 for the industrial land use scenario. These incremental risk calculations indicate insignificant risk to human health from nonradiological COCs considering an industrial land use scenario.

For radiological COCs of the industrial land use scenario, incremental TEDE is 1.4 mrem/yr, which is significantly less than EPA's numerical guideline of 15 mrem/yr. Incremental estimated excess cancer risk is 1.9E-5.

The calculated HI for the residential land use scenario nonradiological COCs is 0.9, which is below the numerical guidance. Excess cancer risk is estimated at 1E-7. The excess cancer risk is driven by chromium, total. Chromium, total, is conservatively assumed to be chromium

VI which is a Class A carcinogen. Therefore, the excess cancer risk for this site is below the suggested acceptable risk value (1E-6). The HI for associated background for the residential land use scenario is 0.6; the excess cancer risk is estimated at 1E-9. The incremental HI is 0.25 and the estimated incremental cancer risk is 1.09E-7 for the residential land use scenario. These incremental risk calculations indicate insignificant contribution to human health risk from the COCs considering the residential land use scenario.

The incremental TEDE for a residential land use scenario from the radiological components is 2.6 mrem/yr, which is significantly less than the numerical guideline of 75 mrem/yr suggested in the SNL/NM RESRAD Input Parameter Assumptions and Justification (SNL/NM February 1998). The estimated excess cancer risk is 3.4E-5.

VI.8 Step 7. Uncertainty Discussion

The determination of the nature, rate, and extent of contamination at SWMU 60 was based upon an initial conceptual model validated with characterization soil sampling prior to the start of the VCA and confirmatory soil sampling after completion of the VCA. The characterization sampling and confirmatory sampling were implemented in accordance with the VCA plan for SWMU 60 (SNL/NM February 1999). The DQOs contained in the VCA plan are appropriate for use in screening risk assessments. The data collected, based upon sample location, density, and depth, are representative of the site. The analytical requirements and results satisfy the DQOs. Data quality was validated in accordance with SNL/NM procedures (SNL/NM December 1999). Therefore, there is no uncertainty associated with the data quality used to perform the screening risk assessment at SWMU 60.

Because of the location, history of the site, and future land use (DOE and USAF March 1996), there is low uncertainty in the land use scenario and the potentially affected populations that were considered in performing the risk assessment analysis. Because the COCs are found in surface and near-surface soils and because of the location and physical characteristics of the site, there is little uncertainty in the exposure pathways relevant to the analysis.

An RME approach was used to calculate the risk assessment values. This means that the parameter values in the calculations are conservative and that calculated intakes are probably overestimates. Maximum measured values of COC concentrations are used to provide conservative results.

Table 7 shows the uncertainties (confidence) in nonradiological toxicological parameter values. There is a mixture of estimated values and values from the IRIS (EPA 1998a), the HEAST (EPA 1997a), EPA Region 3 (EPA 1997c) and EPA Region 9 (EPA 1996c) electronic databases. Where values are not provided, information is not available from the HEAST (EPA 1997a), IRIS (EPA 1998a), or the EPA regions (EPA 1996c, 1997c). Because of the conservative nature of the RME approach, uncertainties in toxicological values are not expected to change the conclusion from the risk assessment analysis.

Risk assessment values for nonradiological COCs are within the human health acceptable range for the industrial and residential land use scenarios compared to established numerical guidance.

For radiological COCs, the conclusion of the risk assessment is that potential effects on human health for both industrial and residential land use scenarios are within guidelines and are a small fraction of the estimated 360 mrem/yr received by the average U.S. population (NCRP 1987).

The overall uncertainty in all of the steps in the risk assessment process is considered not significant with respect to the conclusion reached.

VI.9 Summary

SWMU 60 has identified COCs consisting of some inorganic, organic, and radiological compounds. Because of the location of the site and the nature of contamination, potential exposure pathways identified for this site included soil ingestion and dust inhalation for chemical constituents and soil ingestion, dust inhalation, and direct gamma exposure for radionuclides. Plant uptake was included as an exposure pathway for the residential land use scenario.

Using conservative assumptions and an RME approach to risk assessment, calculations for nonradiological COCs show that for the industrial land use scenario the HI (0.02) is significantly less than the accepted numerical guidance from the EPA. Excess cancer risk (8E-8) is also below the acceptable risk value provided by the NMED for a industrial land use scenario (NMED March 1998). The incremental HI is 0.02, and the incremental cancer risk is 7.48E-8 for the industrial land use scenario. Incremental risk calculations indicate insignificant risk to human health for a industrial land use scenario.

Using conservative assumptions and an RME approach to risk assessment, calculations for nonradiological COCs show that for the residential land use scenario the HI (0.9) is less than the accepted numerical guidance from the EPA. Excess cancer risk (1E-7) is also below the acceptable risk value provided by the NMED for a residential land use scenario (NMED March 1998). The incremental HI is 0.25, and the incremental cancer risk is 1.09E-7 for the residential land use scenario. Incremental risk calculations indicate insignificant risk to human health for a residential land use scenario.

Incremental TEDE and corresponding estimated cancer risk from radiological COCs are much less than EPA guidance values; the estimated TEDE is 1.4 mrem/yr for the industrial land use scenario. This value is much less than the numerical guidance of 15 mrem/yr in EPA guidance (EPA 1997b). The corresponding incremental estimated cancer risk value is 1.9E-5 for the industrial land use scenario. Furthermore, the incremental TEDE for the residential land use scenario that results from a complete loss of institutional control is only 2.6 mrem/yr with an associated risk of 3.4E-5. The guideline for this scenario is 75 mrem/yr (SNL/NM February 1998). Therefore, SWMU 60 is eligible for unrestricted radiological release.

