



Sandia National Laboratories/New Mexico

**PROPOSAL FOR
RISK-BASED NO FURTHER ACTION
ENVIRONMENTAL RESTORATION SITE 232
STORM DRAIN SYSTEM OUTFALL
OPERABLE UNIT 1309**

**August 1997
Environmental
Restoration
Project**



**United States Department of Energy
Albuquerque Operations Office**

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

Prepared for the
U.S. Department of Energy

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ACRONYMS AND ABBREVIATIONS

AST	above storage tank(s)
ATI	Analytical Technologies, Inc.
COC	constituents of concern
DOE	U.S. Department of Energy
DV	data verification/validation
DV1	Data Verification/Validation Level 1
DV2	Data Verification/Validation Level 2
ERCL	Environmental Restoration Chemistry Laboratory
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
HERMES-III	High Energy Radiation Megavolt Electron Source-III
HSWA	Hazardous and Solid Waste Amendment
IT	IT Corporation
LCS	laboratory control sample(s)
LCSD	laboratory control sample duplicate(s)
MDA	minimum detectable activity
mg/L	milligram(s) per liter
mL	milligram(s) per liter
mrem/year	millirem(s) per year
MS	matrix spike(s)
MSD	matrix spike duplicates
NFA	no further action
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
OU	operable unit
PCB	polychlorinated biphenyl(s)
pCi/g	picocurie(s) per gram
ppm	part(s) per million
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RPD	relative percent difference
RQ	reportable quantity
SCS	single control samples
SMCL	secondary maximum contaminant level
SMO	Sample Management Office
SNL/NM	Sandia National Laboratories/New Mexico
SVOC	semivolatile organic compound(s)
TA-IV	Technical Area IV
TDS	total dissolved solids
TOP	technical operating procedure
TPH	total petroleum hydrocarbon(s)
UST	underground storage tank(s)
UXO/HE	unexploded ordnance/high explosive(s)
VCM	voluntary corrective measure(s)
VOC	volatile organic compound(s)

1.0 INTRODUCTION

Sandia National Laboratories/New Mexico (SNL/NM) is proposing No Further Action (NFA) status for Environmental Restoration (ER) Site 232, which is a storm-drain outfall system from Technical Area IV (TA-IV). ER Site 232 is listed in the Hazardous and Solid Waste Amendment (HSWA) Module IV (U.S. Environmental Protection Agency [EPA] 1993) of the SNL/NM Resource Conservation and Recovery Act (RCRA) Hazardous Waste Management Facility Permit (NM5890110518) (EPA 1992). The SNL/NM ER Project manages ER Site 232 under Operable Unit (OU) 1309.

In 1993, ER Site 232 was listed in the HSWA Module because the SNL/NM ER Project assumed that the two outfalls posed an environmental risk. However, no chemical releases had been documented at either outfall. A RCRA Facility Investigation Workplan has not been prepared for OU 1309.

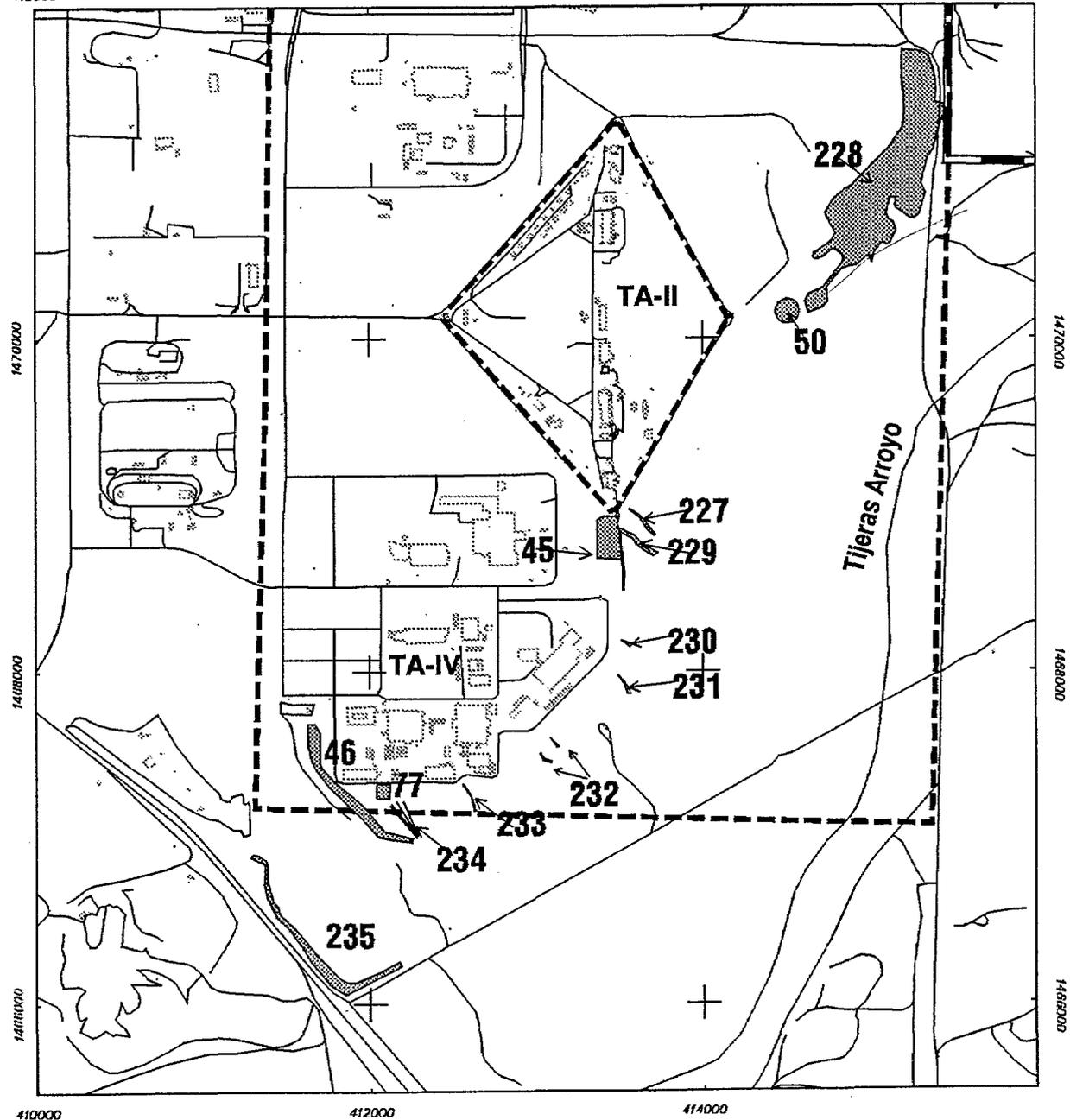
1.1 Description of ER Site 232

ER Site 232 covers 0.033 acres (about 1,450 square feet [ft]) and consists of the two storm-water Outfalls 232-1 and 232-2 (Figure 1-1). In some previous plans, the outfall numbers have occasionally been inadvertently switched. This NFA proposal consistently uses the designations shown on Figure 1-1.

ER Site 232 is located along the northern rim of Tijeras Arroyo on unfenced, industrial land controlled by the U.S. Department of Energy (DOE). The site is located about 100 ft southeast of TA-IV. The topography ranges in elevation from about 5,335 to 5,355 ft above mean sea level and slopes to the southeast toward Tijeras Arroyo. However, the site is situated above the 100-year floodplain. The surficial soil at ER Site 232 consists of Pleistocene-age Embudo gravelly fine sandy loam that is underlain by the Santa Fe Group sediments. No perennial surface water bodies are present near ER Site 232; Tijeras Arroyo is ephemeral and typically flows about five days per year in the active arroyo channel, which is located approximately 1,600 ft southeast of ER Site 232. The depth to ground water at ER Site 232 is approximately 275 ft. The vegetation consists of scattered grasses.

1.2 No Further Action Basis

Review and analysis of all relevant data for ER Site 232 indicate that constituents of concern (COC) at this site are less than applicable risk-based action levels. Thus, ER Site 232 is being proposed for an NFA decision based on confirmatory sampling data demonstrating that COCs that may have been released from this solid waste management unit into the environment pose an acceptable level of risk under current and projected future land use, per NFA Criterion 5 of the ER Document of Understanding (NMED 1996; SNL/NM 1997a).



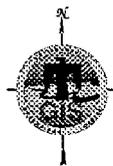
Legend

-  ER Site
-  Technical Area
-  Arroyo (Active Channel)
-  Road
-  Building
-  KAFB Boundary

Figure 1-1
Tijeras Arroyo OU 1309
Environmental Restoration Sites
near TA-IV

0 500 1000
Scale in Feet

0 120 240
Scale in Meters



Sandia National Laboratories, New Mexico
Environmental Geographic Information System

2.0 HISTORY OF ER SITE 232

2.1 Historical Operations

In November 1993, the SNL/NM ER Project listed the two outfalls as ER Site 232. This was a conservative measure because no chemical or radiological releases had occurred at either outfall.

Outfall 232-1 occasionally discharges storm water from two catch basins that are located on the southeast side of Building 970A. Engineering Sheet UAD-H13 shows that both catch basins are plumbed to a headwall that contains the outfall pipe (Figure 2-1). The headwall is the upper end of a four-ft wide, two-ft deep, concrete drainage ditch that is 77 ft long. No spill of a Reportable Quantity (RQ) has occurred in the area that drains to Outfall 232-1.

Outfall 232-2 discharges storm water from seven catch basins and five roof drains that surround Building 983. The catch basins and roof drains are plumbed to a headwall that contains the outfall pipe (Figure 2-1). Unlike Outfall 232-1, storm water from the Outfall 232-2 outfall pipe drains directly onto the soil instead of passing through a concrete drainage ditch. On June 1, 1994, approximately 150 to 300 gallons of mineral oil flowed onto the ground surface below Outfall 232-2 after being spilled from an above-ground tank near Building 986 (Carlson 1994). The spill is discussed in greater detail below in Sections 3.1 and 3.2.

2.2 Previous Audits, Inspections, and Findings

Neither Outfall 232-1 nor Outfall 232-2 was listed as a potential release site as a result of the Comprehensive Environmental Assessment and Response Program interview process conducted in 1985 (DOE 1987). Furthermore, the outfalls were not listed in the EPA RCRA Facility Assessment in 1987 (EPA 1987) or the Hazard Ranking System (DOE 1987). Therefore, no previous audits, inspections, or findings are available. The environmental information presented in Section 3.0 has been solely compiled by the SNL/NM ER Project.

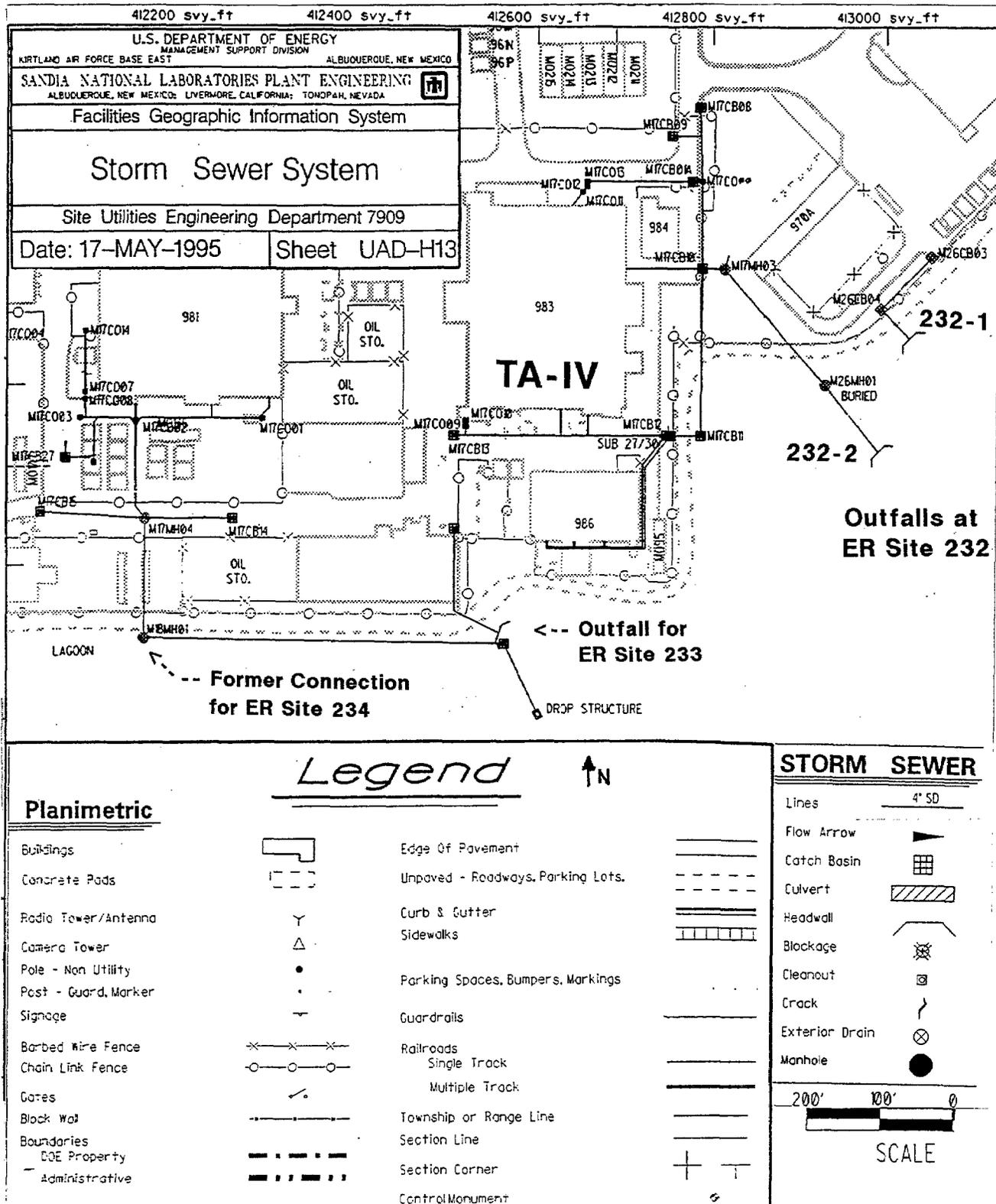


Figure 2-1
TA-IV Storm-Water System at ER Site 232

3.0 EVALUATION OF RELEVANT EVIDENCE

3.1 Unit Characteristics and Operating Practices

The two outfalls were built in 1986 and are intended to reduce the amount of soil erosion caused by storm water. Discharge of storm water only occurs several days per year. Because no process or waste waters flow into the outfalls, waste generation logs are not maintained by the TA-IV facility. However, National Pollutant Discharge Elimination System (NPDES) monitoring is conducted for the TA-IV outfalls and is discussed below.

When the two outfalls were listed as ER Site 232, the potential COCs were considered to be chromium, sodium hydroxide, hydrochloric acid, diesel fuel, mineral oil, and antifoulants (chromates and chromosulfuric acid). This list of potential COCs was conservatively based upon chemicals used at TA-IV. Prior to June 1, 1994, no chemical releases had occurred in the area that drains to either of the ER Site 232 outfalls. Likewise, no stained soil or stressed vegetation had been documented at ER Site 232.

