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1994 Site Environmental Report Tonopah Test Range Tonopah, Nevada

T. Culp, W. Forston

Prepared by
Sandia National Laboratories
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1994 SITE ENVIRONMENTAL REPORT TONOPAH TEST RANGE TONOPAH, NEVADA

T. Culp
Air Quality Department
Sandia National Laboratories
Albuquerque, NM 87185

W. Forston
Kirk-Mayer, Inc.
Tonopah, NV 89049

ABSTRACT

This report summarizes the environmental surveillance activities conducted by Sandia National Laboratories, the U.S. Environmental Protection Agency, and Kirk-Mayer, Inc., for the Tonopah Test Range operated by Sandia National Laboratories. Sandia National Laboratories' responsibility for environmental surveillance results extends to those activities performed by Sandia National Laboratories or under its direction. Results from other environmental surveillance activities are included to provide a measure of completeness in reporting. Other environmental compliance programs such as the National Environmental Policy Act of 1969, environmental permits, and environmental restoration and waste management programs are also included in this report, prepared for the U.S. Department of Energy (DOE) in compliance with DOE Order 5400.1.

ACKNOWLEDGMENTS

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NOTE TO THE READER

If you have comments or questions about this report, or need further information, contact:

Sandia National Laboratories
Media Relations Department
MS 0167
P.O. Box 5800
Albuquerque, NM 87185
(505) 844-4207 or
(505) 844-2282

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ABBREVIATIONS

Units

°C	Celsius degree
cm	centimeter
cm^2	square centimeters
cm^3	cubic centimeters
cm/yr	centimeters per year
°F	Fahrenheit degree
ft	foot
g	gram
g/cm^3	grams per cubic centimeter
gal.	gallon
hr	hour
in.	inch
in./yr	inches per year
kg	kilogram
km	kilometer
km^2	square kilometers
L	liter
m	meter
m^2	square meters
m^3	cubic meters
mg/m^3	milligrams per cubic meter
mi	mile
mi^2	square mile
m/s	meters per second
ppm	parts per million
sec	second
sec/yr	seconds per year
μm	micron
yr	year

ABBREVIATIONS
(Continued)

Frequently Referenced Nuclide Symbols and Components

Al	aluminum	Pu-238	plutonium-238
Am-241	americium-241	Pu-239	plutonium-239
Ba	barium	Pu-240	plutonium-240
Be	beryllium	Pu-241	plutonium-241
Be-7	beryllium-7	Pu-242	plutonium-242
Cd	cadmium	Ra-226	radium-226
Co	cobalt	Si	silica
Cr	chromium	Th-232	thorium-232
Cs-137	cesium-137	Ti	titanium
Fe	iron	U	uranium
H-3	tritium	U-238	uranium-238
K	potassium	U_{tot}	total uranium
Pb	lead	Zn	zinc
Pu	plutonium		

Radioactivity Measurements

Ci	curie (unit of radioactivity)
dpm	disintegrations per minute
mrem	millirem (unit of radiation dose)
mrem/yr	millirem per year
mR/hr	milliroentgen per hour
person-mrem/yr	person-millirem per year
person-rem/yr	person-rem per year
pCi	picocurie
pCi/cm^2	picocuries per square centimeter
pCi/g	picocuries per gram
pCi/L	picocuries per liter
pCi/m^2	picocuries per square meter
pCi/m^3	picocuries per cubic meter
R	roentgen (unit of radiation exposure)
rem	roentgen equivalent man (amount of ionizing radiation required to produce the same biological effect as 1 R of high-penetration X-rays)
$\mu g/m^2$	micrograms per square meter
$\mu g/m^3$	micrograms per cubic meter

Acronyms

ADM	Action Description Memorandum
AEC	U.S. Atomic Energy Commission
AIRFA	American Indian Religious Freedom Act

ABBREVIATIONS
(Continued)

ALI	annual limit of intake
AR	Arkansas
ARPA	Archaeological Resources Protection Act
ASN	Air Surveillance Network
BLM	Bureau of Land Management
BOD	biochemical oxygen demand
CA	California
CAA	Clean Air Act
CEM	Certified Environmental Manager
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CG	Concentration Guide
CV	coefficient of variation
CWA	Clean Water Act
CY	calendar year
DAC	derived air concentration
DCG	derived concentration guides
DOC	U.S. Department of Commerce
DOE	U.S. Department of Energy
DOE/AL	U.S. Department of Energy/Albuquerque Operations Office
DOE/HQ	U.S. Department of Energy/Headquarters
DOE/KAO	U.S. Department of Energy/Kirtland Area Office
DOE/NV	U.S. Department of Energy/Nevada Operations Office
DOI	U.S. Department of the Interior
DRI	Water Resources Center, Desert Research Institute, University of Nevada System
DU	depleted uranium
EA	Environmental Assessment
ECL	Environmental Checklist
EDE	effective dose equivalent
EG&G	Edgerton, Germeshausen & Grier Corporation
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPD	Environmental Programs Departments
ER	Environmental Restoration
ERDA	U.S. Energy Research and Development Administration
ES&H	environment, safety and health
ESA	Endangered Species Act
FIDLER	field instrument for the detection of low-energy radiation

ABBREVIATIONS
(Continued)

FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	finding of no significant impact
FY	fiscal year
ICP	inductively coupled plasma (method)
ICRP	International Commission on Radiological Protection
IT	IT Corporation
KMI	Kirk-Mayer, Inc. (KMI Services)
LTHMP	Long-Term Hydrologic Monitoring Program
MDC	minimum detectable concentrations
MEI	maximum exposed individual
MSDS	Material Safety Data Sheet
MSS	multispectral scanner
MTF	memo-to-file
NA	not applicable, not available
NAEG	Nevada Applied Ecology Group
NAFB	Nellis Air Force Base (Range Complex)
ND	Not detected
NDEP	Nevada Department of Environmental Protection
NEDS	Nonviolent Explosive Destruct System
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NF	None found
NG	noble gas sampler
NHPA	National Historic Preservation Act
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
NTS	Nevada Test Site
NV	Nevada
O&M	Operations and Maintenance
PA	Preliminary Assessment
PCB	polychlorinated biphenyl
PIC	pressurized ion chamber
PMS	portable monitoring station
QA	quality assurance
RCRA	Resource Conservation and Recovery Act
REECo	Reynolds Electrical and Engineering Company
RFI	RCRA Facility Investigation
RWP	Radiological Work Permit
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SHIPO	State Historic Preservation Office
SNL	Sandia National Laboratories
SNL/NM	Sandia National Laboratories/New Mexico
SNL/NV	Sandia National Laboratories/Nevada

ABBREVIATIONS
(Concluded)

SOP	Standard Operating Procedure
SPCC	Spill Prevention, Control, and Countermeasures
STA-14	Station 14
STAR	Stability Array
TA	technical area
TCLP	toxicity characteristic leaching procedure
TECR	Tonopah Electronic Combat Range
TFW	Tactical Fighter Wing
TLD	thermoluminescent dosimeter
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, and disposal facility
TSP	total suspended particulates
TSS	total suspended solid
TTR	Tonopah Test Range
USAF	U.S. Air Force
USGS	U.S. Geological Survey
UST	underground storage tank
UXO	unexploded ordnance

Approximate Conversion Factors For Selected Si (Metric) Units

Multiply SI (Metric) Unit	By	To Obtain U.S. Customary Unit
Cubic Meters (m^3)	35	Cubic feet (ft^3)
Centimeters (cm)	0.39	Inches (in.)
Meters (m)	3.3	Feet (ft)
Kilometers (km)	0.62	Miles (mi)
Square kilometers (km^2)	0.39	Square miles (mi^2)
Hectares (ha)	2.5	Acres
Liters (L)	0.26	Gallons (gal)
Grams (g)	0.035	Ounces (oz)
Kilograms (kg)	2.2	Pounds (lb)
Micrograms per gram ($\mu g/g$)	1	Parts per million (ppm)
Milligrams per liter (mg/L)	1	Parts per million (ppm)
Celsius (°C)	9/5 + 32	Fahrenheit (°F)

1.0 EXECUTIVE SUMMARY

1.1 ASSESSMENT OF POTENTIAL DOSE TO THE PUBLIC

In 1994, no radionuclides were released from the Tonopah Test Range (TTR) from stacks, vents, or other point sources. Based on the types of test activities, such as air drops, gun firing, ground-launched rockets, air-launched rockets, and other explosive tests, the possibility exists that small amounts of material (as part of the test component) could be released to the air or ground because of unusual circumstances (failures) during testing. There were no such failures in 1994.

A large area of transuranic surface contamination located on TTR is a potential diffuse source of airborne radionuclides through the action of wind resuspension of soil particulates. The surface contamination is the result of plutonium dispersal tests performed at the three Clean Slate sites in 1963. A total of 0.32 curies per year (Ci/yr) of contaminated material was calculated to be resuspended from the three Clean Slate sites. The maximum exposed individual (MEI) was determined to be located at the south perimeter fence between TTR and Nellis Air Force Base (NAFB). The effective dose equivalent (EDE) calculated to this location was 1.7 millirem per year (mrem/yr), or approximately 1.7 percent of the 10-mrem/yr dose limit specified by U.S. Department of Energy (DOE) orders and Title 40, Code of Federal Regulations, Part 61, Subpart H (40 CFR 61, Subpart H). The off-range MEI was determined to be located in the town of Goldfield. The EDE calculated to this location was 0.075 mrem, or approximately 0.8 percent of the dose limit.

This report addresses only those responsibilities related to Sandia National Laboratories (SNL) activities at TTR.

1.2 OVERVIEW OF 1994 SURVEILLANCE RESULTS

1.2.1 SNL Soil Sampling

Limited soil sampling was performed at TTR as part of the continuing environmental surveillance activities. Samples were collected from the long-term, routine, sampling locations and from additional locations intended to supplement baseline activities which began in 1992. Baseline soil sampling was performed in areas where SNL has had a long-term, or continued, presence at TTR. Soil samples were collected from off-site, the site perimeter, the Airport Area, Area 9, the Hard Target/Depleted Uranium (DU) Area, the On-Base Housing Area, the Project Roller Coaster Sewage Lagoons, the Mellan Hill Area, the 554th Range Squadron Operations and Maintenance (O&M) Complex, the South Plume Area, the Range Operations Center and Compound, and various additional on-site locations. All samples were analyzed for twenty standard metals by the inductively coupled plasma (ICP) method, isotopic plutonium, and total uranium (U_{tot}), and by gamma spectroscopy. Elevated concentrations of isotopic plutonium, americium-241, U_{tot}, and various stable metals were found at several sampled locations.

1.2.2 SNL Air Monitoring

Limited air monitoring was performed at TTR from August to September 1994. Air monitoring samples were collected from three separate locations at TTR. Composite samples were analyzed for gross alpha, gross beta, isotopic plutonium, U_{tot}, and twenty ICP nonradiological metals, and by gamma spectroscopy. Air monitoring results did not indicate significantly elevated concentrations of radiological or nonradiological constituents.

1.2.3 U.S. Environmental Protection Agency (EPA) Monitoring

The EPA performs routine monitoring at TTR including thermoluminescent dosimeter (TLD) and pressurized ion chamber (PIC) measurements to detect gamma radiation; air monitoring to measure noble gases, tritium (H-3), and other radionuclides; and water monitoring primarily to measure radionuclides. EPA TLD and PIC data were unavailable for inclusion in this report. The EPA air sampling program was placed on standby status approximately October 1, 1994. No air samples were collected after that date. Analytical results for gross alpha and gross beta are considered low; results for H-3 and krypton-85 are both well below the DOE Derived Air Concentration (DAC). The Long-Term Hydrologic Monitoring Program was reduced from quarterly to annual sampling. Analytical results for H-3 in well water from two well stations were below DOE-derived concentration guides.

1.2.4 Drinking Water Sampling Program

Per regulatory statute 40 CFR 141.26, drinking water on TTR should be sampled a minimum of every 3 years (yr) for primary drinking water standards and radionuclides. In previous years, the radionuclides were sampled on a monthly basis by REECo; however, in 1993, Sandia National Laboratories/Nevada (SNL/NV) and DOE discontinued the sampling and analysis by REECo. Sampling for radionuclides for primary and secondary drinking water standards will be accomplished by SNL/NV or one of its contractors at a minimum of every 3 yr. Analytical samples will be collected in 1995.

1.3 OVERVIEW OF COMPLIANCE STATUS

Environmental restoration activities in fiscal year 1994 (FY94) were conducted by the DOE/Nevada Operations Office (DOE/NV) Environmental Restoration Project through an interim agreement with DOE/Albuquerque Operations Office (DOE/AL) and DOE/Kirtland Area Office (DOE/KAO). Activities included the generation of a *Draft Resource Conservation and Recovery Act Facility Investigation (RFI)* Work Plan. The work plan was reviewed by DOE/AL and SNL Environmental Restoration personnel and will be completed in FY95. Other activities in FY94 included a continued inventory of potential release sites, generation of a data report resulting from geophysical surveys conducted in FY93 at potential release sites, completion of National Environmental Policy Act (NEPA) surveys at five unexploded ordnance sites, creation of a site priority ranking model using decision analysis software, and completion of a multispectral scanner aerial survey.

TTR changed status from a large quantity generator of hazardous waste to a small quantity generator. This change will reduce hazardous waste shipments from approximately 3 or 4 per year to 1 or 2 per year. Three hazardous waste shipments were made in 1994. Standard operating procedures have been written to ensure continued compliance with the Resource Conservation and Recovery Act (RCRA). In calendar year 1994 (CY94), 5615 kilograms (kg) of hazardous waste and 9413 kg of non-RCRA waste were shipped off-site for disposal at a permitted treatment and storage facility.

An informal waste minimization program is practiced at TTR. In 1994, antifreeze recycling and Freon recovery units were procured. In part as a result of the decreased test operation schedule and staff, D and U type (chemical) and F type (solvent) hazardous waste was reduced by 56 percent and 74 percent, respectively, in comparison to data from the previous 2 years.

SNL/NV removed five underground storage tanks (USTs) from TTR in 1994. Currently, there are no USTs managed by SNL/NV on TTR.

There are several environmental permits in place at TTR: 13 air permits, 4 public water system permits, 1 National Pollutant Discharge Elimination System (NPDES) permit for the sewage lagoon facility, and 1 EPA identification number for chemical hazardous waste on TTR. TTR was in full compliance with all permit requirements for 1994.

DOE/NV currently holds six air quality permits for TTR. Air emissions in 1994 were in compliance with applicable permits. A National Emission Standards for Hazardous Air Pollutants (NESHAP) annual report was prepared for CY94 (SNL 1995a).

Drinking water for SNL/NV operations at TTR is provided by a well permitted by the State of Nevada in compliance with the Public Water Supply standards. Compliance activities included bacteriological sampling of the drinking water system in accordance with the *Tonopah Test Range Site Sampling Plan* (DOE 1990).

At TTR, NEPA compliance is a joint effort of SNL, DOE/NV, and the Desert Research Institute. In 1994, a categorical exclusion was applied for by SNL/NV and granted by DOE/AL to install lightning protection at TTR.

TTR had two reportable spills of petroleum hydrocarbons in 1994. The first spill occurred when a float valve cracked in the day feeder tank for a generator facility at Area 9. Cleanup efforts involved removing approximately 18 cubic yards of soil. SNL/NV is petitioning the State of Nevada for closure until such time as the facility is demolished. The second reportable spill was discovered upon exposing the four 10,000-gallon fuel storage tanks located at the Area 3 gas station during the removal process. Initial abatement action included excavating approximately 122 tons of soil which were taken off-site, and stockpiling another 700 to 900 tons of soil east of the excavation. Methods of continued treatment and funding issues for site cleanup are currently being addressed.

Occurrence reporting at TTR for 1994 involved one incident in December. A routine radiological survey indicated the presence of radioactive material on a wind radar antenna pedestal mounted on a small trainer in an uncontrolled area. The area around the trailer was posted, and SNL/New Mexico Radiation Protection Operations Department (7714) personnel moved the trailer to a controlled long-term storage area. The final disposition of the contaminated material will be negotiated with DOE/NV.

2.0 INTRODUCTION

As required in U.S. Department of Energy (DOE) Order 5400.1 (DOE 1988a), this site environmental report has been prepared for Tonopah Test Range (TTR) to summarize environmental data that characterize site environmental management performance, confirm compliance with federal, state, and local environmental standards and requirements, and highlight significant programs and efforts. This report represents a key component of the DOE's effort to keep the public informed about environmental conditions at DOE facilities that conduct significant environmental protection programs. The report contains summary information about the radiological and nonradiological conditions of the site environment and identifies trends with regard to effluent releases and environmental conditions.

2.1 HISTORY AND OPERATIONS OF TTR

Sandia National Laboratories (SNL) operates TTR for DOE nuclear ordnance programs. SNL operations at TTR in Nevada date from 1957, when TTR came into limited use after similar facilities at Salton Sea Test Base in California and at Yucca Flat on Nevada Test Site (NTS) became inadequate. The TTR was used as a bombing range during World War II.

TTR was originally designed and equipped to gather raw data on aircraft-delivered inert test vehicles under U.S. Atomic Energy Commission (AEC) cognizance. Over the years, the facilities and capabilities at TTR have been expanded to accommodate tests related to the AEC (later, DOE) weapons development program. Tests conducted vary from simple tests of hardware components and systems needing only limited support to rocket launches and air drops of test vehicles requiring full range support.

The seven categories of test activities at TTR are: (1) air drops, (2) gun firings, (3) ground-launched rockets, (4) air-launched rockets, (5) explosive effects, (6) static rocket tests, and (7) earth penetrator tests. Most of these activities require a remote range for safety and security reasons. The 1994 SNL/Nevada and U.S. Air Force activities included 15,639 flying sorties, 61 rocket/missile flights, and 18 air drops.

2.2 LOCATION AND POPULATION

TTR is located approximately 140 miles (mi) northwest of Las Vegas, NV (Figure 2-1) and covers 624 square miles (mi^2) within the boundaries of the Nellis Air Force Base (NAFB) Range Complex. It is bordered on three sides by the NAFB Range Complex and on the north by sparsely populated public land administered by the Bureau of Land Management (BLM) and the U.S. Forest Service. The nearest population centers are Goldfield, population 659, located approximately 25 mi west of TTR, and Tonopah, population 4400, located 30 mi northwest of TTR (DOC 1991). The total population within a 50-mi region around TTR is 9299. This number includes a population of 1000 to account for base housing and on-site and contractor (non-SNL) personnel.

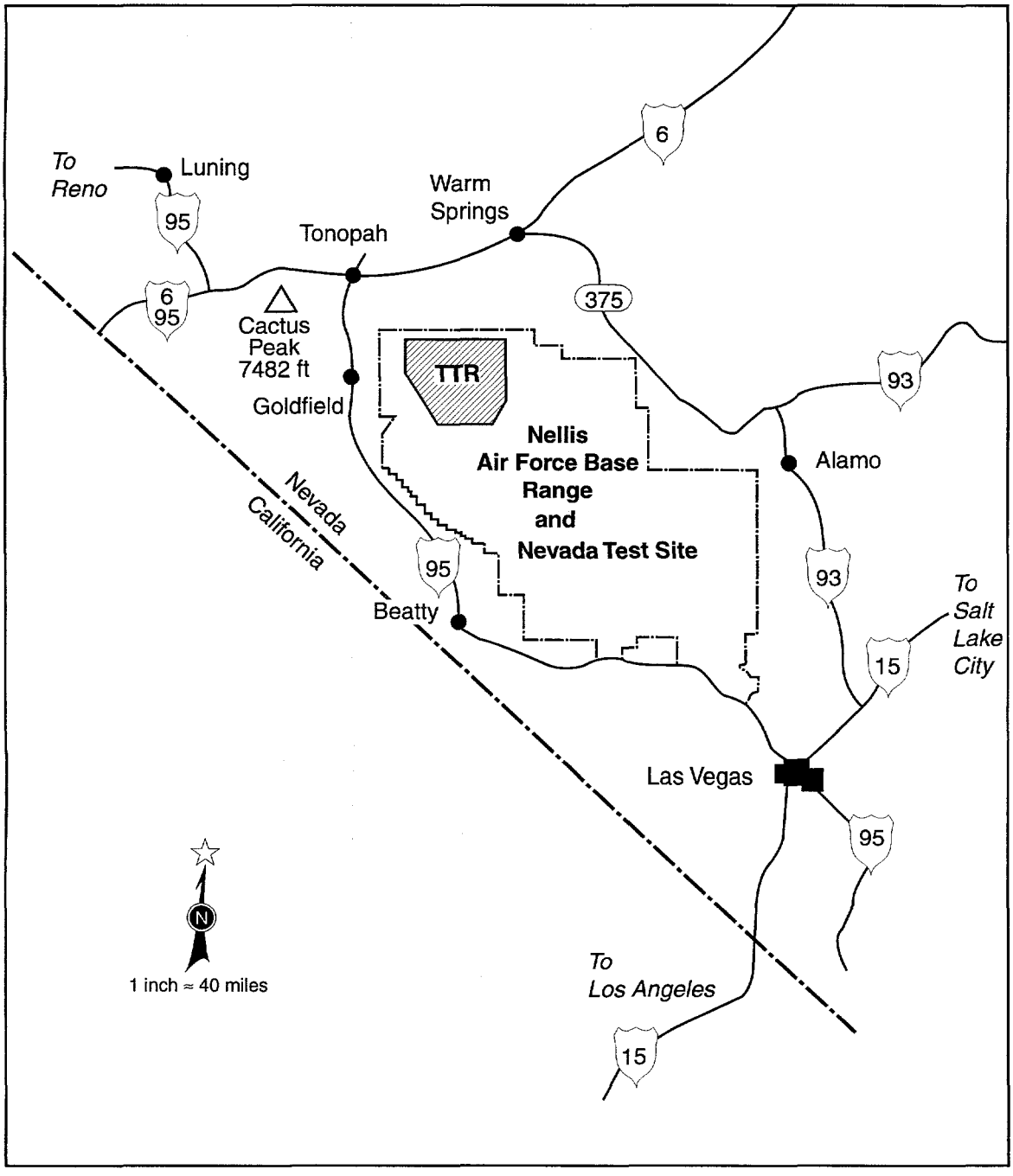

Figure 2-1. Location of Tonopah Test Range, Nevada

2.3 GEOLOGY AND CLIMATOLOGY

TTR is situated in a high desert and consists of broad valleys bordered by north/south-trending mountain ranges in the western part of the Basin-and-Range geophysical province. TTR lies northeast of a zone of transcurrent faulting and shear, termed the Walker Lane, and the Las Vegas Valley shear zone to the southeast (Sinnock 1982). Cactus Flat, which constitutes the basic working area of TTR, is a basin surrounded by the Cactus Range. The Cactus Range is a northwest-trending, raised structural block, one of at least five that lie along the Las Vegas Valley-Walker Lane lineaments (ERDA 1975).

All the working areas of TTR lie within an area of approximately 400 mi^2. The streams in and near TTR are intermittent and end in closed basins. There are three springs within TTR: Cactus, Antelope, and Silverbow. Water from these springs does not travel far; it disappears rapidly through evaporation and infiltration, and its effect on the landscape is purely local. Water used in TTR facilities comes from wells tapping underlying groundwater in alluvium derived from the surrounding mountains. Well depth to groundwater varies from 21 ft (Antelope Mine) to 454 ft (EH2). The depth to groundwater at Area 9 is approximately 131 ft, and depth to groundwater at Area 3 is 361 ft to 394 ft (U.S. Geological Survey [USGS] preliminary data).

The climate is mild and usually dry, but, as is typical of high deserts, it is subject to large diurnal and seasonal changes in temperature, from a record high of 102 degrees Fahrenheit (°F) to a record low of -24°F (Schaeffer 1982). Clear, sunny days with light to moderate winds are usual. Average rainfall is approximately 5 inches per year in the valley, with most precipitation occurring in August (ERDA 1975; Schaeffer 1982). Winds are mostly from the west-northwest and from the south-southeast. Dust storms are common in the spring, and dust devils are common in the summer.

Because of the temperature extremes and arid conditions at TTR, the valley in which most TTR activities occur is sparsely covered with range grasses and low shrubs (ERDA 1975; EG&G 1979a). Joshua trees grow in the foothills. Juniper trees grow in the foothills and mountains. Hundreds of wild horses graze freely throughout TTR and their exposure to TTR activities has apparently had little effect on their population and grazing habits.

2.4 PROJECT ROLLER COASTER TESTS

Project Roller Coaster included a series of four plutonium (Pu) dispersal tests (three at TTR and one at the NAFB Gunnery Range) executed in May and June of 1963. The locations of the three Project Roller Coaster tests at TTR are referred to as Clean Slates 1, 2, and 3; the fourth site is referred to as the Double Tracks site (Figure 2-2). Table 2-1 summarizes test information related to the four Project Roller Coaster sites. Through agreement with DOE's Albuquerque Operations Office (DOE/AL), DOE's Nevada Operations Office (DOE/NV) has the Environmental Restoration (ER) responsibilities for the Clean Slate sites; SNL maintains the environmental surveillance responsibilities.

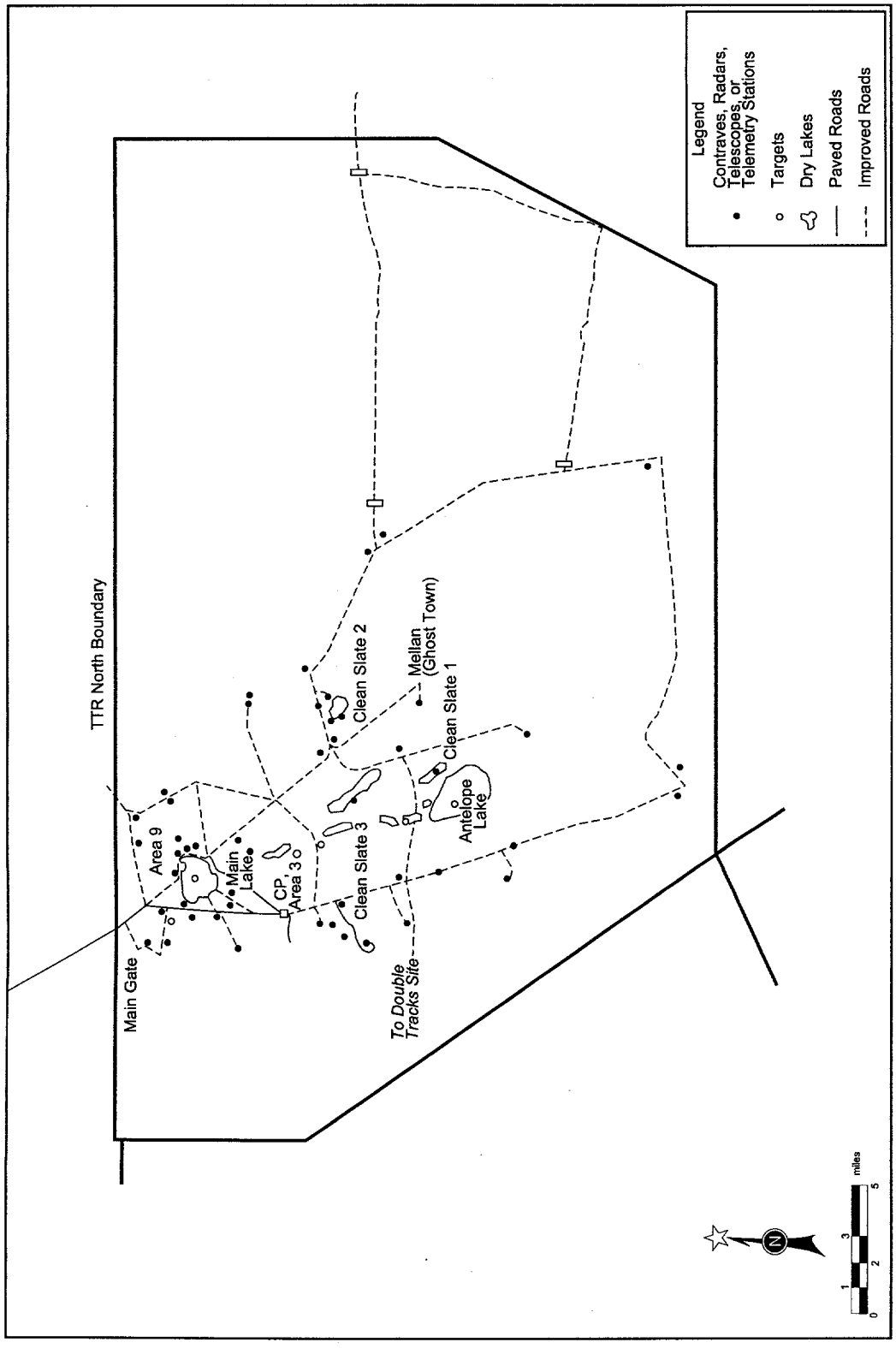

Figure 2-2. Locations of Sandia National Laboratories Facilities at the Tonopah Test Range

Table 2-1. Project Roller Coaster Test Information

Test:	Clean Slate 1	Clean Slate 2	Clean Slate 3	Double Tracks
Date:	May 25, 1963	May 31, 1963	June 9, 1963	May 15, 1963
Location:	Tonopah Test	TTR Range (TTR)	TTR	Nellis Air Force Base
Plutonium Inventory (curies [Ci]):	5.2 ± 1.6	29 ± 6.2	30 ± 4.9	5.0 ± 1.4

Source: Annual Site Environmental Report provided by the U.S. Department of Energy Nevada Operations Office.