Uncertainties associated with the calculations are considered small relative to the conservativeness of risk assessment analysis. It is, therefore, concluded that this site poses insignificant risk to human health under the industrial land use scenario.

VII. Ecological Risk Screening Assessment

VII.1 Introduction

This section addresses the ecological risks associated with exposure to constituents of potential ecological concern (COPEC) in soils at SWMU 60. A component of the NMED Risk-Based Decision Tree (March 1998) is to conduct an ecological screening assessment that corresponds with that presented in EPA's Ecological Risk Assessment Guidance for Superfund (EPA 1997d). The current methodology is tiered and contains an initial scoping assessment followed by a more detailed screening assessment. Initial components of NMED's decision tree (a discussion of DQOs, a data assessment, and evaluations of bioaccumulation and fate and transport potential) are addressed in previous sections of this report. Following the completion of the scoping assessment, a determination is made as to whether a more detailed examination of potential ecological risk is necessary. If deemed necessary, the scoping assessment proceeds to a screening assessment whereby a more quantitative estimate of ecological risk is conducted. Although this assessment incorporates conservatisms in the estimation of ecological risks, ecological relevance and professional judgment are also used as recommended by the EPA (1998b) to ensure that predicted exposures of selected ecological receptors reflect those reasonably expected to occur at the site.

VII.2 Scoping Assessment

The scoping assessment focuses primarily on the likelihood of exposure of biota at/or adjacent to the site to be exposed to constituents associated with site activities. Included in this section are an evaluation of existing data and a comparison of maximum detected concentrations to background concentrations, examination of bioaccumulation potential, and fate and transport potential. A scoping risk management decision (Section VII.2.4) involves summarizing the scoping results and determining whether further examination of potential ecological impacts is necessary.

VII.2.1 Data Assessment

As indicated in Section IV (Tables 3 and 4), inorganic constituents in soil within the 0- to 5-foot depth interval that exceeded background concentrations were as follows:

- Beryllium
- Cadmium
- Chromium (total)
- Lead
- Mercury
- Silver
- Uranium
- Th-232
- U-235
- U-238.

No organic analytes were detected in the soil at this site.

VII.2.2 Bioaccumulation

Among the COPECs listed in Section VII.2.1, the following were considered to have bioaccumulation potential in aquatic environments (Section IV, Tables 3 and 4):

- Cadmium
- Lead
- Mercury
- U-235
- U-238.

It should be noted, however, that as directed by the NMED (March 1998), bioaccumulation for inorganics is assessed exclusively based upon maximum reported bioconcentration factors (BCF) for aquatic species. Because only aquatic BCFs are used to evaluate the bioaccumulation potential for metals, bioaccumulation in terrestrial species is likely to be overpredicted.

VII.2.3 Fate and Transport Potential

The potential for the COPECs to move from the source of contamination to other media or biota is discussed in Section V. As noted in Table 6 (Section V), wind is expected to be of low significance as a transport mechanism for COPECs at this site, but surface-water runoff may be of moderate significance. Migration to groundwater is not anticipated. Food chain uptake is expected to be of moderate to low significance. Degradation/transformation for the inorganic COPECs and radionuclides is expected to be of low significance.

VII.2.4 Scoping Risk-Management Decision

Based upon information gathered through the scoping assessment, it was concluded that complete ecological pathways may be associated with this SWMU and that COPECs also exist at the site. As a consequence, a screening assessment was deemed necessary to predict the potential level of ecological risk associated with the site.

VII.3 Screening Assessment

As concluded in Section VII.2.4, complete ecological pathways and COPECs are associated with this SWMU. The screening assessment performed for the site involves a quantitative estimate of current ecological risks using exposure models in association with exposure parameters and toxicity information obtained from the literature. The estimation of potential ecological risks is conservative to ensure that ecological risks are not underpredicted.

Components within the screening assessment include the following:

- Problem Formulation—sets the stage for the evaluation of potential exposure and risk.
- Exposure Estimation—provides a quantitative estimate of potential exposure.
- Ecological Effects Evaluation—presents benchmarks used to gauge the toxicity of COPECs to specific receptors.
- Risk Characterization—characterizes the ecological risk associated with exposure of the receptors to environmental media at the site.
- Uncertainty Assessment—discusses uncertainties associated with the estimation of exposure and risk.
- Risk Interpretation—evaluates ecological risk in terms of HQs and ecological significance.
- Screening Assessment Scientific/Management Decision Point—presents the decision to risk managers based upon the results of the screening assessment.

VII.3.1 Problem Formulation

Problem formulation is the initial stage of the screening assessment that provides the introduction to the risk evaluation process. Components that are addressed in this section include a discussion of ecological pathways and the ecological setting, identification of COPECs, and selection of ecological receptors. The conceptual model, ecological food webs, and ecological endpoints (other components commonly addressed in a screening assessment) are presented in the "Predictive Ecological Risk Assessment Methodology for SNL/NM ER Program" (IT July 1998) and are not duplicated here.

VII.3.1.1 Ecological Pathways and Setting

SWMU 60 is approximately 2 acres in size. The site is located in woodland habitat; however, much of the habitat at this site was disturbed during use and during the recent VCA. Wildlife may use the area, but the small size of the site makes significant transfers of COPECs through the food chain pathway unlikely. A biological and sensitive species survey of the entire area encompassed by SWMU 10, which includes SWMU 60, was conducted on April 26 and May 24,1994 (IT February 1995). No sensitive species were found at SWMU 60. Although the gray vireo (*Vireo vicinior*), a New Mexico threatened species, has been recorded in the woodland habitats of Kirtland Air Force Base (NMNHP 1995), this species is not known to occur at SWMU 60.

