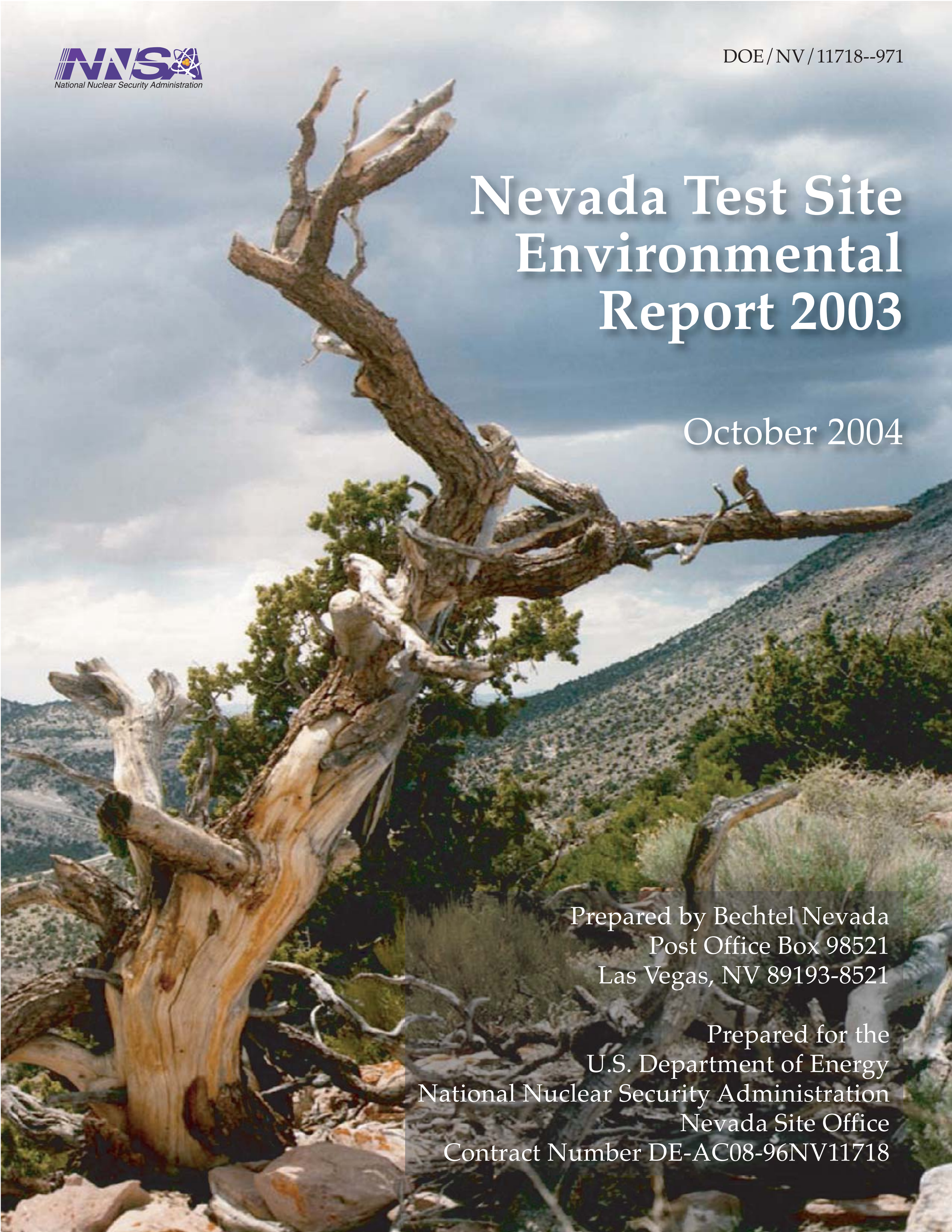

DOE/NV/11718--971

Nevada Test Site Environmental Report 2003

October 2004

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Prepared for the
U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office
Contract Number DE-AC08-96NV11718

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DOE/NV/11718--971

Nevada Test Site
Environmental Report 2003

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October 2004

Work Performed Under
Contract No. DE-AC08-96NV11718

Prepared for:
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Preface

In 2003, the Annual Site Environmental Report for the Nevada Test Site (NTS) was reformatted to improve readability, reduce redundancy, satisfy U.S. Department of Energy (DOE) Headquarters guidance on style and content, and better consolidate compliance status information. It was also renamed the *Nevada Test Site Environmental Report 2003* (NTSER). Noticeably absent this year is an Introduction section which formerly included a description of the NTS and its environment, the NTS mission, and history of the site. The environmental description of the site was expanded to include climatology and cultural resources and was placed in a stand-alone appendix. A description of NTS missions and its history were placed in the Executive Summary. There are five major portions or divisions of the NTSER. The summary below is provided so the reader can see the overall organization and content of the report.

Summary of Sections

Executive Summary – This portion of the report is meant to provide the reader with: (1) the purpose of the NTSER, (2) the current mission and history of the NTS, (3) a description of possible radiological dose pathways to the public, (4) a description of any radiological releases, (5) the estimated radiological dose to the public resulting from site operations, (6) a description of any non-radiological releases from the site, (7) a summary of any environmental incidents of noncompliance that occurred during the year and actions taken in response to them, (8) a description of the management system used to ensure that work is conducted in compliance with environmental and public health protection, and (9) a summary of any significant environmental program or effort.

Compliance Summary – The purpose of this portion (Section 1.0) of the NTSER is to: (1) present those federal, state, and local environmental regulations which govern how operations are conducted on the NTS in order to ensure that the environment and the public are protected; (2) present in tabular form a concise summary of how NTS operations complied with these regulations during the year; and (3) direct the reader to subsequent sections of this NTSER where environmental activities and programs are described in more detail. This section is divided into multiple subsections based on the type of regulations presented (e.g., water quality regulations are presented in a separate subsection from historic preservation regulations). There are a total of 12 sections within the Compliance Summary (Sections 1.1 – 1.12), the last section being a list of all active environmental permits.

Environmental Monitoring and Compliance Activities – This portion constitutes the main body of the NTSER. It is divided into multiple sections (Sections 2.0 – 12.0) which present the reporting year's environmental compliance activities related to monitoring and protecting the public, air, water, biota, cultural resources, and sensitive species and ecosystems on the NTS. These are the sections of the NTSER which are specifically referenced in the Compliance Summary, Section 1.0 and which support the compliance determinations presented in summary tabular form in Section 1.0. They include:

- ***Radiological and Non-Radiological Air Monitoring*** – presents the methods and results of monitoring radioactive air emissions and non-radioactive air emissions (e.g., other air pollutants) on the NTS which are a result of past and present NTS operations.
- ***Radiological and Non-Radiological Water Monitoring*** – presents the methods and results of monitoring radionuclides in surface water and groundwater both on and off the NTS and of monitoring the water quality of drinking water and waste water systems on the NTS.

- ***Direct Radiation Monitoring*** – presents the methods and results of monitoring direct radiation at selected areas on the NTS which may expose the public or non-radiological workers on the NTS to external doses of radiation that are a result of NTS operations.
- ***Oversight Radiological Monitoring of Air and Water*** – presents the methods and results of monitoring radioactive air emissions and radionuclides in surface, groundwater, and private and municipal water supplies within communities surrounding the NTS. This monitoring is conducted by the Community Environmental Monitoring Program (CEMP) operated by the Desert Research Institute (DRI) of the University and Community College System of Nevada.
- ***Biota Monitoring*** – presents the methods and results of monitoring radionuclide concentrations in tissues of NTS game animals and in vegetation for the purpose of estimating radiological dose to NTS biota and for estimating dose to humans from the consumption of NTS game animals.
- ***Radiation Dose Assessment*** – presents the methods and results of calculating the annual 2003 radiological dose to the public within an 80 km (50 mi) radius of the NTS which is a result of exposure from all pathways including air, water, and the consumption of NTS game animals. Also presents the methods and results of assessing radiological dose to NTS terrestrial and aquatic biota resulting from NTS operations.
- ***Waste Management and Environmental Restoration*** – presents a description of NTS operations related to the management of low level radioactive waste, mixed waste, transuranic waste, and hazardous waste; the annual status of these operations; and vadose zone monitoring at the Radioactive Waste Management Complex. It also presents the annual clean-up, safe closure, and post-closure monitoring activities at historic sites on and off the NTS contaminated by nuclear and non-nuclear DOE, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) operations.
- ***Hazardous Materials Control and Management*** – presents the actions taken to safely manage and use regulated hazardous/toxic materials on the NTS.
- ***Pollution Prevention*** – presents a description of activities pursued during the year to meet federal pollution prevention goals in the arena of waste volume and toxicity reduction.
- ***Historic Preservation*** – presents the methods and results of field surveys, inventories, historical evaluations, and consultations between NNSA/NSO and NTS-affiliated American Indian tribes for the purpose of managing cultural resources on the NTS according to federal and state regulations.
- ***Ecological Monitoring*** – presents the methods and results of field monitoring and compliance activities related to protecting federal and state-protected species, monitoring sensitive species and habitats, ecosystem mapping, restoration of disturbed habitat, and evaluating and monitoring impacts of NTS operations on biota and the environment.

Supportive Environmental Programs and Activities – This portion of the NTSER presents descriptions of other programs or activities which support environmental regulatory compliance by providing either: (1) theoretical or empirical data necessary to design effective monitoring networks and to properly interpret monitoring data, (2) an administrative framework by which environmental protection is integrated into routine NTS operations, or (3) quality assurance support for all sample collection and analytical analyses. Sections 13.0 – 18.0 are included in this portion of the NTSER and include the following:

- **Underground Test Area Project**
- **Hydrologic Resources Management Program**
- **Meteorological Monitoring**
- **Environmental Management System**
- **Compliance Quality Assurance Program**
- **Oversight Quality Assurance Program**

Appendices – This portion of the NTSER includes four appendices:

- **Appendix A: NTS Description** – provides descriptive information about the setting and environment of the NTS. Considerable emphasis is given to the geohydrology of the NTS because if its importance in understanding the complexities of modeling and monitoring the impacts of past underground nuclear testing on groundwater resources.
- **Appendix B: Nevada Test Site Satellite Facilities** – describes environmental compliance activities conducted during the year at the North Las Vegas Facility (NLVF), the Cheyenne Facility in Las Vegas, and the Remote Sensing Laboratory (RSL) at Nellis Air Force Base.
- **Appendix C: Helpful Information** – includes tables of radiological measurement units, radiological nomenclature, and explanations of several data reporting concepts such as measurement uncertainty and negative concentration values encountered in the body of the report.
- **Appendix D: Glossary** – provides a list of technical terms used in this document which may be unfamiliar to the general public.
- **Appendix E: Acronyms and Abbreviations**

Report Distribution

This report is physically distributed in both hard-copy format as a bound document and in electronic format as a compact disk-read only memory (CD-ROM). The electronic format is also accessible on the Internet at <http://www.osti.gov/bridge>.

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Acknowledgements

Environmental Technical Services (ETS) of Bechtel Nevada (BN) is responsible for production of this document. Environmental monitoring and compliance data were gathered through the combined efforts of several BN organizations in addition to ETS: Ecological Compliance, Waste Management, Waste Operations, Environmental Restoration, Ecological Services, Health Physics, Procurement, and Program Integration. The Water Resources and Cultural Resources divisions of the Desert Research Institute (DRI) contributed data for offsite water and air monitoring and cultural resource protection. Thanks go to the numerous authors and contributors from these organizations that are listed below. Bob Arnold of BN Technical Publications and Graphics Services composed the layout of the front cover and section dividers in the document. DOE NNSA/NSO and W. Kent Ostler of BN Ecological Services provided the images used in the section dividers. Elaine Upson, Angela McCurdy and Barrett Shaw of BN Technical Publications and Graphics Services provided technical editing support. Tom Fitzmaurice of BN Environmental Restoration provided graphic arts support. Don Van Etten and Bruce Hurley are acknowledged for their encouragement and support throughout the major reformatting efforts involved in producing this report.

A very special "thank you" is due to three individuals whose dedication and commitment to this project were greatly appreciated. They are Angela McCurdy, technical editor responsible for formatting this document many times over; Ashley Cushman, specialist in Geographic Information Systems (GIS) who produced, also many times over, the GIS-generated maps and figures; and Dennis Hansen, senior scientist, who provided assistance at the eleventh-hour for technical review, editing, and compilation of the document.

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Appendix B: NTS Satellite Facilities

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Appendix C: Helpful Information

Modified from Hanford Site 1997 Environmental Report

Appendix D: Glossary

Modified from Lawrence Livermore National Laboratory 2003 Environmental Report

Appendix E: Acronyms and Abbreviations

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Beavertail pricklypear,
Opuntia basilaris var. basilaris,
April 2004

Executive Summary

The *Nevada Test Site Environmental Report 2003* was prepared by Bechtel Nevada (BN) to meet the requirements and guidelines of the U.S. Department of Energy (DOE) and the information needs of the public. This report is meant to be useful to members of the public, public officials, regulators, and Nevada Test Site (NTS) contractors. The Executive Summary strives to present in a concise format the purpose of the document, the NTS mission and major programs, a summary of radiological releases and doses to the public resulting from site operations, a summary of non-radiological releases, and an overview of the NTS Environmental Management System. The Executive Summary, combined with the following Compliance Summary, are written to meet all the objectives of the report and to be stand-alone sections for those who choose not to read the entire document.

Objectives of the NTS Environmental Report

BN prepares this document to satisfy DOE Order 231.1A, "Environment, Safety and Health Reporting". The objectives of this report are to:

- Report compliance status with environmental standards and requirements
- Present results of environmental monitoring of radiological and nonradiological effluents
- Report estimated radiological doses to the public from releases of radioactive material
- Summarize environmental incidents of noncompliance reported during the year and actions taken in response to them
- Describe the NTS Environmental Management System and characterize its performance
- Highlight significant environmental programs and efforts

NTS Mission and History

The U.S. Department of Energy, National Nuclear Security Administration's Nevada Site Office (NNSA/NSO) directs the management and operation of the NTS and auxiliary sites across the nation. The NTS is located about 105 kilometers (65 miles) northwest of Las Vegas. The 3,496 square kilometer (1,350 square mile) site is one of the largest secured areas in the United States. It is surrounded by federal installations with strictly controlled access and by public lands that are open to public entry. Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratories are the principal organizations that sponsor and implement the nuclear weapons programs at the NTS. BN is the Management and Operations (M&O) contractor who is accountable for the successful execution of work and ensuring that work is performed in compliance with environmental regulations. The NTS and its seven auxiliary sites (North Las Vegas Facility, Cheyenne Facility, Remote Sensing Laboratory – Nellis, Remote Sensing Laboratory – Andrews, Livermore Operations, Los Alamos Operations, and Special Technologies Laboratory) all provide support to enhance the NTS as a site for weapons experimentation and nuclear test readiness. The three major NTS programs include: (1) Stockpile Stewardship, (2) National Security Response Program and Operations, and (3) Environmental Management. During the conduct of all programs, the NNSA/NSO complies with applicable environmental and public health protection regulations and strives to manage the land and facilities at the NTS as a unique and valuable national resource.

The history of the NTS, as well as its current missions, directs the focus and design of the environmental monitoring and surveillance activities on and near the site. Between 1940 and 1950, the area now known as the NTS was under the jurisdiction of Nellis Air Force Base and was part of the Nellis Bombing and Gunnery Range. The NTS was established in 1951 to be the primary location for testing the nation's nuclear explosive devices and supported nuclear testing from 1951 to 1992. The NTS currently conducts only subcritical nuclear experiments.

Tests conducted through the 1950s were predominantly atmospheric tests. These tests involved a nuclear explosive device detonated while on the ground surface, on a steel tower, suspended from tethered balloons, dropped from an aircraft, or placed on a rocket. Several tests were categorized as "safety experiments", and "storage-transportation tests", involving the destruction of a nuclear device with non-nuclear explosives. Some of these tests resulted in dispersion of plutonium in the test vicinity. One of these test areas lies just north of the NTS boundary at the south end of the Nevada Test and Training Range (NTTR) (formerly known as Nellis Air Force Range), and four others involving transport/storage safety, are at the north end of the NTTR. All nuclear device tests are listed in United States Nuclear Tests, July 1945 through September 1992 (DOE, 2000).

The first underground test, a cratering test, was conducted in 1951. The first totally-contained underground test was in 1957. Testing was discontinued during a moratorium that began October 31, 1958, but was resumed in September 1961 after tests by the Union of Soviet Socialist Republics began. Since late 1962, nearly all tests have been conducted in sealed vertical shafts drilled into Yucca Flat and Pahute Mesa or in horizontal tunnels mined into Rainier Mesa. From 1951 to 1992, a total of 828 underground nuclear tests were conducted at the NTS. Approximately one third of these tests were detonated near or below the water table and has resulted in the contamination of groundwater in some areas. In 1996, the DOE, U.S. Department of Defense (DoD), and the state of Nevada entered into a Federal Facilities Agreement and Consent Order (FFACO) which established Corrective Action Units (CAUs) on the NTS that delineated and defined areas of concern for groundwater contamination.

Five earth-cratering (shallow-burial) tests were conducted over the period of 1962 through 1968 as part of the Plowshare Program that explored peaceful uses of nuclear explosives. The first and largest Plowshare crater test, Sedan (PHS, 1963) was detonated at the northern end of Yucca Flat on the NTS. The second largest crater test was Schooner, located in the northwest corner of the NTS. From these tests, mixed fission products, tritium, and plutonium were entrained in the soil ejected from the craters and deposited on the ground surrounding the craters.

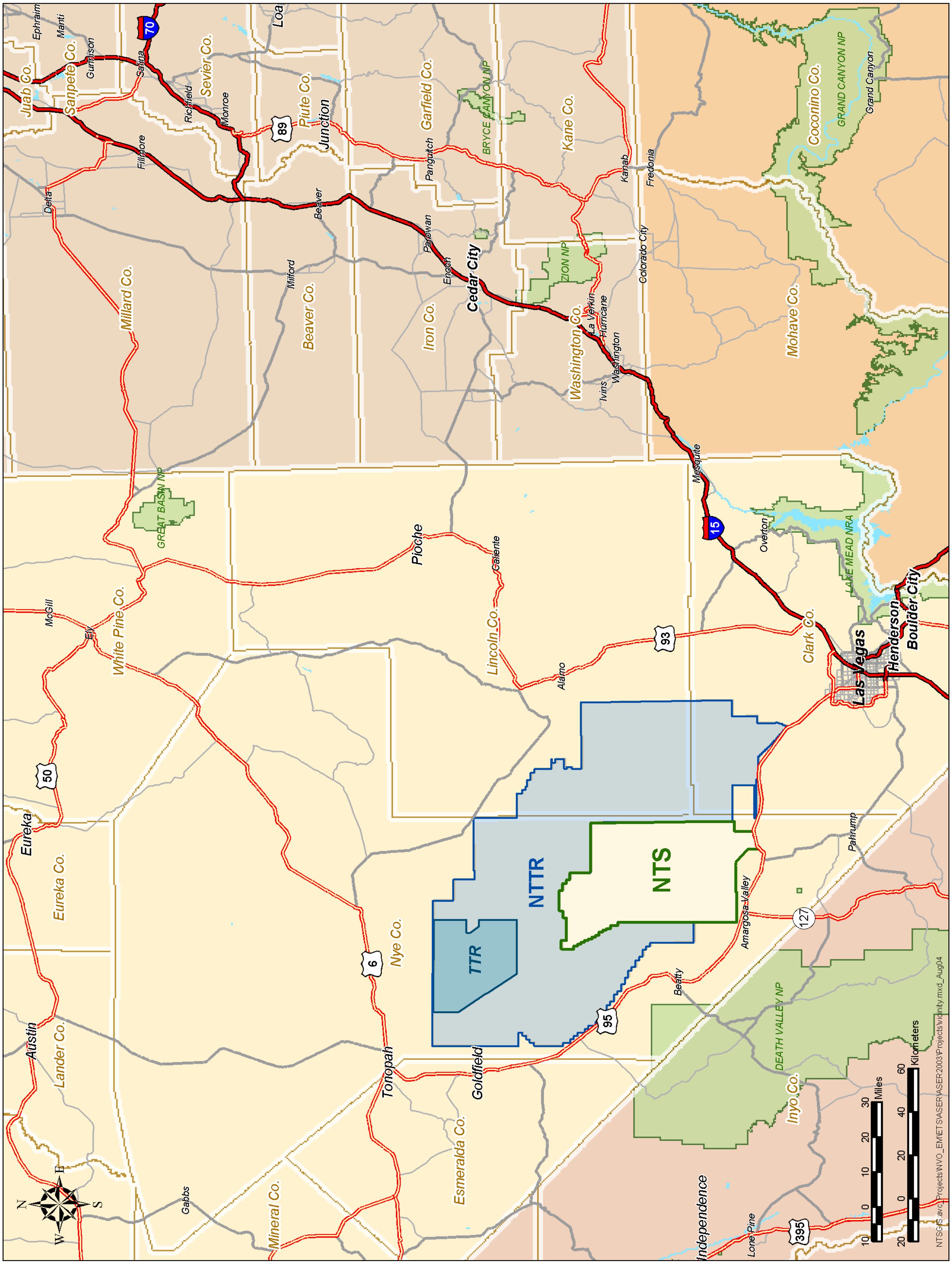
Other nuclear-related tests and experiments at the NTS have included the Bare Reactor Experiment - Nevada series in the 1960s. These tests were performed with a 14-MeV neutron generator mounted on a 465-meter (1,530-feet) steel tower used to conduct neutron and gamma-ray interaction studies on various materials. From 1959 through 1973, a series of open-air nuclear reactor, nuclear engine, and nuclear furnace tests were conducted in Area 25, and a series of tests with a nuclear ramjet engine were conducted in Area 26. Mostly gaseous radioactivity (radio-iodines, radio-

NTS Programs and Missions

Stockpile Stewardship – The primary mission of this program is to conduct high-hazard operations in support of defense-related nuclear and national security experiments and to maintain the capabilities to resume underground nuclear weapons testing, if directed.

National Security Response Program and Operations – The goal of this program is to provide support facilities, training facilities, and capabilities for government agencies involved in counterterrorism activities, emergency response, first responders, national security technology development, and nonproliferation technology development.

Environmental Management – This program includes Waste Management and Environmental Restoration. The goals of this programs are to manage and safely dispose of low-level waste received from DOE and DoD-approved facilities throughout the United States and mixed low-level waste generated in Nevada by DOE Nevada Site Office operations, safely manage and characterize for offsite disposal hazardous and transuranic wastes, characterize and remediate the environmental legacy of nuclear weapons and other testing at the NTS and at offsite locations, and develop and deploy technologies that enhance environmental restoration.



The NTS and Vicinity

xenons, radio-kryptons) and some fuel particles were released due to erosion of the metal cladding on the reactor fuel resulting in negligible deposition on the ground.

NTS activities in 2003 continue to be diverse, with the primary role being to help ensure that the existing United States stockpile of nuclear weapons remains safe and reliable. Facilities that support this mission include the U1a Facility, Big Explosives Experimental Facility (BEEF), the Device Assembly Facility (DAF), and Joint Actinide Shock Physics Experimental Research (JASPER) Facility. Other NTS activities include demilitarization activities; controlled spills of hazardous material at the Hazardous Materials Spill Center (HSC); remediation of industrial sites; processing of waste destined for the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico; disposal of radioactive and mixed waste; and environmental research. In addition, there are continued efforts to bring other business to the NTS, like aerospace and alternative energy technologies and support of U.S. Department of Homeland Security National Center for Combating Terrorism work.