The initial cleanup of each Clean Slate site was conducted shortly after each test and consisted of blading the test-related debris into a hole at test ground-zero. Each hole and debris were then covered with dirt. A fence was then erected around each Clean Slate test area. The fences were set at approximately 1000 micrograms plutonium per square meter as determined using hand-held survey meters (Rarrick 1993). In 1973, outer fences were built. The outer fences were set at 40 picocuries plutonium per gram of soil as determined using hand-held survey meters (Rarrick 1993). This survey was conducted with a field instrument for the detection of low-energy radiation (FIDLER) using 61-meter (m) grids. Surface soil has been sampled intermittently at the Clean Slate sites. An aerial radiologic survey was performed by Edgerton, Germeshausen & Grier Corporation (EG&G) for the Nevada Applied Ecology Group (NAEG) in 1977 using the 1973 grid. The objective of the aerial survey was to determine the surficial distribution of Pu and other transuranic elements dispersed during the Project Roller Coaster tests. The aerial surveys were undertaken to supplement the FIDLER and previous soil sample measurements of americium-241 (Am-241, a plutonium-241 [Pu-241] decay product present in the Pu of the test device). Radiation isopleths showing soil activity caused by Am-241, plutonium-239 (Pu-239), and plutonium-240 (Pu-240) were drawn for each area (EG&G 1979b). This survey showed the extent of the transuranic contamination, both inside and outside the two control fences, of the Clean Slate sites. Twice yearly the test areas are examined visually to determine whether any fence repairs are required. Animals that have wandered inside the areas are promptly removed.

3.0 COMPLIANCE SUMMARY

3.1 COMPLIANCE STATUS

Sandia National Laboratories (SNL) strives to comply with environmental and other requirements established by federal and state regulations, executive orders, and U.S. Department of Energy (DOE) orders. The following paragraphs summarize the status of Tonopah Test Range (TTR) in complying with major environmental statutes.

In late 1992 and early 1993, DOE's Headquarters (DOE/HQ), Kirtland Area Office (DOE/KAO), and Nevada Operations Office (DOE/NV) agreed that DOE/NV would manage all of the DOE/KAO and DOE/NV Environmental Restoration (ER) activities at TTR. This agreement was made because TTR's ER activities would be the first performed in the State of Nevada by the DOE, and it was felt that one field office should develop the remediation and closure plans for all sites in Nevada. ER activities in fiscal year 1994 (FY94) were conducted by the DOE/NV Environmental Restoration Project through an interim agreement with DOE/AL and DOE/KAO. This agreement provided funding to the Environmental Restoration Project with DOE/KAO oversight.

Activities accomplished in FY94 include the following: continued inventory of potential release sites; generation of a data report resulting from geophysical surveys conducted in FY93 at potential release sites (IT 1994a); completion of NEPA surveys at five unexploded ordnance (UXO) sites in anticipation of remediation activities; creation of a site priority ranking model using decision analysis software, which yielded a site ranking report (IT 1994b); completion of a multispectral scanner (MSS) aerial survey (EG&G 1994); and preparation of a draft work plan for the interim action to be conducted at five UXO sites, which are the Bomblet Pit, the Five Points Landfill, the Roller Coaster Sanitary Sewage Lagoons, the Area 9 Landfill, and the Area 9 Construction Debris Area (IT 1994c). The cleanup activities at the UXO sites will be conducted in FY95.

3.1.1 Regulations and Permits

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Superfund Amendments and Reauthorization Act (SARA)—As required under CERCLA/SARA, Section 120(d), a Preliminary Assessment (PA) was submitted for all facilities listed on the *Federal Agency Hazardous Waste Compliance* docket in 1988.

TTR is not on the National Priorities List, an ordered ranking of CERCLA sites. A CERCLA site is placed on this list if the site is above a certain threshold level established by the U.S. Environmental Protection Agency (EPA).

Resource Conservation and Recovery Act (RCRA)—Activities included the generation of a *Draft Resource Conservation and Recovery Act Facility Investigation (RFI) Work Plan* (DOE 1994). Although the Nevada Division of Environmental Protection (NDEP) has not imposed RCRA-mandated penalties or actions, the Environmental Restoration Project has begun this

work in a proactive manner as expressed by DOE's internal orders and best management practice. The *RFI Work Plan* was reviewed by DOE/AL and SNL ER personnel and will be completed in FY95.

TTR is permitted as a less-than-90-day storage area, large quantity generator. A large quantity generator accumulates more than 1000 kilograms (kg) of hazardous waste per month. Before 90 days of storage, the waste must be shipped from the accumulation facility (TTR) to an EPA-permitted treatment, storage, and disposal facility (TSDF). A reduction in operations during 1994 allowed qualification as a small quantity generator. A small quantity generator accumulates more than 100 kg but less than 1000 kg of hazardous waste per month. Before 180 days of storage (or 270 days if the TSDF is more than 200 miles away), the waste must be shipped to an EPA-permitted TSDF.

The change in status from large quantity generator to small quantity generator will reduce hazardous waste shipments from approximately 3 or 4 per year to 1 or 2 per year.

Hazardous chemical wastes are collected, packaged, and shipped off-site to an EPA-permitted TSDF. Standard Operating Procedures (SOPs) have been written to ensure continued compliance with RCRA.

Currently, one Class II sanitary landfill is in operation at TTR. This unit is operated by the management and cooperatively used by all organizations on TTR.

SNL/Nevada (SNL/NV) removed five underground storage tanks (USTs) from TTR in 1994. Currently, there are no USTs managed by SNL/NV on TTR.

Clean Air Act (CAA)—TTR is regulated by the CAA and State of Nevada air quality regulations, published in the Nevada Revised Statutes, Title 40, *Public Health and Safety*, Chapter 445 (Appendix A, Table A-1). The State of Nevada issued the following CAA permits to the identified organizations:

- Six aboveground storage tanks—U.S. Air Force (USAF)
- Two concrete batch plants—DOE/NV
- Vapor extraction unit—USAF
- Incinerator—USAF
- Disturbance land use greater than 5 acres—DOE/NV
- Crusher/screen—DOE/NV

DOE/NV currently holds six air quality permits for TTR (issued December 1993). Air emissions in 1994 were in compliance with applicable permits. A National Emission Standards for Hazardous Air Pollutants (NESHAP) annual report was prepared for CY94 (SNL 1995a).

Clean Water Act (CWA)—TTR is regulated by the CWA and State of Nevada water pollution and sanitary waste systems regulations (Appendix A, Table A-1). The state does not have a permitting process for septic tanks.

The sewage systems in TA-3, the main industrial area, are connected to the USAF facultative sewage lagoon facility. Grab samples are obtained on an annual basis by SNL/NV.

The 13 septic tanks that served TA-3 until 1990, when the consolidated sewage system was installed, will require further testing to ensure that no hazardous constituents are present before disposing of the waste and closing the tanks in conformance with State of Nevada regulations.

The remote locations on TTR are serviced by septic tank systems. These septic systems are maintained by the TTR facilities group.

Safe Drinking Water Act (SDWA)—TTR is regulated by the SDWA and State of Nevada public water supply and public water systems regulations. Drinking water for SNL/NV operations at TTR is provided by a well permitted by the State of Nevada in compliance with the public water supply standards. Compliance activities include bacteriological sampling of the drinking water system in accordance with the *Tonopah Test Range Site Sampling Plan* (DOE 1990). A state-certified water distribution operator is employed on the support contractor staff in fulfillment of state requirements for a certified water distribution operator for community systems. The *Water Conservation Plan for the TTR* complies with State Water Resources Division regulations requiring a water conservation plan for permitted water systems and major water users in Nevada (DOE 1992).

Toxic Substances Control Act (TSCA)—All transformers on TTR owned by DOE/KAO were sampled and analyzed in 1993 (IT 1993). This information was consolidated into a SNL/New Mexico (SNL/NM) database and into the SNL/NV inventory database. None of the samples contained more than 50 parts per billion of polychlorinated biphenyls (PCBs).

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)—Only EPA-registered pesticides are applied at SNL facilities. These pesticides are applied by an EPA-certified applicator. SNL retains records of the quantities and types of pesticides that are used as well as Material Safety Data Sheets (MSDSs) for each pesticide.

Endangered Species Act (ESA)—The DOE must comply with the ESA when planning federal actions or major construction activities. The key provision of the ESA for federal activities is Section 7, *Consultation*, which states that federal agencies must consult with the U.S. Fish and Wildlife Service to ensure that any agency actions are "not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species." There has not been a recent environmental assessment to detail the current situation in regard to sensitive species, though some of these species are known to occur in the area (ERDA 1975; EG&G 1979a). SNL assists the DOE in complying with the ESA at TTR.

Cultural Resources Acts—TTR holds responsibilities for cultural resources management, including those responsibilities applicable under the National Historic Preservation Act (NHPA), the Archaeological Resources Protection Act (ARPA), and the American Indian Religious Freedom Act (AIRFA). SNL integrates cultural resources management into the National Environmental Policy Act (NEPA) program. DOE requires NEPA review for all

DOE actions potentially affecting the environment; thus, even actions that may be categorically excluded are reviewed for impacts on cultural resources, among other things. (See Section 4.4 for further information on NEPA activities.)

Executive Orders—Executive Order 11988, *Floodplain Management*, and Executive Order 11990, *Protection of Wetlands*, require evaluation of the potential effects of actions taken in floodplains and wetlands. There are no floodplains or wetlands at TTR.

3.2 1994 AUDITS

The State of Nevada, Department of Health Protection, conducted an audit in February 1994 of the Clean Slate and Double Track areas. There were no DOE or SNL audits performed at TTR in 1994.

3.3 CURRENT ISSUES AND ACTIONS FOR TTR

SNL strives to achieve full regulatory compliance with environmental requirements at TTR. Ongoing self-assessments of compliance status continue to identify compliance issues. Resolution of these issues is coordinated with regulatory agencies to ensure that they are addressed.

3.3.1 Septic Tanks/Sewage Line

The facility group performed sampling of the septic tanks in FY90 using procedures that met federal and state requirements. Since FY90, federal and state regulations imposed more stringent testing parameters, including the requirement for analytical testing using the toxicity characteristic leaching procedure (TCLP). Septic tank sampling was also performed in 1993. Inactive septic tanks will be sampled again during future ER activities.

3.3.2 Underground Storage Tanks

All known USTs that DOE or SNL is responsible for on TTR were removed in August 1994. Four 10,000-gallon (gal.) fiberglass tanks (two diesel and two gasoline), that provided fuel to the former gas station in Area 3, and one 1,000-gal. steel tank (diesel), for a generator in Area 9, were removed by a Certified Environmental Manager (CEM) and a State of Nevada licensed contracting firm. Certificates of destruction for these five tanks are on file.

3.3.3 Waste Minimization Program

An informal waste minimization program is practiced at TTR. TTR is committed to achieving significant reductions in the amount of both hazardous and non-RCRA wastes. In 1994, antifreeze recycling and Freon recovery units were procured. Waste minimization and recycling activities include the following:

- Solvent recycling
- Fuel recycling
- Oil recycling
- Antifreeze recycling (on-site recycling unit)
- Lead acid battery recycling
- Freon recovery (on-site recovery unit)

In part as a result of the decreased test operation schedule and staff, D and U type (chemical) and F type (solvent) hazardous waste was reduced by 56 percent and 74 percent, respectively, in comparison to data from the previous 2 years. Because of TTR's remote location, it is not cost effective to recycle paper and other waste items.

3.4 ENVIRONMENTAL PERMITS

As part of the DOE complex, the SNL-operated TTR is committed to full compliance with all applicable environmental laws and regulations and to protection of the environment. TTR is regulated by federal laws and State of Nevada regulations for the applicable activities. (See Table A-1 in Appendix A for the state regulations and the corresponding activities.)

The permit application and registration of SNL/NV activities at TTR are administered by Kirk-Mayer, Inc. (KMI Services). There are a total of 13 air permits (8 permits owned by the USAF, 5 by DOE/NV), 4 public water system permits (1 owned by DOE/KAO, 3 by the USAF), 1 National Pollutant Discharge Elimination System (NPDES) permit for the sewage lagoon facility (owned by the USAF), and 1 EPA identification number for chemical hazardous waste on TTR (owned by DOE/KAO) (Table 3-1). The State of Nevada has not made a determination on permitting for the storm-water program. TTR has no waters of the United States within its boundaries; thus, following best management practices, SNL/NV activities on TTR may be permitted by SNL itself. Table A-2 of Appendix A includes detailed permit listings with expiration dates, issuing agencies, and responsible parties. TTR was in full compliance with all permit requirements for 1994.

Table 3-1. Summary of Permit Ownership at the TTR

Permit Type and Location	Permit No.	Ownership
Air Quality		
PetroStorage	2449	U.S. Air Force (USAF)
PetroStorage	2448	USAF
PetroStorage	2447	USAF
PetroStorage	2446	USAF
PetroStorage	2445	USAF
PetroStorage	1661	USAF
Batch Plant (Ross)	2229	U.S. Department of Energy/Nevada (DOE/NV)
Batch Plant (Johnson)	2231	DOE/NV
Crushers	2456, 2457	DOE/NV
Screens	2455	DOE/NV
Incinerator	2450	USAF
Surface Disturbance	2844	DOE/NV
Vapor Extraction*	3172	USAF
Public Water System		
Mancamp	NY-4068-12C	USAF
Industrial Area	NY-5001-12NC	USAF
Sandia Compound	NY-3014-12NC	DOE/Kirtland Area Office (DOE/KAO)
Tonopah Electronic Combat Range (TECR) Compound	NY-5002-12NC	USAF
National Pollutant Discharge Elimination System (NPDES)		
Sewage System	NEV20001	USAF
Hazardous Waste		
SNL/EPA Generator ID No.	NV1890011991	Activated/DOE/KAO

*Permit to construct.

4.0 OTHER ENVIRONMENTAL COMPLIANCE PROGRAMS

It is the policy of the U.S. Department of Energy (DOE) and Sandia National Laboratories (SNL) to conduct operations in an environmentally responsible manner and in compliance with applicable environmental standards. SNL maintains a variety of environmental programs to implement these laws and regulations and enhance the quality of the environment. This chapter describes SNL activities conducted in 1994 at Tonopah Test Range (TTR) to remediate sites contaminated in the past, to manage hazardous, radioactive, mixed, and other wastes, to comply with environmental protection requirements, and to respond to releases and environmental incidents. Other environmental programs at TTR are terrestrial surveillance, air quality surveillance, and water monitoring. These programs are addressed in detail in following chapters.

4.1 SPILL PREVENTION CONTROL AND COUNTERMEASURE PLAN

The *Spill Prevention Control and Countermeasure (SPCC) Plan* for TTR was completed by SNL in 1990 (SNL 1990) and updated in June 1994 (SNL 1994). This plan was prepared in accordance with Title 40, Code of Federal Regulations, Part 112 (40 CFR 112). The SPCC Plan for SNL/Nevada (SNL/NV) at TTR documents 29 locations for secondary containment upgrade, including transformers, aboveground storage tanks, and three bulk storage areas. Construction of the secondary containment areas was completed in fiscal year 1993 (FY93).

4.2 WASTE MANAGEMENT PROGRAMS

Waste management is the safe and effective management of active and standby facilities and the treatment, storage, and disposal of radioactive, hazardous, and mixed wastes. The following sections include summary descriptions of major waste management programs and activities at TTR.

4.2.1 Chemical and Hazardous Waste Management

Chemical wastes generated by SNL/NV activities at TTR during calendar year 1994 (CY94) were managed by Kirk-Mayer, Inc. (KMI Services), the facilities support contractor.

In CY94, 5615 kilograms (kg) of hazardous waste and 9413 kg of non-RCRA waste were shipped off the TTR for disposal at a permitted treatment and storage facility. Table 4-1 shows the breakdown of the waste categories and quantities.

Table 4-2 lists waste transported off-site for recycling or alternative fuel use (1598 kg of non-RCRA waste and 1543 kg of RCRA waste).

Table 4-1. Chemical and Hazardous Waste Shipped Off-Site in 1994 for Disposal

Waste Characteristic	Waste Identification Code	Quantity (kilograms)
Ignitable chemical waste	D001	1,913
Corrosive chemical waste	D002	170
Reactive chemical waste	D003	2
Cadmium chemical waste	D006	74
Lead chemical waste	D008	120
Mercury chemical waste	D009	9
Spent nonhalogenated solvents	F003	384
Dichlorodifluoromethane	U075	46
Trichloromonofluoromethane	U121	45
1,1,1,-Trichloroethane	U226	3
Laboratory packs containing:	D001, D002, D007, D008, D035 F001, F003, F005, and U002	2,806
		Total 5,615
Chlorine gas cylinders	NR	543
Antifreeze	NR	121
Non-RCRA waste (diesel-contaminated soil)	NR	8,749
		Total 9,413

Table 4-2. Waste Shipped Off-Site in 1994 for Recycling

Waste Characteristic	Quantity (kilograms)
Used oil	Total 1,598
Ignitable (gasoline water)	49
Safety Kleen solvent (petroleum naphtha)	1,423
Safety Kleen immersion cleaner (monoethanolamine)	71
	Total 1,543

The wastes in Table 4-2 were shipped to the following facilities for disposal or recycling:

- Ensco (El Dorado, AR)
- Safety Kleen Corporation (Los Angeles, CA)

Three hazardous waste shipments were made in 1994. The change in status from large quantity generator to small quantity generator will reduce hazardous waste shipments from approximately 3 or 4 per year to 1 or 2 per year, thus reducing shipment costs (see Section 3.1.1).

4.3 ENVIRONMENTAL RESTORATION PROJECT

The Environmental Restoration (ER) Project is a phased DOE program to identify, assess, and correct past spill, release, or disposal sites at all DOE Albuquerque Operations Office (DOE/AL) facilities including the SNL-operated TTR. The method parallels the U.S. Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) program to identify, characterize, and clean up inactive release sites. Table 4-3 summarizes the ER Project sites at TTR planned for investigation. DOE's Nevada Operations Office (DOE/NV) is responsible for the three Clean Slate sites.

The initial identification, description, and listing of the ER waste sites was derived from the Preliminary Assessment and the Federal Facility Preliminary Assessment Review. In 1993, IT Corporation (IT) obtained additional information related to these previously identified ER sites and identified new ER sites through the ER sites inventory process, geophysical surveys, and aerial radiological and multispectral surveys. These newly identified sites were included and listed based upon joint efforts of the DOE/NV and SNL in the form of interviews with former site workers, archive reviews, and site visits.

Forty-three listed ER sites located throughout TTR are included in Table 4-3. These sites have been divided into eight groups based on similar waste streams, functions, and/or investigative strategy. The eight groups are (a) underground storage tanks (USTs); (b) landfills and lagoons; (c) septic tanks and leachfields; (d) drains; (e) surface and near-surface radioactive sites; (f) ordnance; (g) photographic french drains; and (h) other. Table 4-3 also summarizes the current status of these ER sites.

IT also identified twelve potential ER sites. These sites, which were not included or listed, were identified during the ER sites inventory process through interviews with site workers, aerial photograph inspection, and site reconnaissance:

- Bunker 2 debris mound
- Station 44 Burn Area
- Colimbo Detonation Site
- Thunderwell Site
- Possible buried artillery round No. 3

Table 4-3. Summary of Environmental Restoration Project Sites Planned for Investigation

ER Site Identification Number	Site Name	Location	Current Status
	Group A: Underground Storage Tanks (USTs)		
03-02-001-03-53	Building 0353 Diesel UST	Area 3	Possible soil contamination from the UST.
03-02-002-03-08	Building 0360 Waste Oil UST	Area 3	Possible soil contamination from the UST.
03-02-003-03-57	First Gas Station USTs	Area 3	A No Further Action recommendation is proposed.
03-02-004-03-60	Second Gas Station USTs	Area 3	Possible soil contamination from the former USTs.
	Group B: Landfills and Lagoons		
03-19-001-03-LF	Area 3 Landfill Complex	Area 3	Possible soil contamination from sanitary and potentially hazardous landfill cells.
09-19-001-09-52	Area 9 Landfill	Area 9	Possible hazardous materials in landfill; miscellaneous surface debris.
TA-19-001-05-PT	Five Points Landfill	Test Area	Landfill, with scattered surface debris, i.e., spent rocket motors, drums, and construction material. Possible unspent rocket fuel with lead contamination.
Pending	Area 9 Construction Debris Pit	Area 9	Landfill with scattered surface debris, i.e., construction material, concrete, and spent rocket motors.

Table 4-3. Summary of Planned Environmental Restoration Investigation Sites (Continued)

ER Site Identification Number	Site Name	Location	Current Status
	Group B: Landfills and Lagoons (concluded)		
Pending	Area 9 Disposal Trenches	Area 9	Two covered disposal trenches; contents unknown.
TA-03-001-TA-RC	Roller Coaster Sanitary Sewer System and Lagoons	Test Area/NW of Antelope Lake	Possible soil contamination near the associated open landfill. Visible contents in the landfill include spent rocket motors, 55-gal. barrels, pallets, wire, ducting, and miscellaneous construction debris.
	Group C: Septic Tanks and Leachfields		
03-04-001-03-52	Septic Tank 33-1	Area 3	Liquid wastes in leachfields.
03-04-002-03-73	Septic Tank 33-2	Area 3	Liquid wastes in leachfields.
03-04-003-03-71	Septic Tank 33-3	Area 3	Liquid wastes in leachfields.
03-04-004-03-70	Septic Tank 33-4	Area 3	Liquid wastes in leachfields.
03-04-005-03-67	Septic Tank 33-5	Area 3	Liquid wastes in leachfields.
03-04-006-03-80	Septic Tank 33-6	Area 3	Liquid wastes in leachfields.
03-04-007-03-57	Septic Tank 33-7	Area 3	Liquid wastes in leachfields.
03-04-008-PB-14	Septic Tank 33-8	Area 3	Liquid wastes in leachfields.
03-04-009-03-85	Septic Tank 33-9	Area 3	Liquid wastes in leachfields.
03-04-010-03-78	Septic Tank 33-10	Area 3	Liquid wastes in leachfields.

Table 4-3. Summary of Planned Environmental Restoration Investigation Sites (Continued)

ER Site Identification Number	Site Name	Location	Current Status
	Group C: Septic Tanks and Leachfields (concluded)		
03-04-011-03-52	Septic Tank 33-11	Area 3	Photographic wastes in leachfields.
03-04-012-03-67	Septic Tank 33-12	Area 3	Possible waste oil in leachfields.
03-04-013-03-65	Septic Tank 33-13	Area 3	Liquid wastes in leachfields.
03-05-001-03-75	Leachfield near Building 0383T	Area 3	May have received liquid wastes from Septic Tanks 33-1 and 33-2.
	Group D: Drains		
03-51-003-03-58	Uninterrupted Power Supply (UPS) Building Drains	Area 3	Received excess liquids on the floor of the UPS building.
03-51-002-03-74	Heavy-Duty Shop Drain	Area 3	Received liquid wastes from Building 0374 floor sumps.
	Group E: Surface/Near-Surface Radioactive Sites		
TA-39-001-TA-RC	Roller Coaster Radioactive Decontamination Area	Test Areas/NW of Antelope Lake	Potentially contaminated soil from equipment and personnel decontamination area; trench with buried personal protective equipment.

Table 4-3. Summary of Planned Environmental Restoration Investigation Sites (Continued)

ER Site Identification Number	Site Name	Location	Current Status
	Group E: Surface/Near-Surface Radioactive Sites (concluded)		
TA-39-001-TA-GR	Cactus Springs	Test Areas/ West of Target Areas	Location of bioaccumulation studies; housed animals that grazed in radioactive field. Potentially contaminated soil from animal feces.
Pending	Double Tracks Decontamination/ Animal-Hide Burial Area	Nellis Range 71	Heavy equipment decontamination; pit with buried animal hides contaminated with plutonium.
TA-55-002-09-60	Buried Depleted Uranium (DU) Artillery Round No. 2	Test Areas/ South of Area 9	Detonated round with DU (W-79 or W-82 round).
TA-52-001-TA-NL	Nonviolent Explosive Destruct System (NEDS) Lake	Test Area/ NEDS Lake	Scattered DU and beryllium; rocket-propellant burn area.
TA-52-001-TA-ML	DU Impact Site	Test Area/SE Main Lake	DU shrapnel found on the edge of Main Lake; DU and soil placed in containers and removed.
Pending	Antelope Lake A. Metal Particle Dispersion Test B. Joint Test Assembly DU Sites	Test Area/ Antelope Lake	Active target area for aerial drops, penetrator tests, and dispersal tests. Possible DU, beryllium, and other hazardous material contamination.

Table 4-3. Summary of Planned Environmental Restoration Investigation Sites (Continued)

ER Site Identification Number	Site Name	Location	Current Status
		Group F: Ordnance	
TA-55-001-TA-B2	Bomblet Pit	Test Area/ near Mid-Target	Ordnance scattered on surface. May contain bomblets with live fuzes.
Pending	Bomblet Target Areas	Test Areas/ Antelope Lake to Mid-Target	Ordnance scattered on surface. Possible live fuzes.
TA-55-001-09-60	Buried DU Artillery Round No. 1	Test Areas/ South of Area 9	Possible live round with DU (W-79 round).
		Group G: Photographic French Drains	
03-51-001-03-55	Photographic Shop French Drains	Area 3	Liquid photographic processing wastes in drains.
09-51-001-09-52	Mobile Photographic Laboratory	Area 9	Leachfield(s) and/or french drain(s) with rinse water containing residual chemicals from photographic processing.

Table 4-3. Summary of Planned Environmental Restoration Investigation Sites (Concluded)

ER Site Identification Number	Site Name	Location	Current Status
		Group H: Other	
03-19-002-03-74	Snow Removal Soil Disposal Area (SRSDA)	Area 3	A No Further Action recommendation is proposed.
03-56-001-03-BA	Fire Training Area	Area 3	Potential soil contamination from fire-training activities, also used as a landfill/burn pit. General garbage, no test equipment.
09-54-001-09-L2	Gun Propellant Burn Area	Area 9	Potential soil contamination from gun propellant.
Pending	Sandia Service Yard	Area 3	Potentially contaminated soil from drum storage activities.
TA-53-001-TA-B2 and TA-53-002-TA-B2	Septic Sludge Disposal Pits 1 and 2	Test Area/ South of Bunker 2 Road	Possible contaminated sludges from septic tanks in Area 3 dumped into auger holes.

- Possible buried artillery round No. 4
- Garbage pit near Antelope Lake
- Buried rocket in Antelope Lake
- Garbage pit at Nonviolent Explosive Destruct System (NEDS) Lake
- Mellan
  - Practice bomb disposal pit
  - Davis gun penetrator test
- Underground vault east of Area 9 Igloo yard
- Hard Target

At present, sufficient information does not exist to identify sampling locations at these sites. Further investigations will be conducted before site characterizations are planned and will include data compilation activities and an ER sites inventory. The schedule for additional site investigations shall be addressed in subsequent fiscal years.

4.4 1994 NATIONAL ENVIRONMENTAL POLICY ACT COMPLIANCE ACTIVITIES AND DOCUMENTATION

The National Environmental Policy Act (NEPA), the nation's most comprehensive legislative and public policy statement on environmental protection, applies to all agencies of the federal government.

The Council on Environmental Quality (CEQ) was created in the Executive Office of the President under the authority of NEPA. CEQ regulations were formally adopted by DOE in August 1979 (10 CFR 1021). DOE NEPA guidelines were last published in full in the *Federal Register* on December 15, 1987. On April 24, 1992, DOE codified its existing rule of compliance with NEPA (10 CFR 1021). The proposed rule incorporates certain policy initiatives instituted by the Secretary of Energy.

Although only DOE has the authority to decide the appropriate level of NEPA documentation, SNL assists DOE by drafting appropriate documentation, such as Environmental Checklists (ECLs), Action Description Memoranda (ADMs), and Environmental Assessments (EAs) for DOE approval. Such environmental documents serve as vehicles for assessing potential environmental impacts of proposed federal actions and disclosing federal activities. Figure 4-1 describes the sequence for creating and reviewing NEPA documents.

At SNL, the Risk Management & NEPA Department carries out various NEPA-related activities, including consulting and training line-organization personnel in NEPA compliance, coordinating document preparation, maintaining a corporate NEPA document file, and reviewing NEPA documents before submittal to DOE. These responsibilities are documented in the SNL NEPA program (SNL 1991).

