



# Sandia National Laboratories/New Mexico

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PROPOSAL FOR  
RISK-BASED NO FURTHER ACTION  
ENVIRONMENTAL RESTORATION SITES 1 AND 3  
RADIOACTIVE WASTE LANDFILL AND CHEMICAL  
DISPOSAL PITS  
OPERABLE UNIT 1303

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September 1997

Environmental  
Restoration  
Project



United States Department of Energy  
Albuquerque Operations Office

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OPERABLE UNIT 1303  
September 1997**

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

Prepared for  
the U. S. Department of Energy

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## ACRONYMS AND ABBREVIATIONS

amp/m <sup>2</sup>	ampere(s) per square meter
CDP	Chemical Disposal Pits
CEARP	Comprehensive Environmental Assessment and Response Program
COC	constituents of concern
COPEC	constituents of potential ecological concern
cpm	counts per minute
cy	cubic yards
DOE	U.S. Department of Energy
EC/VCM	expedited clean-up/voluntary corrective measures
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
fbgs	feet below ground surface
ft	foot (feet)
g	gram(s)
GM	Geiger-Mueller
mg/kg	milligrams per kilogram
mrem/hr	millirem(s) per hour
mR/hr	milliroentgen per hour
NFA	no further action
NMED	New Mexico Environment Department
pCi/g	picocuries per gram
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RWL	Radioactive Waste Landfill
SNL/NM	Sandia National Laboratories/New Mexico
SVOC	semivolatile organic compound
SVS	soil vapor survey
SWMU	solid waste management unit
TA-II	Technical Area II
VOC	volatile organic compound

## 1.0 INTRODUCTION

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a Risk-Based No Further Action (NFA) for Environmental Restoration (ER) Sites 1 and 3, the Radioactive Waste Landfill (RWL), and the Chemical Disposal Pits (CDP), respectively, Operable Unit 1303.

The RWL/CDPs were originally proposed for expedited clean-up/voluntary corrective measures (EC/VCM) through a One Pass Class III permit modification request, which was submitted to the New Mexico Environment Department (NMED) and the U.S. Environmental Protection Agency (EPA) in August 1995. This proposal provides a description, history, evaluation of relevant evidence, and rationale for the NFA decision for ER Sites 1 and 3.

### 1.1 Description of ER Sites 1 and 3

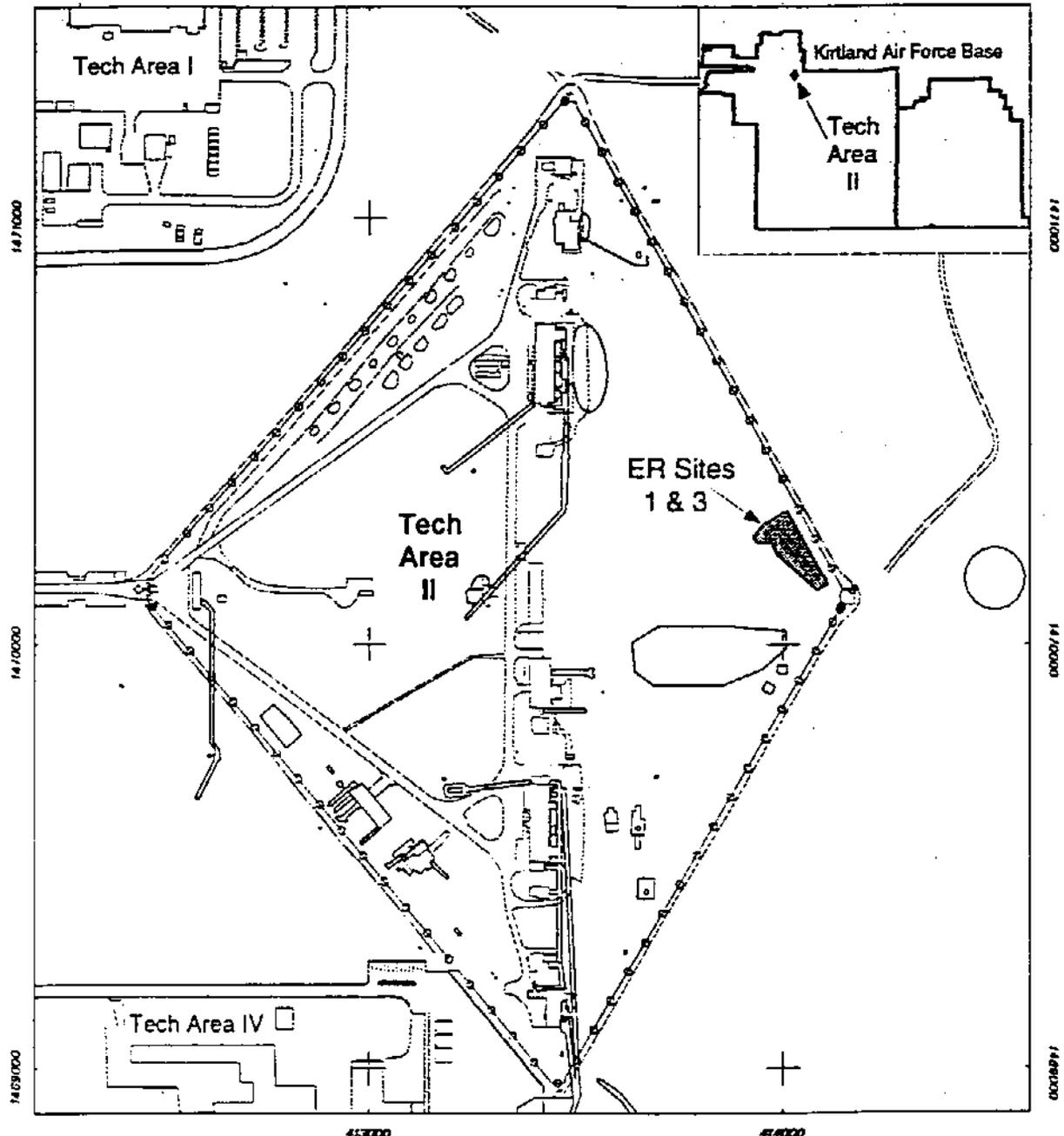
The RWL/CDPs were located in the eastern portion of Technical Area II (TA-II), about 25 feet (ft) west of the eastern apex of the TA-II perimeter fence (Figure 1-1). The 0.3 acre RWL was surrounded by a barbed wire fence posted with radiation warning signs (Haines et al. 1991). The location of the CDPs was based on information collected from interviews with employees, aerial photographs, and regional geophysical survey data.

The regional aquifer in the vicinity of ER Sites 1 and 3 is within the upper unit of the Santa Fe Group. The depth to groundwater in the monitor well nearest to ER Sites 1 and 3 (TA2-NW1-595) is approximately 520 ft below ground surface (fbgs) or 4,889.3 ft above mean sea level. TA2-NW1-595 has a total depth of 598 fbgs, with screens from 535 to 555 fbgs and 585 to 595 fbgs. A shallow water-bearing zone also exists in the vicinity of ER Sites 1 and 3. The depth to the shallow zone in the vicinity of ER Sites 1 and 3 ranges from approximately 267 to 320 fbgs. Monitor wells TA2-SW1-325, TA2-NW1-320, WYO-2, TA2-W-19, and TA2-W-01 are located in the vicinity of ER Sites 1 and 3 and are screened in the shallow water-bearing zone.

The area is essentially flat, with a gentle slope to the west of approximately 4 percent. Tijeras Arroyo, the largest drainage feature at SNL/NM, is located immediately southeast of TA-II. The surface geology at ER Sites 1 and 3 consists of unconsolidated alluvial and colluvial deposits derived from the Sandia and Manzanita Mountains. These deposits consist of sediments ranging from clay to gravel derived from the granitic rocks of the Sandia Mountains and greenstone, limestone, and quartzite derived from the Manzanita Mountains (SNL/NM 1996).

Surficial deposits are underlain by the upper unit of the Santa Fe Group. Hawley and Haase (1992) estimate that in this area, the piedmont-slope alluvium may be up to 100 ft thick, and the upper Santa Fe unit is approximately 1,200 ft thick.

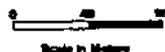
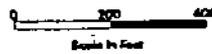
The piedmont-slope alluvium, which was deposited by the ancestral Tijeras Arroyo, is generally coarse-grained sand and gravel. The upper Santa Fe unit was deposited from 5 to 1 million years ago and consists of coarse- to fine-grained fluvial deposits from the ancestral Rio Grande that intertongues with coarse-grained alluvial-fan/piedmont-veneer facies, which extend



### Legend

-  Road
-  Other ER Site Boundary
-  Fence
-  Building/Structure
-  ER Site 1 & 3

**Figure 1-1**  
**ER Sites 1 & 3**  
**Location Map**



Sandia National Laboratories, New Mexico  
Environmental Geographic Information System

westward from the Sandia and Manzanita Mountains. ER Sites 1 and 3 are near the easternmost limit of the ancestral Rio Grande deposits (Hawley and Haase 1992).

Several rift-bounding faults are located east of ER Sites 1 and 3. The nearest is the Sandia fault-zone, characterized by north-trending, west-dipping normal faults. The westernmost fault is located approximately 1.2 miles east of the site (Hawley and Haase 1992). The Sandia fault-zone merges with the Tijeras fault-zone and the Hubbell Springs fault near the southern edge of Kirtland Air Force Base. These faults are discussed in the 1995 Site-Wide Hydrogeologic Characterization Project Annual Report (SNL/NM 1996), as well as in Hawley and Haase (1992).

## **1.2 No Further Action Basis**

Review and analysis of all relevant data for ER Sites 1 and 3 indicate that concentrations of constituents of concern (COC) at these sites are less than the applicable risk assessment action levels (Section 6.1). Thus, ER Sites 1 and 3 are being proposed for a risk-based NFA decision. COCs that may have been released from this site into the environment pose an acceptable level of risk under current and projected future land use, designated as industrial, per NFA Criterion 5 of the ER Document of Understanding (NMED April 1996).

## 2.0 HISTORY OF ER SITES 1 AND 3

This section discusses the historical operations and previous audits, inspections, and findings at ER Sites 1 and 3.

### 2.1 Historical Operations

#### Radioactive Waste Landfill (ER Site 1)

Initial information about the RWL was based on employee interviews (Haines et al. 1991). The RWL had three pits and three trenches where low-level radioactive waste was disposed of from 1949 to 1959. Supposedly, after March 1959, all radioactive waste was disposed of at a separate facility in TA-III, although one item removed from the landfill was dated 1978.

The RWL pits were approximately 12 ft wide by 20 ft long by 25 ft deep. The trenches ranged from 5 to 15 ft wide, 25 to 50 ft long, and 15 ft deep. The pits and trenches were labeled as Pits 1, 2, and 7 and Trenches 3/4, 5, and 6. The majority of the waste was not containerized before disposal. The pits and trenches were unlined and did not contain leachate detection or collection systems. The pits and trenches were filled with debris, and then covered with native soil and capped with 3 ft of concrete.

No detailed records of waste material disposed of in the RWL are available. However, U.S. Department of Energy (DOE) Solid Waste Information Management System records showed that an estimated 11,110 cubic ft of radioactive waste was buried in the landfill, with an estimated total activity of 2,847 curies. This estimated volume reportedly referred to disposed material and did not include the backfilled native soil. The estimate also may not have reflected any classified and/or unclassified hazardous chemicals that were disposed of in the RWL.

Waste material disposed of in the RWL mainly consisted of solids, although lesser amounts of liquids were present. Chemical waste material included lead, which was typically used for radioactive shielding, thermal batteries, and nitric acid.

The RWL primarily contained low-level waste, although some minor transuranic waste material was also present in the landfill. Most of the material buried in the RWL consisted of weapons components, irradiated and neutron-activated material, thermal batteries, and radioactive sources. The weapons components and waste material contained depleted uranium, thorium, tritium, cobalt, cesium, americium, and plutonium.

In 1954, tritiated waste, mainly from booster cylinders, was reportedly buried in the RWL. Other items buried in the RWL included neutron generator parts, irradiated material from nuclear rocket tests, and radium-beryllium neutron sources. In addition, cobalt sources were buried in the RWL. Cesium-containing gap tubes and tracer materials collected on fallout plates were also buried in the landfill.

Other waste material in the RWL consisted of laboratory-generated waste, such as contaminated gloves, pipettes, absorbent pads, forceps, beakers, test tubes, paper, tools, clothing, and soil and bioassay samples. Some of the samples reportedly contained hydrochloric acid, toluene, possibly other solvents, and potentially a total of 2 to 3 grams (g) of plutonium. Low-level waste material from nuclear reactor studies conducted at the Sandia Engineering Reactor Facility and Sandia Pulsed Reactor also were reportedly disposed of in the RWL.

### Chemical Disposal Pits (ER Site 3)

Initial information about the CDPs was based on employee interviews (Haines et al. 1991). The CDPs reportedly were used in the late 1940s and 1950s to dispose of chemical waste. The CDPs may have been originally excavated with a backhoe, filled with waste, and backfilled with native soil. One former employee recalled that one disposal pit was approximately 10 ft by 30 ft with depth unknown. It is not known if chemicals were disposed of in bulk or in drums. Although no information has been found regarding detailed construction of the pits, it was assumed that the pits were unlined and were not constructed with leachate containment or monitoring devices. No records were maintained regarding the actual locations of the pits, the types or volumes of chemicals disposed of in the pits, how chemicals were disposed of, how the pits were excavated, or the length of time the pits were actually used.

## **2.2 Previous Audits, Inspections, and Findings**

In 1987, a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) was performed for the entire SNL/NM installation (EPA 1987). At that time, ER Sites 1 and 3 were identified as solid waste management unit (SWMU) Numbers 32 through 37, and ER Site 3 was identified as SWMU Number 40. Both sites were described as having the potential for release of hazardous waste or constituents. A more comprehensive assessment was performed under Phase 1 of the Comprehensive Environmental Assessment and Response Program (CEARP) (DOE 1987), during which ER Sites 1 and 3 were assessed and, again, were found to require additional investigation. The scope of the Phase 1 assessment included a literature and records search, interviews with current and former employees, and, in some cases, visual site inspections. No samples and only limited background data were collected during both the RFA and CEARP Phase 1 assessment.

## **3.0 EVALUATION OF RELEVANT EVIDENCE**

### **3.1 Unit Characteristics and Operating Practices**

The characteristics and operating practices are described in Section 2.1. No activities are known to have occurred at ER Sites 1 and 3 since those described in Section 2.1.

### **3.2 Results of SNL/NM ER Project Sampling/Surveys**

Several rounds of sampling have occurred at ER Sites 1 and 3, including radiation, organic vapor, geophysical, and soil vapor surveys (SVS). The results of the surveys are summarized in the sections below.

#### **3.2.1 Summary of Prior Investigations**

The following sources of information, presented in chronological order, were used to evaluate ER Sites 1 and 3:

- Aerial photograph interpretation (1939 to 1993)
- Interviews of SNL/NM personnel
- Photographs and field notes collected at the site by SNL/NM ER staff
- Radiological survey (December 1991)
- Organic vapor survey (December 1991)
- SVS (November and December 1993)
- Geophysical surveys (December 1993)
- VCM samples (Summer 1996).

#### **3.2.2 Aerial Photograph Interpretation**

Interpretation of historical aerial photographs taken in 1951 and 1959 clearly show two bermed pits believed to be the CDPs (Ebert and Associates 1994). The 1951 photo shows one pit located on the southeastern boundary of the RWL fence line; the 1959 photo shows another pit on the northwestern boundary of the landfill fence line. No other disturbances were noted during the interpretation of aerial photographs with dates ranging from 1939 to 1993 in the area of the reported chemical disposal pits.

### 3.2.3 Radiological Survey

A radiation survey of the RWL was performed on December 4, 1991. The survey was conducted using a Bicron 2000 gamma detector/survey meter with a Geiger-Mueller (GM) pancake probe held at ground level for beta-gamma detection. The radiation survey was designed to determine radiation levels within the landfill and identify any possible surface contamination. Beta-gamma readings from the surface ranged from 40 to 100 counts per minute (cpm); background activity was established at 60 cpm. The general area radiation levels ranged from 0.01 to 0.035 millirem per hour (mrem/hr); background activity was established at 0.03 mrem/hr. The variations were minor and considered not to be distinguishable from background. The radiation survey determined that no significant external radiation exposure rates were expected for nonintrusive fieldwork.

### 3.2.4 Organic Vapor Survey

An organic vapor survey of the RWL was performed on December 4, 1991. The organic vapor survey was conducted 4 ft above ground level using an HNu PI101 photoionization detector, which was calibrated to benzene. No organic vapors were detected during the survey.

### 3.2.5 Soil Vapor Survey

A passive SVS was conducted in the vicinity of the RWL between November 11 and December 2, 1993. No volatile organic compounds (VOC) or semivolatile organic compounds (SVOC) were identified in soil vapor from the SVS investigation (SNL/NM 1994a).

### 3.2.6 Geophysical Surveys

A STOLST<sup>TM</sup> survey was performed at the RWL in December 1993 (SNL/NM 1994b). Five large (>10 amperes per square meter [ $\text{amp}/\text{m}^2$ ]), three small (0-5  $\text{amp}/\text{m}^2$ ), and two point-source anomalies were identified in the RWL during the survey. The eight objects are directly attributable to buried waste in the RWL pits and trenches. The two point locations could be a product of ferromagnetic near-surface trash or a concentration of ferromagnetic soil or rock.

An electromagnetic survey was performed during the period of December 6, 1993, through February 24, 1994 (SNL/NM 1994c). The RWL was surveyed as part of the Phase I Survey Design using the EM-31 survey instrument. The survey identified the fence line boundary of the landfill. The individual burials were not all distinguishable due to the high "noise" level of the landfill (i.e., too much buried activity).

### 3.2.7 Voluntary Corrective Measures Sampling

The RWL/CDPs were remediated in the summer of 1996 as an EC/VCM. Excavation of the sites began in late May 1996 and continued through August 1996. The following describes the activities performed at the RWL, and the results of sampling, which occurred as part of the VCM.

All waste material and contaminated soil was removed from the excavation, characterized for hazardous and radioactive contamination, and appropriately containerized or stockpiled. Upon completion of excavation activities, verification soil samples were collected and analyzed for hazardous and radioactive constituents. Additionally, geophysical and radiation surveys were conducted to ensure that all material had been removed.

Approximately 96 cubic yards (cy) of solid (radioactive, hazardous, and mixed) waste debris, 700 cy of contaminated soil, 3,000 cy of potentially contaminated soil, and 5,000 cy of clean soil were removed from the RWL/CDPs.

#### Results of Sampling/Surveys

Prior to beginning excavation activities, soil samples were collected and analyzed to determine background radioactivity levels. Soil samples were not analyzed for metals because they were not anticipated to be a COC based on site history. Furthermore, background metals data were available (IT Corporation 1994). Background measurements were required to provide a baseline reference point for segregation of excavated soils and for verification that the excavation was complete. Background soil samples were collected within the vicinity of TA-II at locations unaffected by site operations or potential runoff. A total of 20 surface soil background samples were collected and analyzed as listed in Table 3-1. The background sample location and statistical analysis performed in order to determine background values are included in Section 6.2.

Table 3-1  
Summary of Sampling Performed for Background Determinations

Parameter	On-Site Laboratory	Off-Site Laboratory	Field Screening
Gross alpha/beta	X		X
Gross gamma			X
Gamma spectroscopy	X	X	
Tritium	X	X	

All background samples were analyzed on site for gross alpha/beta, by gamma spectroscopy, and for tritium. Twenty percent of the background samples were also analyzed off site by gamma spectroscopy and for tritium (Section 6.2). Field screening of the background soil samples was used to calibrate field screening instruments to ensure the average value represented the true mean to within +/- 20 percent at the 95 percent confidence level, as specified in NUREG/CR-5849 (NRC 1992).

Soil excavated from the landfill was initially segregated into various stockpiles based on field screening and excavation location. The segregation of all soil stockpiles was verified using laboratory analysis. Excavated soil was segregated into one of two stockpile areas, suspect clean or suspect contaminated. Initial segregation was based on field screening for VOCs and explosives, visual staining or unusual appearance, or radioactivity levels greater than three times background.

For suspect clean soil, approximately 100-g grab samples were collected from each front end loader bucket (approximately 5 cy of soil) as it was placed into a stockpile. Each stockpile was kept to approximately 250 cy. Approximately 50 aliquots (100 g/aliquot) were combined to form one composite sample for each 250 cy stockpile. The composite samples were analyzed for both radiological and chemical parameters. Radiological analyses included 100 percent on-site analyses of gross alpha/beta, tritium, and gamma spectroscopy. Portions of 20 percent of the samples were also analyzed off site for gamma spectroscopy, tritium, and any isotopic analyses determined to be necessary. Chemical analyses included total RCRA metals and beryllium; 100 percent of samples were analyzed on site and portions of 20 percent of the samples were analyzed off site. Organic and high explosives analyses were not performed because no potential for organic soil contamination was present based on excavated debris and field screening. Section 6.3 lists the analytical results for the stockpiled suspect clean soil.