Pathways by Which the Public can be Exposed to NTS Radiation

Man-made radiation from NTS operations has the potential to reach the public. Such radiation includes radioactive elements called radionuclides which emit alpha, beta, or gamma radiation, or a combination of these types of radiation. A *pathway* outlines the route which radionuclide contaminants may follow to reach the general public. They may enter the local environment by air or water and reach humans through inhalation of particulates or water vapor, absorption through the skin, or through ingestion of water (i.e., drinking water). Radiolonuclides released into the air or water can also pass through the soil, plants, or wildlife and reach humans through ingestion of crops and game animals, or through direct external exposure. The primary pathways of radiation exposure to the public in the dry desert environment around the NTS include: (1) air and wind transport via resuspension of surface contamination from legacy sites (historic sites), (2) movement through groundwater from sites of underground nuclear tests or buried waste, and (3) ingestion of contaminated game animals. The NNSA/NSO environmental monitoring programs conducted on and near the NTS are designed to focus on these three primary exposure pathways.

2003 Offsite Radiological Air Emissions

An important component of the NTS monitoring program when demonstrating compliance with radiological air emission and water quality standards off the NTS (offsite), is an oversight monitoring program run by an organization independent of the M&O contractor. This oversight monitoring is performed under the Community Environmental Monitoring Program (CEMP)

Forms of Radiation

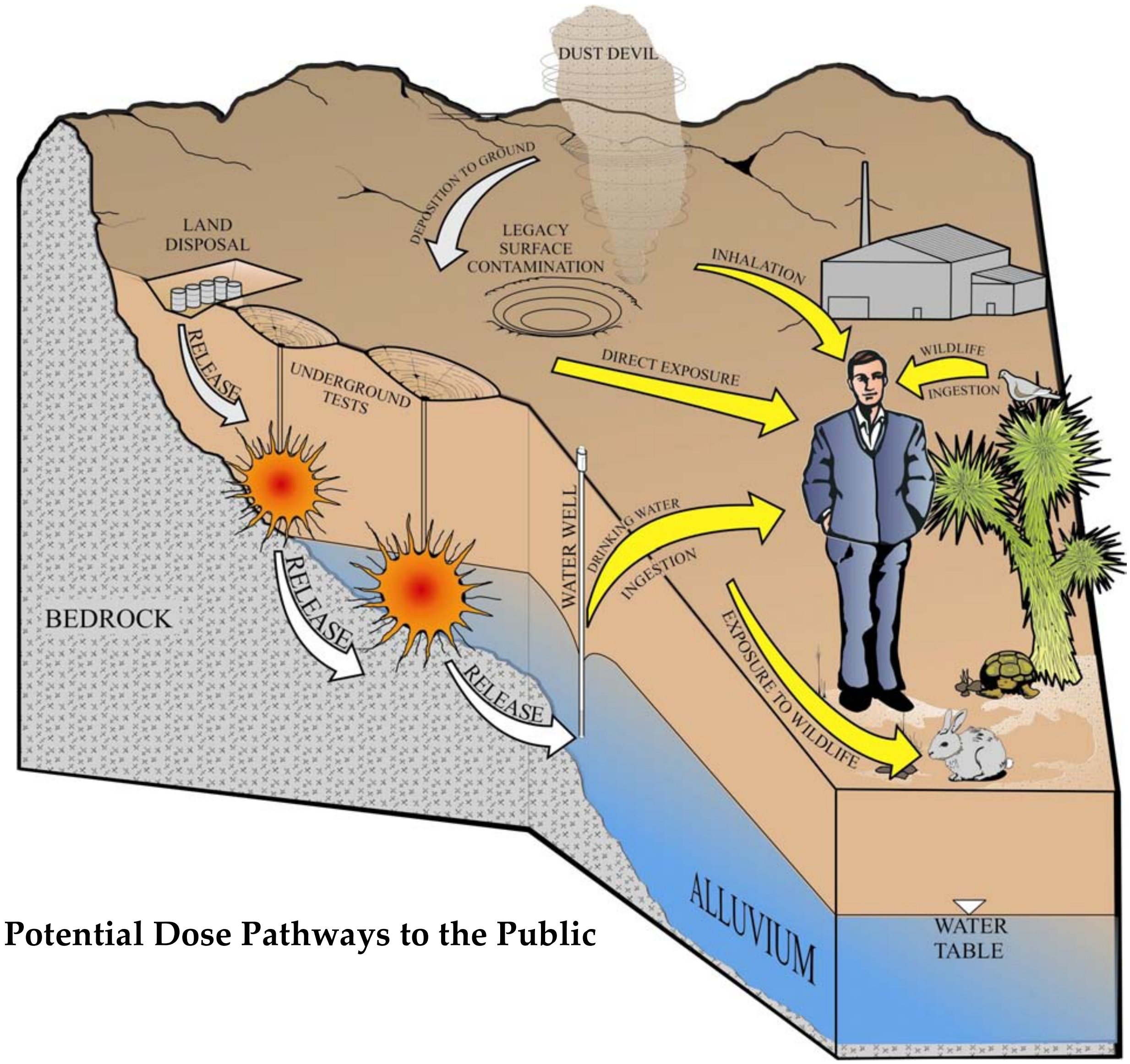
Alpha – heavy, positively charged particles given off by atoms of elements such as uranium. Can be simply washed off the skin. It can be blocked by a sheet of paper. It enters the body through cuts, breathing, food, or water.

Beta – consists of electrons. More penetrating than alpha radiation, beta electrons can pass through several millimeters of skin. A sheet of aluminum only a fraction of an inch thick will stop beta radiation.

Gamma – a form of electromagnetic radiation, similar to x-rays, light and radiowaves which are very penetrating. Can readily pass into the human body. Can be almost completely blocked by about 40 inches of concrete, 40 feet of water, or a few inches of lead.

X-rays – a more familiar form of electromagnetic radiation, usually with a limited penetrating power. Typically used in medical or dental examinations. Television sets, especially color, give off soft x-rays; thus, they are shielded to greatly reduce the risk of radiation exposure.

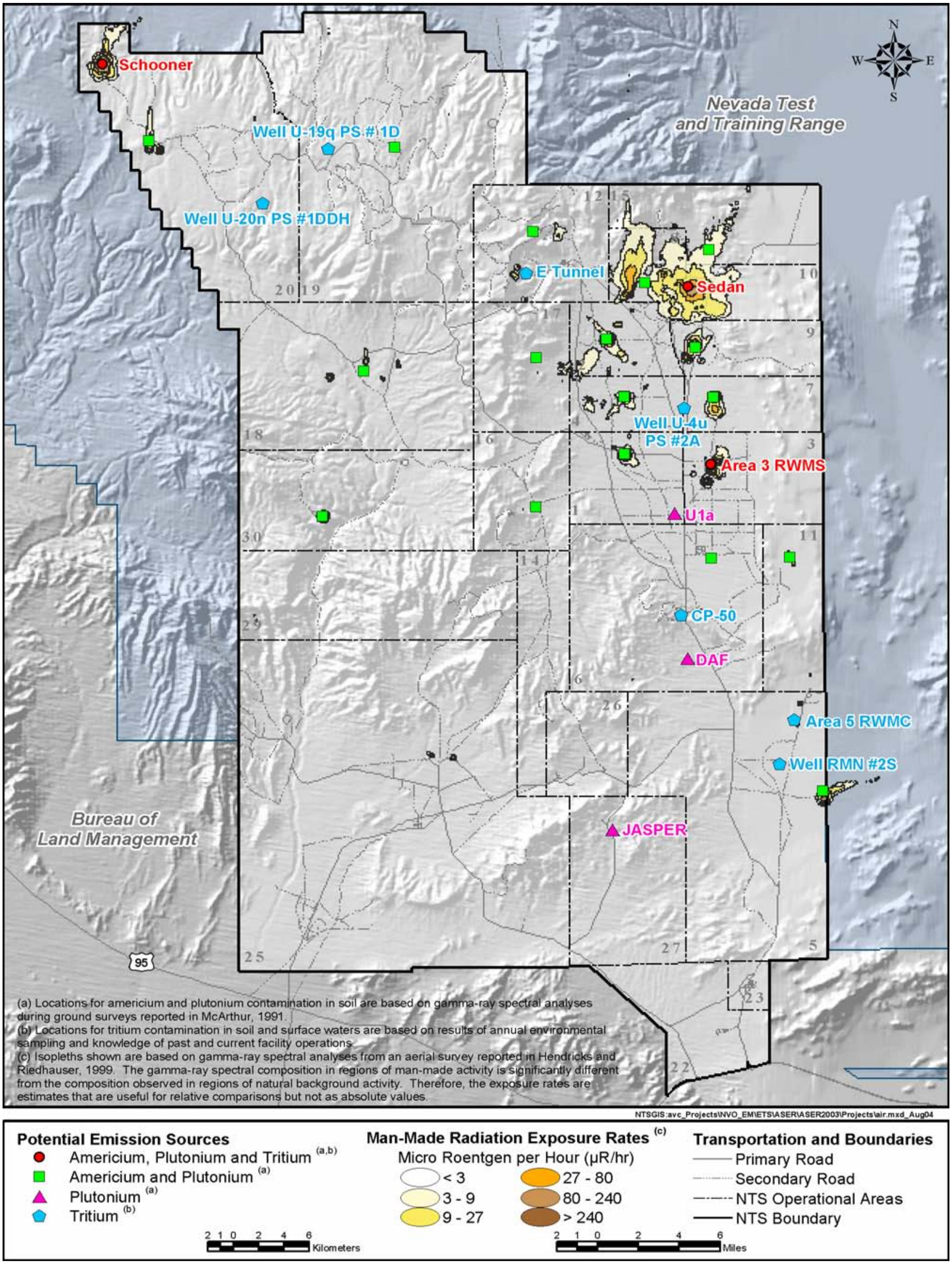
Neutrons – uncharged heavy particles contained in the nucleus of every atom heavier than hydrogen. They induce ionization only indirectly in atoms which they strike, but can damage body tissues. Neutrons, which are released, for example during the fission (splitting) of uranium atoms in the fuel of nuclear power plants, can also be very penetrating. In general, efficient shielding against neutrons can be provided by water.



Potential Dose Pathways to the Public

and is coordinated by the Desert Research Institute (DRI) of the University and Community College System of Nevada under contract with NNSA/NSO. Its purpose is to provide monitoring for radionuclides which may be released from the NTS. A network of 26 CEMP stations, located in selected towns and communities within 240 miles (mi) (386 kilometers [km]) from the NTS, were operated continuously during 2003. The CEMP stations monitored gross alpha and beta radioactivity in airborne particulates using low-volume particulate air samplers, penetrating gamma radiation using thermoluminescent dosimeters (TLDs), gamma radiation exposure rates using pressurized ion chamber detectors (PICs), and meteorological parameters using automated weather instrumentation.

In 2003, no airborne radioactivity related to historic or current NTS operations was detected in any of the samples from the CEMP particulate air samplers. Gross alpha and gross beta radioactivity was detected at all CEMP stations at levels which were consistent with previous years and which reflect radioactivity from naturally-occurring radioactive materials. No man-made gamma-emitting radionuclides were detected. Naturally-occurring radioactive beryllium (^{7}B) was detected in most air particulate samples.



Potential Sources of Radiological Air Emissions on the NTS

The TLD and PIC detectors measured gamma radiation from all sources: natural background radiation from cosmic or terrestrial sources and man-made sources. The offsite TLD and PIC results remained consistent with previous years' background levels and are well within average background levels observed in other parts of the United States. The highest total annual gamma exposure measured offsite was 180.76 mR/yr at Milford, Utah. The lowest offsite gamma exposure rate measured was 69.03 mR/yr in Pahrump, Nevada.

Average Background Radiation of Selected U.S. Cities (Excluding Radon)

City	Radiation Exposure (mR/yr)
Denver, Colorado	164.6
Fort Worth, Texas	68.7
Los Angeles, California	73.6
New Orleans, Louisiana	63.7
Portland, Oregon	86.7
Richmond, Virginia	64.1
Rochester, New York	88.1
St. Louis, Missouri	87.9
Tampa, Florida	63.7
Wheeling, West Virginia	111.9

Source: < http://www.wrcc.dri.edu/cemp/Radiation.html> "Radiation in Perspective," August 1990, as accessed on 9/20/2004

Onsite Radiological Air Emissions

The potential for radioactive air emissions on the NTS is due to operations involving radioactive materials and to legacy soil contamination from past nuclear tests. Therefore, continuous onsite radiological sampling of air is conducted and reported annually by BN to assure the public and regulatory agencies that the emissions are safe and in compliance with state and federal regulations. A network of 21 air sampling stations (six having low-volume particulate air samplers, two having tritium water vapor samplers, and 13 having a combination of both), and a network of 107 TLDs were used to monitor NTS radioactive emissions in 2003. The 2003 monitoring results were also used, in conjunction with U.S. Environmental Protection Agency (EPA)-approved mathematical models, to calculate the radiological dose to the public residing within 80 km (50 mi) of the NTS.

The monitoring results indicate that there were minimal radioactive air emissions in 2003 from only one NTS facility: CP-50 in Area 6. A total of 0.00019 Ci of tritium gas was released at CP-50 during the calibration of laboratory equipment. No radioactivity was detected above minimum detectable concentrations (MDCs) in any of the samples collected from the JASPER Facility stack. No radiological releases occurred at U-1a or DAF, and no increasing trends in the concentrations of man-made radionuclides were detected from air samples collected nearest these facilities.

Gross alpha and gross beta radioactivity was detected at all stations on the NTS, but no increasing trend in levels of radioactivity was observed at any station. The highest average gross alpha and gross beta activities were seen at U3ah/at, a low level radioactive bulk waste disposal cell located in a subsidence crater in Yucca Flat, and at Guard Station 510, located in Jackass Flats at the southwest entrance to the NTS, respectively. The lowest average gross alpha and beta activities were measured at Gate 20-2p located in Area 20, 2.7 mi (4.3 km) south-southeast of Schooner.

Direct gamma radiation exposure to the public from NTS operations in 2003 was negligible. Areas accessible to the public (e.g., the parking lot for commercial trucks outside the NTS entrance gate) had exposure rates which were equal to natural background rates. Radionuclide contamination at legacy sites has resulted in localized elevated gamma exposure rates, but the public has no access to these sites nor are there NTS personnel working in these areas. The highest exposure rate at monitored locations was 959 mR/yr at Schooner, one of the legacy Plowshare sites on Pahute Mesa. The 16 TLD stations that monitor the Radioactive Waste Management Complex in Areas 3 and 5 showed a mean gross gamma exposure rate of 149 mR/yr and ranged from 104 to 466 mR/yr. The public is not allowed unsupervised access to these sites.

Range in Radioactivity/Radiation Levels Measured at Onsite and Offsite Air Sampling Stations

	Average Gross Alpha x 10^{-15} µCi/mL		Average Gross Beta x 10^{-15} µCi/mL		Total Gamma Exposure Rate mR/yr	
	Offsite (CEMP)	Onsite (BN)	Offsite (CEMP)	Onsite (BN)	Offsite (CEMP)[(a)]	Onsite (BN)[(b)]
Highest Average Value	3.2 (*Boulder City*)	6.40 (*U3ah/at*)	27.4 (*Boulder City*)	20.77 (*Guard Station 510*)	181 (*Milford, Utah*)	959 (*Schooner*)
Lowest Average Value	1.1 (*Nyala Ranch*)	2.73 (*Gate 20-2P*)	19.6 (*Nyala Ranch*)	17.11 (*Gate 20-2P*)	69 (*Pahrump*)	63 (*Entrance Gate*)

(a) based on PIC detectors; (b) based on TLDs

Several man-made radionuclides were measured in air samples at levels above their MDCs in 2003: ^{241}Am, ^{137}Cs, ^{3}H (tritium), ^{238}Pu, and $^{239+240}$Pu. They were all attributed to the resuspension of contamination in surface soils from legacy sites and to the evaporation and transpiration of tritium from the soil, plants, and containment ponds at legacy sites. The highest levels of ^{241}Am and ^{137}Cs were detected at Bunker 9-300, a vacant building located within an area of known soil contamination from past nuclear tests. The highest levels of tritium were detected at Schooner, site of the second-largest Plowshare cratering experiment on the NTS where tritium-infused ejecta surrounds the crater. The highest levels of plutonium isotopes in air were at U-3ah/at, a subsidence crater created by an underground nuclear test located at the Area 3 Radioactive Waste Management Site (RWMS). U-3ah/at is used for disposal of bulk low-level radioactive waste. The high plutonium values at the U-3ah/at air sampling station, however are attributed to historical testing and not to waste operations, as the sampling station is within 700 m of ground zero for 13 atmospheric nuclear tests conducted between 1952 and 1958.

Uranium isotopes were also detected in air samples collected in areas where depleted uranium ordnance have been used or tested. However, the samples' isotopic ratios were what one would expect from naturally-occurring uranium in soil and not from man-made depleted uranium.

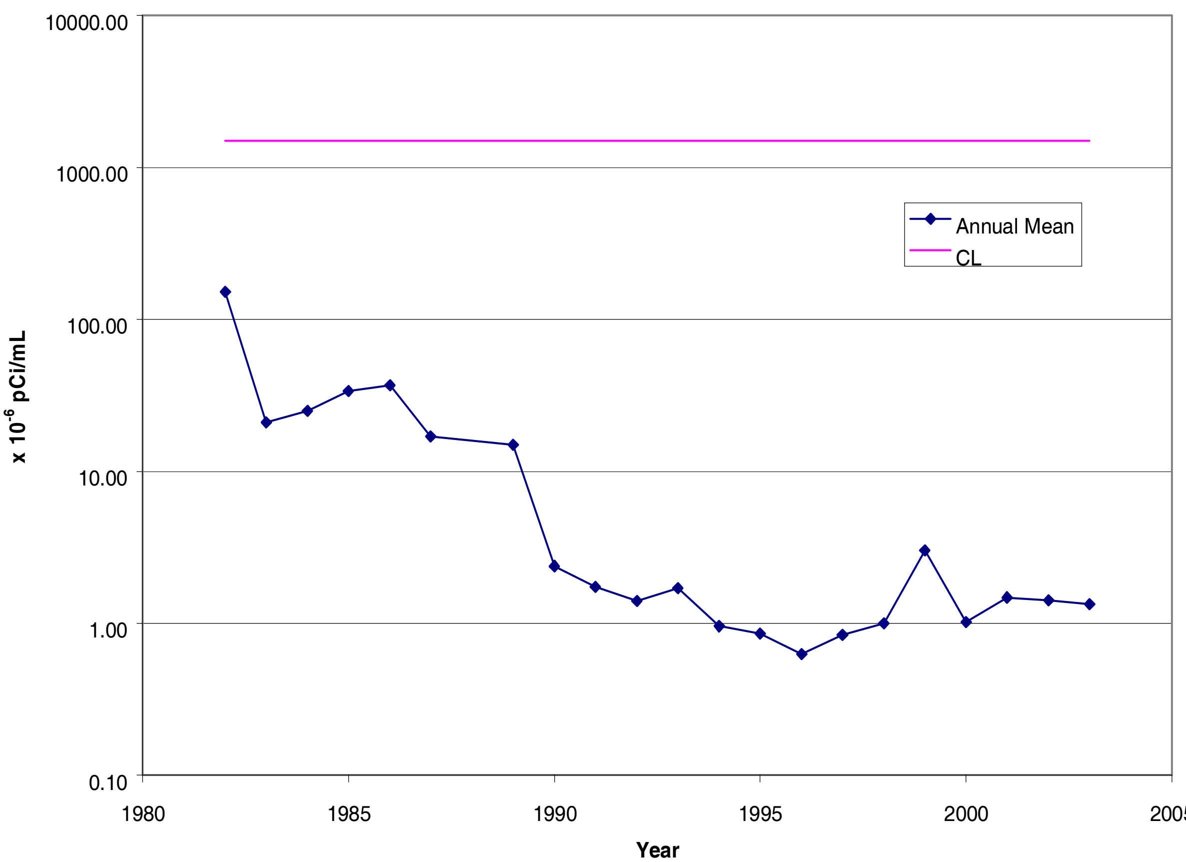
Two of the most commonly-detected man-made radionuclides, tritium and $^{239+240}$Pu, continued to show decreasing trends in concentrations at numerous air sampler sites in 2003. The following figures show the trends in the annual mean concentrations for these radionuclides at air sampling station BJY in Area 1. Station BJY has been sampled consistently over the years and is centrally located on the NTS. Each figure shows a horizontal line labeled "CL" which stands for Clean Air Act National Emission Standards for Hazardous Air Pollutants Concentration Level for Environmental Compliance. It is the annual average concentration (different for each radionuclide) which would result in a dose of 10 mrem/yr, which is the federal dose limit to the public from all radioactive air emissions.

The decrease in tritium air concentrations is a combination of the cessation of testing in 1992 (no additional releases), radioactive decay (half-life of tritium is 12 years), and its depletion from the soil over the years due to evaporation and transpiration (uptake and release of water through plants). Note that the scale of each graph is not linear but logarithmic, and that annual mean tritium concentrations at BJY have dropped over 99 percent from 153 x 10^{-6} pCi/L to just 1.34 x 10^{-6} pCi/L over the past two decades, and that the CL for tritium in air was a factor of 10 times the level measured in the 1980s and is now a factor of 1100 times the level measured in 2003.