To date, no chemical spills have occurred in the area that drains to Outfall 232-1. However, one spill of approximately 150 to 300 gallons of mineral oil has discharged from Outfall 232-2. This is the only RQ-size spill that has occurred in the areas that drain to either outfall.

The mineral oil spilled at Outfall 232-2 was Shell Oil product Diala Oil AX. Diala Oil AX is used as a transformer oil in the TA-IV accelerators and is also known at SNL/NM by the name HERMES oil. HERMES oil is a mineral oil (hydrocarbon distillate) that primarily consists of a mixture of aliphatic and alicyclic hydrocarbons and contains no significant quantities of EPA-regulated hazardous constituents such as polychlorinated biphenyls (PCB) or volatile organic compounds (VOC) (SNL/NM 1996).

Because research operation began in 1980, TA-IV is the newest SNL technical area and has always operated using modern environmental, safety, and health procedures and considerations. Approximately 750 people work at the 83-acre facility. The principal mission for TA-IV is the research, development, and testing of pulsed power technology. Other activities include computer science, flight dynamics, satellite processing, and robotics. Major facilities include the SATURN x-ray facility, the High Energy Radiation Megavolt Electron Source-III (HERMES-III) gamma-ray facility, and the Particle Beam Fusion Accelerator-II. Other smaller facilities include the Rocket Systems and Flight Dynamic Laboratory, the Payload and Satellite Processing Facility, the Parallel Computing Science Laboratory, the Robotics Laboratory, and seven small accelerators.

No ER sites are located within the TA-IV fence. Likewise, no septic tanks have been used at TA-IV. However, 21 above-ground storage tanks (AST) and underground storage tanks (UST) have been used, primarily for storing dielectric oil. Only ASTs are still in use at TA-IV. These 20 tanks store dielectric oil, acids, caustics, and deionized water. No USTs are currently registered with the New Mexico Environment Department (NMED). A fuel-oil UST (970-1) was removed in 1994; no soil contamination was present.

The SNL/NM Storm Water Program is responsible for measuring and reporting storm-water quality associated with storm-water outfalls located across SNL/NM. The storm-water results are reported annually in the Site Environmental Report (SNL/NM 1996b). In accordance with NPDES requirements, SNL/NM submitted an *Application For Permit to Discharge Stormwater - Discharges Associated with Industrial Activity* (SNL/NM 1992) to EPA Region VI in 1992. Due to workload constraints, the EPA has not acted on the permit. In 1996, SNL/NM submitted a multisector permit to the EPA for their approval with State of New Mexico review and concurrence.

Five storm-water outfalls (ER Sites 230, 231, 232, 233, and 234) are located along the steep northern rim of Tijeras Arroyo at the eastern and southern edges of TA-IV. Even though no releases had occurred, the five TA-IV outfalls were added to the ER site list in 1993 as a conservative measure. The SNL/NM ER Project considered the potential COCs in soil at ER Sites 230, 231, 232, 233, and 234 to be chromates, chromium, sodium hydroxide, hydrochloric acid, diesel fuel, petroleum products, and mineral oil.

According to NPDES guidance, only one of the TA-IV outfalls requires monitoring because all the TA-IV outfalls receive storm water from similar sources (Fink 1996). NPDES monitoring is conducted at Outfall 6, which is a catch basin that is located about 50 ft upslope of ER Site 233. During the period of April 7 to December 31, 1995, an automatic flow meter recorded storm-water flows on ten different days. Due to infrequent precipitation that rarely produces sufficient volumes of water for sampling purposes, only two water samples (July 31 and September 15, 1992) have been collected at Outfall 6 (SNL/NM 1992). Except for manganese, total dissolved solids, and coliform, the quality of storm water was better than the federal standards for drinking water (Table 3-1). Manganese was reported at 0.24 milligrams per liter (mg/L) (parts per million [ppm]) which is above the Secondary Maximum Contaminant Level (SMCL) of 0.05 mg/L (ppm). It should be noted that the metal analyses were total values, not the dissolved values that are typically compared to drinking water standards.

Two evaporative lagoons (impoundments) are located at TA-IV and both serve similar functions. The primary purpose of the two lagoons is to store surface-water runoff from precipitation that collects in the sumps of the outdoor transformer-oil tank farm spill-containment areas (SNL/NM 1995a). Both lagoons are lined with synthetic geotextile membranes. Surface-water runoff is pumped to the lagoons by manually operated sump pumps. If visible oil is present in the sumps, a manually operated skimmer is used to transfer the skimmed oil to an oil storage tank. Lagoon #1 (ER Site 77) is located to the south of TA-IV and also receives nonroutine water and transformer oil spills from floor trenches in Buildings 981 and 983. The capacity of Lagoon #1 is 137,000 gallons. Lagoon #2 is located in the eastern part of TA-IV and also receives nonroutine water and transformer oil spills from floor trenches in Building 970. The capacity of Lagoon #2 is 127,000 gallons.

Table 3-1
 Comparison of Federal Drinking Water Standards to Maximum Concentrations Present in
 Storm-Water Composite Samples Collected at NPDES Outfall 6 (Catch Basin Above
 ER Site 233) on July 31 and September 15, 1992 (SNL/NM, 1992)

Analyte	Maximum Concentration of Flow-Weighted Composite Samples, mg/L (ppm)	Lowest MCL, MCLG, or SMCL, mg/L (ppm)	EPA Method
Arsenic, total	<0.0050	0.050	206.2
Barium, total	0.099	2.0	200.7
Cadmium, total	<0.0050	0.005	213.2
Chromium, total	<0.010	0.1	218.2
Copper, total	0.025	1.0	200.7
Lead, total	0.0067	0.015	239.2
Manganese, total	0.24	0.05	200.7
Mercury, total	<0.00080	0.002	245.1
Nickel, total	<0.040	0.1	200.7
Selenium, total	<0.010	0.05	270.2
Silver, total	<0.010	0.1	200.7
Zinc, total	0.20	5.0	200.7
BOD	62.8	n.s.	405.1
COD	422.0	n.s.	410.0
Cyanide	<0.010	n.s.	335.2
Fluoride	0.17	2.0	340.2
Gross alpha	1±6 pCi/L	0 pCi/L	900.0/7110B
Gross beta	10±3 pCi/L	0 mrem	900.0/7110B
HPLC explosives	<0.0032	0.0032	8330
Nitrate + nitrite	2.7	10.0	353.2
Oil and grease	3.2	n.s.	413
Orthophosphate	<0.050	n.s.	614
PCBs	<0.005	0.005	8080
Phenolics	0.048	n.s.	8040
Phosphorous as P	0.060	n.s.	365.3
Residual chlorine	1.9	n.s.	330
SVOCs	<0.085	0.085	8270
TDS	440.0	250.0	160.1
TKN	5.8	n.s.	351
Total coliform	4,000 cf/100mL	0 cf/100mL	9230
TSS	56.0	n.s.	160.2
VOCs	<0.005	n.s.	8240

All water analyses performed by the Quanterra Environmental Services, Inc., laboratory.

BOD = Biochemical oxygen demand.

cf/100mL = Colonies per 100 milliliter of water.

COD = Chemical oxygen demand.

Drinking Water Standards: MCL = Maximum Contaminant Level; MCLG = Maximum Contaminant Level Goal; SMCL = Secondary Maximum Contaminant Level (EPA 1996). The lead value is an action level.

EPA = U.S. Environmental Protection Agency.

HPLC = High performance liquid chromatography.

mg/L = Milligram(s) per liter (ppm).

mrem = Millirem(s).

n.s. = Not specified (EPA 1996).

pCi/L = Picocurie(s) per liter.

PCBs = Polychlorinated biphenyls.

ppm = Part(s) per million.

SVOC = Semivolatile organic compound(s).

TDS = Total dissolved solids.

TKN = Total Kjeldahl nitrogen.

TSS = Total suspended solids.

VOCs = Volatile organic compounds. The reported concentrations of VOCs (2-hexanone at 0.011 mg/L (ppm), 2-butanone at 0.046 mg/L (ppm), and acetone at 0.0723 and 0.110 mg/L (ppm) are considered suspect because all three VOCs are common laboratory contaminants (Bleyler 1988).

The lagoons are regulated by NMED under "Surface Water Discharge Plan 530" (DP-530). The SNL/NM Water Quality Program conducts semiannual inspections that include the measurement of the water levels and the collection of water samples. To date, water has not overflowed onto the ground surface. The water is analyzed for major ions, total dissolved solids (TDS), volatile organics, and extractable organics. Water quality results have not necessitated the pumping of the water for off-site disposal. NMED inspected the surface impoundments twice during 1995; no deficiencies were noted. The SNL/NM Water Quality Program submits a lagoon-monitoring report to NMED on a semiannual basis. The report includes water level measurements and analytical data for the storm water.

3.2 Results of SNL/NM ER Project Sampling/Surveys

This section discusses the various types of environmental investigations that have been conducted at ER Site 232.

3.2.1 Summary of Prior Investigations

The following sources of information, presented in chronological order, were used to evaluate ER Site 232:

- Annual *Site Environmental Reports* from 1985 to the present
- SNL/NM Facilities Engineering Drawings
- Unexploded Ordnance/High Explosive (UXO/HE) Survey
- Radiological Survey
- Cultural-Resources Survey
- Sensitive-Species Survey
- TA-IV Environmental Assessment
- Voluntary Corrective Measure (VCM) and Confirmatory Sampling at Outfall 232-2
- Confirmatory Sampling at Outfall 232-1
- Photographs and field notes collected by the SNL/NM ER staff

3.2.2 UXO/HE Survey

A visual survey for UXO/HE material was conducted in 1994. No UXO/HE materials were present at ER Site 232 (SNL/NM 1994a).

3.2.3 Radiological Survey

In 1994, a surface scan for beta-gamma radiation was conducted using a gamma scintillometer (Eberline ESP2 portable scaler with SPA-8 sodium-iodide probe) and a beta-gamma detector (ASP-1 with HP260 Geiger-Mueller Pancake Probe). No beta or gamma anomalies (defined as more than 30 percent above natural background) were found.

3.2.4 Cultural-Resources Survey

The potential for cultural resources has been evaluated for ER Site 232. A 100-percent coverage pedestrian survey was conducted by an archaeologist in 1994. No cultural resources were evident in the vicinity of the outfalls (Hoagland 1994).

3.2.5 Sensitive-Species Survey

Three biological surveys have been conducted in the vicinity of ER Site 232. IT Corporation (IT) has conducted two surveys (IT 1994), and an additional biological survey was conducted as part of the "Environmental Assessment for Operation, Upgrades, and Modifications in SNL/NM Technical Area IV" (SNL/NM 1996c). The location of ER Site 232 along the northern rim of Tijeras Arroyo is in the vicinity of TA-I, TA-II, TA-IV, Pennsylvania Avenue, a skeet range, KAFB Landfill 8, and the Albuquerque International Sunport. The vicinity of ER Site 232 has been significantly disturbed by construction activities; no undisturbed natural habitat remains. Vegetation is limited to scattered ruderal plants. Sufficient food, water, and cover are not available to support wildlife. No federally listed endangered or threatened species (plants or animals) or state-listed endangered wildlife species (Group 1 or Group 2) are known to occur within the vicinity of TA-IV. No natural water bodies or wetlands are present, and all surface-water flows are intermittent and occur only during periods of precipitation. Therefore, the potential impact of soil contamination upon biological resources is negligible.

3.2.6 Scoping Sampling

Scoping sampling was not performed at ER Site 232 because the site was thoroughly sampled before the SNL/NM ER Project initiated the scoping-sampling program.

In 1994, the soil around both outfalls was sampled for all relevant COCs. Outfall 232-1 has been sampled for the conservative list of COCs discussed in Section 3.1. Outfall 232-2 has been sampled for both the conservative list of COCs and for HERMES oil. Sodium hydroxide and hydrochloric acid were not considered to be COCs for the remainder of this NFA because these chemicals were not expected to persist in the environment due to the buffering capacity of the soil. Soil sampling has demonstrated such buffering capacity along the TA-1 acid-waste line (SNL/NM, 1995b). The sampling results for Outfalls 232-2 and 232-1 are discussed below in Sections 3.2.7 and 3.2.8, respectively.

3.2.7 VCM and Confirmatory Sampling at Outfall 232-2

In June 1994, SNL/NM implemented a VCM to remediate the oil spill at Outfall 232-2. The VCM involved soil sampling and the excavation of oil-contaminated soil.

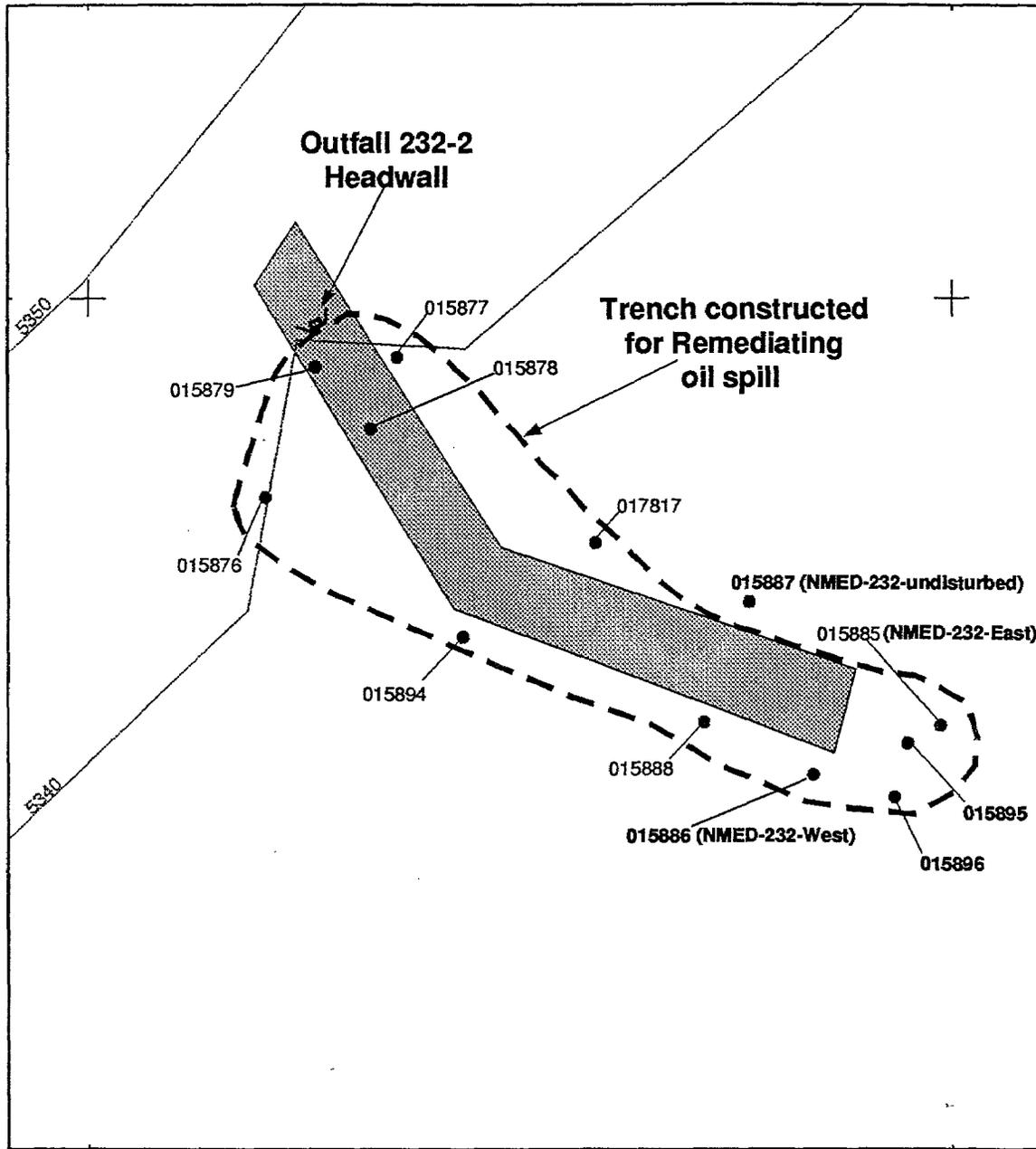
As mentioned previously, approximately 150 to 300 gallons of mineral oil was discharged from Outfall 232-2 in June 1994. The resulting oil-stained area down slope of Outfall 232-2 was about 50 ft long with a width that varied from about 3 to 5 ft. The day after the spill, the Outfall 232-2 area was screened for UXO/HE and beta-gamma radiation anomalies. No UXO/HE material was evident (SNL/NM 1994a). A surface radiation survey was conducted using a gamma scintillometer (Eberline ESP2 portable scaler with SPA-8 sodium-iodide probe) and a beta-gamma detector (ASP-1 with HP260 Geiger-Mueller Pancake Probe). A 30-second integrated count was performed at each sampling location. No beta or gamma activity more than 30 percent above natural background was found (SNL/NM 1994b). For additional radiological characterization, three soil samples were collected on the site and a fourth soil sample was collected approximately 10 ft from the outfall drainage to represent background. Gamma spectroscopy was run on these four soil samples (RPO-1, RPO-2, RPO-3, and RPO-4) by the SNL/NM Radiation Protection Operation Department laboratory. No radioactive contamination was evident (SNL/NM 1994b).