Complete ecological pathways may exist at this site through the exposure of plants and wildlife to COPECs in surface and subsurface soil. It was assumed that direct uptake of COPECs from soil was the major route of exposure for plants and that exposure of plants to wind-blown soil was minor. Exposure modeling for the wildlife receptors was limited to the food and soil ingestion pathways and external radiation. Because of the lack of surface water at this site, exposure to COPECs through the ingestion of surface water was considered insignificant. Inhalation and dermal contact were also considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Groundwater is not expected to be affected by COCs at this site.

VII.3.1.2 COPECs

COPECs for SWMU 60 are listed in Section VII.2.1. These include both radiological and nonradiological analytes. The inorganic analytes and radionuclides were screened against background concentrations and those that exceeded the approved SNL/NM background screening levels (Dinwiddie September 1997) for the area were considered to be COPECs. Nonradiological inorganics that are essential nutrients such as iron, magnesium, calcium, potassium, and sodium were not included in this risk assessment as set forth by the EPA (1989). No organic analytes were detected at the site; therefore, no organic COPECs were identified. In order to provide conservatism, this ecological risk assessment was based upon the maximum soil concentrations of the COPECs measured in the surface soil. Tables 4 and 5 present maximum concentrations for the COPECs.

VII.3.1.3 Ecological Receptors

As described in detail by IT (July 1998), a nonspecific perennial plant was selected as the receptor to represent plant species at the site. Vascular plants are the principal primary producers at the site and are key to the diversity and productivity of the wildlife community associated with the site. The deer mouse (*Peromyscus maniculatus*) and the burrowing owl (*Speotyto cunicularia*) were used to represent wildlife use. Because of its opportunistic food habits, the deer mouse was used to represent a mammalian herbivore, omnivore, and insectivore. The burrowing owl was selected to represent a top predator at this site. Although burrowing owls are not expected to occur in the woodland habitat at SWMU 60, it is used to conservatively represent exposure and risk to other small, predatory birds such as the western screech owl (*Otus kennicottii*) that may inhabit this site. The burrowing owl is present at SNL/NM and is designated a species of management concern by the U.S. Fish and Wildlife Service in Region 2, which includes the state of New Mexico (USFWS September 1995).

VII.3.2 Exposure Estimation

For nonradiological COPECs, direct uptake from the soil was considered the only significant route of exposure for terrestrial plants. Exposure modeling for the wildlife receptors was limited to food and soil ingestion pathways. Inhalation and dermal contact were considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Drinking water was also considered an insignificant pathway because of the lack of surface water at this site. The deer mouse was modeled under three dietary regimes: as an herbivore (100 percent of its diet as plant material), as an omnivore (50 percent of its diet as plants and 50 percent as soil invertebrates), and as an insectivore (100 percent of its diet as soil invertebrates). The burrowing owl was modeled as a strict predator on small mammals (100 percent of its diet as deer mice). Because the exposure in the burrowing owl from a diet consisting of equal parts of herbivorous, omnivorous, and insectivorous mice would be equivalent to the exposure consisting of only omnivorous mice, the diet of the burrowing owl was modeled with intake of omnivorous mice only. Both species were modeled with soil ingestion comprising 2 percent of the total dietary intake. Table 11 presents the species-specific factors used in modeling exposures in the wildlife receptors. Justification for use of the factors presented in this table is described in the ecological risk assessment methodology document (IT July 1998).

Although home range is also included in this table, exposures for this risk assessment were modeled using an area use factor of 1, implying that all food items and soil ingested are from the site being investigated. The maximum measured COPEC concentrations from surface soil samples were used to conservatively estimate potential exposures and risks to plants and wildlife at this site.

For the radiological dose rate calculations, the deer mouse was modeled as an herbivore (100 percent of its diet as plants), and the burrowing owl was modeled as a strict predator on small mammals (100 percent of its diet as deer mice). Both were modeled with soil ingestion comprising 2 percent of the total dietary intake. Receptors are exposed to radiation both internally and externally from Th-232, U-235, and U-238. Internal and external dose rates to the deer mouse and the burrowing owl are approximated using modified dose rate models from DOE (1995) as presented in the ecological risk assessment methodology document for the SNL/NM ER Project (IT July 1998). Radionuclide-dependent data for the dose rate calculations were obtained from Baker and Soldat (1992). The external dose rate model examines the total-body dose-rate to a receptor residing in soil exposed to radionuclides. The soil surrounding the receptor is assumed to be an infinite medium uniformly contaminated with gamma-emitting radionuclides. The external dose rate model is the same for both the deer mouse and the burrowing owl. The internal total-body dose rate model assumes that a fraction of the radionuclide concentration ingested by a receptor is absorbed by the body and concentrated at the center of a spherical body shape. This provides for a conservative estimate for absorbed dose. This concentrated radiation source at the center of the body of the receptor is assumed to be a "point" source. Radiation emitted from this point source is absorbed by the body tissues to contribute to the absorbed dose. Alpha and beta emitters are assumed to transfer 100 percent of their energy to the receptor as they pass through tissues. Gamma-emitting radionuclides only transfer a fraction of their energy to the tissues because gamma rays interact less with matter than do beta or alpha emitters. The external and internal dose rate results are summed to calculate a total dose rate from exposure to Th-232, U-235, and U-238 in soil.

Table 12 presents the transfer factors used in modeling the concentrations of COPECs through the food chain. Table 13 presents maximum concentrations in soil and derived concentrations in tissues of the various food chain elements that are used to model dietary exposures for each of the wildlife receptors.