Highest Average Concentrations of Man-Made Radionuclides in Air Samples on the NTS

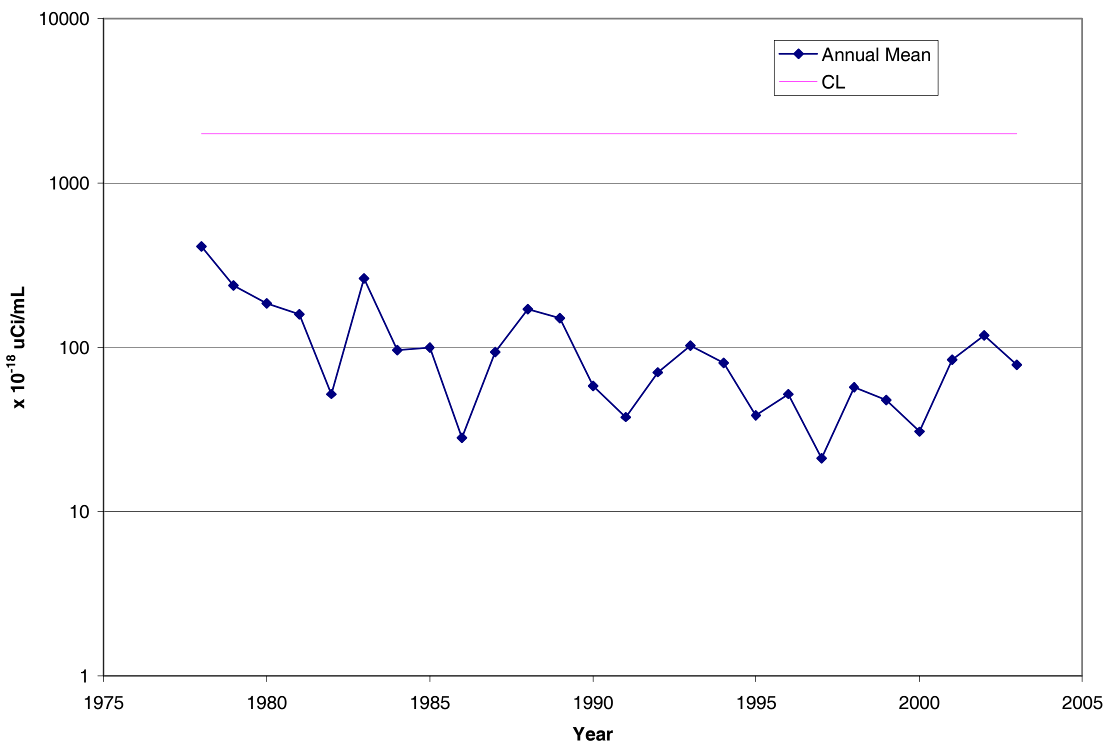
Man-Made Radionuclide	Highest Average Concentration Detected (10^{-15} µCi/mL) [(a)]	Concentration Level for Environmental Compliance (CL) [(b)] (10^{-15} µCi/mL)	Sampler Location
^{241}Am	0.024	1.9	U-3ah/at
^{137}Cs	0.030	19	Bunker 9-300[(c)]
^{3}H (tritium)	420,000	1,500,000	Schooner
^{238}Pu	0.0044	2.1	Yucca
$^{239+240}Pu$	0.16	2.0	U-3ah/at

(a) Concentration units and format for radionuclides have all been standardized for inclusion in this table for ease of comparisons. Units may differ from those reported in detailed radionuclide-specific data tables of this report.
(b) Limits established by the Clean Air Act National Emission Standards for Hazardous Air Pollutants (NESHAP)
(c) Bunker 9-300 was the only air sampling station where ^{137}Cs was detected



Trend in Tritium Air Concentrations at BJY Air Sampling Station

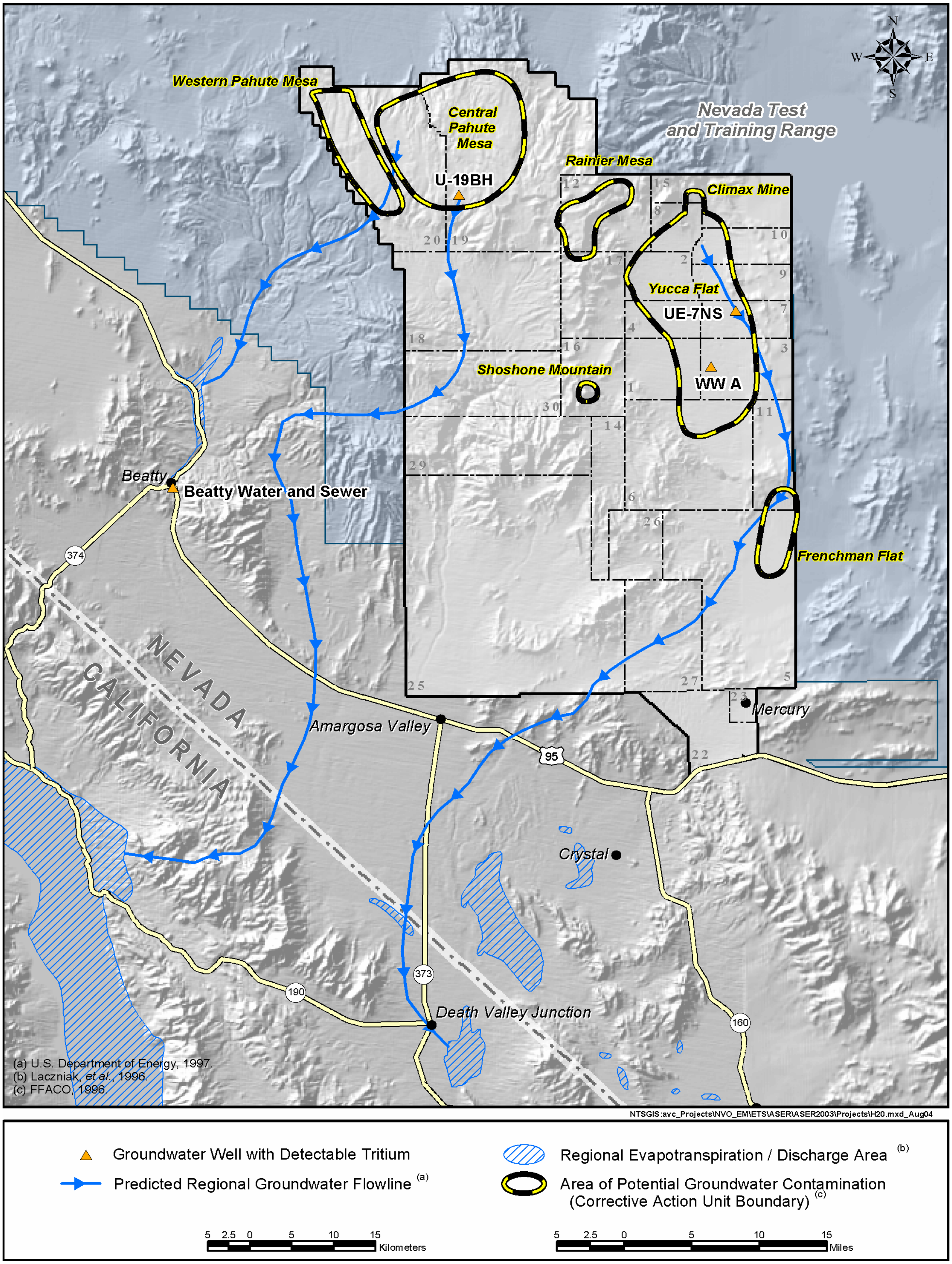
The gradual decrease in plutonium concentrations in air over time is attributed to its initial wind-borne dispersal on resuspended soil particles and its subsequent weathering into the ground where it is bound to less mobile particles. The annual mean $^{239+240}$Pu air concentrations at BJY have dropped over 81 percent from 411 x 10^{-18} µCi/mL to under 78.21 x 10^{-18} µCi/L over the past two decades. The CL for $^{239+240}$Pu in air was a factor of 4.9 times the level measured in the 1970s and is now a factor of 26 times the level measured in 2003.



Trend in $^{239+240}$Plutonium Air Concentrations at BJY Air Sampling Station

Offsite Radiological Monitoring of Groundwater

The DRI, through the CEMP, is tasked by NNSA/NSO to provide independent verification of the tritium activity within some of the offsite groundwater wells, municipal water supply systems, and springs used for water supplies in areas surrounding the NTS. Samples collected by DRI provide a comparison to the results obtained by BN during their annual monitoring of on- and offsite wells and springs. In 2003, the CEMP offsite water sampling locations included 17 wells, three water supply systems, and four springs located in selected towns and communities within 240 mi from the NTS. In 2003, BN conducted radiological monitoring of 21 offsite wells and six offsite springs. The 21 wells included private domestic and local community wells and seven NNSA/NSO wells drilled for hydrogeologic investigations including groundwater flow modeling. All of the BN-sampled wells and springs are in Nevada within 18.6 mi (30 km) from the western and southern borders of the NTS. Only one site, the Beatty Water and Sanitation well, is sampled by both BN and CEMP. The combined efforts of CEMP oversight monitoring and BN compliance-driven monitoring (necessary to verify compliance with radiation protection regulations) provide an extensive network of 37 wells, three water supply systems, and ten springs around the NTS which are each sampled annually for the presence of radionuclides which could be linked to NTS operations.



Areas of Potential Radiological Contamination in Groundwater on the NTS

Tritium is the sole radionuclide for which CEMP water sample analyses are run. Tritium is also the analyte of primary interest for the BN sampling program. Tritium is the radionuclide created in the greatest quantities in underground nuclear tests and is widely believed to be the most mobile. Many of the other radioactive elements generated from subsurface testing have very short half lives, sorb strongly onto the solid phase, or are bound into what is termed "melt glass" and are not available for groundwater transport in the near term. The EPA has established the Maximum Concentration Limit (MCL) of tritium in drinking water to be 20,000 pCi/L. To be able to detect the smallest possible amounts of tritium in offsite water supplies, "enriched" tritium analyses were run on all CEMP and BN water samples. For the 2003 CEMP water samples, the MDC for tritium using this enrichment process was 21 pCi/L. The MDC for enriched tritium analyses of the BN water samples was also reported by their analytical laboratory to be approximately 20 pCi/L for each sample. Without enrichment, the MDC for tritium typically ranges from 200-400 pCi/L.

BN offsite water samples are also analyzed for gross alpha and gross beta activity as a screening technique to determine if alpha or beta activity at any well or spring are increasing over time, and for any man-made gamma-emitting radionuclides which would signify contamination from nuclear testing.

In 2003, no tritium was detectable (i.e., measured above the MDC) in any of the CEMP offsite wells or springs. CEMP results this year, as in past years, continue to verify that no plume of contaminated groundwater has migrated beyond the NTS boundaries into surrounding water supplies used by the public. Samples from two municipal water supplies, Boulder City and Henderson, contained tritium at levels barely above detection. The Boulder City water treatment plant sample contained 35 ± 28 pCi/L and the sample collected at Henderson Community College of Southern Nevada contained 27 ± 20 pCi/L. The uncertainty, or error associated with these measures (the value shown after the ±) indicate that the true concentrations could be as low as 7 pCi/L for both samples, indistinguishable from background. Both of these municipal water systems obtain water from Lake Mead which has documented elevated tritium levels due to residual tritium persisting in the environment that originated from global atmospheric nuclear testing (DOE, 2003).

Summary of Offsite Radiological Water Monitoring

	CEMP	BN
No. of Wells or Water Supply Systems/ Springs Monitored	20 / 4	21 / 6
Tritium Results ***(Drinking water MCL = 20,000 pCi/L)***		
No. of sites where detected	2 / 0	1 / 0
Highest measured value (pCi/L)	35 ± 28 (*Boulder City*)	29.9 ± 15.3 (*Beatty*)
Gamma-Emitting Radionuclide Results		
No. of sites where detected	- - (a)	0 / 0
Gross Alpha Results ***(Drinking water MCL = 15 pCi/L)***		
No. of sites where detected		16 / 6
Highest measured value (pCi/L)		24.4 ± 6.32 (*ER-OV-02*)
Gross Beta Results ***(Drinking water "Level of Concern" = 50 pCi/L)***		
No. of sites where detected		21 / 6
Highest measured value (pCi/L)		22.2 ± 3.80 (*PM-3*)

(a) - - not analyzed

Similarly, the results of BN offsite water monitoring verified that there has been no offsite migration of man-made radionuclides from NTS underground contamination areas. BN detected tritium in only one offsite well: the Beatty Water and Sanitation well, and no offsite wells contained any man-made gamma-emitting radionuclides. All offsite well and spring samples contained detectable gross beta activity, and all spring samples and 16 of the 21 well samples contained detectable gross alpha activity. All gross alpha and beta concentrations in samples from potable water supply wells offsite were less than the EPA established MCL (for gross alpha) and the EPA established "Level of Concern" (for gross beta) for drinking water. Gross alpha was found at levels which exceeded drinking water standards at two offsite monitoring wells, ER-OV-01 and ER-OV-02. These two wells are NNSA/NSO wells drilled specifically for hydrologic investigations, are not used for drinking water, and are closed to the public. These wells produce water from a volcanic acquifer that may have relatively high quantities of natural alpha-yielding elements in the host rock. No man-made gamma-emitting radionuclides and no tritium were detected in these two wells.

The Beatty Water and Sanitation well was sampled in August and tritium was measured at 29.9 ±15.3 pCi/L, just above its sample-specific MDC of 23.9 pCi/L. CEMP sampled the same well in June and measured tritium at 0 ± 18 pCi/L. In all previous years, no detectable levels of tritium have been measured by BN (or previous M&O contractors) or by CEMP. Given that: (1) the Beatty well's tritium concentration is near its MDC, (2) the measure's uncertainty is high, (3) no wells which are upgradient from the Beatty well and downgradient from NTS contaminated groundwater areas had detectable tritium or other man-made radionuclides, (4) the CEMP Beatty well sample was below its MDC, and (5) results for this well from previous years have been below the MDC for tritium, it is concluded that no man-made tritium from NTS operations occurs in the Beatty well.

It should be emphasized that enriched tritium analyses allows laboratories to detect tritium at much lower concentrations with some level of confidence and provides NNSA/NSO hygeodrologists and radioecologists with very sensitive data to detect tritium migration in groundwater and its transport through the ecosystem. However, "detectable" tritium at 20 pCi/L is only 0.001 percent of the allowable drinking water standard of 20,000 pCi/L, and as such, represents negligible risk to public health and the environment.

Onsite Radiological Monitoring of Water

In 2003, BN continued to monitor radioactivity in onsite groundwater and surface waters on the NTS to: (1) ensure that NTS drinking water is safe, (2) determine if permitted facilities on the NTS are in compliance with permit discharge limits for radionuclides, (3) estimate radiological dose to onsite wildlife using natural and man-made water sources, (4) provide data to validate the performance criteria for Area 3 and Area 5 RWMSs established to protect groundwater from disposed radioactive wastes, and (4) support hydrologic investigations. The onsite monitoring network is comprised of ten potable water supply wells, 14 monitoring wells (which include three compliance wells for the Area 5 RWMS and one compliance well for the Area 23 sewage lagoon), one tritiated water containment pond system, and three sewage lagoons.

The 2003 data continue to indicate that underground nuclear testing has not impacted the NTS potable water supply network. All of the water samples from the ten supply wells had non-detectable concentrations of tritium and man-made gamma-emitting radionuclides. Gross alpha and gross beta radioactivity was detected in potable water supply wells represent the presence of naturally-occurring radionuclides.

The 2003 water monitoring results from wells and sewage lagoons indicated that NTS operations and waste disposal/treatment facilities were performing as per their performance criteria and according to permit regulations.

Radiation Dose to the Public by Air Pathways

The maximum radiation dose to a member of the general public from airborne radionuclide emissions at the NTS was computed in 2003 and was less than 10 mrem/yr. This is the dose limit specified by NESHAP. The total radiation dose to a member of the general public attributable to NTS operations from all possible pathways (inhalation, ingestion of water and food) was also computed in 2003 and was less that 100 mrem/yr. This is the dose limit established by DOE Order 5400.5 *Radiation Protection of the Public and the Environment*. This section summarizes how dose via all possible pathways was estimated and presents the 2003 dose estimates.

Man-made radionuclides from past nuclear testing have not been detected in offsite groundwater in the past or during 2003. The only pathways, therefore, by which the offsite public could receive a radiation dose from NTS operations are the air transport and ingestion pathways.

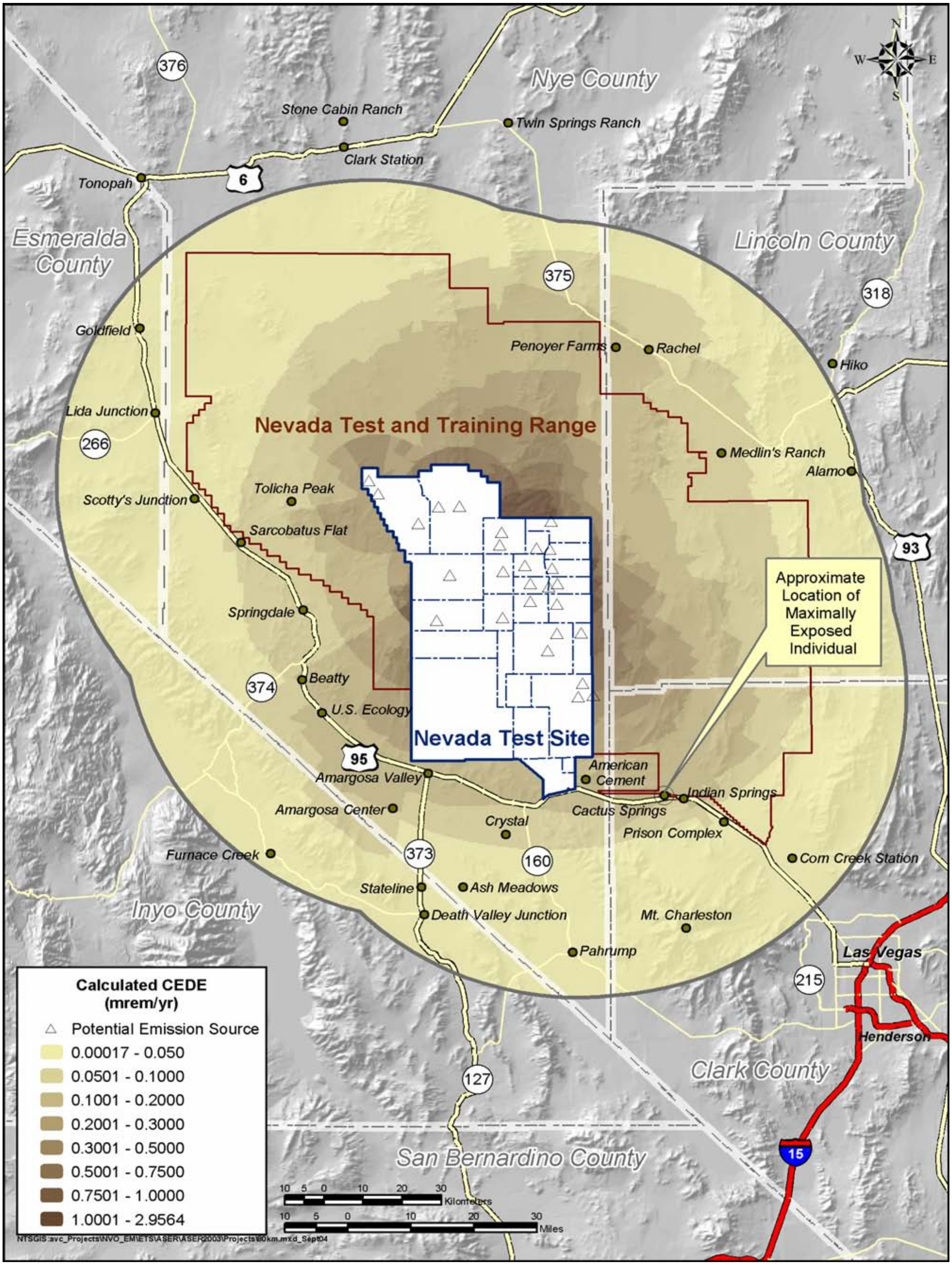
The radiation dose to the general public by just the air transport pathway was estimated using the air sampling results from six onsite EPA-approved "critical receptor" sampling stations which represented the offsite general public. Among these six stations, the Schooner air station in the far northwest corner of the NTS experienced the highest concentrations of radioactive air emissions. If an individual resided at this station, they would experience a dose from air emissions of 2.9 mrem/yr. This dose is less than the limit of 10 mrem/yr. Dose, via the air transport pathway, at offsite populated locations 20-80 km from the Schooner station would be even lower due to wind dispersion.

The radiation dose to the general public from inhalation and ingestion of airborne radioactive contaminants was also estimated using the 2003 air sampling results and air transport models. Estimates of radionuclide emissions from: (1) NTS facilities, (2) the resuspension of legacy deposits of radionuclides in NTS soil, (3) the transpiration and evaporation of tritium at sites of past nuclear tests, and (4) the evaporation of tritium from ponds used during 2003 to contain tritium-contaminated groundwater, were all used to compute total air emissions from source locations on the NTS. The table below lists the location names of NTS air emission sources and their 2003 emission estimates. With the use of NTS meteorological data, the emission estimates, and CAP88-PC software, the radiation dose (expressed as the committed effective dose equivalent [CEDE]) to the maximally exposed individual (MEI) offsite was calculated to be 0.10 mrem/yr at Cactus Springs, Nevada. This dose is consistent with those calculated for past years.

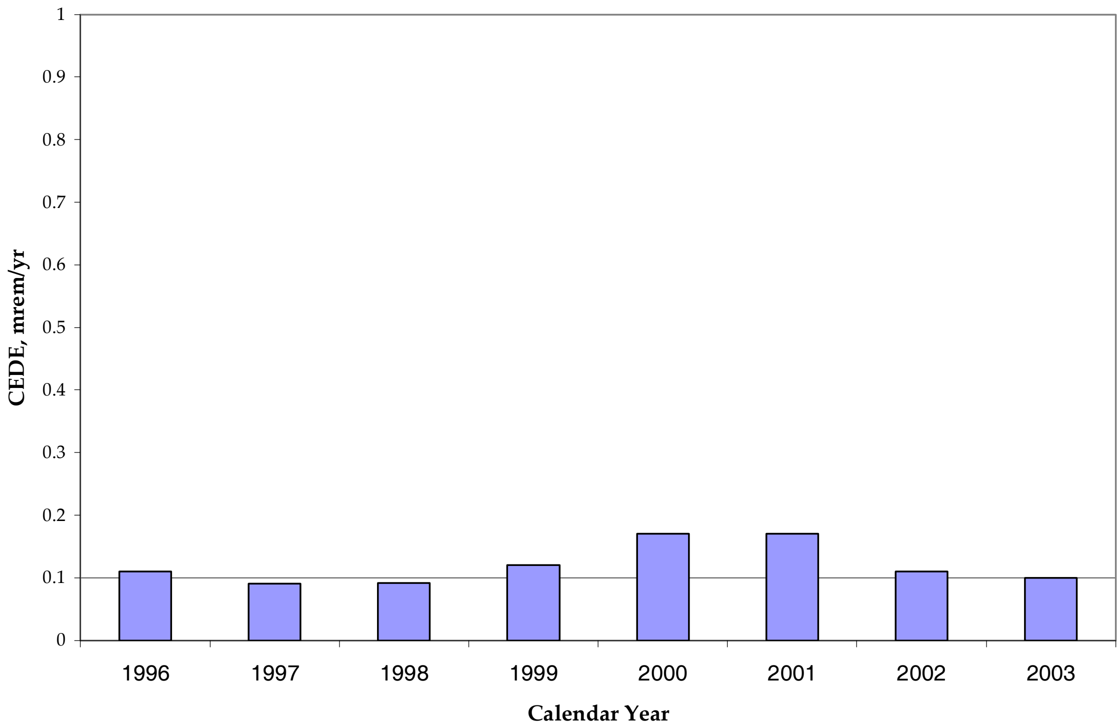
Estimated 2003 Annual Air Emissions from NTS Sources

Source	Radionuclide	Quantity (Ci)[(a)]
Area 6 Building CP-50	^{3}H	0.00019
Area 12 E Tunnel Ponds	^{3}H	13
Well RNM#2S	^{3}H	36
Well U-4u PS #2A	^{3}H	0.73
Well U-19q PS #1D	^{3}H	0.47
Well U-20n PS #1DDH	^{3}H	4.2
Area 5 RWMS	^{3}H	5.9
Area 10 Sedan	^{3}H	64
Area 20 Schooner	^{3}H	190
Total for all ^{3}H Sources	^{3}H	314
Total for Grouped NTS Areas	^{241}Am	0.047
Total for Grouped NTS Areas	$^{239+240}Pu$	0.29

(a) Multiply Ci by 37 to obtain GBq



2003 Calculated Radiation Dose (CEDE) to the Public Within 80 km of the NTS



Trend in Estimated Radiation Dose to the Offsite Maximally Exposed Individual

Radiation Dose to the Public by Air and Wildlife Pathways

The potential radiation dose to the general public by the ingestion pathway was estimated based on radionuclide tissue concentrations in game animals sampled in 2003 on the NTS. Tissues from three mourning doves collected near containment ponds containing tritiated water (e.g., E Tunnel Ponds), one cottontail rabbit collected at the Palanquin Plowshare test location, and two pronghorn antelopes that were hit by a car in southern Frenchman Flat were analyzed for the presence of radionuclides. The doves were meant to represent a worst-case scenario of the most contaminated NTS game animal. As expected in the doves, elevated levels of tritium (as high as 10,800,000 pCi/L in the water fraction of the breast meat), as well as low but detectable levels of ^{137}Cs (0.54 pCi/g dry weight), ^{241}Am (0.0079 pCi/g dry weight), and $^{239+240}$Pu (0.012 pCi/g dry weight) were measured. Detectable levels of ^{90}Sr (average of 0.19 pCi/g dry weight) were found in the muscle tissue of one of the two antelopes. No man-made radionuclides were detected in the rabbit muscle tissue. To calculate human dose from ingestion of theses game species, it was assumed that over one year a hunter would consume the breast meat from 20 doves of similar weight and 10 kg (22 lb) of meat from one antelope. The resultant potential dose from consuming mourning doves and pronghorn antelope was estimated to be 0.36 mrem/yr (0.0036 mSv/yr).