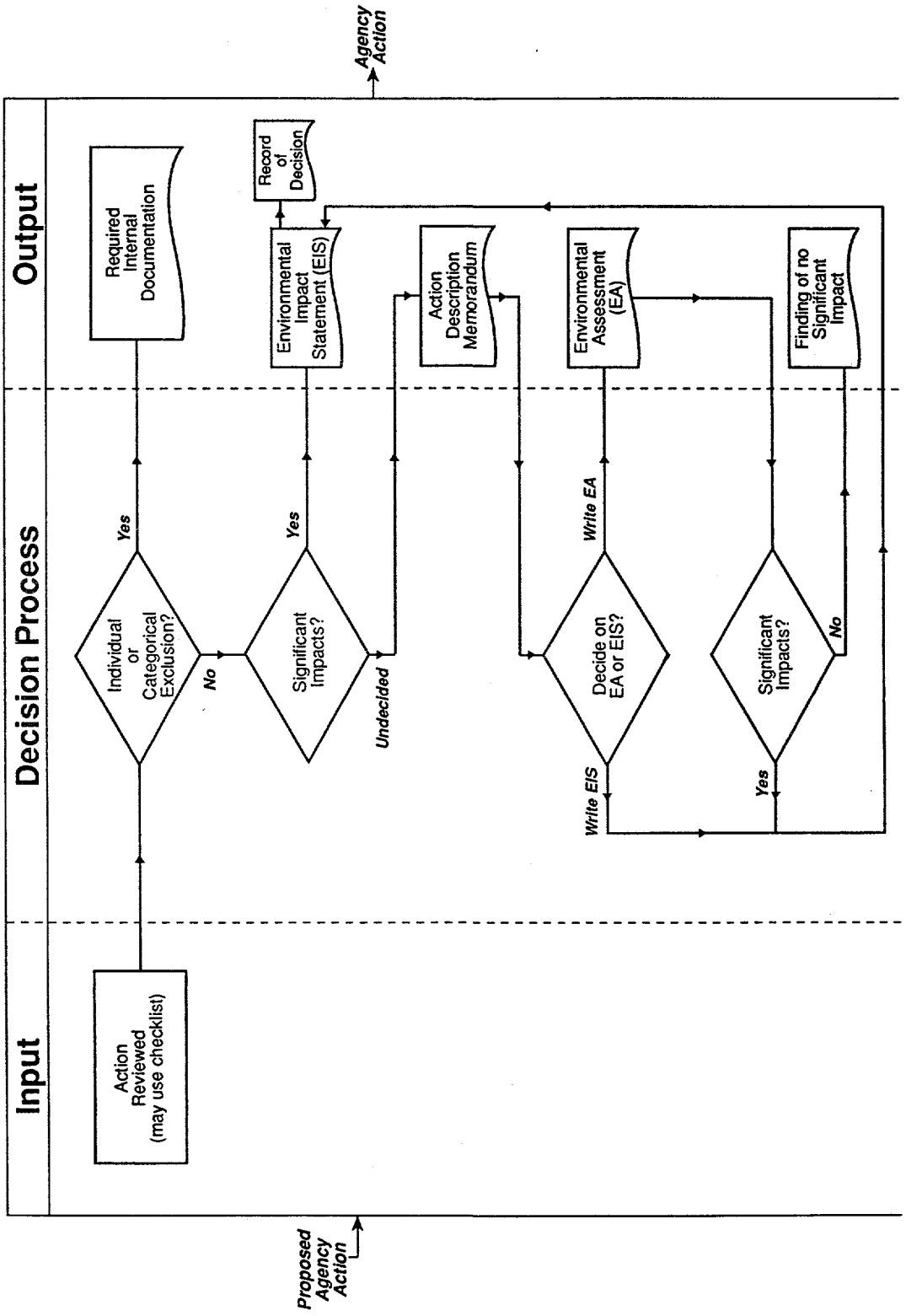

Figure 4-1. Sequence for Creating and Reviewing National Environmental Policy Act Documents

4.4.1 Compliance

The Secretary of Energy's February 5, 1990, NEPA Notice (SEN-15-90), with directives intended to bring DOE into full compliance with NEPA, set in motion events that led to a major increase in commitment to comply with the principles and practices underlying NEPA. At TTR, NEPA compliance is a joint effort by SNL with DOE/NV and the Water Resources Center, Desert Research Institute (DRI), University of Nevada System. DRI and Edgerton, Germeshausen & Grier Corporation (EG&G) prepare archaeological and biological surveys and reports. Final reports are submitted to SNL and DOE/NV for transmittal to the State of Nevada, State Historic Preservation Office (SHIPO), for review and decision making.

4.4.2 Environmental Checklist

An ECL serves to document the use of a categorical exclusion (a category of actions for which neither an EA or an Environmental Impact Statement [EIS] is required).

4.4.3 Action Description Memorandum

An ADM is a document containing a concise description of a proposed action and a brief discussion of relevant potential environmental issues. DOE uses ADMs to determine the appropriate level of NEPA documentation for proposed actions. In the past, ADMs were also used to document categorical exclusions and to support memo-to-file (MTF) reviews.

The MTF was a unique DOE mechanism established in 1980 to justify not preparing EAs on insignificant actions that had not yet been added to the DOE published list of categorical exclusions. This procedure was followed because the categorical exclusions list was not well defined. The MTF system to exclude actions that are clearly insignificant, but not specifically categorically excluded from detailed NEPA documentation, ended on September 30, 1990. At present, actions that are not categorically excluded or covered in approved NEPA documents require preparation of EAs or EISs.

4.4.4 Environmental Assessment

An EA is intended to be a "concise public document" which provides sufficient evidence and analysis to determine whether to prepare an EIS or a Finding of No Significant Impact (FONSI). The EA also aids in the compliance with NEPA when no EIS is required and facilitates preparation of an EIS when one is necessary.

A categorical exclusion was applied for in 1994 by SNL/NV and granted by DOE/AL to install lightning protection at TTR.

4.5 OVERVIEW OF NON-SNL ENVIRONMENTAL MONITORING PROGRAMS AT TTR

The TTR landowner is the Bureau of Land Management (BLM). The U.S. Air Force (USAF) maintains a use permit with BLM that is renewed every 5 years (yr). BLM must approve any

new construction, such as roads. SNL's responsibilities for environmental surveillance extend to those environmental surveillance activities performed by SNL/NV or under its direction. Other agencies and contractors perform environmental monitoring activities at TTR under memoranda of understanding with DOE.

- U.S. Environmental Protection Agency—The EPA Environmental Monitoring Systems Laboratory in Las Vegas, NV, under an interagency agreement with DOE, monitors background radiation at TTR as part of its Off-Site Radiation Monitoring Program. Reports of the monitoring are issued to DOE/NV on both a quarterly and annual basis.

- Water Resources Center, Desert Research Institute, University of Nevada System—DRI is under contract with DOE to provide services that include public information activities and radiation monitoring support.

  DRI provides and trains station managers to run EPA community monitoring stations at such remote locations as Tonopah and Goldfield. These managers generally are local science teachers. The EPA laboratory in Las Vegas, NV, provides equipment and performs the analysis and reporting. DRI also provides external quality assurance (QA) on field measurements taken by EPA at community monitoring stations. Selected locations are monitored concurrently by DRI with a portable monitoring station (PMS) and thermoluminescent dosimeters (TLDs). EPA monitor results are compared to DRI results.

  The QA results that summarize EPA and DRI data at the selected locations are reported annually by DRI. DRI also performs other monitoring, primarily hydrological, for DOE as requested. This may include evaluating environmental impacts due to road construction.

- KMI Services—As part of its TTR support activities, KMI Services performs environmental monitoring activities at TTR. These activities include water monitoring and obtaining permits in compliance with EPA and State of Nevada regulations. KMI Services also performs hazardous waste management for off-site disposal of hazardous wastes at EPA-approved facilities.

Other agencies also prepare reports that may include information on TTR. These reports, described in Volumes 1 through 4 of the *Sandia National Laboratories/Nevada Environmental Compliance Summary Report* (TTR 1992), are available from the respective agencies. Reports that are prepared on a regular basis include the following:

- *Annual Permits/Registration Certificates for Sandia National Laboratories/Nevada*—KMI Services.

- *Off-site Monitoring Report-Nevada Test Site and Other Test Areas, Quarterly Report*—EPA, Dose Assessment Branch, Nuclear Radiation Assessment Division.

- *Environmental Monitoring Report: Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year Report*—EPA, Dose Assessment Branch, Nuclear Radiation Assessment Division (also published as part of the NTS Annual Site Environmental Report).

- *Community Radiation Monitoring Program, Annual Report*—DRI.

4.6 1994 REPORTABLE RELEASES

TTR had two reportable spills of petroleum hydrocarbons in 1994. The first spill occurred when a float valve cracked in the day feeder tank for a generator facility at Area 9. The crack kept the feeder demand on for the tank even though it was full. This sent diesel fuel through the air vent and onto the ground adjacent to the building. Approximately 45 gallons (gal.) of fuel were released in the spill. Cleanup efforts involved removing approximately 18 cubic yards of soil. The site was assessed by a CEM and was determined clean with the exception of the soil under the facility foundation. SNL/NV is petitioning the State of Nevada for closure until such time as the facility is demolished. Final cleanup will be accomplished at that time.

The second reportable spill was discovered upon exposing the four 10,000-gal. fuel storage tanks located at the Area 3 gas station during the removal process. There were obvious fuel stains at the fill ports where overspill may have occurred. There was also evidence of problems with the piping system of the diesel tanks. Fuel may have been released to the soil from the piping. Initial abatement action was accomplished by excavating approximately 122 tons of soil and hauling the soil off-site to the Las Vegas Paving Hydrocarbon Plant. Another 700 to 900 tons of contaminated soil were stockpiled east of the excavation. Abatement was halted when the limits of the trackhoe were met and it was evident that further excavation through the contaminated soil could not be done. Site characterization was accomplished two weeks later after clean fill had been placed in the hole to allow for a level drilling surface. A truck-mounted BK-81 hollow-stem auger drill rig equipped for soil sampling was used. The vertical extent of contamination migration begins at approximately 28 ft and ends at approximately 95 ft below the ground surface. Laterally, the east-west zone of contamination extends approximately 57 ft and the north-south zone extends approximately 31 ft. An estimate of the quantity of remaining soil contamination within this area is 4581 cubic yards. Methods of treatment and funding issues for site cleanup are currently being addressed.

4.7 OCCURRENCE REPORTING

On December 1, 1994, during a routine radiological survey of salvage material, a wind radar antenna pedestal mounted on a small trailer in an uncontrolled area was discovered with radioactive and contaminated material stickers.

An initial survey indicated the presence of radioactive material. The area around the trailer was immediately posted as a "Controlled Area." SNL/NM Radiation Protection Operations

Department was informed and sent radiological personnel to TTR to confirm the isotope and further assess the situation.

A telemetry engineer recalled that approximately 5 yr earlier (approximately 1989) the trailer was discovered by REECo radiation technicians to be contaminated and was to be taken to the Nevada Test Site (NTS) for disposal. At that time, the contamination source was identified as material used to illuminate a dial. The specific identity of the material and the associated activity level were unknown. REECo's health physics representative at TTR indicated the contamination was discovered during routine surveys; the area was swiped and properly posted, and the representative confirmed that REECo would take the trailer to NTS for proper disposal.

On December 6, 1994, the SNL/NM radiological team arrived at TTR and identified the material as radium-226 (Ra-226) with readings of 2.5 milliroentgens per hour (mR/hr) on contact, 34,000 disintegrations per minute (dpm)/100 cm^2 alpha, and 20,000 dpm/100 cm^2 beta/gamma.

On December 7, 1994, a Radiological Work Permit (RWP) was issued to the radiological team to re-enter the controlled area and prepare the trailer for movement to a controlled long-term storage area in Area 9 at TTR. Prior to movement, the contaminated areas on the pedestal and trailer were identified, wrapped in plastic, and securely taped. After movement, the storage area was secured and posted "Controlled Area - Radioactive Material." The trailer and pedestal will be documented by the Radiation Protection Operations Department as requiring semiannual monitoring. The final disposition of the contaminated material will be negotiated with DOE/NV.

5.0 ENVIRONMENTAL SURVEILLANCE AT TTR IN 1994

5.1 1994 SNL ENVIRONMENTAL SURVEILLANCE

In June 1994, staff of Sandia National Laboratories' (SNL) Air Quality Department Environmental Surveillance program collected soil samples at Tonopah Test Range (TTR). Limited air monitoring samples were collected from July to September 1994. The overall objectives of this surveillance program are to detect any potential migration of contaminated material related to on-site operations and also to determine the potential impact (if any) of site-related activities to the population and the surrounding environment. The specific objectives include the annual sampling of the long-term, routine, environmental surveillance locations and supplementing the environmental baseline data collected in 1992 (SNL 1992a). The sampling of the routine surveillance locations provides information related to the long-term environmental conditions and trends of the site. Additional baseline-related sampling was performed in 1994 in areas where SNL has had a long-term or continued presence at TTR. The results of this sampling will be used to evaluate the impact (if any) of that presence.

To support the objectives of the Environmental Surveillance program, soil samples were collected in three distinct areas: off-site, site perimeter, and on-site. The off-site locations provide a sampling of environmental conditions unrelated to SNL activities at TTR. Data collected at these locations serve as a reference point to compare with data collected at perimeter and on-site locations. The perimeter locations are used to monitor the site boundary for potential contamination migrating either onto or off of TTR. On-site locations are near areas of known contamination or potential sources of contamination, or in areas where contamination, if present, would be expected to accumulate. All samples collected in 1994 were from areas of uncontrolled access, outside of the on-site controlled areas.

Most routine environmental surveillance locations remain essentially the same from year to year. Long-term locations are added as necessary to monitor new operations or to supplement data from existing locations. Due to limited resources, the sampling locations, number of samples, and analyses performed were prioritized based on the following: (1) contaminants believed to be present, (2) contamination considered readily dispersible by environmental factors (e.g., wind or rain), and (3) areas with the greatest potential for impact to workers and the environment. To supplement the existing baseline information, limited soil samples were collected from the following areas: the Airport Area, Area 9, the Hard Target/DU Area, the On-Base Housing Area, the South Plume Area, the Project Roller Coaster Sewage Lagoon, the Mellan Hill Area, the 554th Range Squadron Operations and Maintenance (O&M) Complex, and the Range Operations Center and Compound.

The long-term thermoluminescent dosimeter (TLD) network was established in January 1994. Environmental TLDs were placed at various locations off-site, at the site perimeter, and on-site to measure gamma radiation.

5.1.1 Sample Collection and Analysis

Soil samples were gathered in accordance with *Environmental Sampling Procedure* (SNL 1992b), the activity-specific environment, safety, and health (ES&H) Standard Operating Procedure (SOP). In cases of replicate sampling, only the first sample collected (sample A) was used in summary calculations to avoid skewing summary data toward replicate sample data.

As part of the 1994 surveillance activities, 110 soil samples were collected, including replicate samples, from 98 separate locations: 14 from off-site, 5 from the site perimeter, 7 from the Airport Area, 12 from Area 9, 5 from the Hard Target/DU Area, 5 from around the On-Base Housing Area, 6 from the South Plume Area, 4 from the Project Roller Coaster Sewage Lagoons, 4 from the Mellan Hill Area, 3 from the 554th Range Squadron O&M Complex, 24 from the Range Operations Center, and 9 from various on-site locations. All soil samples were analyzed for twenty standard metals by the inductively coupled plasma (ICP) method, isotopic plutonium, and total uranium (U_{tot}), and by gamma spectroscopy.

Only the gamma spectroscopy results for americium-241 (Am-241) and cesium-137 (Cs-137) are included in this report. Americium-241 is a decay product of plutonium-241 (Pu-241); thus the presence of Am-241 infers the presence of Pu-241. Plutonium-241 is a common impurity in weapons-grade plutonium (Pu).

Plutonium analysis was performed on all soil samples. For samples collected from on-site or the site perimeter, isotopic plutonium and Am-241 concentrations were compared to the respective analytical detection limits (0.1 picocuries per gram [pCi/g] each). Locations where soil concentrations were equal to, or greater than, the analytical detection limit are stated in the text. Where concentrations were greater than the respective analytical detection limits, a comparison to the off-site range of values was made. Locations with isotopic plutonium and Am-241 concentrations greater than detection limits and also greater than the off-site range of values were considered potentially contaminated. For samples collected from on-site or the site perimeter, U_{tot}, Cs-137, and nonradiological metal concentrations were compared to the upper 95 percent (mean plus two standard deviations) confidence limit and the range of values from those samples collected off-site. Individual samples with values greater than the upper 95 percent confidence interval and greater than the range of observed values were considered potentially contaminated.

PM_{10} air monitors sample air particulates of 10 microns (μm) or less. This size of particulate is considered respirable. PM_{10} air monitoring samples were collected at three locations on TTR: the 554th Range Squadron O&M Complex, Station 14 (STA-14), and Well 6. The 554th Range Squadron O&M Complex was the maximum exposed individual receptor for a dose assessment performed in 1993 (Culp and Howard 1994). STA-14 is located in the general vicinity between Clean Slates 1 and 3 (the potential sources of airborne contamination) and the SNL/NV-occupied portions of TTR.

Well 6 is the main TTR water well located near the Range Operations Center where the majority of SNL/NV personnel work. Samples were gathered in accordance with TOP-94-07 (Culp 1994).

Air monitoring was performed for approximately 2 months (August and September). Air filters were exchanged weekly and analyzed samples consisted of monthly composites. All composite samples were analyzed for gross alpha, gross beta, isotopic plutonium, U_{tot}, and twenty ICP nonradiological metals, and by gamma spectroscopy.

The effective dose equivalent (EDE) was determined using the measured radionuclide air data. The individual radionuclide concentrations for a given composite period were multiplied by their respective dose conversion factor (Eckerman et al. 1988) and used to determine the EDE assuming unrestricted access, continuous occupancy at the sample location, and that the air concentration for the composite period is representative of the entire year.

The carcinogenic risk and noncarcinogenic hazard quotient were determined using the measured nonradiological air data. The individual concentrations for a given composite period were assessed against the carcinogenic and noncarcinogenic U.S. Environmental Protection Agency (EPA) risk-based concentrations (EPA 1994) using assumptions similar to those used in determination of the EDE.

5.2 1994 SNL RADIOLOGICAL SURVEILLANCE RESULTS

5.2.1 Soil Sampling

Figures B-1 through B-14 of Appendix B show the 1994 environmental surveillance soil sampling locations. Tables B-1 through B-12 of Appendix B list the individual radiological sample results for the soil sampling. Table 5-1 summarizes the radiological soil sampling data.

5.2.2 Off-Site Soil Sampling

Fourteen locations were sampled off-site (see Figure B-1 and Table B-1). No samples contained Am-241 concentrations greater than the analytical detection limit. One sample location (B-1) contained measurable concentrations of Pu-238. These off-site data are believed to be representative of the ambient radionuclide concentrations for the area surrounding TTR.

5.2.3 On-Site Soil Sampling

Site Perimeter—Five locations were sampled at the TTR perimeter (see Figure B-2 and Table B-2). No samples contained Pu-238, Pu-239, Pu-240, or Am-241 concentrations greater than the analytical detection limit. Total U and Cs-137 concentrations were indistinguishable from off-site concentrations.

Table 5-1. Radiological Summary Data for Soil Samples Collected at TTR in 1994

Location	Number of Samples	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-239,240 (pCi/g)	Cs-137 (pCi/g)	Am-241 (pCi/g)
Off-Site	14	2.3 to 6.0	-0.11 to 0.11	-0.05 to 0.02	0.05 to 0.83	ND
Mean		4.2	0.00	-0.01	0.33	
Standard Deviation		1.1	0.05	0.02	0.22	
Site Perimeter	5	3.2 to 5.0	-0.04 to 0.04	-0.02 to 0.06	0.14 to 0.69	ND
Airport Area	7	3.3 to 6.1	-0.06 to 0.07	-0.04 to 0.00	ND to 0.87	ND
Area 9	12	3.8 to 6.1	-0.05 to 0.02	-0.03 to 0.02	ND to 0.41	ND
Hard Target/Depleted Uranium Area	5	3.9 to 12	-0.07 to 0.01	-0.04 to 0.02	0.05 to 0.42	ND
On-Base Housing Area	5	3.4 to 5.0	-0.07 to 0.02	0.00 to 0.02	0.05 to 0.21	ND
South Plume Area	6	2.8 to 5.1	0.00 to 0.23	0.01 to 32	0.49 to 0.97	ND to 4.4
Project Roller Coaster Sewage Lagoons	4	4.8 to 5.9	-0.03 to 0.11	-0.02 to 0.09	0.20 to 0.41	ND
Mellan Hill Area	4	4.1 to 4.5	0.01 to 0.03	0.07 to 0.51	0.37 to 0.64	ND
554th Range Squadron O&M Complex	3	3.8 to 4.7	0.00 to 0.05	0.06 to 0.10	0.34 to 0.60	ND
Range Operations Center and Compound	24	3.5 to 6.3	-0.07 to 0.21	-0.01 to 0.07	ND to 0.53	ND
Various On-Site Locations	9	3.0 to 6.2	-0.01 to 0.11	-0.02 to 3.0	ND to 0.66	ND to 0.35

Note: μg/g = micrograms per gram; pCi/g = picocuries per gram; ND = Not detected.

Airport Area—Seven locations were sampled in the area around the TTR airport (see Figure B-3 and Table B-3). No samples contained Pu-238, Pu-239, Pu-240, or Am-241 concentrations greater than the analytical detection limit. Total U and Cs-137 concentrations were indistinguishable from off-site concentrations.

Area 9—Twelve locations were sampled in and around Area 9 (see Figure B-4 and Table B-4). No samples contained Pu-238, Pu-239, Pu-240, or Am-241 concentrations greater than the

analytical detection limit. Total U and Cs-137 concentrations were indistinguishable from off-site concentrations.

Hard Target/DU Area—Five locations were sampled in the area near the Hard Target including the fenced-off DU Area (see Figure B-5 and Table B-5). Total U was elevated in the sample (T-20) collected from the south fence of the DU Area. No other samples contained U_{tot}, Pu-238, Pu-239, Pu-240, or Am-241 concentrations greater than the analytical detection limit or off-site concentrations. Cesium-137 concentrations were indistinguishable from off-site concentrations.

On-Base Housing Area—Five locations were sampled near the On-Base Housing Area (see Figure B-6 and Table B-6). No samples contained Pu-238, Pu-239, Pu-240, or Am-241 concentrations greater than the analytical detection limit. Total U and Cs-137 concentrations were indistinguishable from off-site concentrations.

South Plume Area—Six locations were sampled in the South Plume Area (see Figure B-7 and Table B-7). The South Plume Area is located south of the known transuranic plume associated with Clean Slate 1. The preliminary results of the 1993 Edgerton, Germeschausen & Grier Corp. (EG&G) aerial radiological survey of a portion of TTR showed the approximately 40 pCi/g transuranic contours associated with the three Clean Slate sites. The aerial survey was discontinued before reaching the end of the downwind contamination associated with Clean Slate 1. Samples were collected in an attempt to further delineate the potential extent of contamination. One sample (T-19) contained Pu-238 concentrations in excess of both the analytical detection limit and off-site concentrations. Four samples (T-14A, T-17, T-18, and T-19) contained Pu-239 and Pu-240 concentrations in excess of both the analytical detection limit and off-site concentrations. Three samples (T-17, T-18, and T-19) contained Am-241 in excess of both the analytical detection limit and off-site concentrations. All other Pu-238, Pu-239, Pu-240, and Am-241 concentrations were less than the analytical detection limit. Total U and Cs-137 concentrations were indistinguishable from off-site concentrations.

Project Roller Coaster Sewage Lagoons—Four locations were sampled outside the control fence at the old Project Roller Coaster Sewage Lagoons (see Figure B-8 and Table B-8). These former sewage lagoons currently contain miscellaneous debris. One sample (LF-1) collected from the east side of the small lagoon contained Pu-238 in excess of the analytical detection limit and equal to the largest Pu-238 value collected off-site. All other Pu-238, Pu-239, Pu-240, and Am-241 concentrations were less than the analytical detection limit. Total U and Cs-137 concentrations were indistinguishable from off-site concentrations.

Mellan Hill Area—Four locations were sampled at the Mellan Hill Area (see Figure B-9 and Table B-9). Two samples (MH-3 and MH-4) contained Pu-239 and Pu-240 concentrations in excess of both the analytical detection limit and off-site concentrations. All other Pu-238, Pu-239, Pu-240, and Am-241 concentrations were less than the analytical detection limit. Total U and Cs-137 concentrations were indistinguishable from off-site concentrations.

554th Range Squadron O&M Complex—Three locations were sampled near the 554th Range Squadron O&M Complex (see Figure B-10 and Table B-10). The O&M complex was determined to be the location of the maximum exposed individual (MEI) due to the potential resuspension of transuranic-contaminated material associated with the three Clean Slate sites according to the NESHAP (40 CFR 61, Subpart H) regulation. Samples were taken on the west side of the O&M complex perimeter fence, facing the SNL/NV-maintained portion of TTR. One sample (OM-2) contained Pu-239 and Pu-240 concentrations equal to the analytical detection limit and greater than the largest off-site value. All other Pu-238, Pu-239, Pu-240, and Am-241 concentrations were less than the analytical detection limit. Total U and Cs-137 concentrations were indistinguishable from off-site concentrations.

Range Operations Center and Compound—Twenty-four samples were taken from various locations in and around the Range Operations Center and Compound (see Figures B-11 through B-13 and Table B-11). In addition to the routine locations around the operations center, sampling focused on the perimeter of the operations compound and the compound storage and maintenance areas. Two samples (OC-20 and OC-22) contained Pu-238 in excess of both the analytical detection limit and off-site concentrations. All other Pu-238, Pu-239, Pu-240, and Am-241 concentrations were less than the analytical detection limit. Total U and Cs-137 concentrations were indistinguishable from off-site concentrations.

Various On-Site Locations—Nine samples were collected from various on-site locations (see Figure B-14 and Table B-12). Sample D-1, collected near the Project Roller Coaster Decontamination Area, contained Pu-238, Pu-239, Pu-240, and Am-241 in excess or equal to both the analytical detection limit and off-site concentrations. Sample T-4, collected near Clean Slate 3, contained Pu-239 and Pu-240 in excess of both the analytical detection limit and off-site concentrations. Sample T-3, collected near Clean Slate 2, contained Pu-239, Pu-240, and Am-241 in excess of both the analytical detection limit and off-site concentrations. Sample T-5, collected near the Site 1 gate, contained Pu-239 and Pu-240 in excess of both the analytical detection limit and off-site concentrations. All other Pu-238, Pu-239, Pu-240, and Am-241 concentrations were less than the analytical detection limit. Total U and Cs-137 concentrations were indistinguishable from off-site concentrations.

Transuranic contamination at locations D-1, T-3, and T-4, regardless how small, was expected based on past sampling results and the proximity to either known or suspected areas of contamination. Although location T-5 has not previously been observed to be elevated in Pu-239 or Pu-240, the current value is considered to be only slightly elevated above off-site concentrations. Sampling of all these locations will continue in the future.

5.2.4 Results of Radiological Air Sampling

Tables 5-2 through 5-4 provide the radiological results from the 2-month PM_{10} monitoring at the 554th Range Squadron O&M Complex, STA-14, and Well 6, respectively. Measured gross alpha, gross beta, and gamma spectroscopy results were consistent between sampling locations and between sampling periods. These results are also consistent with previously

Table 5-2. PM_{10} Radiological Air Monitoring Results for the 554th Range Squadron O&M Complex

Composite Period	Analyte	Concentration	Error
07/29-08/30/94	Beryllium-7 (pCi/m^3)	6.22×10^{-2}	7.94×10^{-3}
	Gross Alpha, total (pCi/m^3)	9.66×10^{-3}	3.43×10^{-3}
	Gross Beta, total (pCi/m^3)	2.15×10^{-2}	3.22×10^{-3}
	Plutonium-238, total (pCi/m^3)	0.00×10^{0}	1.07×10^{-6}
	Plutonium-239+240, total (pCi/m^3)	2.15×10^{-7}	4.51×10^{-6}
	Potassium-40 (pCi/m^3)	6.22×10^{-3}	1.03×10^{-2}
	Uranium, total ($\mu g/m^3$)	4.94×10^{-4}	
	U-238	1.65×10^{-4}	
	U-235	7.61×10^{-6}	
	U-234	1.64×10^{-4}	
09/01-09/27/94	Beryllium-7 (pCi/m^3)	8.00×10^{-2}	1.05×10^{-2}
	Gross Alpha, total (pCi/m^3)	8.00×10^{-3}	3.75×10^{-3}
	Gross Beta, total (pCi/m^3)	2.75×10^{-2}	3.25×10^{-3}
	Plutonium-238, total (pCi/m^3)	2.00×10^{-6}	4.50×10^{-6}
	Plutonium-239+240, total (pCi/m^3)	-1.75×10^{-6}	3.75×10^{-6}
	Potassium-40 (pCi/m^3)	5.75×10^{-3}	9.50×10^{-3}
	Uranium, total ($\mu g/m^3$)	6.25×10^{-4}	
	U-238	2.09×10^{-4}	
	U-235	9.62×10^{-6}	
	U-234	2.07×10^{-4}	

Note: pCi/m^3 = picocuries per cubic meter; $\mu g/m^3$ = micrograms per cubic meter.

measured values on-site (Culp 1994). Isotopic Pu and U_{tot} concentrations were also consistent between sampled locations and between sampling periods.

For determining the dose, it was assumed that an individual had continuous, unrestricted access to the monitoring locations. Calculations were performed on gross concentrations. Also, U_{tot} concentration was converted into its isotopic constituents assuming the uranium isotopes were present in their natural abundance. Table 5-5 lists the calculated dose for each composite period and location. The highest calculated dose, 7.1×10^{-3} millirem per year (mrem/yr), from the measured data is approximately 1400 times less than the NESHAP dose limit of 10 mrem/yr. This is a conservative comparison because continuous, unrestricted access to these monitoring locations is not possible and the EDE was determined using all measured radionuclides, not just those from contaminants known or suspected of being present at TTR.

