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Statement of Basis Approval of No Further Action Volume 14 of 30 January 2000 ER Site 19 Operable Unit 1332 Round 9

Sandia National Laboratories/NM

Sandia National Laboratories

Statement of Basis
Approval of No Further Action
Volume 14 of 30

January 2000

ER Site 19
Operable Unit 1332
Round 9

(RCRA Permit No. NM5890110518)

NFA Originally Submitted September 24, 1997

Environmental Restoration Project

United States Department of Energy
Albuquerque Operations Office

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ACRONYMS AND ABBREVIATIONS

CFR	Code of Federal Regulations
COC	Contaminant of Concern
cps	counts per second
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
HERTF	High Energy Research Test Facility
HQ	Hazard Quotient
HSWA	Hazardous and Solid Waste Amendments
KAFB	Kirtland Air Force Base
mg/g	milligram(s) per gram
mrem	millirem
MS/MSD	matrix spike/matrix spike duplicate
NFA	no further action
pCi	picocuries
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
SNL/NM	Sandia National Laboratories/New Mexico
SWMU	solid waste management unit
TAL	Target Analyte List
USFS	U.S. Forest Service
UTL	upper tolerance limit
UXO	unexploded ordnance
VCM	Voluntary Corrective Measure

1.0 INTRODUCTION

1.1 Description of ER Site 19

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a no further action (NFA) decision based on voluntary corrective measure (VCM)/confirmatory sampling for Environmental Restoration (ER) Site 19, TRUPAK Boneyard Storage Area, Operable Unit 1332. ER Site 19 is listed in the Hazardous and Solid Waste Amendments (HSWA) Module IV (EPA 1993) of the SNL/NM Resource Conservation and Recovery Act (RCRA) Hazardous Waste Management Facility Permit (NM5890110518-1) (EPA 1992).

The early interviews had incorrectly identified the site as the TRUPAK Boneyard Storage Area and was listed in the permit as such. The actual spelling is TRUPACT; however, the permit lists the site using the TRUPAK spelling.

SNL/NM occupies 2,829 acres of land owned by the U.S. Department of Energy (DOE), with an additional 14,920 acres of land provided by land-use permits with Kirtland Air Force Base (KAFB), the U.S. Forest Service (USFS), the State of New Mexico, and the Isleta Indian Reservation. SNL/NM has been involved in nuclear weapons research, component development, assembly, testing, and other research and development activities since 1945 (DOE 1987).

ER Site 19 is located on KAFB, in the USFS Withdrawn Area, in a small canyon approximately 2,000 feet northwest of the Old Aerial Cable Site (ER Site 82) (Figure 1-1). The canyon is oriented northeast-southwest. The site is 2 acres in area bounded by a fence, and has a locked gate at the entrance (Figure 1-2). The site was used as a scrap yard; however, all debris previously stored at this site has been removed as discussed in Section 3.2. The site is posted for radiation. The principal vegetation consists of sage, cholla cactus and piñon trees. There are three small drainages at the site, one running through the site—one on the western boundary of the site, and one on the eastern boundary of the site. All three drainages flow from the northeast to the southwest.

There are no wells in the canyon so exact information on groundwater is not available. The nearest production well to the site is the High Energy Research Test Facility (HERTF) well, which is approximately 2,000 feet away in the next canyon to the southeast. The HERTF water-table elevation is approximately 5,800 feet above mean sea level at this location. The depth to groundwater in the HERTF well is approximately 400 feet. Local groundwater flow is believed to be in a generally westward direction in the vicinity of this site (SNL/NM 1996a).

For a detailed discussion regarding the local setting at ER Site 19, refer to the RCRA Facility Investigation Work Plan for OU 1332, Foothills Test Area (SNL/NM 1995a).

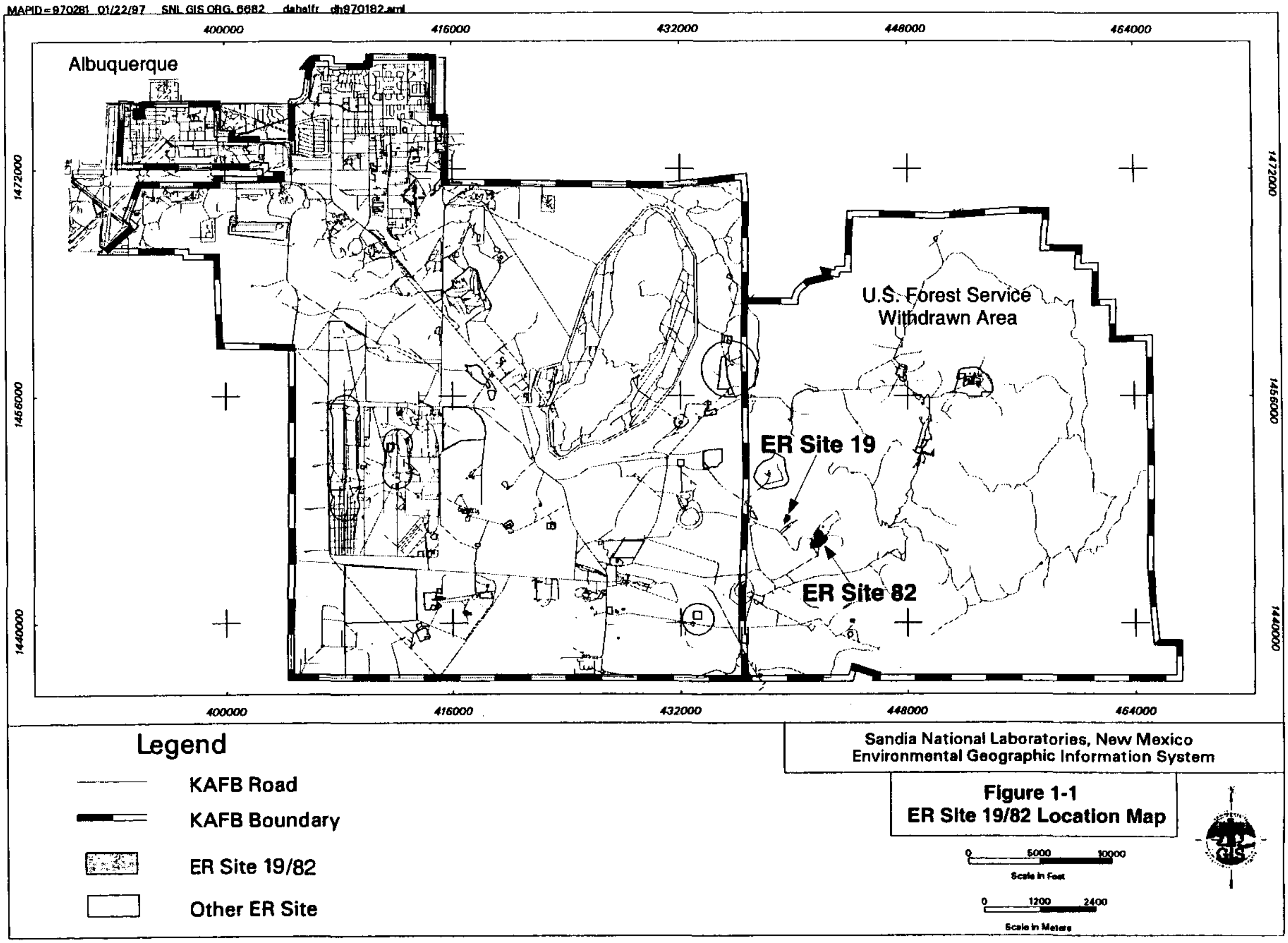
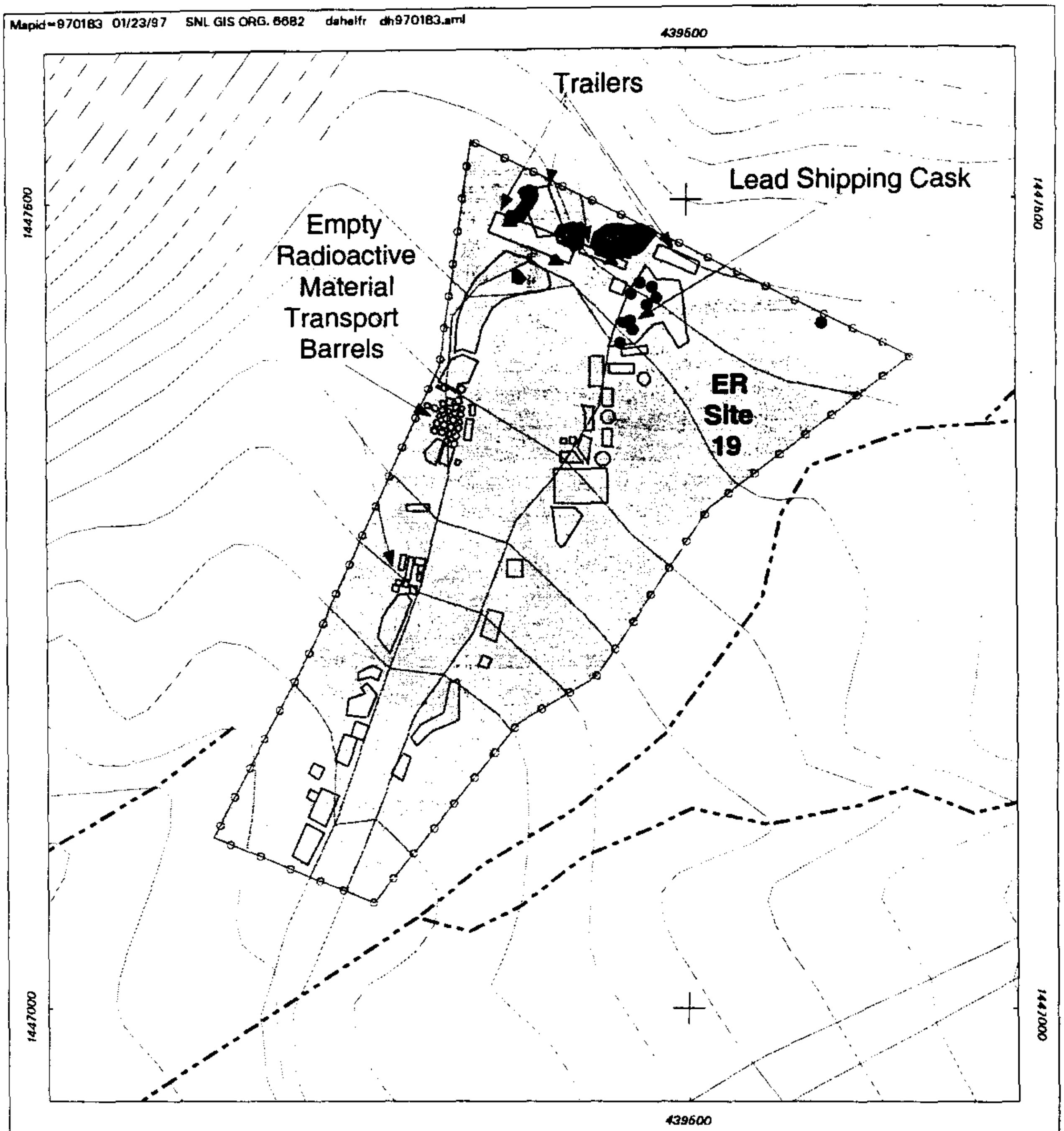