The hypothetical MEI was also assumed to be a hunter who harvested NTS game animals and received the additional radiation dose of 0.36 mrem/yr. The resultant radiation dose to the MEI from airborne emissions and from ingestion of game animals was 0.46 mrem/yr (0.0046 mSv/yr). This dose is a very small fraction (0.13 percent) of the total radiation dose from naturally-occurring sources. DOE Order 5400.5, "Radiation Protection of the Public and the Environment" requires that a collective population dose also be estimated annually. The collective population dose within 80 km (50 mi) of the emission sources was estimated to be 0.45 person-rem/yr (0.0045 person-Sv/yr).

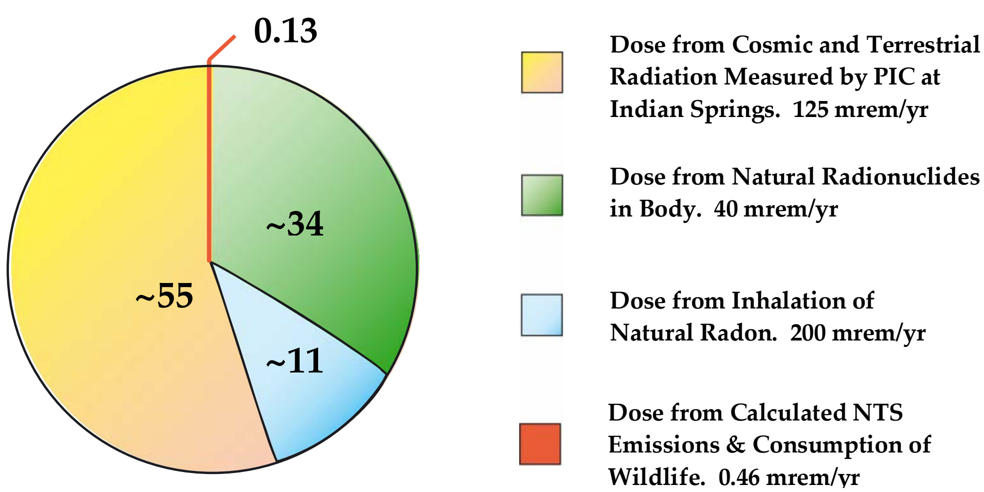
Estimated Radiological Dose to the General Public from the NTS in 2003

Pathway	Dose to Maximally Exposed Individual (mrem/yr)	(mSv/yr)	Percent of DOE 100-mrem/yr Limit	Estimated Collective Population Dose[a] (person-rem/yr)	(person-Sv/yr)
Air	0.10	0.0010	0.10	0.45[a]	0.0045
Water	0	0	0	0	0
Wildlife	0.36	0.0036	0.36	U[b]	U
All Pathways	0.46	0.0046	0.46	0.45	0.0045

(a) Sum of radiation doses from all emission sources at each populated location within 80 km of emission sources multiplied by the population at each location, and then summed over all locations.

(b) Unable to make this estimate due to a lack of data on number of game animals harvested near the NTS by hunters in 2003.

Comparison of Radiation Dose to MEI and the Natural Radiation Background (Percent)



Non-Radiological Onsite Air Emissions

There were no discharges of non-radiological hazardous materials to offsite areas in 2003. Therefore, only onsite non-radiological environmental monitoring of NTS operations was conducted. Air quality was monitored on the NTS throughout the year as required by state of Nevada permits for those operations which release either criteria air pollutants, hazardous air pollutants, or toxic and hazardous chemicals. Air emissions sources common to the NTS include particulates from construction, aggregate production, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, fuel storage facilities, and chemical release tests conducted at the HSC on Frenchman Flat playa in Area 5.

An estimated 12.9 metric tons (14.3 tons) of criteria air pollutants were released on the NTS in 2003. The majority of these were nitrogen oxides from fuel burned by diesel-fired generators. No emission limits for criteria air pollutants were exceeded. Asbestos is the only non-radiological hazardous air pollutant of regulatory concern on the NTS. Building renovation or demolition projects may release asbestos. In 2003, asbestos-containing materials from an old steam plant and theatre in Mercury were removed, and the EPA was notified because the amounts removed exceeded EPA's notification threshold of 260 linear feet or 160 square feet. There were no formal state inspections of NTS equipment regulated by the state air quality permit.

There were four tests consisting of 17 releases of hazardous chemicals at the HSC in 2003. As per the requirements of the NTS air quality operating permit for the HSC, an annual report of the types and amounts of chemicals released and the test plans and final analysis reports for each chemical release were submitted to the state. Based on the low level of risk each test posed to the environment and biota, no test-specific ecological monitoring was performed.

Onsite Non-Radiological Discharges into Water

As there are no liquid discharges to navigable waters, offsite surface water drainage systems, or publicly owned treatment works, no Clean Water Act National Pollution Discharge Elimination System (NPDES) permits were required for NTS operations.

Under the conditions of the state of Nevada operating permits, liquid discharges to onsite sewage lagoons are tested quarterly for biochemical oxygen demand, pH, and total suspended solids. Annually, sewage lagoon pond waters are sampled for a suite of toxic chemicals. In 2003, quarterly analysis of sewage influent waters at the Area 6, Area 12, and Area 23 sewage facilities and annual analysis of sewage pond waters at the Area 6 and Area 23 facilities showed that all water measurements were within permit limits. No detectable levels of toxic chemicals except for arsenic, barium, chromium, and silver, were measured in sewage pond waters, and these contaminants were detected at levels that were only 0.01 - 0.2 percent of the permit limits. The state conducted an annual inspection of sewage lagoon systems in February 2003. A malfunctioning flow meter was discovered at the Area 6 Yucca Lake sewage lagoon and corrective actions were completed and approved by the state in July 2003.

Accidental or Unplanned Environmental Releases or Occurrences

Five environmental occurrences which involved un-permitted discharges into sewage lagoons, spills of fluids onto soil, and the mishandling of potentially-contaminated soil occurred in 2003 and are listed and described below. The direct, contributing, and root causes of these occurrences were determined and were described within occurrence reports. All materials released were cleaned up, corrective actions (e.g., improving work procedure documents) were taken to prevent reoccurrence, and no significant impact to the environment, biota, or the public occurred as a result of these releases.

Un-permitted Discharge of Non – hazardous Synthetic Oil into Area 12 Sewage Lagoons
Blowdown fluid from an Underground Test Area (UGTA) drilling project accumulation tank was mistakenly discharged into dry basins of the Area 12 sewage lagoon system. This incident resulted in the release of approximately 5 gallons (gal) (18.9 liters [L]) of oil.

Diesel Fuel Discharge into Mercury Sewage Lagoon
Approximately 10 to 15 gal (37.9 to 57.9 L) of diesel fuel was discharged into the Area 23 Mercury sewage lagoon system when it leaked from a boiler's fuel system in a building in Mercury and entered the boiler room floor drain.

Hydraulic Fluid Spill Onto Soil in Area 5 Waste Disposal Cell
A water truck operating in the bottom of the disposal cell experienced a hydraulic hose failure resulting in the release of 23 gal (87.1 L) of hydraulic fluid. The amount of soil affected was about 10 cubic yards (7.6 cubic meters).

Unauthorized Excavation of Potentially – Contaminated Soil Located at the Central Nevada Test Area (CNTA) UC-4 Mud Pit C Cover (Corrective Action Unit 417)
While performing erosion repairs to CAU 417 located at the CNTA UC-4 Mud Pit C cover, a front-end loader operator removed soil from within the posted use restriction boundaries of UC-4 Mud Pit B. Soil at depths greater than 1.2 meters (4 feet) below the surface is contaminated with diesel-based drilling mud. The state of Nevada Division of Environmental Protection determined that the unauthorized excavation and subsequent placement of potentially-contaminated soil represents a non-conformance with the approved Corrective Action Decision Document and Closure Report for CAU 417, CNTA Surface, and a potential non-compliance with both the FFACO and Nevada Administrative Code.

Heating Oil Spill Onto Soil in Area 12
During excavation of the dirt from an underground heating oil tank to retrofit spill and overfill protection, an historic heating oil spill was discovered. Approximately 6 cubic yards (4.6 cubic meters) of soil were impacted.

The NTS Environmental Management System

The NNSA/NSO contract with BN, as the M&O contractor for the NTS, requires that an Integrated Safety Management System (ISMS) be implemented. The term *safety* is used synonymously with *environment, safety and health* throughout BN's ISMS implementation policies to encompass protection of the public, the workers, and the environment. In 2000, President Clinton issued Executive Order (EO) 13148, "Greening of the Government Through Leadership in Environmental Management". This EO requires all federal agencies to adopt an environmental management system (EMS). An EMS is a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals.

EO 13148 applies to most of the NNSA as well as to DOE and NNSA contractors. DOE requires contractors who operate DOE sites to develop an EMS and expects full integration of their EMS into their ISMS by December 2005.

In 2003, DOE adopted a set of interim milestones to assist their facilities in tracking their progress towards meeting this deadline.

The first fiscal year (FY) 2003 milestone was to issue a site EMS policy statement. BN satisfied this milestone in 2000 through issuance of a company-level document, PD-0442.001, titled "Environmental Management System Description" which was modeled after the voluntary industry standard established by the International Organization for Standards, ISO 14001, titled "Environmental Management Systems". The document takes each of the seventeen required elements in the ISO standard and describes how they are implemented within BN. An important approach taken is that the EMS is the *environmental* component of the BN ISMS already in place, and not a new requirement for programs. Many of the required processes within a good EMS were previously in place to satisfy the BN ISMS. The BN EMS is a systematic, integrated management approach used to ensure compliance with all applicable environmental legislation and regulations. The company document describes commitments and methods used to integrate environmental management requirements into work planning and execution. BN also has an Environmental Protection Policy that addresses the key areas of an EMS.

The second FY 2003 milestone was to implement EMS training for personnel establishing the system. BN satisfied this milestone by sending its EMS Coordinator to several EMS training classes and workshops in 2001, 2002, and 2003.

The third FY 2003 milestone was to identify significant environmental aspects. An environmental aspect is an action that has potential environmental harm, such as the generation of hazardous waste or a hazardous material release to the air. BN has identified significant environmental aspects and various potential mitigating actions for each. A BN procedure for identifying environment, safety, and health (ES&H) hazards prior to start of work is being updated to include these significant environmental aspects.

During 2003, DOE finalized DOE Order 450.1, "Environmental Protection Program". This new Order adds a few programs or processes not previously considered to be part of the BN EMS, but which were being accomplished within BN. Work began in 2003 on the following items to continue improvement of the EMS: (1) gap analysis to identify programs that need to be added to the EMS, (2) ways to upgrade the pollution prevention (P2) program when DOE funding for P2 has been drastically cut, and (3) strengthening the affirmative procurement program.

Significant Environmental Accomplishments

The following summary of activities represents the most significant environmental accomplishments for 2003. They were performed either as program tasks related to a primary mission of the NTS (e.g., environmental restoration), or as tasks that have been integrated into program mission work processes through implementation of ISMS and the BN EMS discussed above. These environmental accomplishments represent efforts on the part of NNSA/NSO and BN, as the M&O contractor, to remain compliant with environmental regulations, ensure public health and safety, promote environmental awareness among employees, improve the cost-effectiveness of environmental monitoring, foster stakeholder involvement and public oversight, and pursue sound stewardship of NTS natural resources.

Environmental Restoration – The cleanup of historical sites contaminated by past DOE operations on and off the NTS and the hydogeological investigations supporting characterization of underground nuclear contamination areas are the most significant environmental work performed by NNSA/NSO each year. Under the FFACO, the DOE, DoD, and the state of Nevada Division of Environmental Protection (NDEP) identify a work scope and milestone schedule for the cleanup and safe closer of the above-ground sites (Corrective Action Sites) and for field investigations and model development necessary to characterize the underground sites. The underground sites are referred to as Underground Test Area Project Corrective Action Units (UGTA CAUs). In 2003, a total of 81 Corrective Action Sites (CASs) were safely closed. These closures either involved the removal of hazardous or radioactive wastes or were "closures-in-place". For each CAS, NDEP must concur with the site evaluations; corrective action plans; the techniques applied for characterization and clean-up, if necessary or feasible; and any post-closure monitoring plan. NDEP concurred with all 81 CAS closures conducted in 2003. Extensive progress was made towards the development of hydrologic models of groundwater flow and radionuclide transport from the primary UGTA CAUs into the groundwater of public lands outside the boundaries of the NTS. In 2003, this involved well development, aquifer testing, groundwater characterization sampling, and the completion of several technical data documentation packages and modeling approach/strategy documents.

Radiological Compliance Monitoring – In 2003, BN Environmental Technical Services (ETS) conducted an extensive review of the Routine Radiological Environmental Monitoring Plan (RREMP). The RREMP was originally developed in 1998 to address compliance with DOE Orders 5400.1, 5400.5, and other drivers requiring routine radiological effluent monitoring and environmental surveillance on the NTS. Implementation of the RREMP ensures environmental radiological compliance for all NNSA/NSO program activities conducted on and off the NTS, as identified in the 1996 final NTS Environmental Impact Statement and Record of Decision (DOE, 1996). NDEP participated in the 2003 RREMP review and provided input and concurrence on any changes in monitoring design and methods. NDEP's involvement was critical to assure the NNSA/NSO that the state's concerns and stakeholder concerns were addressed. The RREMP was republished in June 2003.

Radiological Oversight Monitoring – The DRI continued work on communication upgrades for the CEMP offsite air surveillance network which is the network of air sampling stations used to monitor gross alpha, gross beta, and gamma radiation exposures in selected Nevada and Utah communities surrounding the NTS. The upgrades, when completed, will allow direct Internet connections with air monitoring station data on a nearly real-time basis. Such capabilities would be useful for oversight monitoring of accidental releases from underground nuclear testing, if such testing were resumed as directed by the President. DRI also installed two new air monitoring stations, one in Warm Springs capable of detecting higher elevation plumes of airborne releases, and one in Ely, another community potentially downwind of NTS radiological releases.

Pollution Prevention/Waste Minimization – In 2003, NNSA/NSO continued to pursue work processes that reduced the volume and toxicity of wastes generated during all operations on the NTS.

Volume of Wastes Reduced Through Pollution Prevention Activities

Calendar Year	Radioactive Waste Reduced (m^3)	Hazardous Waste Reduced (mtons)	Solid Waste Reduced (mtons)
2003	40.0	207.3	1,547.2
2002	63.2	177.2	904.2
2001	79.6	123.5	799.0

Waste Management – The Radioactive Waste Management Complex was reclassified as a Category II Nuclear Facility and as such became subject to more stringent operational controls to ensure the safety of NTS workers and the public. Over 200 NTS workers across the complex who may have access to the RWMS received nuclear facilities general employee training. A total of seven new BN company directives, two new policies, and 75 operating procedures were revised or created to integrate new or expanded environmental controls. Evaluations of all other company documents were initiated for activities which could impact nuclear facility operations, maintenance, or nuclear program elements.

Ecological Monitoring – A tortoise habitat revegetation plan was prepared and sent to the U.S. Fish and Wildlife Service for their approval. The desert tortoise is the only species that resides on the NTS which is protected under the Endangered Species Act (ESA). It is listed as a threatened species. Approval and implementation of the plan, whenever feasible, would redirect mitigation fees for the loss of tortoise habitat ($648/acre) into supporting the cost of restoring NTS tortoise habitat. Without an approved revegetation plan, NNSA/NSO must deposit the fee into a general tortoise recovery fund that does not directly benefit NTS tortoise populations. Future implementation of this plan will satisfy ESA compliance stipulations and also further the goals of Executive Orders and DOE Orders related to the control of invasive species, wildland fires, and soil erosion.

Historical Preservation/Cultural Resources Protection – A survey of all historic nuclear testing structures on Yucca Lake was completed by DRI archeologists in 2003. The survey resulted in the establishment of the Yucca Lake Historic District which brings attention to aspects of the history of above-ground nuclear testing that had gone largely unnoticed. A total of 15 structures on Yucca Lake were determined eligible to the National Register of Historic Places.

Environmental Reporting – BN ETS began work in October 2003 towards the redesign of the NTS Annual Site Environmental Report. This was done in response to a self-assessment of ETS data reporting processes conducted in 2003 to ensure compliance with DOE Order 231.1, "Environment, Safety and Health Reporting" and with DOE Headquarters' supplemental guidance to this Order. This *NTS Environmental Report 2003* incorporates many of the organization and content changes identified for improvement.

Compliance Summary

Sedan,
Plowshare Program,
July 6, 1962

DeBaca,
balloon burst,
October 26, 1958

Line-of-sight pipes for
tunnel experiment at Rainier Mesa,
date unknown

1.0 Compliance Summary

Environmental regulations pertinent to operations on the Nevada Test Site (NTS) are described in this Compliance Summary. They include federal laws, state laws, state permit requirements, Executive Orders (EOs), DOE Orders, and state agreements. They dictate how the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) conducts operations on and off the NTS to ensure the protection of the environment and the public. The regulations are grouped by topic and described in terms of their application to NTS operations.

A compliance status table is presented for each topical group of regulations. For ease of review, all the compliance status tables are presented together at the end of this section. Each table lists those measures or actions which are tracked or performed annually to ensure compliance with a regulation. A description of the field monitoring efforts, actions, and results which support the data in each table can be found in subsequent sections of this document, as noted in the "Reference Section" column of each table.

Non-compliance incidents or compliance issues, if any, are included in the topical subsections along with a listing of compliance reports generated during the reporting year. The last table presented in this section is a list of all 2003 NTS environmental permits.

1.1 Air Quality

1.1.1 Applicable Regulations

Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAP) – Under Title III of the CAA, NESHAP was established to control those pollutants that might reasonably be anticipated to result in either an increase in mortality or an increase in serious irreversible or incapacitating but reversible illness. Industry-wide national emissions standards were developed for 22 of the 189 designated hazardous air pollutants (HAPs). Radionuclides and asbestos were among the 22 HAPs for which standards were established. These standards are promulgated through Title 40 of the Code of Federal Regulations, Part 61, in Subparts H and M, respectively. Under Subpart H, NESHAP establishes a radiation dose limit for individuals of the general public. Subpart M addresses protection of the public from asbestos. Both subparts define the methods to use in determining compliance, recordkeeping, reporting, and in determining whether federal approval is required prior to the construction of new facilities or the modification of an existing facility. NESHAP compliance activities at the NTS are limited to radionuclide monitoring and reporting and notification of asbestos abatement.

CAA, National Ambient Air Quality Standards (NAAQS) – Title I of the CAA established the NAAQS to limit levels of pollutants in the air for six "criteria" pollutants: sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, lead, and particulate matter. Title V of the CAA authorizes the states to implement permit programs in order to regulate emissions of the criteria pollutants. At the NTS there is one main permit that regulates operations and emissions from aggregate-producing facilities, fuel-burning equipment, and fuel storage. Other permits regulating emissions from NTS project-specific activities include the Tactical Demilitarization Development Project (TaDD) and the Hazardous Materials Spill Center (HSC). Nevada air quality permits specify emission limits for these criteria pollutants that are based on published emissions values for other similar industries and on operational data specific to the NTS. Quantities of NAAQS emissions from operations at the NTS are calculated and submitted each year to the state of Nevada. Nevada air quality permits also specify recordkeeping and reporting requirements, visible emissions (opacity) limits for equipment/facilities, opacity field monitoring requirements, and certification requirements for personnel conducting opacity monitoring. The permits also grant the state access to the NTS to conduct inspections of permitted facilities.

State of Nevada regulations prohibit the open burning of combustible refuse and other materials unless specifically exempted (Nevada Administrative Code 445B.122). Some of the exemptions include weed abatement, elimination of hazards, and personnel training. An Open Burn Variance form must be submitted to and approved by the State before an open burn can take place. At the NTS, Open Burn Variances are routinely obtained for fire extinguisher training and various emergency-management exercises.

CAA, New Source Performance Standards (NSPS) – The NSPS were established by Title I of the CAA to set minimum nationwide emission limitations of regulated air pollutants (HAPs and criteria pollutants mentioned above) and for various industrial categories of facilities. The state of Nevada has adopted the NSPS and regulates emissions from subject facilities through state law (NRS 445B as codified in NAC 445B). At the NTS, some of the screens and conveyor belts that were manufactured after August 1981 are subject to NSPS under the category of Nonmetallic Mineral Processing Plants. The NSPS imposes more stringent standards, including a reduced allowance of visible emissions or opacity. NSPS compliance activities on the NTS are reported to the state of Nevada.

CAA, Stratospheric Ozone Protection – Title VI (Section 608) of the CAA establishes production limits and a schedule for the phase-out of ozone-depleting substances (ODS). ODS are defined as those substances that are known or could reasonably be anticipated to cause or contribute to stratospheric ozone depletion. Under Section 608, the U.S. Environmental Protection Agency (EPA) has established regulations through 40 CFR Part 82 that include: maximizing recycling of ozone-depleting compounds during servicing and disposal of air conditioning and refrigeration equipment; establishing requirements for recycling and recovery equipment, technicians and reclaimers; requiring the repair of substantial leaks in certain air conditioning and refrigeration equipment; and establishing safe disposal requirements. While there are no reporting requirements for ODS, recordkeeping is required that documents the usage of ODS and technician certification. Under Section 608, the EPA may conduct random inspections to determine compliance.

At the NTS, refrigerants containing ODS are mainly used in air conditioning units in vehicles and in buildings, refrigerators, water fountains, vending machines, and laboratory equipment. Halon 1211 and 1301, now classified as ODS, have been used in the past in fire extinguishers. Self-assessments are conducted periodically to document adherence to Title VI of the CAA.

Other NTS Air Quality Permit Requirements – Under Title V, Part 70 of the CAA amendments, all owners or operators of Part 70 sources must pay annual fees to the state. Any source which has the potential to emit 45.4 metric tons (mtons) (50 tons) or more of any regulated air pollutant, except carbon monoxide, must pay an annual fee of $3,000. Any source that has the potential to emit less than 22.7 mtons (25 tons) per year must pay an annual fee of $250. NTS operations are subject to these fees. In addition to permit fees, NNSA/NSO must allow the state of Nevada Bureau of Air Pollution Control to conduct inspections of NTS facilities and operations that are regulated by state air quality permits.

1.1.2 Compliance Status

See Table 1-1 for a summary of how NTS complied with air quality regulations in 2003.

1.1.3 Compliance Issues

The NTS Class II Air Quality Operating Permit (AP9711-0549) that regulates operations and emissions generated by aggregate-producing facilities, fuel-burning equipment, and fuel storage tanks, expired in February 2002. An application to renew the permit was submitted prior to the expiration date, but as of yet the renewed permit has not been issued. The delay in issuing the permit is due to a number of factors, including: a decision by the state to combine all NTS air permits into a single permit, permitting facilities that were not previously permitted, and issues pertaining to the opacity limit and more stringent reporting requirements for the HSC.