Although mineral oil is not a RCRA hazardous waste or a RCRA hazardous substance, cleanup of the oil spill was required under the provisions of the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 300). With the depth to groundwater being approximately 275 ft at ER Site 232, the cleanup goal for the removal of oil-contaminated soil was 100 milligrams per kilogram (mg/kg) (ppm) (Brinkman 1994).

The VCM was conducted in July through November of 1994 to remove soil contaminated with mineral oil above 100 mg/kg (ppm) total petroleum hydrocarbons (TPH). The contaminated soil was removed with a backhoe and stored in Wrangler bags or roll-off bins. The resulting trench began at the headwall (i.e., the outlet of the cement culvert) and proceeded southeastward for about 75 ft (Figure 3-1). The average depth of the trench was about 5 ft. At the headwall, the trench was excavated to a depth of about 9 ft. The southern end of the ditch varied in depth from about 4 to 10 ft. The final width of the trench varied from 15 to 30 ft.

Five methods were used to verify that the cleanup goal was reached:

- Visual observation of oil-stained soil
- The use of a Hanby immunoassay kit
- Real-time monitoring with an FID
- On-site analyses of soil samples by the Environmental Restoration Chemistry Laboratory (ERCL)



Legend

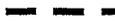
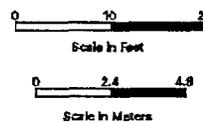
-  Verification Soil Sample Location
-  Headwall for Outfall 232-2
-  20 Foot Contour (ft, msl)
-  Remediation Trench
-  ER Site 232-2

Figure 3-1
ADS 1309 ER Site 232
Verification (post remediation)
Soil Sampling Locations
at Outfall 232-2



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- Analyses of soil samples by two off-site laboratories (Analytical Technologies, Inc. [ATI], and Enseco-Quanterra).

The trench was progressively enlarged until all the oil-stained soil was removed. A total of 79 soil samples were analyzed by immunoassay and flame ionization detection (FID). To facilitate the excavation work, 29 soil samples also were analyzed on a 24-hour basis at the ATI laboratory in Albuquerque. Nine soil samples were also submitted to the Enseco-Quanterra laboratory. Table 3-2 lists the combined analytical results for the 38 soil samples sent to the Enseco-Quanterra and ATI laboratories.

The total amount of excavated soil was approximately 429 cubic yards. The soil was disposed of off-site after being determined to be a nonregulated substance and not a RCRA hazardous waste or a radioactive waste. The soil was shipped to the United States Pollution Control Inc. - Grassy Mountain facility at Clive, Utah.

For verification purposes, both SNL/NM and NMED personnel collected confirmatory soil samples along the edges and floor of the trench (Figure 3-2). The 12 samples collected by SNL/NM personnel were analyzed for TPH and RCRA metals by the Enseco-Quanterra laboratory. TPH was not reported in 11 of the 12 samples above the detection limit of 20 mg/kg (ppm) (Table 3-3). One sample had a TPH concentration of 31.6 mg/kg (ppm). The metal concentrations for the SNL/NM-collected samples are discussed further in Section 3.4.1, Risk Evaluation.

The three verification split-soil samples collected by NMED are NMED 232-east/SNL/NM 015885, NMED 232-west/SNL/NM 015886, and NMED 232-undisturbed/SNL/NM 015887 (Figure 3-2). The NMED Laboratory in Santa Fe analyzed the samples for VOCs and SVOCs by EPA Methods 8240 and 8270, respectively (NMED 1996). No VOCs were detected above the detection limit of 0.050 mg/kg (ppm). No SVOCs were detected above the detection limits of 0.17 or 0.85 mg/kg (ppm). The NMED Laboratory in Santa Fe also analyzed the split-soil samples for metals. As shown in Table 3-4, the maximum NMED-reported metal concentrations compared favorably with the Enseco-Quanterra laboratory results. For example, the NMED laboratory-reported arsenic concentration of 2.3 mg/kg (ppm) was similar to the Enseco-Quanterra laboratory-reported concentration of 2.1 mg/kg (ppm).

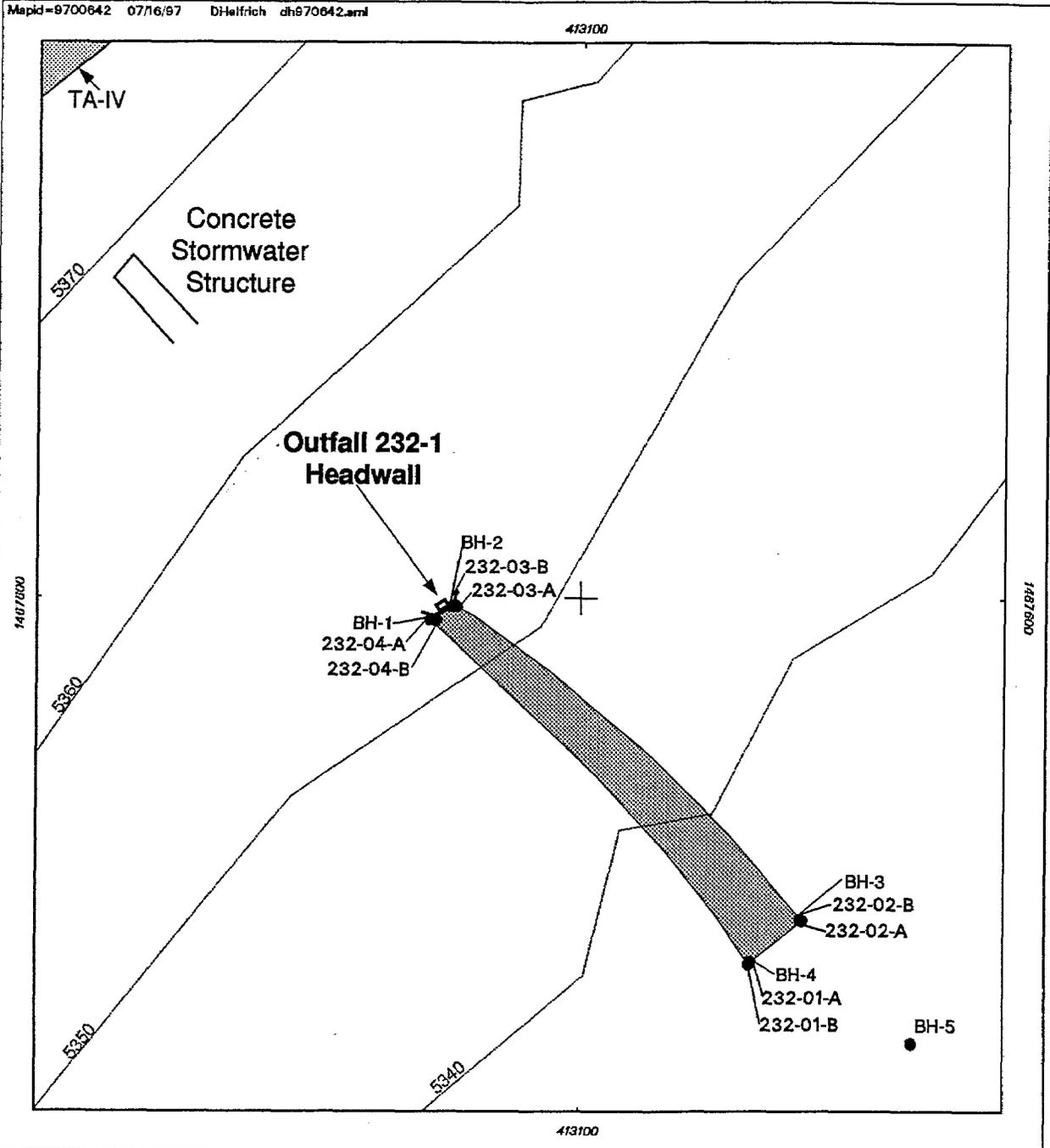
Radiological analyses were also performed by the NMED Laboratory using EPA Method 900.0/9310 on the three split samples (two trench samples and one undisturbed sample) and an additional undisturbed-duplicate sample. The two trench samples had gross alpha activities that ranged from 2.11 to 2.15 picocuries per liter (pCi/L). The two undisturbed-soil samples had gross alpha activities that ranged from 2.47 to 3.32 pCi/L. The trench samples had gross beta activities that ranged from 2.54 to 3.49 pCi/L. The undisturbed-soil samples had gross beta activities that ranged from 3.07 to 4.06 pCi/L. No radiological contamination was evident because the trench-soil samples yielded activities that were below or within the range of the undisturbed-soil sample activities (NMED 1996b).

Table 3-2
TPH Analytical Results for Soil Samples Collected During and
After the Soil-Excavation VCM at Outfall 232-2

Sample Number	Sample Date	Sample Description	TPH Concentration, mg/kg (ppm)	Sample Purpose	Analytical Laboratory
015861	7/18/94	'hot' spot at culvert	16,000	D	ATI
015862	7/18/94	'clean' spot at culvert	370	D	ATI
015863	7/20/94	5 ft north of bend - west	<20	D	ATI
015864	7/20/94	5 ft north of bend - east	<20	D	ATI
015865	7/20/94	5 ft north of bend - bottom	<20	D	ATI
015866	7/20/94	at bend - east	<20	D	ATI
015867	7/20/94	at bend - bottom	6,100	D	ATI
015868	7/20/94	at bend - west	830	D	ATI
015869	7/22/94	10 ft south of bend - east	95	D	ATI
015870	7/22/94	10 ft south of bend - west	<20	D	ATI
015871	7/22/94	10 ft south of bend - bottom	<20	D	ATI
015872	8/1/94	underneath culvert	<20	D	ATI
015873	8/2/94	at culvert - 9 ft deep, 15 ft wide-bottom	<20	D	ATI
015874	8/2/94	at culvert - 9 ft deep, 15 ft wide-west	<20	D	ATI
015875	8/2/94	at culvert - 9 ft deep, 15 ft wide-east	<20	D	ATI
015876	8/4/94	west bank by culvert at 9 ft BGL	31.6	V	E-Q
015877	8/4/94	east bank by culvert at 9 ft BGL	<20	V	E-Q
015878	8/4/94	trench floor at north end at 9 ft BGL	<20	V	E-Q
015879	8/4/94	underneath culvert	<20	V	E-Q
015880	8/17/94	end of drainage - east wall	<20	D	ATI
015881	8/17/94	end of drainage - west wall	<20	D	ATI
015882	8/17/94	end of drainage - bottom	<20	D	ATI
015883	9/1/94	west wall - 10 ft north of 015881	<20	D	ATI
015884	9/1/94	east wall - 10 ft north of 015880	<20	D	ATI
017817	9/6/94	east side at 1 ft BGL	<20	V	E-Q
017818	9/7/94	bottom at 8 ft BGL	<20	D	ATI
015885	9/6/94	SE end of trench - bottom at 10 ft BGL	<20	V	E-Q
015886	9/6/94	SE end of trench - bottom at 6 ft BGL	<20	V	E-Q
015887	9/6/94	east side - bottom at 9 ft BGL	<20	V	E-Q
015888	9/6/94	SW wall - bottom at 6.5 ft BGL	<20	V	E-Q
015889	10/20/94	SE portion, near SW wall - bottom at 6 ft BGL	<20	D	ATI
015890	10/26/94	composite: SE end - SE wall at 1-2 ft BGL and SE shallow bench at 3 ft BGL	<20	D	ATI
015891	10/26/94	SE portion near NE wall - bottom at 10 ft BGL	<20	D	ATI
015892	10/26/94	SE portion, near center - bottom at 7 ft BGL	<20	D	ATI
015893	10/26/94	SE portion, SW sidewall at 4 ft BGL	29.0	D	ATI
015894	10/31/94	SW trench floor at 10.5 ft BGL	<20	V	E-Q
015895	10/31/94	SE trench floor at 9.5 ft BGL	<20	V	E-Q
015896	10/31/94	SE end of trench at 3.5 ft BGL	<20	V	E-Q

ATI = Analytical Technologies, Inc., Albuquerque, New Mexico.
BGL = Below ground level.
D = Delineation (sample used for guiding further soil excavation).
E-Q = Enseco-Quanterra in Arvada, Colorado.
mg/kg = Milligram(s) per kilogram.
NE = Northeast.
ppm = Parts per million.
TPH = Total petroleum hydrocarbons.
SE = Southeast.
SW = Southwest.
V = Verification (sample used to confirm that contaminated soil >100 ppm TPH was fully excavated).
VCM = Voluntary corrective measure.

Analytical Method: EPA Method 418.1.