VII.3.3 Ecological Effects Evaluation

Table 14 shows benchmark toxicity values for the plant and wildlife receptors. For plants, the benchmark soil concentrations are based upon the lowest-observed-adverse-effect level. For wildlife, the toxicity benchmarks are based upon the no-observed-adverse-effect level (NOAEL)

Table 11
Exposure Factors for Ecological Receptors at SWMU 60

Receptor Species	Class/Order	Trophic Level	Body Weight (kg)[a]	Food Intake Rate (kg/day)[b]	Dietary Composition[c]	Home Range (acres)
Deer mouse (*Peromyscus maniculatus*)	Mammalia/ Rodentia	Herbivore	2.39E-2[d]	3.72E-3	Plants: 100% (+ soil at 2% of intake)	2.7E-1[e]
Deer mouse (*Peromyscus maniculatus*)	Mammalia/ Rodentia	Omnivore	2.39E-2[d]	3.72E-3	Plants: 50% Invertebrates: 50% (+ soil at 2% of intake)	2.7E-1[e]
Deer mouse (*Peromyscus maniculatus*)	Mammalia/ Rodentia	Insectivore	2.39E-2[d]	3.72E-3	Invertebrates: 100% (+ soil at 2% of intake)	2.7E-1[e]
Burrowing owl (*Speotyto cunicularia*)	Aves/ Strigiformes	Carnivore	1.55E-1[f]	1.73E-2	Rodents: 100% (+ soil at 2% of intake)	3.5E+1[g]

[a]Body weights are in kg wet weight.
[b]Food intake rates are estimated from the allometric equations presented in Nagy (1987). Units are kg dry weight per day.
[c]Dietary compositions are generalized for modeling purposes. Default soil intake value of 2% of food intake.
[d]From Silva and Downing (1995).
[e]EPA (1993), based upon the average home range measured in semiarid shrubland in Idaho.
[f]From Dunning (1993).
[g]From Haug et al. (1993).
EPA = U.S. Environmental Protection Agency.
kg = Kilogram(s).
kg/day = Kilogram(s) per day.
SWMU = Solid Waste Management Unit.

Table 12
Transfer Factors Used in Exposure Models for Constituents of Potential Ecological Concern at SWMU 60

Constituent of Potential Ecological Concern	Soil-to-Plant Transfer Factor	Soil-to-Invertebrate Transfer Factor	Food-to-Muscle Transfer Factor
Beryllium	1.0E-2[a]	1.0E+0[b]	1.0E-3[a]
Cadmium	5.5E-1[a]	6.0E-1[c]	5.5E-4[a]
Chromium (total)	4.0E-2[d]	1.3E-1[e]	3.0E-2[d]
Lead	9.0E-2[d]	4.0E-2[c]	8.0E-4[d]
Mercury	1.0E+0[d]	1.0E+0[b]	2.5E-1[a]
Silver	1.0E+0[d]	2.5E-1[c]	5.0E-3[d]
Uranium	2.3E-2[f]	1.0E+0[b]	1.0E-2[d]

[a]From Baes et al. (1984).
[b]Default value.
[c]From Stafford et al. (1991).
[d]From NCRP (January 1989).
[e]From Ma (1982).
[f]From IAEA (1994).
IAEA = International Atomic Energy Agency.
NCRP = National Council on Radiation Protection and Measurements.
SWMU = Solid Waste Management Unit.

Table 13
Media Concentrations[a] for Constituents of Potential Ecological Concern at SWMU 60

Constituent of Potential Ecological Concern	Soil (maximum)[a]	Plant Foliage[b]	Soil Invertebrate[b]	Deer Mouse Tissues[c]
Beryllium	1.2E+1	1.2E-1	1.2E+1	2.0E-2
Cadmium	8.1E-1	4.5E-1	4.9E-1	8.3E-4
Chromium (total)	3.2E+1	1.3E+0	4.2E+0	3.2E-1
Lead	2.2E+1	2.0E+0	8.8E-1	4.7E-3
Mercury	5.6E-2	5.6E-2	5.6E-2	4.5E-2
Silver	6.3E-1	6.3E-1	1.6E-1	6.4E-3
Uranium	1.3E+1	3.0E-1	3.0E+1	4.9E-1

[a]In milligram(s) per kilogram. All biotic media are based upon dry weight of the media. Soil concentration measurements are assumed to have been based upon dry weight. Values have been rounded to two significant digits after calculation.
[b]Product of the soil concentration and the corresponding transfer factor.
[c]Based upon the deer mouse with an omnivorous diet. Product of the average concentration ingested in food and soil times the food-to-muscle transfer factor times a wet weight-dry weight conversion factor of 3.125 (EPA 1993).
EPA = U.S. Environmental Protection Agency.
SWMU = Solid Waste Management Unit.

Table 14
Toxicity Benchmarks for Ecological Receptors at SWMU 60

Constituent of Potential Ecological Concern	Plant Benchmark[a,b]	Mammalian NOAELs			Avian NOAELs		
		Mammalian Test Species[c,d]	Test Species NOAEL[d,e]	Deer Mouse NOAEL[e,f]	Avian Test Species[d]	Test Species NOAEL[d,e]	Burrowing Owl NOAEL[e,g]
Beryllium	10	Rat	0.66	1.29	–	–	–
Cadmium	3	Rat[h]	1.0	1.9	Mallard	1.45	1.45
Chromium (total)	1	Rat	2,737	5,354	Black duck	1.0	1.0
Lead	50	Rat	8.0	15.7	American kestrel	3.85	3.85
Mercury (inorganic)	0.3	Mouse	13.2	14.0	Japanese quail	0.45	0.45
Mercury (organic)	0.3	Rat	0.032	0.063	Mallard	0.0064	0.0064
Silver	2	Rat	17.8[i]	34.8	–	–	–
Uranium	5	Mouse[j]	3.07	3.19	Black duck	16.0	16.0