For suspect contaminated soil, an approximately 500-g grab sample was collected from each front end loader bucket as it was placed into a stockpile. Each stockpile was kept to less than 100 cy. Approximately 10 aliquots (500 g/aliquot) were combined to form one composite sample for each stockpile. Based on suspected contaminants, analyses were performed for VOCs, SVOCs, total RCRA metals, polychlorinated biphenyls (PCB), explosives, tritium, gamma spectroscopy, and gross alpha/beta. Section 6.4 lists the analytical results for stockpiled suspect contaminated soil.

Once the excavation was complete, prior to backfilling, the excavation was surveyed and sampled to verify adequate cleanup. Metal detector surveys were conducted to ensure no metal items remained. A shallow detector (White Model 9400-DLMAX) and an ordnance detector (Schonstedt Magnetic Locator Model CA-72 Cd) were used to conduct surveys on an established 10-meter-square grid system. Survey results showed no additional material to be buried beneath the extent of excavation.

Radiological verification closely followed guidance provided by NUREG CR-5849, Manual for Conducting Radiological Surveys in Support of License Termination (NRC 1992), for open land areas. A 10-meter-square grid, including floor and walls of the excavation, was established at each trench/pit location, using the sampling pattern presented in NUREG CR-5849 (NRC 1992). If the excavation area was less than 10 meters square, those sampling locations of the standard grid that fell within the excavation area became sampling points. A GM pancake detector, sodium iodide scintillometer, and a FIDLER low-energy gamma detector were used to survey and count 100 percent of each grid area. Excavation walls were surveyed using shielded detectors to minimize changes in geometry and the influence of Compton scattered gamma-rays from surrounding soils.

When it was determined that 100 percent of the excavated area had radiation levels less than or equal to background plus three standard deviations by field scan, preliminary sampling was

initiated. Preliminary sampling consisted of collecting 13 surface (0 to 6 inches) soil samples inside each grid cell. These samples were analyzed for gross alpha/beta/tritium, gamma spectroscopy, and alpha spectroscopy, if necessary. The average results for the 13 grid samples were compared to background. When an average was less than or equal to three times background, verification sampling for that grid was implemented.

Verification sampling included collecting surface (0 to 6 inches) soil samples at four locations, each equidistant from the center and corner location, within each sampling grid cell. These samples were composited into one sample and analyzed for radionuclides and total RCRA metals. Organic analyses were not conducted because no organic constituents were identified that might contribute to soil contamination. Section 6.5 lists analytical results for the verification samples.

The radionuclide concentrations in the verification pit samples were lower than the site-specific background concentrations (Section 6.2) for all radionuclides, except thorium-232 and thorium-228. The concentration of thorium-232 in the Verification Pit 7 sample was 1.35 picocuries per gram (pCi/g). Although the concentration exceeds the site-specific background concentration of 0.96 pCi/g (Section 6.2), it is less than the regional background concentration (IT Corporation 1994) for thorium-232, which is 1.54 pCi/g.

The concentration for thorium-228 ranged from 1.22 to 1.54 pCi/g in the pits, with a site-specific background concentration of 1.04 pCi/g. The regional background concentration (IT Corporation 1994) is 1.33 pCi/g for thorium-228. The concentration of thorium-228 slightly exceeds the regional background in pits 2, 6, and 7.

The concentrations of metals in the verification pit samples were all nondetects with the exception of results for silver and barium. Silver had a concentration of 5.9 milligrams per kilogram (mg/kg), and barium had concentrations of 260 and 290 mg/kg in Pile 5 samples. The regional concentrations for silver and barium are 5.9 and 200 mg/kg, respectively. The value for silver is considered an anomaly because no sources of silver were seen during the VCM activities. Barium occurs naturally in the soils beneath TA-II, and the variation from background concentration is considered acceptable. No sources of barium were seen during the VCM activities.

### *3.2.7.1 VCM Quality Assurance/Quality Control Summary*

Extensive quality assurance (QA)/quality control (QC) analyses were performed as part of the VCM. Section 6.6 contains three tables that summarize the sampling and corresponding QA/QC analyses performed.

The type of QA/QC samples analyzed included equipment blanks, method blanks, matrix spikes, and matrix spike duplicates. The analysis results indicate a high degree of compliance with QA/QC requirements.

### **3.3 Gaps In Information**

Initial information about the activities at ER Sites 1 and 3 was largely gathered by interpretation of aerial photographs and employee interviews. Landfill contents at ER Sites 1 and 3 were revealed during the VCM. Information obtained during the various survey and sampling events at ER Sites 1 and 3 was used, along with other available information, to help identify the most likely COCs that might be found at the sites. Analytical data from soil samples collected at the sites (Section 3.2.8) and the subsequent risk assessment (Section 3.4) are sufficient to characterize the site and to establish the resulting risk to human health.

### **3.4 Risk Evaluation**

The Risk Assessment Report prepared for ER Sites 1 and 3 is included in Section 6.1.

#### **3.4.1 Human Health Risk Assessment**

ER Sites 1 and 3 have been recommended for industrial land-use (DOE and USAF 1995). A complete discussion of the risk assessment process, results, and uncertainties is provided in Section 6.1. Due to the presence of several metals and radionuclides in concentrations and activities greater than background levels, it was necessary to perform a human health risk assessment analysis for the sites. Metals detected above their reporting limits and any radionuclide compounds either detected above background levels and/or minimum detectable activity (MDA) were included in this assessment. The risk assessment process provides a quantitative evaluation of the potential adverse human health effects caused by constituents in the site soil. The Risk Assessment Report presents calculations of the Hazard Index, excess cancer risk, and total effective dose equivalent (TEDE) for both an industrial land-use and residential land-use setting. The excess cancer risk from nonradioactive COCs and the radioactive COCs is not additive (EPA 1989).

Note that analytical data from potentially contaminated soil piles 5, 15, 20, and 25 were not used in the risk assessment due to a current effort to remediate these piles. Radionuclide contamination is being reduced using a segmented gate system, which sorts soils according to their radiological activities. The results of the effort must be below the maximum concentrations included in the risk assessment or the soil will be shipped off site for disposal and not used as backfill.

In summary, the Hazard Index calculated for ER Sites 1 and 3 nonradiological COCs is 0.08 for an industrial land-use setting, which is 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 Hazard Index is 0.07. The excess cancer risk for ER Sites 1 and 3 nonradiological COCs is  $1 \times 10^{-5}$  for an industrial land-use setting, which is at the low end of the suggested range of acceptable risk of  $10^{-4}$  to  $10^{-6}$  (EPA 1989). The incremental excess cancer risk for the sites is  $8 \times 10^{-6}$ . The incremental total effective dose equivalent for radionuclides for an industrial land-use setting is 3.4 mrem/yr, which is well below the standard dose limit of 15 mrem/yr (40CFR196 1994). The incremental excess cancer risk for radionuclides is  $1 \times 10^{-4}$  for the industrial land-use scenario,

which is much less than risk values calculated due to naturally occurring radiation and from intakes considered background concentration values.

The residential land-use scenarios for these sites are provided only for comparison in the Risk Assessment Report (Section 6.1). The report concludes that ER Sites 1 and 3 do not have significant potential to affect human health under an industrial land-use scenario.

### 3.4.2 Ecological Risk Assessment

An ecological risk assessment was conducted to evaluate potential ecological risks associated with the COCs at ER Sites 1 and 3. Five radionuclides present that might have been an ecological concern were americium-241, plutonium-239/240, plutonium-238, tritium, and uranium-238. The maximum total dose rate calculated for the receptors was approximately  $1.0 \times 10^{-5}$  rad/day, well below the acceptable benchmark of 0.1 rad/day. Nine inorganic COCs were found at levels of potential ecological concern using the maximum values of all the soil piles. The maximum total chromium concentration (18 mg/kg) and barium concentration (230 mg/kg) are within the background ranges. Five other COPECs (arsenic, cadmium, mercury, selenium, and silver) produced HQs greater than 1.0 for more than one receptor. However, Soil Piles 1 through 16 are proposed to be placed at 0 to 10 feet below ground. Using the maximum concentrations in Piles 1 through 16, arsenic (2.4 mg/kg), cadmium (1.05 mg/kg), and mercury (0.03 mg/kg) will produce HQs of less than 1.0 for all receptors. Selenium in Piles 1 through 16 has an average concentration of 7.2 mg/kg, which would result in HQs of 7.2 and 2.21 for the plant and the deer mouse, respectively. However, based upon material retrieved from the RWL and sampling data for the sites, selenium is not a COC. Based upon these results, the ecological risk for ER Sites 1 and 3 is expected to be insignificant.

#### **4.0 RATIONALE FOR NO FURTHER ACTION DECISION**

Based on field investigation data and the human health risk assessment analysis, an NFA is recommended for ER Sites 1 and 3 for the reasons given below.

- VCM sampling results demonstrate that the remediated site no longer poses an unacceptable risk to human health or the environment under the current and projected land use, designated as industrial.
- No VOCs were detected during the field screening program or were reportedly used at the site.
- No COCs (particularly metals, VOCs, or radionuclides) remain in concentrations considered hazardous to human health for an industrial land-use scenario.

Based on the evidence provided above, ER Sites 1 and 3 are proposed for an NFA based on Criterion 5 of the Document of Understanding.

## 5.0 REFERENCES

CFR, see Code of Federal Regulations.

Code of Federal Regulations, Title 40, Part 196 (40 CFR 196), 1994. "Radiation Site Cleanup Regulation," draft, *Federal Register*, U.S. Government, Washington, D.C.

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## **6.0 ANNEXES**

- 6.1 ER Sites 1 and 3: Risk Assessment Report**
- 6.2 Statistical Analysis of TA-II, Radioactive Waste Landfill (ER Sites 1 and 3), Radiological Background Data**
- 6.3 Analytical Results for Stockpiled Suspect Clean Soil**
- 6.4 Analytical Results for Stockpiled Suspect Contaminated Soil**
- 6.5 Analytical Results for Excavation Verification**
- 6.6 Summary of VCM Sampling, Including QA/QC**

**Section 6.1**  
**ER Sites 1 and 3: Risk Assessment Report**

## ER SITES 1 AND 3: RISK ASSESSMENT ANALYSIS

### I. Site Description and History

Sandia National Laboratories/New Mexico (SNL/NM) Environmental Restoration (ER) Sites 1 and 3 consist of the Radioactive Waste Landfill (RWL) and the Chemical Disposal Pit (CDP). The RWL/CDPs were located in the eastern portion of Technical Area (TA) II. The RWL had three pits and three trenches where low-level radioactive waste was disposed of from 1949 to 1959. Supposedly, after March 1959, all radioactive waste was disposed of at a separate facility at TA-III, although one item removed from the landfill was dated 1978. The RWL pits were approximately 12 feet wide by 20 feet long by 25 feet deep. The trenches ranged from 5 to 15 feet wide, 25 to 50 feet long, and 15 feet deep. The majority of the waste was not containerized before disposal. The pits and trenches were not lined and did not contain leachate detection or collection systems. The pits and trenches were filled with debris, and then covered with native soil and capped with 3 feet of concrete.

The CDPs reportedly were used in the late 1940s and 1950s to dispose of chemical waste. The CDPs may have been originally excavated with a backhoe, filled with waste, and backfilled with native soil. One former employee recalled that one disposal pit was approximately 10 feet by 30 feet, with depth unknown. It is not known if chemicals were disposed of in bulk or in drums. Although no information has been found regarding detailed construction of the pits, it was assumed that the pits were unlined and were not constructed with leachate containment or monitoring devices. No records were maintained regarding the actual locations of the pits, the types or volumes of chemicals disposed of in the pits, how chemicals were disposed of, how the pits were excavated, or the years the pits were actually used. The constituents of concern (COC) for the RWL/CDP include 9 metals and 15 radionuclides.

### II. Human Health Risk Assessment Analysis

Risk assessment of this site includes a number of steps, which 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:

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 by which a representative population might be exposed to the COCs are identified.
Step 3. The potential intake of these COCs by the representative population is calculated using a tiered approach. The tiered approach includes screening steps, followed by potential intake calculations and a discussion or evaluation of the uncertainty in those calculations. Potential intake calculations are also applied to background screening data.
Step 4. Data are described on the potential toxicity and cancer effects from exposure to the COCs and associated background constituents and subsequent intake.

Step 5. Potential toxicity effects (specified as a Hazard Index) and 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 U.S. Department of Energy (DOE) to determine if further evaluation, and potential site clean-up, is required. Nonradiological COC risk values are also compared to background risk so that an incremental risk may be calculated.

Step 7. Uncertainties in the previous steps are discussed.

### II.1 Step 1. Site Data

Site history and characterization activities are used to identify potential COCs. The identification of COCs and the sampling to determine the concentration levels of those COCs across the site are described in the ER Sites 1 and 3 No Further Action Proposal. In order to provide conservatism in this risk assessment, the calculation uses only the maximum concentration value of each COC determined for the entire site. Maximum concentrations reported from on-site and off-site laboratories subsurface and surface samples were combined into a single table to provide conservative risk calculations. For radiological COCs, the soil strata were broken up into cover taken from above the landfill caps and along the perimeter of ER Sites 1 and 3 and, as a separate strata, soil taken from within and near the cells beneath the caps. The minimum upper tolerance limit (UTL) or 95th percentile, as appropriate, was selected to provide the background screen in Table 1 and to be used to calculate risk attributable to background in Table 8. Chemicals that are essential nutrients, such as iron, magnesium, calcium, potassium, and sodium, were not included in this risk assessment (EPA 1989). Both radioactive and nonradioactive COCs are evaluated. The nonradioactive COCs evaluated are metals.

Note that analytical data from potentially contaminated soil piles 5, 15, 20, and 25 were not used in the risk assessment due to a current effort to remediate these piles. Radionuclide contamination is being reduced using a segmented gate system, which sorts soils according to their radiological activities. The results of the effort will be included when the remediation is completed.

### II.2 Step 2. Pathway Identification

ER Sites 1 and 3 have been designated with a future land-use scenario of industrial (DOE and USAF 1995) (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 chemical COCs and radon inhalation for radiological exposure. The inhalation pathway for both chemicals and radionuclides is included because of the potential to inhale dust and volatiles. The soil ingestion pathway is included for radionuclides. No contamination at depth was determined, and therefore no pathways to the groundwater are considered. Depth to groundwater at ER Sites 1 and 3 is approximately

320 feet below ground surface. 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

Chemical Constituents	Radionuclide Constituents
Soil ingestion	Soil ingestion
Inhalation (dust)	Inhalation (dust and volatiles)
Plant uptake (residential only)	Plant uptake (residential only)
	Direct gamma

#### II.3 Steps 3-5. Calculation of Hazard Indices and Cancer Risks

Steps 3 through 5 are discussed in this section. These steps include the discussion of the tiered approach in eliminating potential COCs from further consideration in the risk assessment process and the calculation of intakes from all identified exposure pathways, the discussion of the toxicity information, and the calculation of the hazard indices and cancer risks.

The risks from the COCs at ER Sites 1 and 3 were evaluated using a tiered approach. First, the maximum concentrations of COCs were compared to the SNL/NM background screening level for this area (IT Corporation 1996), as modified during verbal discussion with representatives of New Mexico Environment Department (NMED). If a SNL/NM-specific screening level was not available for a constituent, then a background value was obtained, when possible, from the U.S. Geological Survey (USGS) National Uranium Resource Evaluation program (USGS 1994).

The maximum concentration of each COC was used in order to provide a conservative estimate of the associated risk. If any nonradiological COCs were above either the SNL/NM background screening levels or the USGS background value, all nonradiological COCs 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 orders. Radioactive 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. This step is performed (rather than carry the below-background radioactive COCs through the risk assessment and then perform a background risk assessment to determine incremental TEDE and estimated cancer risk) to prevent the "masking" of radiological contamination that may occur if on-site background radiological COCs exist in concentrations far enough below the assigned background level. When this "masking" occurs, the final incremental TEDE and estimated cancer risk are reduced and, therefore, provide a nonconservative estimate of the potential impact on an on-site receptor. This approach is also consistent with the regulatory approach (40 CFR Part 196

1994), which sets a TEDE limit to the on-site receptor in excess of background. The resultant radioactive COCs remaining after this step are referred to as background-adjusted radioactive COCs.

Second, if any nonradiological COC failed the initial screening step, the maximum concentration for each nonradiological COC was compared with action levels calculated using methods and equations promulgated in the proposed Resource Conservation and Recovery Act (RCRA) Subpart S (40 CFR Part 264 1990) and Risk Assessment Guidance for Superfund (RAGS) (EPA 1989) documentation. If there are ten or fewer COCs and each has a maximum concentration less than one-tenth of the action level, then the site would be judged to pose no significant health hazard to humans. If there are more than ten COCs, the Subpart S screening procedure was skipped.

Third, hazard indices and risk due to carcinogenic effects were calculated using reasonable maximum exposure (RME) methods and equations promulgated in RAGS (EPA 1989). The combined effects of all nonradiological COCs in the soils were calculated. The combined effects of the nonradiological COCs at their respective UTL or 95th percentile background concentration in the soil were also calculated. For toxic compounds, the combined effects were calculated by summing the individual hazard quotients for each compound into a total Hazard Index. This Hazard Index is compared to the recommended guideline of 1. For potentially carcinogenic compounds, the individual risks were summed. The total risk was compared to the recommended acceptable risk range of  $10^{-4}$  to  $10^{-6}$ . For the radioactive COCs, the incremental TEDE was calculated and the corresponding incremental cancer risk estimated using DOE's RESRAD computer code. In determining the incremental TEDE and corresponding incremental cancer risk, a separate analysis was performed on the two soil strata. The first was performed on the backfill cover containing limited levels of various radionuclides discussed below. The final analysis was performed on the second soil strata consisting of soils taken from within the landfill. The resultant incremental TEDEs and incremental cancer risks from these two analyses were then added to develop a final incremental TEDE and incremental cancer risk.

### II.3.1 Comparison to Background and Action Levels

Nonradioactive ER Sites 1 and 3 COCs are listed in Table 1, and radioactive COCs are listed in Tables 2 and 3. All tables show the associated 95th percentile or UTL background levels (IT Corporation 1996), as modified during verbal discussion with representatives of NMED.

The SNL/NM background levels have not yet been approved by the EPA or the NMED but are the result of a comprehensive study of joint SNL/NM and U.S. Air Force data from Kirtland Air Force Base (KAFB). The values shown in Table 1 supersede the background values described in an interim background study report (IT Corporation 1994).

Several compounds have maximum measured values greater than background screening levels. Therefore, all nonradiological COCs were retained for further analysis with the exception of lead. The maximum concentration value for lead is 41 milligrams per kilogram (mg/kg). The EPA intentionally does not provide any toxicological data on lead, and therefore no risk parameter values can be calculated. However, EPA guidance for the screening value for lead for an industrial land-use scenario is 2,000 mg/kg (EPA 1996a); for a residential land-

**Table 1**  
**Nonradioactive COCs at ER Sites 1 and 3 and Comparison to the**  
**Background Screening Values**

COC name	Maximum concentration (mg/kg)	SNL/NM 95th% or UTL Level (mg/kg)	Is maximum COC concentration less than or equal to the applicable SNL/NM background screening value?
Arsenic	13*	4.4	No
Barium	300	200	No
Beryllium	2	0.80	No
Cadmium	6.5	<1^	No
Chromium, total**	16	NC	NA
Lead	41	11.2	No
Mercury	7.8	<0.1^	No
Selenium	25*	<1^	No
Silver	8.5	<1^	No

NC - Not calculated.

NA - Not applicable.

\*values are one-half the detection limit.

\*\*total chromium assumed to be chromium VI (most conservative).

^ uncertainty due to detection limits.

**Table 2**  
**Radioactive COCs from the Landfill Soil Strata at ER Sites 1 and 3 and**  
**Comparison to the Background Screening Values**

COC name	Maximum concentration (pCi/g)	SNL/NM 95th % or UTL Level (pCi/g)	Is maximum COC concentration less than or equal to the applicable SNL/NM background screening value?
U-238	326	1.3	No
U-235	9.19	0.18	No
U-234	97.8	1.6	No
Th-232	3.47	1.54	No
Ra-228	3.75 <sup>1</sup>	1.2	No
Th-228	3.75	1.2 <sup>2</sup>	No
Th-230	2.79	1.6 <sup>3</sup>	No
Am-241	19.7	NC <sup>4</sup>	No
Pu-239/240	113.5	NC	No
Pu-238	2.23	NC	No
Co-60	ND <sup>5</sup>	NC	Yes
Sr-90	1.7	NC	No
H-3	1616	NC	No
Cs-137	14.8	0.08	No
Cs-134	ND	NC	Yes
Ra-226	0.97	1.76	Yes

Note 1: Reported maximum was lower, assumed maximum concentration of daughter product, Th-228.