Legend

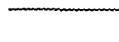
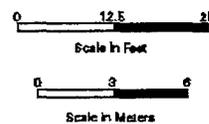
-  Soil Sample Location
-  Headwall for Outfall 232-1
-  10 Foot Contour (ft, MSL)
-  Concrete Stormwater Structure
-  ER Site 232-1

Figure 3-2
ADS 1309 ER Site 232
Soil Sampling Locations
at Outfall 232-1



Sandia National Laboratories, New Mexico
 Environmental Geographic Information System

Table 3-3
RCRA Metal and TPH Analytical Results for the 12 Verification-Soil Samples Collected in the
Trench Below Outfall 232-2 to Confirm that Soil Greater than 100 mg/kg (ppm) of TPH Was Completely Excavated

Sample Number	Sample Date	Sample Location/ Depth (ft BGL)	Concentration in Soil, mg/kg (ppm)								
			TPH	As	Ba	Se	Cd	Ag	Cr	Hg	Pb
015876	8/4/94	West side of trench by culvert/9 ft	31.6	2.4	114.0	<0.5	0.68	<1	7.6	<0.1	4.9
015877	8/4/94	East side of trench by culvert/9 ft	<20.0	2.6	126.0	<0.5	<0.50	<1	6.6	<0.1	4.6
015878	8/4/94	Trench floor at north end of trench/9 ft	<20.0	1.2	153.0	<0.5	<0.50	<1	7.5	<0.1	3.7
015879	8/4/94	Underneath culvert	<20.0	1.4	68.8	<0.5	<0.50	<1	3.5	<0.1	3.3
015885	9/6/94	Southeast end of trench/10 ft	<20.0	1.6	92.8	<0.5	<0.50	<1	5.9	<0.1	5.1
015886	9/6/94	Southeast end of trench/6 ft	<20.0	1.7	89.5	<0.5	<0.50	<1	6.5	<0.1	5.1
015887	9/6/94	East site/9 ft	<20.0	2.1	92.6	0.41 J	<0.50	<1	6.5	<0.1	6.1
015888	9/6/94	Southwest bank near south end of trench/ 6.5 ft	<20.0	0.71 J	101.0	<0.5	<0.50	<1	7.6	<0.1	5.2
017817	9/6/94	East side/1 ft	<20.0	2.3	103.0	<0.5	<0.50	<1	6.5	<0.1	7.3
015894	10/31/94	Southwest trench floor/10.5 ft	<20.0	2.0	134.0	<0.5	<0.50	<1	6.3	<0.1	4.2
015895	10/31/94	Southeast trench floor/9.5 ft	<20.0	2.0	121.0	<0.5	<0.50	<1	5.9	<0.1	3.3
015896	10/31/94	Southeast end of trench/3.5 ft	<20.0	2.4	124.0	<0.5	<0.50	<1	6.6	<0.1	4.7
		Maximum Concentration	31.6	2.6	153.0	0.41 J	0.68	<1	7.6	<0.1	7.3
		Detection Limit	20.0	1.0	1.0	0.5	0.50	1	1.0	0.1	0.30

J = Qualifier denotes that the analyte was reported at a concentration below the laboratory detection limit.

mg/kg = Milligram(s) per kilogram.

ppm = Part(s) per million.

SE = Southeast.

TPH = Total petroleum hydrocarbons.

Analytical Laboratories: Enseco-Quanterra in St. Louis, Missouri.

Analytical Methods: TPH by EPA Method 418.1; Metals by EPA Method 6010 except mercury by EPA Method 7471.

Table 3-4
Concentrations of RCRA Metals, VOCs, and SVOCs in the Three Split-Soil Samples Collected as Verification by SNL/NM and NMED at the Trench Below Outfall 232-2 After the Excavation of Oil-Contaminated Soil

Sample Number	Sample Date	Sample depth (ft BGL)	Concentration in Soil, mg/kg (ppm)									
			As	Ba	Se	Cd	Ag	Cr	Hg	Pb	VOCs	SVOCs
SNL/NM 015885	9/6/94	10	1.6	92.8	<0.5	<0.5	<1	5.9	<0.1	5.1	n.a.	n.a.
NMED 232-east;	9/6/94	10	2.3	98.0	<0.5	<0.5	<1	6.0	<0.2	15.0	<0.050	<0.17 or <0.85
SNL/NM 015886	9/6/94	6	1.7	89.5	<0.5	<0.5	<1	6.5	<0.1	5.1	n.a.	n.a.
NMED 232-west,	9/6/94	6	2.0	98.0	<0.5	<0.5	<1	6.0	<0.2	12.0	<0.050	<0.17 or <0.85
SNL/NM 015887	9/6/94	9	2.1	92.6	0.41J	<0.5	<1	6.5	<0.1	6.1	n.a.	n.a.
NMED 232-undisturbed	9/6/94	9	<0.5	103.0	<0.5	<0.5	<1	6.0	<0.2	16.0	<0.050	<0.17 or <0.85
		Maximum Concentration	2.3	103.0	0.41J	<0.5	<1	6.5	<0.2	16.0	<0.050	<0.17 or <0.85
		Enseco Detection Limit	0.5	1.0	1.0	0.50	1	1.0	0.1	0.30	0.050	<0.17 or <0.85
		NMED Detection Limit	0.5	1	0.5	0.5	1	1	0.2	5	n.a.	n.a.

BGL = Below ground level.

EPA = U.S. Environmental Protection Agency.

mg/kg = Milligram(s) per kilogram.

n.a. = Not analyzed.

NMED = New Mexico Environment Department.

ppm = Parts per million.

SNL/NM = Sandia National Laboratories/New Mexico.

SVOC = Semivolatile organic compounds(s)

VOC = Volatile organic compound(s).

Analytical Laboratories: Enseco-Quanterra in Arvada, Colorado for samples collected by SNL/NM; NMED laboratory in Santa Fe for samples collected by NMED.

Analytical Methods for Enseco-Quanterra: EPA Method 6010 for all metals, except EPA Method 7471 for mercury.

Analytical Methods for NMED: EPA Method 6010 for all metals, except EPA Method 7471 for Hg and EPA Method 7060 for As. EPA Method 8240 for VOCs and EPA Method 8270 for SVOCs.

Sample splits (duplicates): SNL/NM 015885 = NMED 232-east; SNL/NM 015886 = NMED 232-west, SNL/NM 015887 = NMED 232-undisturbed.

Based on the chemical analyses of the verification samples (Table 3-2) all of the mineral-oil contamination greater than the 100 mg/kg (ppm) cleanup goal was successfully excavated. Thus, Outfall 232-2 poses no significant risk to human health or the environment. Section 3.4.1, Risk Evaluation, summarizes the risk assessment discussion for metals, VOCs, SVOCs, and radionuclides that is presented in Section 6.1.

At the conclusion of the VCM field activities, the drainage below the outfall was backfilled with soil and the preexcavation grade was reestablished.

See Section 3.2.9 for a summary of quality assurance/quality control (QA/QC) results relevant to sampling at Outfall 232-2.

3.2.8 Confirmatory Sampling at Outfall 232-1

Two soil sampling investigations, September 1994 and September 1995, were conducted at Outfall 232-1. The first investigation collected eight soil samples with four surface (0 to 6 inches) and four shallow-subsurface (6 to 36 inches) soil samples being collected at the most likely locations of contamination. Four of these eight samples (232-03-A, 232-03-B, 232-04-A, and 232-04-B) were collected next to the headwall outfall pipe with the other four samples (232-01-A, 232-01-B, 232-02-A, and 234-02-B) collected at the farthest extent of visible erosion and scour (Figure 3-2).

Table 3-5 lists the maximum metal concentrations in the Outfall 232-1 soil samples. The metal concentrations are discussed further in Section 3.4, Risk Evaluation.

Table 3-6 compares the maximum radionuclide activities in Outfall 232-1 soil. Two samples, 232-01-A and 232-03-A were analyzed by the Enseco-Quanterra Laboratory and had similar background levels as the four samples (232-01-A, 232-01-B, 232-03-A, and 232-03-B) that were analyzed by the Radiation Protection Sample Diagnostics laboratory. The radionuclides are discussed further in Section 3.4, Risk Evaluation.

Table 3-7 contains all reported concentrations, including "J" and "B" values, for both VOCs and SVOCs. No VOC or SVOC contamination was detected in the Outfall 232-1 soil samples. One organic compound was reported with qualification. Four soil samples had 2-butanone concentrations of 0.004 mg/kg (ppm) but had both "J" and "B" qualifiers as being below the laboratory reporting limit, and being detected in the associated blank sample, respectively. The reported bis(2-ethylhexyl)phthalate concentration of 2.5 mg/kg (ppm) was a "B" value. Both 2-butanone and phthalates are common laboratory contaminants (Bleyler 1988).

As shown in Table 3-8, the soil samples from the first investigation contained TPH concentrations that ranged from <50 mg/kg (ppm) to a maximum of 860 mg/kg (ppm). TPH was detected in five of the eight samples at depths of 0.5 to 3 ft. The four samples (232-03-A, 232-03-B, 232-04-A, and 232-04-B) collected near the headwall contained TPH concentrations ranging from 430 to 860 mg/kg (ppm). The two highest TPH concentrations, both at 860 mg/kg (ppm), were present in the surface soil samples 232-03-A and 232-04-A. The two lesser concentrations of 430 and 560 mg/kg (ppm) were from samples (232-03-B and 232-04-B)

Table 3-5
Concentrations of RCRA Metals in Soil Samples Collected at Outfall 232-1

Sample Number	ER Sample ID	Sample Date	Sample Depth (ft BGL)	Concentration in Soil, mg/kg (ppm)								
				As	Ba	Se	Cd	Ag	Cr	Cr-VI	Hg	Pb
017890-2	232-01-A	9/22/94	0.0 - 0.5	5.1	130	<0.25	2.2	<0.5	6.3	<0.10	<0.04	6.2
017890-7	232-01-B	9/22/94	0.5 - 3.0	1.0	140	<0.25	1.6	<0.5	4.0	<0.10	<0.04	6.0
017891-2	232-02-A	9/22/94	0.0 - 0.5	1.1	180	<0.25	2.0	<0.5	5.3	<0.10	<0.04	9.4
017891-5	232-02-B	9/22/94	0.5 - 3.0	0.98	150	<0.25	1.6	<0.5	5.0	<0.10	<0.04	9.2
017892-2	232-03-A	9/22/94	0.0 - 0.5	1.8	200	<0.25	3.1	<0.5	7.8	<0.10	<0.04	11.0
017892-7	232-03-B	9/22/94	0.5 - 3.0	1.4	170	<0.25	2.0	<0.5	6.6	<0.10	<0.04	6.9
017893-2	232-04-A	9/22/94	0.0 - 0.5	1.3	190	<0.25	2.7	<0.5	5.4	<0.10	<0.04	8.3
017893-5	232-04-B	9/22/94	0.5 - 3.0	1.6	290	<0.25	2.3	<0.5	7.6	<0.10	<0.04	9.8
			Maximum concentration	5.1	290	<0.25	3.1	<0.5	7.8	<0.10	<0.04	11.0
			Detection limit	0.50	10	0.25	0.25	1.2	1.0	0.10	0.04	2.0

3-14

BGL = Below ground level.

ER = Environmental restoration.

EPA = U.S. Environmental Protection Agency.

mg/kg = Milligram(s) per kilogram.

ppm = Part(s) per million.

Analytical Laboratory: ENCOTEC in Ann Arbor, Michigan.

Analytical Methods: EPA Method 7471 for Hg, EPA Method 6020 for As, EPA Method 7196 for Cr-VI, and EPA Method 6010 for all other metals.

Table 3-6
Activity of Radionuclides Detected in Soil Samples Collected at Outfall 232-1

Sample Number	ER Sample ID	Sample Date	Sample Depth (ft BGL)	Activity in Soil, pCi/g					
				Pu-238	Pu-239/240	Tritium	U-234	U-235	U-238
017890-4	232-01-A	9/22/94	0 - 0.5	0.001 ± 0.004	0.000 ± 0.000	0.004 ± 0.007	1.07 ± 0.19	0.11 ± 0.06	0.77 ± 0.15
017892-4	232-03-A	9/22/94	0 - 0.5	n.v.	n.v.	0.011 ± 0.017	n.v.	n.v.	n.v.
Analytical Method	n.r.	n.r.	n.r.	SL13028/ SL13033	SL13028/ SL13033	EERF H.01	NAS-NS- 3050	NAS-NS- 3050	NAS-NS- 3050
Minimum Detectable Activity	n.a.	n.a.	n.a.	0.008	0.009	0.011	0.04	0.03	0.03

BGL = Below ground level.

ER = Environmental restoration.

n.a. = Not applicable

n.v. = No value. Analysis was not performed.

n.r. = Not relevant.

pCi/g = Picocurie(s) per gram.

Analytical Laboratory: Enseco - Quanterra in St. Louis, Missouri.

Table 3-7
All Reported VOC and SVOC Concentrations in the Eight Soil Samples Collected at
Outfall 232-1 During the First Soil-Sampling Investigation

Sample Number	ER Sample ID ¹	Sample Date	Sample Depth (ft BGL)	Concentration in Soil, mg/kg, (ppm)	
				2-butanone	Bis(2-ethylhexyl) phthalate
017890-5	232-01-B	9/22/94	0.5 - 3.0	0.004 BJ	N.A
017891-3	232-02-B	9/22/94	0.5 - 3.0	0.004 BJ	N.A
017892-5	232-03-B	9/22/94	0.5 - 3.0	0.004 BJ	N.A
017893-3	232-04-B	9/22/94	0.5 - 3.0	0.004 BJ	N.A
017890-1	232-01-A	9/22/94	0.0 - 0.5	N.A.	n.r.
017891-1	232-02-A	9/22/94	0.0 - 0.5	N.A.	n.r.
017893-2	232-04-A	9/22/94	0.0 - 0.5	N.A.	n.r.
017892-1	232-03-A	9/22/94	0.0 - 0.5	<0.010	2.5 B
Detection limit	n.a.	n.a.	n.a.	0.010	0.330
Analyte suite	n.a.	n.a.	n.a.	VOC	SVOC

¹Sample ID: First set of numbers denotes ER Site, second set of numbers denotes sample location, letter designator denotes sample depth (A denotes sample depth of 0 - 6 inches; B denotes sample depth of 6 - 36 inches).

B = Qualifier denotes that the analyte was measured in the associated blank sample.

BGL = Below ground level.

EPA = U.S. Environmental Protection Agency.

J = Qualifier denotes that the analyte was reported at or below the laboratory detection limit.

mg/kg = Milligram(s) per kilogram.

n.a. = Not applicable.

N.A. = Not analyzed.

N.R. = Concentration was not reported as a detection.

ppm = Part(s) per million.

SVOC = Semivolatile organic compound(s) (EPA Method 8270).

VOC = Volatile organic compound(s) (EPA Method 8240).

Analytical Laboratory: ENCOTEC in Ann Arbor, Michigan.

Note: Only five of the eight samples had reported VOC or SVOC concentrations.