[a]In milligram(s) per kilogram soil dry weight.
[b]From Efroymson et al. (1997).
[c]Body weights (in kilogram[s]) for the NOAEL conversion are as follows: lab mouse, 0.030; lab rat, 0.350 (except where noted).
[d]From Sample et al. (1996), except where noted.
[e]In milligram(s) per kilogram body weight per day.
[f]Based upon NOAEL conversion methodology presented in Sample et al. (1996), using a deer mouse body weight of 0.0239 kilogram and a mammalian scaling factor of 0.25.
[g]Based upon NOAEL conversion methodology presented in Sample et al. (1996). The avian scaling factor of 0.0 was used, making the NOAEL independent of body weight.
[h]Body weight: 0.303 kilogram.
[i]Based upon a rat LOAEL of 89 mg/kg/d (EPA 1998a) and an uncertainty factor of 0.2.
[j]Body weight: 0.028 kilogram.

EPA = U.S. Environmental Protection Agency.
LOAEL = Lowest-observed-adverse-effect level.
mg/kg/d = Milligrams per kilogram per day.
NOAEL = No-observed-adverse-effect level.
SWMU = Solid waste management unit.
– = Insufficient toxicity data.

for chronic oral exposure in a taxonomically similar test species. Insufficient toxicity information was found to estimate the NOAELs for beryllium and silver for the burrowing owl.

The benchmark used for exposure of terrestrial receptors to radiation was 0.1 rad/day. This value has been recommended by the International Atomic Energy Agency (IAEA 1992) for the protection of terrestrial populations. Because plants and insects are less sensitive to radiation than vertebrates (Whicker and Schultz 1982), the dose of 0.1 rad/day should also offer sufficient protection to other components within the terrestrial habitat of SWMU 60.

VII.3.4 Risk Characterization

Maximum concentrations in soil and estimated dietary exposures were compared to plant and wildlife benchmark values, respectively. Table 15 presents results of these comparisons. HQs are used to quantify the comparison with benchmarks for plants and wildlife exposure.

Analytes with HQs exceeding unity for plants were beryllium, chromium (total), and uranium. Beryllium exhibited a HQ greater than unity for the insectivorous deer mouse. HQs for the burrowing owl could not be determined for beryllium and silver. As directed by the NMED, HIs were calculated for each of the receptors (the HI is the sum of chemical-specific HQs for all pathways for a given receptor). Plants, the omnivorous deer mouse, and the insectivorous deer mouse had total HIs greater than unity, with a maximum HI of 37 for plants (with chromium accounting for approximately 86 percent of the value).

Tables 16 and 17 summarize the internal and external dose rate model results for Th-232, U-235, and U-238. The total radiation dose rate to the deer mouse was predicted to be 1.3E-3 rad/day. Total dose rate to the burrowing owl was predicted to be 1.2E-3 rad/day. The dose rates for the deer mouse and the burrowing owl are considerably less than the benchmark of 0.1 rad/day.

VII.3.5 Uncertainty Assessment

Many uncertainties are associated with the characterization of ecological risks at SWMU 60. These uncertainties result from assumptions used in calculating risk that could overestimate or underestimate true risk presented at a site. For this risk assessment, assumptions are made that are more likely to overestimate exposures and risk rather than to underestimate them. These conservative assumptions are used to be more protective of the ecological resources potentially affected by the site. Conservatisms incorporated into this risk assessment include the use of maximum measured analyte concentrations in soil to evaluate risk, the use of wildlife toxicity benchmarks based upon NOAEL values, the incorporation of strict herbivorous and strict insectivorous diets for predicting the extreme HQ values for the deer mouse and the use of 1.0 as the area use factor for wildlife receptors regardless of seasonal use or home range size. Each of these uncertainties, which are consistent among each of the SWMU-specific ecological risk assessments, is discussed in greater detail in the uncertainty section of the ecological risk assessment methodology document for the SNL/NM ER Project (IT July 1998).

Uncertainties associated with the estimation of risk to ecological receptors following exposure to Th-232, U-235, and U-238 are primarily related to those inherent in the radionuclide-specific data. Radionuclide-dependent data are measured values that have their associated errors. The dose rate models used for these calculations are based upon conservative estimates on

Table 15
HQs for Ecological Receptors at SWMU 60

Constituent of Potential Ecological Concern	Plant HQ	Deer Mouse HQ (Herbivorous)	Deer Mouse HQ (Omnivorous)	Deer Mouse HQ (Insectivorous)	Burrowing Owl HQ
Beryllium	**1.2E+0**	4.3E-2	7.6E-1	**1.5E+0**	–
Cadmium	2.7E-1	3.8E-2	4.0E-2	4.1E-2	1.3E-3
Chromium (total)	**3.2E+1**	5.6E-5	9.8E-5	1.4E-4	1.1E-1
Lead	4.4E-1	2.4E-2	1.9E-2	1.3E-2	1.3E-2
Mercury (inorganic)	1.9E-1	6.4E-4	6.4E-4	6.4E-4	1.1E-2
Mercury (organic)	1.9E-1	1.4E-1	1.4E-1	1.4E-1	8.0E-1
Silver	3.2E-1	2.9E-3	1.8E-3	7.6E-4	–
Uranium	**2.6E+0**	2.7E-2	3.4E-1	6.5E-3	3.3E-3
HI[a]	**3.7E+1**	2.8E-1	**1.3E+0**	**2.3E+0**	9.3E-1

Note: **Bold** text indicates HQ or HI exceeds unity.
[a]The HI is the sum of individual HQs using the value for organic mercury as a conservative estimate of the HI.
HI = Hazard index.
HQ = Hazard quotient.
SWMU = Solid Waste Management Unit.
– = Insufficient toxicity data available for risk estimation purposes.