Figure 1-1
ER Site 19/82 Location Map



Legend

- ● Sample Location
- ▲ Post-cleanup Sample from Area Source Anomaly
- Road
- 5 Foot Contour
- Fence
- Drainage
- Debris
- Area Source Gamma Radiation Anomaly
- ER Site 19

Figure 1-2
ER Site 19

0 50 100 Scale In Feet

0 12 24 Scale In Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

1.2 No Further Action Basis

This proposal for a determination of a NFA decision based on VCM/confirmatory sampling was prepared using the process presented in Section 4.5.3 of the SNL/NM Program Implementation Plan (SNL/NM 1995b). It follows guidance documented in proposed Title 40, Code of Federal Regulations (40 CFR 264.514[a][2]) (EPA 1990) that states NFAs "must contain information demonstrating that there are no releases of hazardous waste (including hazardous constituents) from solid waste management units (SWMU) at the facility that may pose a threat to human health or the environment" (EPA 1990). The HSWA Module IV contains the same requirements for an NFA demonstration.

This request for an NFA decision for ER Site 19 is based primarily on VCMs to remove radioactive materials and analytical results of confirmatory soil samples collected at the site. Concentrations of site-specific constituents of concern (COC) detected in the soil samples were compared to background 95th percentile or upper tolerance limit (UTL) concentrations of COCs found in SNL/NM soils (IT Corporation 1997). A risk assessment was conducted since some COC concentrations exceeded the SNL/NM background limits.

A site is eligible for a NFA proposal if it meets the following criteria presented in the Environmental Restoration Document of Understanding (NMED 1996):

- NFA Criterion 5: The ER Site has been characterized or remediated in accordance with current applicable state or federal regulations, and the available data indicate that contaminants pose an acceptable level of risk under current and projected future land use.

Review and analysis of the ER Site 19 soil sample analytical data indicate that concentrations of COCs remaining in soils at this site pose an acceptable level of risk based on a risk assessment. Thus, ER Site 19 is being proposed for an NFA decision based on confirmatory sampling data demonstrating that the site has been remediated in accordance with current applicable state or federal regulations, and the available data indicate that contaminants pose an acceptable level of risk under current and projected future land use (NFA Criterion 5).

2.0 HISTORY OF ER SITE 19

2.1 Historical Operations

The 2-acre site was established in 1980 as a storage area for test hardware from the Old Aerial Cable Facility. Some tests involved shipping casks for nuclear material, and some of these casks were made of lead. Sampling equipment arrays used in radioactive materials release or dispersion testing were also stored here. Transportation containers and flat bed trailers used in some of the tests were also stored at the site. After the tests were conducted, it would take time to evaluate the effects on the equipment, and visitors would often want to inspect the test hardware (SNL/NM 1994f). The adjacent canyon was, therefore, selected as a convenient place to store the used equipment. A small area was bladed off and the test equipment was stored there. Prior to this time, the area was undeveloped. Materials were stored on open ground with no containment. The site was used strictly as surface storage: no testing occurred, and no materials were burned there (SNL/NM 1994f, SNL/NM 1994d). No rocket motors or ordnance were disposed of at ER Site 19 (SNL/NM 1994e). No hazardous chemicals were disposed of at ER Site 19. Nothing was buried at the site (SNL/NM 1994f, SNL/NM 1994d). The site was closed in the mid-1980s when it came under the control of the 6000 Group (Environmental Programs). Figure 2-1 shows the site before the stored materials were removed.

Table 2-1 shows the materials stored at ER Site 19, their status while stored, and the date each was removed from the site (also see Figure 1-2).

In 1985, a chain-link fence was erected around the site. This was as a result of individuals who had entered the site when it was uncontrolled and became concerned over a sign on the Helicopter Accident Resistant Containers units (SNL/NM 1994f).

Cleanup of the storage area, which was initially undertaken by SNL Organization 6600, the facility owners, began in March 1986. The first cleanup was primarily a cosmetic cleanup and involved hauling off benign material (SNL/NM 1994e).

In October 1989, the lead shipping cask and the Gravel Gertie Aerosol Sampling Package units were removed. This was in preparation for the major cleanup (SNL/NM 1994d).

Ten samples of the packing foam at the site were sampled in October 1989. The samples all passed Extraction Procedure Toxicity standards for metals. The foam was therefore considered nonhazardous and was disposed of as solid waste in May 1990 (SNL/NM Ref. 366).

Sixty-seven empty 55-gallon drums labeled as "fissile nuclear material" were surveyed for radiation and found to have no elevated radioactive levels. The labels were removed and the drums disposed of as solid waste in May 1990 (SNL/NM Ref. 366).

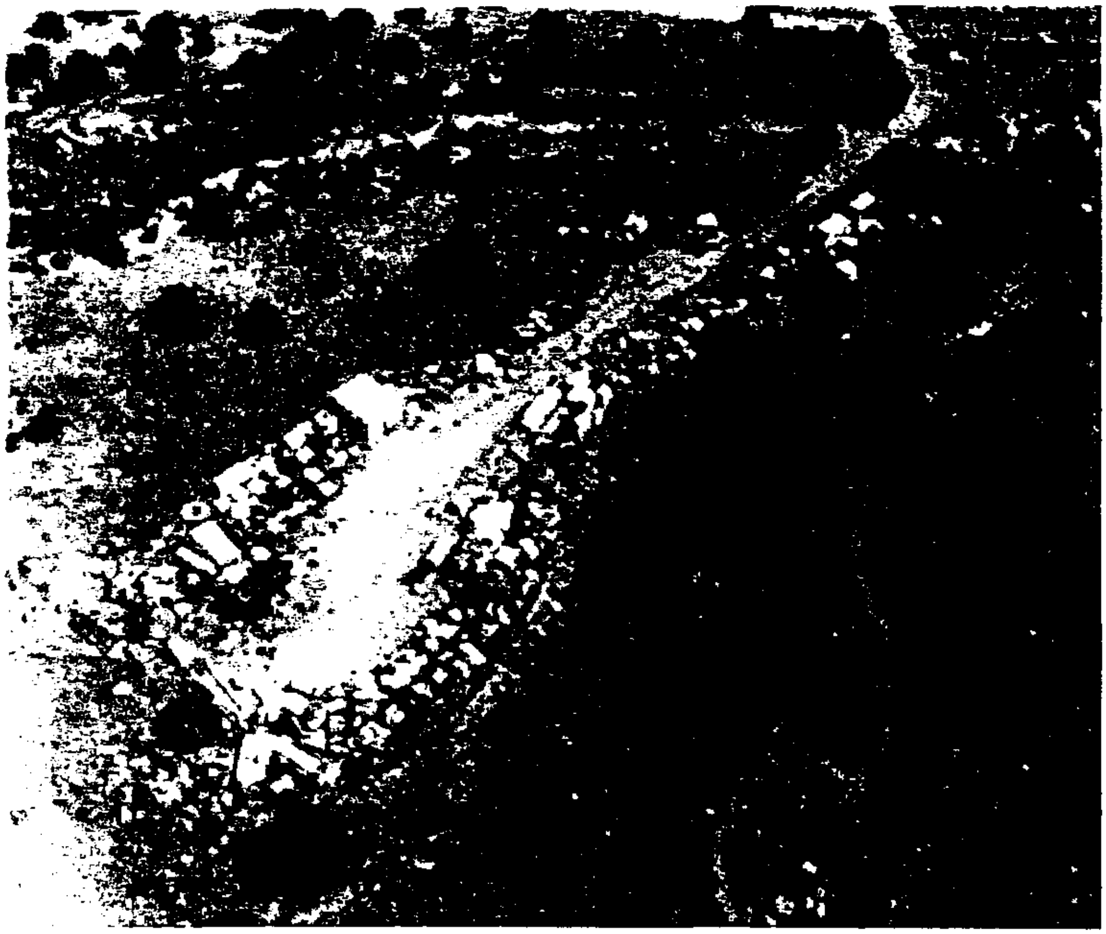


Figure 2-1. ER Site 19, Before Stored Materials Were Removed.