Table 3-8

TPH Analytical Results for Soil Samples Collected at Outfall 232-1 During the First and Second Soil-Sampling Investigations

Sample Number	Off-Site Sample Number	Investigation	Sample Date	Sample Depth (ft BGL)	Sample Location Relative to Outfall	TPH Concentration, mg/kg (ppm)	Analytical Laboratory
232-01-A	017890-1	First	9/22/94		Southwest corner	88	ENCOTEC
232-01-B	017890-6	First	9/22/94	3	Southwest corner	<50	ENCOTEC
BH-4-6	n.a.	Second	9/12/95	6	Southwest corner	15	ERCL
BH-4-10	n.a.	Second	9/12/95	10	Southwest corner	11	ERCL
232-02-A	017891-1	First	9/22/94	0.5	Southeast corner	<50	ENCOTEC
232-02-B	017891-4	First	9/22/94	3	Southeast corner	<50	ENCOTEC
BH-3-5	n.a.	Second	9/12/95	5	Southeast corner	32	ERCL
BH-3-10	n.a.	Second	9/12/95	10	Southeast corner	13	ERCL
232-03-A	017892-1	First	9/22/94	0.5	Northeast corner	860	ENCOTEC
232-03-B	017892-6	First	9/22/94	3	Northeast corner	430	ENCOTEC
BH-2-5	n.a.	Second	9/13/95	5	Northeast corner	8	ERCL
BH-2-10	n.a.	Second	9/13/95	10	Northeast corner	6	ERCL
BH-2-10d	026145-01	Second	9/13/95	10-duplicate	Northeast corner	<10	Core Labs - Denver
232-04-A	017893-1	First	9/22/94	0.5	Northwest corner	860	ENCOTEC
232-04-B	017893-4	First	9/22/94	3	Northwest corner	560	ENCOTEC
BH-1-5	n.a.	Second	9/13/95	5	Northwest corner	7	ERCL
BH-1-10	n.a.	Second	9/13/95	10	Northwest corner	7	ERCL
BH-1-10d1	n.a.	Second	9/13/95	10-duplicate	Northwest corner	6	ERCL
BH-1-10d2	026144-01	Second	9/13/95	10-duplicate	Northwest corner	<10	Core Labs - Denver
BH-5-5	n.a.	Second	9/12/95	5	30 feet southeast of site	17	ERCL
BH-5-10	n.a.	Second	9/12/95	10	30 feet southeast of site	13	ERCL

ERCL = SNL/NM Environmental Restoration Chemistry Laboratory at Building 6540.

mg/kg = Milligram(s) per kilogram.

n.a. = not applicable.

ppm = Parts per million.

SNL/NM = Sandia National Laboratories/New Mexico.

TPH = Total Petroleum Hydrocarbons.

Analytical Methods: ENCOTEC - EPA Method 418.1; Core Labs - EPA Method 418.1; ERCL - Method Thermal Desorption/Gas Chromotography.

collected at a depth of about 3 ft. Sample 232-01-A was collected from the ground surface at the farthest extent of visible scour and contained a TPH concentration of 88 mg/kg (ppm).

A second investigation was subsequently implemented at Outfall 232-1 to define the extent of the TPH in soil. Samples were collected at greater depths from five GeoProbe™ spots (BH-1, BH-2, BH-3, BH-4, and BH-5), which were placed at the same four sample locations as the first investigation and one additional location farther down slope (Figure 3-2). Soil samples were collected at depths of 5, 6, and 10 ft. As shown in Table 3-8, the 13 soil samples from the second investigation contained TPH concentrations that ranged from 6 to 32 mg/kg (ppm). Two duplicate soil samples (026144-01/BH-1-10d2 and 026145-01/BH-2-10d) were analyzed by both ERCL and Core Laboratories. The TPH results were similar for the two laboratories. For example, ERCL reported 6 mg/kg (ppm) of TPH for sample BH-2-10, while Core Laboratories reported a non-detect TPH concentration (<10 mg/kg [ppm]).

The first and second investigations show that soil containing TPH concentrations above 100 mg/kg (ppm) is limited to the immediate vicinity of the Outfall 232-1 headwall. TPH concentrations decreased both with depth and down slope. TPH concentrations above 100 mg/kg (ppm) were restricted to soil samples collected next to the headwall at depths of 3 ft or less. According to NMED UST regulations (NMED 1990), the maximum TPH concentration of 880 mg/kg (ppm) appears to be insignificant because the depth to groundwater at ER Site 232 is 275 ft. Due to the limited extent of TPH contamination and relatively low concentrations, TPH does not appear to pose a significant risk to either human health or the environment at Outfall 232-1. The significance of COCs in soil is discussed further in Section 3.4, Risk Evaluation.

3.2.9 Quality Assurance/Quality Control Results

Table 3-9 shows that a total of 136 soil-sample fractions were analyzed for ER Site 232. Forty-three soil samples were analyzed for Outfall 232-1, whereas 93 soil samples were analyzed for Outfall 232-2.

For the soil sampling at the two outfalls, both laboratory and field QA/QC samples were collected and analyzed to evaluate the validity of the analytical data. Table 3-10 presents a summary of the QA/QC procedures and results that are discussed in the following subsections. Original laboratory reports are available for review in Excel™ format at the Environmental Operations Records Center in Building 6584.

3.2.9.1 Laboratory QA/QC Results

Internal laboratory QA/QC procedures varied between the laboratories and included method blanks, matrix spikes (MS), matrix spike duplicates (MSD), duplicate control samples, single control samples (SCS), laboratory control samples (LCS), laboratory control sample duplicates (LCSD), replicates, calibration blanks, and LCS recovery samples. These QA/QC samples were evaluated using relative percent difference (RPD), percent recovery, and LCS recovery criteria. All reported data was within QA/QC control limits. Table 3-10 lists the QA/QC results by laboratory and analytical method. The QA/QC process is also discussed below in further detail.

Table 3-9
 Total Number of Analyses for Soil-Sample Fractions Collected at Outfall 232-1,
 Outfall 232-2, and ER Site 232

	VOCs	SVOCs	TPH	Metals	Radionuclides	Total ¹
Outfall 232-1	4	4	21	8	6	43
Outfall 232-2	11	11	41	15	15	93
Total for ER Site 232	15	15	62	23	21	136

¹Does not include analyses by NMED laboratory.

SVOC = Semivolatile organic compounds.

TPH = Total petroleum hydrocarbon(s).

VOC = Volatile organic compounds.

Table 3-10
 Summary of QA/QC Procedures and Results for Soil Samples Collected at ER Site 232

Sample Number (with alternate ER Sample ID, where applicable)	Outfall	Analytical Laboratory	Analytes and Methods	QA/QC Procedure and Results
017890-2 (232-01-A), 017890-7 (232-01-B), 017891-2 (232-02-A), 017891-5 (232-02-B), 017892-2 (232-03-A), 017892-7 (232-03-B), 017893-2 (232-04-A), 017893-5 (232-04-B)	232-1	ENCOTEC	<ul style="list-style-type: none"> TAL metals by EPA Method 6010 except mercury by EPA Method 7471, arsenic by EPA Method 6020. Chromium-VI by EPA Method 7196. 	<ul style="list-style-type: none"> ENCOTEC utilized method blanks, LCS, and LCSD samples. RPD and percent recovery were within QC limits. SNL/NM SMO compiled DV1 and DV2 checklists; no significant QA/QC problems were noted.
017890-4 (232-01-A), 017892-4 (232-03-A)	232-1	Enseco-Quanterra	<ul style="list-style-type: none"> Plutonium isotopes by Method SL13028/ SL13033. Tritium by EERF H.01. Uranium isotopes by Method NAS-NS-3050. 	<ul style="list-style-type: none"> Enseco-Quanterra utilized method blanks, LCS, MS, and MSD samples. RPD and percent recovery were within QC limits. SNL/NM SMO compiled DV1 and DV2 checklists; no significant QA/QC problems were noted.
017890-3 (232-01-A), 017890-8 (232-01-B), 017892-3 (232-03-A), 017892-8 (232-03-B)	232-1	Radiation Protection Sample Diagnostics - SNL/NM Department 7714	<ul style="list-style-type: none"> Cobalt, cesium, radium, actinium, americium, bismuth, lead, radon, thorium, thallium and uranium isotopes by gamma spectroscopy. 	<ul style="list-style-type: none"> Radiation Protection Sample Diagnostics utilized blank, duplicate, and LCS samples. LCS recovery values were within QA/QC limits.
017890-1 (232-01-A), 017890-5 (232-01-B), 017890-6 (232-01-B), 017891-1 (232-02-A), 017891-3 (232-02-B), 017891-4 (232-02-B), 017892-1 (232-03-A), 017892-1 (232-03-A), 017892-5 (232-03-B), 017892-6 (232-03-B), 017893-1 (232-04-A), 017893-3 (232-04-B), 017893-4 (232-04-B)	232-1	ENCOTEC	<ul style="list-style-type: none"> VOCs by EPA Method 8240. SVOCs by EPA Method 8270. TPH by EPA Method 418.1. 	<ul style="list-style-type: none"> ENCOTEC utilized method blanks, LCS, and LCSD samples. RPD and percent recovery were within QC limits. SNL/NM SMO compiled DV1 and DV2 checklists; no significant QA/QC problems were noted. Trip blank 017990-1 contained no VOCs; no cross contamination was evident.

Refer to footnotes at end of table.

Table 3-10 (Continued)
Summary of QA/QC Procedures and Results for Soil Samples Collected at ER Site 232

Sample Number (with alternate ER Sample ID, where applicable)	Outfall	Analytical Laboratory	Analytes and Methods	QA/QC Procedure and Results
BH-1-10, BH-1-10d1, BH-1-5, BH-2-10, BH-2-5, BH-3-10, BH-3-5, BH-4-10, BH-4-6, BH-5-10, BH-5-5	232-1	ERCL	<ul style="list-style-type: none"> TPH by Method TD/GC. 	<ul style="list-style-type: none"> ERCL utilized replicate and calibration samples. RPD and percent recovery were within QC limits.
026144-01 (BH-1-10), 026145-01 (BH-2-10)	232-1	Core Labs	<ul style="list-style-type: none"> TPH by EPA Method 418.1. 	<ul style="list-style-type: none"> Core Labs utilized method blanks; RPD and percent recovery were within QC limits. SNL/NM SMO compiled DV1 checklist; no significant QA/QC problems were noted.
RPO-1, RPO-2, RPO-3, RPO-4	232-2	Radiation Protection Sample Diagnostics - SNL/NM Department 7714	<ul style="list-style-type: none"> Cobalt, cesium, radium, actinium, americium, bismuth, lead, radon, thorium, thallium and uranium isotopes by gamma spectroscopy. 	<ul style="list-style-type: none"> Radiation Protection Sample Diagnostics utilized blank, duplicate, and LCS samples. LCS recovery was within QA/QC limits.
015861, 015862, 015863, 015864, 015865, 015866, 015867, 015868, 015869, 015870, 015871, 015872, 015873, 015874, 015875, 015880, 015881, 015882, 015883, 015884, 015889, 015890, 015891, 015892, 015893, 015894, 015895, 015896, 017818	232-2	Analytical Technologies, Inc.	<ul style="list-style-type: none"> TPH by EPA Method 418.1. 	<ul style="list-style-type: none"> ATI utilized MS samples. RPD and percent recovery were within QC limits.

Refer to footnotes at end of table.

Table 3-10 (Continued)
Summary of QA/QC Procedures and Results for Soil Samples Collected at ER Site 232

Sample Number (with alternate ER Sample ID, where applicable)	Outfall	Analytical laboratory	Analytes and Methods	QA/QC Procedure and Results
015876, 015877, 015878, 015879, 015885, 015886, 015887, 015888, 015894, 015895, 015896, 017817	232-2	Enseco-Quanterra	<ul style="list-style-type: none"> TPH by EPA Method 418.1. TAL metals by EPA Method 6010 except mercury by EPA Method 7471. 	<ul style="list-style-type: none"> Enseco-Quanterra utilized method blanks, LCS, MS, and MSD samples. RPD and percent recovery were within QC limits. SNL/NM SMO compiled DV1 and DV2 checklists; no significant QA/QC problems were noted.
NMED 232-east, NMED 232-west, NMED 232-undisturbed	232-2	NMED	<ul style="list-style-type: none"> TAL metals by EPA Method 6010 except mercury and arsenic by EPA Methods 7471 and 7060, respectively. VOCs by EPA Method 8240. SVOCs by EPA Method 8270. Alpha/beta by EPA Method 900.0/9310 	<ul style="list-style-type: none"> All metals, except antimony, within QC limits (NMED 1996) All VOCs, except 1,1-dichloroethene, within QC limits SVOCs within RPD limits but below percent recovery limits Gross alpha/beta within QC limits
SNLA013906-3, SNLA013907-3, SNLA013908-3, SNLA013909-3, SNLA013910-3, SNLA013911-3, SNLA013912-3, SNLA013913-3	232-2	TMA Eberline	<ul style="list-style-type: none"> Cobalt, cesium, radium, actinium, americium, bismuth, lead, radon, thorium, thallium and uranium isotopes by gamma spectroscopy. 	<ul style="list-style-type: none"> TMA Eberline utilized LCS samples. Percent recovery was within QC limits. SNL/NM SMO compiled DV1 and DV2 checklists; no significant QA/QC problems were noted.
Duplicates: 017905-9, 017913-2, 017916-2, 017918-12, 017918-6, 017912-8, 017912-9, 017920-13, 017920-14, 017921-8, 0179122-7, 017923-10, 017924-12, 017925-3, 018081-5, 018081-10, 018082-7, 018082-4	11 other OU 1309 sites	ENCOTEC	<ul style="list-style-type: none"> VOCs by EPA Method 8240. SVOCs by EPA Method 8270. TAL metals by EPA Method 6010, except mercury by EPA Method 7471. Chromium-VI by EPA Method 7196. TPH by EPA Method 418.1. Nitrates by EPA Method 353.2. High explosives by EPA Method 8330. Cyanide by EPA Method 9010. 	<ul style="list-style-type: none"> ENCOTEC utilized method blanks, LCS, and LCSD samples. RPD and percent recovery were within QC limits. SNL/NM SMO compiled DV1 and DV2 checklists; no significant QA/QC problems were noted. A total of 34 QA/QC samples were collected in the field during the initial OU 1309 sampling program which consisted of: 18 soil duplicates, 12 rinsate (equipment wash) blanks, and 4 soil-trip blanks. No equipment decontamination problems were evident in the rinsate samples. Cross contamination was not evident because the four trip blanks did not contain VOCs. Calculated RPDs for field duplicates were adequate.

Refer to footnotes at end of table.

Table 3-10 (Concluded)
 Summary of QA/QC Procedures and Results for Soil Samples Collected at ER Site 232

Sample Number (with alternate ER Sample ID, where applicable)	Outfall	Analytical laboratory	Analytes and Methods	QA/QC Procedure and Results
<u>Rinsate samples:</u> 018082-4, 018082-7, 018083-1, 018083-2, 018083-3, 018083-4, 018083-5, 018083-6, 018083-7, 018083-8, 018086-1, 018086-2				
<u>Trip Blanks:</u> TB 017905-10, TB 017988, TB 018092-1, TB 018093				

ATI = Analytical Technologies, Inc.
 DV = Data verification/validation.
 DCS = Duplicate control samples.
 DV1 = Data Verification/Validation Level 1.
 DV2 = Data Verification/Validation Level 2.
 ENCOTEC = Environmental Control Technology Corporation
 ERCL = Environmental Restoration Chemistry Laboratory
 EPA = U.S. Environmental Protection Agency.
 LCS = Laboratory control sample.
 LCSD = Laboratory control sample duplicate.
 MS = Matrix spike.
 MSD = Matrix spike duplicate.
 NMED = New Mexico Environment Department.
 PID = Photoionization detector.
 RPD = Relative percent difference.