Table 16
Internal and External Dose Rates for Deer Mice Exposed to Radionuclides at SWMU 60

Radionuclide	Maximum Concentration (pCi/g)	Internal Dose (rad/day)	External Dose (rad/day)	Total Dose (rad/day)
Th-232	1.48	5.9E-7	2.8E-4	2.8E-4
U-235	0.254	2.8E-6	4.1E-6	6.9E-6
U-238	5.93	6.0E-5	9.0E-4	9.6E-4
Total		6.3E-5	1.2E-3	1.3E-3

pCi/g = Picocurie(s) per gram.
SWMU = Solid Waste Management Unit.

Table 17
Internal and External Dose Rates for Burrowing Owls Exposed to Radionuclides at SWMU 60

Radionuclide	Maximum Concentration (pCi/g)	Internal Dose (rad/day)	External Dose (rad/day)	Total Dose (rad/day)
Th-232	1.48	8.7E-7	2.8E-4	2.8E-4
U-235	0.254	1.1E-6	4.1E-6	5.3E-6
U-238	5.93	2.4E-5	9.0E-4	9.3E-4
Total		2.6E-5	1.2E-3	1.2E-3

pCi/g = Picocurie(s) per gram.
SWMU = Solid Waste Management Unit.

receptor shape, radiation absorption by body tissues, and intake parameters. The goal is to provide a realistic but conservative estimate of a receptor's internal and external exposure to radionuclides in soil.

In the estimation of ecological risk, background concentrations are included as a component of maximum on-site concentrations. For some inorganic COPECs, conservatisms in the modeling of exposure and risk result in the prediction of risk to ecological receptors when exposed at background concentrations. As shown in Table 18, the HQ for plants associated with exposure to background concentrations of chromium is greater than 1.0. Background may account for as much as 59 percent the HQ for chromium. It is, therefore, likely that actual risk from chromium at SWMU 60 is significantly overestimated by the HQs calculated in this screening assessment because of conservatism in the plant toxicity benchmark for this COPEC.

A significant source of uncertainty associated with the prediction of ecological risks at this site is the use of the maximum measured concentrations or detection limits to evaluate risk. This results in a conservative exposure scenario that does not necessarily reflect actual site conditions. To assess the potential degree of overestimation caused by using the maximum measured soil concentrations in the exposure assessment, average soil concentrations were calculated for the COPECs with HQs greater than unity to determine whether these HQs can be accounted for by the magnitude of the extreme measurement. The mean concentrations of beryllium, total chromium, and uranium were determined to be 1.5, 13, and 3.3 mg/kg, respectively. The means for total chromium and uranium are less than their respective background screening values; therefore, their HQ values will be less than those shown in Table 18. For beryllium, the mean soil concentrations resulted in HQs less than 1.0, with a maximum HQ (for the insectivorous deer mouse) equal to 0.18.

Based upon this uncertainty analysis, ecological risks at SWMU 60 are expected to be very low. HQs greater than unity were initially predicted; however, closer examination of the exposure assumptions revealed an overestimation of risk primarily attributed to highly conservative exposure scenarios and background risk.

VII.3.6 Risk Interpretation

Ecological risks associated with SWMU 60 were estimated through a screening assessment that incorporated site-specific information when available. Overall, risks to ecological receptors are expected to be low because predicted risks associated with exposure to COPECs are based upon calculations using maximum detected values. Predicted risks from exposure to beryllium, chromium (total), and uranium were attributed to using maximum detected values. The average chromium and uranium concentrations at the site were within the range of background concentrations and that of beryllium was less than that required to indicate potential risk. Based upon this final analysis, ecological risks associated with SWMU 60 are expected to be low.

VII.3.7 Screening Assessment Scientific/Management Decision Point

After potential ecological risks associated with the site have been assessed, a decision is made regarding whether the site should be recommended for NFA or whether additional data should

Table 18
HQs for Ecological Receptors Exposed to Background Concentrations at SWMU 60

Constituent of Potential Ecological Concern	Plant HQ	Deer Mouse HQ (Herbivorous)	Deer Mouse HQ (Omnivorous)	Deer Mouse HQ (Insectivorous)	Burrowing Owl HQ
Beryllium	7.5E-2	2.7E-3	4.8E-2	9.2E-2	–
Cadmium	2.1E-1	3.0E-2	3.1E-2	3.3E-2	1.0E-3
Chromium (total)	**1.9E+1**	3.3E-5	5.7E-5	8.2E-5	6.3E-2
Lead	3.8E-1	2.1E-2	1.6E-2	1.1E-2	1.1E-2
Mercury (inorganic)	1.8E-1	6.3E-4	6.3E-4	6.3E-4	1.1E-2
Mercury (organic)	1.8E-1	1.4E-1	1.4E-1	1.4E-1	7.8E-1
Silver	1.3E-1	1.1E-3	7.2E-4	3.0E-4	–
Uranium	6.8E-1	7.2E-3	8.9E-2	1.7E-1	8.7E-4
HI[a]	**2.1E+1**	2.0E-1	3.2E-1	4.5E-1	8.7E-1

Note: **Bold** text indicates HQ or HI exceeds unity.
[a]The HI is the sum of individual HQs using the value for organic mercury as a conservative estimate of the HI.
HI = Hazard index.
HQ = Hazard quotients.
SWMU = Solid Waste Management Unit.
– = Insufficient toxicity data available for risk estimation purposes.

be collected to assess actual ecological risk at the site more thoroughly. With respect to this site, ecological risks are predicted to be low. The scientific/management decision is to recommend this site for NFA.