Table 5-3. PM_{10} Radiological Air Monitoring Results for Station 14

Composite Period	Analyte	Concentration/m^3	Error
07/29-08/30/94	Beryllium-7 (pCi/m^3)	7.56×10^{-2}	9.46×10^{-3}
	Gross Alpha, total (pCi/m^3)	1.06×10^{-2}	4.25×10^{-3}
	Gross Beta, total (pCi/m^3)	3.07×10^{-2}	3.78×10^{-3}
	Plutonium-238, total (pCi/m^3)	0.00×10^{0}	1.18×10^{-6}
	Plutonium-239+240, total (pCi/m^3)	-2.36×10^{-6}	6.62×10^{-6}
	Potassium-40 (pCi/m^3)	6.62×10^{-3}	1.13×10^{-2}
	Uranium, total (μg/m^3)	1.09×10^{-3}	
	U-238	3.64×10^{-4}	
	U-235	1.68×10^{-5}	
	U-234	3.61×10^{-4}	
09/01-09/27/94	Beryllium-7 (pCi/m^3)	7.88×10^{-2}	1.12×10^{-2}
	Gross Alpha, total (pCi/m^3)	6.97×10^{-3}	3.33×10^{-3}
	Gross Beta, total (pCi/m^3)	2.12×10^{-2}	3.63×10^{-3}
	Plutonium-238, total (pCi/m^3)	2.12×10^{-6}	4.24×10^{-6}
	Plutonium-239+240, total (pCi/m^3)	-2.12×10^{-6}	4.24×10^{-6}
	Potassium-40 (pCi/m^3)	1.30×10^{-2}	1.21×10^{-2}
	Uranium, total (μg/m^3)	5.45×10^{-4}	
	U-238	1.82×10^{-4}	
	U-235	8.39×10^{-6}	
	U-234	1.80×10^{-4}	

Note: pCi/m^3 = picocuries per cubic meter; μg/m^3 = micrograms per cubic meter.

5.2.5 Results of the TLD Program Sampling

As part of the long-term, routine, environmental surveillance program at TTR, SNL began an ambient gamma-radiation program in January 1994. This program includes a TLD monitoring network to measure radiation exposure at 5 community (off-site) locations, 4 perimeter locations, and 13 on-site locations. Table 5-6 summarizes the TLD measurements of annual radiation exposure off-site, at the site perimeter, and on-site. Table B-13 of Appendix B lists the TLD locations and results. Exposure results include natural background and man-made radiation (if any).

Table 5-4. PM_{10} Radiological Air Monitoring Results for Well 6

Composite Period	Analyte	Concentration/m^3	Error
07/29-08/30/94	Beryllium-7 (pCi/m^3)	6.93×10^{-2}	8.91×10^{-3}
	Gross Alpha, total (pCi/m^3)	1.01×10^{-2}	4.21×10^{-3}
	Gross Beta, total (pCi/m^3)	2.97×10^{-2}	4.21×10^{-3}
	Plutonium-238, total (pCi/m^3)	5.69×10^{-6}	5.94×10^{-6}
	Plutonium-239+240, total (pCi/m^3)	-1.73×10^{-6}	3.47×10^{-6}
	Potassium-40 (pCi/m^3)	8.17×10^{-3}	1.19×10^{-2}
	Uranium, total (μg/m^3)	6.44×10^{-4}	
	U-238	2.15×10^{-4}	
	U-235	9.92×10^{-6}	
	U-234	2.13×10^{-4}	
09/01-09/27/94	Beryllium-7 (pCi/m^3)	1.07×10^{-1}	1.28×10^{-2}
	Gross Alpha, total (pCi/m^3)	7.66×10^{-3}	3.83×10^{-3}
	Gross Beta, total (pCi/m^3)	3.32×10^{-2}	4.34×10^{-3}
	Plutonium-238, total (pCi/m^3)	2.04×10^{-6}	4.09×10^{-6}
	Plutonium-239+240, total (pCi/m^3)	-1.79×10^{-6}	3.58×10^{-6}
	Potassium-40 (pCi/m^3)	1.05×10^{-2}	1.02×10^{-2}
	Uranium, total (μg/m^3)	6.39×10^{-4}	
	U-238	2.13×10^{-4}	
	U-235	9.84×10^{-6}	
	U-234	2.12×10^{-4}	

Note: pCi/m^3 = picocuries per cubic meter; μg/m^3 = micrograms per cubic meter.

The average annual exposure for the perimeter and off-site locations were 119 $\pm$ 9.8 milliroentgen per year (mR/yr) and 108 $\pm$ 17.8 mR/yr, respectively. The average on-site exposure was 127 $\pm$ 10.1 mR/yr. Individual on-site values ranged from 111 $\pm$ 14.8 mR/yr to 148 $\pm$ 10.6 mR/yr.

During 1994, the first year TLDs were deployed at TTR, several TLD holders were damaged, preventing usable data from being obtained. Corrective actions have been taken in an attempt to increase the amount of usable TLD data. TLD monitoring locations and results will be evaluated annually for adequacy.

Table 5-5. Summary of Calculated Effective Dose Equivalent (EDE) for PM_{10} Air Monitoring Locations

Location	Composite Period	EDE (mrem/yr)
554th Range Squadron O&M Complex	07/29-08/30/94	2.3×10^{-3}
	09/01-09/27/94	2.4×10^{-3}
Station-14	07/29-08/30/94	3.4×10^{-3}
	09/01-09/27/94	3.7×10^{-3}
Well 6	07/29-08/30/94	3.1×10^{-3}
	09/01-09/27/94	7.1×10^{-3}

Note: mrem/yr = millirem per year.

Table 5-6. Summary of Thermoluminescent Dosimeter Measurements for 1994

Location	Number of Measurements	Annual Exposure (mR/yr) Mean	Standard Deviation	Range
Community (C) (off-site)	3	108	17.8	88.5 to 123
Perimeter (P)	2	119	9.8	112 to 126
On-Site (S)	12	127	10.1	111 to 148

Note: mR/yr = milliroentgen per year.

5.3 1994 SNL NONRADIOLOGICAL SURVEILLANCE RESULTS

5.3.1 Soil Sampling

Figures B-1 through B-14 of Appendix B show the 1994 environmental surveillance soil sampling locations. Tables C-1 through C-12 of Appendix C list the individual nonradiological sample results for the soil sampling. Table 5-7 summarizes the nonradiological results for the different areas sampled. The summary includes the mean, standard deviation, and range of values for the off-site samples and the range of values for all other sampled areas for the twenty metals analyzed by the ICP method.

5.3.2 Off-Site Soil Sampling

Nonradiological results from the fourteen off-site soil sampling locations were consistent with previous years' results and are believed to represent the normal, expected range of values for the twenty analyzed metals (see Figure B-1 and Table C-1).

5.3.3 On-Site Soil Sampling

Site Perimeter—Five samples were collected from the TTR site perimeter (see Figure B-2 and Table C-2). Sample T-6 contained elevated chromium (Cr) concentrations; T-11 contained elevated Cr, cobalt (Co), silica (Si), and zinc (Zn) concentrations; T-12 contained elevated Si concentrations; and T-13 contained elevated Cr concentrations. All other analyses performed on samples collected from the site perimeter were indistinguishable from off-site concentrations.

Airport Area—Seven samples were collected in the Airport Area (see Figure B-3 and Table C-3). Five samples (AP-1, AP-2, AP-3, AP-5, and AP-6) contained elevated Si concentrations. In addition, AP-1 contained elevated Cr concentrations; AP-2 contained elevated aluminum (Al), beryllium (Be), potassium (K), and titanium (Ti) concentrations; AP-3 contained elevated Ti concentrations; AP-4 contained elevated Zn concentrations; and AP-6 contained elevated Al, Cr, and Ti concentrations. All other analyses performed on samples collected from the Airport Area were indistinguishable from off-site concentrations.

Area 9—Twelve samples were collected in and around Area 9 (see Figure B-4 and Table C-4). Six samples (T-23, T-28, T-29, T-30, T-31, and T-32) contained elevated Si concentrations. In addition, T-25 contained elevated barium (Ba), lead (Pb), and Zn concentrations; T-26 contained elevated cadmium (Cd), Pb, and Zn concentrations; and T-28 contained elevated Cr concentrations. All other analyses performed on samples collected from the vicinity of Area 9 were indistinguishable from off-site concentrations.

Hard Target/DU Area—Five samples were collected near the Hard Target/DU Area (see Figure B-5 and Table C-5). All five samples contained elevated Si concentrations. In addition, T-21 contained elevated Al, Be, Cd, Cr, Co, iron (Fe), K, and Ti concentrations; and T-20 contained elevated Al, K, and Ti concentrations. All other analyses performed on

Table 5-7. Summary of Nonradiological Soil Results (in μg/g)

Location	Number of Samples	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron
Off-Site	14	5,600 to 10,000	110 to 440	<0.5 to 0.7	<0.5 to 0.9	2,200 to 43,000	11 to 20	1.7 to 4.4	4 to 18	5,400 to 11,000
Mean		7,464	176	0.53	0.53	11,864	15	3.2	9	8,164
Standard Deviation		1,336	80	0.07	0.11	10,858	2	0.8	4	1,794
Site Perimeter	5	4,200 to 7,700	93 to 160	<0.5 to 0.6	<0.5 to 0.5	1,700 to 7,100	15 to 27	1.3 to 5	4 to 16	4,600 to 12,000
Airport Area	7	9,000 to 14,000	110 to 140	<0.5 to 0.9	<0.5 to 0.6	4,400 to 12,000	16 to 28	3.3 to 4.8	5 to 9	8,900 to 12,000
Area 9	12	3,600 to 6,100	88 to 960	<0.5 to 0.5	<0.5 to 1	3,800 to 12,000	10 to 22	1.5 to 4.3	3 to 6	4,200 to 7,700
Hard Target/Depleted Uranium Area	5	5,400 to 20,000	110 to 180	<0.5 to 1	<0.5 to 1	7,000 to 16,000	14 to 24	1.8 to 5.3	4 to 12	6,600 to 14,000
On-Base Housing Area	5	3,700 to 5,800	79 to 130	<0.5 to <0.5	<0.5 to <0.5	1,600 to 9,500	9.4 to 21	1.4 to 2	3 to 4	4,400 to 6,300
South Plume Area	6	6,300 to 12,000	200 to 250	<0.5 to 0.5	<0.5 to 0.9	4,800 to 9,800	10 to 16	2.8 to 4.6	6 to 10	6,800 to 11,000
Project Roller Coaster Sewage Lagoons	4	8,000 to 12,000	250 to 270	0.5 to 0.8	<0.5 to <0.5	8,800 to 28,000	16 to 24	4.2 to 4.5	7 to 8	12,000 to 15,000
Mellan Hill Area	4	5,300 to 10,000	74 to 120	<0.5 to 0.6	<0.5 to <0.5	2,100 to 22,000	14 to 28	1.5 to 2.8	4 to 7	5,200 to 8,700
554th Range Squadron O&M Complex	3	5,900 to 7,400	69 to 110	<0.5 to 0.6	<0.5 to <0.5	1,800 to 2,800	16 to 24	1.1 to 2.5	4 to 6	5,000 to 7,300
Range Operations Center and Compound	24	3,700 to 12,000	82 to 170	<0.5 to 0.8	<0.5 to 4.4	4,700 to 19,000	11 to 24	1.9 to 4.3	4 to 11	5,500 to 11,000
Various On-Site Locations	9	5,300 to 12,000	97 to 280	<0.5 to 0.6	<0.5 to <0.5	2,300 to 23,000	12 to 24	2.2 to 5.9	5 to 14	6,700 to 13,000

Note: μg/g = micrograms per gram.

Table 5-7. Summary of Nonradiological Soil Results (in μg/g) (Concluded)

Location	Number of Samples	Lead	Magnesium	Manganese	Nickel	Potassium	Silica	Silver	Strontium	Titanium	Vanadium	Zinc
Off-Site	14	5 to 32	1,800 to 9,600	140 to 800	<2 to 19	2,300 to 4,100	90 to 200	<0.5 to <0.5	35 to 200	140 to 350	8.6 to 33	16 to 60
Mean		12	3,614	344	6	3,007	128	<0.5	76	230	16	33
Standard Deviation		7	1,909	158	4	597	26	NA	45	80	6	13
Site Perimeter	5	<0.5 to 17	1,300 to 3,000	120 to 770	2 to 8	2,200 to 3,100	140 to 320	<0.5 to <0.5	8 to 45	70 to 220	6.9 to 21	23 to 63
Airport Area	7	10 to 13	2,600 to 5,100	290 to 430	5 to 8	3,400 to 5,400	150 to 280	<0.5 to <0.5	44 to 70	320 to 490	17 to 21	29 to 120
Area 9	12	<5 to 460	1,700 to 2,700	120 to 190	2 to 5	1,900 to 2,900	100 to 270	<0.5 to <0.5	45 to 120	100 to 260	7 to 11	16 to 1,400
Hard Target/Depleted Uranium Area	5	<5 to 31	2,100 to 7,200	150 to 400	3 to 11	2,800 to 6,900	230 to 380	<0.5 to <0.5	73 to 130	180 to 550	11 to 22	30 to 52
On-Base Housing Area	5	<0.5 to <5	1,200 to 1,900	120 to 160	2 to 4	1,800 to 2,600	160 to 350	<0.5 to <0.5	19 to 46	100 to 220	6.6 to 11	14 to 20
South Plume Area	6	6 to 13	3,000 to 5,300	320 to 760	4 to 8	3,400 to 6,100	93 to 210	<0.5 to <0.5	47 to 81	300 to 570	10 to 18	24 to 37
Project Roller Coaster Sewage Lagoons	4	8 to 12	3,600 to 5,000	220 to 350	3 to 5	2,800 to 4,300	150 to 250	<0.5 to <0.5	94 to 160	100 to 130	15 to 20	33 to 300
Mellan Hill Area	4	6 to 12	1,400 to 3,900	180 to 430	2 to 4	2,200 to 3,500	45 to 96	<0.5 to <0.5	24 to 67	140 to 260	6.6 to 12	17 to 29
554th Range Squadron O&M Complex	3	5 to 8	1,400 to 2,700	190 to 360	2 to 3	2,600 to 2,900	160 to 200	<0.5 to <0.5	21 to 28	100 to 220	6.7 to 11	18 to 26
Range Operations Center and Compound	24	<5 to 20	1,500 to 4,900	160 to 350	<2 to 8	2,000 to 4,500	65 to 400	<0.5 to <0.5	35 to 110	56 to 360	8.8 to 35	21 to 260
Various On-Site Locations	9	7 to 28	2,100 to 6,300	180 to 420	3 to 7	2,300 to 4,000	160 to 410	<0.5 to <0.5	29 to 160	110 to 260	9.8 to 22	22 to 41

Note: μg/g = micrograms per gram; NA = not applicable.

samples collected from the Hard Target Area were indistinguishable from off-site concentrations.

On-Base Housing—Five samples were collected near the On-Base Housing Area (see Figure B-6 and Table C-6). Three samples (T-35A, T-7A, and T-36) contained elevated Si concentrations and one sample (T-35A) contained elevated Cr concentrations. All other analyses performed on samples collected from the On-Base Housing Area were indistinguishable from off-site concentrations.

South Plume Area—Six samples were collected in the South Plume Area (see Figure B-7 and Table C-7). Sample T-15 contained elevated K and Si concentrations; T-16 contained elevated K and Ti concentrations; T-19 contained elevated Al and K concentrations. All other analyses performed on samples collected from the South Plume Area were indistinguishable from off-site concentrations.

Project Roller Coaster Sewage Lagoons—Four samples were collected from outside perimeter fences at the old Project Roller Coaster Sewage Lagoons (see Figure B-8 and Table C-8). LF-1 contained elevated Cr concentrations; LF-2 contained elevated Be and Si concentrations; LF-3 contained elevated Al, Be, Fe, and Si concentrations; and LF-4 contained elevated Cr, K, Si, and Zn concentrations. All other analyses performed on samples collected from the old Project Roller Coaster Sewage Lagoons were indistinguishable from off-site concentrations.

Mellan Hill Area—Four samples were collected at the Mellan Hill Area (see Figure B-9 and Table C-9). One sample (MH-3) contained elevated Cr concentrations. All other analyses performed on samples collected from the Mellan Hill Area were indistinguishable from off-site concentrations.

554th Range Squadron O&M Complex—Three samples were collected near the 554th Range Squadron O&M Complex (see Figure B-10 and Table C-10). One sample (OM-1) contained elevated Cr concentrations. All other analyses performed on samples collected from the area around the 554th Range Squadron O&M Complex were indistinguishable from off-site concentrations.

Range Operations Center and Compound—Twenty-four samples were collected from various locations in and around the Range Operations Center and Compound (see Figures B-11 through B-13 and Table C-11). Eleven samples (OC-4, OC-2, OC-3, OC-14, OC-15, OC-17, OC-18, OC-20, OC-21, OC-22, and OC-23) contained elevated Si concentrations; OC-2 contained elevated Al, Be, and K concentrations; OC-3 contained elevated K concentrations; OC-7 contained elevated Cr concentrations; OC-10 contained elevated Zn concentrations; OC-18 contained elevated Zn concentrations; OC-19 contained elevated Cd, Cr, and Zn concentrations; OC-23 contained elevated Cr and Zn concentrations; and OC-24A contained elevated Cr concentrations. All other analyses performed on samples collected from the Range Operations Center and Compound were undistinguishable from off-site concentrations.

Various On-Site Locations—Nine samples were collected from various locations on-site (see Figure B-14 and Table C-12). Four samples (BR-4, T-1, T-4, and T-10) contained elevated Si concentrations. D-1 (Roller Coaster Decontamination Area) contained elevated Co and Fe concentrations; OP-3 (Range Operations Center, PM_{10} monitoring location) contained Cr concentrations; T-1 (Brownes Lake Road) contained elevated Al, Co, and Fe concentrations; and T-5 (south guard shack) contained elevated Co concentrations. All other analyses performed on samples collected from the various on-site locations were indistinguishable from off-site concentrations.

The off-site distribution of sample concentrations serves as a reference to compare with on-site samples. Due to the limited size of the off-site sampling (14 samples), the wide range in expected values of some constituents, and the potential differences in the geological makeup of some of the sample collection areas, this comparison should not be considered as exact in the identification of contamination. Some locations with metal concentrations marginally elevated above off-site concentrations may in fact not be contaminated, but rather show the normal, or expected, variation in sample concentrations; e.g., many locations on-site display Si concentrations marginally greater than off-site. These samples may represent the normal variation in Si concentrations in uncontaminated soils near TTR and not extensive low-level Si contamination. Where sample concentrations are considerably greater than off-site concentrations, it was assumed that contamination is potentially present.

5.3.4 Results of Nonradiological Air Sampling

Tables 5-8 through 5-10 provide the nonradiological results from the 2-month PM_{10} air monitoring at the 554th Range Squadron O&M Complex, STA-14, and Well 6, respectively. Calendar year 1994 (CY94) represents the first year that nonradiological constituents have been reported for air samples. These data not only indicate the air concentration of these constituents in 1994 but also serve as a baseline, or reference, for future comparisons. Results are consistent between sampling locations and between sampling periods, and do not indicate gross contamination of any constituent at any location.

The results of the carcinogenic risk assessment and the noncarcinogenic hazard quotient are presented in Table 5-11 for each sample location and composite period. The EPA considers an overall carcinogenic risk of between one in one million (10^{-6}) and one in one thousand (10^{-3}) as acceptable, and a noncarcinogenic hazard quotient of less than one as acceptable. The highest calculated carcinogenic risk was determined to be 10^{-5}. The highest calculated noncarcinogenic hazard quotient was determined to be 0.368. The reported air concentrations represent gross measurements and do not include subtraction of the chemical makeup of the glass-fiber filter used to collect the sample.

5.4 ENVIRONMENTAL PERSPECTIVE

It is generally accepted that once Pu comes in contact with soil in the environment, it becomes firmly attached to the host particle. Previous studies (Tamura 1974, 1975, 1976) of soil samples from safety-shot areas at the Nevada Test Site (NTS) showed Pu particle-size

Table 5-8. PM_{10} Nonradiological Air Monitoring Results for the 554th Range Squadron O&M Complex

Composite Period	Analyte (total)	Concentration (mg/m^3)
07/29-08/30/94	Arsenic	1.72×10^{-6}
	Barium	1.03×10^{-5}
	Beryllium	1.72×10^{-7}
	Cadmium	1.72×10^{-7}
	Chromium	1.55×10^{-6}
	Cobalt	3.43×10^{-7}
	Copper	1.12×10^{-5}
	Iron	4.64×10^{-4}
	Lead	2.06×10^{-6}
	Manganese	1.80×10^{-5}
	Molybdenum	3.43×10^{-7}
	Nickel	6.87×10^{-7}
	Potassium	8.59×10^{-4}
	Selenium	1.72×10^{-6}
	Silver	1.72×10^{-7}
	Thallium	3.43×10^{-6}
	Vanadium	1.72×10^{-6}
	Zinc	1.46×10^{-5}
09/01-09/27/94	Arsenic	2.00×10^{-6}
	Barium	1.00×10^{-5}
	Beryllium	2.00×10^{-7}
	Cadmium	2.00×10^{-7}
	Chromium	1.50×10^{-6}
	Cobalt	3.00×10^{-7}
	Copper	1.20×10^{-5}
	Iron	4.00×10^{-4}
	Lead	2.00×10^{-6}
	Manganese	1.50×10^{-5}
	Molybdenum	4.00×10^{-7}
	Nickel	8.00×10^{-7}
	Potassium	7.90×10^{-4}
	Selenium	2.00×10^{-6}
	Silver	2.00×10^{-7}
	Thallium	4.00×10^{-6}
	Vanadium	1.20×10^{-6}
	Zinc	1.20×10^{-5}

Note: mg/m^3 = milligrams per cubic meter.

Table 5-9. PM_{10} Nonradiological Air Monitoring Results for Station 14

Composite Period	Analyte (total)	Concentration (mg/m^3)
07/29-08/30/94	Arsenic	1.89×10^{-6}
	Barium	9.08×10^{-6}
	Beryllium	1.89×10^{-7}
	Cadmium	1.89×10^{-7}
	Chromium	1.32×10^{-6}
	Cobalt	2.84×10^{-7}
	Copper	3.03×10^{-5}
	Iron	3.03×10^{-4}
	Lead	1.89×10^{-6}
	Manganese	10.4×10^{-5}
	Molybdenum	3.78×10^{-7}
	Nickel	7.56×10^{-7}
	Potassium	7.94×10^{-4}
	Selenium	1.89×10^{-6}
	Silver	1.89×10^{-7}
	Thallium	3.78×10^{-6}
	Vanadium	1.42×10^{-6}
	Zinc	1.42×10^{-5}
09/01-09/27/94	Arsenic	2.42×10^{-6}
	Barium	1.16×10^{-5}
	Beryllium	2.42×10^{-7}
	Cadmium	2.42×10^{-7}
	Chromium	1.58×10^{-6}
	Cobalt	2.42×10^{-7}
	Copper	3.03×10^{-5}
	Iron	2.67×10^{-4}
	Lead	2.42×10^{-6}
	Manganese	8.48×10^{-6}
	Molybdenum	4.85×10^{-7}
	Nickel	9.69×10^{-7}
	Potassium	9.69×10^{-4}
	Selenium	2.42×10^{-6}
	Silver	2.42×10^{-7}
	Thallium	4.85×10^{-6}
	Vanadium	1.09×10^{-6}
	Zinc	1.45×10^{-5}

Note: mg/m^3 = milligrams per cubic meter.

Table 5-10. PM_{10} Nonradiological Air Monitoring Results for Well 6

Composite Period	Analyte (total)	Concentration (mg/m^3)
07/29-08/30/94	Arsenic	1.98×10^{-6}
	Barium	1.98×10^{-6}
	Beryllium	1.98×10^{-7}
	Cadmium	1.98×10^{-7}
	Chromium	3.96×10^{-7}
	Cobalt	1.98×10^{-7}
	Copper	2.38×10^{-6}
	Iron	7.92×10^{-6}
	Lead	1.98×10^{-6}
	Manganese	1.98×10^{-7}
	Molybdenum	3.96×10^{-7}
	Nickel	7.92×10^{-7}
	Potassium	1.29×10^{-4}
	Selenium	1.98×10^{-6}
	Silver	1.98×10^{-7}
	Thallium	3.96×10^{-6}
	Vanadium	1.98×10^{-7}
	Zinc	2.67×10^{-6}
09/01-09/27/94	Arsenic	2.04×10^{-6}
	Barium	1.02×10^{-5}
	Beryllium	2.04×10^{-7}
	Cadmium	2.04×10^{-7}
	Chromium	1.43×10^{-6}
	Cobalt	2.04×10^{-7}
	Copper	2.15×10^{-5}
	Iron	2.04×10^{-4}
	Lead	2.04×10^{-6}
	Manganese	6.64×10^{-6}
	Molybdenum	4.09×10^{-7}
	Nickel	8.17×10^{-7}
	Potassium	8.38×10^{-4}
	Selenium	2.04×10^{-6}
	Silver	2.04×10^{-7}
	Thallium	4.09×10^{-6}
	Vanadium	9.20×10^{-7}
	Zinc	9.60×10^{-6}

Note: mg/m^3 = milligrams per cubic meter.

Table 5-11. Summary of Results for Carcinogenic Risk and Noncarcinogenic Hazard Quotient Determination for Nonradiological Air Sampling

Location	Composite Period	Carcinogenic Risk	Noncarcinogenic Hazard Quotient
554th Range Squadron O&M Complex	07/29 - 08/30/94	1×10^{-5}	0.368
	09/01 - 09/27/94	1×10^{-5}	0.309
Station 14	07/29 - 08/30/94	1×10^{-5}	0.220
	09/01 - 09/27/94	1×10^{-5}	0.189
Well 6	07/29 - 08/30/94	6×10^{-6}	0.110
	09/01 - 09/27/94	1×10^{-5}	0.150

association was primarily with coarse silts (50 to 20 μm) and fine sands (125 to 50 μm). Whereas the inhalation of fine sizes (<7 μm diameter at a density of 1 gram per cubic centimeter [g/cm^3]) is considered most hazardous (Tamura 1976), the coarser soil particles should not be ignored with regard to environmental transport, as these particle sizes are readily subjected to movement by wind (Leavitt 1980). Leavitt (1976) studied five safety-shot areas in Nevada and reported that the wind had a dominant influence on the surface texture of the desert soil by depositing soil fines around the base of brush or vegetation. Another study (Tamura 1977) discussed the occurrence of sandy mounds formed under desert shrubbery. These mounds were formed by the filtering action of the desert vegetation in intercepting saltation and creeping particles. The vegetation intercepts the material being moved through the environment by wind. This study and additional studies found that in Pu-contaminated areas, the Pu activity levels were higher in the desert mounds than in the contiguous desert pavement (areas without vegetation). This demonstrates the effect of wind erosion in dispersal of contaminated material. The Tamura (1977) study also discussed evidence of Pu migration downward into the soil profile.

Evidence of water erosion has been observed within the outer control fence at Clean Slate 2. The erosive effects of water may pose another mechanism for transport of the contaminated material. Essington and Fowler (1976) observed the ability of Pu to migrate to deeper layers of soil with time. Vertical transport of contaminants into the soil column may allow greater exposure of roots and a potential for root uptake of contaminants by the plants. Soil profiles from the safety-shot areas at TTR indicate a decrease in the Pu-to-Am ratio with depth (Romney et al. 1975), suggesting greater vertical movement of Am-241 relative to Pu-239 and Pu-240. This same report also stated that there is evidence showing that Am is much more readily available to plants through roots than is Pu. Gilbert et al. (1975) stated that erosive

processes and penetration into the soil would eventually flatten out peak contaminant concentrations, and that there was a need for long-term hazard evaluation to determine the change in contaminant concentrations over time at the safety-shot areas.

5.5 EPA MONITORING

The EPA performs routine monitoring around both the NTS and TTR, including TLD and pressurized ion chamber (PIC) measurements to detect gamma radiation; air monitoring to measure noble gases, tritium (H-3), and other radionuclides; and water monitoring primarily to measure radionuclides. In the past, EPA routine samples results were reported on a quarterly basis to U.S. Department of Energy/Nevada Operations Office (DOE/NV). The EPA TLD data was unavailable for inclusion in this report. Noble gas sampling and H-3 in air samplers were placed on stanby on approximately October 1, 1994 and no samples have been collected after that date. The routine air sampler at TTR was placed on standby at the end of 1994. Table 5-12 summarizes the EPA air monitoring results at TTR, Goldfield, and Tonopah, NV. Hydrological monitoring was reduced from quarterly to annual sampling; Table 5-13 summarizes the H-3 monitoring results.

5.6 KMI SERVICES MONITORING PROGRAM

KMI Services routine environmental-monitoring activities at TTR generally are limited to water monitoring and obtaining permits in compliance with EPA regulations. In 1994, KMI Services staff installed and operated PM_{10} air monitors to detect any airborne radiological contamination. The staff also installed and changed out the long-term environmental TLD network.

Environmental compliance permits for TTR include those for the potable water supply, sewage, and air quality. These permits are updated annually or as necessary. Table A-2 of Appendix A shows the current permit list.

In addition, KMI Services assists SNL in meeting two other annual requirements: the Superfund Amendments and Reauthorization Act (SARA), Title III (the Emergency Planning and Community Right-to-Know Act [EPCRA]), reporting requirements for all TTR activities and the State of Nevada extremely hazardous material reporting requirements.

5.6.1 Water

Using preserved sample bottles supplied by a state-certified laboratory, KMI Services staff collected water samples quarterly from the Well 6 distribution system that services Technical Area 3 (TA-3) and transported the samples to the laboratory in Las Vegas, NV for bacteriological analysis (Table 5-14). All analyses met the requirements of the total coliform rule. Monthly samples will be collected in 1995.

Table 5-14 summarizes water sampling of the public water systems at TTR and the frequency and type of analysis and results. Waste water is sampled quarterly by the U.S. Air Force (USAF) at the headwater end of the facultative sewage lagoon (Table 5-15).