Note 2: Th-228 background assumed to be that of its parent nuclide Ra-228.

Note 3: Th-230 background assumed to be that of its parent nuclide U-234.

Note 4: Not Calculated.

Note 5: Not Detected.

**Table 3**  
**Radioactive COCs from the Landfill Cover at ER Sites 1 and 3 and Comparison to the Background Screening Values**

COC name	Maximum concentration (pCi/g)	SNL/NM 95th % or UTL Level (pCi/g)	Is maximum COC concentration less than or equal to the applicable SNL/NM background screening value?
U-238	1.42 <sup>1</sup>	1.3	No
U-235	0.105	0.18	Yes
U-234	NS <sup>2</sup>	1.6	Yes
Th-232	0.937	1.54	Yes
Ra-228	1.03	1.33	Yes
Th-228	0.86	1.33 <sup>3</sup>	Yes
Am-241	0.16	NC	No
Pu-239/240	1.28 <sup>4</sup>	NC	No
Pu-238	0.053 <sup>5</sup>	NC	No
Co-60	ND	NC	Yes
H-3	78.9	NC	No
Cs-137	0.185	0.836	Yes
Cs-134	ND	NC	Yes

Note 1: Based on the activity of its short-lived daughter Th-234.

Note 2: Not Sampled. Since U-238 was not found above background it was assumed that U-234 would be within background.

Note 3: Th-228 background assumed to be that of its parent nuclide Ra-228.

Note 4: Pu-239 not detected, conservatively assumed to be 8x the activity of Am-241 to be consistent with higher activity samples taken from within the landfill.

Note 5: Pu-238 not detected, conservatively assumed to be 0.33x the activity of Am-241 to be consistent with higher activity samples taken from within the landfill.

use scenario, the EPA screening guidance value is 400 mg/kg (EPA 1994). The maximum concentration value for lead at this site is less than both of those screening values, and therefore lead is eliminated from further consideration in this risk assessment.

Because several nonradiological COCs had concentrations greater than their respective SNL/NM background 95th percentile or UTL, the site fails the background screening criteria, and all nonradiological COCs proceed to the proposed Subpart S action level screening procedure.

Table 4 shows the nonradioactive COCs compared to the proposed Subpart S action level for soils. The table compares the maximum concentration values to 1/10 of the proposed Subpart S action level. This methodology was guidance given to SNL/NM from the EPA (EPA 1996b). This is the second screening process in the tiered risk assessment approach. Several compounds had a concentration greater than 1/10 of the proposed Subpart S action level. Because of these compounds, the site fails the proposed Subpart S screening criteria, and a Hazard Index value and cancer risk value must be calculated for all of the nonradioactive COCs.

**Table 4**  
**Comparison of ER Sites 1 and 3 Nonradioactive COC Concentrations to Proposed**  
**Subpart S Action Levels**

COC name	Maximum concentration (mg/kg)	Proposed Subpart S Action Level (mg/kg)	Is individual contaminant less than 1/10 the Action Level?
Arsenic	13**	0.5	No
Barium	300	6,000	Yes
Beryllium	2	0.2	No
Cadmium	6.5	80	Yes
Chromium, total*	16	400	Yes
Mercury	7.8	20	No
Selenium	25**	400	Yes
Silver	8.5	400	Yes

\* total chromium assumed to be chromium VI (most conservative).

\*\* concentrations are assumed to be one-half of the detection limit.

### II.3.2 Identification of Toxicological Parameters

Tables 5 and 6 show the COCs that have been retained in the risk assessment and the values for the toxicological information available for those COCs. Dose conversion factors (DCF) used in determining the excess TEDE values for the individual pathways were the default values provided in the RESRAD computer code as developed in the following:

- For ingestion and inhalation, DCFs 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 1988a).
- The 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).
- The 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* (Health Physics 28:193-205) (Kocher 1983), and ANL/EAIS-8, *Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil* (Yu et al. 1993a).

Radioactive contamination does not have predetermined action levels analogous to proposed Subpart S, and therefore this step in the screening process is not performed for radionuclides.

**Table 5**  
**Nonradioactive Toxicological Parameter Values for ER Sites 1 and 3 COCs**

COC name	RfD <sub>o</sub> (mg/kg/d)	RfD <sub>inh</sub> (mg/kg/d)	Confidence	Sf <sub>o</sub> (kg-d/mg)	SF <sub>inh</sub> (kg-d/mg)	Cancer Class <sup>^</sup>
Arsenic	0.0003	--	M	1.5	15.1	A
Barium	0.07	0.000143	M	--	--	D
Beryllium	0.005	--	L	4.3	8.4	B2
Cadmium	0.0005	0.0000571	H	--	6.3	B1
Chromium, total*	0.005	--	L	--	42	A
Mercury	0.0003	0.0000857	M	--	--	D
Selenium	0.005	--	H	--	--	D
Silver	0.005	--	L	--	--	D

\* total chromium assumed to be chromium VI (most conservative).

RfD<sub>o</sub> - oral chronic reference dose in mg/kg-day.

RfD<sub>inh</sub> - inhalation chronic reference dose in mg/kg-day.

Confidence - L = low, M = medium, H = high.

Sf<sub>o</sub> - oral slope factor in (mg/kg-day)<sup>-1</sup>.

SF<sub>inh</sub> - inhalation slope factor in (mg/kg-day)<sup>-1</sup>.

<sup>^</sup> EPA weight-of-evidence classification system for carcinogenicity:

A - human carcinogen.

B1 - probable human carcinogen. Limited human data are available.

B2 - probable human carcinogen. Indicates sufficient evidence in animals and inadequate or no evidence in humans.

C - possible human carcinogen.

D - not classifiable as to human carcinogenicity.

E - evidence of noncarcinogenicity for humans.

-- information not available.

**Table 6**  
**Radiological Toxicological Parameter Values for ER Sites 1 and 3 COCs**

COC name	SF <sub>o</sub> (1/pCi)	Sf <sub>inh</sub> (1/pCi)	SF <sub>ev</sub> (g/pCi-yr)	Cancer Class <sup>^</sup>
U-238	6.2E-11	1.2E-8	5.7E-8	A
U-235	4.7E-11	1.3E-8	2.7E-7	A
U-234	4.4E-11	1.4E-8	2.1E-11	A
Th-232	3.3E-11	1.9E-8	2.0E-11	A
Ra-228	2.5E-10	9.9E-10	3.3E-6	A
Th-228	2.3E-10	9.7E-8	9.9E-7	A
Am-241	3.3E-10	3.9E-8	4.6E-9	A
Pu-239/240	3.2E-10	2.8E-8	1.3E-11	A
Pu-238	3.0E-10	2.7E-8	1.9E-11	A
Sr-90	5.6E-11	6.9E-11	1.9E-8	A
H-3	7.2E-14	9.6E-14	0	A
Cs-137	3.2E-11	1.9E-11	2.1E-6	A

SF<sub>o</sub> - oral (ingestion) slope factor (risk/pCi).

SF<sub>inh</sub> - inhalation slope factor (risk/pCi).

SF<sub>ev</sub> - external volume exposure slope factor (risk/yr per pCi/g).

<sup>^</sup> EPA weight-of-evidence classification system for carcinogenicity:

A - human carcinogen.

B1 - probable human carcinogen. Limited human data are available.

B2 - probable human carcinogen. Indicates sufficient evidence in animals and inadequate or no evidence in humans.

C - possible human carcinogen.

D - not classifiable as to human carcinogenicity.

E - evidence of noncarcinogenicity for humans.

### II.3.3 Exposure Assessment and Risk Characterization

Section II.3.3.1 describes the exposure assessment for this risk assessment. Section II.3.3.2 provides the risk characterization, including the Hazard Index value and the excess cancer risk, for both the potential nonradiological COCs and associated background industrial and residential land-uses. The incremental TEDE and incremental estimated for cancer risk are provided for the background-adjusted radiological COCs for industrial and residential land-uses.

#### II.3.3.1 Exposure Assessment

Appendix 1 shows the equations and parameter values used in the calculation of intake values and the subsequent Hazard Index and excess cancer risk values for the individual exposure pathways. The appendix shows the parameters for both industrial and residential land-use scenarios. The equations are based on RAGS (EPA 1989). The parameters are based on information from RAGS (EPA 1989) as well as other EPA guidance documents and reflect the RME approach advocated by RAGS (EPA 1989). For radionuclides, the coded equations provided in the RESRAD computer code were used to estimate the incremental TEDE and

cancer risk for the individual exposure pathways. Further discussion of this process is provided in Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0 (Yu et al. 1993b).

Although the designated land-use scenario is industrial for this site, the risk and TEDE values for a residential land-use scenario are also presented. These residential risk and TEDE values are presented to only provide perspective of the potential for risk to human health under the more restrictive land-use scenario.

### II.3.3.2 Risk Characterization

Table 7 shows that for the ER Sites 1 and 3 nonradioactive COCs, the Hazard Index value is 0.08, and the excess cancer risk is  $1 \times 10^{-5}$  for the designated industrial land-use scenario. The numbers presented included exposure from soil ingestion and dust inhalation for the nonradioactive COCs. Table 8 shows that assuming the maximum background concentrations of the ER Sites 1 and 3 associated nonradiological background constituents, the Hazard Index is 0.01, and the excess cancer risk is  $4 \times 10^{-6}$  for the designated industrial land-use scenario.

For the radioactive COCs, contribution from the direct gamma exposure pathway is included. The incremental TEDE for industrial land use is 3.4 millirem per year (mrem/yr). This includes 3.3 mrem/yr attributed to the landfill soil strata radon emanation from below the 10-foot cover and 0.1 mrem/yr due to the residual radionuclides that exist in the 10-foot cover material. In accordance with proposed EPA guidance, the standard being utilized is an incremental TEDE of 15 mrem/yr (40 CFR Part 196 1994) for the probable land-use scenario (industrial in this case); the calculated dose value for ER Sites 1 and 3 for the industrial land-use scenario is below this standard. The estimated excess cancer risk is  $1 \times 10^{-4}$  from the landfill soil strata and  $1 \times 10^{-6}$  from the cover, for a net estimated excess cancer risk of  $1 \times 10^{-4}$ .

For the residential land-use scenario, the Hazard Index value increases to 29, and the excess cancer risk is  $1 \times 10^{-4}$ . The numbers presented include exposure from soil ingestion, dust and volatile 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 potential for soil in Albuquerque, New Mexico, to be eroded and, subsequently, for dust to be present even in predominantly residential areas. Because of the nature of the local soil, other exposure pathways are not considered (see Appendix 1). Table 6 shows that for the ER Sites 1 and 3 associated nonradiological background constituents, the Hazard Index increases to 0.3, and the excess cancer risk is  $6 \times 10^{-5}$ .

For the radioactive COCs, the incremental TEDE for residential land use is 15.5 mrem/yr. This includes 13.2 mrem/yr attributed to the landfill soil strata radon emanation from below the 10-foot cover and 2.3 mrem/yr due to the residual radionuclides that exist in the 10-foot cover material. In accordance with proposed EPA guidance, the standard being utilized is an excess TEDE of 75 mrem/yr (40 CFR Part 196 1994) for a loss of institutional controls (residential land use in this case); the calculated dose value for ER Sites 1 and 3 for the residential land use is below this standard. The estimated excess cancer risk is  $2 \times 10^{-4}$  from the landfill soil strata and  $7 \times 10^{-5}$  from the cover, for a net estimated excess cancer risk of  $3 \times 10^{-4}$ . The excess cancer risk from the nonradioactive COCs and the radioactive COCs is not additive, as noted in RAGS (EPA 1989).

**Table 7**  
**Nonradioactive Risk Assessment Values for ER Sites 1 and 3 COCs**

COC Name	Maximum concentration (mg/kg)	Industrial Land-Use Scenario		Residential Land-Use Scenario	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Arsenic	13	0.04	8E-6	0.74	1E-4
Barium	300	0.00	--	0.04	--
Beryllium	2	0.00	4E-6	0.00	2E-5
Cadmium	6.5	0.01	3E-9	5.31	4E-9
Chromium, total*	16	0.00	4E-8	0.01	6E-8
Mercury	7.8	0.03	--	13.44	--
Selenium	25	0.00	--	8.8	--
Silver	8.5	0.00	--	0.35	--
<b>TOTAL</b>		<b>0.08</b>	<b>1E-5</b>	<b>29</b>	<b>1E-4</b>

\* total chromium assumed to be chromium VI (most conservative).

-- information not available.

**Table 8**  
**Nonradioactive Risk Assessment Values for ER Sites 1 and 3 Background Constituents**

Constituent Name	Background concentration (mg/kg)	Industrial Land-Use Scenario		Residential Land-Use Scenario	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Arsenic	4.4	0.01	3E-6	0.25	5E-5
Barium	200	0.00	--	0.03	--
Beryllium	0.80	0.00	1E-6	0.00	6E-6
Cadmium	<1	--	--	--	--
Chromium, total*	NC	--	--	--	--
Mercury	<0.1	--	--	--	--
Selenium	<1	--	--	--	--
Silver	<1	--	--	--	--
<b>TOTAL</b>		<b>0.01</b>	<b>4E-6</b>	<b>0.3</b>	<b>6E-5</b>

-- information not available.

\* total chromium assumed to be chromium VI (consistent with Table 5).

#### II.4 Step 6. Comparison of Risk Values to Numerical Guidelines

The risk assessment analyses considered the evaluation of the potential for adverse health effects for both an industrial land-use scenario, which is the designated land-use scenario for this site, and a residential land-use scenario.

For the industrial land-use scenario, the Hazard Index calculated for the nonradioactive COCs is 0.08; this is much less than the numerical guideline of 1 suggested in RAGS (EPA 1989). The excess cancer risk is estimated at  $1 \times 10^{-5}$ . In RAGS, the EPA suggests that a range of values ( $10^{-6}$  to  $10^{-4}$ ) be used as the numerical guideline; the value calculated for these sites is in the middle of the suggested acceptable risk range. This risk assessment also determined risks considering background concentrations of the potential nonradiological COCs for both the industrial and residential land-use scenarios. For the industrial land-use scenario, the Hazard Index is 0.01. The excess cancer risk is estimated at  $4 \times 10^{-6}$ . Incremental risk is determined by subtracting risk associated with background from potential nonradiological 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 discussed within the text. The incremental Hazard Index is 0.07, and the incremental cancer risk is  $8 \times 10^{-6}$  for the industrial land-use scenario. These incremental risk calculations indicate insignificant risk to human health from the COCs considering an industrial land-use scenario.

For the radioactive components of the industrial land-use scenario, the incremental TEDE is 3.4 mrem/yr, which is less than the numerical standard of 15 mrem/yr suggested in the draft EPA guidance. The incremental estimated excess cancer risk is  $1 \times 10^{-4}$ .

For the residential land-use scenario, the calculated Hazard Index for the nonradioactive COCs is 29, which is above the numerical guidance. The excess cancer risk is estimated at  $1 \times 10^{-4}$ ; this value is at the upper limit of the suggested acceptable risk range. The Hazard Index for associated background for the residential land-use scenario is 0.3. The excess cancer risk is estimated at  $6 \times 10^{-5}$ . For the residential land-use scenario, the incremental Hazard Index is 28.41, and the incremental cancer risk is estimated at  $6.4 \times 10^{-5}$ . These incremental risk calculations indicate significant contribution to human health risk from the COCs considering a residential land-use scenario.

The incremental TEDE from the radioactive components is 15.5 mrem/yr, which is less than the numerical standard of 75 mrem/yr suggested in the draft EPA guidance. The estimated excess cancer risk is  $3 \times 10^{-4}$ .

#### II.5 Step 7 Uncertainty Discussion

The RWL/CDPs were remediated in the summer of 1996 as an expedited clean-up/voluntary corrective measure. Three types of sampling, in accordance with the VCM Plan, were performed: sampling of potentially clean piles, sampling of potentially contaminated piles, and verification pit samples. The nonradioactive COCs are listed in Table 1, and the radioactive COCs are listed in Tables 2 and 3. The nonradioactive COCs were analyzed using EPA Methods 6010 and 7470. The radioactive COCs were analyzed using alpha spectroscopy and gamma spectroscopy, with the exception of tritium, which was analyzed using liquid scintillation.

The analyses were performed using a combination of on-site and off-site laboratories. The off-site laboratories are Contract Laboratory Program (CLP) certified. The composite samples

were analyzed for both radiological and chemical parameters. For the suspect clean piles, radiological analyses included 100 percent on-site analyses of gross alpha/beta, tritium, and gamma spectroscopy. Twenty percent of the samples were also analyzed off site for gamma spectroscopy, tritium, and any isotopic analyses determined necessary. Chemical analyses included total RCRA metals and beryllium, also split 100 percent on site/20 percent off site. For the suspect contaminated piles and verification samples, a similar split of on-site and off-site analyses were performed. A summary of the sampling performed, including the quality assurance/quality control samples, is included in Section 6.6 of this report. The data provided by the CLP laboratory, as well as the on-site laboratory, are considered definitive data suitable for use in a risk assessment analysis.

The conclusion from the risk assessment analysis is that the potential effects caused by potential nonradiological COCs on human health are within the acceptable range compared to established numerical guidelines for the industrial land-use scenario. Calculated incremental risk between potential nonradiological COCs and associated background indicates small contribution of risk from nonradiological COCs when considering the industrial land-use scenario.

For the radiological COCs, the conclusion from the risk assessment is that the potential effects on human health, for both the industrial and residential land-use scenario, are within proposed standards (40 CFR Part 196 1994) and are a small fraction of the estimated 290 mrem/yr received due to natural background (NCRP 1987). To address potential uncertainties associated with the risk assessment, a sensitivity analysis was performed on the parameters most likely to affect the incremental TEDE result for the residential (i.e., most limiting) land-use scenario. This did not include residual radionuclide concentrations in the soil. All varied parameters were adjusted by a factor of two (i.e., divided by 2 and multiplied by 2). Results from this analysis showed that in no case did the incremental TEDE exceed those referenced above (40 CFR Part 196 1994).

The potential effects on human health for the nonradiological COCs are greater when considering the residential land-use scenario. Incremental risk between potential nonradiological COCs and associated background also indicates an increased contribution of risk from the nonradiological COCs. The increased effects on human health are primarily the result of including the plant uptake exposure pathway. Constituents that posed little to no risk considering an industrial land-use scenario (some of which are below background screening levels) contribute a significant portion of the risk associated with the residential land-use scenario. These constituents bioaccumulate in plants. Because ER Sites 1 and 3 are designated as an industrial land-use area (DOE and USAF 1995), the likelihood of significant plant uptake in this area is highly unlikely. The uncertainty in this conclusion is considered to be small.

Because of the locations, history of the sites, and the future land uses (DOE and USAF 1995), there is low uncertainty in the land-use scenarios and the potentially affected populations that were considered in making 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 sites, there is little uncertainty in the exposure pathways relevant to the analysis.

A RME approach was used to calculate the risk assessment values, which means that the parameter values used in the calculations were conservative and that the calculated intakes are likely overestimates. Maximum measured values of the concentrations of the COCs and minimum value of the 95th UTL or percentile background concentration value, as applicable, of background concentrations associated with the COCs were used to provide conservative results.

Table 5 shows the uncertainties (confidence) in the nonradiological toxicological parameter values. There is a mixture of estimated values and values from the Health Effects Assessment Summary Tables (HEAST) (EPA 1996c) and Integrated Risk Information System (IRIS) (EPA 1988b, 1997a) databases. Where values are not provided, information is not available from HEAST, IRIS, or EPA regions. Because of the conservative nature of the RME approach, the uncertainties in the toxicological values are not expected to be of high enough concern to change the conclusion from the risk assessment analysis.

The nonradiological risk assessment values are within the acceptable range for the industrial land-use scenario compared to the established numerical guidelines. Although the residential land-use Hazard Index is above the numerical guideline and the excess cancer risk is at the upper limit of the acceptable risk range, it has been determined that future land use at these localities will not be residential (DOE and USAF 1995). The overall uncertainty in all of the steps in the risk assessment process is considered insignificant with respect to the conclusion reached.

## II.6 Summary

ER Sites 1 and 3, the RWL and the CDPs, had contamination consisting of some inorganic nonradioactive and radioactive compounds. Because of the location of the sites on KAFB, the designated industrial land-use scenario (DOE and USAF 1995), and the nature of the contamination, the potential exposure pathways identified for these sites included soil ingestion and dust and volatile inhalation. Plant uptake was included as an exposure pathway for the residential land-use scenario. These sites are designated for industrial land-use (DOE and USAF 1995); the residential land-use scenario is provided for perspective only.

Using conservative assumptions and employing a RME approach to the risk assessment, the calculations for the nonradiological COCs show that for the industrial land-use scenario the Hazard Index (0.08) is significantly less than the accepted numerical guidance from the EPA. The estimated cancer risk ( $1 \times 10^{-5}$ ) is in the middle of the suggested acceptable risk range. The incremental Hazard Index is 0.07, and the incremental cancer risk is  $8 \times 10^{-6}$  for the industrial land-use scenario. Incremental risk calculations indicate insignificant contribution to risk from the nonradiological COCs considering an industrial land-use scenario.