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APPENDIX 1
EXPOSURE PATHWAY DISCUSSION FOR CHEMICAL AND RADIONUCLIDE CONTAMINATION

Introduction

Sandia National Laboratories/New Mexico (SNL/NM) proposes that a default set of exposure routes and associated default parameter values be developed for each future land use designation being considered for SNL/NM Environmental Restoration (ER) project sites. This default set of exposure scenarios and parameter values would be invoked for risk assessments unless site-specific information suggested other parameter values. Because many SNL/NM solid waste management units (SWMU) have similar types of contamination and physical settings, SNL/NM believes that the risk assessment analyses at these sites can be similar. A default set of exposure scenarios and parameter values will facilitate the risk assessments and subsequent review.

The default exposure routes and parameter values suggested are those that SNL/NM views as resulting in a Reasonable Maximum Exposure (RME) value. Subject to comments and recommendations by the U.S. Environmental Protection Agency (EPA) Region VI and New Mexico Environment Department (NMED), SNL/NM proposes that these default exposure routes and parameter values be used in future risk assessments.

At SNL/NM, all SWMUs exist within the boundaries of the Kirtland Air Force Base (KAFB). Approximately 157 potential waste and release sites have been identified where hazardous, radiological, or mixed materials may have been released to the environment. Evaluation and characterization activities have occurred at all of these sites to varying degrees. Among other documents, the SNL/NM ER draft Environmental Assessment (DOE 1996) presents a summary of the hydrogeology of the sites, the biological resources present and proposed land use scenarios for the SNL/NM SWMUs. At this time, all SNL/NM SWMUs have been tentatively designated for either industrial or recreational future land use. The NMED has also requested that risk calculations be performed based upon a residential land use scenario. All three land use scenarios will be addressed in this document.

The SNL/NM ER project has screened the potential exposure routes and identified default parameter values to be used for calculating potential intake and subsequent Hazard index (HI), excess cancer risk and dose values. The EPA (EPA 1989a) provides a summary of exposure routes that could potentially be of significance at a specific waste site. These potential exposure routes consist of:

- Ingestion of contaminated drinking water
- Ingestion of contaminated soil
- Ingestion of contaminated fish and shell fish
- Ingestion of contaminated fruits and vegetables

- Ingestion of contaminated meat, eggs, and dairy products
- Ingestion of contaminated surface water while swimming
- Dermal contact with chemicals in water
- Dermal contact with chemicals in soil
- Inhalation of airborne compounds (vapor phase or particulate)
- External exposure to penetrating radiation (immersion in contaminated air; immersion in contaminated water and exposure from ground surfaces with photon-emitting radionuclides).

Based upon the location of the SNL/NM SWMUs and the characteristics of the surface and subsurface at the sites, we have evaluated these potential exposure routes for different land use scenarios to determine which should be considered in risk assessment analyses (the last exposure route is pertinent to radionuclides only). At SNL/NM SWMUs, there does not currently occur any consumption of fish, shell fish, fruits, vegetables, meat, eggs, or dairy products that originate on site. Additionally, no potential for swimming in surface water is present due to the high-desert environmental conditions. As documented in the RESRAD computer code manual (ANL 1993), risks resulting from immersion in contaminated air or water are not significant compared to risks from other radiation exposure routes.

For the industrial and recreational land use scenarios, SNL/NM ER has, therefore, excluded the following four potential exposure routes from further risk assessment evaluations at any SNL/NM SWMU:

- Ingestion of contaminated fish and shell fish
- Ingestion of contaminated fruits and vegetables
- Ingestion of contaminated meat, eggs, and dairy products
- Ingestion of contaminated surface water while swimming.

That part of the exposure pathway for radionuclides related to immersion in contaminated air or water is also eliminated.

For the residential land use scenario, we will include ingestion of contaminated fruits and vegetables because of the potential for residential gardening.

Based upon this evaluation, for future risk assessments, the exposure routes that will be considered are shown in Table 1. Dermal contact is included as a potential exposure pathway in all land use scenarios. However, the potential for dermal exposure to inorganics is not considered significant and will not be included. In general, the dermal exposure pathway is generally considered to not be significant relative to water ingestion and soil ingestion pathways but will be considered for organic components. Because of the lack of toxicological parameter values for this pathway, the inclusion of this exposure pathway into risk assessment calculations may not be possible and may be part of the uncertainty analysis for a site where dermal contact is potentially applicable.

Table 1
Exposure Pathways Considered for Various Land Use Scenarios

Industrial	Recreational	Residential
Ingestion of contaminated drinking water	Ingestion of contaminated drinking water	Ingestion of contaminated drinking water
Ingestion of contaminated soil	Ingestion of contaminated soil	Ingestion of contaminated soil
Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)
Dermal contact	Dermal contact	Dermal contact
External exposure to penetrating radiation from ground surfaces	External exposure to penetrating radiation from ground surfaces	Ingestion of fruits and vegetables
		External exposure to penetrating radiation from ground surfaces

Equations and Default Parameter Values for Identified Exposure Routes

In general, SNL/NM expects that ingestion of compounds in drinking water and soil will be the more significant exposure routes for chemicals; external exposure to radiation may also be significant for radionuclides. All of the above routes will, however, be considered for their appropriate land use scenarios. The general equations for calculating potential intakes via these routes are shown below. The equations are from the Risk Assessment Guidance for Superfund (RAGS): Volume 1 (EPA 1989a, 1991). These general equations also apply to calculating potential intakes for radionuclides. A more in-depth discussion of the equations used in performing radiological pathway analyses with the RESRAD code may be found in the RESRAD Manual (ANL 1993). Also shown are the default values SNL/NM ER suggests for use in RME risk assessment calculations for industrial, recreational, and residential scenarios, based upon EPA and other governmental agency guidance. The pathways and values for chemical contaminants are discussed first, followed by those for radionuclide contaminants. RESRAD input parameters that are left as the default values provided with the code are not discussed. Further information relating to these parameters may be found in the RESRAD Manual (ANL 1993).