Table 2-1
Materials Stored at ER Site 19

Material Stored at ER Site 19	Hazard Status	Action Taken
One 15,000-pound lead shipping cask	Possible lead contamination in soils	Lead shipping cask removed from site October 1989 (SNL/NM 1994e)
Gravel Gertie Aerosol Sampling Package	Contaminated internally but external contamination is unknown (SNL/NM 1994d)	Removed from site October 1989 (SNL/NM 1994e)
TRUPAK Shipping Casks	Not contaminated (SNL/NM 1994d, SNL/NM 1994b)	Removed from site May 1990 (SNL/NM Ref. 366)
Packing Foam	Not contaminated (Foam was analyzed for contaminants and found to be clean) (SNL/NM Ref. 366)	Removed from site May 1990 (SNL/NM Ref. 366)
Sixty-Seven 55-gallon Drums labeled "Fissile Nuclear Material"	Not contaminated (Drums were screened for radiation and declared uncontaminated) (SNL/NM Ref. 366, SNL/NM 1994d, SNL/NM 1994a)	Removed from site May 1990 (SNL/NM Ref. 366)
Helicopter Accident Resistant Containers	Not contaminated (SNL/NM 1994c)	Units removed from site May 1990 (SNL/NM 1994f)
Three 40-foot flatbed trailers	Trailers have known radiation contamination (SNL/NM 1994d, SNL/NM Ref. 366). Rad contamination in soils around trailers (RUST Geotech Inc. 1994)	Removed from site May 1996 (SNL/NM 1996d)
One winch and two blast shields	Rad contaminated (SNL/NM 1994d, SNL/NM Ref. 366)	Removed from site May 1996 (SNL/NM 1996d)
Scrap aluminum (Truck Cabs)	Rad Contaminated (SNL/NM 1994d, SNL/NM Ref. 366)	Removed from site May 1996 (SNL/NM 1996d)

In May 1990, the major cleanup occurred. The scrap steel was removed. Everything was removed except the trailers, blast shields, and winch. From process knowledge about the tests, the scrap steel was considered benign and therefore was not screened for radioactivity (SNL/NM 1994d, SNL/NM 1994e).

2.2 Previous Audits, Inspections, and Findings

ER Site 19 was first listed as a potential release site in the RCRA Facility Assessment (RFA) report to the U.S. Environmental Protection Agency (EPA) in 1987 (EPA 1987a). This SWMU was included in the RFA report as ER Site 19 at SNL/NM.

3.0 EVALUATION OF RELEVANT EVIDENCE

3.1 Unit Characteristics and Operating Practices

The site is presently inactive, except for routine inspection by the SNL Organization 6000, which is responsible for the site. Signing and posting was conducted by the ER project in August 1994. All materials have been removed as discussed in Section 3.2.7.

3.2 Results of Previous Sampling/Surveys

3.2.1 Summary of Prior Investigations

The following Sources of information presented in chronological order were used to evaluate ER Site 19:

- The RFA report (EPA 1987a)
- Interviews with employees
- Site history detailed in the "Boneyard Cleanup Data Book" (SNL/NM Ref. 366)
- Results of Unexploded Ordnance (UXO)/High Explosives Survey Final Report (SNL/NM 1994g)
- Results of radiation surveys (RUST Geotech Inc. 1994)
- Confirmatory surface soil sampling (Lockheed Analytical Services 1995, SNL/NM 1996a, General Engineering Lab 1997)
- VCM documentation (SNL/NM 1996b)
- Photographs and field notes collected at the site by SNL/NM ER staff
- SNL/NM Geographic Information System data

3.2.2 Summary of UXO/HE Survey of ER Site 19

A UXO survey was conducted at the site on January 11, 1994. This survey covered 100 percent of the site, slowly, on foot. Some ordnance debris was found, including smoke grenades, a slap flare, and empty shotgun and small arms shells. All the ordnance debris was expended or empty and was removed (SNL/NM 1994g).

No visible evidence of soil discoloration, staining, or odors indicating residual contamination was observed during the UXO survey or when soil samples were collected.

3.2.3 Summary of Radiological Surveys of ER Site 19

Five radioactive anomalies were detected by the surface radiation survey conducted by RUST Geotech Inc. on January 23, 1994. These anomalies were in the area of the contaminated trailers and ranged from 160 to 650 counts per second (cps). Background readings at the site were 150 cps. The survey covered 100 percent of the site. Contaminated material detected in this area during this survey include scrap metal and soil (RUST Geotech Inc. 1994).

On March 19, 1996, the three flatbed trailers were surveyed for radiation. Radioactive areas on the trailers ranged from 200 to 140,000 counts per minute. Gamma spec soil sample results found only two radioactive constituents: Cs-137 estimated at 1.13E+05 picocuries (pCi) per container and Co-60 estimated at 1.29E+02 pCi per container (SNL/NM 1996d).

3.2.4 Summary of Cultural-Resources Survey of ER Site 19

A Cultural Resources survey was conducted in 1994 and is discussed in detail in the "Environmental Assessment of the Environmental Restoration Project at Sandia National Laboratories/New Mexico" (DOE and USAF 1995). No cultural resources concerns were found at ER Site 19.

3.2.5 Summary of Sensitive-Species Survey of ER Site 19

A Sensitive Species survey was conducted in 1994 and is discussed in detail in the "Environmental Assessment of the Environmental Restoration Project at Sandia National Laboratories/New Mexico" (DOE 1996). The survey found three species of cactus that were considered endangered at the time of the survey, Grama Grass Cactus, Wright's Pincushion, and Visnagita Cactus. Each of these cacti have since been taken off the endangered species lists. No other sensitive species concerns were found on the site.

3.2.6 Summary of Scoping Sampling of ER Site 19

On October 27, 1996 three samples of the paint on trailers and truck cab were analyzed for lead using flame atomic absorption. Lead concentrations were as follows: Truck cab white paint—2.3 milligrams per gram (mg/g), trailer white paint—23.51 mg/g, and trailer blue paint 40.06 mg/g. The trailers and cab were determined to be nonhazardous for lead due to the extremely low volume of paint versus the other materials (SNL/NM 1996e).

3.2.7 VCMs

In May 1996, all remaining debris including the radioactive truck frames, cabs, and blast shield were removed from the site under the direction of the SNL/NM ER Project and taken to the SNL/NM Radioactive and Mixed Waste Management Facility (Figures 3-1 and 3-2) (SNL/NM 1996b).

In June 1996, RUST Geotech Inc. conducted a VCM to resurvey the site and remove radioactive contaminated soil. A total of 19 drums of soil were removed. Post cleanup verification samples were collected from the areas with the highest radiation levels during pre-VCM surveys. The higher radiation levels corresponded to areas near the radioactive trailers that were removed as discussed above. Figure 3-3 shows the locations of the trailers and the locations of the post cleanup verification sampling. See Table 3-1 and the risk assessment discussion in Section 6.1 for results. With the completion of this VCM, all known contamination above action levels has been removed from the site (SNL/NM 1997).

3.2.8 Confirmatory Sampling

Confirmatory surface soil sampling was conducted by the SNL/NM ER Project in 1996 and 1997. The locations of target analyte list (TAL) metals samples are shown in Figures 1-2 and 3-3. These samples were taken from the area where the lead shipping cask was stored. The samples were analyzed by the on-site laboratory and an off-site commercial laboratory for metals, and were screened for radionuclides using SNL/NM on-site gamma spectroscopy. Routine SNL/NM chain-of-custody and sample documentation procedures were employed for all samples collected at this site. Table 3-2 summarizes the types of samples collected, analysis type, laboratories used, and the number of soil samples analyzed.

Samples were field screened for elevated radiation, primarily for worker health and safety during sampling. No significant elevation in radiation was observed.

Summaries of all constituents detected by the commercial laboratory analyses for the soil samples are presented in Table 3-3. Complete soil sample analytical data packages are archived in the SNL/NM Environmental Safety and Health Records Center and are readily available for review (SNL/NM 1995c). Risk calculations and a discussion of maximum metals values versus background, are found in Section 3.4 and 6.1. Lead was above background levels but well below action levels. No other COC metals were found above background. Arsenic and barium were included on the COC list because they are a concern on some ER sites. Both are present at background levels.

3.2.8.1 Data Quality Summary

Quality assurance/quality control (QA/QC) samples for TAL metals collected during two sampling events consisted of two duplicate soil samples, two rinsate blanks, and two field blanks. These were analyzed for TAL metals at the off-site laboratory. The off-site metals QA

Figure 3-1. Radioactive Trailer Components.

Figure 3-2. VCM to Remove Trailer Components.