The main contributor to the nonradiological industrial land-use scenario risk assessment was arsenic. The maximum arsenic concentration (13 mg/kg) is within the subsurface samples background range (0.033 to 17.0) and therefore may not be indicative of contamination.

The incremental TEDE and corresponding estimated cancer risk from the radioactive components are less than EPA guidance values; the estimated TEDE is 3.4 mrem/yr for the industrial land-use scenario. This value is less than the numerical guidance of 15 mrem/yr (for

industrial land use) in draft EPA guidance. The corresponding estimated incremental cancer risk value is  $1 \times 10^{-4}$  for the industrial land-use scenario.

The uncertainties associated with the calculations are considered small relative to the conservativeness of the risk assessment analysis. It is therefore concluded that these sites do not have significant potential to affect human health under an industrial land-use scenario.

### **III. Ecological Risk Assessment**

#### **III.1 Introduction**

This section addresses the ecological risks associated with exposure to constituents of potential ecological concern (COPEC) at SNL/NM ER Sites 1 and 3, the RWL and the CDPs. The ecological risk assessment process performed for these site is a screening-level assessment that follows the methodology presented in IT Corporation (1997) and SNL/NM (1997). The methodology was based on screening-level guidance presented by the EPA (EPA 1992, 1996d, 1997b) and by Wentzel et al. (1996) and is consistent with a phased approach. This assessment utilizes conservatism in the estimation of ecological risks; however, ecological relevance and professional judgment are also incorporated as recommended by the EPA (1996d) and Wentzel et al. (1996) to ensure that the predicted exposures of selected ecological receptors reasonably reflect those expected to occur at the sites.

#### **III.2 Site Description and Ecological Pathways**

ER Sites 1 and 3 are part of Operable Unit 1303 and are located in TA-II near its eastern boundary fence. In general, the land within TA-II has been developed or is highly disturbed (IT Corporation 1995). The vegetation in and around ER Sites 1 and 3 is best described as disturbed grassland dominated by early successional and ruderal species. No threatened, endangered, or sensitive species are known to occur at these sites, and none are expected due to the disturbed condition of the habitat. Complete ecological pathways may exist through the exposures of plants, soil invertebrates, and small mammals to COPECs on the sites and through the potential for consumption of the small mammals by predators. These pathways are limited, however, to soils from the landfill cover strata.

#### **III.3 Constituents of Potential Ecological Concern**

The potential nonradiological COCs at these sites are arsenic, barium, beryllium, cadmium, chromium, lead, mercury, selenium, and silver. All of these COCs were found to exceed their respective background screening levels (Table 1) and were, therefore, identified as COPECs. Inorganic constituents that are essential nutrients, such as iron, magnesium, calcium, potassium, and sodium, were not included as COPECs in this assessment. Radioactive COCs from the landfill cover at ER Sites 1 and 3 that exceeded background screening values were americium-241, plutonium-239/240, plutonium-238, uranium-239, and tritium (Table 3).

### III.4 Receptors and Exposure Modeling

A nonspecific perennial plant was used as the receptor to represent plant species at these sites. Two wildlife receptors (deer mouse and burrowing owl) were used to represent wildlife use of the sites. Exposure modeling for the wildlife receptors was limited to the food ingestion pathway. 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 as an omnivore (50 percent of the diet as plants and 50 percent as soil invertebrates), and the burrowing owl was modeled as a strict predator on small mammals (100 percent of the diet as deer mice). Both were modeled with soil ingestion comprising 2 percent of the total dietary intake. Table 9 presents the species-specific factors used in modeling exposures in the wildlife receptors. Although home range is also included in this table, exposures for this screening-level assessment were modeled using an area use factor of 1, implying that all food items and soil ingested are from the sites being investigated.

The maximum measured COPEC concentrations from both surface and subsurface soil samples were used to conservatively estimate potential exposures and risks to plants and wildlife at these sites. Table 10 presents the transfer factors used in modeling the concentrations of COPECs through the food chain. Table 11 presents the maximum concentrations of COPECs in soil and the derived concentrations in the various food-chain elements.

With respect to the radionuclides, the receptors are exposed to radiation internally and externally from americium-241, plutonium-239/240, plutonium-238, and uranium-238, and are exposed internally from tritium. Internal and external dose rates to the deer mouse and burrowing owl are approximated using dose rate models from the *Hanford Site Risk Assessment Methodology* (DOE 1995). Radionuclide-dependent data for the dose rate calculations were referenced from Baker and Soldat (1992). The external dose rate models assume a soil density of 1.5 grams per cubic centimeter ( $\text{g/cm}^3$ ). Only gamma-emitting radionuclides are considered for the external dose rate calculation. The average gamma energy per disintegration (MeV/disintegration) was used for each particular gamma emitter. The internal dose rate model assumes that absorbed energy (Baker and Soldat 1992) is a function of the effective body radius of the receptor. Any radionuclides present in the body of the receptor are assumed to concentrate at the center of the organism and contribute to a whole-body dose. The internal dose rate model assumes that the deer mouse ingests radionuclides from soil and plants and the burrowing owl is assumed to ingest radionuclides from soil and its diet of deer mice. A detailed description of the method to estimate radiation dose to these receptors is presented in DOE (1995) and IT (1997). The total dose rate to a receptor is the sum of the external and internal dose rates.

**Table 9**  
**Exposure Factors for Ecological Receptors at**  
**Environmental Restoration Sites 1 and 3,**  
**Sandia National Laboratories, New Mexico**

Receptor species	Class/ Order	Trophic level	Body weight (kg) <sup>a</sup>	Food intake rate (kg/d) <sup>b</sup>	Dietary Composition <sup>c</sup>	Home range (acres)
Deer Mouse ( <i>Peromyscus maniculatus</i> )	Mammalia/ Rodentia	Omnivore	0.0239 <sup>d</sup>	0.00372	Plants: 50% Invertebrates: 50% (+ Soil at 2% of intake)	0.27 <sup>e</sup>
Burrowing owl ( <i>Speotyto cunicularia</i> )	Aves/ Strigiformes	Carnivore	0.155 <sup>f</sup>	0.0173	Rodents: 100% (+ Soil at 2% of intake)	34.6 <sup>g</sup>

<sup>a</sup>Body weights are in kilograms wet weight.

<sup>b</sup>Food intake rates are estimated from the allometric equations presented in Nagy (1987). Units are kilograms dry weight per day.

<sup>c</sup>Dietary compositions are generalized for modeling purposes. Default soil intake value of 2 percent of food intake.

<sup>d</sup>From Silva and Downing (1995).

<sup>e</sup>From EPA (1993), based on the average home range measured in semi-arid shrubland in Idaho.

<sup>f</sup>From Dunning (1993).

<sup>g</sup>From Haug et al. (1993).

**Table 10**  
**Transfer Factors Used in Exposure Models for**  
**Constituents of Potential Ecological Concern at**  
**Environmental Restoration Sites 1 and 3,**  
**Sandia National Laboratories, New Mexico**

Constituent of Potential Ecological Concern	Soil-to-Plant Transfer Factor	Soil-to-Invertebrate Transfer Factor	Food-to-Muscle Transfer Factor
Arsenic	$4.00 \times 10^{-2k}$	$1.00 \times 10^{0b}$	$2.00 \times 10^{-3a}$
Barium	$1.50 \times 10^{-1a}$	$1.00 \times 10^{0b}$	$2.00 \times 10^{-4c}$
Beryllium	$1.00 \times 10^{-2a}$	$1.00 \times 10^{0b}$	$1.00 \times 10^{-3c}$
Cadmium	$5.50 \times 10^{-1a}$	$6.00 \times 10^{-1d}$	$5.50 \times 10^{-4a}$
Chromium (Total)	$4.00 \times 10^{-2a}$	$1.30 \times 10^{-1d}$	$3.00 \times 10^{-2c}$
Lead	$9.00 \times 10^{-2a}$	$4.00 \times 10^{-2d}$	$8.00 \times 10^{-4k}$
Mercury	$1.00 \times 10^{0k}$	$1.00 \times 10^{0b}$	$2.50 \times 10^{-1c}$
Selenium	$5.00 \times 10^{-1c}$	$1.00 \times 10^{0b}$	$1.00 \times 10^{-1c}$
Silver	$1.00 \times 10^{0c}$	$2.50 \times 10^{-1d}$	$5.00 \times 10^{-3c}$

<sup>a</sup>From Baes et al. (1984).

<sup>b</sup>Default value.

<sup>c</sup>From NCRP (1989).

<sup>d</sup>From Stafford et al. (1991).

**Table 11**  
**Media Concentrations (mg/kg)<sup>a</sup> for**  
**Constituents of Potential Ecological Concern at**  
**Environmental Restoration Sites 1 and 3,**  
**Sandia National Laboratories, New Mexico**

Constituent of Potential Ecological Concern	Soil (maximum) <sup>a</sup>	Plant Foliage <sup>b</sup>	Soil Invertebrate <sup>b</sup>	Deer Mouse Tissues <sup>c</sup>
Arsenic	$1.30 \times 10^1$	$5.20 \times 10^{-1}$	$1.30 \times 10^1$	$4.39 \times 10^{-2}$
Barium	$3.00 \times 10^2$	$4.50 \times 10^1$	$3.00 \times 10^2$	$1.12 \times 10^{-1}$
Beryllium	$2.00 \times 10^0$	$2.00 \times 10^{-2}$	$2.00 \times 10^0$	$3.28 \times 10^{-3}$
Cadmium	$6.50 \times 10^0$	$3.58 \times 10^0$	$3.90 \times 10^0$	$6.65 \times 10^{-3}$
Chromium (total)	$1.60 \times 10^1$	$6.40 \times 10^{-1}$	$2.08 \times 10^0$	$1.58 \times 10^{-1}$
Lead	$4.10 \times 10^1$	$3.69 \times 10^0$	$1.64 \times 10^0$	$8.71 \times 10^{-3}$
Mercury	$7.80 \times 10^0$	$7.80 \times 10^0$	$7.80 \times 10^0$	$6.22 \times 10^0$
Selenium	$2.50 \times 10^1$	$1.25 \times 10^1$	$2.50 \times 10^1$	$6.02 \times 10^0$
Silver	$8.50 \times 10^0$	$8.50 \times 10^0$	$2.13 \times 10^0$	$8.57 \times 10^{-2}$

<sup>a</sup>Milligrams per kilogram. All are based on dry weight of the media.

<sup>b</sup>Product of the soil concentration and the corresponding transfer factor.

<sup>c</sup>Product of the average concentration in food times the food-to-muscle transfer factor times the wet weight-dry weight conversion factor of 3.125 (from EPA 1993).

### III.5 Toxicity Benchmarks

Benchmark toxicity values for the plant and wildlife receptors are presented in Table 12. For plants, the benchmark soil concentrations are based on the lowest-observed-adverse-effect level. For wildlife, the toxicity benchmarks are based on the no-observed-adverse-effect level (NOAEL) for chronic oral exposure in a taxonomically similar test species. The benchmark used for exposure of terrestrial receptors to radiation is 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 offer sufficient protection to other components within the terrestrial environment of ER Sites 1 and 3.

### III.6 Risk Characterization

The maximum soil concentrations and estimated dietary exposures were compared to plant and wildlife benchmark values, respectively. The results of these comparisons are presented in Table 13. Hazard quotients (HQ) are used to quantify the comparison with the benchmarks for wildlife exposure. HQs for plants exceeded unity for arsenic (HQ = 1.3), cadmium (HQ = 2.17), total chromium (HQ = 16.0), mercury (HQ = 26.0), selenium (HQ = 25.0), and silver (HQ = 4.25). In the deer mouse, HQs exceeded unity for arsenic (HQ = 8.19), barium (HQ = 2.64), mercury (HQ = 19.8), and selenium (HQ = 7.66). In the burrowing owl,

**Table 12**  
**Toxicity Benchmarks for Ecological Receptors at**  
**Environmental Restoration Sites 1 and 3,**  
**Sandia National Laboratories, New Mexico**

Constituent of Potential Ecological Concern	Plant Benchmark <sup>a</sup>	Mammalian NOAELs			Avian NOAELs		
		Mammalian Test Species <sup>b</sup>	Test Species NOAEL <sup>c</sup>	Deer Mouse NOAEL <sup>d</sup>	Avian Test Species <sup>e</sup>	Test Species NOAEL <sup>f</sup>	Burrowing Owl NOAEL <sup>g</sup>
Arsenic	10	Lab mouse	0.126	0.13	Mallard	5.14	5.14
Barium	500	Lab rat <sup>h</sup>	5.1	10.53	Chicks	20.8	20.8
Beryllium	10	Lab rat	0.66	1.29			
Cadmium	3	Lab rat <sup>h</sup>	1.0	1.89	Mallard	1.45	1.45
Chromium (total)	1	Lab rat	2,737	5,354	Black Duck	1.0	1.0
Lead	50	Lab rat	8	15.7	American kestrel	3.85	3.85
Mercury	0.3	Lab rat	0.032	0.06	Mallard	0.0064	0.0064
Selenium	1	Lab rat	0.20	0.39	Screech owl	0.44	0.44
Silver	2	Lab rat	17.8	34.8			

<sup>a</sup>From Will and Suter (1995).

<sup>b</sup>From Sample et al. (1996), except where noted. Body weights (in kilograms) for NOAEL conversion are: lab mouse, 0.030, and lab rat, 0.350 (except where noted).

<sup>c</sup>From Sample et al. (1996).

<sup>d</sup>Based on NOAEL conversion methodology presented in Sample et al. (1996), using a deer mouse body weight of 0.239 kilograms and a mammalian scaling factor of 0.25.

<sup>e</sup>From Sample et al. (1996).

<sup>f</sup>Based on 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.

<sup>g</sup>Study-specific body weight: 0.435 kg.

<sup>h</sup>Study-specific body weight: 0.303 kg.

selenium (HQ = 1.65) and mercury (HQ = 111) were found to produce HQs greater than unity. Although the maximum total chromium concentration of 16.0 mg/kg was carried through the risk assessment, the background value for total chromium (18.8 mg/kg), which is not reported in the human health risk assessment screening table, is actually greater than the maximum concentrations at ER Sites 1 and 3. The total radiation dose rate to the mouse was predicted to be  $9.70 \times 10^{-6}$  rad/day (Table 14). The total dose rate to the burrowing owl was predicted to be  $8.12 \times 10^{-6}$  rad/day (Table 15). The internal dose rate, for this case, is the major contributor to the total dose rate. The dose rates for the deer mouse and the burrowing owl are considerably less than the benchmark of 0.1 rad/day. Based upon this information, radiological risks associated with ER Sites 1 and 3 are expected to be insignificant; however, potential risks from exposures in ecological receptors to nonradiological COPECs at this site may exist. These COPECs include arsenic, barium, cadmium, chromium, mercury, selenium, and silver.

**Table 13**  
**Comparisons to Toxicity Benchmarks for**  
**Ecological Receptors at**  
**Environmental Restoration Sites 1 and 3,**  
**Sandia National Laboratories, New Mexico**

Constituent of Potential Ecological Concern	Plant Hazard Quotient <sup>a</sup>	Deer Mouse Hazard Quotient	Burrowing Owl Hazard Quotient
Arsenic	<b>1.30 x 10<sup>0</sup></b>	<b>8.19 x 10<sup>0</sup></b>	6.59 x 10 <sup>-3</sup>
Barium	6.00 x 10 <sup>-1</sup>	<b>2.64 x 10<sup>0</sup></b>	3.28 x 10 <sup>-2</sup>
Beryllium	2.00 x 10 <sup>-1</sup>	1.27 x 10 <sup>-1</sup>	--- <sup>b</sup>
Cadmium	<b>2.17 x 10<sup>0</sup></b>	3.19 x 10 <sup>-1</sup>	1.05 x 10 <sup>-2</sup>
Chromium (total)	<b>1.60 x 10<sup>1</sup></b>	4.88 x 10 <sup>-5</sup>	5.32 x 10 <sup>-2</sup>
Lead	8.20 x 10 <sup>-1</sup>	3.47 x 10 <sup>-2</sup>	2.40 x 10 <sup>-2</sup>
Mercury	<b>2.60 x 10<sup>1</sup></b>	<b>1.98 x 10<sup>1</sup></b>	<b>1.11 x 10<sup>2</sup></b>
Selenium	<b>2.50 x 10<sup>1</sup></b>	<b>7.66 x 10<sup>0</sup></b>	<b>1.65 x 10<sup>0</sup></b>
Silver	<b>4.25 x 10<sup>0</sup></b>	2.45 x 10 <sup>-2</sup>	—

<sup>a</sup>Bold text indicates hazard quotient exceeds unity.

<sup>b</sup>--- designates insufficient toxicity data available for risk estimation purposes.

### III.7 Uncertainties

Many uncertainties are associated with the characterization of ecological risks at ER Sites 1 and 3. These uncertainties result in the use of assumptions in estimating risk that may lead to an overestimation or underestimation of the true risk presented at a site. For this screening-level risk assessment, assumptions are made that are more likely to overestimate risk rather than to underestimate it. These conservative assumptions are used to be more protective of the ecological resources potentially affected by the sites. Conservatisms incorporated into this risk assessment include the use of the maximum measured soil concentration to evaluate risk, the use of wildlife toxicity benchmarks based on NOAEL values, the use of earthworm-based transfer factors or a default factor of 1.0 for modeling COPECs into soil invertebrates in the absence of insect data, and the use of 1.0 as the area use factor for wildlife receptors regardless of seasonal use or home range size.

Uncertainties associated with the estimation of risk to ecological receptors following exposure to radiological COPECs are primarily related to those inherent in the dose rate models and related exposure parameters. The external dose rate models are based on the assumption that the receptor is underground in soil uniformly contaminated with the maximum detected concentration of the radionuclides present at the site. The internal models are based on the assumption that ingested radionuclides are present at the center of a spherical-shaped receptor, forming a point source of radiation. In addition, the receptor is assumed to be exposed uniformly from this source of radiation at the center and receives a total-body dose.

**Table 14**  
**Internal and External Dose Rates for**  
**Mice Exposed to Radionuclides at**  
**Environmental Restoration Sites 1 and 3,**  
**Sandia National Laboratories, New Mexico**

Radionuclide	Maximum Concentration (pCi/g)	Internal Dose (rad/d)	External Dose (rad/d)	Total Dose (rad/d)
Americium-241	0.16	$5.86 \times 10^{-8}$	$3.43 \times 10^{-7}$	$4.02 \times 10^{-7}$
Plutonium-239/240 <sup>a</sup>	1.28	$4.40 \times 10^{-7}$	$6.39 \times 10^{-8}$	$5.04 \times 10^{-7}$
Plutonium-238	0.053	$1.94 \times 10^{-8}$	$6.47 \times 10^{-9}$	$2.59 \times 10^{-8}$
Tritium	78.9	$7.43 \times 10^{-6}$	NA <sup>b</sup>	$1.21 \times 10^{-6}$
Uranium-238	1.42	$7.40 \times 10^{-6}$	$1.31 \times 10^{-7}$	$7.56 \times 10^{-6}$
Totals		$9.16 \times 10^{-6}$	$5.45 \times 10^{-7}$	$9.70 \times 10^{-6}$

<sup>a</sup> Modeled as Plutonium-239.

<sup>b</sup> NA indicates that this radionuclide does not significantly contribute to the external dose.

**Table 15**  
**Internal and External Dose Rates for**  
**Owl Exposed to Radionuclides at**  
**Environmental Restoration Sites 1 and 3,**  
**Sandia National Laboratories, New Mexico**

Radionuclide	Maximum Concentration (pCi/g)	Internal Dose (rad/d)	External Dose (rad/d)	Total Dose (rad/d)
Americium-241	0.16	$3.66 \times 10^{-8}$	$3.43 \times 10^{-7}$	$3.80 \times 10^{-7}$
Plutonium-239/240 <sup>a</sup>	1.28	$6.21 \times 10^{-7}$	$6.39 \times 10^{-8}$	$6.85 \times 10^{-7}$
Plutonium-238	0.053	$2.74 \times 10^{-8}$	$6.47 \times 10^{-9}$	$3.39 \times 10^{-8}$
Tritium	78.9	$2.12 \times 10^{-6}$	NA <sup>b</sup>	$2.12 \times 10^{-6}$
Uranium-238	1.42	$4.76 \times 10^{-6}$	$1.31 \times 10^{-7}$	$4.89 \times 10^{-6}$
Totals		$7.57 \times 10^{-6}$	$5.45 \times 10^{-7}$	$8.12 \times 10^{-6}$

<sup>a</sup> Modeled as Plutonium-239.

<sup>b</sup> NA indicates that this radionuclide does not significantly contribute to the external dose.