RPO = Radiation Protection Operations.
 QA/QC = Quality assurance/quality control.
 SCS = Sample control samples.
 SMO = Sample management office.
 SNL/NM = Sandia National Laboratories/New Mexico.
 SVOC = Semivolatile organic compounds.
 TAL = Target analyte list.
 TCLP = Toxicity characteristic leaching procedure.
 TD/GC = Thermal Desorption/Gas Chromatography.
 TMA = Thermo Analytical, Inc./Eberline
 TPH = Total petroleum hydrocarbons.
 VOC = Volatile organic compounds.

3.2.9.2 Data Verification and Validation

Verification and validation of the Tijeras Arroyo OU 1309 analytical data were performed in accordance with the SNL/NM procedure "Verification and Validation of Chemical and Radiochemical Data" (technical operating procedure [TOP] 94-03), (SNL/NM 1994c). The SNL/NM Sample Management Office (SMO) performed such data verification/validation(DV) review using the DV Level 1 (DV1) and DV Level 2 (DV2) checklists specified in TOP 94-03. Table 3-10 summarizes the DV1/DV2 checklists.

3.2.9.3 Field QA/QC Data

Field QA/QC samples for ER Site 232 included seven soil duplicates/splits and one soil-trip blank. The field procedures for ER Site 232 were based upon the Tijeras Arroyo-OU 1309 sampling program for 11 other ER sites that collected 18 soil duplicates/splits, 12 equipment wash (rinsate) samples, and 4 soil-trip blanks (SNL/NM 1996c). The results for the field QA/QC samples are discussed below.

3.2.9.4 Field Duplicate Samples

Where possible, RPD values were calculated for the duplicates that were collected for the Tijeras Arroyo-OU 1309 sampling program (SNL/NM 1995c; SNL/NM 1996d). The lack of detectable VOCs, SVOCs, and HE compounds did not allow RPDs to be calculated for those compounds. However, RPDs were calculated for the metals, nitrate/nitrite, and radionuclides. Of the 111 detectable metal and nitrate/nitrite concentrations, 85 percent of the RPDs were below the NMED target of 35 percent. The remaining 15 percent of the RPDs were above the 35 percent target and probably are a function of soil heterogeneity rather than a systematic error in sampling or analytical procedures.

Of the nine detectable radionuclide activities, six of the RPDs were above the target of 35 percent. However, the use of RPDs to evaluate the radionuclide values does not appear to be realistic because the activities were less than one picocurie per gram (pCi/g). Such low activities are well below background and are reported with relatively large 2-sigma errors. For example, U-235/236 was reported at 0.023 pCi/g with a 2-sigma error of 0.018 pCi/g. With a 95 percent confidence interval, the U-235/236 activity is in the range of 0.005 to 0.041 pCi/g and could therefore actually be below the minimum detectable activity (MDA) of 0.009 pCi/g. Soil heterogeneity could also account for the range of RPD values for the radionuclides. To conclude, the RPD values indicate that both the metal, nitrate/nitrite, and radionuclide analyses are of sufficient quality.

As mentioned in Section 3.2.7, NMED collected three split-soil samples along the Outfall 232-2 remediation trench. The NMED laboratory in Santa Fe analyzed the samples for VOCs and SVOCs by EPA Methods 8240 and 8270, respectively (NMED 1996). No VOCs were detected above the detection limit of 0.050 mg/kg (ppm). Likewise, no SVOCs were detected above the detection limits of 0.17 or 0.85 mg/kg (ppm). The lack of detectable VOCs and SVOCs is consistent with the Enseco-Quanterra reporting of non-detectable TPH. The NMED laboratory also analyzed the split-soil samples for metals. As shown in Table 3-4, the maximum NMED-

reported metal concentrations compared favorably with the Enseco-Quanterra laboratory results. For example the NMED laboratory-reported arsenic concentration of 2.3 mg/kg (ppm) was similar to the Enseco-Quanterra laboratory-reported concentration of 2.1 mg/kg (ppm).

3.2.9.5 Field and Equipment Rinsate Blanks

Aqueous equipment wash (rinsate) blanks were collected following completion of soil sampling and final equipment decontamination. No contaminants were detected in any of the equipment rinsate and field-blank samples. These results indicate that the samples were not cross-contaminated by the sampling equipment or containers. The lack of detectable VOCs in the five soil-trip blanks also demonstrates that cross contamination did not affect the sampling results.

3.2.10 Site-Specific Background Sampling

Site-specific background sampling was conducted along Tijeras Arroyo in 1994 (SNL/NM 1995b). Twenty-four soil samples were collected along the northern rim of Tijeras Arroyo between Pennsylvania Avenue and the Eubank Extension (Powerline Road). The samples were collected to a maximum depth of 3 ft. The calculated background values for these soil samples are discussed in Section 6.1, Risk Assessment Report.

3.3 Gaps in Information

The completion of the items in Section 3.2.1 has eliminated the data gaps for ER Site 232.

3.4 Risk Evaluation

3.4.1 Human Health Risk Assessment

ER Site 232 has been recommended for industrial land use (SNL/NM 1997b). A complete discussion of the risk assessment process, results, and uncertainties is provided in Section 6.1. Due to the presence of several metals and radionuclides in concentrations and activities greater than background levels, it was necessary to perform a human health risk assessment analysis for the site. Besides metals, any VOCs or SVOCs detected above their reporting limits and any radionuclides 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 soil. The Risk Assessment Report calculated the Hazard Index and excess cancer risk for both industrial and residential land-use settings. The excess cancer risk for nonradioactive COCs and radioactive COCs is not additive (EPA 1989).

In summary, the Hazard Index calculated for ER Site 232 nonradiological COCs is 0.03 for an industrial land-use setting, which is less than the numerical standard of 1.0 suggested by risk assessment guidance (EPA 1989). Incremental risk is determined by subtracting risk associated with background from potential nonradiological COC risk. The incremental Hazard Index is 0.02. The excess cancer risk for ER Site 232 nonradiological COCs is 3×10^{-6} for an industrial land-use setting, which is at the lower end of the acceptable risk range of 10^{-4} to 10^{-6} (EPA 1989). There is no incremental excess cancer risk for ER Site 232. The incremental total effective dose equivalent (TEDE) for radionuclides for an industrial land-use setting is 2×10^{-5} millirems (mrem)/year, which is well below the standard dose limit of 15 mrem/yr (40 CFR 196.1994). The incremental excess cancer risk for radionuclides is 1×10^{-10} for an industrial land-use scenario, which is much less than risk values calculated due to naturally occurring radiation and from intakes considered background concentration values.

The residential land-use scenarios for this site are provided only for comparison in the Risk Assessment Report (Section 6.1). The report concludes that ER Site 232 does not have significant potential to human health under an industrial land-use scenario.

3.4.2 Ecological Risk Assessment

A complete discussion of the ecological risk for ER Site 232 is provided in Section 6.1. None of the nonradiological or radiological constituents in the site soil warrant ecological concern.

4.0 RATIONALE FOR NFA DECISION

Based on field investigation data and the human-health risk assessment analysis, NFA is being recommended for ER Site 232 for the following reasons:

- Field surveys indicated that no elevated radiation or UXO/HE material were present.
- The soil surrounding Outfall 232-1 has been sampled for all relevant COCs.
- The soil surrounding Outfall 232-2 also has been sampled for all relevant COCs, including the HERMES mineral oil.
- All oil-stained soil has been removed down slope of Outfall 232-2. Sampling along the trench margins indicates that no TPH concentrations in excess of the 100 mg/kg (ppm) clean-up criterion remain at Outfall 232-2.
- None of the nonradiological or radiological constituents were present at either outfall in levels considered hazardous to human health for an industrial land-use scenario.
- None of the nonradiological or radiological constituents warrant ecological concern at either outfall.

Based on the evidence provided above, ER Site 232 is proposed for NFA according to Criterion 5 of the ER Document of Understanding (NMED 1996a).

5.0 REFERENCES

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6.0 ANNEXES

6.1 Risk Assessment Report

Section 6.1
Risk Assessment Report

ER SITE 232: RISK ASSESSMENT ANALYSIS

I. Site Description and History

ER Site 232 is located on the northern rim of Tijeras Arroyo on land owned by the Department of Energy (USDOE). ER Site 232 consists of the two storm-water Outfalls 232-1 and 232-2. The two outfalls were built in 1986 and are still in use. The purpose of the outfalls is to reduce the amount of soil erosion caused by storm water from TA-IV. Discharge of storm water only occurs several days per year. No process or waste waters flow into the outfalls. NPDES monitoring is conducted for the TA-IV outfalls by the SNL/NM Storm Water Program. With research operations beginning in 1980, TA-IV is the newest SNL technical area and has operated using modern environmental, safety, and health procedures and considerations. The principal mission for TA-IV is the research, development, and testing of pulsed power technology. Other activities include computer science, flight dynamics, satellite processing, and robotics. No ER sites are located within the TA-IV fence. No archaeological resources are present in the vicinity of ER Site 232. Likewise, no sensitive species are present.

In November 1993, the SNL/NM ER Project listed the two outfalls as ER Site 232. The potential constituents of concern (COCs) were considered to be chromium, sodium hydroxide, hydrochloric acid, diesel fuel, mineral oil, and cooling tower antifoulants (chromates and chromosulfuric acid). This list of potential COCs was conservatively based upon chemicals used at TA-IV. Only one RCRA metal, chromium, is a COC for ER Site 232. However, all eight RCRA metals and Chromium VI were evaluated in this risk assessment.

On June 1, 1994, approximately 150 to 300 gallons of mineral oil flowed onto the ground surface below Outfall 232-2 after being spilled from an aboveground tank near Building 986. This is the only Reportable Quantity-size spill that has occurred in the areas that drain to either outfall. The mineral oil spilled at Outfall 232-2 was the Shell Oil product Diala Oil AX, which is used as a transformer oil in the TA-IV accelerators and is also known at SNL/NM by the name HERMES oil. HERMES oil is a mineral oil (hydrocarbon distillate) that primarily consists of a mixture of aliphatic and alicyclic hydrocarbons, and contains no significant quantities of USEPA-regulated hazardous constituents such as polychlorinated biphenyls (PCBs) or volatile organic compounds (VOCs). Although mineral oil is not a hazardous waste or a hazardous substance, cleanup of the oil spill was conducted with a cleanup goal of 100 mg/kg (ppm). The total amount of excavated soil was approximately 429 cubic yards. The excavated soil was disposed of off-site after being characterized as a non-regulated substance, i.e., not a Resource Conservation and Recovery Act (RCRA) hazardous waste or a radioactive waste.

II. Human Health Risk Assessment Analysis

Risk assessment of this site includes a number of steps which culminate in a quantitative evaluation of the potential adverse human health effects caused by constituents located at the site. The steps to be discussed in this section include:

Step 1. Site data are described which 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 standards established by the United States (U.S.) Environmental Protection Agency (USEPA) and U.S. Department of Energy (USDOE) 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. Discussion of uncertainties in the previous steps.

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 232 No Further Action (NFA) 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

(both outfalls). Chemicals that are essential nutrients such as iron, magnesium, calcium, potassium, and sodium were not included in this risk assessment (USEPA 1989a). Both radioactive and nonradioactive COCs are evaluated. The nonradioactive COCs evaluated are both metals and organics.

II.2 Step 2. Pathway Identification

ER Site 232 has been designated with a future land-use scenario of industrial (USDOE and USAF, 1996)(see Appendix 1 for default exposure pathways and parameters). Because of the location and the characteristics of the potential contaminants, the primary pathway for human exposure for nonradiological COCs is considered to be soil ingestion. For radiological COCs, the primary pathway for human exposure is inhalation for the industrial land-use scenario and plant ingestion for the residential land-use scenario. The inhalation pathway for chemicals is included because of the potential to inhale dust and volatiles. Direct gamma exposure is also included in the radioactive contamination risk assessment. No contamination at depth was determined and therefore no water pathways to the groundwater are considered. Depth to groundwater at Site 232 is approximately 275 feet. Because of the lack of surface water or other significant mechanisms for dermal contact, the dermal exposure pathway is considered to not be significant. No intake routes through plant, meat, or milk ingestion are considered appropriate for the industrial land-use scenario. However, plant uptake is considered for the residential land-use scenario.

PATHWAY IDENTIFICATION

Chemical Constituents	Radionuclide Constituents
Soil Ingestion	Soil Ingestion
Inhalation (Dust and volatiles)	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 232 were evaluated using a tiered approach. First, the maximum concentrations of nonradiological COCs were compared to Tijeras Arroyo specific background screening levels using 95th upper tolerance limits (UTLs) or percentile values (Sandia National Laboratories/New Mexico (SNL/NM), 1996a). If a maximum concentration of a particular COC exceeded the Tijeras Arroyo specific background screening level, or if it was a radiological COC, then the COC was compared to the SNL/NM background screening level for this area (IT, 1996). The

SNL/NM UTL chosen for comparison was the minimum value when comparing surface and subsurface UTL values. This procedure was implemented to ensure use of the most conservative value during the comparison process and due to uncertainties associated with some sample depths. 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 (NURE) 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 both the Tijeras Arroyo and SNL/NM background screening levels or, as applicable, the USGS background value, all nonradiological COCs were considered in further risk assessment analyses.

For radiological COCs that exceeded 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 USDOE Orders. Radioactive COCs that did not have a background value and were detected above the analytical minimum detectable activity (MDA) 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 non-conservative 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 maximum concentration for each remaining nonradiological COC was compared with the relevant action level calculated using methods and equations promulgated in the proposed Resource Conservation and Recovery Act (RCRA) Subpart S (40 CFR Part 264, 1990) and Risk Assessment Guidance for Superfund (RAGS) (USEPA, 1989a) 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 10 or fewer COCs and each has a maximum concentration less than one-tenth of the relevant action level, then the site would be judged to pose no significant health hazard to humans. If there are more than 10 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 (USEPA, 1989a). The combined effects of all nonradiological COCs in the soils were calculated. The combined effects of all associated nonradiological background constituents in the soils were also calculated. The most conservative background concentration between the Tijeras Arroyo specific and SNL/NM concentration (minimum value of the 95th UTL or percentile concentration value, as applicable) was used in the risk calculation. 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 standard 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 USDOE's RESRAD computer code.

II.3.1 Comparison to Background and Action Levels

Nonradioactive ER Site 232 COCs are listed in Table 1; radioactive COCs are listed in Table 2. Both tables show the associated 95th percentile or UTL background levels (SNL/NM, 1996a; IT, 1996). Background levels for plutonium and tritium are not applicable because these radionuclides do not occur naturally, or, when due to fallout, at levels detectable by common laboratory analytical instrumentation.