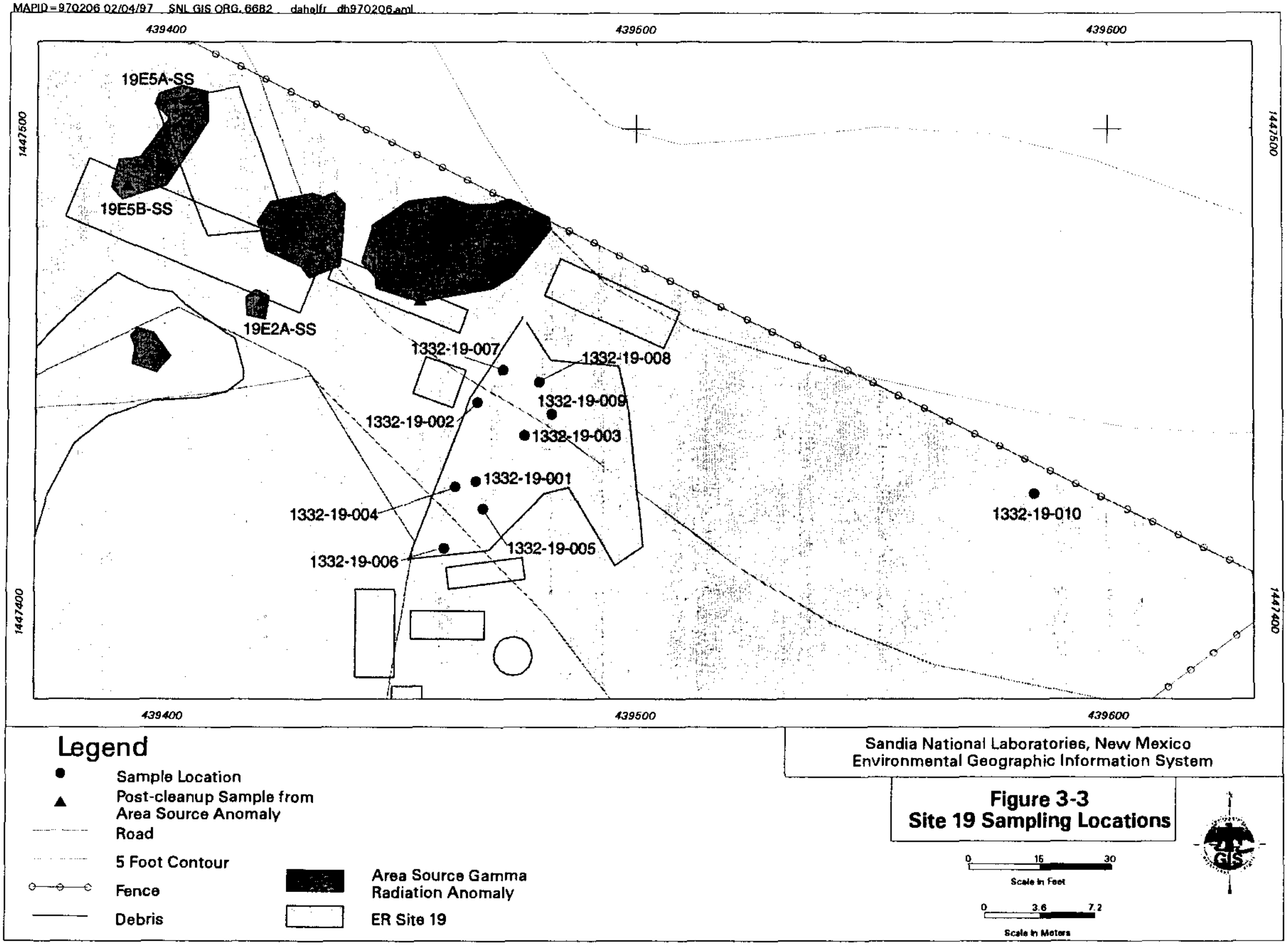


Figure 3-3
Site 19 Sampling Locations

Table 3-1
Summary of Radionuclides in Post VCM Samples Collected at ER Site 19
(On-site Laboratory only)

Sample Number	ER Sample ID (Fig. 3-3)	Sample Matrix	Sample Date	Sample Depth	Gamma Spectroscopy Activity[a]								Units
					Cs-137[b]	Co-60[b]	Th-232[b]	Th-234[b]	Ra-226[b]	Ra-228[b]	U-235[b]	U-238[b]	
NA	19E2A-SS	Soil	6/1/96	0-6 in.	0.593 (0.0349)	2.13 (0.0315)	1.13 (0.169)	0.827 (0.484)	1.55 (0.573)	1.32 (0.251)	ND (0.209)	ND (1.48)	pCi/g
NA	19E4A-SS	Soil	6/1/96	0-6 in.	0.137 (0.0279)	ND (0.0407)	1.27 (0.156)	0.75 (0.458)	1.36 (0.503)	ND (1.36)	ND (0.185)	ND (1.36)	pCi/g
NA	19E4B-SS	Soil	6/1/96	0-6 in.	0.686 (0.03)	ND (0.0413)	1.37 (0.156)	0.91 (0.531)	1.69 (0.612)	1.46 (0.612)	ND (0.204)	ND (1.51)	pCi/g
NA	19E5A-SS	Soil	6/1/96	0-6 in.	0.952 (0.0299)	0.176 (0.0296)	1.15 (0.165)	0.751 (0.509)	1.67 (0.639)	1.18 (0.189)	ND (0.2)	ND (1.45)	pCi/g
NA	19E5B-SS	Soil	6/1/96	0-6 in.	0.715 (0.033)	1.3 (0.0329)	1.17 (0.184)	1.31 (0.476)	1.72 (0.64)	1.01 (0.225)	ND (0.206)	ND (1.35)	pCi/g
SNL/NM Foothills Background Range[c]	NA	NA	NA	NA	0.007-0.876	NR	.0113-1.18	0.69-2.03	0.16-5.47	0.113-1.32	0.004-3.0	0.153-2.86	pCi/g
SNL/NM Foothills Soil Background UTL or 95th Percentile	NA	NA	NA	NA	1.063	NR	1.03	2.31	2.6	1.08	0.16	2.31	NA

[a]U-238 and Th-232 decay chain isotopes with a short half-life are not presented in this table.
[b]Value in parenthesis represents the minimum detection activity.
[c]Background range for U-235 from SNL/NM sitewide background data (IT 1996).
Bi = Bismuth.
Co = Cobalt.
Cs = Cesium.
D = Duplicate.
ER = Environmental restoration.
ID = Identification.
in. = Inches.
MDA = Minimum detection activity.
NA = Not applicable.
ND = Nondetect; the analyte was not observed above the MDA
NR = Not reported.
pCi/g = Picocuries per gram.
Pb = Lead.
Ra = Radium.
SS = Soil sample.
Th = Thorium.
U = Uranium.
UTL = Upper tolerance limit.

Table 3-2
ER Site 19: Confirmatory Sampling Summary Table

Sample Type	Analysis Type	Laboratory	No. of Samples[a]
Surface soil	TAL Metals	Off-site lab	10

[a]Excluding QA samples.
TAL = Target analyte list.

Table 3-3
Summary of TAL Metals in Confirmatory Samples Collected at ER Site 19
(Off-Site Laboratory only)

Sample Number	ER Sample ID (Figure 3-3)	Sample Depth	TAL Metals, Methods 6010 and 7470/7471							Units
			As	Ba	Be	Cd	Cr	Hg	Pb	
033879-001	1332-19R-001-0.5-SS	0-6 in.	6.52	101	0.524	0.387J	7.91	ND (0.0167)	10.8	mg/kg
033880-001	1332-19R-002-0.5-SS	0-6 in.	4.54	100	0.508	0.446J	7.82	0.0179J	12.5	mg/kg
033881-001	1332-19R-003-0.5-SS	0-6 in.	3.76	91.1	0.482J	0.549	7.36	ND (0.0167)	30.1	mg/kg
033882-001	1332-19R-004-0.5-SS	0-6 in.	3.92	101	0.512	0.594	7.16	0.0230J	14.5	mg/kg
024912-02	1332-19-005-0.5-SS	0-6 in.	7.7N	100	ND (1)	ND (1)	6.4	ND (0.1)	17	mg/kg
033883-001	1332-19R-006-0.5-SS	0-6 in.	4.07	81.3	0.416J	0.410J	5.86	0.0255J	16.8	mg/kg
033884-001	1332-19R-007-0.5-SS	0-6 in.	3.92	83.9	0.468J	0.503	6.73	0.0237J	35.3	mg/kg
033885-001	1332-19R-008-0.5-SS	0-6 in.	5.72	82.9	0.475J	0.464J	6.96	0.0333	12.8	mg/kg
033886-001	1332-19R-009-0.5-SS	0-6 in.	4.35	85.4	0.49	0.467J	7.83	0.0246	14	mg/kg
033887-001	1332-19R-011-0.5-SD dup of 1332-19R009-0.5-SS	0-6 in.	4.37	82.3	0.473J	0.469J	8.18	0.0202J	13.7	mg/kg
024913-02	1332-19-010-0.5-SS[a]	0-6 in.	7.5N	76	ND (1)	ND (1)	4.8	ND (0.1)	14	mg/kg
024914-02	1332-19-010-0.5-D[a]	0-6 in.	7.5N	88	ND (1)	ND (1)	5.4	ND (0.1)	15	mg/kg
Rinsate Blank 024914-12	1332-19-010-R	NA	ND (0.010)	ND (0.20)	ND (0.005)	ND (0.005)	ND (0.010)	ND (0.0002)	ND (0.003)	mg/L
Field Blank 024915-03	1332-19-010-FB	NA	ND (0.010)	ND (0.20)	ND (0.005)	ND (0.005)	ND (0.010)	ND (0.0002)	ND (0.003)	mg/L
Rinsate Blank 033890-001	1332-19R-014-EB	NA	ND (0.00276)	0.00845J	ND (0.000135)	ND (0.000209)	ND (0.000621)	ND (0.0001)	ND (0.00136)	mg/L
Field Blank 033889-001	1332-19R-013-FB	NA	ND (0.00276)	0.00122J	ND (0.000135)	ND (0.000209)	0.00122J	ND (0.0001)	ND (0.00136)	mg/L