### III.6 Summary

An ecological risk assessment was conducted to evaluate potential ecological risks associated with the COCs at ER Sites 1 and 3. Five radionuclides present that might have been an ecological concern were americium-241, plutonium-239/240, plutonium-238, tritium, and

uranium-238. The maximum total dose rate calculated for the receptors was approximately  $1.0 \times 10^{-5}$  rad/day, well below the acceptable benchmark of 0.1 rad/day. Nine inorganic COCs were found at levels of potential ecological concern using the maximum values of all the soil piles. The maximum total chromium concentration (18 mg/kg) and barium concentration (230 mg/kg) are within the background ranges. Five other COPECs (arsenic, cadmium, mercury, selenium, and silver) produced HQs greater than 1.0 for more than one receptor. However, Soil Piles 1 through 16 are proposed to be placed at 0 to 10 feet below ground. Using the maximum concentrations in Piles 1 through 16, arsenic (2.4 mg/kg), cadmium (1.05 mg/kg), and mercury (0.03 mg/kg) will produce HQs of less than 1.0 for all receptors. Selenium in Piles 1 through 16 has an average concentration of 7.2 mg/kg, which would result in HQs of 7.2 and 2.21 for the plant and the deer mouse, respectively. However, based upon material retrieved from the RWL and sampling data for the sites, selenium is not a COC. Based upon these results, the ecological risk for ER Sites 1 and 3 is expected to be insignificant.

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**APPENDIX 1.**

## **Sandia National Laboratories Environmental Restoration Program**

### **EXPOSURE PATHWAY DISCUSSION FOR CHEMICAL AND RADIONUCLIDE CONTAMINATION**

#### **BACKGROUND**

Sandia National Laboratories (SNL) 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 ER sites have similar types of contamination and physical settings, SNL 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 views as resulting in a Reasonable Maximum Exposure (RME) value. Subject to comments and recommendations by the USEPA Region VI and NMED, SNL proposes that these default exposure routes and parameter values be used in future risk assessments.

At SNL/NM, all Environmental Restoration sites exist within the boundaries of the Kirtland AFB. 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/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 ER sites. At this time, all SNL/NM ER sites have been tentatively designated for either industrial or recreational future land use. The NMED has also requested that risk calculations be performed based on 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, risk and dose values. 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), and;

- External exposure to penetrating radiation (immersion in contaminated air; immersion in contaminated water and exposure from ground surfaces with photon-emitting radionuclides).

Based on the location of the SNL ER sites 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 ER sites, there does not presently 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 ER site:

- Ingestion of contaminated fish and shell fish;
- Ingestion of contaminated fruits and vegetables;
- Ingestion of contaminated meat, eggs, and dairy products; and
- 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 on 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.

## **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 and 1991). These general equations also apply to

**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

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 Reasonable Maximum Exposure (RME) risk assessment calculations for industrial, recreational, and residential scenarios, based on 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 Quotient/Index, 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)

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

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 hazard index) 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 COCs 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  $10^{-4}$  to  $10^{-6}$ . The evaluation of the noncarcinogenic health hazard produces a quantitative estimate (i.e., the Hazard Index) 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 Hazard Index 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 at ER sites, based on 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 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 on 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 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 ER sites, but this scenario has been requested to be considered by the NMED. For sites designated as industrial or recreational land-use, SNL will provide risk parameter values based on 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 Sandia ER sites. The parameter values are based on 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 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
<b>General Exposure Parameters</b>			
Exposure frequency (d/y)	***	***	***
Exposure duration (y)	30 <sup>a,b</sup>	30 <sup>a,b</sup>	30 <sup>a,b</sup>
Body weight (kg)	70 <sup>a,b</sup>	56 <sup>a,b</sup>	70 adult <sup>a,b</sup> 15 child
Averaging Time (days) for carcinogenic compounds (=70 y x 365 d/y)	25550 <sup>a</sup>	25550 <sup>a</sup>	25550 <sup>a</sup>
for noncarcinogenic compounds (=ED x 365 d/y)	10950	10950	10950
<b>Soil Ingestion Pathway</b>			
Ingestion rate	100 mg/d <sup>c</sup>	6.24 g/y <sup>d</sup>	114 mg-y/kg-d <sup>a</sup>
<b>Inhalation Pathway</b>			
Inhalation rate (m <sup>3</sup> /yr)	5000 <sup>a,b</sup>	146 <sup>d</sup>	5475 <sup>a,b,d</sup>
Volatilization factor (m <sup>3</sup> /kg)	chemical specific	chemical specific	chemical specific
Particulate emission factor (m <sup>3</sup> /kg)	1.32E9 <sup>a</sup>	1.32E9 <sup>a</sup>	1.32E9 <sup>a</sup>
<b>Water Ingestion Pathway</b>			
Ingestion rate (L/d)	2 <sup>a,b</sup>	2 <sup>a,b</sup>	2 <sup>a,b</sup>
<b>Food Ingestion Pathway</b>			
Ingestion rate (kg/yr)	NA	NA	138 <sup>b,d</sup>
Fraction ingested	NA	NA	0.25 <sup>b,d</sup>
<b>Dermal Pathway</b>			
Surface area in water (m <sup>2</sup> )	2 <sup>b,e</sup>	2 <sup>b,e</sup>	2 <sup>b,e</sup>
Surface area in soil (m <sup>2</sup> )	0.53 <sup>b,e</sup>	0.53 <sup>b,e</sup>	0.53 <sup>b,e</sup>
Permeability coefficient	chemical specific	chemical specific	chemical specific

\*\*\* The exposure frequencies for the land use scenarios are often integrated into the overall contact rate for specific exposure pathways. When not included, the exposure frequency for the industrial land use scenario is 8 h/d for 250 d/y; for the recreational land use, a value of 2 hr/wk for 52 wk/y is used (EPA 1989b); for a residential land use, all contact rates are given per day for 350 d/y.

<sup>a</sup> RAGS, Vol 1, Part B (EPA 1991).

<sup>b</sup> Exposure Factors Handbook (EPA 1989b)

<sup>c</sup> EPA Region VI guidance.

<sup>d</sup> For radionuclides, RESRAD (ANL 1993) is used for human health risk calculations; default parameters are consistent with RESRAD guidance.

<sup>e</sup> Dermal Exposure Assessment (EPA 1992).

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**Section 6.2  
Statistical Analysis of TA-II,  
Radioactive Waste Landfill (ER Sites 1 and 3),  
Radiological Background Data**



**Statistical Analysis of TA-II, Radioactive Waste  
Landfill (ER Site 1), Radiological Background Data**

**By Tom Tharp  
Date: 4/5/97**

## 1. Introduction

A statistical analysis was performed on background radiological data collected from the ER Site 1 area. The purpose of the analysis was to develop background UTLs or 95th percentiles, as appropriate, for evaluating additional characterization needs, if any, and VCM results for the Radioactive Waste Landfill (RWL). A total of 20 surface samples were collected from areas near the RWL (Table 1, Figure 1). Each constituent was subjected to the statistical analysis. Statistical analyses are described in Appendix 1.

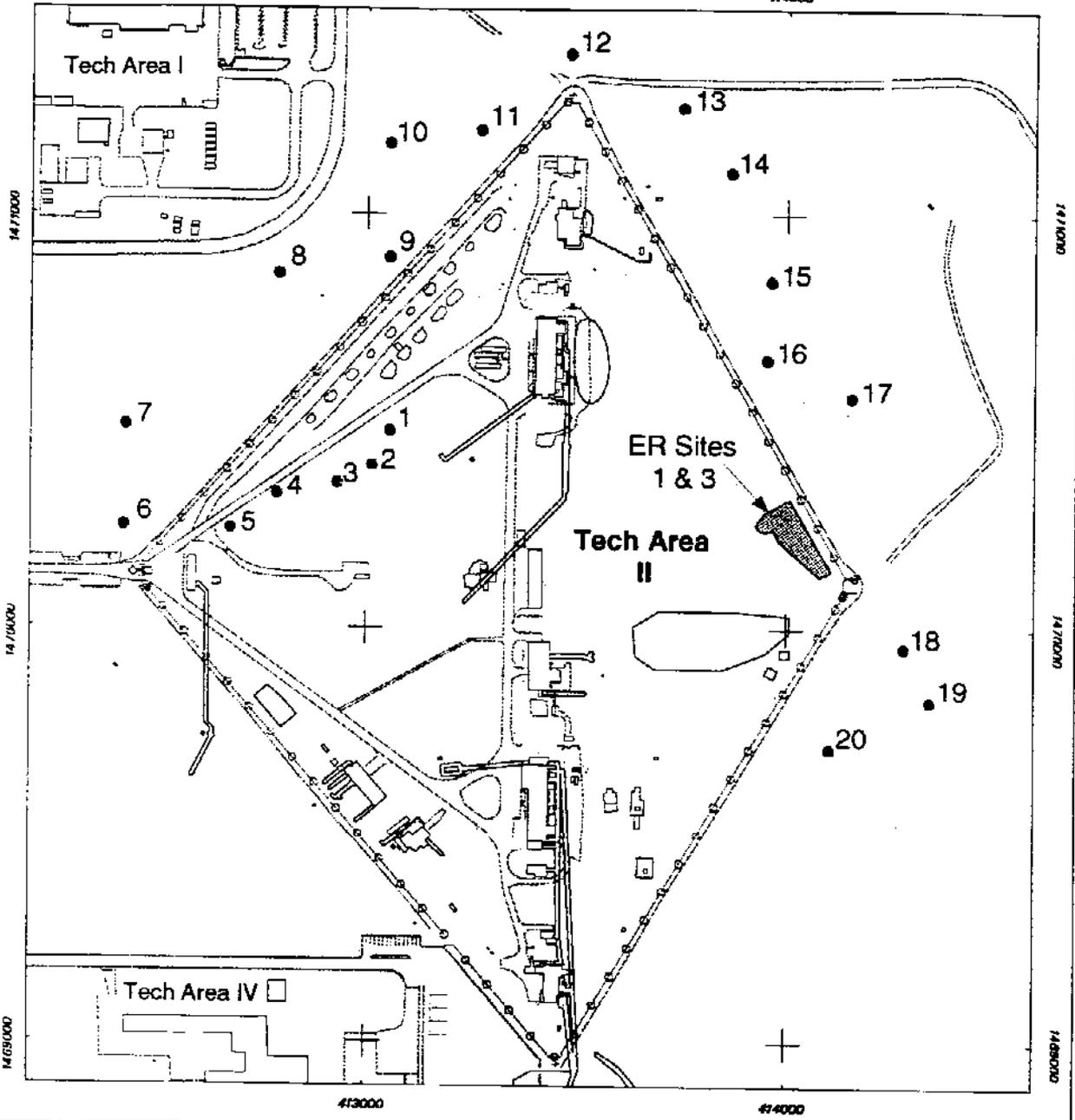
## 2. Distribution Analyses

A distribution fitting analysis, detailed in Appendix 1, was applied to the background radiological data set to determine distribution types. Following are the results of that analysis.

As detailed in Appendix 1, the first step in a distribution analysis is to screen outliers from the data set via the *a priori* procedure. Table 2 shows the results of the *a priori* screening. No values were eliminated during this screening process. Distribution fitting techniques, also detailed in Appendix 1, were then applied to the data. Data were determined to be parametric (normal or lognormal) or nonparametric. The distribution fitting summary for this data set is provided in Table 3. A final screening procedure, the  $T_n$  statistic, was then applied to the parametric data. This test is summarized in Table 4. The maximum value for Th-232 was eliminated based on the results of this test. A reanalysis of distribution type was performed on the remaining samples (Table 3).

### **3. Determination of Background UTLs for Background Radionuclides**

The 95th UTL or Percentile was calculated for the individual constituents of the RWL radionuclide data set. If the distribution of a particular constituent was parametric, an UTL was calculated. If the distribution was non-parametric, a 95th percentile was determined. These values are provided in Table 5. A summary of the UTLs/percentiles, as appropriate, and the range of concentrations for a particular radionuclides are provided in Table 6.



**Legend**

- Background Soil Sample Location
- Road
- Other ER Site Boundary
- ○ ○ ○ Fence
- Building/Structure
- ▨ ER Site 1 & 3

**Figure 1**  
**Radioactive Waste Landfill**  
**Background Soil Sample Locations**



Sandia National Laboratories, New Mexico  
Environmental Geographic Information System

Table 1. Radiological background concentrations for TA-II, Radioactive Waste Landfill

Sample #	028081-01	028082-01	028083-01	028084-01	028085-01	028086-01	028087-01	028088-01	028089-01	028090-01
U-238	3.25 (ND)	1.19 (ND)	3.20 (ND)	1.11 (ND)	2.95 (ND)	1.10 (ND)	3.23 (ND)	1.11 (ND)	3.26 (ND)	1.13
Th-234	0.56 (ND)	1.01	0.53 (ND)	1.15	0.752	1.04	0.811	0.896	0.776	0.856
Ra-226	1.08	1.47	1.38	1.97	0.762	1.42	1.18	1.59	1.57	1.56
Pb-214	0.542	0.733	0.552	0.725	0.578	0.675	0.666	0.653	0.658	0.757
Bi-214	0.504	0.701	0.51	0.641	0.501	0.657	0.602	0.637	0.603	0.711
Th-232	0.792	0.734	0.695	0.861	0.707	0.799	0.814	0.777	0.778	0.82
Ra-228	0.821	0.679	0.839	0.911	0.651	0.723	0.853	0.751	0.84	0.855
Ac-228	0.748	0.828	0.863	0.827	0.735	0.754	0.756	0.725	0.824	0.983
Th-228	0.683	0.497	0.878	0.497	0.583	0.669	0.719	0.644 (ND)	0.568	0.518
Ra-224	0.894	0.833	0.755	0.854	0.703	0.789	0.862	0.732	0.865	0.96
Pb-212	0.767	0.826	0.773	0.808	0.709	0.758	0.817	0.722	0.831	0.885
Bi-212	0.681	0.771	0.918	0.722	0.72	0.974	0.753	0.779	0.781	1.05
Tl-208	0.672	0.771	0.706	0.83	0.691	0.696	0.692	0.674	0.733	0.826
U-235	0.231 (ND)	0.178 (ND)	0.228 (ND)	0.165 (ND)	0.204 (ND)	0.159 (ND)	0.227 (ND)	0.169 (ND)	0.227 (ND)	0.172 (ND)
Cs-137	0.0146	0.169	0.0364 (ND)	0.147	missing	0.105	0.443	0.0957	0.31	missing
Sample #	028091-01	028092-01	028093-01	028094-01	028095-01	028096-01	028097-01	028098-01	028099-01	028100-01
U-238	3.17 (ND)	1.11 (ND)	3.22 (ND)	1.23 (ND)	3.19 (ND)	1.13 (ND)	3.00 (ND)	1.22 (ND)	3.28 (ND)	3.29 (ND)
Th-234	0.978	1.02	0.969	1.13	0.784	1.18	0.941	1.18	0.96	1.02
Ra-226	1.23	1.16	1.5	2.28	1.2	1.45	1.09	1.59	1.21	1.52
Pb-214	0.642	0.761	0.636	0.824	0.662	0.836	0.58	0.764	0.715	0.688
Bi-214	0.543	0.658	0.607	0.79	0.633	0.785	0.501	0.717	0.597	0.588
Th-232	0.635	0.824	0.767	0.929	0.713	0.89	0.782	1.07	0.86	0.802
Ra-228	0.789	0.798	0.886	0.884	0.77	0.833	0.804	0.939	0.839	0.832
Ac-228	0.768	0.842	0.76	0.952	0.809	0.817	0.714	0.872	0.871	0.887
Th-228	0.731	0.648 (ND)	0.729	0.701 (ND)	0.736	0.788	0.467	0.831	0.536	0.917
Ra-224	0.742	0.951	0.81	0.827	0.778	0.912	0.724	0.791	0.971	0.863
Pb-212	0.776	0.806	0.781	0.855	0.787	0.845	0.713	0.914	0.852	0.939
Bi-212	0.696	0.509	0.788	1.15	0.775	0.99	0.82	0.799	0.961	0.986
Tl-208	0.701	0.701	0.716	0.819	0.679	0.707	0.63	0.91	0.814	0.715
U-235	0.225 (ND)	0.166 (ND)	0.225 (ND)	0.185 (ND)	0.225 (ND)	0.168 (ND)	0.214 (ND)	0.187 (ND)	0.227 (ND)	0.225 (ND)
Cs-137	0.358	0.208	0.402	0.534	0.308	0.221	0.405	0.782	0.0903	0.472

Table 2. *A Priori* Screening for TA II, Radioactive Waste Landfill, Background Radionuclides

Parameter	Max Value	Next Max	X Factor	Results
Th-234	1.18	1.18	1.00	PASS
Ra-226	2.28	1.97	1.16	PASS
Pb-214	0.836	0.824	1.01	PASS
Bi-214	0.79	0.785	1.01	PASS
Th-232	1.07	0.929	1.15	PASS
Ra-228	0.939	0.911	1.03	PASS
Ac-228	0.983	0.952	1.03	PASS
Th-228	0.917	0.878	1.04	PASS
Ra-224	0.971	0.96	1.01	PASS
Pb-212	0.939	0.914	1.03	PASS
Bi-212	1.15	1.05	1.10	PASS
Tl-208	0.91	0.83	1.10	PASS
Cs-137	0.782	0.534	1.46	PASS

X Factor - maximum value divided by next maximum value

Table 3. Distribution Summary for TA-II, Radioactive Waste Landfill, Background Radionuclides

Parameter	Distribution Type	Shapiro-Wilk Test (0.905) (0.897 for Cs-137 and 0.801 for Th-232)	Coefficient of Skewness (-1 to 1)	Histogram	Probability Plot	Number of Samples	Distribution
Th-234	Normal	0.828 (F)	-1.44 (F)	?	?	20	Nonparametric
	Lognormal	0.666 (F)	-2.15 (F)	?	?	20	
Ra-226	Normal	0.933	0.69	X		20	Lognormal
	Lognormal	0.951	-0.24		X	20	
Pb-214	Normal	0.969	0.07		X	20	Normal
	Lognormal	0.966	-0.16	X		20	
Bi-214	Normal	0.945	0.25		*	20	Lognormal
	Lognormal	0.945	-0.006	X	*	20	
Th-232	Normal	0.986	-0.14	X	X	19	Normal
	Lognormal	0.977	-0.39			19	
Ra-228	Normal	0.957	-0.61	*	X	20	Normal
	Lognormal	0.936	-0.83	*		20	
Ac-228	Normal	0.943	0.59			20	Lognormal
	Lognormal	0.953	0.42	X	X	20	
Th-228	Normal	0.958	-0.12	X	X	20	Normal
	Lognormal	0.926	-0.6			20	
Ra-224	Normal	0.962	0.19			20	Lognormal
	Lognormal	0.966	0.05	X	X	20	
Pb-212	Normal	0.973	0.3	*		20	Lognormal
	Lognormal	0.977	0.13	*	X	20	
Bi-212	Normal	0.951	0.21	X	X	20	Normal
	Lognormal	0.944	-0.36			20	
Tl-208	Normal	0.880 (F)	0.95	?	?	20	Nonparametric
	Lognormal	0.899 (F)	0.79	?	?	20	
Cs-137	Normal	0.945	0.69	X	X	18	Normal
	Lognormal	0.874 (F)	-1.17 (F)			18	

F - failed statistical test

\* - both plots exhibit same degree of being parametrically distributed

? - constituent does not exhibit a parametric distribution

Table 4.  $T_n$  Statistic Analysis for TA-II, Radioactive Waste Landfill, Background Radionuclides

Parameter	Distribution	Maximum Observation	Mean	Standard Deviation	$T_n$ Statistic	N	Upper 5% Critical Value	Pass or Fail $T_n$ Statistic
Th-234	Nonparametric	N/A	N/A	N/A	N/A	20	N/A	N/A
Ra-226	Lognormal	0.824175	0.31822	0.234747	2.155	20	2.557	Pass
Pb-214	Normal	0.836	0.68235	0.0832247	1.846	20	2.557	Pass
Bi-214	Lognormal	-0.235722	-0.480466	0.14034	1.744	20	2.557	Pass
Th-232	Lognormal	0.0676586	-0.22629	0.113235	2.596	20	2.557	Fail
Th-232	Normal	0.929	0.788368	0.0714852	1.967	19	2.532	Pass
Ra-228	Normal	0.939	0.81485	0.0728829	1.703	20	2.557	Pass
Ac-228	Lognormal	-0.0171462	-0.206208	0.0887606	2.130	20	2.557	Pass
Th-228	Normal	0.917	0.617175	0.178508	1.680	20	2.557	Pass
Ra-224	Lognormal	-0.0294288	-0.1898	0.0965696	1.661	20	2.557	Pass
Pb-212	Lognormal	-0.0629398	-0.215779	0.0771079	1.982	20	2.557	Pass
Bi-212	Normal	1.15	0.83115	0.151062	2.111	20	2.557	Pass
Tl-208	Nonparametric	N/A	N/A	N/A	N/A	20	N/A	N/A
Cs-137	Normal	0.782	0.282378	0.202391	2.469	18	2.504	Pass