Generic Equation for Calculation of Risk Parameter Values

The equation used to calculate the risk parameter values (i.e., hazard quotients/hazard index [HI], excess cancer risk, or radiation total effective dose equivalent [dose]) is similar for all exposure pathways and is given by:

Risk (or Dose) = Intake x Toxicity Effect (either carcinogenic, noncarcinogenic, or radiological)

$$= C \times (CR \times EFD/BW/AT) \times \text{Toxicity Effect} \qquad (1)$$

where

- C = contaminant concentration (site specific)
- CR = contact rate for the exposure pathway
- EFD = exposure frequency and duration
- BW = body weight of average exposure individual
- AT = time over which exposure is averaged.

The total risk/dose (either cancer risk or HI) is the sum of the risks/doses for all of the site-specific exposure pathways and contaminants.

The evaluation of the carcinogenic health hazard produces a quantitative estimate for excess cancer risk resulting from the constituents of concern (COC) present at the site. This estimate is evaluated for determination of further action by comparison of the quantitative estimate with the potentially acceptable risk range of 1E-6 for Class A and B carcinogens and 1E-5 for Class C carcinogens. The evaluation of the noncarcinogenic health hazard produces a quantitative estimate (i.e., the HI) for the toxicity resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of this quantitative estimate with the EPA standard HI of unity (1). The evaluation of the health hazard due to radioactive compounds produces a quantitative estimate of doses resulting from the COCs present at the site.

The specific equations used for the individual exposure pathways can be found in RAGS (EPA 1989a) and the RESRAD Manual (ANL 1993). Table 2 shows the default parameter values suggested for used by SNL/NM at SWMUs, based upon the selected land use scenario. References are given at the end of the table indicating the source for the chosen parameter values. The intention of SNL/NM is to use default values that are consistent with regulatory guidance and consistent with the RME approach. Therefore, the values chosen will, in general, provide a conservative estimate of the actual risk parameter. These parameter values are suggested for use for the various exposure pathways based upon the assumption that a particular site has no unusual characteristics that contradict the default assumptions. For sites for which the assumptions are not valid, the parameter values will be modified and documented.

Summary

SNL/NM proposes the described default exposure routes and parameter values for use in risk assessments at sites that have an industrial, recreational or residential future land use scenario. There are no current residential land use designations at SNL/NM ER sites, but this scenario has been requested to be considered by the NMED. For sites designated as industrial or recreational land use, SNL/NM will provide risk parameter values based upon a residential land use scenario to indicate the effects of data uncertainty on risk value calculations or in order to potentially mitigate the need for institutional controls or restrictions on SNL/NM ER sites. The parameter values are based upon EPA guidance and supplemented by information from other government sources. The values are generally consistent with those proposed by Los Alamos National Laboratory, with a few minor variations. If these exposure routes and parameters are acceptable, SNL/NM will use them in risk assessments for all sites where the assumptions are consistent with site-specific conditions. All deviations will be documented.

Table 2
Default Parameter Values for Various Land Use Scenarios

Parameter	Industrial	Recreational	Residential
General Exposure Parameters			
Exposure frequency	8 hr/day for 250 day	4 hr/wk for 52 wk/yr	350 day/yr
Exposure duration (yr)	25[a,b]	30[a,b]	30[a,b]
Body weight (kg)	70[a,b]	70 adult[a,b] 15 child	70 adult[a,b] 15 child
Averaging Time (days) for carcinogenic compounds (= 70 y x 365 day/yr) for noncarcinogenic compounds (= ED x 365 day/yr)	 25,550[a] 9,125	 25,550[a] 10,950	 25,550[a] 10,950
Soil Ingestion Pathway			
Ingestion rate	100 mg/day[c]	200 mg/day child 100 mg/day adult	200 mg/day child 100 mg/day adult
Inhalation Pathway			
Inhalation rate (m^3/yr)	5,000[a,b]	260[d]	7,000[a,b,d]
Volatilization factor (m^3/kg)	chemical specific	chemical specific	chemical specific
Particulate emission factor (m^3/kg)	1.32E9[a]	1.32E9[a]	1.32E9[a]
Water Ingestion Pathway			
Ingestion rate (liter/day)	2[a,b]	2[a,b]	2[a,b]
Food Ingestion Pathway			
Ingestion rate (kg/yr)	NA	NA	138[b,d]
Fraction ingested	NA	NA	0.25[b,d]
Dermal Pathway			
Surface area in water (m^2)	2[b,e]	2[b,e]	2[b,e]
Surface area in soil (m^2)	0.53[b,e]	0.53[b,e]	0.53[b,e]
Permeability coefficient	chemical specific	chemical specific	chemical specific

[a]Risk Assessment Guidance for Superfund, Vol. 1, Part B (EPA 1991).
[b]Exposure Factors Handbook (EPA 1989b).
[c]EPA Region VI guidance.
[d]For radionuclides, RESRAD (Argonne National Laboratory, 1993. *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD*, Version 5.0, ANL/EAD/LD-2, Argonne National Laboratory, Argonne, IL. 1993) is used for human health risk calculations; default parameters are consistent with RESRAD guidance.
[e]Dermal Exposure Assessment (EPA 1992).

ED = Exposure duration.
EPA = U.S. Environmental Protection Agency.
hr = Hour.
kg = Kilogram(s).
m = Meter(s).
mg = Milligram(s).
NA = Not available.
wk = Week.
yr = Year.

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