During CY 2003 and early CY 2004, meetings were held with the state to reach an agreement on some of the terms of the permit. It is anticipated that the renewed NTS air permit will be issued in CY 2004.

1.1.4 Compliance Reports

The following reports were generated for NTS operations in 2003 in compliance with air quality regulations:

- *National Emissions Standards for Hazardous Pollutants, Calendar Year 2003* (submitted to EPA Region IX)
- *Annual Asbestos Abatement Notification Form* (submitted to EPA Region IX)
- *Calendar Year 2003 Actual Production/Emissions Reporting Form* (submitted to the Nevada Division of Environmental Protection)
- HSC Pre-test and Post-test Reports (submitted to the Nevada Division of Environmental Protection)

1.2 Water Quality and Protection

1.2.1 Applicable Regulations

Clean Water Act (CWA) – The CWA establishes the basic structure for regulating discharges of pollutants into the waters of the U.S. It gives the EPA the authority to implement pollution control programs such as setting wastewater standards for industry. The CWA also sets water quality standards for all contaminants in surface waters. At the NTS, applicable CWA regulations are followed through compliance with permits issued by the Nevada Division of Environmental Protection (NDEP) and the Nevada State Health Division, Bureau of Health Protection Services (BHPS) for wastewater discharges and disposal of wastewater from facilities.

NTS operations which may be affected by the CWA involve the disturbance of drainage patterns into "waters of the U.S." and disturbance to naturally-occurring wetlands from construction activities or other site operations. There are two intermittently wet lakes or playas (Yucca Lake and Frenchman Lake) which are potential "waters of the U.S.," which may fall under the jurisdiction of the U.S. Army Corps of Engineers (USACE) and the Section 404 permit regulations of the CWA. NNSA/NSO has obtained a determination from the USACE that NTS playas and ephemeral washes are only "potential" waters of the U.S.; however, NDEP has not endorsed this determination. NDEP has indicated that these potential areas will be regulated as "waters of the State." No determination has been obtained yet from the USACE regarding the status of the vegetated wetlands, but they are protected and managed on the NTS by NNSA/NSO as unique, valuable wildlife habitats (see Section 1.9).

Safe Drinking Water Act (SDWA) – Established to protect the quality of drinking water in the U.S., this law focuses on all waters actually or potentially designed for drinking use, whether from above ground or underground sources. It authorizes the EPA to establish safe standards of purity and requires all owners or operators of public water systems to comply with primary (health-related) standards. State governments, which assume this power from the EPA, also set Secondary Standards, which are related to taste, odor, and visual aspects of drinking water. Nevada state law pertaining to public water systems (NAC 445A) ensures that such water systems meet the EPA water quality standards specified under the SDWA.

Nevada Administrative Code (NAC) 445A: Water Controls (Public Water Systems) – Enforces the SDWA requirements. This Nevada regulation sets standards for permitting, design, construction, operation, maintenance, certification of operators, and water quality of public water systems (PWS). The NTS has three PWS that are monitored to ensure they meet water quality standards, and that they follow the other applicable requirements in the regulation. The BHPS regulates the three NTS PWS through the issuance of permits. Although the SDWA sets drinking water standards for radionuclides, the state of Nevada does not require radionuclide monitoring of drinking water on the NTS because the NTS does not have a "community water system" (a PWS having at least 15 service connections and used by year-round residents). However, all potable water supply wells are monitored on the NTS for radionuclides in compliance with DOE Order 5400.5 *Radiation Protection of the Public and the Environment* (see Section 1.3).

NAC 444 and 445A: Water Controls (Water Pollution Control) – Regulates the collection, treatment, and disposal of wastewater and sewage at the NTS. The requirements of this state regulation are issued in permits for sewage lagoons, septic tanks, and septic hauler contractors and pumpers. In 2003, NNSA/NSO held a general permit covering three active sewage lagoon systems and eight inactive sewage lagoon systems, seven active systems, four septic tank pumpers, one septic tanker, and one septic pumper contractor (see Table 1-12 for list of all 2003 NTS permits). NDEP regulates the permits for active and inactive NTS sewage lagoons. Water quality and toxicity of the active sewage lagoons are monitored quarterly and annually, respectively, to meet permit requirements. In 2003, all 16 septic systems on the NTS processed less than 5,000 gallons/day (18,927 liters/day), therefore they are not regulated by NDEP. The BHPS regulates the NTS septic systems as commercial individual systems which treat domestic sewage only in quantities less than 5,000 gallons/day. The BHPS does not require collection or analysis of sewage samples from these septic systems.

NAC 534: Nevada Division of Water Resources Regulations for Water Well and Related Drilling – Regulates the drilling and construction of new wells and the reworking of existing wells in order to prevent the waste of underground waters and their pollution or contamination. Two site operations that are affected by this state regulation are the Underground Test Area (UGTA) Project and the Borehole Management Project. New water wells are drilled for ongoing UGTA investigations of site-specific hydrogeologic characteristics, underground source terms, and contaminant movement through groundwater. Over 1,100 existing boreholes on the NTS are being plugged according to these regulations, under the Borehole Management Project.

1.2.2 Compliance Status

See Table 1-2 for a summary of how NTS complied with water quality and protection regulations in 2003.

1.2.3 Out-of-Compliance Incidents

Water Pollution Control General Permit GNEV93001 – On January 21, 2003, approximately 1,700 gallons (6,435 liters) of condensate blowdown (oil/water mixture) was pumped from a drilling site tank and inadvertently disposed in a lined secondary lagoon in Area 12 that is used as a drying bed for portable toilet waste containing propylene glycol (anti-freeze). Also, on February 18, 2003, approximately 15 gallons (56.8 liters) of diesel fuel was released to a floor drain in the boiler room of Building 111, Area 23 which subsequently drained into the Area 23 sewage lagoon system. These accidental releases of petroleum products into NTS sewage treatment facilities were reported to the state as per the requirements of the permit (see Section 1.11). Table 1-11 provides a full description of these reportable spills. No fines or penalties were incurred by these two un-permitted discharges.

1.2.4 Compliance Reports

The following reports were generated for NTS operations in 2003 in compliance with water quality regulations:

- *Quarterly Monitoring Report for Nevada Test Site Sewage Lagoons* was submitted April 3, July 3, and October 3, 2003, and January 4, 2004 to NDEP (in compliance with permit #GNEV93001).
- Results of water quality analyses for PWSs were sent to the state throughout the year as they were obtained from the laboratory.

1.3 Radiation Protection

1.3.1 Applicable Regulations

Clean Air Act (CAA), 40 CFR 61 Subpart H, National Emission Standards for Hazardous Air Pollutants (NESHAP) – NESHAP establishes radiation dose limit of 10 mrem/yr (0.1 mSv/yr) to individuals in the general public from just the air pathway. Sources of radioactive emissions on the NTS include: evaporation of tritiated water (HTO) from containment ponds; diffusion of HTO vapor from the soil (at Area 5 Radioactive Waste Management

Complex, Sedan crater, and Schooner crater); tritium gas released during experiment test calibrations at Building CP-50 in Area 6; and re-suspension of plutonium and americium from contaminated soil at nuclear device safety test and atmospheric test locations. NTS compliance in 2003 with NESHAP for radiological air emissions is summarized in Table 1-1 and Table 1-3.

Safe Drinking Water Act (SDWA) – The National Primary Drinking Water Regulations (40 CFR 141), promulgated by the SDWA (Federal Register, Vol. 65, No. 236, December 7, 2000), requires that the maximum contaminate level goal for any radionuclide be zero. But, when this is not possible (e.g., in groundwater containing naturally-occurring radionuclides), the SDWA specifies that the concentration of one or more radionuclides should not result in a whole body or organ dose greater than 4 mrem/yr (0.04 mSv/yr). Sources of radionuclide contamination in groundwater are the numerous underground nuclear tests conducted at the NTS which were detonated near or below the water table.

DOE Order 5400.5, "Radiation Protection of the Public and the Environment" – Protection of the public and the environment is further mandated by this Order and by flow-down procedural standards established to help implement the objectives of the Order. DOE Order 5400.5 establishes requirements for: (1) measuring radioactivity in the environment, (2) applying the ALARA process (As Low As Reasonably Achievable) to all operations, (3) using mathematical models for estimating radiation doses, (4) releasing property having residual radioactive material, and (5) maintaining records demonstrating compliance with the requirements. DOE Order 5400.5 specifies a radiation dose limit of 100 mrem/yr (1 mSv/yr) to individuals in the general public from all pathways of exposure combined. DOE Order 5400.5 also provides the derived concentration guides (DCGs) for all radionuclides. The DCGs are the annual average concentrations of a radionuclide that could deliver a dose of 100 mrem/yr. The DCGs are provided as reference values to use in radiological protection programs at DOE facilities.

DOE Standard DOE-STD-1153-2002 – This Standard, titled *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE, 2002a), provides methods, computer models, and guidance in implementing a graded approach to evaluating the radiation doses to populations of aquatic animals, terrestrial plants, and terrestrial animals residing on DOE facilities. A dose limit of 1 rad/d (10 mGy/d) for terrestrial plants and aquatic animals, and of 0.1 rad/d (1 mGy/d) for terrestrial animals is specified by this DOE standard. Dose rates below these levels are believed to cause no measurable adverse effects to populations of plants and animals.

DOE Order 435.1, "Radioactive Waste Management" – This order ensures that all DOE radioactive waste is managed in a manner that is protective of the worker, public health and safety, and the environment. This orders' directive manual (DOE M435.1-1) specifies that operations at the RWMC (includes the Area 5 and Area 3 RWMSs) must not contribute a dose to the general public in excess of 25 mrem/yr. The order also directs how radioactive waste management operations are conducted on the NTS. These operational requirements are summarized in the next section of this report (Section 1.4) titled Waste Management and Environmental Restoration.

DOE Order 450.1, "Environmental Protection Program" – This DOE Order requires federal facilities to: "Conduct environmental monitoring to detect, characterize, and respond to releases from DOE activities; assess impacts; estimate dispersal patterns in the environment; characterize the pathways of exposure to members of the public; characterize the exposures and doses to individuals, to the population; and to evaluate the potential impacts to the biota in the vicinity of the DOE activity." Such releases, exposures, and doses apply to radiological contaminants.

1.3.2 Compliance Status

See Table 1-3 for a summary of how NTS complied with radiation protection regulations in 2003.

1.3.3 Compliance Reports

In compliance with NESHAP under the CAA, the report titled *National Emissions Standards for Hazardous Pollutants, Calendar Year 2003,* was submitted to EPA Region IX in June 2004. This NTS Environmental Report was generated to report 2003 compliance with DOE Order 5400.5 and DOE-STD-1153-2002.

1.4 Waste Management and Environmental Restoration

1.4.1 Applicable Regulations

10 CFR 830: Nuclear Safety Management – Establishes requirements for the safe management of DOE contractor and subcontractor work at DOE's nuclear facilities. It governs the possession and use of special nuclear material, and byproduct materials deemed necessary for the protection of health and minimization of danger to life or property. Part 830 also covers activities at facilities even where no nuclear material is present such as facilities that prepare the non-nuclear components of nuclear weapons, but which could cause radiological damage at a later time. It governs the conduct of the "management and operating contractor and other persons at DOE nuclear facilities" (including visitors to the facility). When coupled with the Price-Anderson Amendments Act (PAAA) of 1988 (Section 234A to the Atomic Energy Act) it provides DOE with authority to assess civil penalties for violation of rules, regulations or orders relating to nuclear safety by contractors, subcontractors, and suppliers who are indemnified under PAAA. The broad intent of the regulation is to ensure compliance with all enforceable rules, regulations, or orders relating to nuclear safety adopted by DOE for the NTS.

DOE Order 435.1, "Radioactive Waste Management" – Ensures that all DOE radioactive waste is managed in a manner that is protective of the worker, public health and safety, and the environment. Radioactive waste management activities conducted on the NTS which are subject to this Order include:

- Characterization of low level radioactive waste (LLW) and mixed low level radioactive waste (MW) generated by DOE within the state of Nevada.
- Disposal of LLW and MW at the Radioactive Waste Management Complex (RWMC) which includes the Area 3 Radioactive Waste Management Site (RWMS) and the Area 5 RWMS.
- Characterization, visual examination, and repackaging of transuranic (TRU) waste at the Waste Examination Facility (WEF) just south of RWMS 5.
- Loading of TRU waste at the Mobile Loading Unit (MLU) at the Area 5 RWMS for shipment to the Waste Isolation Pilot Plant (WIPP) at Carlsbad, New Mexico.

Resource Conservation and Recovery Act (RCRA) – Ensures the safe and environmentally responsible management of hazardous and non-hazardous solid waste. RCRA (1976, 1996) and the Hazardous and Solid Waste Amendments of 1984 constitute the statutory basis for the regulation of hazardous waste and underground storage tanks (USTs). Under Section 3006 of RCRA, the EPA may authorize states to administer and enforce hazardous waste regulations. Nevada has received such authorization and acts as the primary regulator for many NNSA/NSO facilities.

The state of Nevada has issued a RCRA Hazardous Waste Operating Permit (NEV HW009) to NNSA/NSO. The permit governs operation of the Hazardous Waste Storage Unit (HWSU) in Area 5, the Explosive Ordnance Disposal Unit (EODU) in Area 11, and the disposal of MW at the Pit 3 Mixed Waste Disposal Unit (P03U) at the Area 5 RWMS. The permit also prescribes post-closure monitoring for five closed waste sites on the NTS that are RCRA Part B-identified Corrective Action Units (CAUs). They include: the Area 23 Hazardous Waste Trenches (CAU 112), the U3fi Injection Well (CAU 91), the U3ax/bl Subsidence Crater (CAU 110), the Area 2 Bitcutter Containment, and the Area 6 Decon Pond.

The NTS has 5 USTs which are either (1) fully-regulated under RCRA and registered with the state (1 tank), (2) regulated under RCRA and registered with the state, but deferred from leak detection requirements (1 tank), or (3) excluded from federal and state regulation (3 tanks). The NTS UST program reports, upgrades, and removes USTs as per regulatory compliance schedules.

RCRA also requires generators of hazardous waste to have a program in place to reduce the volume or quantity and toxicity of such waste. These waste reduction requirements and NTS compliance with them are addressed under the Pollution Prevention and Waste Minimization sections of this Environmental Report (Section 1.7, Section 10.0).

The specific Nevada laws which govern hazardous waste management operations mentioned above are the Facilities for Management of Hazardous Waste (NAC 444.842-8482) and the Disposal of Hazardous Waste (NAC 444.850-8746).

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/ Superfund Amendments and Reauthorization Act (SARA) – Provides a framework for the cleanup of waste sites containing hazardous substances and an emergency response program in the event of a release of a hazardous substance to the environment. There are no hazardous waste cleanup operations on the NTS which are regulated under CERCLA as they are regulated under RCRA. The only applicable requirements of CERCLA applicable to NTS operations pertain to an emergency response program for hazardous substance releases to the environment (see discussion of Emergency Planning and Community Right-to-Know Act in Section 1.5).

Federal Facility Compliance Act (FFCA) – Extends the full range of enforcement authorities in federal, state, and local laws for management of hazardous wastes to federal facilities, including the NTS. Compliance with this act is demonstrated by compliance with other federal and state waste regulations applicable to the NTS listed in this section.

Federal Facilities Agreement and Consent Order (FFACO) – Pursuant to Section 120(a)(4) of CERCLA and to Sections 6001 and 3004(u) of RCRA, NNSA/NSO, the Defense Threat Reduction Agency (formerly the Defense Nuclear Agency), and the state of Nevada entered into a FFACO in April 1996. This FFACO addressed the environmental restoration of historic contaminated sites at the NTS, parts of Tonopah Test Range (TTR), parts of the Nevada Test and Training Range (NTTR) (formerly known as Nellis Air Force Range), the Central Nevada Test Area (CNTA), and the Project SHOAL Area. Under the FFACO, hundreds of historic contaminated sites on and off the NTS have been identified for cleanup and closure.

40 CFR Subchapter I, Parts 239-299: Solid Wastes – At the NTS, these federal solid waste management regulations are followed through compliance with permits issued by the NDEP.

NAC 444.570-7499 – Solid Waste Disposal – Enforces the federal regulations pertaining to solid wastes (40 CFR Subchapter I, Parts 239-299). This Nevada regulation sets standards for solid waste management systems, including the storage, collection, transportation, processing, recycling, and disposal of solid waste. The NTS has four permitted landfills for solid waste disposal which are regulated and permitted by the state: Area 5 Asbestiform Low-Level Solid Waste Disposal Site, Area 6 Hydrocarbon, Disposal Site, Area 9 U10c Solid Waste Disposal Site, and Area 23 Solid Waste Disposal Site. These landfills are designed, constructed, operated, maintained, and monitored in adherence to the requirements of their state-issued permits.

1.4.2 Compliance Status

See Table 1-4 for a summary of how NTS complied with waste management and environmental restoration regulations in 2003.

1.4.3 Out-of-Compliance Incidents

On June 18, 2003, a front-end loader removed soil from within the boundaries of a posted use-restricted area to repair the UC-4 Mud Pit C cover at CNTA Corrective Action Unit 417. The use-restricted area was around the backfilled UC-4 Mud Pit B, a contaminated site identified under the FFACO which was closed in-place. The un-permitted soil removal violated the administrative control stipulations of the closure report for UC-4 Mud Pit B and was reported to the state. See Table 1-11 for a full description of this reportable event.

1.4.4 Compliance Reports

Quarterly reports were prepared and sent to the state for the amounts of hazardous wastes handled at the three RCRA permitted waste disposal facilities. Post-closure monitoring reports for the five RCRA Part B identified CAUs were prepared and submitted to the state. The following reports were also prepared in 2003 to comply with state permits for solid waste operation on the NTS:

- *Annual Asbestos Disposal Report* (for the Area 5 RWMS asbestiform LLW disposal cell P06U)
- *Quarterly LLW/MLLW Disposal Reports* (for all active LLW and MW disposal cells)
- *Biannual Neutron Monitoring Report for the Nevada Test Site Area 9 10c and Area 6 Hydrocarbon Landfills*
- *January – June 2003 Biannual Solid Waste Disposal Site Report for the Nevada Test Site Area 23 Sanitary Landfill*
- *July – December 2003 Biannual Solid Waste Disposal Site Report for the Nevada Test Site Area 23 Sanitary Landfill*
- *2003 Annual Solid Waste Disposal Site Report for the Nevada Test Site Area 6 Hydrocarbon Landfill and Area 9 U10c Landfills*

1.5 Hazardous Materials Control and Management

1.5.1 Applicable Regulations

Toxic Substances Control Act (TSCA) – Requires testing and regulation of chemical substances that enter the consumer market. Since the NTS does not produce chemicals, compliance with TSCA is primarily directed toward management of polychlorinated biphenyls (PCBs). The regulations implementing TSCA for the state of Nevada contain record keeping requirements for PCB activities (NAC 444.9452). There are no known pieces of PCB electrical equipment (transformers, capacitors or regulators) at the NTS; but remediation activities and maintenance of fluorescent lights can result in the disposal of PCB-contaminated waste and light ballasts, which are regulated. Waste classified as "bulk product waste" generated on the NTS can be disposed of onsite in the U10c landfill with prior state approval. PCB-containing light ballasts removed during normal maintenance can also go to an onsite landfill; but when remediation or upgrade activities generate several ballasts, these must be disposed of offsite at an approved PCB disposal facility. Soil and other materials contaminated with PCBs must also be sent offsite for disposal.

When PCB equipment or PCB fluids are managed during a calendar year, NNSA/NSO has been submitting an annual report to the EPA by July 1 of the following year. In 2003, NNSA/NSO determined that annual reports were not required to be sent to regulators since the NTS is not considered a commercial storer or disposer of PCBs.

Federal Insecticide, Fungicide, Rodenticide Act (FIFRA) – Sets forth procedures and requirements for pesticide registration, labeling, classification, devices for use, and certification of applicators. Use of non-registered pesticides (as available in consumer products) is not regulated. On the NTS, both registered and non-registered pesticides are applied under the direction of a state of Nevada certified applicator. Pesticide applications in food service facilities are subcontracted to state-certified vendors who provide these services.

Emergency Planning and Community Right-to-Know Act (EPCRA) – This act is a free-standing provision under Title III of the 1986 Superfund Amendments and Reauthorization Act (SARA Title III) amendments to CERCLA. It requires that federal, state, and local emergency planning authorities be provided information regarding the presence and storage of hazardous substances and their planned and unplanned environmental releases, including providing response to emergency situations involving hazardous materials. EO 13148 "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements," requires all federal facilities to comply with the provisions of EPCRA. Under EPCRA, NNSA/NSO is required to submit reports pursuant to Sections 302, 304, 311, 312, and 313 of SARA Title III described below.

> **Section 302-303, Planning Notification** – Requires that the state emergency response commission and the local emergency planning committee be notified when an extremely hazardous substance (EHS) is present at a facility in excess of the threshold planning quantity. An inventory of the location and amounts of all hazardous substances stored on the NTS is maintained and inventory data are included in a report produced annually called the Nevada Combined Agency (NCA) Report. Also, NNSA/NSO monitors hazardous materials while they are in transit on the NTS through a computerized system called HAZTRAK.
>
> **Section 304, Extremely Hazardous Substances Release Notification** – Requires that the local emergency planning committee and state emergency response agencies be notified immediately of accidental or

unplanned releases of an EHS to the environment. Also, the national response center is notified if the release exceeds the CERCLA reportable quantity for the particular hazardous substance.

Section 311-312, Material Safety Data Sheet (MSDS)/Chemical Inventory – Requires facilities to provide applicable emergency response agencies with MSDSs, or a list of MSDSs for each hazardous chemical stored on site. This is essentially a one-time reporting unless chemicals or products change. Any new MSDSs are provided annually in the NCA Report. Section 312 requires facilities to report maximum amounts of chemicals onsite at any one time. This report is submitted to the State Emergency Response Commission, the Local Emergency Planning Committee, and the local fire department.

Section 313, Toxic Release Inventory (TRI) Reporting – Requires facilities to submit an annual report entitled "Toxic Chemical Release Inventory, Form R" to the EPA and to the state if annual usage quantities of listed toxic chemicals exceed specified thresholds.

NAC Chapter 555 – Control of Insects, Pests and Noxious Weeds (NAC 555) – Provides regulatory framework for certification of several classifications of registered pesticide and herbicide applicators in the state of Nevada. The Nevada Department of Agriculture (NDOA) administers this program and has the primary role to enforce FIFRA in Nevada. Inspections of pesticide/herbicide applicator programs are carried out by NDOA. Restricted use pesticides are not used by BN at the NTS.

NAC Chapter 444 – Polychlorinated Biphenyl – This code incorporates by reference the federal requirements for the handling, storage, and disposal of PCBs at the NTS.

State of Nevada Chemical Catastrophe Prevention Act – This state act directed the NDEP to develop and implement an accident prevention program which was named the Chemical Accident Prevention Program (CAPP). The act requires registration of facilities storing EHSs above listed thresholds. A report is submitted to the NDEP if any storage quantity thresholds are exceeded.

1.5.2 Compliance Status

See Table 1-5 for a summary of how NTS complied with regulations for hazardous materials control and management in 2003.