The Tijeras Arroyo background levels have not yet been approved by the USEPA or the NMED, but are the result of statistical analyses of samples collected from background areas within Tijeras Arroyo. These background concentrations have been recalculated from those used in the June 1995 NFA proposals. The values shown in Table 1 supersede the background values described in an interim background study report (IT, 1994). The recalculated Tijeras Arroyo values were prepared using a more rigorous

Table 1. Nonradioactive COCs at ER Site 232 and Comparison to the Background Screening Values.

COC name	Maximum concentration (mg/kg)	Tijeras Arroyo 95th % or UTL Level (mg/kg)	Is maximum COC concentration less than or equal to the applicable Tijeras Arroyo background screening value?	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	5.1	5.9	Yes		
Barium	290	298	Yes		
Cadmium	3.1	3.0	No	0.9	No
Chromium, total	7.8	17.6	Yes		
Chromium VI	<0.1	NC	No	NC	No
Lead	11	23.1	Yes		
Mercury	<0.1	NC	No	<0.1	No [^]
Selenium	0.41	NC	No	<1	No [^]
Silver	<1.0	NC	No	<1	No [^]

NC - not calculated

[^] uncertainty due to detection limits

Table 2. Radioactive COCs at ER Site 232 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?
Pu-239/240	0.000	NC	Yes
Pu-238	0.001	NC	No
H-3	0.011	NC	No
U-238	0.77	1.3	Yes
U-235/236	0.11	0.18	Yes
U-234	1.07	1.6	Yes

NC - not calculated

statistical approach according to USEPA guidance (USEPA, 1989b, 1992a, and 1992b). The Tijeras Arroyo background locations were not differentiated on the basis of depth because of the homogeneous nature of the soil and the limited sampling depth of 0 to 36 inches.

As part of the IT (1996) SNL/NM study, background concentrations were calculated for both the surface (0-6 inch depth) and subsurface (>6 inch depth) soils of the North Super Group, which is defined as soils present in TA-I, TA-II, TA-IV, the northern rim of Tijeras Arroyo, and the northeastern portion of KAFB. The SNL/NM UTL chosen for comparison was the minimum value when comparing surface and subsurface UTL values. The SNL/NM background levels have not yet been approved by the USEPA or the NMED but are the result of a comprehensive study of joint SNL/NM and U.S. Air Force data for Kirtland Air Force Base (KAFB) (IT, 1996). The report was submitted for regulatory review in early 1996.

Several compounds have maximum measured values greater than background screening levels. Therefore all nonradiological COCs were retained for further analysis with the exception of lead. The maximum concentration value for lead at Site 232 is 11 mg/kg. The USEPA intentionally does not provide any toxicological data on lead and therefore no risk parameter values can be calculated. However, USEPA guidance for the screening value for lead for an industrial land-use scenario is 2000 mg/kg (USEPA, 1996a); for a residential land-use scenario, the USEPA screening guidance value is 400 mg/kg (USEPA, 1994a). The maximum concentration value for lead at this site is less than both of those screening values and therefore lead is eliminated from further consideration in this risk assessment. Because organic compounds do not have calculated background values, this screening step was skipped, and all organics are carried into the risk assessment analyses.

Because several nonradiological COCs had concentrations greater than their respective Tijeras Arroyo specific or SNL/NM background 95th percentile or UTL, the site fails the background screening criteria and all nonradiological COCs proceed to the proposed Subpart S action level screening procedure. Because the ER Site 232 sample set had more than 10 COCs that continued past the first screening level, the proposed Subpart S screening process was skipped. All remaining nonradiological COCs must have a Hazard Index value and cancer risk value calculated.

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.

II.3.2 Identification of Toxicological Parameters

Tables 3 and 4 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 (DCFs) used in determining the incremental 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* (USEPA, 1988b).

- The DCFs for surface contamination (contamination on the surface of the site) were taken from USDOE/EH-0070, *External Dose-Rate Conversion Factors for Calculation of Dose to the Public* (USDOE, 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* (Kocher, D.C., 1983), and ANL/EAIS-8, *Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil* (Yu, C., 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; industrial and residential land-uses.

Table 3. Nonradioactive Toxicological Parameter Values for ER Site 232 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
Cadmium	0.0005	0.0000571	H	--	6.3	B1
Chromium, total*	1	0.00000057 1	L	--	--	D
Chromium VI	0.005	--	L	--	42	A
Mercury	0.0003	0.0000857	--	--	--	D
Selenium	0.005	--	H	--	--	D
Silver	0.005	--	--	--	--	D
TPH	--	--	--	--	--	--
2-Butanone	0.6	0.286	--	--	--	D
bis(2-ethylhexyl) phthalate	0.02	--	--	0.014	--	B2

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, Est. = estimated

Heast - Heast Table from USEPA 1996b

SF_o - oral slope factor in (mg/kg-day)⁻¹

SF_{inh} - inhalation slope factor in (mg/kg-day)⁻¹

[^] USEPA 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

* total chromium is assumed to be chromium III because chromium VI is calculated separately

Table 4: Radiological Toxicological Parameter Values for ER Site 232 COCs

COC name	Sf _o (1/pCi)	SF _{inh} (1/pCi)	SF _{ev} (g/pCi-yr)	Cancer Class [^]
Pu-238	3.0E-10	2.7E-08	1.9E-11	A
H-3	7.2E-14	9.6E-14	0	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)

[^] USEPA 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

The incremental TEDE and incremental estimated cancer risk are provided for the background-adjusted radiological COCs; industrial and residential land-uses.

II.3.3.1 Exposure Assessment

Appendix 1 shows the equations and parameter values used in the calculation of intake values and the subsequent Hazard Index and excess cancer risk values for the individual exposure pathways. The appendix shows the parameters for both industrial and residential land-use scenarios. The equations are based on RAGS (USEPA, 1989a). The parameters are based on information from RAGS (USEPA, 1989a) as well as other USEPA guidance documents and reflect the RME approach advocated by RAGS (USEPA, 1989a). For radionuclides, the coded equations provided in the RESRAD computer code were used to estimate the excess dose 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, C., et al., 1993b).

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

II.3.3.2 Risk Characterization

Table 5 shows that for the ER Site 232 nonradioactive COCs, the Hazard Index value is 0.03 and the excess cancer risk is 3×10^{-6} for the designated industrial land-use scenario. The numbers presented included exposure from soil ingestion and dust and volatile inhalation for the nonradioactive COCs. Table 6 shows that for the ER Site 232 associated nonradiological background constituents, the Hazard Index is 0.01 and the excess cancer risk is 3×10^{-6} for the designated industrial land-use scenario.

For the radioactive COCs, contribution from the direct gamma exposure pathway is included. The TEDE for industrial land-use is 2×10^{-5} mrem/yr. In accordance with proposed USEPA guidance, the standard being utilized is an excess TEDE of 15 mrem/yr (40 CFR Part 196, 1994) for the probable land-use scenario (industrial in this case); the calculated dose value for ER Site 232 for the industrial land-use is well below this standard.

For the residential land-use scenario, the Hazard Index value increases to 3 and the excess cancer risk is 6×10^{-5} . The numbers presented included exposure from soil ingestion, dust and volatile inhalation, and plant uptake. Although USEPA (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, NM, to be eroded and, subsequently, for dust to be present even in predominantly residential areas. Because of the nature of the local soil, other exposure pathways are not considered (see Appendix 1). Table 6 shows that for the ER Site 232 associated nonradiological background constituents, the Hazard Index is 2 and the excess cancer risk is 5×10^{-5} .

For the radioactive COCs, the TEDE for residential land-use is 1×10^{-4} mrem/yr. In accordance with proposed USEPA guidance, the standard 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 values for ER Site 232 for the residential land-use is well below this standard. It should also be noted that, consistent with the proposed guidance (40 CFR Part 196, 1994), ER Site 232 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.

Table 5. Nonradioactive Risk Assessment Values for ER Site 232 COCs.

COC Name	Maximum concentration (mg/kg)	Industrial Land-Use Scenario		Residential Land-Use Scenario	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Arsenic	5.1	0.02	3E-6	0.29	6E-5
Barium	290	0.00	--	0.04	--
Cadmium	3.1	0.01	1E-9	2.53	2E-9
Chromium, total*	7.8	0.00	--	0.00	--
Chromium VI	<0.1	0.00	3E-10	0.00	4E-10
Mercury	<0.1	0.00	--	0.17	--
Selenium	0.41	0.00	--	0.14	--
Silver	<1.0	0.00	--	0.04	--
TPH	860	--	--	--	--
2-Butanone	0.004	0.00	--	0.00	--
bis(2-Ethylhexyl) phthalate	2.5	0.00	2E-8	0.00	6E-8
TOTAL		0.03	3E-6	3	6E-5

-- information not available

* total chromium assumed to be chromium III because chromium VI is calculated separately

Table 6. Nonradioactive Risk Assessment Values for ER Site 232 Background Constituents.

Constituent Name	Background concentration (mg/kg)	Industrial Land-Use Scenario		Residential Land-Use Scenario	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Arsenic	4.4	0.01	3E-6	0.25	5E-5
Barium	200	0.00	--	0.03	--
Cadmium	0.9	0.00	4E-10	0.74	5E-10
Chromium, total*	12.8	0.00	--	0.00	--
Chromium VI	NC	--	--	--	--
Mercury	0.1	0.00	--	0.17	--
Selenium	1.0	0.00	--	0.35	--
Silver	1.0	0.00	--	0.04	--
TOTAL		0.01	3E-6	2	5E-5

-- information not available

* total chromium assumed to be chromium III because chromium VI is calculated separately

NC - not calculated due to absence in SNL/NM background reports (IT, 1996; SNL/NM, 1996a)

The excess cancer risk from the nonradioactive COCs and the radioactive COCs is not additive, as noted in RAGS (USEPA, 1989a).

II.4 Step 6. Comparison of Risk Values to Numerical Standards.

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

For the industrial land-use scenario, the Hazard Index calculated is 0.03; this is much less than the numerical standard of 1 suggested in RAGS (USEPA, 1989a). The excess cancer risk is estimated at 3×10^{-6} . In RAGS, the USEPA suggests that a range of values (10^{-6} to 10^{-4}) be used as the numerical standard; the value calculated for this site is in the low end of the suggested acceptable risk range. Therefore, for an industrial land-use scenario, the Hazard Index risk assessment value is significantly less than the established numerical standard and the excess cancer risk 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 industrial and residential land-use scenarios. For the industrial land-use scenario, the Hazard Index is 0.01. The excess cancer risk is estimated at 3×10^{-6} . Incremental risk is determined from subtracting risk associated by background from potential nonradiological COC risk. These

numbers are not rounded before the difference is determined and therefore may appear to be inconsistent with numbers presented in tables and within the text. The incremental Hazard Index is 0.02 and there is no incremental cancer risk for the industrial land-use scenario.

For the radioactive components of the industrial land-use scenario, the calculated incremental TEDE is 2×10^{-5} mrem/yr, which is significantly less than the numerical standard of 15 mrem/yr suggested in the draft USEPA guidance. The excess cancer risk estimate is 1×10^{-10} .

For the residential land-use scenario, the calculated Hazard Index is 3, which is greater than the numerical guidance. The excess cancer risk is estimated at 6×10^{-5} ; this value is in the middle of the suggested acceptable risk range. The Hazard Index for associated background for the residential land-use scenario is 2. The excess cancer risk is estimated at 5×10^{-5} . For the residential land-use scenario, the incremental Hazard Index is 1.63 and the incremental cancer risk is 1×10^{-5} . The incremental TEDE from the radioactive components is 1×10^{-4} mrem/yr, which is significantly less than the numerical standard of 75 mrem/yr suggested in the draft USEPA guidance. The associated cancer risk is 2×10^{-9} .

II.5 Step 7 Uncertainty Discussion

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 standards for the industrial land-use scenario. Calculated incremental risk between potential nonradiological COCs and associated background indicate small contribution of risk from nonradiological COCs when considering the industrial land-use scenario.

The main contributors to the adverse effects on human health is arsenic (5.1 mg/kg). This constituent is below its respective background screening level (5.6 mg/kg). Therefore, this risk assessment is considered conservative as arsenic is probably not indicative of contamination.

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

The potential effects on human health, for the nonradiological COCs, are greater when considering the residential land-use scenario. Incremental risk between potential nonradiological COCs and associated background also indicate a increased contribution of risk from the nonradiological COCs. The increased effects on human health are primarily the result of including the plant uptake exposure pathway. Nonradiological constituents that posed little to no risk considering an industrial land-use scenario (some of which are below background screening levels), contribute a

significant portion of the risk associated with the residential land-use scenario. These constituents bioaccumulate in plants. Because ER Site 232 is an industrial site, the likelihood of significant plant uptake in this area is highly unlikely as is the likelihood that this site will be residential in the near future (USDOE and USAF, 1996). The uncertainty in this conclusion is considered to be small.

For the radiological COCs the conclusion from the risk assessment is that the potential effects on human health, for the residential land-use scenario, is well within proposed standards (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 (USDOE and USAF, 1996), 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 and near-surface soils and because of the location and physical characteristics of the site, there is little uncertainty in the exposure pathways relevant to the analysis.

An RME approach was used to calculate the risk assessment values, 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 3 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) (USEPA, 1996b) and Integrated Risk Information System (IRIS) (USEPA, 1988b, 1994b) data bases. Where values are not provided, information is not available from HEAST, IRIS, or USEPA regions. The constituents without toxicological parameters have low concentrations and are judged to be insignificant contributors to the overall risk. 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 are within the acceptable range for the industrial land-use scenario compared to the established numerical standards. Though the residential land-use Hazard Index is above the numerical standard, it has been determined that future land-use at this locality will not be residential (USDOE and USAF, 1996). 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 standards (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 232 has relatively minor soil contamination consisting of some inorganic and organic nonradioactive compounds and radionuclides. Because of the location of the site on KAFB, the designated industrial land-use scenario and the nature of the contamination, the potential exposure pathways identified for this site included soil ingestion and dust and volatile inhalation for chemical constituents and soil ingestion, dust and volatile inhalation, and direct gamma exposure for radionuclides. Plant uptake was included as an exposure pathway for the residential land-use scenario.

The main contributors to the industrial land-use scenario risk assessment values are arsenic (5.1 mg/kg). This constituent is below the respective background screening level (5.6 mg/kg). Therefore, this risk assessment is considered conservative as arsenic is probably not indicative of contamination.

Using conservative assumptions and employing a RME approach to the risk assessment, the calculations show that for the industrial land-use scenario the Hazard Index (0.03) is significantly less than the accepted numerical guidance from the USEPA. The estimated cancer risk (3×10^{-6}) is in the low end of the suggested acceptable risk range. The incremental Hazard Index is 0.02 and the incremental cancer risk is zero for the industrial land-use scenario. Incremental risk calculations indicate insignificant contribution to risk from the COCs considering an industrial land-use scenario.

The incremental TEDE and corresponding estimated cancer risk from the radioactive components are much less than USEPA guidance values; the estimated incremental TEDE is 2×10^{-5} mrem/yr for the industrial land-use scenario. This value is much less than the numerical guidance of 15 mrem/yr in draft USEPA guidance. The corresponding estimated cancer risk value is 1×10^{-10} for the industrial land-use scenario.