Table 3-3 (Concluded)
Summary of TAL Metals in Confirmatory Samples Collected at ER Site 19
(Off-Site Laboratory only)

Sample Number	ER Sample ID (Figure 3-3)	Sample Depth	TAL Metals, Methods 6010 and 7470/7471							Units
			As	Ba	Be	Cd	Cr	Hg	Pb	
SNL/NM Foothills Background Range[a]	NA	NA	1.6-9.6	39-400	0.20-0.73	0.09-0.99	2.5-20	0.01-0.13	4.7-51	mg/kg
SNL/NM Foothills Soil Background UTL or 95th Percentile[a]	NA	NA	9.8	246	0.75	0.64	18.8	0.055	18.9	mg/kg

[a] IT Corporation 1997.
As = Arsenic.
Ba = Barium.
Be = Beryllium.
Cd = Cadmium.
Cr = Chromium.
D = Duplicate.
ER = Environmental restoration.
FB = Field blank.
Hg = Mercury.
ID = Identification.
in. = Inches.
MDL = Method detection limit.
mg/kg = Milligrams per kilogram.
mg/L = Milligrams per liter.
N = Matrix spike recovery exceeded acceptance limits.
NA = Not applicable.
ND = Nondetect; the analyte was not observed above the MDL.
Pb = Lead.
R = Rinsate.
SS = Soil sample.
TAL = Target analyte list.
UTL = Upper tolerance limit.

samples were acceptable during the first sampling event, except for arsenic as discussed below. The duplicate soil samples have good correlation. The rinsate blank and the field blank did not have any metals above the detection limits. The matrix spike/matrix spike duplicate (MS/MSD) and laboratory control samples were within limits for all COCs except arsenic. The off-site laboratory MS for arsenic was 63 percent recovery, and the MSD had 112 percent recovery.

The off-site metal QA samples for the 1997 sampling event were acceptable with the exception of the matrix spike for arsenic, beryllium, cadmium, cobalt, chromium, selenium, silver, and thallium. See Table 3-4 for recovery percentages for each metal.

Table 3-4
Out-of-Range Recovery Percentages for Off-Site Metals Analyses

Metal	Recovery Percentage	Acceptable Range
Arsenic	57.1	59.6–118
Beryllium	63.9	70.7–120
Cadmium	57.9	67.3–117
Chromium	63.9	66.6–122
Cobalt	61.8	67.5–118
Copper	62.8	65.2–113
Selenium	59.7	61.0–112
Silver	61.4	63.6–130
Thallium	56.9	69.9–115

The matrix spike duplicate was acceptable for all metals.

Since the matrix spike duplicate values from both sampling events are acceptable, the MS recovery variance should not be significant.

3.2.9 Site-Specific Background Sampling

Local background was established using background sampling locations approved by NMED-OB. The results of this sampling were statistically evaluated by IT Corporation. The data is summarized in their July 1, 1997 report. The background range and soil background 95th percentile (UTL) are shown on Table 3-3.

3.2.9.1 Quality Assurance/Quality Control Results

The background sample results came from at least 5 separate sampling events, some of which were conducted by NMED personnel. The QA/QC information on Non-ER sampling was not available for review but since this data was used by NMED for their background evaluation and to recommend background numbers to SNL/NM ER, it is assumed that the QA/QC was acceptable. The QA/QC of ER sampling is discussed below.

<u>1995 ER Samples</u>

Matrix spike recovery were outside the control limits for arsenic (72.6% versus the control range of 75-125%) due to matrix interference. The matrix spike duplicate recovery was acceptable. All other QA/QC data was acceptable.

<u>1997 ER Samples</u>

Laboratory Control Sample recovery for chromium was above the acceptable range (131% recovered versus the acceptable range of 74.3 - 130). All other QA/QC data was acceptable.

3.3 Gaps in Information

The pre-SNL/NM ER Project gaps in information included:

- Did radioactive contamination on the trailers impact the soils on site?
- Did the lead shipping cask contaminate the soils due to weathering?

Both gaps were addressed by sampling after the removal of the lead shipping cask and the rad contaminated debris.

3.4 Risk Evaluation

3.4.1 Human Health Risk Assessment

ER Site 19 has been recommended for recreational land-use (DOE 1996). A complete discussion of the risk assessment process, results, and uncertainties is provided in Section 6.1. Due to the presence of lead and radionuclides in concentrations and activities greater than background levels, it was necessary to perform a human health risk assessment analysis for the site. Besides metals, any radionuclide compounds either detected above background levels and/or MDAs 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's soil. The Risk Assessment Report calculated the Hazard Index and excess cancer risk for both a recreational land-use and residential land-use setting. The excess cancer risk from nonradioactive COCs and the radioactive COCs is not additive (EPA 1989).

In summary, the Hazard Index calculated for ER Site 19 nonradiological COCs is 0.02 for a recreational 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 0.00. The excess cancer risk for ER Site 19 nonradiological COCs is 4 X 10^{-6} for a recreational 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 ER Site 19 is 0.00. The incremental total effective dose equivalent for radionuclides for a recreational land-use setting is 0.37 millirem (mrem)/yr, which is well below the standard dose limit of 15 mrem/yr (40CFR196 1994). The incremental excess cancer risk for radionuclides is 7 X 10^{-6} for recreational 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 this site are provided only for comparison in the Risk Assessment Report (Section 6.1). The report concludes that the ER Site 19 does not have significant potential to affect human health under a recreational 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 Site 19. The only radionuclides present that might have been of ecological concern were cobalt-60, thorium-232, and radium-228. The total dose rate calculated for receptors was less than 6 x 10^{-4} rad/day, well below the acceptable benchmark of 0.1 rad/day. Two metals were found at levels of potential ecological concern, lead and chromium. The Hazard Quotients (HQ) for all three receptors, calculated from the maximum lead value, were all below one. The chromium value produced an HQ of 8.18 for the plant; however, the highest site value is below the area-specific background value (18.8 mg/kg), and no incremental risk from the site is expected. Based upon these results, no ecological risk is expected from the COCs of ER Site 19.

4.0 RATIONALE FOR PURSUING A NO FURTHER ACTION DECISION

Based on field investigation data and the human health and environmental risk assessment analysis, an NFA is being recommended for ER Site 19 for the following reasons:

- Metal levels at the site result in a 4 x 10^{-6} risk, which is within the acceptable range
- The radioactive component results is an effective dose equivalent of 0.35 mrem/year, which is well below the proposed EPA guidance of 15 mrem/year.
- The ecological risk were acceptable for all COCs except total chromium, which was below background levels and thus poses no incremental risk to the environment.

Based on this data and the conservative assumptions used in the risk assessment, the site is deemed to have an acceptable risk.

The risk assessment of chemical and radiological analytical results of soil samples has demonstrated that any contaminants remaining after the remediation at this site pose an acceptable level of risk under current and projected future land use. Based on the evidence provided above, ER Site 19 is proposed for an NFA based on Criterion 5.

5.0 REFERENCES

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6.0 ANNEXES

6.1 ER Site 19: Risk Assessment Report

ER SITE 19: RISK ASSESSMENT ANALYSIS

I. Site Description and History

Sandia National Laboratories/New Mexico (SNL/NM) Environmental Restoration (ER) Site 19 is located on Kirtland Air Force Base (KAFB), in a small canyon approximately 2,000 feet west of the Old Aerial Cable Site (ER Site 82). The canyon is oriented northeast-southwest. The site is 2 acres in area bounded by a fence and a locked gate. The site is radiologically posted as a Soil Contamination Area. The principal vegetation consists of sage, cholla cactus, and piñon trees. There are three small drainages at the site flowing from the northeast to the southwest, one running through the site, one on the western boundary of the site, and one on the eastern boundary of the site.

The site was established in 1980 as a storage area for test hardware from the Old Aerial Cable Site. Some tests involved shipping casks for nuclear material, and some of these casks were made of lead. Sampling equipment arrays used in radioactive materials release or dispersion testing were also stored here. Transportation containers and flat-bed trailers used in some of the tests were also stored at the site. Often, after the tests were conducted, it would take a long time to evaluate the effects on the equipment, and visitors would often want to inspect the test hardware. The scrap yard was, therefore, selected as a convenient place to store the used equipment. Shrubs were bladed off, and the test equipment was stored there. Prior to this time, the area was undeveloped. The site was closed in the mid-1980s.