N/A - not applicable because constituent had more than 15% non-detects (nonparametric distribution by default)  
 N - number of samples

Table 5. 95th UTL or Percentile Calculations for TA-II, Radioactive Waste Landfill, Background Radionuclides

Parameter	Distribution	Censored?	Log Mean	Log SD	Mean	SD	One-sided Tolerance Factor (K)	Log UTL	UTL/95th (pCi/g)	Sample #
U-238	Nonparametric (95% NDs)	No							N/A	20
Th-234	Nonparametric	No							1.18	20
Ra-226	Lognormal	No	0.31822	0.234747			2.396	0.88067	2.41	20
Pb-214	Normal	No			0.68235	0.08322	2.396		0.88	20
Bi-214	Lognormal	No	-0.480466	0.14034			2.396	-0.14421	0.87	20
Th-232	Normal	Yes			0.78837	0.07149	2.423		0.96	19
Ra-228	Normal	No			0.81485	0.07288	2.396		0.99	20
Ac-228	Lognormal	No	-0.206208	0.088761			2.396	0.00646	1.01	20
Th-228	Normal	No			0.61718	0.17851	2.396		1.04	20
Ra-224	Lognormal	No	-0.1898	0.09657			2.396	0.04158	1.04	20
Pb-212	Lognormal	No	-0.215779	0.077108			2.396	-0.03103	0.97	20
Bi-212	Normal	No			0.83115	0.15106	2.396		1.19	20
Tl-208	Nonparametric	No							0.87	20
U-235	Nonparametric (100% NDs)	No							N/A	20
Cs-137	Normal	No			0.28238	0.20239	2.543		0.80	18

N/A - not applicable because constituent had 95% or greater non-detects

ND - concentration was non-detect

SD - standard deviation

UTL - upper tolerance limit

Log - natural log of value

Table 6. Summary of TA-II, Radioactive Waste Landfill,  
UTLs/95th percentiles and concentration ranges

Parameter	Distribution	UTL/95th (pCi/g)	Range (pCi/g)
U-238	Nonparametric (95% NDs)	N/A	ND to 1.13
Th-234	Nonparametric	1.18	0.265 to 1.18
Ra-226	Lognormal	2.41	0.762 to 2.28
Pb-214	Normal	0.88	0.542 to 0.836
Bi-214	Lognormal	0.87	0.501 to 0.79
Th-232	Normal	0.96	0.635 to 1.07
Ra-228	Normal	0.99	0.651 to 0.939
Ac-228	Lognormal	1.01	0.714 to 0.983
Th-228	Normal	1.04	0.322 to 0.917
Ra-224	Lognormal	1.04	0.703 to 0.971
Pb-212	Lognormal	0.97	0.709 to 0.939
Bi-212	Normal	1.19	0.509 to 1.15
Tl-208	Nonparametric	0.87	0.63 to 0.91
U-235	Nonparametric (100% NDs)	N/A	All ND
Cs-137	Normal	0.80	0.0146 to 0.782

N/A - not applicable because constituent had 95% or greater non-detects  
ND - concentration was non-detect

**Section 6.3**  
**Analytical Results for Stockpiled Suspect Clean Soil**

Section 6.3, Table 1  
 Summary of Radionuclides in Clean Soil Stockpile Samples Collected at RWL/CDPs  
 (Off-Site Laboratory Only)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	Gamma Spectroscopy Activity <sup>b</sup>													Units
				Am-241	Cs-134	Cs-137	Ra-226	Ra-228	Th-232	U-235	U-238	Co-60	Tritium				
029498-04	Pile 1	Soil	5/17/96	<0 U (0.128)	<0 U (0.0319)	0.165 (0.0363)	0.865 U (0.0668)	1.03 (0.106)	0.975 U (0.0476)	0.221 U (0.191)	0.480 U (1.12)	<0 U (0.0361)			pCi/g		
029498-05	Pile 1	Soil	5/17/96										0.0301		pCi/g		
030602-05	Pile 10	Soil	7/31/96	<0 U (0.112)	<0 U (0.0234)	0.0281 (0.0294)	0.756 (0.0450)	0.845 (0.103)	0.927 (0.0408)	0.0476 U (0.153)	0.474 (0.922)	0.00152 U (0.0342)			pCi/g		
030602-06	Pile 10	Soil	7/31/96										19.44		pCi/g		
030603-05	Pile 11	Soil	7/31/96	<0 U (0.105)	<0 U (0.0265)	0.0297 (0.0318)	0.786 (0.0550)	0.922 (0.124)	0.937 (0.0447)	0.0170 U (0.165)	0.713 (0.898)	0.0118 (0.0423)			pCi/g		
030603-06	Pile 11	Soil	7/31/96										0.28		pCi/g		
030604-05	Pile 12	Soil	7/31/96	<0 U (0.122)	<0 U (0.0266)	0.00512 U (0.0332)	0.643 (0.0540)	0.911 (0.121)	0.936 (0.0465)	0.105 (0.179)	1.42 (0.973)	<0 U (0.0343)			pCi/g		
030604-06	Pile 12	Soil	7/31/96										1.66		pCi/g		
032609-001	Pile 16	Soil	1/29/97										0.16606		pCi/g		
Equipment Blank 029499 04																	
Equipment Blank 029499 05																	
TA-II Background Range <sup>c</sup>	NA	Water	5/17/96	5.73 U (17.2)	0.894 U (3.74)	0.480 U (4.04)	0.519 U (7.77)	0.00 U (15.7)	0.00 U (7.41)	2.46 U (26.6)	52.7 U (167)	0.308 U (4.05)		0.0488 UB	pCi/L		
TA-II Soil Background UTL or 95th Percentile	NA	Water	5/17/96														
	NA	NA	NA												pCi/g		
	NA	NA	NA												NA		

Section 6.3 Table 1 (Concluded)  
 Summary of Radionuclides in Clean Soil Stockpile Samples Collected at RWL/CDPs  
 (Off-Site Laboratory Only)

<sup>a</sup>half-lives < 6 months are not included in this table.  
<sup>b</sup>Value in parenthesis represents the minimum detection activity (MDA).  
<sup>c</sup>Background ranges are site-specific.  
 Am = americium  
 B = detected in blank  
 Co = cobalt  
 Cs = cesium

ID = identification  
 MDA = minimum detection activity  
 pCi/g = picocuries per gram  
 pCi/L = picocuries per liter  
 NA = not applicable  
 ND = nondetect - the analyte was not observed above the MDA  
 Ra = radium  
 Th = thorium

Section 6.3, Table 2  
 Summary of Radionuclides in Clean Soil Stockpile Samples Collected at RWL/CDPs  
 (On-site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	Gamma Spectroscopy Activity*												Units
				Am-241	Cs-134	Cs-137	Ra-226	Ra-228	Th-232	U-235	U-238	Co-60	Trifium			
029498-01	Pile 1	Soil	5/17/96	ND (.108)	ND (.0189)	.170 (.0246)	1.76 (.577)	.721 (.120)	.782 (.155)	ND (.117)	ND (.926)	ND (.0247)			pCi/g	
029498-03	Pile 1	Soil	5/17/96										3.66		pCi/g	
029500-01	Pile 1 D	Soil	5/17/96	ND (.148)	ND (.0543)	.174 (.0263)	1.84 (.509)	.652 (.166)	.795 (.148)	ND (.171)	0.991 (.991)	ND (.0391)			pCi/g	
029500-03	Pile 1 D	Soil	5/17/96										6.05		pCi/g	
029501-01	Pile 2	Soil	5/22/96	ND (.107)	ND (.0193)	.0311 (.0226)	1.43 (.581)	.784 (.121)	0.755 (.157)	ND (.118)	ND (.937)	ND (.0233)			pCi/g	
030288-01	Pile 3	Soil	7/10/96	ND (.138)	ND (.0517)	.0260 (.0238)	1.25 (.455)	.772 (.151)	.679 (.112)	ND (.164)	.645 (.649)	ND (.0374)			pCi/g	
030288-03	Pile 3	Soil	7/10/96										37		pCi/g	
030289-01	Pile 4	Soil	7/10/96	ND (.125)	ND (.0478)	ND (.0339)	1.38 (.446)	.767 (.142)	.707 (.130)	.0353 (.0909)	ND (1.03)	ND (.0368)			pCi/g	
030289-03	Pile 4	Soil	7/10/96										5.96		pCi/g	
030290-01	Pile 5	Soil	7/10/96	.157 (.114)	ND (.0523)	ND (.0358)	1.41 (.464)	.863 (.162)	.813 (.140)	ND (.167)	ND (1.13)	ND (.0370)			pCi/g	
030290-03	Pile 5	Soil	7/10/96										17.7		pCi/g	
030292-01	Pile 6	Soil	7/26/96	ND (.187)	ND (.0377)	ND (.0392)	1.34 (.475)	.717 (.147)	.719 (.128)	ND (.167)	ND (1.21)	ND (.0351)			pCi/g	
030292-03	Pile 6	Soil	7/26/96										35.3		pCi/g	
030293-01	Pile 7	Soil	7/26/96	ND (.158)	ND (.0374)	ND (.222)	1.65 (.528)	.719 (.141)	.631 (.133)	.0720 (.114)	ND (1.2)	ND (.0375)			pCi/g	
030293-03	Pile 7	Soil	7/26/96										35.6		pCi/g	
030294-01	Pile 8	Soil	7/26/96	ND (.174)	ND (.0380)	ND (.0368)	1.55 (.561)	.898 (.163)	.768 (.143)	ND (.170)	ND (1.32)	ND (.0380)			pCi/g	
030294-03	Pile 8	Soil	7/26/96										78.9		pCi/g	
030599-01	Pile 9	Soil	7/26/96	ND (.173)	ND (.0391)	ND (.0346)	1.41 (.474)	.732 (.140)	.682 (.138)	ND (.178)	ND (1.34)	ND (.0399)			pCi/g	
030599-03	Pile 9	Soil	7/26/96										32.5		pCi/g	
030602-01	Pile 10	Soil	7/31/96	ND (.462)	ND (.0436)	.0121 (.0152)	1.62 (.499)	.716 (.117)	.727 (.120)	ND (.209)	ND (2.91)	ND (.0294)			pCi/g	
030602-03	Pile 10	Soil	7/31/96										44.4		pCi/g	

Section 6.3, Table 2 (Continued)  
 Summary of Radionuclides in Clean Soil Stockpile Samples Collected at RWL/CDPs  
 (On-site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	Gamma Spectroscopy Activity <sup>a</sup>												Units
				Am-241	Cs-134	Cs-137	Ra-226	Ra-228	Th-232	U-235	U-238	Co-60	Trillium			
030603-01	Pile 11	Soil	7/31/96	ND (.483)	ND (.0458)	ND (.0326)	1.22 (.433)	.819 (.132)	.697 (.115)	ND (.214)	ND (2.97)	ND (.0317)		pCi/g		
030603-03	Pile 11	Soil	7/31/96										45.2	pCi/g		
030604-01	Pile 12	Soil	7/31/96	ND (.450)	ND (.0418)	.0199 (.0144)	1.37 (.458)	.678 (.110)	.660 (.109)	ND (.195)	ND (2.78)	ND (.0304)		pCi/g		
030604-03	Pile 12	Soil	7/31/96										52.6	pCi/g		
030607-01	Pile 13	Soil	8/5/96	ND (.182)	ND (.0407)	.0402 (.02790)	1.35 (.530)	.880 (.158)	.772 (.143)	ND (.189)	ND (1.39)	ND (.0386)		pCi/g		
030607-03	Pile 13	Soil	8/5/96										55	pCi/g		
030608-01	Pile 14	Soil	8/5/96	ND (.172)	ND (.0411)	ND (.0363)	1.47 (.531)	.679 (.158)	.767 (.130)	ND (.183)	ND (1.33)	ND (.0398)		pCi/g		
030608-03	Pile 14	Soil	8/5/96										41.3	pCi/g		
030609-01	Pile 15	Soil	8/5/96	ND (.162)	ND (.0371)	ND (.0330)	1.22 (.487)	.674 (.132)	.616 (.139)	ND (.165)	ND (1.24)	ND (.0356)		pCi/g		
030609-03	Pile 15	Soil	8/5/96										28.5	pCi/g		
032607-001	Pile 16	Soil	1/29/97	ND (.101)	ND (.0191)	ND (.0215)	1.45 (.421)	.666 (.245)	.656 (.113)	ND (.116)	ND (.940)	ND (.0250)		pCi/g		
032608-001	Pile 16	Soil	1/29/97										<0	pCi/g		
Equipment Blank 029499 01				ND (.0538)	ND (.0151)	ND (.0154)	ND (.261)	ND (.0896)	ND (.0811)	ND (.0733)	ND (.503)	ND (.0172)		pCi/mL		
Equipment Blank 029499 03													2.01	pCi/g		
TA-II Background Range <sup>c</sup>	NA	NA	NA											pCi/g		
TA-II Soil Background UTL or 95th Percentile	NA	NA	NA											NA		

Section 6.3, Table 2 (Concluded)  
 Summary of Radionuclides in Clean Soil Stockpile Samples Collected at RWL/CDPs  
 (On-site Laboratory)

<sup>a</sup>half-lives < 6 months are not included in this table.  
<sup>b</sup>Value in parenthesis represents the minimum detection activity.  
<sup>c</sup>Background ranges are site specific.  
 Am = americium  
 Co = cobalt  
 Cs = cesium  
 D = duplicate  
 ER = environmental restoration

ID = identification  
 MDA = minimum detection activity  
 pCi/g = picocuries per gram  
 pCi/L = picocuries per liter  
 NA = not applicable  
 ND = nondetect - the analyte was not observed above the MDA  
 Ra = radium  
 Th = thorium  
 D = duplicate  
 U = uranium

Section 6.3 Table 3  
 Summary of RCRA Metals in Clean Soil Stockpile Samples Collected at RWL/CDPs  
 (On-site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	RCRA Metals plus Ba, Methods 6010 and 7470													Units									
				Ag	As	Ba	Ba	Cd	Cr	Hg	Pb	Sb	Se	U												
029498-11	Pile 1	Soil	5/17/96	U	U	170	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg		
029500-07	Pile 1 D	Soil	5/17/96	U	U	170	U	U	U	5.3	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
029501-04	Pile 2	Soil	5/22/96	U	U	130	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
030288-04	Pile 3	Soil	7/10/96	7.4	U	200	2	U	U	14	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
030289-04	Pile 4	Soil	7/10/96	6.9	U	170	U	U	U	5.4 J	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
030290-04	Pile 5	Soil	7/10/96	5.8	U	200	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
030292-04	Pile 6	Soil	7/26/96	U	U	180	0.72	U	U	6.1 J	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
030293-04	Pile 7	Soil	7/26/96	U	U	150	0.69	U	U	9.5 J	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
030294-04	Pile 8	Soil	7/26/96	U	U	160	0.72	U	U	8.8 J	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
030599-04	Pile 9	Soil	7/26/96	U	U	140	0.64	U	U	5 J	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
030602-04	Pile 10	Soil	7/31/96	U	U	89	0.96	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
030603-04	Pile 11	Soil	7/31/96	U	U	99	1.1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
030604-04	Pile 12	Soil	7/31/96	U	U	100	0.98	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
030607-04	Pile 13	Soil	8/5/96	4 J	U	200	U	U	U	7 J	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
060608-04	Pile 14	Soil	8/5/96	8.5	U	230	U	U	U	8.9 J	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
030609-04	Pile 15	Soil	8/5/96	U	U	210	U	U	U	9.4 J	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
032912-001	Pile 16	Soil	1/29/97	ND (.041)	1.7 (.61)	80 (.51)	.21 (.028)	.14 (.041)	5.8 (.71)	ND (.041)	4.0 (.3)	.47 (.3)													mg/kg	
Equipment Blank																										
029499-07	Pile 1	Water	5/17/96	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/L	
Matrix Spike																										
029498-12	Pile 1	Soil	5/17/96	U	U	180	U	U	U	7.2	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/kg	
Matrix Spike Duplicate																										
029498-13	Pile 1	Soil	5/17/96	U	U	180	U	U	U	8.6	U	U	U	U	U	U	U	U	U	U	U	U	U	U	mg/L	

Section 6.3 Table 3 (Continued)  
 Summary of RCRA Metals in Clean Soil Stockpile Samples Collected at RWL/CDPs  
 (On-site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	RCRA Metals plus Be, Methods 6010 and 7470											Units
				Ag	As	Ba	Be	Cd	Cr	Hg	Pb	Se			
Method Detection Limit	Pile 1, 2	Soil	5/17/96	1.7	26	10	0.11	2.1	5	0.06	3.4	50	mg/kg		
Method Detection Limit	Pile 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	Soil	7/10/96	0.66	4.8	2.2	0.11	1	1.8	0.06	2.4	10	mg/kg		
Method Detection Limit	Pile 1	Water	5/17/96	0.017	0.26	0.1	0.001	0.021	0.05	0.06	0.034	0.5	mg/L		
SNL/NM Background Range <sup>a</sup>	NA	NA	NA	0.00159-8.7	0.033-17.0	0.587-1,300	0.01-1.8	0.00265-6.2	0.0056-58.4	0.0001-0.68	0.0159-11.2	0.037-17.2	mg/kg		
SNL/NM Background UTL or 95th Percentile <sup>a</sup>	NA	NA	NA	<1	4.4	336	0.8	0.9	12.8	<0.1	11.2	<1	mg/kg		
Proposed Subpart S Action Level for Soil <sup>b</sup>	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		

Section 6.3 Table 3 (Concluded)  
Summary of RCRA Metals in Clean Soil Stockpile Samples Collected at RWL/CDPs  
(On-site Laboratory)

<sup>a</sup>Background range from SNL/NM sitewide background data (SNL/NM 1996).

<sup>b</sup>Subpart S Action Level value only applies to sites within a residential land-use scenario and if only one contaminant has been identified at the site.

Ag = silver

As = arsenic

Ba = barium

Be = beryllium

Cd = cadmium

Cr = chromium

D = duplicate

ER = environmental restoration

Hg = mercury

ID = identification

J = detected below PQL or above highest calibration limit

MDL = method detection limit

mg/kg = milligrams per kilogram

mg/L = milligrams per liter

NA = not applicable/analyzed

U = undetected - the analyte was not observed above the MDL

Pb = lead

RCRA = Resource Conservation and Recovery Act

Se = selenium

Section 6.3, Table 4  
 Summary of RCRA Metals in Clean Soil Stockpile Samples Collected at RWL/CDPs  
 (Off-site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	RCRA Metals plus Be, Methods 6010 and 7470														Units
				Ag	As	Ba	Be	Cd	Cr	Hg	Pb	Se						
029498-08	Pile 1	Soil	5/17/96	ND	2.65	109 B	0.378 JB	ND	7.92 B	0.0180 JB	9.18	0.301 J	mg/kg					
030602-07	Pile 10	Soil	7/31/96	ND U	2.33	159	0.262 J	0.146 J	3.95	ND U	5.31	ND U	mg/kg					
030603-07	Pile 11	Soil	7/31/96	ND U	2.46	126	0.257 J	0.0883 J	4.53	0.00334 J	6.2	0.214 J	mg/kg					
030604-07	Pile 12	Soil	7/31/96	ND U	2.16	164	0.228 J	0.0813 J	3.52	0.00801 J	5.29	ND U	mg/kg					
Equipment Blank 029499-06	Pile 1	Water	5/17/96	ND	ND	0.000191 JB	0.0000449 JB	ND	ND	ND	ND	ND	mg/L					
Method Detection Limit	Pile 1	Soil	5/17/96	0.247	0.184	0.00856	0.00113	0.0096	0.059	0.00244	0.112	0.142	mg/kg					
Method Detection Limit	Pile 10, 11, 12	Soil	7/31/96	0.124	0.093	0.003	0.0005	0.005	0.596	0.02	0.565	0.072	mg/kg					
Method Detection Limit	Pile 1	Water	5/17/96	0.00249	0.00186	0.0000663	0.0000114	0.000097	0.000596	0.0000148	0.00113	0.00143	mg/L					
SNL/NM Background Range	NA	NA	NA	0.00159-8.7	0.033-17.0	0.567-1,300	0.01-1.8	0.00265-6.2	0.0056-58.4	0.0001-0.68	0.0159-112	0.037-17.2	mg/kg					
SNL/NM Background UTL or 95th Percentile	NA	NA	NA	<1	4.4	336	0.8	0.9	12.8	<0.1	11.2	<1	mg/kg					
Proposed Subpart S Action Level for Soil*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA					

Section 6.3, Table 4 (Concluded)  
Summary of RCRA Metals in Clean Soil Stockpile Samples Collected at RWL/CDPs  
(Off-site Laboratory)

<sup>a</sup>Background range from SNL/NM sitewide background data (SNL/NM 1996).