The calculations show that, for the residential land-use scenario, the Hazard Index (3) is greater than the accepted numerical guidance from the USEPA. The estimated cancer risk (6×10^{-5}) is in the middle of the suggested acceptable risk range. The increased effects on human health are primarily the result of the inclusion of the plant uptake exposure pathway. Nonradiological constituents that posed little to no risk considering an industrial land-use scenario (some of which are below background screening levels), contribute a large portion of the risk associated with the residential land-use scenario. These constituents bioaccumulate in plants. Because ER Site 232 is an industrial site (USDOE and USAF, 1996), the likelihood of significant plant uptake in this area is highly unlikely. For the residential land-use scenario, the incremental Hazard Index is 1.63 and the incremental cancer risk is 1×10^{-5} . Increased risk from the COCs was evident considering residential land-use, due to plant uptake, but future use will be restricted to industrial land-use (USDOE and USAF, 1996).

The incremental TEDE and corresponding estimated cancer risk from the radioactive components are much less than USEPA guidance values; the estimated incremental TEDE is 1×10^{-4} mrem/yr for the residential land-use scenario. This value is much less than the numerical guidance of 75 mrem/yr in draft USEPA guidance. The corresponding estimated cancer risk value is 2×10^{-9} for the residential land-use scenario.

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

III. Ecological Risk Assessment

III.1 Introduction

This section addresses the ecological risks associated with exposure to constituents of potential ecological concern (COPECs) in soils from SNL/NM ER Site 232. The ecological risk assessment process performed for this site is a screening level assessment which follows the methodology presented in IT (1997) and SNL/NM (1997). The methodology was based on screening level guidance presented by USEPA (USEPA, 1992c; 1996c; 1996d) and by Wentzel, et al. (1996) and is consistent with a phased approach. This assessment utilizes conservatism in the estimation of ecological risks; however, ecological relevance and professional judgment are also incorporated as recommended by USEPA (1996c) and Wentzel et al., (1996) to insure that the predicted exposures of selected ecological receptors reasonably reflect those expected to occur at the site.

III.2 Ecological Pathways

Fill material from TA-IV has been pushed over the northern embankment of Tijeras Arroyo, covering much of the original soil and vegetation. Two outfalls descend this slope. The vegetation is dominated by ruderals on the slope and at the base. The top of the slope is sparsely vegetated due to disturbance. No sensitive species were observed at this site and none are expected due to the degree of habitat modification (IT, 1995). Complete ecological pathways may exist at this site through the exposure of plants and wildlife to COPECs in surface and subsurface soil.

III.3 Constituents of Potential Ecological Concern

The potential COCs at this site are RCRA metals, 2-butanone, and bis(2-ethylhexyl)phthalate. Following the screening process used for the selection of potential COCs for the human health risk assessment, the inorganic COCs were

screened against background upper tolerance limits (UTLs). Five inorganic analytes, cadmium, chromium VI, mercury, silver, and zinc were identified as COPECs at ER Site 232. Three of these (chromium VI, mercury, and silver) were not detected in either surface or subsurface samples (less than 5 ft. deep; IT, 1997); however, the detection limits exceeded the UTLs of the background soil concentrations, and therefore, these analytes could not be excluded from the list of COPECs. Two organic compounds, 2-butanone and bis(2-ethylhexyl)phthalate were also identified as COPECs at this site. The only radionuclides that were detected in soil at above background concentrations were Pu-238 and H-3. The maximum concentrations of these radionuclides were 0.001 pCi/g and 0.004 pCi/g, respectively. Chemicals that are essential nutrients such as iron, magnesium, calcium, potassium, and sodium were not included in this risk assessment per USEPA, 1989a.

III.4 Receptors and Exposure Modeling

A non-specific 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. 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 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 7 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 both surface and subsurface soil samples were used to conservatively estimate potential exposures and risks to plants and wildlife at this site. Detection limits from the on-site laboratory were used for chromium VI, mercury, and silver, which were not otherwise detected but were retained due to the high detection limit.

Table 8 presents the transfer factors used in modeling the concentrations of COPECs through the food chain. Table 9 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 the wildlife receptor species.

With respect to exposure of the receptors to Pu-238 and H-3, external doses to the deer mouse and burrowing owl were estimated using a dose model developed by Pacific Northwest Laboratories (USDOE, 1995). A description of the method to estimate radiation dose to these receptors is presented in USDOE, 1995 and IT, 1997. Because Pu-238 and H-3 are primarily alpha or beta emitters, respectively, external

dose was assumed to be insignificant compared to internal dose (USDOE, 1995) and was therefore not quantitatively evaluated.

III.5 Toxicity Benchmarks

Benchmark toxicity values for the plant and wildlife receptors are presented in Table 10. For plants, the benchmark soil concentrations are based on the Lowest-Observed-Adverse-Effect-Level (LOAEL) with the adverse effect being a 20 percent reduction of growth. For wildlife, the toxicity benchmarks are based on the No-Observed-Adverse-Effect-Level (NOAEL) for chronic oral exposure (with emphasis on reproductive effects) in a taxonomically similar test species. Mercury in these soils was assumed to be inorganic in form. Insufficient toxicity information was found to estimate plant benchmark values for 2-butanone and bis(2-ethylhexyl)phthalate and NOAELs for chromium VI, silver, and 2-butanone for the burrowing owl.

Table 7. Exposure Factors for Ecological Receptors at Environmental Restoration Site 232, 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 (<i>Peromyscus maniculatus</i>)	Mammalia/ Rodentia	Omnivore	0.0239 ^d	0.00372	Plants: 50% Invertebrates: 50% (+ Soil at 2% of intake)	0.27 ^e
Burrowing owl (<i>Speotyto cunicularia</i>)	Aves/ Strigiformes	Carnivore	0.155 ^f	0.0173	Rodents: 100% (+ Soil at 2% of intake)	34.6 ^g

^aBody weights are in kilograms wet weight.

^bFood intake rates are estimated from the allometric equations presented in Nagy (1987). Units are kilograms dry weight per day.

^cDietary compositions are generalized for modeling purposes. Default soil intake value of 2% of food intake.

^dFrom Silva and Downing (1995).

^eFrom USEPA (1993), based on the average home range measured in semi-arid shrubland in Idaho.

^fFrom Dunning (1993).

^gFrom Haug et al. (1993).

Table 8. Transfer Factors Used in Exposure Models for Constituents of Potential Ecological Concern at Environmental Restoration Site 232, 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
Cadmium	5.50×10^{-1a}	6.00×10^{-1b}	5.50×10^{-4a}
Chromium VI	4.00×10^{-2c}	1.30×10^{-1d}	3.00×10^{-2c}
Mercury	1.00×10^{0c}	1.00×10^{0e}	2.50×10^{-1a}
Silver	1.00×10^{0c}	2.50×10^{-1b}	5.00×10^{-3c}
2-butanone	2.63×10^{1f}	1.36×10^{1g}	3.67×10^{-8f}
Bis (2-ethylhexyl) phthalate	5.78×10^{-2f}	2.31×10^{1g}	2.07×10^{-3f}

^aFrom Baes et al. (1984).

^bFrom Stafford et al. (1991).

^cFrom NCRP (1989).

^dFrom Ma (1982).

^eDefault value.

^fFrom equations developed in Travis and Arms (1988).

^gFrom equations developed in Connell and Markwell (1990).

Table 9. Media Concentrations for Constituents of Potential Ecological Concern at Environmental Restoration Site 232, Sandia National Laboratories, New Mexico

Constituent of Potential Ecological Concern	Soil ^a (maximum)	Plant Foliage ^{a,b}	Soil Invertebrate ^{a,b}	Deer Mouse Tissues ^{a,c}
Cadmium	3.10×10^0	1.71×10^0	1.86×10^0	3.17×10^{-3}
Chromium VI	1.0×10^{-1}	4.00×10^{-3}	1.30×10^{-2}	9.84×10^{-4}
Mercury	1.0×10^{-1}	1.00×10^{-1}	1.00×10^{-1}	7.97×10^{-2}
Silver	1.00×10^0	1.00×10^0	2.50×10^{-1}	1.01×10^{-2}
2-butanone	4.00×10^{-3}	1.05×10^{-1}	5.44×10^{-2}	9.17×10^{-9}
Bis (2-ethylhexyl) phthalate	2.50×10^0	1.44×10^{-1}	5.77×10^1	1.88×10^{-1}

^aMilligrams per kilogram. All are based on dry weight of the media.

^bProduct of the soil concentration and the corresponding transfer factor.

^cProduct 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 USEPA, 1993).

Table 10. Toxicity Benchmarks for Ecological Receptors at Environmental Restoration Site 232, Sandia National Laboratories, New Mexico

Constituent of Potential Ecological Concern	Plant Benchmark ^a (mg/Kg)	Mammalian NOAELs (mg/Kg/d)			Avian NOAELs (mg/Kg/d)		
		Mammalian Test Species ^b	Test Species NOAEL ^c	Deer Mouse NOAEL ^d	Avian Test Species ^e	Test Species NOAEL ^e	Burrowing Owl NOAEL ^f
Cadmium	3	Lab rat ^g	1.0	1.89	Mallard	1.45	1.45
Chromium VI	1	Lab rat	3.28	6.42	--- ^h	---	---
Mercury	0.3	Lab rat	0.032	0.0626	Mallard	0.0064	0.0064
Silver	2	Lab rat	17.8 ⁱ	34.8	---	---	---
2-butanone	---	Lab rat	1771	3460	---	---	---
Bis (2-ethylhexyl) phthalate	---	Lab mouse	18.3	19.4	Ringed dove	1.1	1.1

^aFrom Will and Suter (1995).

^bFrom 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.

^cFrom Sample et al. (1996), except where noted.

^dBased 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.

^eFrom Sample et al. (1996).

^fBased 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.

^gBody weight of lab rat, 0.303 kg, for NOAEL conversion (Sample et al., 1996).

^h--- designates insufficient toxicity data.

ⁱFrom USEPA (1997).

The benchmark used for exposure of terrestrial receptors to radiation was 0.1 rad/day. This value has been recommended by IAEA (1992) for the protection of terrestrial populations. Because plants and insects are less sensitive to radiation than vertebrates (Whicker and Schultz, 1982), the dose of 0.1 rad per day should also offer sufficient protection to other ecological receptors, such as these, within the terrestrial habitat of Site 232.

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 11. Maximum soil concentrations for cadmium exceeded their respective plant benchmark

Table 11. Comparisons to Toxicity Benchmarks for Ecological Receptors at Environmental Restoration Site 232, Sandia National Laboratories, New Mexico

Constituent of Potential Ecological Concern	Plant Hazard Quotient	Deer Mouse Hazard Quotient	Burrowing Owl Hazard Quotient
Cadmium	1.03 x 10⁰	1.52 x 10 ⁻¹	5.01 x 10 ⁻³
Chromium VI	1.00 x 10 ⁻¹	2.55 x 10 ⁻⁴	--- ^a
Mercury	3.33 x 10 ⁻¹	2.51 x 10 ⁻¹	1.42 x 10⁰
Silver	5.00 x 10 ⁻¹	2.88 x 10 ⁻³	---
2-butanone	---	3.59 x 10 ⁻⁶	---
Bis (2-ethylhexyl) phthalate	---	2.33 x 10 ⁻¹	2.41 x 10 ⁻²

Bold text indicates hazard quotient is greater than one.

^a--- designates insufficient toxicity data available for risk estimation purposes.

concentrations. Hazard quotients (HQs) are used to quantify the comparison with the benchmarks for wildlife exposure. In the burrowing owl, only the HQ for mercury (HQ = 1.42) exceeded unity. The radiation dose to the mouse and owl were predicted to be 2.29×10^{-9} and 1.64×10^{-9} rad/day, respectively. This is considerably less than the benchmark of 0.1 rad/day.

III.7 Uncertainties

Many uncertainties are associated with the characterization of ecological risks at ER Site 232. These uncertainties result in the use of assumptions in estimating risk which 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. Conservatism incorporated into this risk assessment include the use of the maximum measured soil concentration or maximum detection limit to evaluate risk, the use of wildlife toxicity benchmarks based on NOAEL values, the use of maximum transfer factors found in the literature for modeling plant and mouse tissue concentrations, the use of earthworm-based transfer factors or a default factor of 1.0 for modeling COPECs into soil invertebrates, 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 Pu-238 and H-3 are primarily related to those inherent in the dose models and exposure parameters. As an example, the internal dose model is based on the assumption that the receptor are exposed to the maximum detected concentration of Pu-238 and H-3 measured at the site and external exposure is assumed to be insignificant.

III.8 Summary

Potential risks were indicated for two ecological receptors (plant and burrowing owl) at Site 232; however, the use of the maximum measured soil concentration or maximum detection limit to evaluate risk provided the "worst case" scenario for the ecological risk assessment. Detection limits were used to evaluate risk for chromium VI, mercury, and silver. Detection limits for chromium VI and silver did not produce HQs greater than 1.0 for any of the ecological receptors. Mercury was the only COPEC with a detection limit that resulted in a HQ greater than one (1.4) for the burrowing owl. However, because, the detection limit for mercury is within the range of background concentrations, ecological risks associated with exposure to mercury at this site are expected to be insignificant.

Use of the maximum soil concentration for cadmium resulted in a HQ of 1.03 for the plant. However, the average of eight data points for cadmium from one sample set was 2.1 mg/kg; samples from a second data set containing six data points were all less than 0.5 mg/kg (detection limit). The use of an UTL 95% value for cadmium would therefore not produce a HQ greater than one. No ecological risks were predicted from exposure to Pu-238 and H-3 at the site. Based on this analysis, it is concluded that the COPECs at Site 232 are not at concentrations that warrant ecological concern.

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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.

Table 1. Exposure Pathways Considered for Various Land Use Scenarios

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

EQUATIONS AND DEFAULT PARAMETER VALUES FOR IDENTIFIED EXPOSURE ROUTES

In general, SNL/NM expects that ingestion of compounds in drinking water and soil will be the more significant exposure routes for chemicals; external exposure to radiation may also be significant for radionuclides. All of the above routes will, however, be considered for their appropriate land use scenarios. The general equations for calculating potential intakes via these routes are shown below. The equations are from the Risk Assessment Guidance for Superfund (RAGS): Volume 1 (EPA, 1989a 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)

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

where

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

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

The evaluation of the carcinogenic health hazard produces a quantitative estimate for excess cancer risk resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of the quantitative estimate with the potentially acceptable risk range of 10^{-4} to 10^{-6} . The evaluation of the noncarcinogenic health hazard produces a quantitative estimate (i.e., the Hazard Index) for the toxicity resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of this quantitative estimate with the EPA standard Hazard Index of unity (1). The evaluation of the health hazard due to radioactive compounds produces a quantitative estimate of doses resulting from the COCs present at the site.

The specific equations used for the individual exposure pathways can be found in RAGS (EPA, 1989) 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

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)	25550 ^a	25550 ^a	25550 ^a
for noncarcinogenic compounds (=ED x 365 d/y)	10950	10950	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, 1992.

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.

References

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