On March 19, 1996, the trailers were surveyed for radiological contamination. Radiologically contaminated areas on the trailers ranged from 200 counts per minute (cpm) to 140,000 cpm using a Geiger-Mueller counter. Gamma spectroscopy results found only two radioactive constituents: Cesium-137 and Cobalt (Co)-60. In addition to radionuclides, lead may be present from the shipping cask. No other constituents of concern (COC) are known.

II. 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 Site 19 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. Chemicals that are essential nutrients, such as iron, magnesium, calcium, potassium, and sodium, were not included in this risk assessment per EPA guidance (EPA 1989). Both radioactive and nonradioactive COCs are evaluated. The nonradioactive COCs evaluated include only metals.

II.2 Step 2. Pathway Identification

ER Site 19 has been designated with a future land-use scenario of recreational use (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 the nonradioactive COCs and, for the radioactive COCs, direct gamma exposure. The inhalation pathway for both nonradioactive and radioactive COCs is included because of the potential to inhale dust. Soil ingestion is included for the radioactive COCs as well. No contamination at depth was determined, and therefore no water pathways to the groundwater are considered. Depth to groundwater at ER Site 19 is unknown. 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 recreational 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 Site 19 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 1997a). 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 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, the remaining maximum concentrations of nonradioactive COCs were compared with action levels calculated using methods and equations promulgated in the proposed Resource Conservation and Recovery Act Subpart S (40 CFR Part 264 1990) and Risk Assessment Guidance for Superfund (RAGS) (EPA 1989) documentation. Accordingly, all calculations were based on the assumption that receptor doses from both toxic and potentially carcinogenic compounds result most significantly from ingestion of contaminated soil. Because the samples were all taken from the surface or near-surface, this assumption is considered valid. 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 nonradioactive COCs in the soils were calculated. The combined effects of the nonradiological COCs at their respective upper tolerance limit (UTL) or 95th percentile background concentration in the soil were also calculated. For toxic compounds, calculating combined effects was accomplished 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.

II.3.1 Comparison to Background and Action Levels

Nonradioactive ER Site 19 COCs are listed in Table 1; radioactive COCs are listed in Table 2. Both tables show the associated 95th percentile or UTL background levels (IT Corporation 1997a). Background for Co-60 is not applicable because it does not occur naturally. The SNL/NM background levels have not yet been approved by the EPA or the New Mexico Environment Department but are the result of a comprehensive study of joint SNL/NM and U.S. Air Force data from KAFB. This report was submitted for regulatory review in early 1997. The values shown in Table 1 (IT Corporation 1997a) supersede the background values described in an interim background study report (IT Corporation 1996). One parameter had a maximum measured value greater than its background screening level. Therefore, all nonradiological COCs were retained for further analysis with the exception of lead. The maximum concentration value for lead is 35.3 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-use scenario, the EPA screening guidance value is 400 mg/kg (EPA 1994). Though the designated land-use is recreational, the maximum concentration value for lead at this site is less than both screening values, and therefore lead is eliminated from further consideration in this risk assessment.

Because one COCs had a concentration greater than its respective SNL/NM background 95th percentile, the site fails the background screening criteria, and all nonradioactive COCs proceed to the proposed Subpart S action level screening procedure. Table 3 shows the inorganic COCs and the proposed Subpart S action level for the contaminants. 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. Two COCs had concentrations greater than 1/10 of the proposed Subpart S action level. Because of these COCs, the site fails the proposed Subpart S screening criteria and a Hazard Index value and cancer risk value must be calculated for all the COCs.

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

Table 1
Nonradioactive COCs at ER Site 19 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	7.7 N	9.8	Yes
Barium	101	246	Yes
Beryllium	0.524	0.75	Yes
Cadmium	0.594	0.64	Yes
Chromium, total	8.18	NC	NA
Lead	35.3	18.9	No
Mercury	0.05**	0.055	Yes

N - matrix spike recovery exceeded acceptance limits.
NC - not calculated.
NA - not applicable.
** concentration assumed to be one-half of the detection limit.

Table 2
Radioactive COCs at ER Site 19 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?
Cs-137	0.952	1.06	Yes
Co-60	2.13	NC	No
Th-232	1.37	1.03	No
Ra-228	1.46	1.08	No

NC - not calculated.

Table 3
Comparison of ER Site 70 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	7.7 N	0.5	No
Barium	101	6000	Yes
Beryllium	0.524	0.2	No
Cadmium	0.594	80	Yes
Chromium, total*	8.18	400	Yes
Mercury	0.05**	20	Yes

* total chromium assumed to be chromium VI (most conservative).
^ concentrations are assumed to be one-half of the detection limit.
N - matrix spike recovery exceeded acceptance limits.
** concentration assumed to be one-half of the detection limit.

II.3.2 Identification of Toxicological Parameters

Tables 4 and 5 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).

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 for recreational and

Table 4
Nonradioactive Toxicological Parameter Values for ER Site 19 COCs

COC name	RfD_o (mg/kg/d)	RfD_{inh} (mg/kg/d)	Confidence	SF_o (kg-d/mg)	SF_{inh} (kg-d/mg)	Cancer Class ^
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

* total chromium assumed to be chromium VI (most conservative).
RfD_o - oral chronic reference dose in mg/kg-day.
RfD_{inh} - inhalation chronic reference dose in mg/kg-day.
Confidence - L = low, M = medium, H = high.
SF_o - oral slope factor in $(mg/kg\text{-}day)^{-1}$.
SF_{inh} - inhalation slope factor in $(mg/kg\text{-}day)^{-1}$.
^ 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 5
Radiological Toxicological Parameter Values for ER Site 19 COCs

COC name	Sf_O (1/pCi)	SF_{inh} (1/pCi)	SF_{ev} (g/pCi-yr)	Cancer Class^
Co-60	1.9E-11	6.9E-11	9.8E-6	A
Th-232	3.3E-11	1.9E-08	2.0E-11	A
Ra-228	2.5E-10	9.9E-10	3.3E-06	A

SF_o - oral (ingestion) slope factor (risk/pCi).
SF_{inh} - inhalation slope factor (risk/pCi).
Sf_{ev}- external volume exposure slope factor (risk/yr per pCi/g).
^ 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.

residential land uses. The incremental TEDE and incremental estimated 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 recreational 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 recreational 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 6 shows that for the ER Site 19 nonradioactive COCs, the Hazard Index value is 0.02, and the excess cancer risk is 4×10^{-6} for the designated recreational land-use scenario. The numbers presented included exposure from soil ingestion and dust inhalation for the nonradioactive COCs. Table 7 shows that assuming the maximum background concentrations of the ER Site 19 associated background constituents, the Hazard Index is 0.02, and the excess cancer risk is 4×10^{-6} for the designated recreational land-use scenario.

Table 6
Nonradioactive Risk Assessment Values for ER Site 19 COCs

COC Name	Maximum concentration (mg/kg)	Recreational Land-Use Scenario		Residential Land-Use Scenario	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Arsenic	7.7 N	0.02	3E-6	0.44	9E-5
Barium	101	0.00	--	0.02	--
Beryllium	0.524	0.00	6E-7	0.00	4E-6
Cadmium	0.594	0.00	2E-11	0.49	3E-10
Chromium, total*	8.18	0.00	2E-9	0.01	3E-8
Mercury	0.05**	0.00	--	0.09	--
TOTAL		0.02	4E-6	1	9E-5

* total chromium assumed to be chromium VI (most conservative).
-- information not available.
** concentration assumed to be one-half of detection limit.
N - matrix spike recovery exceeded acceptance limits.

Table 7
Nonradioactive Risk Assessment Values for ER Site 19 Background Constituents

COC Name	Background concentration (mg/kg)	Recreational Land- Use Scenario		Residential Land- Use Scenario	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Arsenic	9.8	0.02	4E-6	0.56	1E-4
Barium	246	0.00	--	0.04	--
Beryllium	0.75	0.00	8E-7	0.00	6E-6
Cadmium	0.64	0.00	2E-11	0.52	4E-10
Chromium, total*	NC	--	--	--	--
Mercury	0.055	0.00	--	0.09	--
TOTAL		0.02	4E-6	1	1E-4

* total chromium assumed to be chromium VI (consistent with Table 6).
-- information not available.
NC - not calculated due to absence in SNL/NM background report (IT Corporation 1997a).

For the radioactive COCs, contribution from the direct gamma exposure pathway is included. The incremental TEDE for recreational land-use is 0.37 millirem per year (mrem/yr). In accordance with proposed EPA guidance, the guideline being utilized is an incremental TEDE of 15 mrem/yr (40 CFR Part 196 1994) for the probable land-use scenario (recreational in this case); the calculated dose value for ER Site 19 for the recreational land-use is well below this guideline. The estimated excess cancer risk is 7×10^{-6}.

For the residential land-use scenario, the Hazard Index value increases to 1, and the excess cancer risk is 9×10^{-5}. The numbers presented included exposure from soil ingestion, dust inhalation, and plant uptake. Although 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 7 shows that for the ER Site 19 associated background constituents, the Hazard Index is 1, and the excess cancer risk is 1×10^{-4}.