1.5.3 Compliance Reports

The following reports were generated for NTS operations in 2003 in compliance with hazardous materials control and management regulations:

- *Nevada Combined Agency Report - Calendar Year 2003* submitted to state and local agencies on March 5, 2004.
- *Toxic Release Inventory Report, Form R for CY2003 Operations* submitted to the EPA and to the state on June 23, 2004.
- *Nevada Chemical Accident Prevention Program Report for CY2003 Operations* submitted to the state on June 21, 2004.
- *Calendar Year (CY) 2002 Polychlorinated Biphenyls (PCBs) Report for the Nevada Test Site (NTS)*, submitted to the EPA on May 22, 2003.
- *PCB Annual Report for the NTS, Calendar Year 2003* (this report was prepared, but is no longer required to be submitted to the EPA).

1.6 Environmental Impact Analysis

1.6.1 National Environmental Policy Act

Before any project or activity is initiated at the NTS, it must be evaluated for possible impacts to the environment. Under the National Environmental Policy Act (NEPA) federal agencies are required to consider environmental effects and values and reasonable alternatives before making a decision to implement any major federal action that may have a significant impact on the human environment. NNSA/NSO uses four levels of documentation to demonstrate compliance with NEPA:

- Environmental Impact Statement (EIS) – a full disclosure of the potential environmental effects of proposed actions and the reasonable alternatives to those actions.
- Environmental Assessment (EA) – a concise discussion of proposed actions and alternatives and the potential environmental effects to determine if an EIS is necessary.
- Supplement Analysis (SA) – a collection and analysis of information for an action already addressed in an existing EIS or EA, to determine whether a supplemental EIS/EA should be prepared, a new EIS/EA should be prepared, or whether no further NEPA documentation is required.
- Categorical Exclusion (CX) – a category of actions which do not have a significant adverse environment impact based on similar previous activities, and for which, therefore, neither an EA nor an EIS is required.

A NEPA Environmental Evaluation Checklist (Checklist) is completed for all proposed projects or activities on the NTS, as required under the NNSA/NV Work Acceptance Process Procedural Instructions (Carlson, 2000). The Checklist is reviewed by the NNSA/NSO NEPA Compliance Officer to determine whether the activity's environmental impacts have been addressed in any existing NEPA documents. If a proposed project has not been covered under any previous NEPA analysis and it does not qualify as a CX, then a new NEPA analysis is performed, which may result in preparation of a new EA or a new SA to the existing programmatic NTS EIS (DOE, 1996). The NEPA Compliance Officer must approve each Checklist before a project proceeds.

1.6.2 Compliance Status

See Table 1-6 for a summary of how NTS complied with NEPA in 2003.

1.7 Pollution Prevention and Waste Minimization

1.7.1 Applicable Regulations

Resource Conservation and Recovery Act of 1976 (RCRA) – Through 42 USC 6922 (b) (1) of RCRA, generators of hazardous waste are required to have a program in place to reduce the volume or quantity and toxicity of such waste to the degree determined by the generator to be economically practicable. Through 42 USC 6962 of RCRA, the EPA was required to develop a list of types of commercially-available products (e.g., copy machine paper, plastic desk top items) and then specify that a certain minimum percentage of the product type's content be comprised of recycled materials if they are to be purchased by a federal agency (e.g., all federally-purchased copy machine paper must be comprised of a minimum of 30 percent recycled paper). It then requires federal facilities to have a procurement process in place to ensure that they purchase product types which satisfy the EPA-designated minimum percentages of recycled material.

EO 13101, "Greening the Government through Waste Prevention, Recycling and Federal Acquisition" – This EO requires federal facilities to incorporate waste prevention and recycling into daily operations. It requires federal facilities to maintain an affirmative procurement process that ensures that 100 percent of products purchased which are found on the EPA-designated product list contain recycled material at the EPA-specified minimum content. The Secretary of Energy's goal is for DOE sites to become 100 percent compliant with this EO by the end of CY 2005.

DOE Order 450.1, "Environmental Protection Program" – This DOE Order requires federal facilities to implement an Environmental Management System (EMS) that includes pollution prevention. The EMS must be fully integrated into the site Integrated Safety Management System (ISMS).

Nevada Division of Environmental Protection (NDEP) Hazardous Waste Permit Number NEV HW009 – This state permit for hazardous waste management activities at the NTS requires the permittee to maintain an Annual

Waste Minimization Summary Report in the Facility Operating Records which should include a description of the efforts undertaken during the year to reduce the volume and toxicity of waste generated as per RCRA, 42 USC 6922 (b) (1), and a description of the changes in volume and toxicity of waste actually achieved during the year in comparison to previous years to the extent such information is available for the years prior to 1984.

Secretary of Energy's Pollution Prevention and Energy Efficiency Leadership Goals – On November 12, 1999, the Secretary of Energy set numerous pollution prevention and energy efficiency goals that each DOE site is required to meet. They include goals for: (1) reducing wastes, (2) increasing recycling and purchases of recycled materials, and (3) reducing ODS and greenhouse gasses. Table 1-7b presents the status of site compliance with the first two goals.

1.7.2 Compliance Status

See Tables 1-7a and 1-7b for a summary of how NTS complied with pollution prevention and waste minimization regulations in 2003.

1.7.3 Compliance Issues

The 1993 baselines for LLW, MW, and TRU waste were all 0 m^3. However, the new JASPER and ATLAS projects will generate routine radioactive wastes in the future. As long as these projects generate routine radioactive waste, NNSA/NSO will not be able to meet the leadership goals for reducing these waste types.

Before CY 2001, NNSA/NSO was not required to submit a Toxic Release Inventory (TRI) (also known as a Form R report) to the EPA. Effective January 1, 2001, the EPA lowered the reporting threshold for lead, a toxic chemical subject to TRI reporting, to 100 pounds (45 kilograms). NNSA/NSO has since reported lead releases from ammunition at the security contractor firing range on the NTS. No reduction in lead releases is anticipated as long as lead ammunition continues to be used.

NNSA/NSO only recycled 7 percent of solid waste generated by all operations in CY 2003 (leadership goal is 45 percent). Only 5 percent of waste resulting from cleanup, stabilization, and decommissioning activities was reduced in CY 2003 (leadership goal is 10 percent). Because of an accelerated cleanup schedule, large volumes of waste were generated and disposed in landfills. Little attempt was made to salvage any of this waste before disposal. As a result, waste generation totals were inflated, lowering the percentage of waste reduced/recycled.

In CY 2003, 86 percent of NNSA/NSO purchases of EPA-designated items contained recycled materials. NNSA/NSO is working to improve the environmentally preferable procurement process in order to meet the CY 2005 leadership goal of 100 percent.

1.7.4 Compliance Reports

The compliance reports generated in 2003 to comply with pollution prevention and waste minimization (P2/WM) directives are presented in Table 1-7a.

1.8 Historic Preservation and Cultural Resource Protection

1.8.1 Applicable Regulations

National Historic Preservation Act of 1966, as amended – Section 106 requires federal agencies to take into account the effect of their undertakings on properties included in, or eligible for inclusion in, the National Register of Historic Places (NRHP) and to consult with interested parties. The Section 106 process involves the agency reviewing background information, conducting an effort to identify National Register eligible properties within the area of potential effect, making a determination of effect (when applicable), and developing a mitigation plan when an adverse effect is unavoidable. Determinations of eligibility, effect, and mitigation are conducted in consultation with the Nevada State Historic Preservation Officer and, in some cases, the Advisory Council on Historic Preservation.

Section 110 sets out the broad historic preservation responsibilities of federal agencies and is intended to ensure that historic preservation is fully integrated into the ongoing programs of all federal agencies. Included in this directive, is the requirement that federal agencies develop and implement a Cultural Resources Management Plan. Federal agencies are also required to identify and evaluate the eligibility of historic properties for long-term management, as well as for future project-specific planning. Agencies are also required to maintain archaeological collections and their associated records at professional standards. At the NTS, a long-term management strategy includes (1) monitoring NRHP-listed and eligible properties to determine if environmental or other actions are negatively affecting the integrity or other aspects of eligibility and (2) taking corrective actions if necessary.

EO 11593, "Protection and Enhancement of the Cultural Environment" – This EO reinforces the obligation of federal agencies to conduct adequate surveys to locate any and all sites of historic value under their jurisdiction. This law also requires proper curation of artifacts and associated records from NNSA/NSO undertakings and lands under the agency's jurisdiction.

Archeological Resources and Protection Act of 1979 – The purpose of this act is to secure, for the present and future benefit of the American people, the protection of archaeological resources and sites which are on public lands and Indian lands, and addresses the irreplaceable heritage of archaeological sites and materials. It requires the issuance of a federal archaeology permit to qualified archaeologists for any work that involves excavation or removal of archaeological resources on federal and Indian lands and notification to Indian tribes of these activities. Unauthorized excavation, removal, damage, alteration, or defacement of archaeological resources is prohibited, as is the sale, purchase, exchange, transport, receipt of, or offer for sale of, such resources. Criminal and civil penalties apply to such actions. Information concerning the nature and location of any archaeological resource may not be made available to the public unless the federal land manager determines that the disclosure would not create a risk of harm to the resources or site. Also, this law reinforces the requirement under the Archeological and Historic Preservation Act of 1974 that the Secretary of Interior submit an annual report at the end of each fiscal year to Congress. The report indicates the scope and effectiveness of all federal agencies' efforts on the protection of archaeological resources, specific projects surveyed, resources excavated or removed, damage or alterations to sites, criminal and civil violations, the results of permitted archaeological activities, and the costs incurred by the federal government to conduct this work. All archaeologists working at the NTS must have qualifications that meet federal standards and work under a permit issued by NNSA/NSO. In the event of vandalism, NNSA/NSO would need to investigate the actions.

American Indian Religious Freedom Act of 1978 – This law established the government policy to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise the traditional religions, including but not limited to access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites. There are locations on the NTS that have religious significance to Western Shoshone and Southern Paiute and visits to these places involve prayer and other activities. Access is provided by NNSA/NSO as long as there are no safety or health hazards.

Native American Graves Protection and Repatriation Act of 1990 (NAGPRA) – This act requires federal agencies to identify Native American human remains, funerary objects, sacred objects, and objects of cultural patrimony in their possession. Agencies are required to prepare an inventory of human remains and associated funerary objects, and a summary with a general description of sacred objects, objects of cultural patrimony, and unassociated funerary objects. Through consultation with Native American tribes, the affiliation of the remains and objects are determined and the tribes can request repatriation of their cultural items. The agency is required to publish a notice of inventory completion in the Federal Register. The law also protects the physical location where human remains are placed during a death rite or ceremony. The NTS artifact collection is subject to NAGPRA and the locations of American Indian human remains at the NTS have to be protected from NTS activities.

1.8.2 Compliance Status

See Table 1-8 for a summary of how NTS complied with historic preservation and cultural resource protection regulations in 2003.

1.8.3 Compliance Reports

NNSA/NSO submits Section 106 cultural resources survey reports and historical evaluations to the Nevada State Historic Preservation Office for review and concurrence. Mitigation plans and mitigation documents also are submitted to the Nevada State Historic Preservation Office and some types of documents go to the Advisory Council on Historic Preservation and the National Park Service. Reports containing restricted data on site locations are not available to the public. Some technical reports, however, are available to the public upon request and can be obtained from the National Technical Information Service. The 2003 reports submitted to agencies are discussed in Section 11.

1.9 Conservation and Protection of Biota and Wildlife Habitat

1.9.1 Applicable Regulations

Endangered Species Act (ESA) – Section 7 of this act requires federal agencies to ensure that their actions do not jeopardize the continued existence of federally listed endangered or threatened species or their critical habitat. The desert tortoise is the only animal on the NTS protected under this Act. It is listed as threatened. NTS activities within tortoise habitat are conducted so as to comply with the terms and conditions of a Biological Opinion issued by the U.S. Fish and Wildlife Service (FWS).

Migratory Bird Treaty Act (MBTA) – Prohibits the harm of any migratory bird, their nest, or eggs without authorization by the Secretary of the Interior. All but two of the 239 bird species observed on the NTS (Wills and Ostler, 2001) are protected under this act. Biological surveys are conducted for projects to prevent direct harm to protected birds, nests, and eggs.

Bald Eagle Protection Act – Prohibits the capture or harm of bald and golden eagles without special authorization. Both bald and golden eagles occur on the NTS. Biological surveys are conducted for projects to prevent direct harm to eagles, their nests, and eggs.

Clean Water Act, Section 404, Wetlands Regulations – Regulates land development affecting wetlands by requiring a permit obtained from the USACE to discharge dredged or fill material into waters of the United States, which includes most wetlands on public and private land. NTS projects are evaluated for their potential to disturb wetlands and their need for Section 404 permit application. Although there are more than 20 water sources on the NTS (see Appendix A, Figure A-7), none meet the criteria needed to be considered "jurisdictional" wetlands. Support for this finding has been officially requested from USACE, but has yet to be received.

National Wildlife Refuge Administration Act – Forbids a person to knowingly disturb or injure vegetation or kill vertebrate or invertebrate animals, their nests, or eggs on any National Wildlife Refuge lands unless permitted by the Secretary of the Interior. The boundary of the Desert National Wildlife Refuge (DNWR) land administered within this System is approximately 5 km (3.1 mi) downwind of the HSC. Biological monitoring is conducted to verify that approved tests do not disperse toxic chemicals that could harm biota on DNWR.

EO 11990, "Protection of Wetlands" – Requires governmental agencies to minimize the destruction, loss, or degradation of wetlands and preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities, including managing federal lands and facilities. Projects are evaluated for their potential to disturb the more than 20 natural water sources on the NTS (see Appendix A, Figure A-7). NTS wetlands are monitored to document their use by wildlife even though it is unlikely they would be considered "jurisdictional" wetlands because they are isolated wetlands that are not on Indian lands, nor used for recreation (e.g., bird watching, photography, or hunting). The change in jurisdictional status of NTS wetlands by the USACE is due to a recent ruling by the U.S. Supreme Court over isolated waters of the U.S. (Solid Waste Agency of Northern Cook County vs. U.S. Army Corps of Engineers, No. 99-1178, January 9, 2001).

EO 11988, "Floodplain Management" – Ensures protection of property and human wellbeing within a floodplain, and protection of floodplains themselves. The Federal Emergency Management Agency (FEMA) publishes guidelines and specifications for assessing alluvial fan flooding. NNSA/NSO generally satisfies EO 11988 through DOE Order 420.1, *Facility Safety*, and invoked standards. DOE Order 420.1 and the associated implementation guide for mitigation of natural phenomena hazards, call for a graded approach to assessing risk to all facilities (Structures, Systems, and Components [SSC]) from potential natural hazards. Chapter 4 of DOE Standard 1020 (DOE-STD-1020-2002) provides flood design and evaluation criteria for SSC. Evaluations of flood hazards at the NTS are generally conducted to ensure protection of property and human wellbeing.

EO 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds" – Directs federal agencies to take certain actions to further implement the MBTA if agencies have, or are likely to have, a measurable negative effect on migratory bird populations. It also directs federal agencies to support the conservation intent of the MBTA and conduct actions, as practicable, to benefit the health of migratory bird populations. NTS projects are evaluated for their potential to impact such bird populations.

EO 13112, "Invasive Species" – Directs federal agencies to act to prevent the introduction of, or to monitor and control, invasive (non-native) species, to provide for restoration of native species, and to exercise care in taking actions that could promote the introduction or spread of invasive species. Land-disturbing activities on the NTS have resulted in the spread of numerous invasive plant species. Habitat reclamation and other controls are evaluated and conducted when feasible to control such species and meet the purposes of this EO.

Wild Free-Roaming Horse and Burro Act – Requires the protection, management, and control of wild horses and burros on public lands and calls for the management and protection of these animals in a manner that is designed to achieve and maintain a thriving natural ecological balance. Wild horses on the NTS may wander off the NTS onto public lands and therefore are protected under this act. This act makes it unlawful to harm wild horses and burros.

Five-Party Cooperative Agreement – Agreement between NNSA/NSO, Nellis Air Force Base, FWS, Bureau of Land Management (BLM), and the state of Nevada Clearinghouse that calls for cooperation in conducting resource inventories and developing resource management plans for wild horses and burros and to maintain favorable habitat on federally withdrawn lands for these animals. BLM considers NTS a zero herd-size management area. NNSA/NSO consults with BLM regarding any issue of NTS horse management.

NAC 503.010-503.104 Protection of Wildlife – Identifies Nevada animal species which are protected and un-protected and prohibits the harm of protected species without special permit. Over 200 bird species and one bat species on the NTS are State-protected. Biological surveys are conducted for projects to prevent direct harm to protected birds, nests, eggs, and protected bats.

NAC 527.270 Protection of Flora – Specifies that the State Forester Firewarden determines the protective status of a Nevada plant and prohibits removal or destruction of protected plants without special permit. Currently, no State-protected plant species are known to occur on the NTS. Annual reviews of the protection status of NTS plants are conducted.

1.9.2 Compliance Status

See Table 1-9 for a summary of how NTS complied with regulations related to the conservation and protection of biota and wildlife habitat in 2003.

1.9.3 Out-of-Compliance Incidents

Thirty-five reports of mortality among migratory birds were recorded in 2003 (see Table 12-6). They included 30 mourning doves (*Zenaida macroura*), 15 which died of predation, and 15 of disease; an electrocuted great-horned owl (*Bubo virginianus*); an electrocuted red-tailed hawk (*Buteo jamaicensis*); a road-killed chukar (*Alectoris chukar*); a road-killed loggerhead shrike (*Lanius ludovicianus*); and a Say's phoebe (*Sayornis saya*) that died of unknown causes. The great-horned owl and the red-tailed hawk are also state-protected raptors. Since 1990, a cumulative total of 10 electrocutions and 22 road-kills have been recorded. The electrocutions and road-kills in 2003 occurred at different locations. No feasible mitigation actions were identified or taken to reduce future bird mortality from these causes.

1.9.4 Compliance Reports

The following reports were prepared in 2003 to meet requirements of the regulations or to document compliance activities:

- *Annual Report of Actions Taken Under Authorization of the Biological Opinion on Nevada Test Site Activities (File No. 1-5-96-F-33) – January 1, 2003 Through December 31, 2003,* submitted to the FWS Southern Nevada Field Office in January 2004
- Annual report for handling permit S23391 for 2003, submitted via email to Nevada Division of Wildlife on January 20, 2004
- Annual report for Federal Migratory Bird Scientific Collecting Permit MB008695-0, submitted via FAX to FWS Portland Office on December 22, 2003
- *Ecological Monitoring and Compliance Program Fiscal Year 2003 Report, DOE/NV11718--850, December 2003*

1.10 Environmental Management System

1.10.1 Applicable Regulations

EO 13148, "Greening the Government through Leadership in Environmental Management" – This EO requires federal facilities to have an EMS that considers potential environmental impacts in all aspects of its work. This is especially important in the work planning and budgeting stages. Pollution prevention, eliminating potential wastes, and recycling materials must always be addressed when planning work. The EO requires that the EMS be in place by December 31, 2005.

DOE Order 450.1 "Environmental Protection Program" – requires each DOE facility to implement an EMS which is a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals. The objectives are to implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by DOE operations and by which DOE cost effectively meets or exceeds compliance with applicable environmental; public health; and resource protection laws, regulations, and DOE requirements. The EMS must be fully integrated into each DOE site's ISMS by December 31, 2005.

1.10.2 Compliance Status

See Table 1-10 for a summary of how NTS complied with EMS regulations.

1.10.3 Compliance Reports

NNSA/NSO submitted quarterly reports to DOE/HQ in 2003 regarding progress towards meeting interim goals that were established to help facilities meet the December 31, 2005 deadline.

1.11 Occurrence Reporting/Releases

1.11.1 Applicable Regulations

40 CFR 302.1 – 302.8: Designation, Reportable Quantities, and Notification – Requires facilities to notify federal authorities of spills or releases of certain hazardous substances designated under CERCLA and the CWA. It specifies what quantities of hazardous substance spills/releases must be reported to authorities and delineates the notification procedures for a release that equals or exceeds the reportable quantities.

NAC 445A.345 – 445.348: Notification of Release of Pollutant – Requires state notification for the unplanned or accidental releases of specified quantities of pollutants, hazardous wastes, and contaminants.

Water Pollution Control General Permit GNEV93001 – This general wastewater discharge permit issued by the state to the NTS specifies that no petroleum products will be discharged into treatment works without first being processed through an oil/water separator or other approved methods. It also specifies how NNSA/NSO shall report each bypass, spill, upset, overflow, or release of treated or untreated sewage.

Other NTS Permits/Agreements – As with General Permit GNEV93001 mentioned above, there are other state permits and agreements cited in previous subsections of this chapter (e.g., FFACO) which specify that accidents or events of non-compliance must be reported. They include events that may create an environmental hazard.

1.11.2 Compliance Status

Five reportable environmental occurrences which involved un-permitted discharges into sewage lagoons, spills of fluids onto soil, and the mishandling of potentially-contaminated soil occurred in 2003, and are described in Table 1-11. Accidental spills or releases during 2003 which were less than federal or state-designated reportable quantities are not presented in Table 1-11. The direct, contributing, and root causes of these occurrences were determined and were described within occurrence reports prepared for each occurrence and submitted to NNSA/NSO by the BN Environmental Compliance Department (ECD).

1.11.3 Continuous Releases

Section 103(f)(2) of CERCLA provides that releases of hazardous substances that are "continuous" and "stable in quantity and rate" may qualify for reduced reporting (notification requirements). There are no continuous releases on the NTS.

1.12 Summary of Permits

Table 1-12 presents the complete list of all federal and state permits active in 2003 that have been issued to NNSA/NSO and to BN for NTS operations and which have been referenced in previous subsections of this chapter. The table includes those pertaining to air quality monitoring, operation of drinking water and sewage systems, hazardous materials and hazardous waste management and disposal, and endangered species protection. Reports associated with these permits are submitted to the appropriate designated state or federal office. Copies of reports may be obtained upon request.