Table 5-12. Summary of 1994 EPA Air Monitoring Results

Radionuclide Location	Number of Samples	Results
Tritium (in air):		
Goldfield, NV	37	$0.0 \pm 1.6 \times 10^{-6}$ pCi/mL
Tonopah, NV	38	$0.1 \pm 1.3 \times 10^{-6}$ pCi/mL
Noble gas sampler (NGS) krypton-85:		
Goldfield, NV	32	$28 \pm 1.9 \times 10^{-12}$ μCi/mL
Tonopah, NV	34	$28 \pm 2.1 \times 10^{-12}$ μCi/mL
Alpha (in air):		
Goldfield, NV	52	$0.91 \pm 0.49 \times 10^{-15}$ μCi/mL
Tonopah, NV	50	$1.05 \pm 0.60 \times 10^{-15}$ μCi/mL
TTR, NV	50	$1.40 \pm 0.98 \times 10^{-15}$ μCi/mL
Beta (in air):		
Goldfield, NV	52	$1.61 \pm 0.40 \times 10^{-14}$ μCi/mL
Tonopah, NV	50	$1.51 \pm 0.41 \times 10^{-14}$ μCi/mL
TTR, NV	50	$1.56 \pm 0.44 \times 10^{-14}$ μCi/mL

Note: pCi/mL = picocuries per milliliter; μCi/mL = microcuries per milliliter.

Table 5-13. Summary of 1994 EPA Long-Term Hydrologic Monitoring Program Results for Tritium

Location	Number of Samples	Tritium
Tonopah City Well	3	2.4 ± 0.41 pCi/L
TTR Well 6	3	-3.2 ± 0.32 pCi/L

Note: pCi/L = picocuries per liter.

Table 5-14. Summary of 1994 SNL/NV Public Water Systems Sampling

Public Water System	Frequency/Analysis	Results
NY3014 12*	Quarterly/bacteriologic, total coliform	All analyses were negative for coliform.

*TTR Well 6.

Table 5-15. Summary of 1994 SNL/NV Waste-Water Sampling Program

Location	Number of Samples	Frequency	Analysis	Analytical Laboratory
Area 3 Waste Water Monitoring Station	1 Grab Sample	Annually	Inorganic (metals)	Environmental Control Technology
			Inorganic (general)	
			Organic (EPA Method 608)	
			Volatile Organics (EPA Method 624)	
			Semi-Volatile Organics (EPA Method 625)	
			Gross Alpha/Beta Gamma Scan	TMA Eberline
			Tritium	

Well 6 is also sampled by the EPA to provide a radiological analysis survey for the Long-Term Hydrologic Monitoring Program. Sampling sites are based on the *Tonopah Test Range Site Sampling Plan* (DOE 1990) for compliance with the Safe Drinking Water Act.

Well 6's permit is renewed annually by the State of Nevada Bureau of Health Protection Services. Permit updates are obtained annually by the U.S. Department of Energy's Kirtland Area Office (DOE/KAO) and copies are forwarded to SNL/Nevada (SNL/NV).

5.6.2 Sewage System

Sewage from SNL facilities at TA-3 of TTR goes to the USAF facultative sewage lagoon. The National Pollutant Discharge Elimination System (NDPES) permit was held by DOE/NV through July 1992 when it was transferred to the USAF Nellis Air Force Base (NAFB) Range Complex. The sewage from locations in remote areas flows into septic tanks and associated drain fields. These discharges fall primarily under the statutory authority of the Clean Water Act (CWA) and SDWA (as amended). These discharges are regulated under Nevada Administrative Code, Chapters 444-445 (Appendix A, Table A-1), and are administered by the State of Nevada, Bureau of Health Protection Services, and the Nevada Department of Environmental Protection (NDEP). The waste-water samples from headworks and sewage lagoons are analyzed quarterly for biochemical oxygen demand (BODs) and total suspended solids (TSSs). Quarterly discharge monitoring reports are prepared and submitted to DOE for review and transmittal to NDEP.

5.7 ASSESSMENT OF POTENTIAL DOSE TO THE PUBLIC

The three Clean Slate sites are considered a potential source of airborne radionuclide contamination through the process of wind resuspension of the transuranic-contaminated surface soils associated with each site. A radiation dose was calculated based on the resuspension of this material. The dose assessment was performed for on-site and off-site receptors where non-SNL/NV personnel abide or reside. The concept of "on-site receptors" is conservatively assumed to include members of the military, military contractors, and other non-SNL/NV personnel who work at TTR but over whom SNL/NV has little or no operational control. This definition is believed to be consistent with current EPA and DOE guidance. Four different on-site receptor locations were evaluated as suspected locations of the MEI. In addition to on-site receptor locations, four off-site receptor locations were evaluated.

The dose calculation results summarized in this section were performed to document NESHAP (40 CFR 61, Subpart H) compliance using the EPA CAP88-PC computer code (EPA 1991). More detailed information pertaining to this calculation may be found in the *NESHAP Annual Report for CY 1994, Sandia National Laboratories, Nevada* (SNL 1995a), *Radiological Dose Calculations for NESHAP Compliance for Sandia National Laboratories, Nevada, 1994* (SNL 1995b), and *Supplemental Dose Assessment Data for Sandia National Laboratories, Nevada, 1994* (SNL 1995c).

5.7.1 Receptor Locations

For determination of potential dose to the public, receptor locations were divided into on-site and off-site. The TTR on-site receptor locations consist of the On-Base Housing Area, the Airport Area, the south perimeter, and the 554th Range Squadron O&M Complex (Figure 5-1). The TTR off-site region includes distinct populations of seasonal workers and permanent residents. Zones for these two sets of public receptors are shown in Figure 5-2. The first zone shows the permanent public-receptor zone and the second zone shows the seasonal public-receptor zone.

5.7.2 Meteorological Data

Meteorological data for the TTR area are derived from the joint frequency distribution table for the Tonopah Municipal Airport located approximately 65 km north of TTR (DOC 1993). Although the meteorological measurements were taken north of TTR, wind patterns are not believed to be appreciably different due to the geographic similarities of these locations.

5.7.3 Release Sources

During 1994, no radiological point-source releases occurred as a result of TTR operations. The potential releases associated with the Clean Slate sites occur as a result of the wind resuspension of soil particulates (fugitive dust) contaminated with transuranic radionuclides. The 1977 EG&G aerial radiological survey of Clean Slates 1, 2, and 3 documented the level of residual surface-soil activity in the form of radiation isopleths showing the soil activity of Am-241, Pu-239, and Pu-240 (EG&G 1979b). The study concluded that the contaminated area associated with the Clean Slate sites is approximately 20 million square meters.

The annual diffuse source term associated with the Clean Slate sites was calculated using a wind resuspension model which calculates the rate at which soil particulates become airborne. This model uses site-specific information (e.g., wind speed, wind direction, and contaminant source term) whenever appropriate.

A release of 0.32 curies per year (Ci/yr) of total activity (Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, and Am-241) was calculated as the resuspended source term associated with the Clean Slate sites. This resuspended source term is for particulate matter which is 10 μm or less in diameter, and is assumed to be entirely respirable.

5.7.4 Radiological Dose Assessment

The diffuse emissions associated with the three Clean Slate sites were the focus of the dose assessment because there were no point-source radionuclide emissions. The regional population dose was calculated to be 0.00042 person-millirem per year (person-mrem/yr). The dose to the MEI was calculated to be 1.7 mrem/yr. The MEI is located at the south perimeter fence between TTR and NAFB. It is important to note that this location is not the location of any identifiable individuals. NAFB is located south of TTR; a complete population survey of

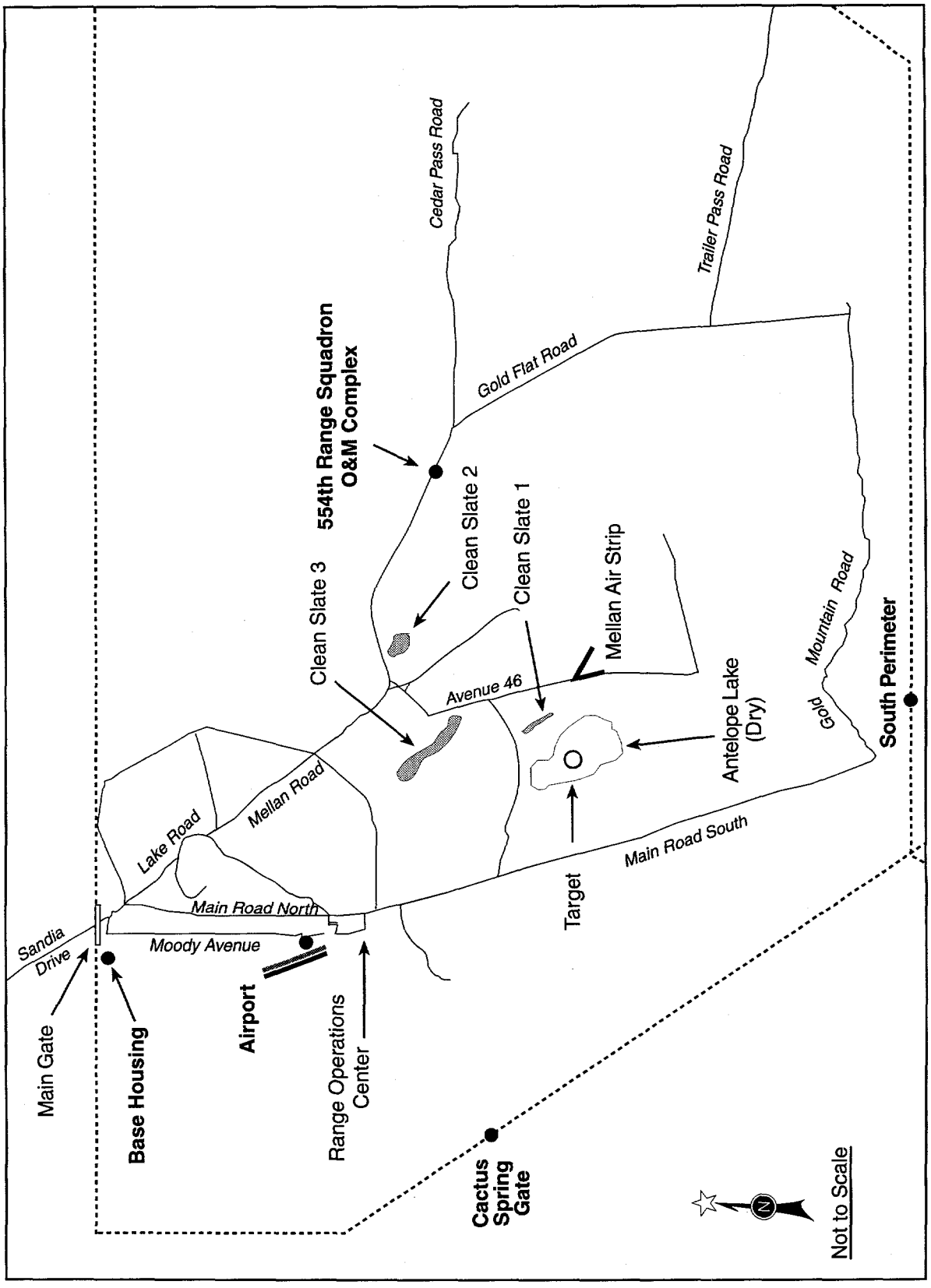

Figure 5-1. On-Site Receptor Locations

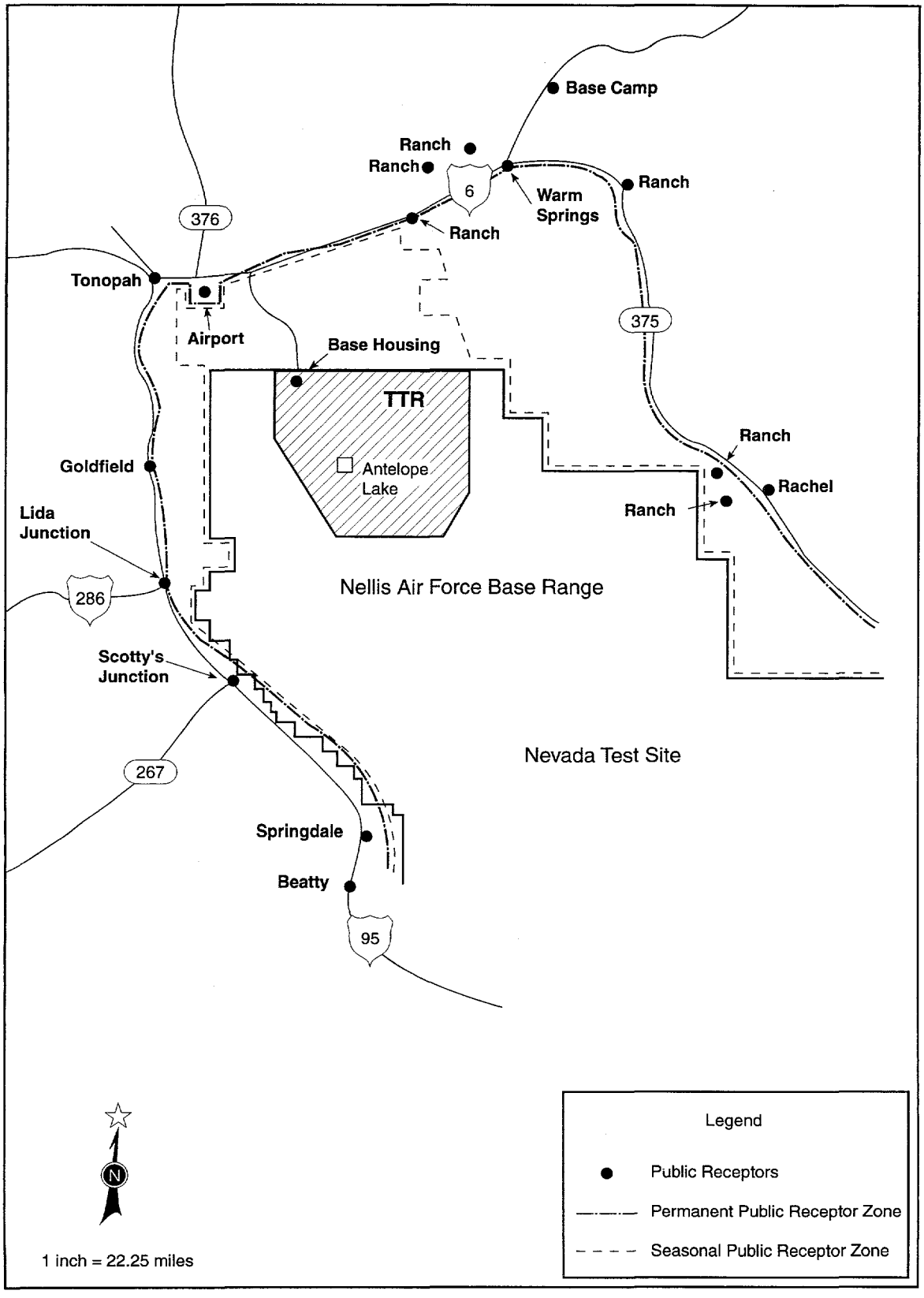

Figure 5-2. Public Receptor Zone Around the Tonopah Test Range

NAFB to locate the closest southern receptor is not possible. The south perimeter fence is conservatively the closest any southern receptor could be to the Clean Slate sites.

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APPENDIX A

STATE OF NEVADA REGULATIONS AND PERMIT LISTINGS

CONTENTS

TABLES

Table A-1. State of Nevada Regulations Applicable to the Tonopah Test Range

Regulation	Applicable Activity
Nevada Wildlife Regulations Nevada Revised Statute, Title 45, Chapter 501. NRS 501.010-501.243 Wildlife Regulations NAC 504.510-504.550	- Diversion of surface drainage channels - Clearing, leveling, and grading of site - Road construction - Highway improvement - Installation of water lines - Installation of water reservoirs - Installation of fuel storage tanks - Construction of sanitary landfill - Construction of explosives bunkers
Nevada Air Quality Regulations Nevada Revised Statutes, Title 40, Public Health and Safety, Chapter 445. NRS 445.401-445.601 NAC 445.430-445.995	- Diversion of surface drainage channels - Clearing, leveling, and grading of site - Road construction - Highway improvement - Installation of water lines - Installation of water reservoirs - Installation of fuel storage tanks - Construction of sanitary landfill - Construction of explosives bunkers - Construction of support buildings - Incinerator - Diesel-powered emergency generator
Nevada Water Pollution Nevada Revised Statutes, Title 40, Public Health and Safety, Chapter 445. NRS 445.131-445.354 NAC 445.070-445.194	- Construction of operation of Control Regulations sewage treatment plant - Disposal of drilling fluids - Water treatment plant

Table A-1. State of Nevada Regulations Applicable to the Tonopah Test Range (Continued)

Regulation	Applicable Activity
Nevada Regulations Solid Waste Management Nevada Revised Statutes, Title 40, Public Health and Safety, Chapter 444. NRS 444.510-444.610 Regulations Governing Solid Waste Management	- Clearing, leveling, and grading of site - Construction of support buildings - Construction and operation of sanitary landfill - Daily sanitary wastes - Disposal of sewage sludge
Nevada Regulations Governing Individual Sewage Systems Nevada Revised Statutes, Title 40, Public Health and Safety, Chapter 444. NRS 444.650 NAC 444.750-444.840	- Construction of sewage collection systems
Nevada Public Water Supply and Public Water Systems Regulations Nevada Revised Statutes, Title 40, Public Health and Safety, Chapter 445. NRS 445.030 NAC 445.370-445.420	- Installation of water lines - Installation of water reservoirs

Table A-1. State of Nevada Regulations Applicable to the Tonopah Test Range (Concluded)

Regulation	Applicable Activity
Nevada Water Resources Nevada Revised Statutes, Underground Water and Wells, Chapters 533 and 534. NRS 534.010-534.190 Regulations for Drilling Wells	- Installation of water lines - Installation of water reservoirs
Radiation Control Nevada Revised Statutes, Title 40, Public Health and Safety, Chapter 459. NRS 459.010-459.290 Nevada Regulations for Radiation Control	- Use of radioactive sources

Table A-2. Tonopah Test Range Permits and Registrations

	Type of Activity	Permit Expiration Date	Report to Agency Due by	Comments
Air Quality*				
1.	Petro Storage JP-4	09/15/97		State of Nevada (NV) to U.S. Air Force (USAF) Permit #2449
2.	Petro Storage JP-4	03/26/97		State of NV to USAF Permit #2448
3.	Petro Storage JP-4	03/26/97		State of NV to USAF Permit #2447
4.	Petro Storage JP-4	03/26/97		State of NV to USAF Permit #2446
5.	Petro Storage Diesel #1	03/26/97		State of NV to USAF Permit #2445
6.	Petro Storage Diesel #1	09/15/93 (in process of being renewed)		State of NV to USAF Permit #1661
7.	Large Batch Plant (Ross)	02/12/96	04/15/93†	State of NV to U.S. Department of Energy/ Nevada Operations Office (DOE/NV) Permit #2229

*Air Quality Activities 1 to 6 apply to the surface tanks in Technical Area 10 (Industrial Area).
†Annual Summary Report transmitted through the DOE/NV/Environmental Programs Departments (EPD) Office to Nevada Division of Environmental Protection.
‡National Pollutant Discharge Elimination System (NPDES) permit renewal application has been transmitted to the State of Nevada. The State is presently renewing the application and design modification. Expected renewal date is unknown.

Table A-2. Tonopah Test Range Permits and Registrations (Continued)

	Type of Activity	Permit Expiration Date	Report to Agency Due by	Comments
8.	Small Batch Plant (S.C. Johnson)	02/19/96	04/15/93†	State of NV to DOE/NV Permit #2231
9.	Crusher Cedarapids Mdl #2416		04/15/93†	State of NV to DOE/NV Permit to Operate #2456
10.	Crusher Cedarapids Mdl #1524		04/15/93†	State of NV to DOE/NV Permit to Operate #2457
11.	Screen Cedarapids Mdl #2416		04/15/93†	State of NV to DOE/NV Permit to Operate #2455
12.	Surface Disturbance	09/15/98	04/15/93†	State of NV to DOE/Kirtland Area Office (DOE/KAO) Air Quality Permit #2844
13.	Incinerator (MDL 500CA)	03/26/98	04/15/93†	State of NV to USAF Permit #2450
14.	Vapor Extraction (Fire Training Pit)	03/28/05		State of NV to USAF Air Quality Permit #AP9999-0547

*Air Quality Activities 1 to 6 apply to the surface tanks in Technical Area 10 (Industrial Area).

†Annual Summary Report transmitted through the DOE/NV/Environmental Programs Departments (EPD) Office to Nevada Division of Environmental Protection.

‡National Pollutant Discharge Elimination System (NPDES) permit renewal application has been transmitted to the State of Nevada. The State is presently renewing the application and design modification. Expected renewal date is unknown.

Table A-2. Tonopah Test Range Permits and Registrations (Concluded)

	Type of Activity	Permit Expiration Date	Report to Agency Due by	Comments
Water Systems				
1.	Mancamp Area Well 1A Bureau of Land Management (BLM) Well	09/30/95	Monthly	State of NV to USAF Permit #NY-4068-12C
2.	Industrial Area Well 3A Well 3B Well EH-2	09/30/95	Monthly	State of NV to USAF Permit #NY-5001-12NC
3.	SNL Compound Well 6	09/30/95	Monthly	State of NV to DOE/KAO Permit #NY-3014-12NC
4.	Tonopah Electric Combat Range (TECR) (Operations and Maintenance [O&M]) Well	09/30/95	Monthly	State of NV to USAF Permit #NY-5002-12NC
Sewage System				
1.	Tonopah Integrated Air Defense System (TIADS) Mancamp Industrial Area	08/20/92‡	Quarterly	State of NV to USAF Permit #NEV20001
Hazardous Waste				
1.	EPA Waste ID Number TTR	N/A	Yearly	EPA to DOE/KAO EPA I.D. #NV1890011991

*Air Quality Activities 1 to 6 apply to the surface tanks in Technical Area 10 (Industrial Area).
†Annual Summary Report transmitted through the DOE/NV/Environmental Programs Departments (EPD) Office to Nevada Division of Environmental Protection.
‡National Pollutant Discharge Elimination System (NPDES) permit renewal application has been transmitted to the State of Nevada. The State is presently renewing the application and design modification. Expected renewal date is unknown.

APPENDIX B

RADIOLOGICAL SAMPLING LOCATIONS AND RESULTS

CONTENTS

FIGURES

TABLES

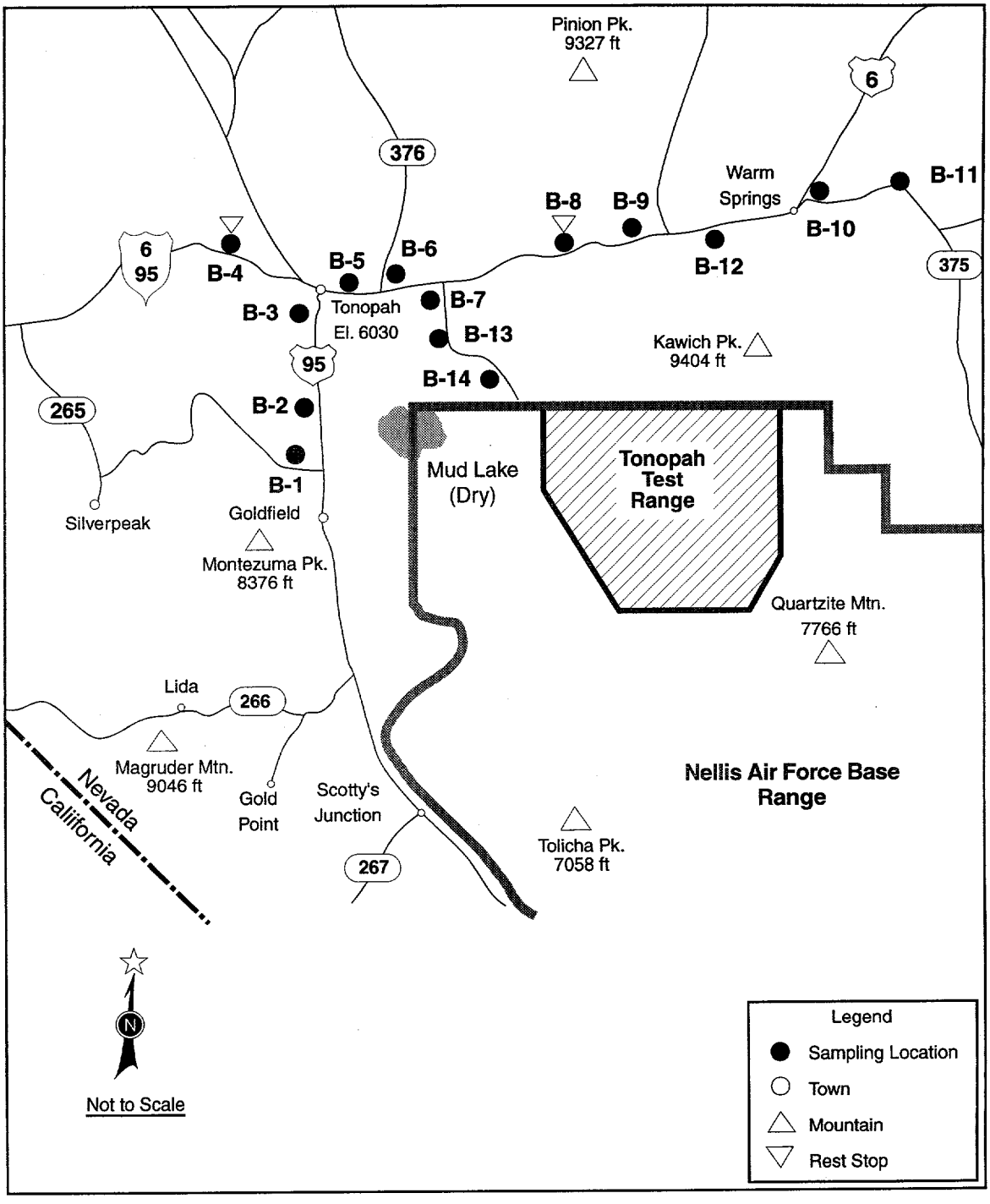

Figure B-1. Off-Site Soil Sampling Locations

Table B-1. Radiological Results of Off-Site Soil Sampling

Location	H_2O (%)	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-238 (pCi/g) Error	Pu-239,240 (pCi/g)	Pu-239,240 (pCi/g) Error	Cs-137 (pCi/g)	Cs-137 (pCi/g) Error
B-1	<0.1	5.9	0.11	0.13	0.00	0.01	0.59	0.07
B-2	<0.1	2.9	-0.06	0.13	-0.05	0.05	0.19	0.04
B-3A	<0.1	5.4	0.01	0.04	0.00	0.01	0.44	0.06
B-4	<0.1	4.1	0.01	0.03	0.00	0.01	0.22	0.04
B-5	<0.1	6	0.01	0.04	0.02	0.03	0.83	0.08
B-6	<0.1	4	0.00	0.01	0.00	0.04	0.50	0.06
B-7	<0.1	4.6	-0.11	0.12	-0.03	0.06	0.46	0.06
B-8	<0.1	4.8	0.03	0.04	-0.02	0.02	0.22	0.04
B-9	<0.1	3.5	0.02	0.05	0.00	0.05	0.09	0.03
B-10	<0.1	5.1	0.02	0.03	-0.02	0.02	0.05	0.03
B-11	<0.1	2.3	0.00	0.01	0.01	0.06	0.34	0.05
B-12	<0.1	3.6	0.00	0.01	-0.02	0.02	0.34	0.05
B-13	<0.1	3.7	0.03	0.05	-0.02	0.03	0.28	0.04
B-14	<0.1	3.4	-0.09	0.12	0.02	0.08	0.12	0.04

Note: No samples contained americium-241 concentrations greater than the analytical detection limit (0.1 picocuries per gram [pCi/g]). μg/g = micrograms per gram.