For the radioactive COCs, the incremental TEDE for residential land-use is 9.5 mrem/yr. In accordance with proposed EPA guidance, the guideline being utilized is an excess TEDE of 75 mrem/yr (40 CFR Part 196 1994) for a complete loss of institutional controls (residential land-use in this case); the calculated dose value for ER Site 19 for the residential land-use is well below this guideline. It should also be noted that, consistent with the proposed guidance (40 CFR Part 196 1994), ER Site 19 should be eligible for unrestricted radiological release as the residential scenario resulted in an incremental TEDE to the on-site receptor of less than 15 mrem/yr. The estimated excess cancer risk is 2×10^{-4}. The excess cancer risk from the nonradioactive COCs and the radioactive COCs is not additive, as noted in RAGS (EPA 1989).

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 recreational land-use scenario, which is the designated land-use scenario for this site, and a residential land-use scenario.

For the recreational land-use scenario, the Hazard Index calculated is 0.02; this is much less than the numerical guideline of 1 suggested in RAGS (EPA 1989). The excess cancer risk is estimated at 4×10^{-6}. 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 this site is in the low end of the suggested acceptable risk range. This risk assessment also determined risks considering background concentrations of the potential nonradiological COCs for both the recreational and residential land-use scenarios. For the recreational land-use scenario, the Hazard Index is 0.02. The excess cancer risk is estimated at 4×10^{-6}. Incremental risk is determined from subtracting risk associated with background from potential COC risk. These numbers are not rounded before the difference is determined and therefore may appear to be inconsistent with numbers presented in tables and within the text. The incremental Hazard Index is 0.00, as is the incremental cancer risk for the recreational land-use scenario. These incremental risk calculations indicate zero contribution to human health risk from the COCs considering a recreational land-use scenario.

For the radioactive components of the recreational land-use scenario, the incremental TEDE is 0.37 mrem/yr, which is significantly less than the numerical guideline of 15 mrem/yr suggested in the draft EPA guidance. The incremental estimated excess cancer risk is 7×10^{-6}.

For the residential land-use scenario, the calculated Hazard Index is 1, which is at the numerical guidance. The excess cancer risk is estimated at 9×10^{-5}; this value is at the upper end of the suggested acceptable risk range. The Hazard Index for associated background for the residential land-use scenario is 1. The excess cancer risk is estimated at 1×10^{-4}. The incremental Hazard Index is 0.00 as is the incremental cancer risk for the residential land-use scenario. Incremental risk calculations indicate zero contribution to human health risk from the COCs considering a residential land-use scenario.

The incremental TEDE from the radioactive components is 9.5 mrem/yr, which is significantly less than the numerical guideline of 75 mrem/yr suggested in the draft EPA guidance. The estimated excess cancer risk is 2×10^{-4}.

II.5 Step 7 Uncertainty Discussion

The data used to characterize ER Site 19 for metals, were provided by ten surface samples biased towards the area where the lead shipping cask was found. This was considered a worst case for the weathering/leaching of metals from the debris stored at ER Site 19. The samples were deemed sufficient to establish whether or not significant leaching occurred. The COC for this portion of the site was solely metals. The soil samples were analyzed for target analyte list metals by EPA Method 6010A and mercury by Method 7471 and gamma spectroscopy. Only metals considered potential COCs are reported. Quality assurance/quality control samples for the sampling events consisted of 2 duplicates, two field blanks, an equipment blank and a rinsate. Samples were analyzed for metals at two off-site commercial Contract Laboratory Program (CLP) laboratories. The gamma spectroscopy samples were analyzed at the SNL/NM on-site radiological laboratory. The data provided by the CLP laboratory are considered definitive data suitable for use in a risk assessment analysis. The verification samples for the radioactive soil voluntary corrective measures were selected from the highest radioactive soil contamination areas before cleanup.

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 recreational land-use scenario. Calculated incremental risk between potential nonradiological COCs and associated background indicate zero contribution of risk from nonradiological COCs when considering the recreational land-use scenario.

For the radiological COCs the conclusion from the risk assessment is that the potential effect on human health, for both the recreational and residential land-use scenarios, is within proposed guidelines (40 CFR Part 196 1994) and is a small fraction of the estimated 290 mrem/yr received due to natural background (NCRP 1987).

Because of the location, history of the site, and the future land-use (DOE and USAF 1995), there is low uncertainty in the land-use scenario and the potentially affected populations that were considered in making the risk assessment analysis. Because the COCs are found in surface soils and because of the location and physical characteristics of the site, there is little uncertainty in the exposure pathways relevant to the analysis.

An RME approach was used to calculate the risk assessment values, 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 concentration value, as applicable, of background concentrations associated with the COCs were used to provide conservative results.

Table 4 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 1996b) 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 risk assessment values for nonradiological COCs are within the acceptable range for the recreational land-use scenario compared to the established numerical guidelines. Though the residential land-use Hazard Index is at the numerical guideline, it has been determined that future land-use at this locality will not be residential. The radiological incremental TEDE is a very small fraction of estimated background TEDE for both the industrial and residential land-use scenarios, and both are well within proposed guidelines (40 CFR Part 196 1994). The overall uncertainty in all of the steps in the risk assessment process is considered not significant with respect to the conclusion reached.

II.6 Summary

ER Site 19 had relatively minor contamination consisting of some inorganic and radioactive compounds. Because of the location of the site on KAFB, the designated recreational land-use scenario, and the nature of the contamination, the potential exposure pathways identified for this site included soil ingestion and dust inhalation for chemical constituents and soil ingestion, dust inhalation, and direct gamma exposure for radionuclides. Plant uptake was included as an exposure pathway for the residential land-use scenario.

Using conservative assumptions and employing an RME approach to the risk assessment, the calculations for the nonradioactive COCs show that for the recreational land-use scenario the Hazard Index (0.02) is significantly less than the accepted numerical guidance from the EPA. The estimated cancer risk (4×10^{-6}) is in the low end of the suggested acceptable risk range. The incremental Hazard Index is 0.00, as is the incremental cancer risk for the recreational land-use scenario. Incremental risk calculations indicate zero contribution to risk from the COCs considering an recreational land-use scenario.

The calculated risk is driven by arsenic (7.7 mg/kg). This arsenic concentration is below the background screening value of 9.8 mg/kg and is not indicative of contamination.

The incremental TEDE and corresponding estimated cancer risk from the radioactive components are much less than EPA guidance values; the estimated TEDE is 0.37 mrem/yr for the recreational land-use scenario. This value is much less than the numerical guidance of 15 mrem/yr (for recreational) in draft EPA guidance. The corresponding incremental estimated cancer risk value is 7×10^{-6} for the recreational land-use scenario.

The incremental TEDE and corresponding estimated cancer risk from the radioactive components are much less than EPA guidance values; the estimated TEDE is 9.5 mrem/yr for the residential land-use scenarios. This value is much less than the numerical guidance of 75 mrem/yr (for residential) in draft EPA guidance. The increased effects on human health, for the radioactive COCs, are primarily due to more time spent on site. The corresponding incremental estimated cancer risk value is 2×10^{-4} for the residential 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 this site does not have significant potential to affect human health under an recreational land-use scenario.

III. Ecological Risk Assessment

III.1 Introduction

This document addresses the ecological risks associated with exposure to constituents of potential ecological concern (COPEC) in soils from SNL/NM ER Site 19. The ecological risk assessment process performed for this site is a screening level assessment that follows the methodology presented in IT Corporation (1997b) and SNL/NM (1997). The methodology was based on screening level guidance presented by EPA (EPA, 1992; 1996c; 1997b) and by Wentsel 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 EPA (1996) and Wentsel et al. (1996) to ensure that the predicted exposures of selected ecological receptors reasonably reflect those expected to occur at the site.

III.2 Ecological Pathways

ER Site 19 is surrounded by piñon-juniper woodland habitat, but the actual site, the area inside the fenced perimeter, is largely disturbed. Complete ecological pathways may exist at this site through the exposure of plants and wildlife to COPECs in surface and subsurface soil. Results of a previous sensitive-species survey conducted at the site show that no sensitive species were found within the fenced area. One visnagita cactus (*Neolloydia intertexta*) was found in the buffer area outside of the fence during the survey. In addition, a Wright's pincushion cactus (*Mammillaria wrightii*) was found near the fence, but outside of the enclosure, during the signing and posting activities at this site (IT Corporation 1995). Both species were previously listed as List 1 endangered by the New Mexico Forestry and Resource Conservation Division, but have since been delisted. The state-endangered gray vireo (*Vireo vicinoir*) has been documented in the piñon-juniper habitat near ER Site 19, but has not been recorded on or adjacent to the site (NMNHP 1995).

III.3 Constituents of Potential Ecological Concern

The potential COCs at this site are beryllium, cadmium, lead, and mercury. Following the screening process used for the selection of potential COCs for the human health risk assessment, the inorganic COCs were screened against background UTLs. Two inorganic analytes were identified as COPECs at ER Site 19, chromium (total) and lead. Inorganic constituents that are essential nutrients, such as iron, magnesium, calcium, potassium, and sodium, were not included in this risk assessment per EPA 1989. Results of gamma spectroscopy analysis indicate that Co-60, Th-232, and Ra-228 were the radionuclides of potential ecological concern. The Co-60, Th-232, and Ra-228 maximum concentrations in soil are 2.13 pCi/g, 1.37 pCi/g, and 1.46 pCi/g, respectively.

III.4 Receptors and Exposure Modeling

A nonspecific perennial plant was used as the receptor to represent plant species at the site. Two wildlife receptors (deer mouse and burrowing owl) were used to represent wildlife use of the site. 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 8 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 site being investigated.