Table 1-1. NTS compliance status with applicable air quality regulations

Compliance Measure/Actions	Compliance Limit	Compliance Status - 2003	Section Reference[a]
Clean Air Act – NESHAP			
Annual dose equivalent from all radioactive air emissions	10 mrem/yr[b]	Compliant 0.10 mrem/yr[b]	2.1.3.2; 7.1.2.3
Notify EPA Region IX if the number of linear or square feet of asbestos to be removed from a facility exceeds limit.	260 linear ft or 160 ft^2[c]	Compliant	2.2.3.7
Maintain asbestos abatement plans, data records, and activity/maintenance records	For up to 25 or 75 years	Compliant	2.2.3.7
Clean Air Act – NAAQS			
Submit annual report of calculated emissions to state of Nevada	Due March 1	Compliant	2.2.3.1
Number of gallons of fuel used, hours of operation, and rate of aggregate/concrete production by permitted equipment/facility	Limit varies[d]	Compliant	2.2.3.2
Tons of emissions of each criteria pollutant produced by permitted equipment/ facility based on calculations	100 tons[e] for each pollutant	Compliant 14.26 tons[e] for all pollutants combined	2.2.3.1; Table 2-12
Conduct opacity readings from permitted equipment/facility	Monthly	Compliant	2.2.3.3
Percent opacity of emissions from permitted equipment/facility	20%	Compliant 0 to 20% for 6 facilities	2.2.3.3
Submit test plans/final analysis reports for each test conducted at the HSC and annual report of all chemicals released during the year to state of Nevada	Annual report due March 1	Compliant - 4 tests conducted	2.2.3.4; Table 2-14
Clean Air Act - NSPS			
Conduct opacity readings from permitted equipment/facility	Monthly	Compliant	2.2.3.3
Percent opacity of emissions from permitted equipment/facility	10%	Compliant 0 - 10% for 1 facility	2.2.3.3
Clean Air Act - Stratospheric Ozone Protection			
Maintain ODS technician certification records, approvals for ODS-containing equipment recycling/recovery, and applicable equipment servicing records	NA[f]	Compliant	2.2.3.6
Generic Nevada Air Quality Permit Regulations			
Allow Nevada Bureau of Air Pollution Control personnel access to NTS to conduct inspections of facilities and operations regulated by state air permits	NA	Compliant No state inspections conducted in 2003	- -

(a) The section(s) within this document that describe how compliance summary data were collected

(b) 10 mrem/yr = 0.1 mSv/yr; 0.10 mrem/yr = 1.0 x 10^{-3}mSv/yr

(c) 260 linear ft or 160 ft^2 = 79.3 linear meters or 14.9 m^2

(d) Compliance limit is specific for each piece of permitted equipment/facility

(e) 100 tons = 90.7 mtons; 14.26 tons = 12.94 mtons

(f) Not applicable

Table 1-2. NTS compliance status with applicable water quality and protection regulations

Compliance Measure/Action	Compliance Limit	2003 Compliance Status or Actions Taken	Section Reference[a]
Safe Drinking Water Act and Nevada Water Controls (NAC 445A - Water Controls - Public Water Systems)			
Number of water samples containing coliform bacteria	1 per month	0	3.2.2.2; Table 3-10
Concentration of lead in a water system	0.015 mg/L	0.0135 mg/L	3.2.2.2; Table 3-10
Concentration of copper in a water system	1.3 mg/L	0.094 mg/L	3.2.2.2; Table 3-10
Concentration of nitrates in a water system	10.0 mg/L	0.31 – 4.0 mg/L [b]	3.2.2.2; Table 3-10
Concentration of fluoride in a water system	4.0 mg/L	1.8 mg/L	3.2.2.2; Table 3-10
Adherence to design, construction, maintenance, and operation regulations	NA[c]	Compliant	
Clean Water Act and Nevada Water Pollution Controls - Sewage Disposal (NAC 444 – Sewage Disposal)			
Adherence to all design/construction/operation requirements for new systems and those specified in 16 active septic system permits and 5 active septic tank pumper permits	NA	Compliant	3.2.3.2
Adherence to all operation requirements specified by 6 active permits	NA	Compliant	3.2.3.2
Allow BHPS access to conduct inspections of PWS and water hauling trucks	NA	Compliant No inspections conducted in 2003	- -
Allow NDEP access to conduct inspections of active sewage lagoon systems	NA	Compliant Inspection conducted February, 2003	3.2.4.1.4
Clean Water Act and Nevada Water Pollution Controls (NAC 445A - Water Pollution Controls)			
Measurements of 5-day Biological Oxygen Demand (BOD), total suspended solids (TSS), and pH in one sewage lagoon water sample sampled quarterly	BOD: varies [d] TSS: no limit pH: 6.0 - 9.0 S.U.	Compliant – Samples collected in Sep., Jan., Apr., and Jul.	3.2.4.1.1; Table 3-11

Table 1-2. (continued)

Compliance Measure/Action	Compliance Limit	2003 Compliance Status or Actions Taken	Section Reference[(a)]
Concentration of 36 specified contaminants in the filtrate from one sewage lagoon sample collected annually from each of two permitted facilities	Limit varies[(e)]	Compliant - concentrations within limits	3.2.4.1.2; Table 3-12
pH value and concentration of 18 specified contaminants in a representative water sample collected annually from one sewage facility's groundwater monitoring well (SM-23-1)	Limit varies[(e)]	Compliant -concentrations within limits	3.2.4.1.3; Table 3-13
Inspection by operator of active sewage lagoon systems	Weekly	Compliant	3.2.4.1.4
Inspection by operator of inactive sewage lagoon systems	Quarterly	Compliant	3.2.4.1.4
Submit quarterly monitoring reports for 3 active sewage lagoons (for Area 6, 12, and 23)	Due end of Jan., Apr., Jul., Oct.	Compliant	
NAC 534: Nevada Division of Water Resources Regulations for Water Well and Related Drilling			
Maintain state well-drilling license for personnel supervising well construction/reconditioning	NA	Compliant - 5 licensed personnel supervised well activities	- -
File notices of intent and affidavits of responsibility for plugging	NA	Compliant - 3 notices of intent with 2 affidavits were filed	- -
Adhere to well construction requirements/waivers	NA	Compliant - 2 new wells and 1 reconditioned well completed for UGTA Project; 112 boreholes plugged for Borehole Management Program	- -
Maintain required records and submit required reports		Compliant	- -

(a) The section(s) within this document that describe how compliance summary data were collected
(b) Lowest and highest concentrations measured from samples analyzed
(c) Not applicable
(d) BOD limit is calculated based on the volume of the sewage lagoon
(e) Compliance limit is specific for each contaminant; see referenced tables for specific limits

Table 1-3. NTS compliance status with regulations for radiation protection of the public and the environment

Compliance Measure	Compliance Limit	Compliance Status - 2003	Section Reference[(a)]
Clean Air Act - NESHAP			
Annual dose to the general public from all radioactive air emissions	10 mrem/yr (0.1 mSv/yr)	0.10 mrem/yr (0.001 mSv/yr)	2.1.3.2; 7.1.2.3
Safe Drinking Water Act			
Annual dose equivalent to the general public from drinking water	4 mrem/yr (0.04 mSv/yr)	0 mrem/yr[(b)] (0 mSv/yr)	3.1.3.1; Table 3-1
DOE Order 5400.5, "Radiation Protection of the Public and the Environment"			
Annual dose equivalent to the general public from all pathways	100 mrem/yr (1 mSv/yr)	0.46 mrem/yr (0.0046 mSv/yr)	7.1.3.1; Table 7-3
DOE Standard 1153-2002			
Absorbed radiation dose to terrestrial plants	1 rad/day (0.01 Gy/day)	<1 rad/day (<0.01 Gy/day)	7.2.2
Absorbed radiation dose to aquatic animals	1 rad/day (0.01 Gy/day)	<1 rad/day (<0.01 Gy/day)	7.2.2
Absorbed radiation dose to terrestrial animals	0.1 rad/day (1 mGy/day)	<0.1 rad/day (<1 mGy/day)	7.2.2
DOE Order 435.1, "Radioactive Waste Management"			
Annual dose to the general public due to RWMC operations	25 mrem/yr (0.25 mSv/yr)	Compliant[(c)]	4.3.2
DOE Order 450.1, "Environmental Protection Program"			
Conduct radiological environmental monitoring	NA[(d)]	Compliant	2.1; 3.1; 4.0; 6.0
Characterize pathways of radiological exposure to the public	NA	Compliant	7.1.2.1
Characterize exposures and doses to individuals, population, and biota	NA	Compliant	7.1.3.1; 7.1.3.2; 7.2

(a) The section(s) within this document that describe how compliance summary data were collected
(b) Migration of radioactivity in groundwater to offsite wells has never been detected
(c) Nearest populations to the Area 3 and Area 5 RWMSs (Amargosa Valley [55 km away] and Cactus Springs [36 km away], respectively) are too distant to receive any radiation exposure from operations at the sites.
(d) Not applicable

Table 1-4. NTS compliance status with applicable waste management and environmental restoration regulations

Compliance Measure/Action	Compliance Limit	Compliance Status - 2003	Section Reference[(a)]
10 CFR 830: Nuclear Facilities			
Completion and maintenance of proper conduct of operations documents required for Class II Nuclear Facility for disposal/characterization/storage of radioactive waste	Six types of guiding documents required	Compliant	8.1.3.4
DOE Order 435.1, "Radioactive Waste Management"			
Establishment of Waste Acceptance Criteria (WAC) for radioactive wastes received for disposal/storage at Area 3 and 5 RWMSs	NA[(b)]	Compliant	8.1.3.4
Vadose zone monitoring at Area 3 and Area 5 RWMSs	Not required by Order - performed to validate performance assessment criteria of RWMSs	Conducted	8.1.3.6
Groundwater monitoring at wells UE5 PW-1, UE5 PW-2, and UE5 PW-3	Not required by Order - performed to validate performance assessment criteria of Area 5 RWMS	Conducted	3.1.3.4; Table 3-4; 8.1.3.6
Volume of disposed LLW at Area 3 and Area 5 RWMSs	No limit	Area 3: 57,108 m^3 Area 5: 34,631 m^3	8.1.3.2
Resource Conservation and Recovery Act (as enforced through permits issued by the state of Nevada)			
Volume of stored non-radioactive hazardous waste at the Hazardous Waste Storage Unit	61,600 liters (16,280 gallons)	Compliant	8.2
Weight of approved explosive ordnance wastes detonated at the Explosive Ordnance Disposal Unit	45.4 kg (100 lbs) at a time, not to exceed 1 detonation event/hour	Compliant	8.2
Volume of disposed MW at Pit 3 Mixed Waste Disposal Unit (P03U)	20,000 m^3 (26,159 yd^3)	Compliant	8.1.3.2
Conduct vadose zone monitoring (VZM) for RCRA closure sites: Area 23 Hazardous Waste Trenches, U-3fi Injection Well, and U3ax/bl Subsidence Crater	A23: semi-annually using NL[(c)] U3fi: quarterly using NL U3ax/bl: continuous using TDR[(d)]	Compliant	8.4.2.2

Table 1-4. (continued)

Compliance Measure/Action	Compliance Limit	Compliance Status - 2003	Section Reference[(a)]
Upgrade, remove, and report on underground storage tanks (USTs)	NA	Compliant	8.3
Federal Facilities Agreement and Consent Order			
Adherence to CY 2003 work scope for site characterization, remediation, and closures	34 CAUs identified for some phase of action in 2003, 5 UGTA CAUs assigned 2003 milestones	Compliant All milestones were met	8.4.3.1; Table 8-2
Post-closure monitoring and inspections of closed sites	17 sites requiring monitoring/inspecting	Compliant	8.4.3.2
Nevada Solid Waste Disposal Controls (NAC 444.750-8396)			
Track weight and volume of waste disposed each calendar year	Area 5 P06U - No limit Area 6 - No limit Area 9 - No limit Area 23 - 20 tons/day	Compliant	8.1.3.2; 8.5.2
Monitor vadose zone for the Area 6 Hydrocarbon and Area 9 U10c Solid Waste disposal sites	Semi-annually using neutron tubes	Compliant	8.5.2
Monitor groundwater quality at well SM-23-1 for the Area 23 Solid Waste Disposal Site	Once every 5 years	Compliant - last monitored in 2002	8.5.2

(a) The section(s) within this document that describe how compliance summary data were collected
(b) Not applicable
(c) Neutron logging through access tubes
(d) Time domain reflectometry sensors

Table 1-5. NTS compliance status with applicable regulations for hazardous substance control and management

Compliance Measure/Action	Compliance Limit	Compliance Status - 2003	Section Reference[(a)]
Toxic Substances Control Act (TSCA) and NAC 444 - Polychlorinated Biphenyl			
Storage and offsite disposal of PCB materials	Required if >50 ppm PCB	Compliant	9.2.1
Storage and onsite disposal of PCB materials	Allowed if <50 ppm PCB	Compliant	9.2.1
Disposal of bulk product waste (BPW) containing PCBs generated by remediation and site operations	Case-by-case approval by NDEP	Compliant	9.2.1
Generate report of quantities of PCB liquids and materials disposed offsite during previous calendar year	Due July 1 of following year	Compliant - submitted May 22, 2003	9.2.1
Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and NAC 55: Control of Insect, Pests and Noxious Weeds			
Application of restricted use pesticides are conducted under the direct supervision of a state-certified applicator	NA[(b)]	Compliant - no restricted use pesticides were applied	9.2.2
Maintain state certification of onsite pesticide and herbicide applicator	NA	Compliant	9.2.2
Emergency Planning and Community Right-to-Know Act (EPCRA)			
Section 302-303 Planning Notification	NCA Report due in March	Compliant - submitted March 5, 2004, no EHS thresholds exceeded	9.2.3
Section 304 – EHS Release Notification	Notification Report due immediately after a release	Compliant - no releases occurred	9.2.3
Section 311-312 – MSDS/Chemical Inventory	NCA Report due in March	Compliant - submitted March 5, 2004	9.2.3
Section 313 – TRI Reporting	TRI Report, Form R due July 1	Compliant - submitted June 23, 2004 - lead was the only reportable substance	9.2.3
State of Nevada Chemical Catastrophe Prevention Act			
Registration of NTS with the state if EHSs are stored above listed threshold quantities	NDEP-CAPP[(c)] Report due June 21, 2004	submitted July 15, 2004 - oleum was the only reportable EHS	9.2.4

(a) The section(s) within this document that describe how compliance summary data were collected.

(b) Not applicable

(c) CAPP = Chemical Accident Prevention Program

Table 1-6. NTS NEPA compliance activities conducted in 2003

Results of NEPA Checklist Reviews / NEPA Compliance Activities
37 projects were exempted from further NEPA analysis because they were of CX status
29 projects were exempted from further NEPA analysis due to their inclusion under previous analysis in the NTS EIS (DOE, 1996) and its Record of Decision.
2 projects were exempted from further NEPA analysis due to their inclusion under previous analysis in the SA to the NTS EIS (DOE, 2002b).
4 projects were exempted from further NEPA analysis due to their inclusion under previous analysis in the Hazardous Materials Spill Center EA (DOE, 2002c)
3 projects were reviewed which were not adequately addressed in existing NEPA analysis, and a new SA to the NTS EIS was prepared in 2003. This was an SA for NTS activities related to combating terrorism (DOE, 2003a). Based on the analysis in this SA, NNSA/NSO determined that there are no substantial changes to the NTS EIS or Record of Decision or significant new circumstances or information relevant to environmental concerns, and that no supplemental EIS is needed.
Preparation was initiated for one EA, the *Environmental Assessment for Tests and Experiments Using Biological Materials and Releases of Chemicals Including Modification of Release Parameters for the Hazardous Materials Spill Center at the Nevada Test Site.* This document has not yet been completed.

Note: CX = Categorical Exclusion
EA = Environmental Assessment
EIS = Environmental Impact Statement
SA = Supplement Analysis

Table 1-7a. NTS compliance status with applicable pollution prevention/waste minimization regulations

Compliance Measure/Action	Compliance Limit	Compliance Status 2003	Section Reference [(a)]
Resource Conservation and Recovery Act of 1976 (RCRA) 42 USC 6922 (b) (1)			
Have a program in place to reduce the volume or quantity and toxicity of generated hazardous waste to the degree it is economically practicable.	NA[(b)]	Compliant	10.1
Have a process in place to ensure that EPA-designated List products are purchased containing the minimum content of recycled materials.	NA	Compliant	10.1
EO13101, "Greening the Government through Waste Prevention, Recycling and Federal Acquisition"			
Incorporate waste prevention and recycling into daily operations	N/A	Compliant	10.1
Percent of all purchased items which contain the minimum content of recycled material as specified on the EPA-designated product list.	100%	86%	
Submit a calendar year RCRA/EO13101Report to DOE/Headquarters (HQ) by entering the site's data into the DOE/HQ electronic database.	Due December 30, 2003	Submitted December 12, 2003	- -
DOE Order 450.1, "Environmental Protection Program"			
Implement an EMS that includes pollution prevention.	Implement by December 31, 2005	On schedule	16.0
Submit a fiscal year Waste Generation and Pollution Prevention Progress Report to DOE/HQ that includes annual recycling totals and waste minimization accomplishments by entering the site's data into the DOE/HQ electronic database.	Due December 12, 2003	Submitted November 11, 2003	10.3, 10.4
NDEP Hazardous Waste Permit Number NEV HW009			
Submit a calendar year Waste Minimization Summary Report to NDEP	Due by March 1, 2003	Submitted February 26, 2003	10.3, 10.4
Submit a calendar year Waste Minimization Summary Report to NDEP	Due by March 1, 2003	Submitted February 26, 2003	- -
Secretary of Energy's P2 Leadership Goals			
See Table 1-7b			

(a) The section(s) within this document that describe how compliance summary data were collected
(b) Not applicable

Table 1-7b. NTS compliance status with the Secretary of Energy's pollution prevention and energy efficiency leadership goals

Leadership Goal	1993 Baseline	CY 2005 Goal	CY 2003 Status	CY 2003 Reduction
Reduce waste from routine operations by the following percentages for each waste type by 2005, using a 1993 baseline:				
Hazardous by 90%	3,724 mtons[(a)]	372 mtons	10.4 mtons	99.7%
Low Level Radioactive by 80%	0 m^3 [(b)]	0 m^3	0 m^3	N/A
Low Level Mixed Radioactive by 80%	0 m^3	0 m^3	0 m^3	N/A
Transuranic (TRU) by 80%	0 m^3	0 m^3	0 m^3	N/A
Reduce solid waste from routine operations by 75% by 2005, using a 1993 baseline	13,735 mtons	3,434 mtons	4,502 mtons	67%
Reduce releases of toxic chemicals subject to Toxic Release Inventory (TRI) reporting by 90% by 2005, using a 1993 baseline	0 pounds reported	No reduction possible[(c)]	1.77 mtons of lead	No reduction possible
		Waste Disposed	**Waste Recycled**	**CY 2003 Reduction**
Recycle 45% of solid waste from all operations by 2005 and 50% by 2010		21,477 mtons	1,547 mtons	7%
		Waste Disposed	**Waste Reduced**	**CY 2003 Reduction**
Reduce waste resulting from cleanup, stabilization, and decommissioning activities by 10% on an annual basis		18,142 mtons	966 mtons	5%
			CY 2005 Goal	**CY 2003 Status**
Increase purchases of EPA-designated items with recycled content to 100%, except when not available competitively at a reasonable price or that do not meet performance standards.			100%	86%

(a) metric tons, 1 mton = 1.10 ton
(b) cubic meters, $1m^3 = 1.35\ yd^3$
(c) No measurable reduction can be reported because no waste of this type was reported on the NTS in 1993

Table 1-8. NTS compliance status with historic preservation regulations

Compliance Action	Compliance Status - 2003	Section Reference[(a)]
National Historic Preservation Act of 1966, as amended, and Executive Order 11593		
Maintain and implement NTS Cultural Resources Management Plan	Compliant	11.0
Conduct cultural resources pre-activity surveys, inventories and evaluations of historic structures	Conducted for 8 projects	11.1.3; Table 11-1
Make determinations of eligibility to the National Register	Determined 20 properties eligible	11.1.3; Table 11-1
Make assessments of impact to eligible properties	All eligible sites avoided by NTS activities	11.1.3
Manage artifact collection as per required professional standards	Compliant	11.2.2
Archaeological Resources and Protection Act of 1979		
Conduct archaeological work by qualified permittees	Compliant	--
Determine if archaeological sites have been damaged	None damaged	--
Complete and submit Secretary of the Interior Archaeology Questionnaire	Completed	11.1.4
American Indian Religious Freedom Act of 1978		
Allow American Indians access to NTS locations for ceremonies and traditional use	Access provided	11.3.2
Native American Graves Protection and Repatriation Act		
Consult with affiliated American Indian tribes regarding repatriation of cultural items	Completed	11.2.2
Protect American Indian burial locations on NTS	Compliant	11.2.2
Overall Requirement		
Consult with tribes regarding various cultural resources issues	Compliant	11.3.2

(a) The section(s) within this document that describe how compliance summary data were collected

Table 1-9. NTS compliance status with applicable biota and wildlife habitat regulations

Compliance Measure/Action	Compliance Limit	Compliance Status - 2003	Section Reference[a]
Endangered Species Act			
Number of tortoises accidentally injured or killed due to NTS activities per year	3	0	12.1.3
Number of tortoises captured and displaced from project sites per year	10	0	12.1.3
Number of tortoises taken since 1992 in form of injury or mortality on NTS paved roads by vehicles other than those in use during a project	Unlimited	5	12.1.3
Number of total acres of desert tortoise habitat disturbed during NTS project construction since 1992	3,015	217.71	12.1.3
Follow 23 terms and conditions of the Biological Opinion during construction and operation of NTS projects	NA[b]	Compliant	12.1.3
Conduct biological surveys at proposed project sites to assess presence of protected species	NA	Compliant	12.2.3
Migratory Bird Treaty Act; Bald Eagle Protection Act; EO 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds"			
Number of birds/nests/eggs harmed by NTS project activities	0	35 bird deaths recorded, 21 bird nests removed from buildings	12.3.2; Table 12-6
National Wildlife Refuge System Administration Act			
Number of animals, their nests, or eggs killed and amount of vegetation disturbed or injured on System lands (the Desert National Wildlife Range) as a result of NTS activities	0	0	12.5
Wild Free-Roaming Horse and Burro Act and Five-Party Cooperative Agreement			
Number of horses harassed or killed due to NTS activities	0	0	12.3.2
Cooperation in conducting resource inventories and developing resource management plans for horses on NTS, Nellis Air Force Range, and the Desert National Wildlife Range	NA	NTS annual horse inventory conducted	12.3.2 Figure 12-4

Table 1-9. (continued)

Compliance Measure/Action	Compliance Limit	Compliance Status - 2003	Section Reference[(a)]
EO 11988 Floodplain Management			
Conduct flood hazard evaluations	NA	Evaluations were conducted for: (1) Legacy Compliance Project - Smoky site, Area 8 (2) Yucca Lake runway, Area 11 (3) Egg Point Fire burn site, Area 12 (4) Mercury, Area 23	--
EO 11990, "Protection of Wetlands"			
Number of wetlands disturbed by NTS activity	NA	None	12.3.2
EO 13112, "Invasive Species"			
Disturbed habitat is revegetated with native plant species on occasion to mitigate for loss of tortoise habitat (in lieu of payment), to stabilize soil, and to prevent invasion of non-native plants.	NA	Revegetation of a 300 acre wildfire in Area 12 was completed and monitored	12.4.2
Nevada Protective Measures for Wildlife and Flora (NAC 503.010-503.104 and NAC 527.270)			
Number of state-protected animals harmed or killed and number of state-protected plants collected or harmed due to NTS activities	0	2 bird deaths recorded	12.3.2 Table 12-6

(a) The sections within this document that describe how compliance summary data were collected

(b) Not applicable

Table 1-10. NTS compliance status with Environmental Management System regulations

Compliance Measure/Action	Compliance Limit	Compliance Status - 2003	Section Reference[(a)]
Executive Order (EO) 13148, "Greening the Government through Leadership in Environmental Management"			
Have an EMS in place	December 31, 2005	On schedule	16.0
Issue site EMS policy statement	December 31, 2003	Compliant - issued in 2000	16.0
Implement EMS training to personnel establishing the system	December 31, 2003	Compliant	16.0
Identify significant environmental aspects	December 31, 2003	Compliant	16.0
DOE Order 450.1 "Environmental Protection Program"			
Incorporate the EMS into the site's ISMS	December 31, 2005	On schedule	16.0

(a) The section(s) within this document that describe compliance summary data

Table 1-11. Environmental occurrences on the NTS in 2003

Occurrence Report Number and Date	Type of Occurrence
NVOO-BN-NTS-2003-0002, January 27, 2003	**Un-permitted Discharge of Nonhazardous Synthetic Oil into Area 12 Sewage Lagoons** On January 21, 2003, site personnel pumped out 1,200 gallons (4,542 liters) of condensate blowdown fluid from an Underground Test Area (UGTA) drilling project (ER-12-2) accumulation tank. This fluid is mostly water with about 2-5 percent nonhazardous Royal Purple Synfilm brand synthetic oil. This material should have been brought to an oil/water separator in Area 23, with the separated water discharging into the Area 23 sewage lagoon system. In this case however the blowdown fluid was transferred into dry basins of the Area 12 sewage lagoon system that are permitted for discharge or wintertime septage from portable toilets. The final determination was that about 5 gallons (18.9 liters) of oil was spilled. The spill was cleaned up, and the corrective actions taken included revising the applicable work package and operating procedure.
NVOO-BN-NTS-2003-0004, February 18, 2003	**Diesel Fuel Discharge into Mercury Sewage Lagoon** On February 18, 2003 at 0700 hrs it was discovered that there had been a leak of diesel over the holiday weekend in the boiler room of Building 111 in Mercury. The leak was fixed rapidly, but it was determined that approximately 10 to 15 gallons (37.9 to 57.8 liters) of diesel fuel had entered the boiler room floor drain and been discharged into the Mercury Sewage Lagoon System. The diesel fuel leak occurred due to a crack that developed in the boiler's fuel system piping because of metal fatigue. The lagoon and spill site were cleaned up, and the defective piping was replaced.
NVOO-BN-NTS-2003-0005, February 19, 2003	**Hydraulic Fluid Spill Onto Soil in Area 5 Disposal Cell** A construction superintendent supporting construction of a new disposal cell in Area 5 reported that a water master truck (#71508) operating in the bottom of the disposal cell experienced a hydraulic hose failure. Repairs to the hydraulic system revealed that 23 gallons (87.1 liters) of hydraulic fluid had spilled. Hydraulic fluid spilled onto the bottom of the cell in a linear pattern, 800 ft. long x 2 ft wide (243.8 m long x 0.6 m wide). The material impacted was Type II soil being placed in the bottom of the cell in a 6 inch lift. The amount of soil affected is estimated at 10 cubic yards (7.6 cubic meters). The contaminated soil was removed and disposed of appropriately.
NVOO-BN-NTS-2003-0010, July 22, 2003	**Unauthorized Excavation of Potentially-Contaminated Soil Located at the CNTA UC-4 Mud Pit C Cover** On June 18, 2003, while performing erosion repairs to CAU 417 located at the CNTA UC-4 Mud Pit C cover, a front-end loader operator removed soil from within the boundaries of the UC-4 Mud Pit B posted area. In a letter issued July 15, 2003 to the NNSA/NSO Environmental Restoration Division, the State of Nevada Division of Environmental Protection (NDEP) determined that the unauthorized excavation and subsequent placement of potentially-contaminated soil represents a non-conformance with the approved Corrective Action Decision Document and Closure Report for CAU 417, CNTA Surface, and a potential non-compliance with both the Federal Facilities Agreement and Consent Order and Nevada Administrative Code. The corrective actions taken included creating new operational instructions, revising the work package, establishing work "hold points", and providing training to construction personnel.
NVOO-BN-NTS-2003-0013, September 18, 2003	**Heating Oil Spill Onto Soil in Area 12** During excavation of the dirt from an underground heating oil tank (located in Area 12, outside of building 12-30) to retrofit spill and overfill protection, a legacy heating oil spill was discovered. Approximately 6 cubic yards (4.6 cubic meters) of soil were impacted. The contaminated soil was excavated and disposed of appropriately.