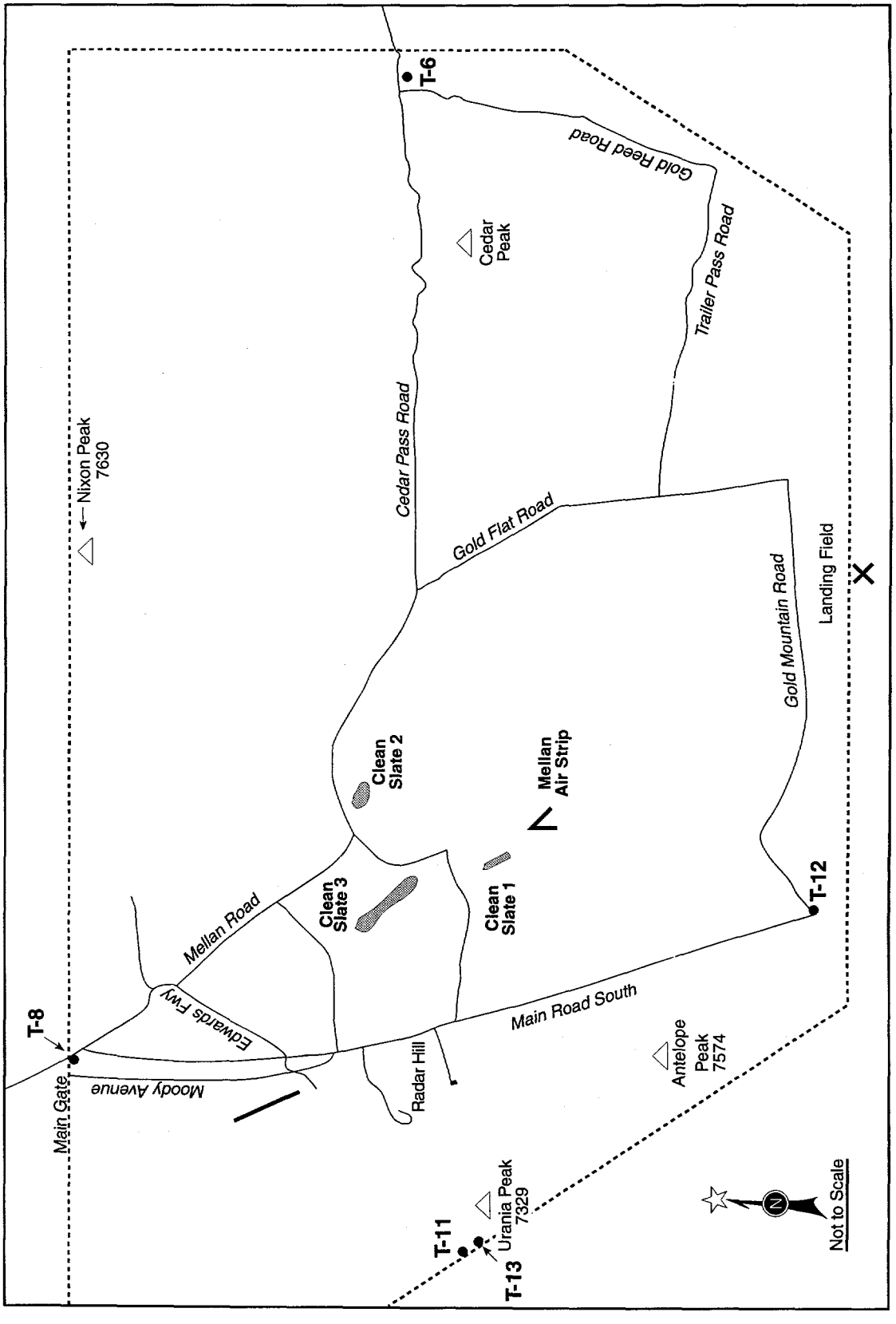

Figure B-2. Perimeter Soil Sampling Locations

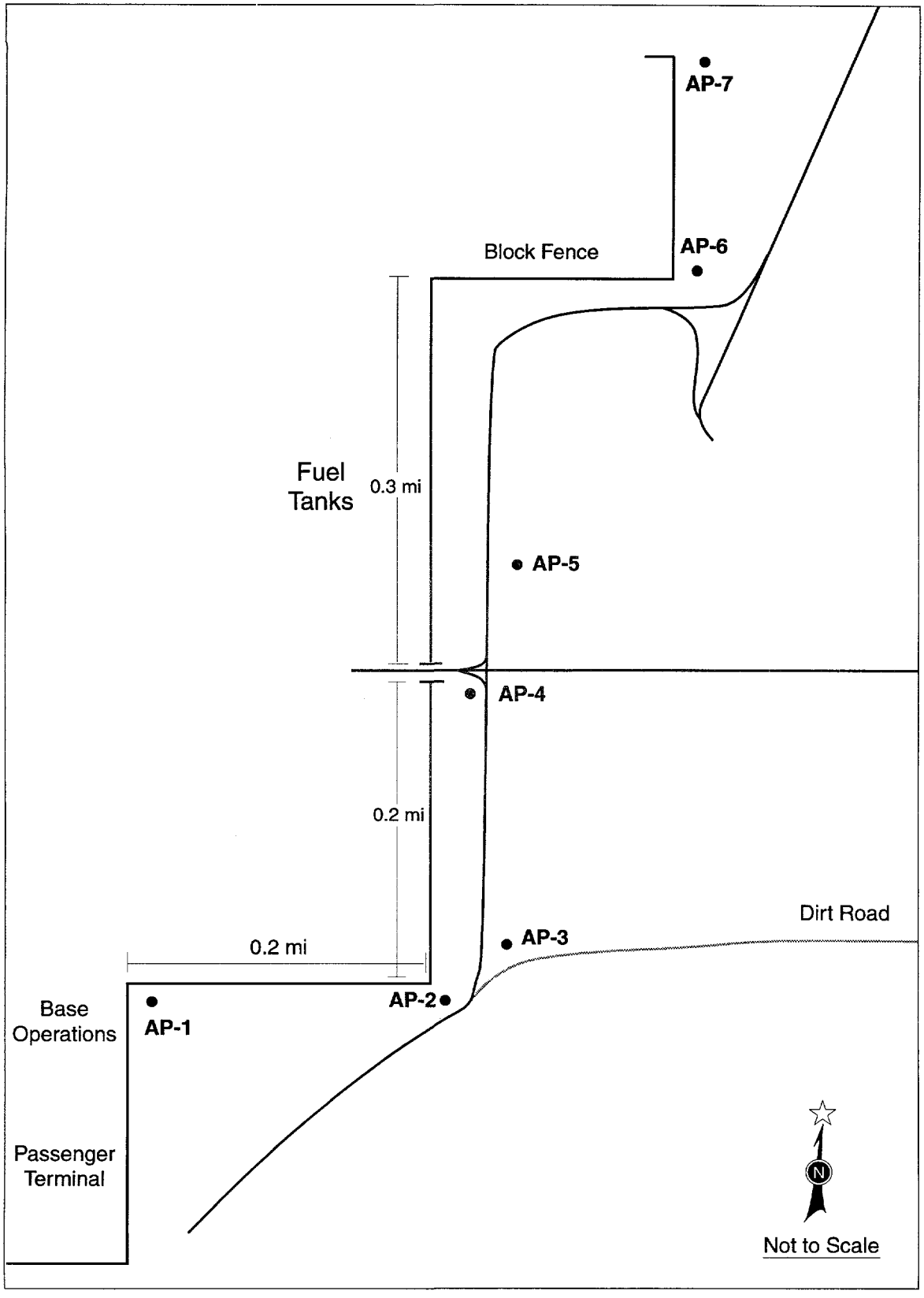

Figure B-3. Soil Sampling Locations in the Airport Area

Table B-2. Radiological Results of Perimeter Soil Sampling

Location	H_2O (%)	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-238 (pCi/g) Error	Pu-239,240 (pCi/g)	Pu-239,240 (pCi/g) Error	Cs-137 (pCi/g)	Cs-137 (pCi/g Error
T-6	<0.1	5	0.04	0.10	0.00	0.05	0.60	0.07
T-8	<0.1	3.2	-0.04	0.08	0.00	0.01	0.14	0.04
T-11	0.1	4.2	0.03	0.07	0.02	0.06	0.21	0.04
T-12	<0.1	4.1	-0.01	0.04	-0.02	0.04	0.44	0.06
T-13	0.1	4.3	0.00	0.05	0.06	0.08	0.69	0.09

Note: No samples contained americium-241 concentrations greater than the analytical detection limit (0.1 picocuries per gram [pCi/g]).
μg/g = micrograms per gram.

Table B-3. Radiological Results of Soil Sampling in the Airport Area

Location	H_2O (%)	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-238 (pCi/g) Error	Pu-239,240 (pCi/g)	Pu-239,240 (pCi/g) Error	Cs-137 (pCi/g)	Cs-137 (pCi/g) Error
AP-1	<0.1	4.7	0.01	0.11	-0.04	0.05	0.05	0.03
AP-2	<0.1	5.7	-0.05	0.08	-0.04	0.05	0.17	0.04
AP-3	<0.1	4.5	0.02	0.10	0.00	0.07	0.87	0.09
AP-4	<0.1	6.1	-0.03	0.08	-0.01	0.07	ND	ND
AP-5	<0.1	3.3	0.07	0.12	-0.01	0.07	0.45	0.06
AP-6	<0.1	4.7	-0.05	0.08	-0.04	0.05	0.15	0.04
AP-7	<0.1	4.9	-0.06	0.07	-0.04	0.05	0.07	0.03

Note: No samples contained americium-241 concentrations greater than the analytical detection limit (0.1 picocuries per gram [pCi/g]).
μg/g = micrograms per gram; ND = not detected.

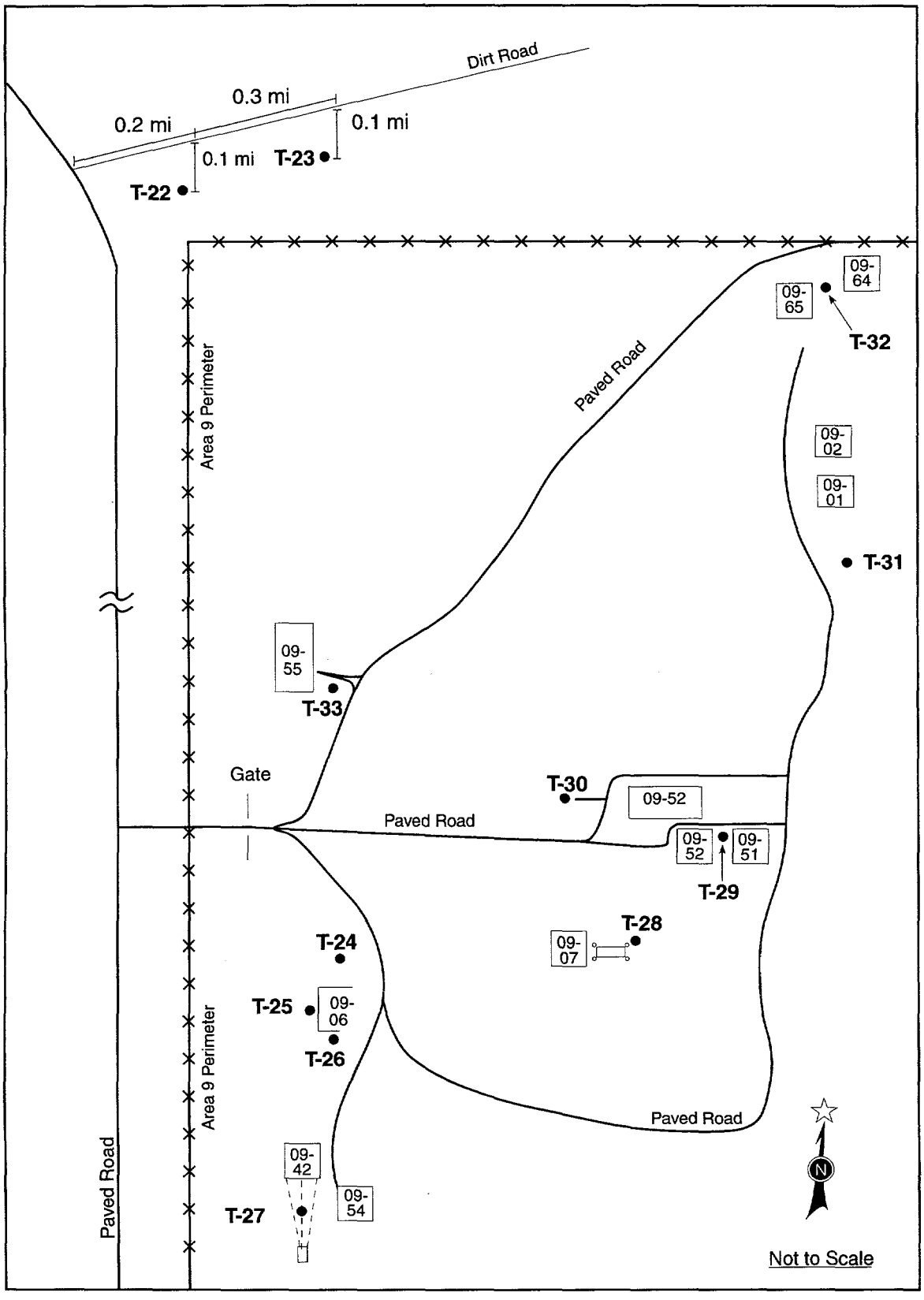

Figure B-4. Soil Sampling Locations near Area 9

Table B-4. Radiological Results of Soil Sampling near Area 9

Location	H_2O (%)	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-238 (pCi/g) Error	Pu-239,240 (pCi/g)	Pu-239,240 (pCi/g) Error	Cs-137 (pCi/g)	Cs-137 (pCi/g) Error
T-22	<0.1	3.8	-0.05	0.08	-0.03	0.06	0.21	0.04
T-23	<0.1	5.3	0.02	0.04	-0.02	0.02	0.07	0.03
T-24	<0.1	4.9	0.00	0.03	0.02	0.03	0.14	0.04
T-25	0.1	5.2	0.00	0.02	0.00	0.01	0.24	0.05
T-26	<0.1	4.9	0.01	0.03	0.00	0.01	0.10	0.40
T-27	<0.1	4.7	0.01	0.03	0.00	0.01	0.05	0.03
T-28	0.1	6.1	-0.01	0.01	0.00	0.01	0.10	0.03
T-29	0.1	4.9	-0.01	0.02	0.00	0.01	0.06	0.04
T-30	<0.1	4.7	-0.01	0.02	0.00	0.01	0.05	0.03
T-31	<0.1	5.4	-0.01	0.01	0.01	0.02	0.12	0.04
T-32	<0.1	6	0.00	0.03	0.02	0.02	ND	ND
T-33A	<0.1	5.5	-0.01	0.02	0.01	0.01	0.41	0.07

Note: No samples contained americium-241 concentrations greater than the analytical detection limit (0.1 picocuries per gram [pCi/g]). μg/g = micrograms per gram; ND = not detected.

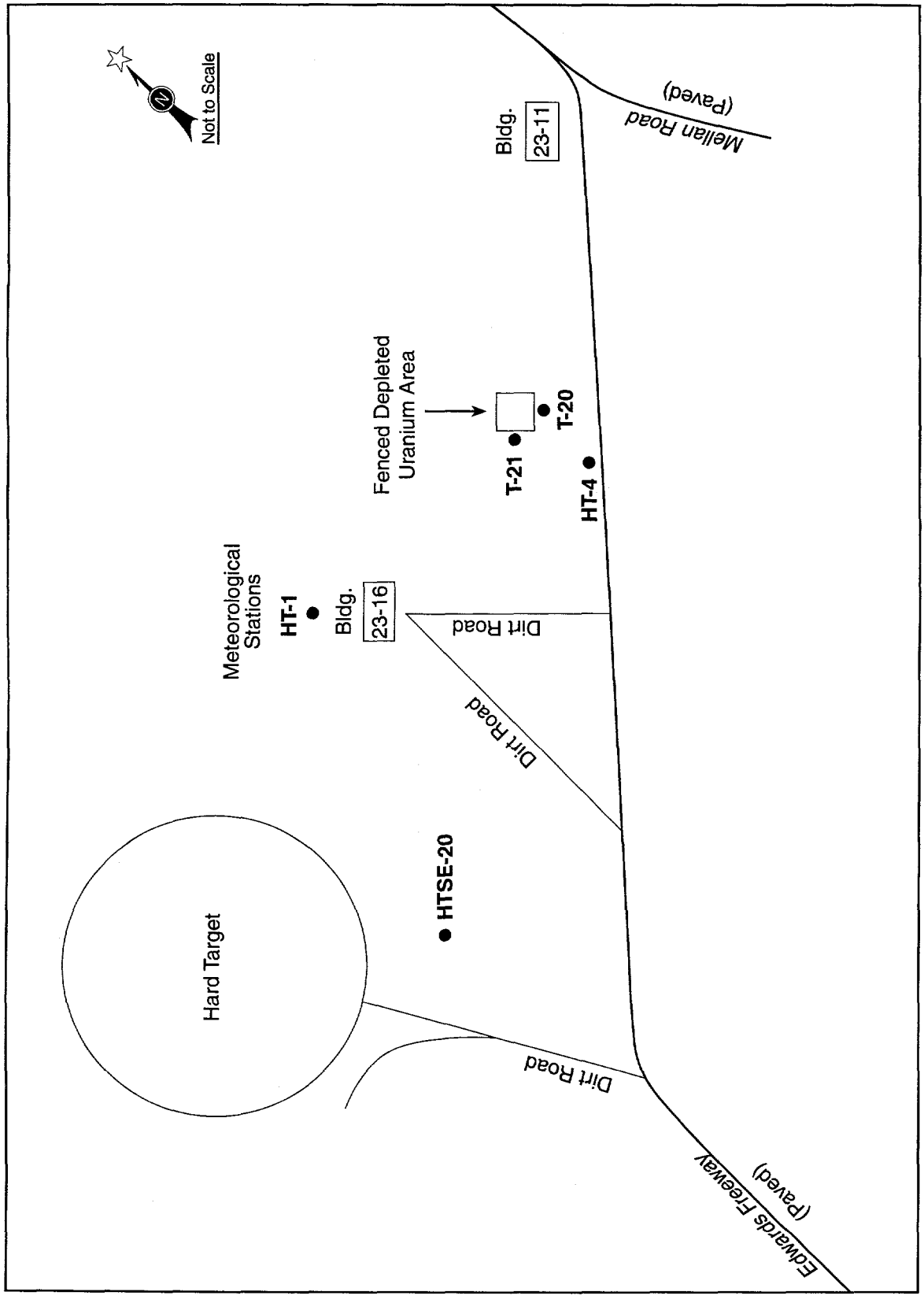

Figure B-5. Soil Sampling Locations near the Hard Target/Depleted Uranium Area

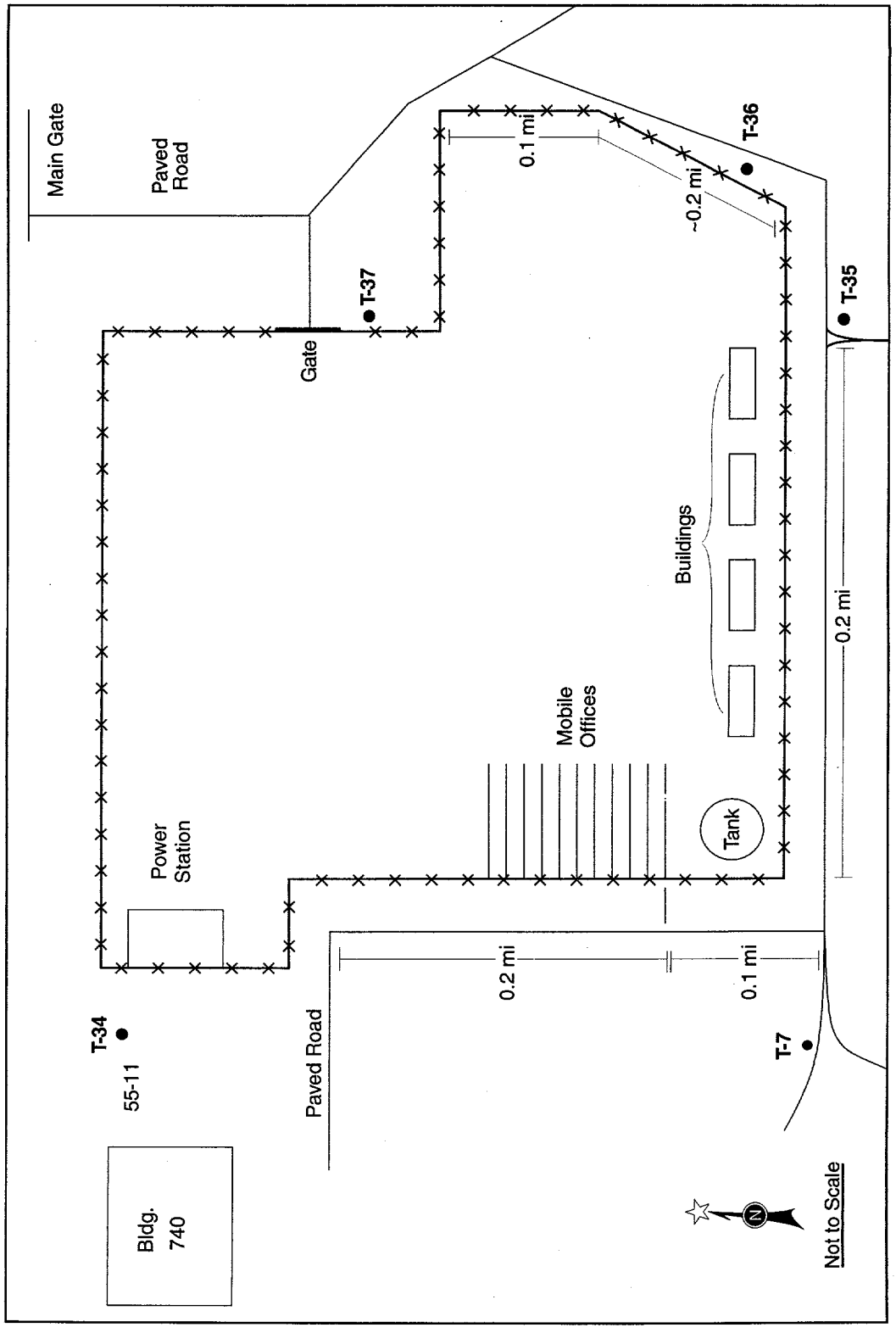

Figure B-6. Soil Sampling Locations near the On-Base Housing Area

Table B-5. Radiological Results of Soil Sampling near the Hard Target/Depleted Uranium Area

Location	H_2O (%)	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-238 (pCi/g) Error	Pu-239,240 (pCi/g)	Pu-239,240 (pCi/g) Error	Cs-137 (pCi/g)	Cs-137 (pCi/g) Error
HT-1	<0.1	4.3	-0.07	0.07	0.02	0.02	0.14	0.04
HT-4	<0.1	4.6	-0.07	0.07	0.00	0.01	0.05	0.03
HTSE-20	<0.1	4.1	0.01	0.02	-0.01	0.02	0.08	0.03
T-20	<0.1	12	-0.04	0.08	-0.04	0.05	0.38	0.07
T-21	<0.1	3.9	-0.04	0.07	-0.02	0.06	0.42	0.06

Note: No samples contained americium-241 concentrations greater than the analytical detection limit (0.1 picocuries per gram [pCi/g]).
μg/g = micrograms per gram; pCi/g = picocuries per gram.

Table B-6. Radiological Results of Soil Sampling near the On-Base Housing Area

Location	H_2O (%)	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-238 (pCi/g) Error	Pu-239,240 (pCi/g)	Pu-239,240 (pCi/g) Error	Cs-137 (pCi/g)	Cs-137 (pCi/g) Error
T-7A	<0.1	4	-0.07	0.07	0.02	0.04	0.05	0.03
T-34	<0.1	3.9	0.01	0.01	0.00	0.01	0.09	0.03
T-35A	<0.1	5	0.00	0.01	0.00	0.01	0.06	0.03
T-36	<0.1	4.2	0.01	0.02	0.00	0.01	0.21	0.04
T-37	<0.1	3.4	0.02	0.02	0.00	0.01	0.05	0.03

Note: No samples contained americium-241 concentrations greater than the analytical detection limit (0.1 picocuries per gram [pCi/g]).
μg/g = micrograms per gram.

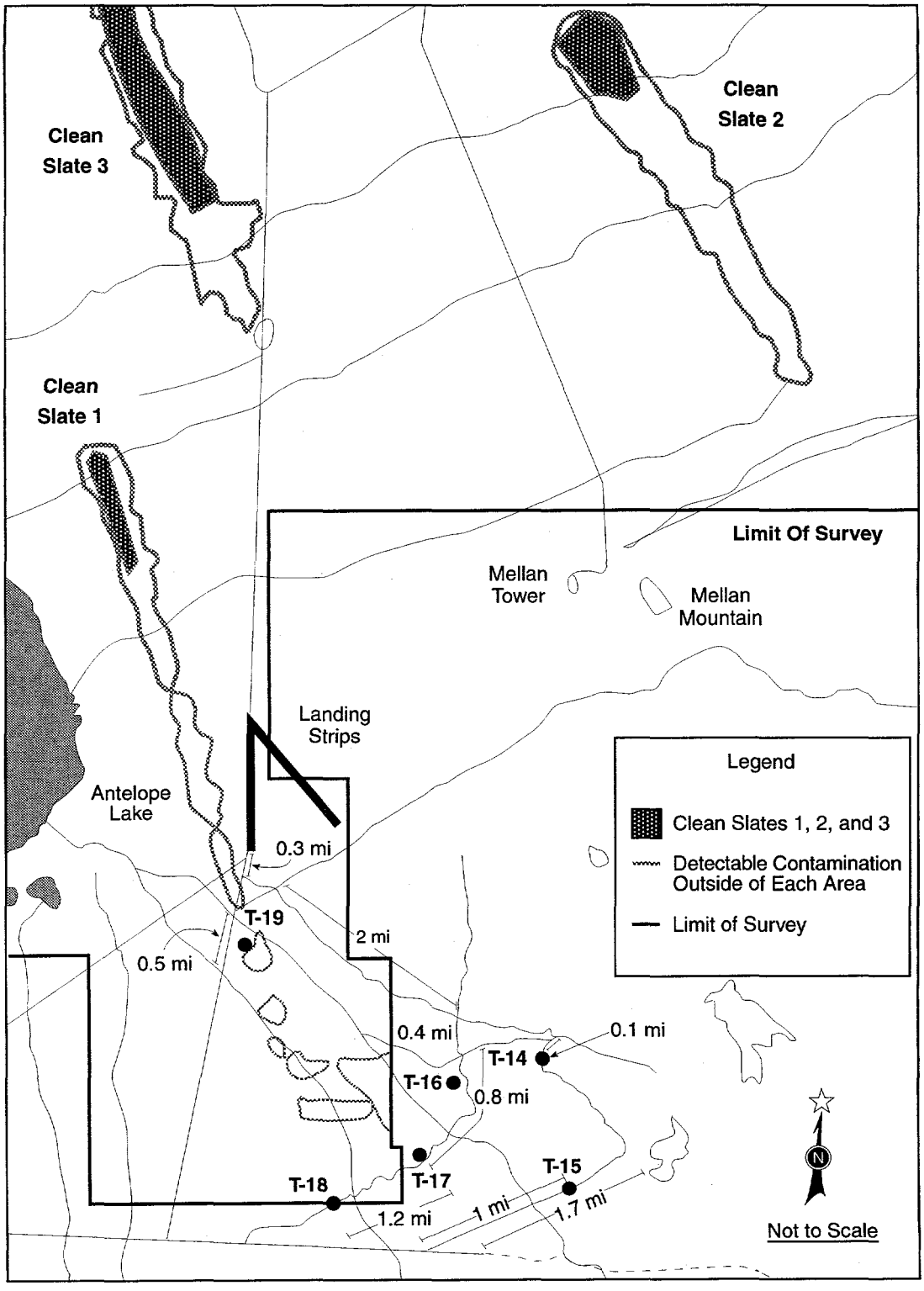

Figure B-7. Soil Sampling Locations in the South Plume Area

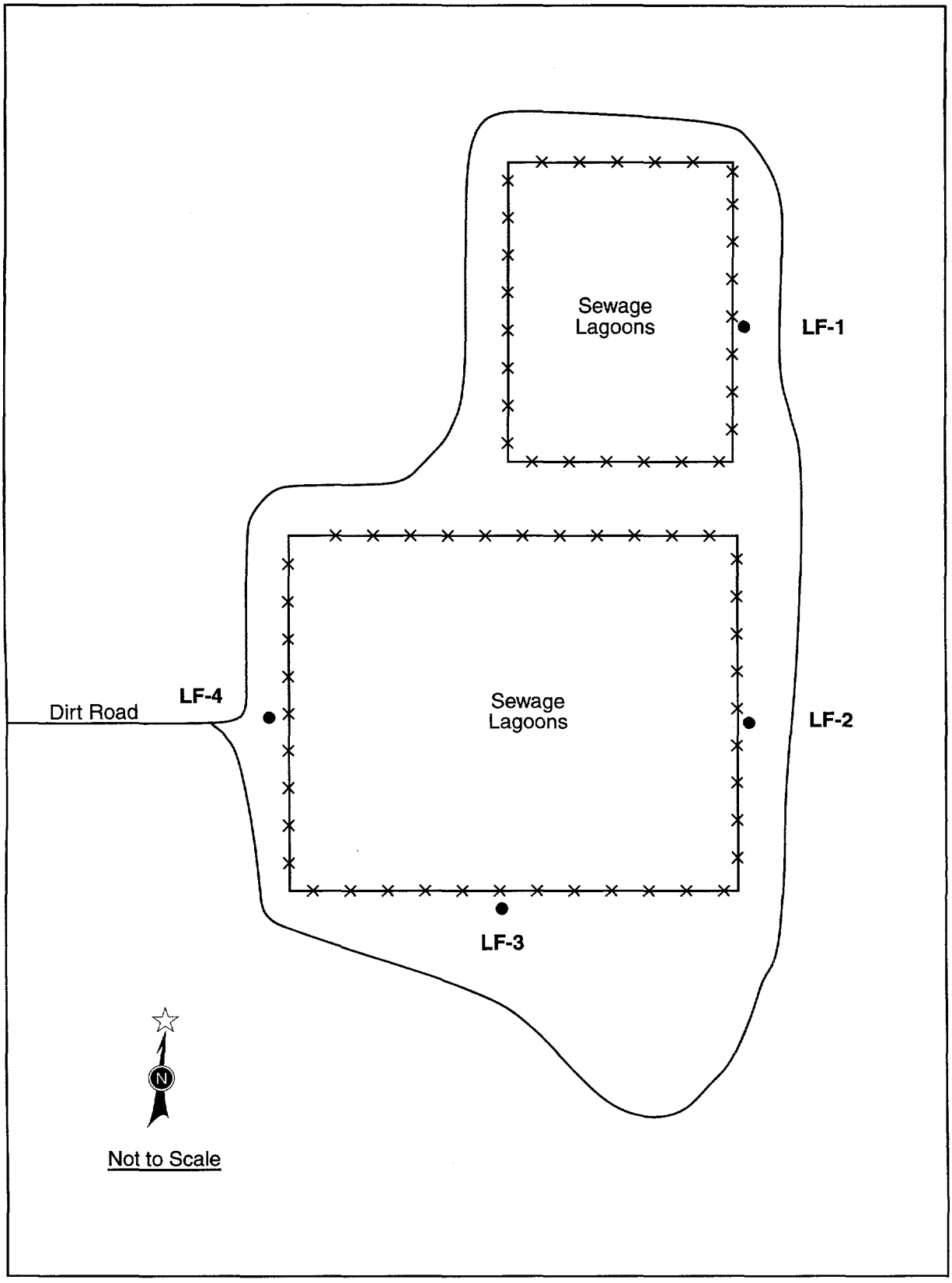

Figure B-8. Soil Sampling Locations at the Project Roller Coaster Sewage Lagoons

Table B-7. Radiological Results of Soil Sampling in the South Plume Area

Location	H_2O (%)	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-238 (pCi/g) Error	Pu-239,240 (pCi/g)	Pu-239,240 (pCi/g) Error	Cs-137 (pCi/g)	Cs-137 (pCi/g) Error	Am-241 (pCi/g)	Am-241 (pCi/g) Error
T-14A	<0.1	5.1	0.05	0.04	0.40	0.09	0.49	0.06	ND	ND
T-15	<0.1	3.3	0.01	0.03	0.01	0.02	0.62	0.07	0.05	0.03
T-16	<0.1	3.2	0.02	0.03	0.03	0.03	0.69	0.08	ND	ND
T-17	<0.1	3.1	0.00	0.02	1.20	0.20	0.65	0.07	0.21	0.04
T-18	<0.1	2.8	0.05	0.05	1.20	0.20	0.82	0.08	0.22	0.05
T-19	<0.1	3.8	0.23	0.10	32.00	1.10	0.97	0.10	4.40	0.39

Note: μg/g = micrograms per gram; pCi/g = picocuries per gram; ND = not detected.