The maximum measured COPEC concentrations from surface soil samples were used to conservatively estimate potential exposures and risks to plants and wildlife at this site. Table 9 presents the transfer factors used in modeling the concentrations of COPECs through the food chain. Table 10 presents the maximum concentrations of COPECs in soil, the derived concentrations in the various food-chain elements, and the modeled dietary exposures for each of wildlife receptor species.

With respect to the radionuclides, the receptors are assumed to be exposed to radiation externally from Co-60. The receptors are exposed to radiation internally from Co-60, Th-232, and Ra-228. 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 (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.

Table 8
Exposure Factors for Ecological Receptors at Environmental Restoration Site 19, Sandia National Laboratories, New Mexico

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

[a]Body weights are in kilograms wet weight.
[b]Food intake rates are estimated from the allometric equations presented in Nagy (1987). Units are kilograms dry weight per day.
[c]Dietary compositions are generalized for modeling purposes. Default soil intake value of 2% of food intake.
[d]From Silva and Downing (1995).
[e]From EPA (1993), based on the average home range measured in semi-arid shrubland in Idaho.
[f]From Dunning (1993).
[g]From Haug et al. (1993).

Table 9
Transfer Factors Used in Exposure Models for Constituents of Potential Ecological Concern at Environmental Restoration Site 19, 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
Chromium (Total)	4.00×10^{-2} [a]	1.30×10^{-1} [b]	3.00×10^{-2} [c]
Lead	9.00×10^{-2} [c]	4.00×10^{-2} [d]	8.00×10^{-4} [c]

[a]From Baes et al. (1984).
[b]From Ma (1992).
[c]From NCRP (1989).
[d]From Stafford et al. (1991).

Table 10
Media Concentrations (mg/kg)[a] for Constituents of Potential Ecological Concern at Environmental Restoration Site 19, Sandia National Laboratories, New Mexico

Constituent of Potential Ecological Concern	Soil (maximum)[a]	Plant Foliage[b]	Soil Invertebrate[b]	Deer Mouse Tissues[c]
Chromium (Total)	8.18×10^{0}	3.27×10^{-1}	1.06×10^{0}	8.05×10^{-2}
Lead	3.53×10^{1}	3.18×10^{0}	1.41×10^{1}	7.50×10^{-3}

[a]Milligrams per kilogram. All are based on dry weight of the media.
[b]Product of the soil concentration and the corresponding transfer factor.
[c]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).

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 Corporation (1997b). The total dose rate to a receptor is the sum of the external and internal dose rates.

III.5 Toxicity Benchmarks

Benchmark toxicity values for the plant and wildlife receptors are presented in Table 11. 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 (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 Site 19.

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 12. Hazard quotients (HQ) are used to quantify the comparison with the benchmarks for wildlife exposure. The only HQ found to exceed unity was that for plants exposed to total chromium (HQ = 8.18). Although the maximum total chromium concentration of 8.18 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 ER Site 19 concentration.

Table 11
Toxicity Benchmarks for Ecological Receptors at Environmental Restoration Site 19, Sandia National Laboratories, New Mexico

		Mammalian NOAELs			Avian NOAELs		
Constituent of Potential Ecological Concern	Plant Benchmark[a]	Mammalian Test Species[b]	Test Species NOAEL[c]	Deer Mouse NOAEL[d]	Avian Test Species[e]	Test Species NOAEL[e]	Burrowing Owl NOAEL[f]
Chromium (Total)	1	Lab rat	2737	5354	Black Duck	1.0	1.0
Lead	50	Lab rat	8	15.7	American kestrel	3.85	3.85

[a]From Will and Suter (1995).
[b]From Sample et al. (1996), except where noted. Body weights (in kilograms) for NOAEL conversion are: lab mouse, 0.030; lab rat, 0.350 (except where noted); and mink, 1.0.
[c]From Sample et al. (1996), except where noted.
[d]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.
[e]From Sample et al. (1996).
[f]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.

Table 12
Comparisons to Toxicity Benchmarks for Ecological Receptors at Environmental Restoration Site 19, Sandia National Laboratories, New Mexico

Constituent of Potential Ecological Concern	Plant Hazard Quotient[a]	Deer Mouse Hazard Quotient	Burrowing Owl Hazard Quotient
Chromium (Total)	**8.18×10^{0}**	2.50×10^{-5}	2.72×10^{-2}
Lead	7.06×10^{-1}	2.98×10^{-2}	2.07×10^{-2}

[a]Bold text indicates hazard quotient exceeds unity.

The total radiation dose rate to the mouse was predicted to be 5.17 x 10^{-4} rad/day (Table 13). The total dose rate to the burrowing owl was predicted to be 5.69 x 10^{-4} rad/day (Table 14). The external 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 on this information and that obtained through the ecological risk assessment screen, chemical and radiological risks associated with ER Site 19 are expected to be insignificant.

III.7 Uncertainties

Many uncertainties are associated with the characterization of ecological risks at ER Site 19. 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 site. 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 Co-60, Th-232, and Ra-228 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.

III.8 Summary

An ecological risk assessment was conducted to evaluate potential ecological risks associated with the COCs at ER Site 19. The only radionuclides present that might have been of ecological concern were Co-60, Th-232, and Ra-228. The total dose rate calculated for receptors was less than 6 x 10^{-4} rad/day, well below the acceptable benchmark of 0.1 rad/day. Two metals were found at levels of potential ecological concern, lead and chromium. The HQs for all three receptors, calculated from the maximum lead value, were all below one. The chromium value produced an HQ of 8.18 for the plant; however, the highest site value is below the area-specific background value (18.8 mg/kg), and no incremental risk from the site is expected. Based upon these results, no ecological risk is expected from the COCs of ER Site 19.

Table 13
Internal and External Dose Rates for Mice Exposed to Radionuclides at Environmental Restoration Site 19, Sandia National Laboratories, New Mexico

Radionuclide	Maximum Concentration (pCi/g)	Internal Dose (rad/d)	External Dose (rad/d)	Total Dose (rad/d)
Co-60	2.13	3.79×10^{-7}	4.07×10^{-4}	4.08×10^{-4}
Th-232	1.37	7.50×10^{-8}	1.25×10^{-7}	2.00×10^{-7}
Ra-228	1.46	1.09×10^{-4}	NA[a]	1.09×10^{-4}
Total		1.09×10^{-4}	4.08×10^{-4}	5.17×10^{-4}

[a]NA indicates that this radionuclide does not significantly contribute to the external dose rate.

Table 14
Internal and External Dose Rates for Owl Exposed to Radionuclides at Environmental Restoration Site 19, Sandia National Laboratories, New Mexico

Radionuclide	Maximum Concentration (pCi/g)	Internal Dose (rad/d)	External Dose (rad/d)	Total Dose (rad/d)
Co-60	2.13	5.08×10^{-7}	4.07×10^{-4}	4.08×10^{-4}
Th-232	1.37	1.06×10^{-7}	1.25×10^{-7}	2.13×10^{-7}
Ra-228	1.46	1.61×10^{-4}	NA[a]	1.61×10^{-4}
Total		1.62×10^{-4}	4.08×10^{-4}	5.69×10^{-4}

[a]NA indicates that this radionuclide does not significantly contribute to the external dose rate.

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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

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

the Risk Assessment Guidance for Superfund (RAGS): Volume 1 (EPA 1989a and 1991). These general equations also apply to calculating potential intakes for radionuclides. A more in-depth discussion of the equations used in performing radiological pathway analyses with the RESRAD code may be found in the RESRAD Manual (ANL 1993). Also shown are the default values SNL/NM ER suggests for use in 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)

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

where

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

The total risk/dose (either cancer risk or 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
General Exposure Parameters			
Exposure frequency (d/y)	***	***	***
Exposure duration (y)	30[a,b]	30[a,b]	30[a,b]
Body weight (kg)	70[a,b]	56[a,b]	70 adult[a,b] 15 child
Averaging Time (days) for carcinogenic compounds (=70 y x 365 d/y) for noncarcinogenic compounds (=ED x 365 d/y)	25550[a] 10950	25550[a] 10950	25550[a] 10950
Soil Ingestion Pathway			
Ingestion rate	100 mg/d[c]	6.24 g/y[d]	114 mg-y/kg-d[a]
Inhalation Pathway			
Inhalation rate (m^3/yr)	5000[a,b]	146[d]	5475[a,b,d]
Volatilization factor (m^3/kg)	chemical specific	chemical specific	chemical specific
Particulate emission factor (m^3/kg)	1.32E9[a]	1.32E9[a]	1.32E9[a]
Water Ingestion Pathway			
Ingestion rate (L/d)	2[a,b]	2[a,b]	2[a,b]
Food Ingestion Pathway			
Ingestion rate (kg/yr)	NA	NA	138[b,d]
Fraction ingested	NA	NA	0.25[b,d]
Dermal Pathway			
Surface area in water (m^2)	2[b,e]	2[b,e]	2[b,e]
Surface area in soil (m^2)	0.53[b,e]	0.53[b,e]	0.53[b,e]
Permeability coefficient	chemical specific	chemical specific	chemical specific

*** 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.

[a] RAGS, Vol 1, Part B (EPA 1991).

[b] Exposure Factors Handbook (EPA 1989b)

[c] EPA Region VI guidance.

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

[e] Dermal Exposure Assessment (EPA 1992).

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