<sup>b</sup>Subpart S Action Level value only applies to sites within a residential land-use scenario and if only one contaminant has been identified at the site.

Ag = silver

As = arsenic

B = detected in the blank

Ba = barium

Be = beryllium

Cd = cadmium

Cr = chromium

D = duplicate

ER = environmental restoration

Hg = mercury

ID = identification

J = detected below the MDL

MDL = method detection limit

mg/kg = milligrams per kilogram

mg/L = milligrams per liter

NA = not applicable

ND = nondetect

U = undetected - the analyte was not observed above the MDL

Pb = lead

RCRA = Resource Conservation and Recovery Act

Se = selenium

**Section 6.4**  
**Analytical Results for Stockpiled Suspect Contaminated Soil**

Section 6.4, Table 1  
 Summary of Radionuclides in Potentially Contaminated Soil Stockpile Collected at RWL/CDPs  
 (Off-Site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	Gamma Spectroscopy Activity <sup>a</sup>											Tritium	Units
				Am-241	Cs-134	Cs-137	Co-60	Ra-226	Ra-228	Th-232	U-235	U-238				
030594-02	Pile 2	Soil	7/15/96	0.145 (0.261)	<0 U (0.0308)	0.126 (0.0372)	<0 U (0.0344)	0.779 (0.0630)	0.769 (0.126)	0.807 (0.0575)	2.63 (0.362)	117 (1.90)	15.24	pCi/g		
030594-12	Pile 2	Soil	7/15/96											pCi/g		
030595-02	Pile 3	Soil	7/15/96										13.14	pCi/g		
030595-12	Pile 3	Soil	7/15/96	0.0478 (0.142)	<0 U (0.0240)	0.0331 (0.0293)	0.00345 U (0.0375)	0.707 (0.0527)	0.842 (0.121)	0.805 (0.0463)	0.0215 U (0.194)	6.85 (1.13)		pCi/g		
030295-02	Pile 4	Soil	7/17/96										31.02	pCi/g		
030295-12	Pile 4	Soil	7/17/96	0.315 (0.154)	0.000133 U (0.0291)	0.119 (0.0323)	<0 U (0.0329)	0.698 (0.0597)	0.747 (0.136)	0.935 (0.0487)	0.147 (0.235)	18.8 (1.30)		pCi/g		
030296-02	Pile 5	Soil	7/17/96										6.21	pCi/g		
030296-12	Pile 5	Soil	7/17/96	0.0214 U (0.124)	0.00630 U (0.0248)	0.0238 (0.0300)	<0 U (0.0298)	0.663 (0.0487)	0.742 (0.101)	0.767 (0.0402)	0.117 (0.157)	5.90 (0.931)		pCi/g		
030297-02	Pile 5	Soil	7/19/96										6.72	pCi/g		
030297-12	Pile 5	Soil	7/19/96	0.0190 U (0.157)	<0 U (0.0265)	0.0248 (0.0348)	0.0203 (0.0393)	0.725 (0.0574)	0.723 (0.117)	0.661 (0.0472)	0.139 (0.209)	9.65 (1.08)		pCi/g		
030298-02	Pile 7	Soil	7/19/96										51.08	pCi/g		
030298-12	Pile 7	Soil	7/19/96	0.306 (0.332)	<0 U (0.0362)	0.0205 (0.0452)	0.00217 U (0.0378)	0.717 (0.0798)	0.634 (0.136)	0.715 (0.0676)	2.21 (0.425)	106 (2.49)		pCi/g		
030596-02	Pile 8	Soil	7/25/96										60.32	pCi/g		
030596-10	Pile 8	Soil	7/25/96	0.0678 (0.123)	0.00469 U (0.0271)	0.0597 (0.0290)	0.000743 U (0.0368)	0.689 (0.0552)	0.867 (0.111)	0.841 (0.0411)	0.103 (0.170)	1.34 (0.967)		pCi/g		
030596-10	Pile 8 D	Soil	7/25/96	0.181 (0.0977)	0.00764 U (0.0257)	0.0538 (0.0311)	0.000539 U (0.0361)	0.785 (0.0522)	0.970 (0.104)	0.960 (0.0403)	0.101 (0.154)	1.44 (0.792)		pCi/g		
030600-02	Pile 9	Soil	7/29/96										254.2	pCi/g		
030600-09	Pile 9	Soil	7/29/96	19.7 (0.163)	<0 U (0.0239)	0.0193 (0.0297)	<0 U (0.0333)	0.543 (0.0494)	0.784 (0.0988)	0.782 (0.0391)	0.0455 U (0.159)	1.59 (0.866)		pCi/g		
030601-02	Pile 10 - 14	Soil	7/30/96										30.97	pCi/g		
030601-10	Pile 10 - 14	Soil	7/30/96	1.61 (0.137)	<0 U (0.0245)	0.307 (0.0324)	0.00445 U (0.0345)	0.841 (0.0534)	0.953 (0.118)	0.970 (0.0420)	0.0748 (0.195)	2.82 (1.04)		pCi/g		
030605-02	Pile 15	Soil	8/2/96										91.23	pCi/g		
030605-10	Pile 15	Soil	8/2/96	0.636 (0.181)	<0 U (0.0384)	15.6 (0.0439)	0.000472 U (0.0384)	0.515 (0.0606)	2.97 (0.115)	2.99 (0.0770)	0.108 (0.261)	2.53 (1.45)		pCi/g		
030606-02	Pile 16	Soil	8/2/96										461.84	pCi/g		
030606-10	Pile 16	Soil	8/2/96	3.14 (0.111)	0.00568 U (0.0250)	0.0790 (0.0270)	0.00238 U (0.0360)	0.605 (0.0516)	0.827 (0.0983)	0.840 (0.0408)	0.185 (0.161)	2.40 (0.794)		pCi/g		

Section 6.4, Table 1 (Concluded)  
 Summary of Radionuclides in Potentially Contaminated Soil Stockpile Collected at RWL/CDPs  
 (Off-Site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	Gamma Spectroscopy Activity*											Tritium	Units		
				Am-241	Cs-134	Cs-137	Co-60	Ra-226	Ra-228	Th-232	U-235	U-238						
030610-02	Pile 17 - 22	Soil	8/6/96														554.35	pCi/g
030610-08	Pile 17 - 22	Soil	8/6/96	40.9 (0.227)	0.00551 U (0.0258)	0.0268 (0.0305)	<0 U (0.0313)	0.616 (0.0551)	0.748 (0.110)	0.760 (0.0413)	0.130 (0.160)	2.31 (1.04)						pCi/g
030612-02	Pile 23	Soil	8/7/96														3.56	pCi/g
030612-08	Pile 23	Soil	8/7/96	0.308 (0.106)	<0 U (0.0264)	0.0791 (0.0912)	0.00660 U (0.0375)	0.609 (0.0524)	0.902 (0.106)	0.782 (0.0421)	0.0639 (0.161)	1.17 (0.898)						pCi/g
030613-02	Pile 24	Soil	8/7/96														29.75	pCi/g
030613-08	Pile 24	Soil	8/7/96	0.757 (0.183)	0.000438 U (0.0389)	13.5 (0.0418)	0.00221 U (0.0368)	0.619 (0.0645)	1.78 (0.112)	1.69 (0.0741)	0.0126 U (0.264)	0.849 (1.40)						pCi/g
030619-02	Pile 25	Soil	8/13/96														125.96	pCi/g
030619-08	Pile 25	Soil	8/13/96	0.427 (0.408)	<0 U (0.568)	18.1 (0.0958)	0.00156 U (0.0763)	0.966 (0.162)	29.8 (0.233)	30.6 (0.146)	<0 U (0.545)	2.98 (3.32)						pCi/g
Equipment Blank 030600-10	Pile 9	Water	7/29/96														10.8	pCi/L
TA-II Background Range	NA	NA	NA															pCi/g
TA-II Soil Background (JTL or 95th Percentile)	NA	NA	NA															NA

\*Value in parenthesis represents the minimum detection activity (MDA).

<sup>b</sup>Background ranges are site-specific.

Am = americium

B = detected in blank

Co = cobalt

Cs = cesium

D = duplicate

ER = environmental restoration

ID = identification

pCi/g = picocuries per gram

NA = not applicable

Ra = radium

Sr = strontium

Th = thorium

U = detected below the MDA

U-235/238 = uranium

Section 6.4, Table 2  
 Summary of Radionuclides in Potentially Contaminated Soil Stockpiles  
 (Off-Site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	Alpha Spectroscopy Activity													H-3	Sr-89	Sr-90	Units*
				Am-241	Pu-238	Pu-239/240	Th-228	Th-230	Th-232	U-233/234	U-235	U-238								
032590-001	Pile 1	Soil	3/3/97	5.78 (.012)	.626 (.0047)	31.1 (.0095)	.995 (.029)	.774 (.011)	.830 (.0083)	.77 (.037)	.073 (.024)	.85 (.022)	0.146	-0.25 (1.5)	0.30 (1.4)	pCi/g				
030594-04	Pile 2	Soil	7/15/96	0.163 (0.033)	0.0724 (0.0215)	1.45 (0.00897)	1.27 B (0.643)	1.69 B (0.200)	1.03 B (0.200)	97.8 (0.278)	9.19 (0.276)	326 (0.320)				pCi/g				
032591-001	Pile 2	Soil	2/3/97											0.9 (1.8)	-0.45 (1.7)	pCi/g				
030595-04	Pile 3	Soil	7/15/96	1.08 (0.0845)	0.808 (0.279)	6.08 (0.289)	0.894 B (0.562)	1.33 B (0.219)	1.16 B (0.117)	15.5 (0.229)	1.32 (0.144)	52.7 (0.116)				pCi/g				
032592-001	Pile 3	Soil	2/3/97											0.38 (1.6)	-0.16 (1.5)	pCi/g				
030295-04	Pile 4	Soil	7/17/96	0.141 (0.0301)	0.0616 (0.0239)	2.16 (0.00836)	0.875 B (0.305)	1.46 B (0.0442)	0.944 B (0.111)	197 (0.812)	17.3 (0.861)	666 (0.861)				pCi/g				
032593-001	Pile 4	Soil	2/3/97										-1.3 (2.3)	1.01 (1.4)	pCi/g					
030296-04	Pile 5	Soil	7/17/96	0.132 (0.0240)	0.0239 (0.0248)	0.461 (0.00307)	1.25 B (0.229)	1.83 B (0.116)	1.03 B (0.116)	3.65 (0.289)	0.235 (0.210)	9.03 (0.289)				pCi/g				
032594-001	Pile 5	Soil	2/4/97											-0.56 (1.4)	0.60 (1.3)	pCi/g				
030297-04	Pile 6	Soil	7/19/96	0.112 (0.0537)	0.0342 (0.0301)	0.577 B (0.0175)	0.955 B (0.101)	0.900 B (0.0127)	0.943 (0.0321)	2.67 B (0.0467)	0.227 (0.0420)	8.45 B (0.0297)				pCi/g				
032595-001	Pile 6	Soil	2/6/97											-0.25 (1.5)	0.46 (1.5)	pCi/g				
030298-04	Pile 7	Soil	7/19/96	0.0214 (0.00800)	0.0165 (0.0157)	0.123 B (0.00269)	0.710 B (0.0661)	0.683 B (0.0348)	0.631 (0.0247)	16.8 B (0.199)	1.52 (0.0492)	76.5 B (0.124)				pCi/g				
032596-001	Pile 7	Soil	2/17/96											-0.3 (2.1)	0.56 (1.5)	pCi/g				
030296-04	Pile 8	Soil	7/25/96	0.327 (0.0443)	0.0203 (0.0196)	1.01 (0.0104)	1.26 (0.200)	1.50 (0.0484)	0.983 (0.0484)	0.419 (0.170)	0.0348 (0.171)	0.984 (0.171)				pCi/g				
032597-001	Pile 8	Soil	2/17/97											0.6 (2.0)	0.53 (1.5)	pCi/g				
030600-04	Pile 9	Soil	7/29/96	18.4 (0.0413)	2.12 (0.273)	107 (0.178)	1.48 (0.171)	1.20 (0.0910)	0.762 (0.0910)	1.04 (0.0151)	0.0962 (0.0189)	1.92 (0.0188)				pCi/g				
032598-001	Pile 9	Soil	2/17/97											-1.0 (1.9)	0.86 (1.3)	pCi/g				
032578-001	Pile 10	Soil	2/17/97		-0.0009 (.015)	0.064 (.0070)	1.01 (.033)	0.776 (.019)	.954 (.013)	1.11 (.037)	.066 (.017)	1.65 (.027)			-1.4 (2.0)	1.24 (1.4)	pCi/g			
032578-002	Pile 10	Soil	2/17/97										6.5048			pCi/g				
030601-04	Pile 10 - 14	Soil	7/30/96	0.532 (0.0544)	0.0514 (0.0275)	1.85 (.00623)	1.07 (0.186)	1.42 (.0328)	0.744 (0.0826)	1.56 (0.0157)	0.125 (0.0158)	3.75 (0.0157)				pCi/g				



Section 6.4, Table 2 (Concluded)  
 Summary of Radionuclides in Potentially Contaminated Soil Stockpiles  
 (Off-Site Laboratory)

Sample Number	Sample ID	Sample Matrix	Sample Date	Alpha Spectroscopy Activity														Units*
				Am-241	Pu-238	Pu-239/240	Th-228	Th-230	Th-232	U-233/234	U-235	U-238	H-3	Sr-89	Sr-90			
032587-001	Pile 21	Soil	2/11/97		.060 (0.014)	3.32 (0.011)	.833 (0.040)	.803 (0.017)	.870 (0.017)	2.08 (0.033)	.062 (0.020)	1.90 (0.030)		-0.7 (2.0)	0.69 (1.3)	pCi/g		
032587-002	Pile 21	Soil	2/11/97										187.11			pCi/g		
032588-001	Pile 22	Soil	2/10/97		.500 (0.012)	25.5 (0.0064)	.786 (0.015)	.967 (0.095)	.791 (0.011)	65.9 (0.044)	3.05 (0.033)	70.4 (0.052)		-0.1 (2.0)	.36 (1.3)	pCi/g		
032588-002	Pile 22	Soil	2/10/97										1616.46			pCi/g		
030612-04	Pile 23	Soil	8/7/96	0.704 (0.0460)	0.0403 U (0.129)	0.486 (0.0734)	1.23 (0.434)	1.06 (0.576)	0.768 (0.0576)	0.986 (0.250)	<0 U (0.293)	0.787 (0.250)				pCi/g		
032601-001	Pile 23	Soil	2/11/97											-1.1 (2.1)	0.30 (1.4)	pCi/g		
030613-04	Pile 24	Soil	8/7/96	1.48 (0.0599)	0.145 (0.160)	8.33 (0.100)	2.05 (0.489)	1.37 (0.687)	1.74 (0.0687)	7.05 (0.401)	0.247 (0.388)	1.13 (0.252)				pCi/g		
032602-001	Pile 24	Soil	2/7/97											-0.42 (1.4)	0.52 (1.2)	pCi/g		
030619-04	Pile 25	Soil	8/13/96	0.00262 U (0.0465)	0.000904 U (0.0891)	0.0692 (0.0462)	6.78 (0.371)	2.21 (0.170)	6.18 (0.208)	0.887 (0.0204)	.0422 (0.250)	0.796 (0.0204)				pCi/g		
032603-001	Pile 25	Soil	3/3/97		0.056 (0.0071)	2.45 (0.011)	1.41 (0.035)	0.911 (0.016)	1.34 (0.011)	1.88 (0.029)	0.10 (0.024)	1.28 (0.024)		-0.12 (1.5)	0.25 (1.5)	pCi/g		
032589-001	Pile 26	Soil	2/10/97											-0.1 (2.1)	.27 (1.4)	pCi/g		
032589-002	Pile 26	Soil	2/10/97										41.405			pCi/g		
Equipment Blank 030600-12	Pile 9	Water	7/29/96	0.00730 U (0.0698)	0.00792 U (0.0845)	0.0663 (0.0451)	0.987 U (0.282)	0.754 (0.0371)	0.0124 U (0.0371)	0.126 (0.0549)	<0 U (0.0452)	0.0276 (0.0312)				pCi/L		

\*Value in parenthesis represents the minimum detection activity (MDA).

<sup>b</sup>Background ranges are site specific.

\*Percent moisture is not available.

Am = americium

B = detected in blank

Co = cobalt

Cs = cesium

D = duplicate

ER = environmental restoration

ID = identification

pCi/g = picocuries per gram

NA = not applicable

Ra = radium

Sr = strontium

Th = thorium

U = detected below the MDA

U-235/238 = uranium

Section 6.4, Table 3  
 Summary of Radionuclides in Potentially Contaminated Soil Stockpiles at RWL/CDPs  
 (On-Site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	Gamma Spectroscopy Activity*											Units
				Am-241	Cs-134	Cs-137	Co-60	Ra-228	Th-232	U-235	U-238				
030286-01	Pile 1	Soil	7/8/96	1.01 (.153)	ND (.0183)	.0384 (.0186)	ND (.0236)	.772 (.121)	.586 (.106)	ND (.112)	ND (.889)	pCi/g			
030594-01	Pile 2	Soil	7/15/96	ND (.178)	ND (.0462)	.0652 (.0225)	ND (.0373)	.713 (.154)	.745 (.135)	ND (.112)	ND (1.09)	pCi/g			
029503-01	Pile 3	Soil	5/24/96	121 (.545)	ND (.0600)	.0317 (.0246)	ND (.0432)	.760 (.168)	.902 (.166)	ND (.189)	ND (1.79)	pCi/g			
030595-01	Pile 3	Soil	7/15/96	.219 (.175)	ND (.0434)	.0727 (.0249)	ND (.0368)	.830 (.153)	.683 (.139)	.404 (.149)	14.5 (1.47)	pCi/g			
030295-01	Pile 4	Soil	7/17/96	ND (.235)	ND (.0455)	0.117 (.0250)	ND (.0413)	.779 (.0963)	.821 (.156)	.388 (.149)	13.3 (1.59)	pCi/g			
030296-01	Pile 5	Soil	7/17/96	.206 (.152)	ND (.0461)	.0249 (.0215)	ND (.0370)	.770 (.172)	.754 (.137)	.0929 (.192)	4.08 (1.17)	pCi/g			
030297-01	Pile 6	Soil	7/19/96	ND (.184)	ND (.0434)	ND (.0208)	ND (.0378)	ND (.167)	.612 (.134)	.0718 (.116)	4.50 (1.53)	pCi/g			
030298-01	Pile 7	Soil	7/19/96	ND (.174)	ND (.0460)	ND (.0359)	ND (.0397)	.540 (.156)	.522 (.139)	ND (.187)	3.39 (1.78)	pCi/g			
0300596-01	Pile 8	Soil	7/25/96	.311 (.1588)	ND (.0426)	.189 (.0264)	ND (.0429)	.758 (.178)	.690 (.159)	ND (.187)	ND (1.35)	pCi/g			
030598-01	Pile 8 D	Soil	7/25/96	ND (.125)	ND (.0403)	.0760 (.0249)	ND (.0390)	.649 (.188)	.723 (.140)	ND (.184)	ND (1.35)	pCi/g			
030600-01	Pile 9	Soil	7/29/96	1.71 (.137)	ND (.0376)	ND (.0354)	ND (.0355)	.828 (.140)	.674 (.133)	ND (.0970)	ND (1.27)	pCi/g			
030601-01	Pile 12	Soil	7/30/96	ND (.439)	ND (.0393)	.0580 (.173)	ND (.0270)	.634 (.104)	.617 (.114)	ND (.188)	ND (2.75)	pCi/g			
030601-01	Pile 10 - 14	Soil	7/30/96	ND (.439)	ND (.0393)	.0580 (.0173)	ND (.0270)	.634 (.104)	.617 (.114)	ND (.188)	ND (2.75)	pCi/g			
030605-01	Pile 15	Soil	8/2/96	ND (2.49)	ND (.133)	.197 (.0791)	ND (.0468)	3.87 (.169)	4.30 (.925)	ND (1.06)	ND (14.9)	pCi/g			
030606-01	Pile 16	Soil	8/2/96	12.9 (.528)	ND (.0484)	.0927 (.0220)	ND (.0375)	.779 (.134)	.627 (.141)	.127 (.140)	ND (3.48)	pCi/g			
030610-01	Pile 17 - 20	Soil	8/6/96	10.4 (.196)	ND (.0494)	.0545 (.0226)	ND (.0408)	.621 (.166)	.588 (.136)	.167 (.113)	ND (1.63)	pCi/g			

Section 6.4, Table 3 (Concluded)  
 Summary of Radionuclides in Potentially Contaminated Soil Stockpiles at RWL/CDPs  
 (On-Site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	Gamma Spectroscopy Activity <sup>a</sup>										Units
				Am-241	Cs-134	Cs-137	Co-60	Ra-228	Th-232	U-235	U-238			
032604-001	Pile 21	Soil	2/11/97	.995 (.162)	ND (.004)	.0398 (.0214)	ND (.0341)	.545 (.163)	.546 (.130)	ND (.175)	ND (.879)	pCi/g		
032605-001	Pile 22	Soil	2/10/97	1.85 (.390)	ND (.0511)	ND (.0354)	ND (.0470)	.561 (.216)	.650 (.196)	2.83 (.250)	51.6 (2.66)	pCi/g		
030612-01	Pile 23	Soil	8/9/96	.387 (.340)	ND (.420)	.695 (.0220)	ND (.0279)	.605 (.106)	.662 (.118)	ND (.202)	ND (2.88)	pCi/g		
030613-01	Pile 24	Soil	8/9/96	1.16 (.708)	ND (.0575)	14.8 (.0379)	.0255 (.0234)	3.59 (.142)	ND (.270)	.360 (.304)	ND (5.90)	pCi/g		
030619-001	Pile 25	Soil	8/13/96	ND (.390)	ND (.0586)	12.90 (.0686)	ND (.0548)	29.90 (.251)	28.10 (.403)	ND (.404)	ND (3.21)	pCi/g		
032606-001	Pile 26	Soil	2/10/97	.205 (.154)	ND (.0428)	.512 (.0265)	ND (.0405)	.815 (.170)	ND (.156)	ND (.196)	ND (1.37)	pCi/g		
Equipment Blank 030600-15	Pile 9	Water	7/29/96	ND (.0979)	ND (.0235)	ND (.0236)	ND (.0244)	ND (.152)	ND (.155)	ND (.116)	ND (.729)	pCi/mL		
TA-II Background Range	NA	NA	NA									pCi/g		
TA-II Soil Background UTL or 95th Percentile	NA	NA	NA									pCi/g		

<sup>a</sup>Value in parenthesis represents the minimum detection activity.