Table B-8. Radiological Results of Soil Sampling at the Project Roller Coaster Sewage Lagoons

Location	H_2O (%)	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-238 (pCi/g) Error	Pu-239,240 (pCi/g)	Pu-239,240 (pCi/g) Error	Cs-137 (pCi/g)	Cs-137 (pCi/g) Error
LF-1	<0.1	5.4	0.11	0.11	0.02	0.06	0.41	0.06
LF-2	<0.1	4.8	-0.01	0.06	-0.02	0.03	0.20	0.04
LF-3	<0.1	5.9	-0.01	0.07	0.09	0.09	0.36	0.05
LF-4	<0.1	4.9	-0.03	0.04	0.01	0.04	0.20	0.04

Note: No samples contained americium-241 concentrations greater than the analytical detection limit (0.1 picocuries per gram [pCi/g]).

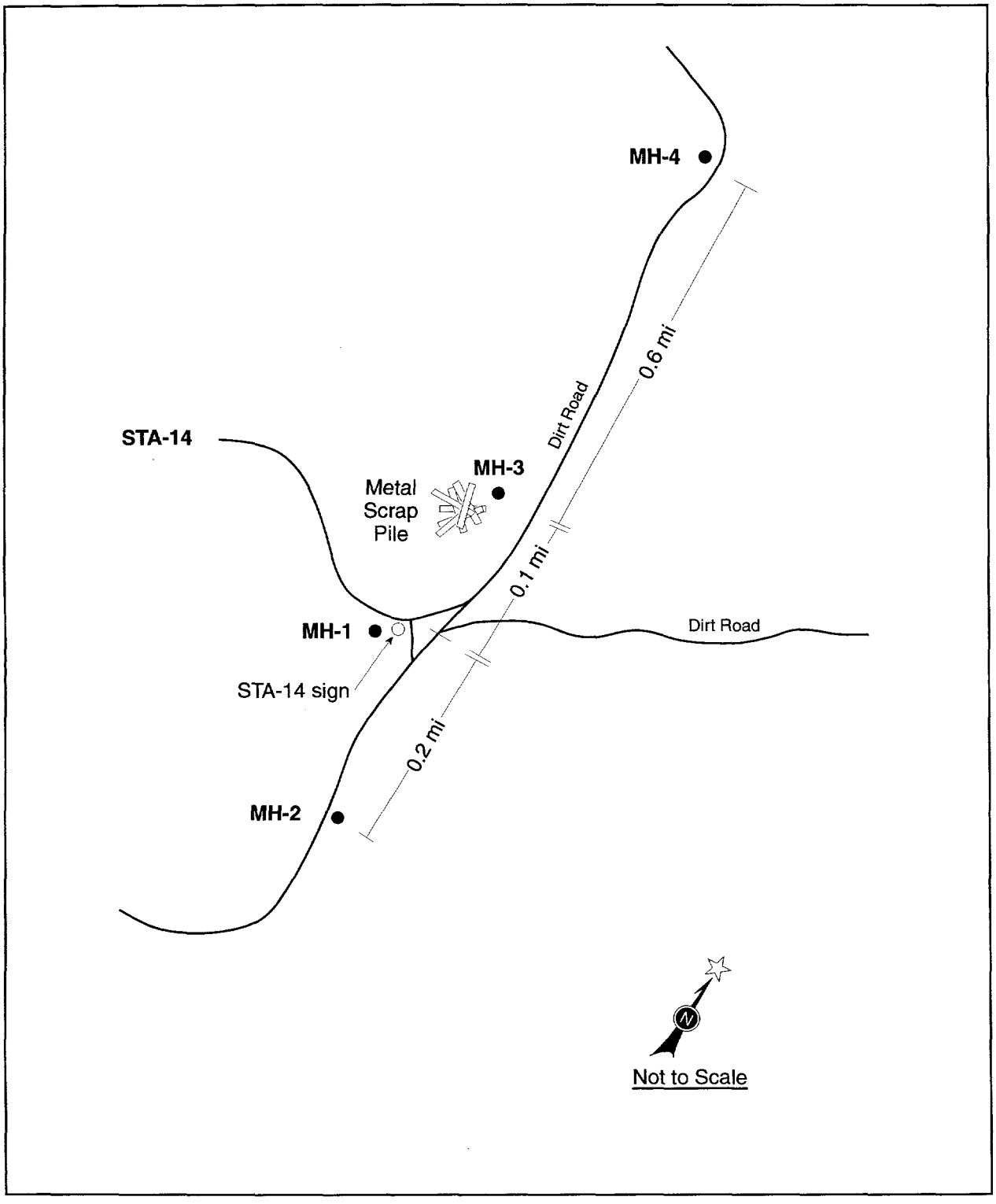

Figure B-9. Soil Sampling Locations at the Mellan Hill Area

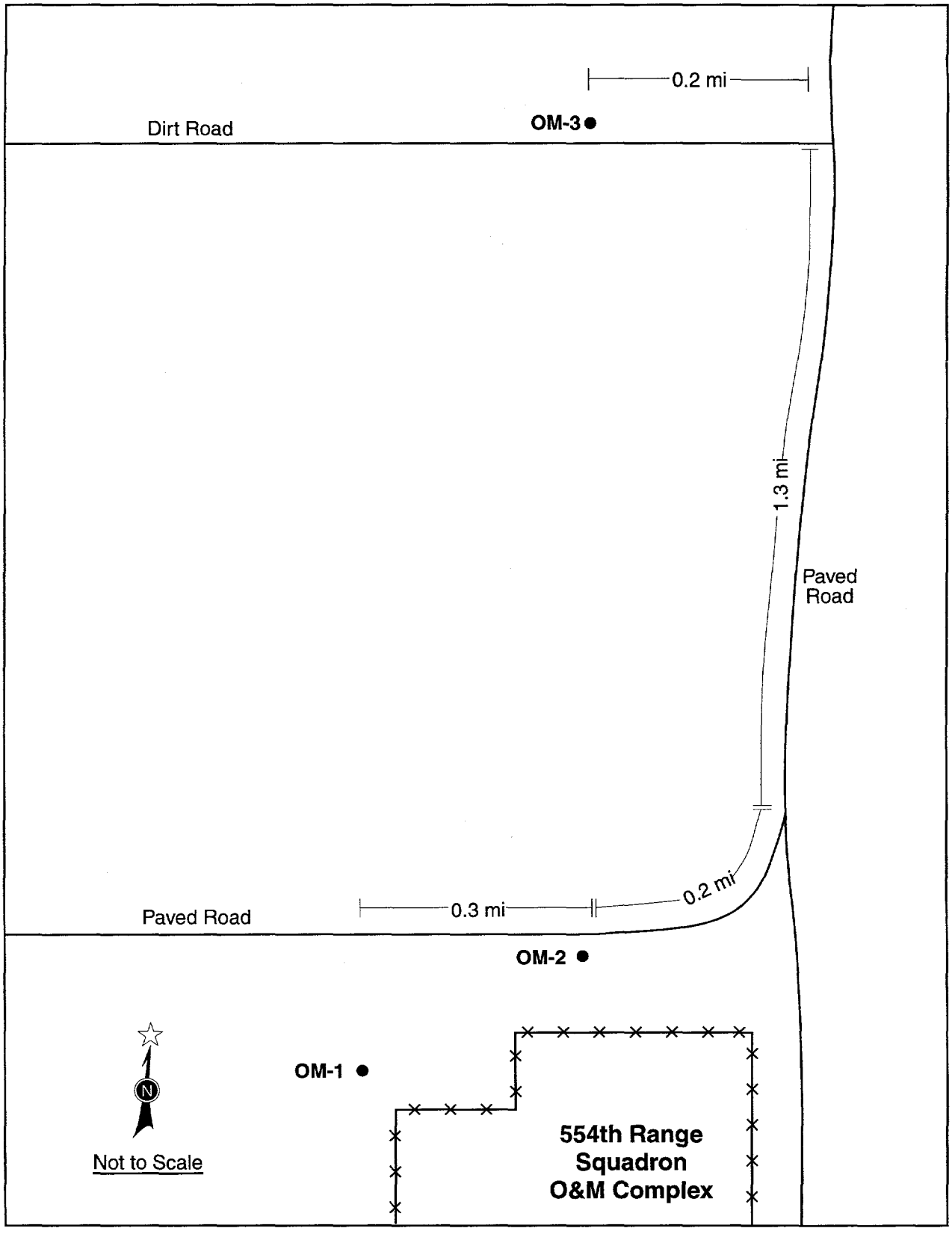

Figure B-10. Soil Sampling Locations near the 554th Range Squadron O&M Complex

Table B-9. Radiological Results of Soil Sampling at the Mellan Hill Area

Location	H_2O (%)	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-238 (pCi/g) Error	Pu-239,240 (pCi/g)	Pu-239,240 (pCi/g) Error	Cs-137 (pCi/g)	Cs-137 (pCi/g) Error
MH-1	<0.1	4.1	0.01	0.04	0.07	0.05	0.37	0.05
MH-2	<0.1	4.2	0.03	0.04	0.07	0.06	0.38	0.06
MH-3	<0.1	4.2	0.01	0.03	0.17	0.05	0.64	0.07
MH-4	<0.1	4.5	0.01	0.03	0.51	0.16	0.53	0.07

Note: No samples contained americium-241 concentrations greater than the analytical detection limit (0.1 picocuries per gram [pCi/g]). μg/g = micrograms per gram.

Table B-10. Radiological Results of Soil Sampling near the 554th Range Squadron O&M Complex

Location	H_2O (%)	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-238 (pCi/g) Error	Pu-239,240 (pCi/g)	Pu-239,240 (pCi/g) Error	Cs-137 (pCi/g)	Cs-137 (pCi/g) Error
OM-1	<0.1	4.7	0.05	0.08	0.08	0.05	0.34	0.05
OM-2	<0.1	3.8	0.00	0.06	0.10	0.08	0.36	0.05
OM-3	<0.1	4.3	0.03	0.09	0.06	0.09	0.60	0.07

Note: No samples contained americium-241 concentrations greater than the analytical detection limit (0.1 picocuries per gram [pCi/g]). μg/g = micrograms per gram.

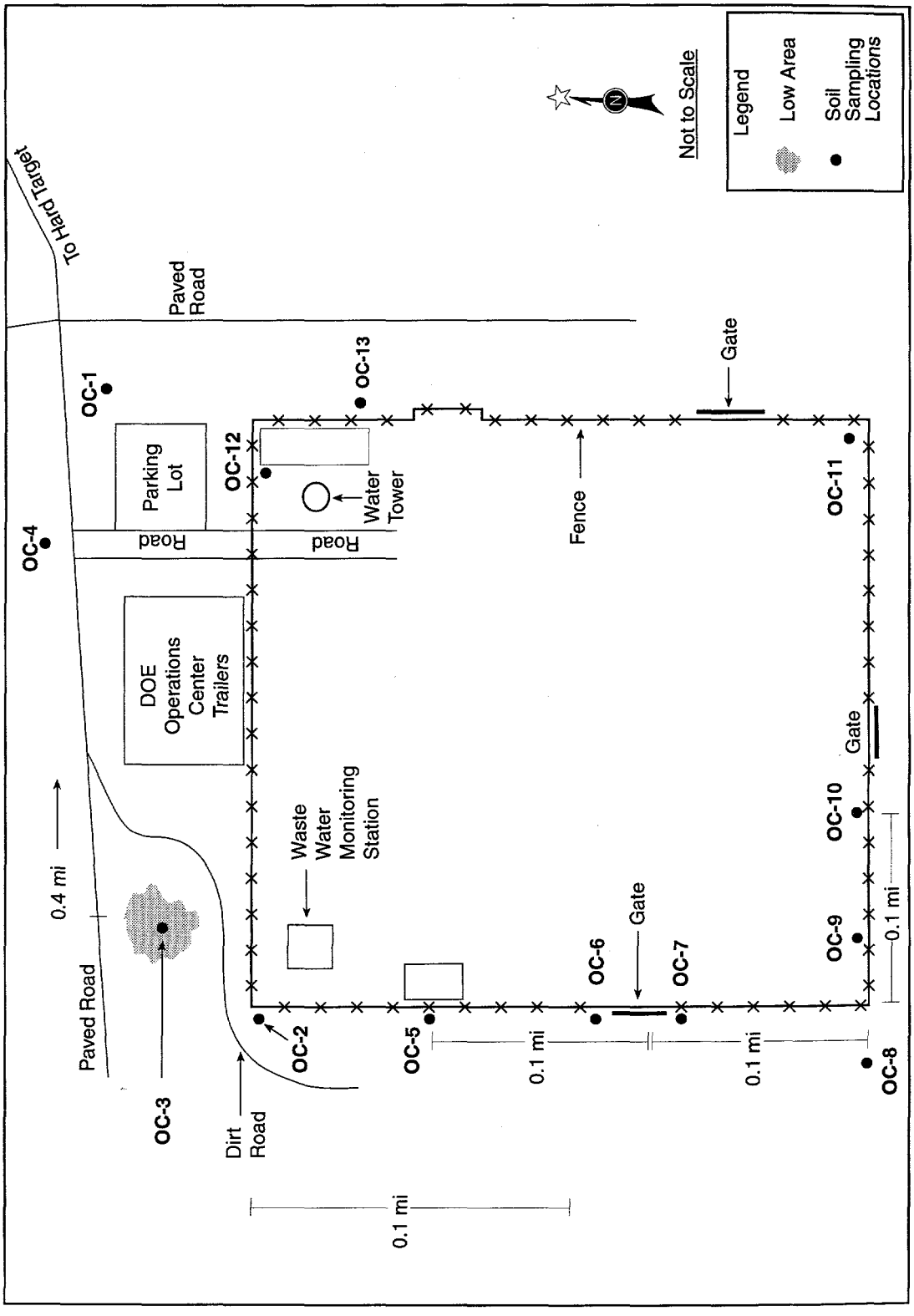

Figure B-11. Soil Sampling Locations Around the Range Operations Center

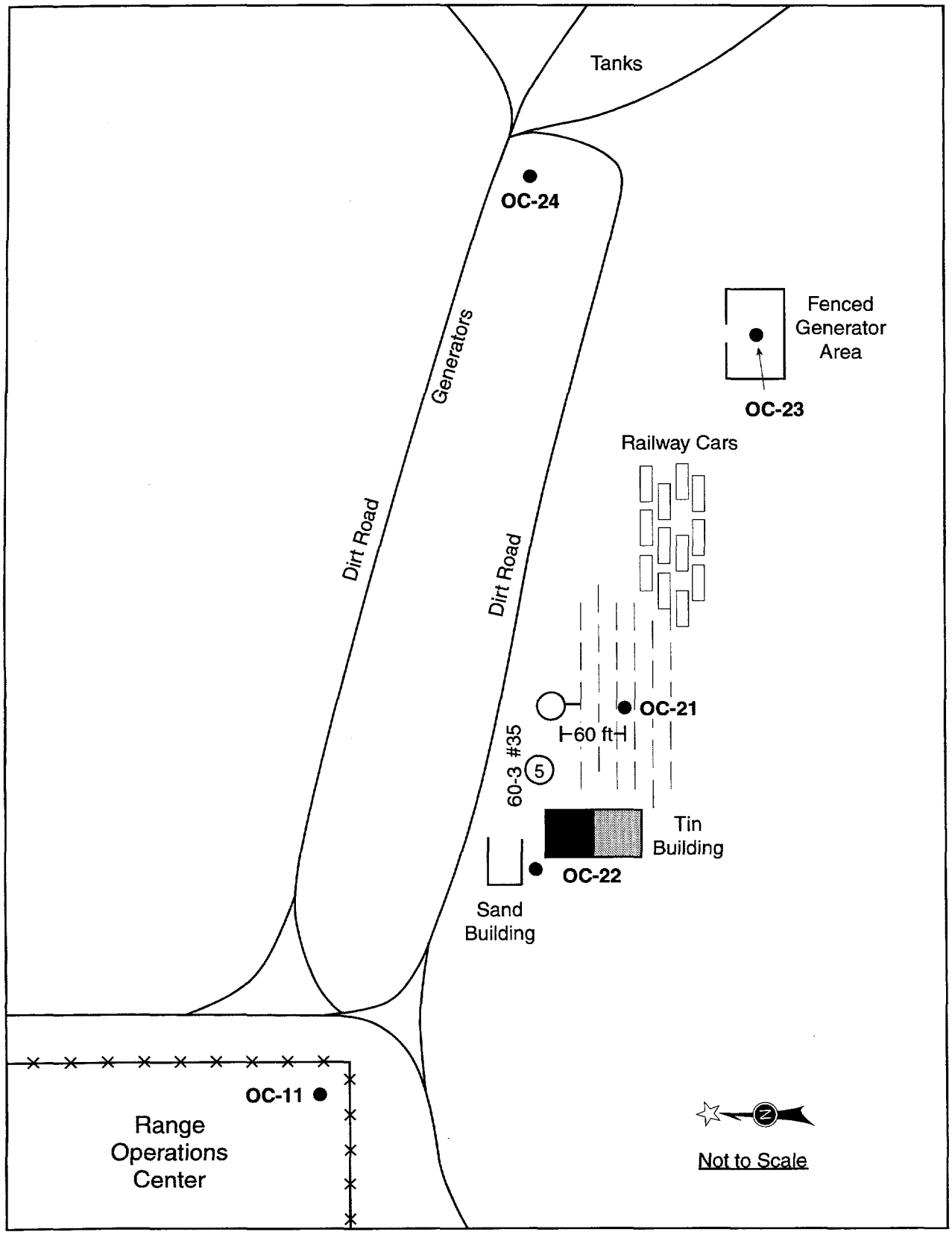

Figure B-12. Soil Sampling Locations Around the Range Operations Center Storage Yard

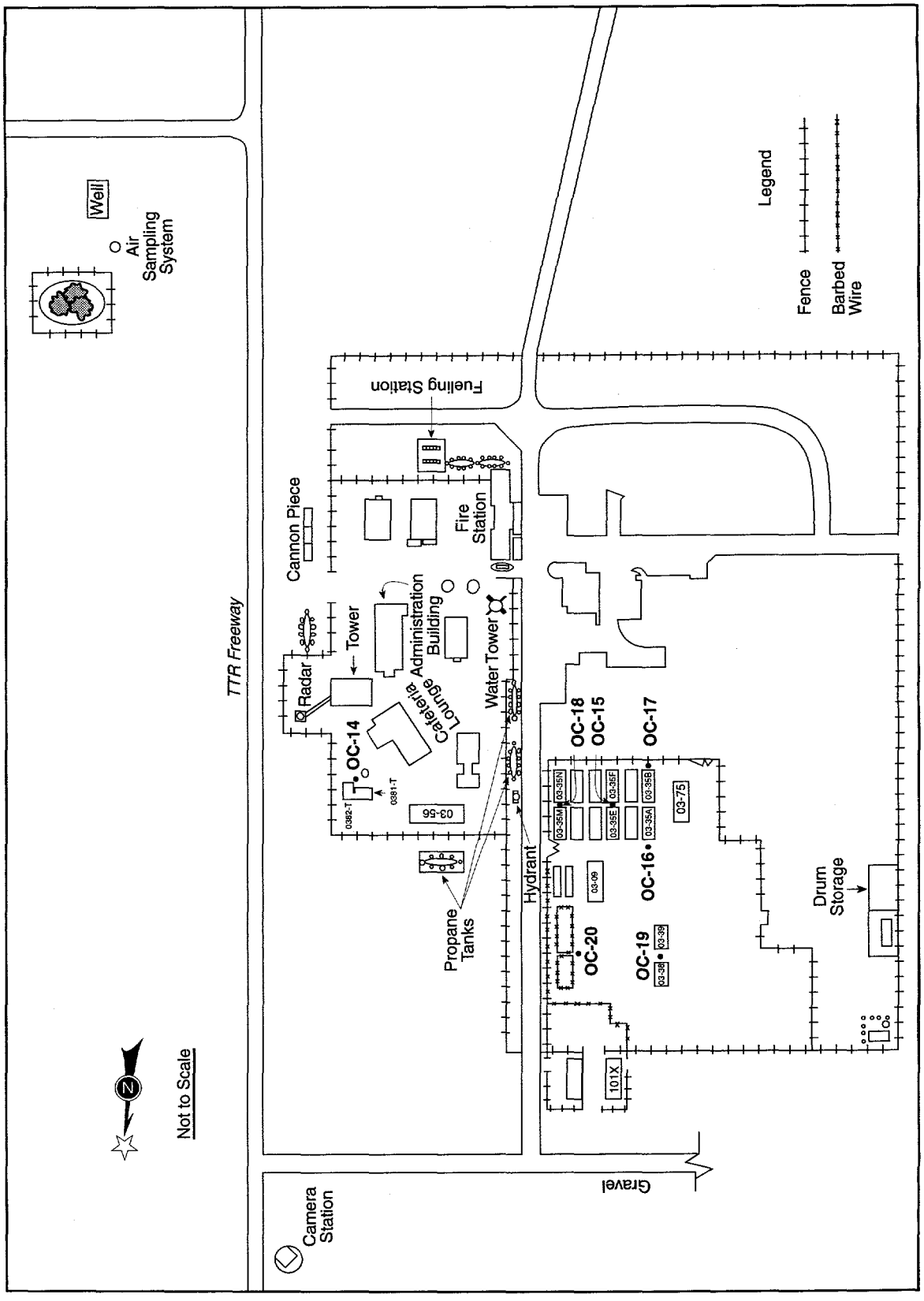

Figure B-13. Soil Sampling Locations in the Range Operations Center and Compound

Table B-11. Radiological Results of Soil Sampling Around the Range Operations Center and Compound

Location	H_2O (%)	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-238 (pCi/g) Error	Pu-239,240 (pCi/g)	Pu-239,240 (pCi/g) Error	Cs-137 (pCi/g)	Cs-137 (pCi/g) Error
OC-1	<0.1	4.8	-0.07	0.07	0.02	0.03	0.11	0.04
OC-2	<0.1	3.8	-0.04	0.09	0.07	0.08	0.21	0.04
OC-3	<0.1	4.2	0.01	0.04	-0.01	0.02	0.23	0.05
OC-4	<0.1	4.3	-0.06	0.08	0.02	0.03	0.53	0.06
OC-5	<0.1	5.4	0.04	0.05	0.00	0.01	0.19	0.04
OC-6	<0.1	6.3	0.02	0.03	0.01	0.01	ND	ND
OC-7	<0.1	5.1	0.01	0.03	0.05	0.03	ND	ND
OC-8	<0.1	5.3	0.03	0.05	0.01	0.03	0.11	0.04
OC-9	<0.1	4.1	0.02	0.03	0.00	0.01	0.06	0.03
OC-10	<0.1	4.6	0.01	0.04	0.03	0.04	ND	ND
OC-11	<0.1	4.5	0.04	0.05	0.01	0.01	ND	ND
OC-12	<0.1	6	0.02	0.03	0.01	0.01	ND	ND
OC-13	<0.1	4.7	0.01	0.02	0.01	0.02	0.17	0.04
OC-14	0.2	3.5	0.02	0.05	0.01	0.02	ND	ND
OC-15	<0.1	5	-0.02	0.03	0.00	0.01	ND	ND
OC-16	0.1	4.8	-0.01	0.04	0.00	0.01	ND	ND
OC-17	<0.1	4.9	0.01	0.05	0.00	0.01	ND	ND
OC-18	<0.1	5.6	0.00	0.06	0.02	0.05	ND	ND
OC-19	<0.1	4.2	0.01	0.06	0.06	0.08	ND	ND
OC-20	0.4	5.6	0.13	0.11	0.00	0.01	ND	ND
OC-21	0.2	4.9	0.03	0.06	0.03	0.03	0.06	0.03
OC-22	0.1	4.2	0.21	0.12	0.00	0.01	0.09	0.03
OC-23	<0.1	4.2	0.00	0.04	0.00	0.01	0.08	0.03
OC-24A	<0.1	4.3	0.00	0.07	0.04	0.06	0.25	0.05

Note: No sample contained americium-241 concentrations greater than the analytical detection limit (0.1 picocuries per gram [pCi/g]).
μg/g = micrograms per gram; ND = not detected.

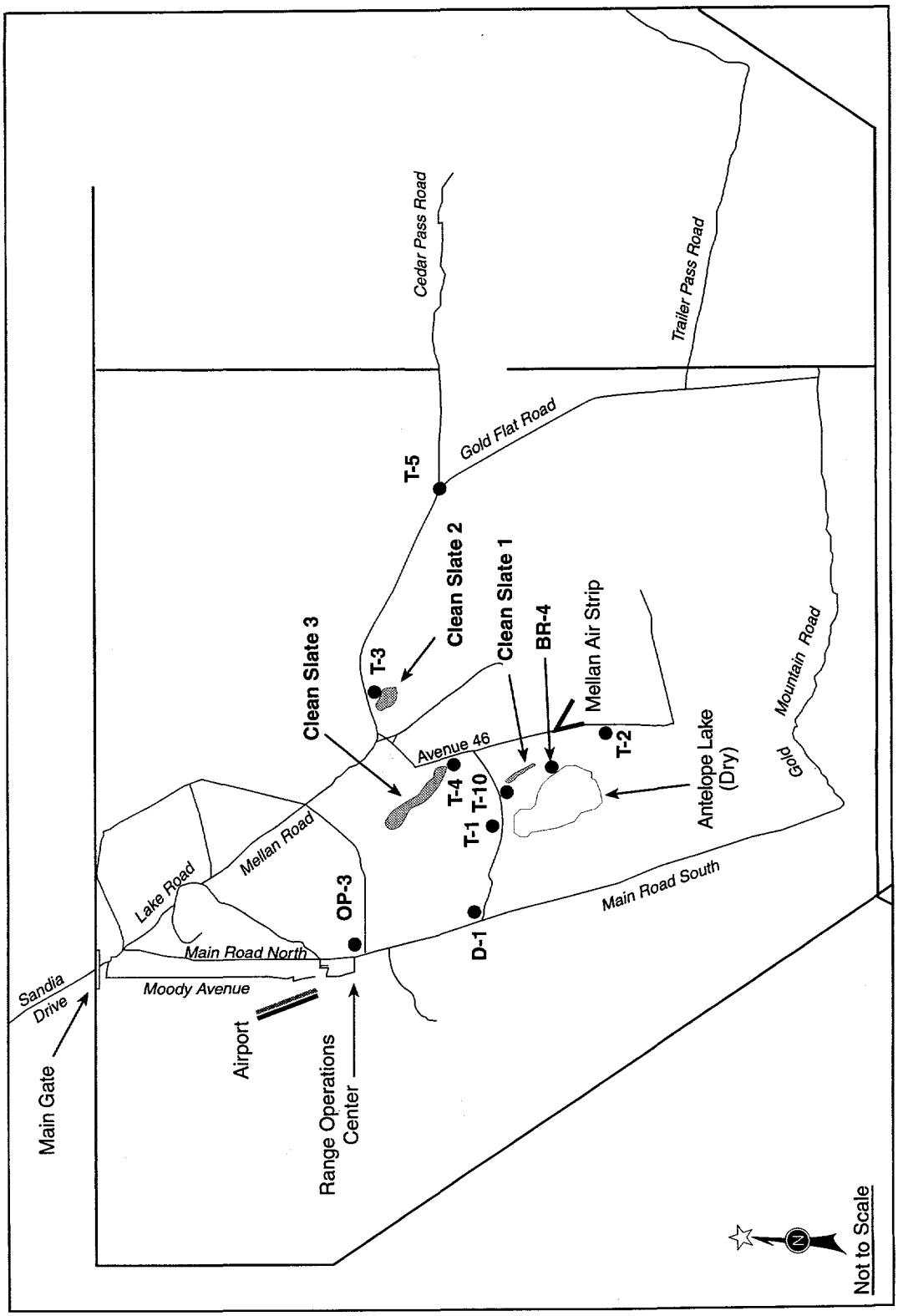

Figure B-14. Various On-Site Soil Sampling Locations

Table B-12. Radiological Results of Soil Sampling at Various On-Site Locations

Location	H_2O (%)	U_{tot} (μg/g)	Pu-238 (pCi/g)	Pu-238 (pCi/g) Error	Pu-239,240 (pCi/g)	Pu-239,240 (pCi/g) Error	Cs-137 (pCi/g)	Cs-137 (pCi/g) Error	Am-241 (pCi/g)	Am-241 (pCi/g) Error
BR-4	<0.1	3	0.02	0.06	0.00	0.05	0.12	0.04	ND	ND
D-1	<0.1	4	0.11	0.13	2.10	0.44	0.14	0.04	0.35	0.06
OP-3	0.2	6.2	0.00	0.06	0.00	0.05	0.19	0.04	ND	ND
T-1	<0.1	3.6	-0.01	0.04	-0.02	0.04	ND	ND	ND	ND
T-2	<0.1	3.7	0.01	0.03	0.06	0.07	0.47	0.06	ND	ND
T-3	<0.1	5.3	0.03	0.08	3.00	0.46	0.50	0.06	0.14	0.06
T-4	<0.1	3.6	0.02	0.06	0.12	0.11	0.66	0.08	ND	ND
T-5	<0.1	4.7	0.03	0.12	0.17	0.16	0.46	0.06	ND	ND
T-10	<0.1	3.8	0.00	0.05	0.00	0.05	0.41	0.06	ND	ND

Note: μg/g = micrograms per gram; pCi/g = picocuries per gram; ND = not detected.

Table B-13. Thermoluminescent Dosimeter Results for the Tonopah Test Range

Location	Description	Type*	First Period		Second Period		Third Period		Annual Exposure (mR/yr)
			Field Days	Exposure (mR)	Field Days	Exposure (mR)	Field Days	Exposure (mR)	
T-1	Antelope Lake/Target Area	S	98	None Reported	105	5.5 ± 1.8	175	None Reported	NA
T-2	Mellan Airstrip	S	98	23.8 ± 2.8	105	35.1 ± 1.4	175	73.7 ± 4.5	133 ± 8.7
T-3	Clean Slate 2	S	98	25.0 ± 2.3	105	39.7 ± 2.7	175	74.3 ± 6.4	139 ± 11.4
T-4	Clean Slate 3, 2.3 mi south on Gaven Rd. (Ave. 46)	S	98	24.9 ± 4.0	105	35.1 ± 2.7	175	71.2 ± 8.8	131 ± 15.5
T-5	Gate 1	S	98	22.6 ± 4.4	105	35.0 ± 3.6	175	72.5 ± 9.5	130 ± 17.5
T-6	Cedar Gate	P	98	None Reported	105	5.7 ± 1.5	175	None Reported	NA
T-7	On-Site Housing	S	98	17.0 ± 3.2	105	32.2 ± 3.6	175	65.5 ± 1.0	115 ± 7.8
T-8	Main Gate	P	98	19.8 ± 2.1	105	29.6 ± 4.7	175	62.5 ± 14.6	112 ± 21.4
T-9	Project Roller Coaster Decontamination Area	S	98	15.4 ± 3.6	105	33.7 ± 2.3	175	61.7 ± 8.9	111 ± 14.8

*S = on-site; P = perimeter; C = community (off-site).
Note: mR = milliroentgen; mR/yr = milliroentgen per year; NA = not applicable due to less than three periods of data.

Table B-13. Thermoluminescent Dosimeter Results for the Tonopah Test Range (Continued)

Location	Description	Type*	First Period		Second Period		Third Period		Annual Exposure (mR/yr)
			Field Days	Exposure (mR)	Field Days	Exposure (mR)	Field Days	Exposure (mR)	
T-10	Intersection of Denton Freeway and Brownes Lake Rd.	S	98	24.1 ± 3.2	105	32.4 ± 5.3	175	67.0 ± 7.6	124 ± 16.1
T-11	Cactus Springs Gate	S	98	26.7 ± 3.0	105	42.9 ± 4.0	175	77.9 ± 3.6	148 ± 10.6
T-12	South Perimeter	P	98	20.0 ± 4.7	105	35.3 ± 3.1	175	70.5 ± 7.9	126 ± 15.7
T-13	Operations Center, northeast corner	P	98	None Reported	105	32.6 ± 3.8	175	108.1 ± 9.9	NA
T-14	Operations Center, southwest corner	S	98	18.4 ± 2.3	105	34.1 ± 2.0	175	66.2 ± 6.1	119 ± 10.4
T-15	Airport	S	98	22.2 ± 3.7	105	36.0 ± 6.4	175	66.2 ± 7.3	124 ± 17.4
T-16	Area 9	S	98	19.6 ± 3.7	105	35.0 ± 2.6	175	69.8 ± 7.3	124 ± 13.6
T-17	Hard Target	S	98	20.9 ± 5.0	105	33.5 ± 1.9	175	72.3 ± 3.7	127 ± 10.6
T-18	Town of Tonopah	C	98	15.6 ± 3.2	105	36.7 ± 3.0	175	59.9 ± 7.6	112 ± 13.8

*S = on-site; P = perimeter; C = community (off-site).
Note: mR = milliroentgen; mR/yr = milliroentgen per year; NA = not applicable due to less than three periods of data.

Table B-13. Thermoluminescent Dosimeter Results for the Tonopah Test Range (Concluded)

Location	Description	Type*	First Period		Second Period		Third Period		Annual Exposure (mR/yr)
			Field Days	Exposure (mR)	Field Days	Exposure (mR)	Field Days	Exposure (mR)	
T-19	Town of Goldfield	C	98	9.5 ± 3.2	105	27.9 ± 1.9	175	51.1 ± 4.2	89 ± 9.3
T-20	Roadside rest located on Hwy 95, west of the town of Tonopah	C	98	None Reported	105	33.3 ± 1.3	175	53.8 ± 11.8	NA
T-21	Roadside rest located on Hwy 6, east of the town of Tonopah	C	98	22.2 ± 4.7	105	37.4 ± 1.3	175	None Reported	NA
T-22	Intersection of TTR entrance and Hwy 6 Junction	C	98	18.0 ± 4.2	105	36.6 ± 3.8	175	68.7 ± 3.2	123 ± 11.2

*S = on-site; P = perimeter; C = community (off-site).
Note: mR = milliroentgen; mR/yr = milliroentgen per year; NA = not applicable due to less than three periods of data.

APPENDIX C

NONRADIOLOGICAL ANALYTICAL DATA

CONTENTS

TABLES

Table C-1. Concentrations (in μg/g) of Metals in Off-Site Soil Samples

Location	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
B-1	8,200	160	0.5	<0.5	17,000	11.0	4.4	16.0	10,000	12.0
B-2	8,400	140	0.5	<0.5	17,000	15.0	4.4	9.0	9,600	14.0
B-3A	9,500	160	0.7	<0.5	17,000	13.0	4.2	9.0	11,000	12.0
B-4	5,600	110	<0.5	<0.5	5,800	14.0	2.3	8.0	6,500	10.0
B-5	6,900	150	<0.5	<0.5	13,000	13.0	3.0	13.0	6,800	7.0
B-6	8,600	220	<0.5	<0.5	13,000	20.0	3.7	11.0	8,400	14.0
B-7	7,100	160	0.5	<0.5	5,200	15.0	2.9	10.0	8,900	32.0
B-8	7,100	160	<0.5	<0.5	3,400	16.0	2.9	6.0	8,300	14.0
B-9	10,000	150	0.7	<0.5	2,800	16.0	3.7	7.0	11,000	18.0
B-10	6,100	440	0.5	0.9	43,000	17.0	3.8	18.0	8,500	12.0
B-11	7,000	160	<0.5	<0.5	18,000	17.0	2.8	5.0	6,900	5.0
B-12	6,900	170	<0.5	<0.5	5,500	17.0	2.9	5.0	6,800	9.0
B-13	7,500	160	0.5	<0.5	3,200	14.0	2.2	4.0	6,200	6.0
B-14	5,600	120	<0.5	<0.5	2,200	16.0	1.7	4.0	5,400	6.0

Location	Magnesium	Manganese	Nickel	Potassium	Silica-ICP	Silver	Strontium	Titanium	Vanadium	Zinc
B-1	4,400	400	8	2,800	130	<0.5	83	350	19	42
B-2	3,900	420	6	2,700	120	<0.5	63	170	17	35
B-3A	4,500	800	6	4,100	110	<0.5	77	260	21	48
B-4	3,200	230	4	2,400	110	<0.5	41	200	13	32
B-5	3,400	290	4	2,500	130	<0.5	84	210	15	26
B-6	3,600	300	4	3,400	90	<0.5	130	300	18	29
B-7	2,800	380	6	3,200	140	<0.5	43	140	11	48
B-8	2,200	400	6	2,400	120	<0.5	40	350	15	31
B-9	3,400	260	5	3,100	130	<0.5	42	320	17	34
B-10	9,600	240	19	2,300	120	<0.5	100	160	33	60
B-11	3,300	270	<2	3,500	110	<0.5	200	300	18	19
B-12	2,400	440	5	3,000	160	<0.5	43	150	9.8	24
B-13	2,100	240	3	4,100	120	<0.5	77	160	11	21
B-14	1,800	140	3	2,600	200	<0.5	35	150	8.6	16

Note: μg/g = micrograms per gram; ICP = inductively coupled plasma (method).

Table C-2. Concentrations (in μg/g) of Metals in Perimeter Soil Samples

Location	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
T-6	7,700	130	0.5	0.5	7,100	27.0	4.2	5.0	8,100	8.0
T-8	4,200	93	<0.5	<0.5	1,800	17.0	1.3	4.0	4,600	<0.5
T-11	7,300	99	0.6	<0.5	3,400	24.0	5.0	16.0	12,000	17.0
T-12	6,800	140	0.5	<0.5	6,200	15.0	3.4	6.0	8,300	11.0
T-13	5,200	160	0.6	<0.5	1,700	21	3.2	6	12,000	17

Location	Magnesium	Manganese	Nickel	Potassium	Silica-ICP	Silver	Strontium	Titanium	Vanadium	Zinc
T-6	3,000	350	5	3,000	160	<0.54	8	160	14	28
T-8	1,300	120	3	2,200	160	<0.5	21	170	6.9	23
T-11	2,600	770	8	2,600	320	<0.5	32	160	21	63
T-12	3,000	450	4	3,100	280	<0.5	39	220	13	37
T-13	1,500	370	2	2,900	140	<0.5	45	70	8.5	43

Note: μg/g = micrograms per gram; ICP = inductively coupled plasma (method).

Table C-3. Concentrations (in μg/g) of Metals in Airport Area Soil Samples

Location	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
AP-1	9,000	110	0.5	<0.5	5,800	28.0	3.7	9.0	9,200	12.0
AP-2	14,000	140	0.9	<0.5	12,000	20.0	4.8	9.0	12,000	12.0
AP-3	9,000	120	0.6	0.5	4,800	20.0	3.3	6.0	9,100	11.0
AP-4	9,400	110	0.5	<0.5	5,600	16.0	3.4	6.0	9,200	10.0
AP-5	9,800	130	0.6	<0.5	4,400	19.0	3.9	5.0	8,900	11.0
AP-6	12,000	130	<0.5	0.6	5,400	21.0	4.4	6.0	11,000	11.0
AP-7	10,000	110	0.6	0.5	8,500	22.0	3.6	6.0	9,300	13.0

Location	Magnesium	Manganese	Nickel	Potassium	Silica-ICP	Silver	Strontium	Titanium	Vanadium	Zinc
AP-1	2,700	320	6	3,800	230	<0.5	48	330	18	48
AP-2	5,100	380	8	5,400	220	<0.5	70	490	20	52
AP-3	3,100	340	6	3,600	230	<0.5	44	420	17	29
AP-4	2,700	330	6	3,400	150	<0.5	48	320	17	120
AP-5	2,700	390	5	3,600	260	<0.5	45	360	17	30
AP-6	3,200	430	8	3,800	280	<0.5	50	480	21	34
AP-7	2,600	290	6	3,400	190	<0.5	54	390	19	44

Note: μg/g = micrograms per gram; ICP = inductively coupled plasma (method).

Table C-4. Concentrations (in μg/g) of Metals in Area 9 Soil Samples

Location	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
T-22	6,100	130	<0.5	<0.5	4,400	16.0	2.0	4.0	5,800	6.0
T-23	5,100	95	<0.5	<0.5	8,300	14.0	1.9	3.0	5,300	<5.0
T-24	4,600	110	<0.5	0.5	5,500	19.0	1.9	5.0	5,300	7.0
T-25	4,400	960	<0.5	0.9	6,000	17.0	4.3	5.0	5,000	460.0
T-26	5,300	240	0.5	1.0	11,000	18.0	2.6	4.0	5,500	91.0
T-27	3,600	88	<0.5	<0.5	8,100	10.0	1.6	4.0	4,200	<5.0
T-28	5,100	130	<0.5	<0.5	6,300	22.0	2.3	4.0	7,700	13.0
T-29	4,600	110	<0.5	<0.5	11,000	13.0	1.8	4.0	5,400	<5.0
T-30	4,700	100	<0.5	0.6	6,500	17.0	2.0	6.0	5,500	7.0
T-31	5,900	140	<0.5	<0.5	5,900	19.0	2.1	6.0	5,800	6.0
T-32	5,900	110	<0.5	<0.5	12,000	18.0	2.3	5.0	6,200	<5.0
T-33A	4,400	110	<0.5	<0.5	3,800	14.0	1.5	4.0	4,800	6.0

Location	Magnesium	Manganese	Nickel	Potassium	Silica-ICP	Silver	Strontium	Titanium	Vanadium	Zinc
T-22	2,100	160	2	2,700	100	<0.5	54	260	11	17
T-23	2,100	120	3	2,600	220	<0.5	86	210	9.7	16
T-24	2,100	180	3	2,600	180	<0.5	54	120	8.7	22
T-25	1,700	160	3	1,900	190	<0.5	45	160	8.4	1,400
T-26	2,200	190	4	2,500	200	<0.5	60	120	9.3	320
T-27	2,000	160	3	2,200	200	<0.5	72	100	7	16
T-28	2,000	180	3	2,500	230	<0.5	75	140	10	30
T-29	2,100	130	5	2,500	240	<0.5	76	140	7.9	40
T-30	2,000	150	3	2,400	230	<0.5	59	160	9.8	33
T-31	2,600	180	4	2,900	270	<0.5	61	160	8.2	20
T-32	2,700	170	4	2,900	220	<0.5	120	190	11	19
T-33A	2,000	150	2	2,300	190	<0.5	48	140	7.9	16

Note: μg/g = micrograms per gram; ICP = inductively coupled plasma (method).

Table C-5. Concentrations (in μg/g) of Metals in Hard Target/Depleted Uranium Area Soil Samples

Location	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
HT-1	6,600	160	<0.5	<0.5	9,800	18.0	2.4	6.0	6,600	13.0
HT-4	5,400	110	<0.5	<0.5	7,000	14.0	1.8	4.0	6,800	<0.5
HTSE-20	9,000	110	0.7	<0.5	16,000	19.0	3.2	9.0	7,600	31.0
T-20	12,000	180	0.5	<0.5	9,900	18.0	3.8	7.0	10,000	10.0
T-21	20,000	160	1.0	1.0	16,000	24.0	5.3	12.0	14,000	10.0

Location	Magnesium	Manganese	Nickel	Potassium	Silica-ICP	Silver	Strontium	Titanium	Vanadium	Zinc
HT-1	2,800	260	6	3,300	320	<0.5	73	190	11	30
HT-4	2,100	150	3	2,800	380	<0.5	94	180	12	34
HTSE-20	3,700	280	4	4,000	380	<0.5	110	180	11	31
T-20	4,400	290	6	4,500	230	<0.5	88	420	18	33
T-21	7,200	400	11	6,900	300	<0.5	130	550	22	52

Note: μg/g = micrograms per gram; ICP = inductively coupled plasma (method).

Table C-6. Concentrations (in μg/g) of Metals in On-Base Housing Area Soil Samples

Location	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
T-7A	4,200	130	<0.5	<0.5	9,500	9.4	1.5	4	5,100	<0.5
T-34	5,000	94	<0.5	<0.5	2,000	11.0	1.8	3.0	5,400	<5.0
T-35A	5,800	120	<0.5	<0.5	2,700	21.0	1.8	4.0	6,300	<5.0
T-36	3,700	79	<0.5	<0.5	1,600	12.0	1.4	3.0	4,400	<5.0
T-37	5,000	100	<0.5	<0.5	2,900	13.0	2.0	4.0	5,500	<5.0

Location	Magnesium	Manganese	Nickel	Potassium	Silica-ICP	Silver	Strontium	Titanium	Vanadium	Zinc
T-7A	1,700	140	2	2,300	350	<0.5	46	170	9.1	20
T-34	1,500	130	2	2,200	180	<0.5	25	190	8.4	20
T-35A	1,600	150	3	2,600	250	<0.5	30	220	11	18
T-36	1,200	120	3	1,800	250	<0.5	19	140	6.6	14
T-37	1,900	160	4	2,400	160	<0.5	27	100	8.4	20

Note: μg/g = micrograms per gram; ICP = inductively coupled plasma (method).

Table C-7. Concentrations (in μg/g) of Metals in South Plume Area Soil Samples

Location	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
T-14A	8,200	200	<0.5	<0.5	4,900	13.0	2.8	6.0	7,300	6.0
T-15	9,500	240	0.5	<0.5	6,400	11.0	3.4	6.0	8,300	8.0
T-16	8,900	240	<0.5	<0.5	4,900	12.0	3.6	6.0	11,000	8.0
T-17	7,700	220	<0.5	<0.5	4,800	13.0	3.3	6.0	8,000	8.0
T-18	6,300	220	<0.5	0.9	4,900	10.0	2.9	6.0	6,800	13.0
T-19	12,000	250	0.5	<0.5	9,800	16.0	4.6	10.0	10,000	10.0

Location	Magnesium	Manganese	Nickel	Potassium	Silica-ICP	Silver	Strontium	Titanium	Vanadium	Zinc
T-14A	3,100	320	5	3,400	190	<0.5	48	300	10	27
T-15	3,500	370	5	4,800	210	<0.5	81	380	14	27
T-16	3,200	380	5	4,600	150	<0.5	74	570	18	30
T-17	3,200	360	4	4,100	93	<0.5	63	350	13	25
T-18	3,000	470	4	3,500	110	<0.5	47	310	11	24
T-19	5,300	760	8	6,100	120	<0.5	68	350	13	37

Note: μg/g = micrograms per gram; ICP = inductively coupled plasma (method).

Table C-8. Concentrations (in μg/g) of Metals in the Project Roller Coaster Sewage Lagoon Soil Samples

Location	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
LF-1	8,000	260	0.5	<0.5	8,800	24.0	4.4	7.0	12,000	12.0
LF-2	10,000	260	0.8	<0.5	20,000	16.0	4.2	7.0	14,000	9.0
LF-3	12,000	250	0.8	<0.5	28,000	18.0	4.5	8.0	15,000	10.0
LF-4	9,600	270	0.6	<0.5	18,000	23.0	4.4	8.0	13,000	8.0

Location	Magnesium	Manganese	Nickel	Potassium	Silica-ICP	Silver	Strontium	Titanium	Vanadium	Zinc
LF-1	3,600	350	4	2,800	150	<0.5	94	130	15	33
LF-2	4,400	250	3	3,300	250	<0.5	120	100	16	36
LF-3	4,400	220	5	3,800	210	<0.5	160	130	20	36
LF-4	5,000	350	5	4,300	240	<0.5	110	130	15	300

Note: μg/g = micrograms per gram; ICP = inductively coupled plasma (method).

Table C-9. Concentrations (in μg/g) of Metals in Mellan Hill Area Soil Samples

Location	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
MH-1	10,000	120	0.6	<0.5	22,000	20.0	2.8	7.0	8,600	6.0
MH-2	5,300	74	<0.5	<0.5	2,100	14.0	1.5	4.0	5,200	6.0
MH-3	8,100	110	<0.5	<0.5	7,100	28.0	2.4	6.0	8,700	12.0
MH-4	6,900	120	<0.5	<0.5	3,100	19.0	2.7	5.0	7,500	9.0

Location	Magnesium	Manganese	Nickel	Potassium	Silica-ICP	Silver	Strontium	Titanium	Vanadium	Zinc
MH-1	3,900	260	4	3,500	96	<0.5	67	260	11	28
MH-2	1,400	180	2	2,200	45	<0.5	24	140	6.6	17
MH-3	3,100	250	3	3,400	70	<0.5	51	250	12	29
MH-4	2,500	430	4	2,900	89	<0.5	30	250	10	25

Note: μg/g = micrograms per gram; ICP = inductively coupled plasma (method).

Table C-10. Concentrations (in μg/g) of Metals in the 554th Range Squadron O&M Complex Area Soil Samples

Location	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
OM-1	5,900	69	0.5	<0.5	1,800	24.0	1.1	4.0	5,000	5.0
OM-2	7,200	90	0.6	<0.5	2,300	18.0	2.5	5.0	6,100	8.0
OM-3	7,400	110	<0.5	<0.5	2,800	16.0	2.3	6.0	7,300	6.0

Location	Magnesium	Manganese	Nickel	Potassium	Silica-ICP	Silver	Strontium	Titanium	Vanadium	Zinc
OM-1	1,400	190	2	2,600	160	<0.5	21	100	6.7	18
OM-2	2,100	260	2	2,900	160	<0.5	25	130	8.3	22
OM-3	2,700	360	3	2,700	200	<0.5	28	220	11	26

Note: μg/g = micrograms per gram; ICP = inductively coupled plasma (method).

Table C-11. Concentrations (in μg/g) of Metals in the Range Operations Center and Compound Soil Samples

Location	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
OC-1	6,200	110	0.6	<0.5	8,000	15.0	2.6	5.0	6,600	6.0
OC-2	12,000	160	0.8	<0.5	13,000	16.0	4.3	11.0	11,000	14.0
OC-3	10,000	120	0.6	<0.5	9,800	18.0	3.8	9.0	9,900	13.0
OC-4	5,400	170	<0.5	<0.5	9,000	13.0	3.4	6.0	7,000	7.0
OC-5	4,200	110	<0.5	<0.5	6,600	14.0	2.4	10.0	5,900	8.0
OC-6	3,700	93	<0.5	<0.5	4,700	14.0	1.9	4.0	5,500	7.0
OC-7	6,500	94	<0.5	<0.5	5,700	21.0	2.5	6.0	8,600	6.0
OC-8	5,100	98	<0.5	<0.5	6,900	16.0	2.1	5.0	7,200	8.0
OC-9	7,300	130	<0.5	0.6	14,000	17.0	3.0	7.0	9,900	8.0
OC-10	7,800	130	<0.5	<0.5	19,000	19.0	3.2	7.0	9,700	11.0
OC-11	4,600	95	<0.5	<0.5	11,000	11.0	2.5	5.0	6,200	7.0
OC-12	7,600	150	<0.5	<0.5	19,000	13.0	3.0	6.0	7,500	<5.0
OC-13	7,000	150	<0.5	<0.5	14,000	12.0	2.8	6.0	7,800	8.0
OC-14	6,400	170	<0.5	<0.5	12,000	18.0	2.7	6.0	7,100	8.0
OC-15	6,100	90	0.6	<0.5	8,300	20.0	2.6	4.0	6,600	10.0
OC-16	4,300	110	<0.5	<0.5	7,300	13.0	2.4	7.0	5,900	16.0
OC-17	4,900	100	0.5	<0.5	10,000	16.0	2.6	5.0	6,000	9.0
OC-18	6,000	130	0.6	<0.5	8,100	19.0	3.0	4.0	6,600	13.0
OC-19	5,400	82	<0.5	4.4	5,700	24.0	2.7	6.0	7,300	17.0
OC-20	8,500	120	0.7	<0.5	16,000	14.0	3.0	6.0	8,000	<5.0
OC-21	4,600	95	<0.5	<0.5	6,000	17.0	2.8	5.0	6,500	5.0
OC-22	6,200	89	<0.5	<0.5	5,800	19.0	3.2	6.0	8,100	20.0
OC-23	6,100	110	<0.5	<0.5	4,800	22.0	4.1	7.0	7,500	8.0
OC-24A	5,800	120	<0.5	<0.5	13,000	21.0	3.0	6.0	6,900	7.0

Note: μg/g = micrograms per gram.

Table C-11. Concentrations (in μg/g) of Metals in the Range Operations Center and Compound Soil Samples (Concluded)

Location	Magnesium	Manganese	Nickel	Potassium	Silica-ICP	Silver	Strontium	Titanium	Vanadium	Zinc
OC-1	2,400	270	5	2,600	200	<0.5	56	220	13	23
OC-2	4,900	350	8	4,500	400	<0.5	87	350	20	56
OC-3	3,800	330	6	4,400	310	<0.5	61	310	18	39
OC-4	2,700	310	4	2,400	360	<0.5	57	280	15	22
OC-5	2,100	230	3	2,400	68	<0.5	39	260	10	31
OC-6	1,500	160	<2	2,100	65	<0.5	35	200	8.8	21
OC-7	2,000	180	3	2,600	70	<0.5	45	350	19	27
OC-8	2,000	200	<2	2,600	81	<0.5	40	290	15	38
OC-9	2,700	270	2	2,800	80	<0.5	67	320	21	34
OC-10	2,600	220	4	2,500	80	<0.5	110	340	24	61
OC-11	1,900	230	<2	2,200	73	<0.5	57	160	11	49
OC-12	2,800	200	4	2,400	100	<0.5	110	210	17	26
OC-13	2,600	210	5	2,800	81	<0.5	110	260	21	43
OC-14	2,000	180	4	2,000	280	<0.5	110	140	35	27
OC-15	2,100	240	<2	2,600	240	<0.5	56	110	10	53
OC-16	1,700	210	2	2,000	190	<0.5	57	56	9.5	28
OC-17	1,900	200	<2	2,200	220	<0.5	59	110	10	39
OC-18	2,000	220	<2	2,400	220	<0.5	57	92	11	130
OC-19	1,700	230	4	2,400	180	<0.5	44	160	12	180
OC-20	2,700	200	2	2,700	270	<0.5	88	160	16	54
OC-21	2,000	270	<2	2,500	220	<0.5	40	160	9.6	22
OC-22	2,400	270	2	2,800	240	<0.5	38	210	13	52
OC-23	2,700	350	5	2,900	390	<0.5	36	360	11	260
OC-24A	2,800	250	3	3,500	190	<0.5	54	210	12	24

Note: μg/g = micrograms per gram; ICP = inductively coupled plasma (method).

Table C-12. Concentrations (in μg/g) of Metals in Soil Samples from Various On-Site Locations

Location	Aluminum	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
BR-4	5,700	280	<0.5	<0.5	4,500	19	2.4	6	7,300	7
D-1	9,800	140	0.6	<0.5	5,100	17	5.9	8	13,000	10
OP-3	5,300	130	<0.5	<0.5	13,000	24	2.2	6	6,700	28
T-1	12,000	190	0.6	<0.5	23,000	14	5.9	8	13,000	7
T-2	7,000	110	0.5	<0.5	2,400	12	2.7	8	6,900	9
T-3	6,800	110	<0.5	<0.5	2,300	18	2.7	7	6,700	7
T-4	6,200	120	0.5	<0.5	2,800	14	2.5	5	7,200	7
T-5	7,500	97	0.5	<0.5	2,600	20	4.9	6	6,700	9
T-10	5,900	120	<0.5	<0.5	3,800	17	2.5	14	6,800	7

Location	Magnesium	Manganese	Nickel	Potassium	Silica-ICP	Silver	Strontium	Titanium	Vanadium	Zinc
BR-4	2,200	250	4	2,700	300	<0.5	41	210	12	22
D-1	4,700	370	5	4,000	210	<0.5	55	160	18	37
OP-3	2,100	180	3	2,300	170	<0.5	81	110	11	33
T-1	6,300	400	7	3,600	330	<0.5	160	190	22	41
T-2	2,300	250	6	2,900	410	<0.5	33	200	11	23
T-3	2,100	350	3	2,300	160	<0.5	34	180	10	24
T-4	2,400	420	3	2,400	270	<0.5	29	260	11	25
T-5	2,500	330	5	3,200	160	<0.5	31	190	9.8	23
T-10	2,500	380	5	2,900	380	<0.5	33	220	10	24

Note: μg/g = micrograms per gram; ICP = inductively coupled plasma (method).

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Albuquerque City Environmental
Services (1)
400 Marquette Ave. NW
Albuquerque, NM 87117

Captain Robert C. Viramontes (1)
2000 Wyoming Blvd.
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KAFB, NM 87117-5606

Director (1)
Inhalation Toxicology Research Institute
P.O. Box 5800
Albuquerque, NM 87185

Environmental Protection Agency (EPA) (1)
Headquarters Office
401 M Street, SW
Washington, DC 20460

Environmental Protection Agency (EPA) (1)
Region IX Office
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