<sup>b</sup>Background ranges are site specific.

<sup>c</sup>Ra-226 values from on-site laboratory not provided due to inaccurate results. Analysis of Ra-226 short-lived daughters showed background concentrations in all samples.

Am = americium

Co = cobalt

Cs = cesium

D = duplicate

ER = environmental restoration

ID = identification

pCi/g = picocuries per gram

pCi/L = picocuries per liter

NA = not applicable

ND = nondetect - the analyte was not observed above the

minimum detection activity

Ra = radium

Th = thorium

U = uranium

Section 6.4, Table 4  
 Summary of RCRA Metals in Potentially Contaminated Soil Stockpiles at RWL/CDPs  
 (On-Site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	RCRA Metals, Methods 6010 and 7470													Units
				Ag	As	Ba	Cd	Cr	Hg	Pb	Se						
032552-001	Pile 1	Soil	3/3/97	.067 (.044)	3.6 (.66)	130 (.55)	.18 (.044)	7.1 (.77)	ND (.044)	6.8 (.33)	.90 (.33)						mg/kg
032553-001	Pile 2	Soil	2/3/97	ND (.043)	2.5 (.64)	190 (.54)	.45 (.043)	11 (.75)	ND (.043)	7.7 (.32)	1.0 (.32)						mg/kg
032554-001	Pile 3	Soil	2/3/97	ND (.043)	3.0 (.65)	120 (.54)	.5 (.043)	8.9 (.76)	ND (.043)	9.5 (.32)	.97 (.32)						mg/kg
032555-001	Pile 4	Soil	2/3/97	.068 (.041)	2.6 (.61)	130 (.51)	.35 (.041)	7.7 (.72)	ND (.041)	6.3 (.31)	.82 (.31)						mg/kg
032556-001	Pile 5	Soil	2/4/97	ND (.042)	2.4 (.63)	120 (.52)	.32 (.042)	7.1 (.74)	ND (.042)	6.2 (.32)	.69 (.32)						mg/kg
032557-001	Pile 6	Soil	2/6/97	ND (.042)	2.4 (.64)	170 (.53)	4.1 (.042)	8.5 (.74)	ND (.042)	5.4 (.32)	.97 (.32)						mg/kg
032558-001	Pile 7	Soil	2/17/97	ND (.041)	3.3 (.62)	180 (.52)	.53 (.041)	6.4 (.72)	ND (.041)	4.6 (.31)	.58 (.31)						mg/kg
032559-001	Pile 8	Soil	2/17/97	ND (.04)	1.3 (.6)	200 (.5)	.6 (.04)	11 (.7)	.14 (.04)	5.8 (.3)	.79 (.3)						mg/kg
032560-001	Pile 9	Soil	2/17/97	ND (.042)	2 (.63)	110 (.53)	.65 (.042)	7.3 (.74)	1.8 (.042)	6.6 (.32)	.48 (.32)						mg/kg
032561-001	Pile 10	Soil	2/17/97	ND (.046)	2.4 (.69)	120 (.57)	.2 (.046)	6.8 (.8)	.54 (.046)	4.9 (.34)	.58 (.34)						mg/kg
032562-001	Pile 11	Soil	2/7/97	ND (.042)	2.2 (.62)	140 (.52)	.25 (.042)	16 (.73)	.074 (.042)	8.4 (.31)	.66 (.31)						mg/kg
032563-001	Pile 12	Soil	1/31/97	ND (.04)	1.8 (.6)	150 (.5)	.32 (.04)	8.4 (.7)	.18 (.04)	6.5 (.3)	.85 (.3)						mg/kg
032564-001	Pile 13	Soil	1/31/97	ND (.041)	2.2 (.61)	240 (.51)	.44 (.041)	11 (.71)	.095 (.041)	6.7 (.3)	1.1 (.3)						mg/kg
032565-001	Pile 14	Soil	1/31/97	ND (.043)	2.0 (.65)	120 (.54)	.41 (.043)	12 (.76)	.19 (.043)	7.3 (.32)	1.3 (.32)						mg/kg
032566-001	Pile 15	Soil		ND (.043)	2.6 (.64)	140 (.53)	3.6 (.043)	9.8 (.75)	1.5 (.043)	9.4 (.32)	1.1 (.32)						mg/kg
032567-001	Pile 16	Soil	1/30/97	ND (.04)	2.1 (.6)	130 (.5)	.40 (.04)	8.4 (.7)	.12 (.04)	41 (.3)	.71 (.3)						mg/kg

Section 6.4, Table 4 (Continued)  
 Summary of RCRA Metals in Potentially Contaminated Soil Stockpiles at RWL/CDPs  
 (On-Site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	RCRA Metals, Methods 6010 and 7470											Units
				Ag	As	Ba	Cd	Cr	Hg	Pb	Se				
032568-001	Pile 17	Soil	2/11/97	ND (.04)	2.6 (.6)	300 (.5)	.35 (.04)	6.6 (.7)	.18 (.04)	5.5 (.3)	.62 (.3)	mg/kg			
032569-001	Pile 18	Soil	2/11/97	ND (.042)	2.1 (.63)	100 (.52)	.55 (.042)	8.0 (.73)	.13 (.042)	4.7 (.31)	.43 (.31)	mg/kg			
032570-001	Pile 19	Soil	2/11/97	ND (.042)	2.0 (.64)	110 (.53)	.41 (.042)	8.2 (.74)	.15 (.042)	4.8 (.32)	.59 (.32)	mg/kg			
032571-001	Pile 20	Soil	2/7/97	.28 (.042)	1.4 (.63)	100 (.53)	.29 (.042)	8.2 (.74)	1.3 (.042)	9.4 (.32)	.42 (.32)	mg/kg			
032572-001	Pile 21	Soil	2/11/97	ND (.046)	4.2 (.88)	200 (.57)	.20 (.046)	7.3 (.80)	.69 (.046)	7.2 (.34)	.70 (.34)	mg/kg			
032573-001	Pile 22	Soil	2/10/97	.048 (.043)	3.5 (.65)	200 (.54)	2.6 (.043)	9.3 (.76)	1.2 (.043)	20 (.32)	.73 (.32)	mg/kg			
032574-001	Pile 23	Soil	2/11/97	1.8 (.044)	1.9 (.065)	89 (.54)	3.6 (.044)	12 (.76)	3.0 (.044)	14 (.33)	.63 (.33)	mg/kg			
032575-001	Pile 24	Soil	2/7/97	ND (.04)	2.3 (.6)	98 (.5)	.98 (.04)	7.1 (.7)	.77 (.04)	7.0 (.3)	.52 (.3)	mg/kg			
032576-001	Pile 25	Soil	3/3/97	.49 (.041)	2.4 (.61)	110 (.51)	6.5 (.041)	12 (.71)	7.8 (.041)	24 (.30)	.59 (.30)	mg/kg			
032577-001	Pile 26	Soil	2/10/97	ND (.041)	2.0 (.62)	100 (.52)	.60 (.041)	5.2 (.72)	.50 (.041)	6.7 (.31)	.79 (.31)	mg/kg			
030600-17	Pile 9	Soil	7/29/96	6.4	U	140	U	U	U	U	U	mg/kg			
030612-10	Pile 23	Soil	8/9/96	U	U	140	U	10 J	U	5.7 J	U	mg/kg			
030613-10	Pile 24	Soil	8/9/96	U	U	110	34	8.8 J	U	79	U	mg/kg			
030295-13	Pile 24	Soil	8/13/96	U	U	190	5.8 J	9.6 J	U	15	U	mg/kg			
030619-10	Pile 25	Soil	8/13/96	U	U	210	190	9.3 J	U	150	U	mg/kg			
Equipment Blank															
030600-16	Pile 9	Water	7/29/96	U	U	U	U	U	U	U	U	mg/L			
Method Detection Limit	Pile 9, 23, 24, 25	Soil	7/29/96	0.66	4.8	2.2	1	1.8	0.06	2.4	10	mg/kg			

Section 6.4, Table 4 (Concluded)  
 Summary of RCRA Metals in Potentially Contaminated Soil Stockpiles at RWL/CDPs  
 (On-Site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	RCRA Metals, Methods 6010 and 7470											Units	
				Ag	As	Ba	Cd	Cr	Hg	Pb	Se					
Method Detection Limit	Pile 9	Water	7/29/96	0.005	0.012	0.022	0.009	0.001	0	0.019						mg/L
SNL/NM Background Range	NA	NA	NA	0.00159-8.7	0.033-17.0	0.587-1,300	0.00265-6.2	0.0056-58.4	0.0001-0.68	0.0159-112	0.037-17.2					mg/kg
SNL/NM Background UTL or 95th Percentile	NA	NA	NA	<1	4.4	336	0.9	12.8	<0.1	11.2	<1				mg/kg	
Proposed Subpart S Action Level for Soil <sup>b</sup>	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

<sup>a</sup>Background range from SNL/NM sitewide background data (SNL/NM 1996).

<sup>b</sup>Subpart S Action Level value only applies to sites within a residential land use scenario and if only one contaminant has been identified at the site.

Ag = silver

As = arsenic

Ba = barium

Be = beryllium

Cd = cadmium

Cr = chromium

D = duplicate

ER = environmental restoration

Hg = mercury

ID = identification

MDL = method detection limit

mg/kg = milligrams per kilogram

mg/L = milligrams per liter

NA = not applicable/analyzed

U = undetected - the analyte was not observed above the MDL

Pb = lead

RCRA = Resource Conservation and Recovery Act

Se = selenium

**Section 6.5**  
**Analytical Results for Excavation Verification**



Section 6.5, Table 2  
Summary of Radionuclides in Verification Pits  
(Off-Site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	Alpha Spectroscopy Activity											Units*
				Am-241	Pu-238	Pu-239/240	Th-228	Th-230	Th-232	U-233/234	U-235	U-238			
030617-04	Ver. Pit 1	Soil	8/1/96	0.00105 U (0.0492)	0.0237 (0.0563)	0.0213 (0.0273)	1.29 (0.440)	2.35 (0.227)	0.761 (0.251)	0.962 (0.0268)	0.0614 (0.0221)	0.726 (0.0363)	pCi/g		
030618-04	Ver. Pit 2	Soil	8/1/96	0.0299 U (0.0587)	0.00313 U (0.0995)	0.0591 (0.0489)	1.35 (0.527)	1.63 (0.0740)	0.866 (0.232)	0.718 (0.00883)	0.0546 (0.0186)	0.724 (0.00883)	pCi/g		
030616-04	Ver. Pit 3/4	Soil	8/1/96	0.152 U (0.152)	0.00858 U (0.0482)	0.871 (0.0104)	1.22 (0.681)	2.79 (0.258)	0.760 (0.317)	0.894 (0.198)	0.0681 (0.0681)	1.26 (0.143)	pCi/g		
NA	Ver. Pit 5	Soil	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	pCi/g		
030614-04	Ver. Pit 6	Soil	8/1/96	0.0326 U (0.0431)	0.014 U (0.0973)	0.101 (0.0715)	1.54 (0.434)	1.50 (0.169)	0.768 (0.169)	0.949 (0.0216)	0.0326 (0.0300)	0.935 (0.0216)	pCi/g		
030615-04	Ver. Pit 7	Soil	8/1/96	0.0324 U (0.0489)	<0 U (0.0418)	0.101 (0.0271)	1.35 (0.444)	1.89 (0.186)	1.35 (0.186)	1.07 (0.0251)	0.0599 (0.0120)	1.25 (0.0306)	pCi/g		
030284-03	Pit 6	Concrete	6/28/96	NA	0.161 (0.0213)	6.24 (0.00491)	NA	NA	NA	NA	NA	NA	pCi/g		
030285-03	Other Pits	Concrete	6/28/96	NA	0.0446 (0.0116)	0.922 (0.0116)	NA	NA	NA	NA	NA	NA	pCi/g		

\*Value in parenthesis represents the minimum detection activity (MDA).

<sup>b</sup>Background ranges are site-specific.

Am = americium

B = detected in blank

Co = cobalt

Cs = cesium

D = duplicate

ER = environmental restoration

ID = identification

pCi/g = picocuries per gram

NA = not applicable

Ra = radium

Th = thorium

U = detected below the MDA

U-235/238 = uranium

Section 6.5, Table 3  
 Summary of Radionuclides in Verification Pits  
 (On-Site Laboratory)

Sample Number	ER Sample ID	Sample Matrix	Sample Date	Gamma Spectroscopy Activity <sup>a</sup>											Units
				Am-241	Cs-134	Cs-137	Co-60	Ra-226	Ra-228	Th-232	U-235	U-238			
030617-001	Ver. Pit 1	Soil	8/16/96	ND (.154)	ND (.0355)	.128 (.0220)	ND (.0330)	2.27 (.476)	.680 (.157)	.640 (.127)	ND (.171)	ND (1.18)	pCi/g		
030618-001	Ver. Pit 2	Soil	8/16/96	ND (.161)	ND (.0373)	.0178 (.0218)	ND (.0360)	1.40 (.463)	.677 (.145)	.584 (.130)	ND (.167)	.907 (1.04)	pCi/g		
030616-001	Ver. Pit 3/4	Soil	8/16/96	ND (.147)	ND (.0332)	ND (.0309)	ND (.0350)	1.29 (.491)	.584 (.135)	.529 (.124)	ND (.155)	ND (1.09)	pCi/g		
030597-01	Ver. Pit 5	Soil	7/25/96	ND (.148)	ND (.0353)	ND (.0308)	ND (.0324)	1.15 (.414)	.510 (.136)	.560 (.123)	ND (.157)	ND (1.15)	pCi/g		
030614-001	Ver. Pit 6	Soil	8/16/96	ND (.178)	ND (.0402)	ND (.0363)	ND (.0383)	1.82 (.614)	.730 (.169)	ND (.146)	ND (.183)	.899 (.993)	pCi/g		
030615-001	Ver. Pit 7	Soil	8/16/96	ND (.150)	ND (.0323)	ND (.0293)	ND (.0317)	1.62 (.430)	.912 (.135)	.809 (.122)	ND (.159)	ND (1.14)	pCi/g		
030284-01	Pit 6	Concrete	6/28/96	.454 (.150)	ND (.0431)	.0332 (.0221)	ND (.0359)	1.25 (.426)	.709 (.128)	.728 (.130)	ND (.169)	.693 (1.06)	pCi/g		
030285-01	Other Pits	Concrete	6/28/96	.127 (.142)	ND (.0437)	.0538 (.0239)	ND (.0358)	1.46 (.510)	.820 (.144)	.790 (.139)	ND (.172)	ND (1.27)	pCi/g		

<sup>a</sup>Value in parenthesis represents the minimum detection activity (MDA).

<sup>b</sup>Background ranges are site-specific.

Am = americium

B = detected in blank

Co = cobalt

Cs = cesium

D = duplicate

ER = environmental restoration

ID = identification

pCi/g = picocuries per gram

NA = not applicable

Ra = radium

Sr = strontium

Th = thorium

U = detected below the MDA

U-235/238 = uranium

Section 6.5, Table 4  
 Summary of RCRA Metals in Verification Pits  
 (On-Site Laboratory)

Sample Number	Sample ID	Sample Matrix	Sample Date	RCRA Metals, Methods 6010 and 7470										Units	
				Ag	As	Ba	Cd	Cr	Hg	Pb	Se				
030597-08	Ver. Pit 5	Soil	7/24/96	5.9	U	260	U	U	U	U	U	U	U	U	mg/kg
030597-10	Ver. Pit 5 D	Soil	7/24/96	5.9	U	290	U	U	U	U	U	U	U	U	mg/kg
Matrix Spike															
Matrix Spike															
Duplicate															
030597-08	Ver. Pit 5	Soil	7/24/96	5.3	U	280	U	U	U	U	U	U	U	U	mg/kg
Method															
Detection Limit	Ver. Pit 5	Soil	7/29/96	0.66	4.8	2.2	1	1.8	0.06	2.4	10				mg/kg

\*Background range from SNL/NM site-wide background data (SNL/NM 1996).

- Ag = silver
- As = arsenic
- Ba = barium
- Be = beryllium
- Cd = cadmium
- Cr = chromium
- D = duplicate
- ER = environmental restoration
- Hg = mercury
- ID = identification
- MDL = method detection limit
- mg/kg = milligrams per kilogram
- mg/L = milligrams per liter
- NA = not applicable/analyzed
- U = undetected - the analyte was not observed above the MDL
- Pb = lead
- RCRA = Resource Conservation and Recovery Act
- Se = selenium

**Section 6.6**  
**Summary of VCM Sampling, Including QA/QC**

**Table 1  
Sampling at 26 Potentially Contaminated Soil Piles**

<b>Laboratory</b>	<b>Analysis</b>	<b>Sampling Performed</b>	<b>QA/QC</b>	<b>QA/QC Results</b>
Off-site CLP laboratory	Analysis for 9 radionuclides using gamma spectroscopy	16 samples		
	Analysis for tritium	15 samples	1 equipment blank	Tritium: 10.8 pCi/l
	Analysis for 9 radionuclides using alpha spectroscopy	27 samples	1 equipment blank	See data in Annex 6.4
	Analysis for tritium	12 samples		
	Analysis for Sr-89, Sr-90	26 samples	Method blank, matrix spike, matrix spike duplicate for every analysis	See data in Annex 6.4
On-site SNL/NM laboratory	Analysis for 9 radionuclides using gamma spectroscopy	22 samples	1 equipment blank	All nondetects
	Analysis for 8 RCRA metals using Method 6010	26 samples	1 equipment blank	All nondetects

**Table 2  
Sampling at 7 Verification Pits**

<b>Laboratory</b>	<b>Analysis</b>	<b>Sampling Performed</b>	<b>QA/QC</b>	<b>QA/QC Results</b>
Off-site CLP laboratory	Analysis for 9 radionuclides using gamma spectroscopy	6 samples		
	Analysis for tritium	6 samples		
	Analysis for 9 radionuclides using alpha spectroscopy	5 samples		
	Analysis for 7 RCRA metals using Method 6010	6 samples		
On-site SNL/NM laboratory	Analysis for 9 radionuclides using gamma spectroscopy	8 samples		
	Analysis for 7 RCRA metals using Method 6010	7 samples	Matrix spike, matrix spike duplicate	Ag 5.3 mg/kg Ba 280 mg/kg, others nondetects

**Table 3  
Sampling at 16 Clean Soil Piles**

<b>Laboratory</b>	<b>Analysis</b>	<b>Sampling Performed</b>	<b>QA/QC</b>	<b>QA/QC Results</b>
Off-site CLP laboratory	Analysis for 9 radionuclides using gamma spectroscopy	4 samples	2 equipment blanks	See Annex 6.3
	Analysis for tritium	5 samples		Ba and Be values < mdl, see Annex 6.3
	Analysis for 9 RCRA metals using Method 6010	4 samples	1 equipment blank	
On-site SNL/NM laboratory	Analysis for 9 radionuclides using gamma spectroscopy	16 samples	1 equipment blanks	All nondetects
	Analysis for tritium	16 samples	1 equipment blank	2.01 pCi/g
	Analysis for 9 RCRA metals using Method 6010	17 samples	1 equipment blank, 1 ms/msd	See Annex 6.3