Table 1-12. Environmental permits required for NTS operations

Permit Number	Description		Expiration Date	Reporting
Air Quality Permits				
AP9711-0549	Area 1 Facilities Shaker Plant Circuit Rotary Dryer Circuit Wet Aggregate Plant Concrete Batch Plant Sandbag Facility Cedar Rapids Screen Shotcrete Hopper/Conveyor Cambilt Conveyor Commander Crusher Kolberg Screen Plant Area 3 Facilities Mud Plant Various Areas Diesel Fired Generators Diesel Fired Compressors Laboratory Hoods All Areas NTS Surface Disturbances	Area 6 Facilities Cementing Equipment (Silos) Decontamination Boiler Bulk Diesel Fuel Storage Tank Bulk Gasoline Storage Tank Portable Cement Bins Portable Stemming System 1 Portable Stemming System 2 Diesel Engines (11) Two-Part Epoxy Batch Plant Area 12 Facilities Concrete Batch Plant Area 23 Facilities Building 753 Boiler Diesel Fuel Tank Gasoline Fuel Tank NTS Surface Disturbances Incinerator (Wackenhut)	Permit renewal pending; operating under existing expired permit per NAC445B.323 until new permit is issued	Annually
AP9711-0556	Area 5 Hazmat Spill Center		Permit renewal pending; operating under existing expired permit per NAC445B.323 until new permit is issued	Annually
AP9711-0814	Area 11 TaDD Facility		Permit renewal pending; operating under existing expired permit per NAC445B.323 until new permit is issued	Annually
03-140	Area 27 Burn Variance (LLNL)		March 5, 2004	None
03-30	NTS Burn Variance (Training Fires)		March 11, 2004	None

Table 1-12. (continued)

Permit Number	Description	Expiration Date	Reporting
Drinking Water Permits			
NY-0360-12NTNC	Areas 6 and 23	September 30, 2004	None
NY-4098-12NTNC	Area 25	September 30, 2004	None
NY-4099-12NTNC	Area 12	September 30, 2004	None
NY-0835-12NP	NTS Water Hauler #84846	September 30, 2004	None
NY-0836-12NP	NTS Water Hauler #84847	September 30, 2004	None
Septic Systems and Pumpers			
NY-1076	Septic System, Area 6 (ART Hangar)	None	None
NY-1077	Septic System, Area 27 (Baker Compound)	None	None
NY-1106	Septic System, Area 5 (Building 05-08)	None	None
NY-1079	Septic System, Area 12 (U12g Tunnel)	None	None
NY-1080	Septic System, Area 23 (Building 1103)	None	None
NY-1081	Septic System, Area 6 (CP-170)	None	None
NY-1082	Septic System, Area 22 (Building 22-01)	None	None
NY-1083	Septic System, Area 5 Radioactive Material Management Site	None	None
NY-1084	Septic System, Area 6 (Device Assembly Facility)	None	None
NY-1085	Septic System, Area 25 (Central Support Area)	None	None
NY-1086	Septic System, Area 25 (Reactor Control Point)	None	None
NY-1087	Septic System, Area 27 (Able Compound)	None	None
NY-1089	Septic System, Area 12 (Camp)	None	None
NY-1090	Septic System, Area 6 (LANL Construction Camp Site)	None	None
NY-1091	Septic System, Area 23 (Gate 100)	None	None
NY-1103	Septic System, Area 22 (Desert Rock Airport)	None	None
NY-17-03313	Septic Tank Pumper E-105293	November 30, 2004	None
NY-17-03315	Septic Tank Pumper E-105919	November 30, 2004	None
NY-17-03317	Septic Tank Pumper E-105918	November 30, 2004	None
NY-17-03318	Septic Tank Pumping Contractor	November 30, 2004	None
NY-17-06838	Septic Tank Pumping Contractor (one unit)	November 30, 2004	None
NY-17-06839	Septic Tank Pumping Contractor (one unit)	November 30, 2004	None
Wastewater Discharge			
GNEV93001	Water Pollution Control General Permit	December 7, 2004	Quarterly
NEV96021	Water Pollution Control for E-Tunnel; Waste Water Disposal System and Monitoring Well ER-12-1	September 25, 2007	Quarterly

Table 1-12. (continued)

Permit Number	Description	Expiration Date	Reporting
Hazardous Materials			
2287-5146	NTS Hazardous Materials	February 29, 2004	Annually
2287-5147	Hazmat Spill Center Hazardous Materials	February 29, 2004	Annually
Hazardous Waste			
NEV-HW009	NTS Hazardous Waste Management (RCRA)	November 17, 2005	Biennially
Disposal Sites			
SW 13 000 01	Area 5 Asbestiform Low-Level Solid Waste Disposal Site	Postclosure[(a)]	Annually
SW 13 097 02	Area 6 Hydrocarbon Disposal Site	Postclosure	Annually
SW 13 097 03	Area 9 U10c Solid Waste Disposal Site	Postclosure	Annually
SW 13 097 04	Area 23 Solid Waste Disposal Site	Postclosure	Annually
Endangered Species/Wildlife			
File No. 1-5-96-F-33	U.S. Fish and Wildlife Service - Desert Tortoise Incidental Take Authorization	December 31, 2006	Annually
MB008695-0	U.S. Fish and Wildlife Service – Migratory Bird Scientific Collecting Permit	December 31, 2004	Annually
S23391	Nevada Division of Wildlife - Scientific Collection of Wildlife Samples	December 31, 2004	Annually

(a) Permit expires 30 years after closure of the landfill

Ringtail,
Bassariscus astutis (male),
Frenchman Flat,
January 1990

Environmental Monitoring and Compliance Activities

Collared lizard,
Crotaphytus bicinctores,
date unknown

Gambel's quail,
Callipepla gambelli,
date unknown

2.0 Radiological and Non-Radiological Air Monitoring

Section 2.1 of this chapter presents the results of radiological air monitoring conducted on and off the Nevada Test Site (NTS) to ensure compliance with National Emission Standard Hazardous Air Pollutants (NESHAP) radioactive air emission standards (see Section 1.1). Sources of radioactive air emissions from the NTS include evaporation of tritiated water from containment ponds; diffusion of tritiated water vapor from the soil at Area 5 Radioactive Waste Management Complex, Sedan crater, and Schooner crater; tritium gas released during equipment calibrations at Building CP-50 in Area 6; and resuspension of plutonium and americium from contaminated soil at historical nuclear device safety test locations and atmospheric test locations. Radiological monitoring is conducted by Bechtel Nevada (BN) Environmental Technical Services.

Data presented in Section 2.1 are limited to the concentrations of radioactivity in air samples. These data are then used to assess radiological dose to the general public, via inhalation, in the vicinity of the NTS. The reader is directed to Section 7.0 (Radiological Dose Assessment) of this Nevada Test Site Environmental Report (NTSER) where the calculated doses are presented. The 2003 calculated doses are based on the air sampling data presented in Section 2.1, the water sampling data presented in Section 3.1, and the direct radiation exposure data presented in Section 4.0.

An oversight monitoring program has been established by U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) to independently monitor radionuclide contamination of air within communities adjacent to the NTS. This independent oversight program is managed by Desert Research Institute (DRI). DRI's 2003 air monitoring results are presented in Section 5.0 of this NTSER.

Section 2.2 of this chapter presents the results of non-radiological air quality assessments conducted on the NTS to ensure compliance with current air quality permits (see Section 1.1). NTS operations which are sources of non-radiological air pollution include aggregate production, surface disturbance (e.g., construction), release of fugitive dust from driving on unpaved roads, use of fuel burning equipment, open burning, venting from bulk fuel storage facilities, and releases of various chemicals during testing at the Hazardous Materials Spill Center (HSC). Air quality assessments are conducted by BN Environmental Compliance Department (ECD).

2.1 Radiological Air Monitoring

DOE Order 5400.5, "*Radiation Protection of the Public and the Environment*," and the Clean Air Acts (CAA's) NESHAP require air monitoring for radiological emissions at the NTS. An air surveillance network of sampling stations has been established for such monitoring. The objectives and design of the network are described in detail in the Routine Radiological Environmental Monitoring Plan (RREMP) (DOE, 2003b). This section describes briefly the RREMP goals, compliance measures, and methods, and presents the results of 2003 field sample collection and analysis.

2.1.1 Goals and Compliance Measures

The goals of radiological air monitoring are to monitor all radionuclide emissions on the NTS that are above some reasonable lower limit such that no significant emission source that contributes to calculable offsite exposures is ignored, and to ensure that the NTS is in full compliance with the requirements of the CAA. To accomplish this, an air surveillance network comprised of air particulate samplers and samplers for tritium in atmospheric moisture has been established. The network monitors airborne radioactivity near NTS sites at which radioactivity from past nuclear testing was deposited on and in the soil, and at NTS operating facilities that may produce radioactive air emissions. Data from all sampling stations are analyzed specifically to:

- Determine if radioactive air emissions from past or present NTS activities result in a radiation dose to any member of the public that exceeds the NESHAP standard of 10 mrem/yr (0.1 mSv/yr).
- Provide data to determine if radioactive air emissions from past or present NTS activities result in a radiation dose to any member of the public from all pathways (air, water, food) that exceeds the DOE Order 5400.5 standard of 100 mrem/yr (1 mSv/yr).
- Provide point source operational monitoring as required under NESHAP for any facility which has the potential to emit radionuclides into the air which could cause a dose greater than 0.1 mrem/yr (0.001 mSv/yr) to any

member of the public. The JASPER facility in Area 27 is currently the only operation which has the potential to emit radionuclides and which is monitored to satisfy this goal.

- Measure radionuclide concentrations in air at or near historic or current operation sites which have the potential to release airborne radioactivity to (1) detect and identify local and site-wide trends, (2) identify radionuclides emitted to air, and (3) detect accidental and unplanned releases.

The dose measures which are calculated to show compliance with federal radiation protection regulations are defined and presented in Section 7.0, Radiological Dose Assessment. The measures listed below are gathered through analytical analyses of air samples and comprise the base data needed to calculate dose measures. They include concentrations of the following radionuclides or radioactivity which are most likely to be present in the air as a result of past or current NTS operations:

- ^{241}Am
- ^{137}Cs
- Tritium (^{3}H)
- ^{238}Pu
- $^{239+240}$Pu
- $^{233+234}$U
- $^{235+236}$U
- ^{238}U
- Gross alpha radioactivity
- Gross beta radioactivity

These analytes were selected based on the results of NTS inventories of radionuclides in surface soil (McArthur, 1991), and upon their volatility and availability for resuspension. Uranium is included on this list because depleted uranium (see Glossary, Appendix D) ordinances are used during exercises in Areas 20 and 25. It is measured in air particulates only from selected sampling locations in the vicinity of these areas. Gross alpha and gross beta readings are also used in air monitoring as a rapid screening measure and for looking at air emission trends.

2.1.2 Methods

2.1.2.1 Monitoring System Design

Critical Receptor Samplers – Six air particulate and tritium sampling stations located near the boundaries of the NTS and near the center of the NTS are approved by U.S. Environmental Protection Agency (EPA) Region IX as critical receptor samplers (Figure 2-1). Radionuclide concentrations measured at these six stations can be used to assess compliance with the NESHAP dose limit to the public of 10 mrem/yr (0.1 mSv/yr). Sampling and analysis of air particulates and tritium was performed at these six stations as described in Section 2.1.2.2 below. The annual average concentrations from each station were then compared with the concentration limits listed in Table 2-1. To be in compliance with NESHAP, the annual average concentrations must be less than the concentration limits in Table 2-1. If multiple radionuclides are detected at a station, then compliance with NESHAP is demonstrated when each: (1) the measured annual average concentration of each radionuclide is less than its regulatory concentration limit, and (2) the sum of the fractions, determined by dividing each radionuclide's concentration by its concentration limit and then adding the fractions together, is less than 1.0.

Point–Source (Stack) Sampler – Only one facility on the NTS, the JASPER facility in Area 27 (Figure 2-1), requires stack monitoring because it has the potential to emit airborne radionuclides that could result in an offsite radiation dose ≥ 0.1 mrem/yr. Air emissions from the facility are filtered through a high efficiency particulate air (HEPA) filter, and Lawrence Livermore National Laboratory (LLNL) performs stack monitoring down-stream of the filter. Environmental sampling of air particulates adjacent to the facility is performed as stated in Section 2.1.2.2 below. If air concentrations of any man-made radionuclide are above the minimum detectable concentration (MDC), (see Glossary, Appendix D) then an assessment of offsite dose to the public would be performed to determine NESHAP compliance and LLNL would investigate the cause of the emission and implement corrective actions.

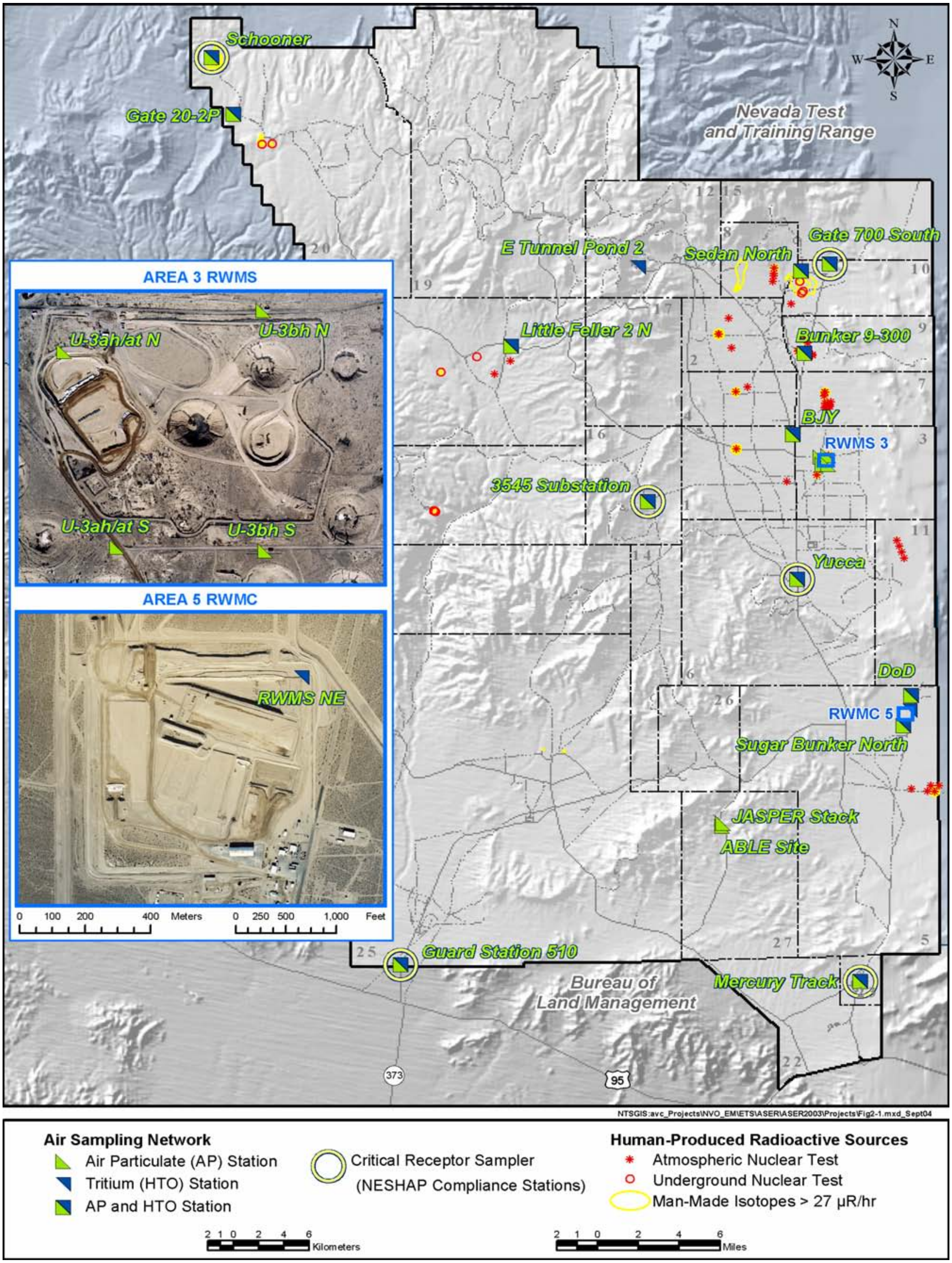


Figure 2-1. Radiological air sampling network on the NTS in 2003

Table 2-1. Regulatory concentration limits for radionuclides in air

Radionuclide	Concentration (x 10^{-15} µCi/mL)	
	NESHAP Concentration Level for Environmental Compliance (CL)[(a)]	Derived Concentration Guide (DCG)[(b)]
^{241}Am	1.9	2
^{137}Cs	19	40,000
^{3}H	1,500,000	10,000,000
^{238}Pu	2.1	3
^{239}Pu	2	2
^{233}U	7.1	9
^{234}U	7.7	9
^{235}U	7.1	10
^{236}U	7.7	10
^{238}U	8.3	10

Note: Both the CL and DCG values represent the annual average concentration which would result in a committed effective dose equivalent (CEDE) of 10 mrem/yr which is the federal dose limit to the public from all radioactive air emissions. When they differ, the CLs are more conservative than the DCGs. They are computed using different dose models.

(a) From Table 2, Appendix E of 40 CFR 61, NESHAP, 1999.

(b) From Chapter 3 of DOE Order 5400.5, 1990.

Environmental Samplers – There are a total of 21 sampling stations that are referred to as environmental samplers. The six previously-described critical receptor samplers are included in this count. The environmental samplers include 6 stations which have only low-volume air particulate samplers, 2 which have only tritium samplers, and 13 which have a combination of both air particulate and tritium samplers (Figure 2-1). They are located throughout the NTS in or near diffuse radiation sources such as large areas with: (1) radioactivity in surface soil that can be resuspended by the wind, (2) tritium that transpires or evaporates from plants and soil at the sites of past nuclear cratering tests, and (3) tritium that evaporates from ponds receiving tritiated water either pumped from contaminated wells or directed from tunnels that cannot be sealed shut. Sampling and analysis of air particulates and tritium was performed at these stations as described in Section 2.1.2.2 below. Radionuclide concentrations measured at these stations are used for trending, determining ambient background concentrations in the environment, and identifying unplanned releases of radioactivity. Air concentrations approaching 10 percent of the NESHAP Concentration Levels for Environmental Compliance (CLs) (second column of Table 2-1) are investigated for causes so that they may be mitigated to avoid exceeding regulatory dose limits.

2.1.2.2 Air Particulate and Tritium Sampling

A weekly sample of airborne particulates was collected from each air sampling station by drawing air through a 10-cm (4-in) diameter glass-fiber filter at a constant flow rate of 85 L/min (3 cfm). The particulate filter is mounted in a filter holder that faces downward at a height of 1.5 m (5 ft) above ground. A run-time clock measures the operating time. The run time, multiplied by 85 L/min yields the volume of air sampled, which is about 860 m^3 (30,000 ft^3) during a typical seven-day sampling period. Flows and subsequent volumes were measured with a mass-flow meter which corrects for variations in temperature and elevation on the NTS.

The 10-cm (4-in) diameter filters were analyzed for gross alpha and gross beta radioactivity five days after collection to allow for the decay of the progeny of naturally-occurring radon and thoron. The filters from four weeks of sampling were composited, analyzed by gamma spectroscopy, and then analyzed for $^{239+240}$Pu and ^{241}Am by alpha spectroscopy after radiochemical separation. To monitor for any potential emissions from tests using depleted uranium, the filter composites from Yucca (Area 6), Substation 3545 (Area 16), Gate 20-2p (Area 20), Guard Station 510 (Area 25), and Able Site (Area 27) were analyzed for uranium isotopes by alpha spectroscopy.

Tritiated water vapor in the form of $^{3}H^{3}HO$ or ^{3}HHO (HTO) was monitored every two weeks at each tritium sampling station. Tritium samplers were operated at a constant flow rate of 566 cc/min (1.2 ft^3/hr) by microprocessors which summed the total volume sampled (about 11 m^3 [14.4 yd^3] over a two-week sampling period). The HTO vapor was removed from the air stream by two molecular sieve columns connected in series (one for routine collection and a second one to indicate if breakthrough occurred during collection). These columns were exchanged biweekly. An aliquot of the total moisture collected was extracted from the columns and analyzed for tritium by liquid scintillation counting.

2.1.2.3 Data Quality

Quality Assurance and Quality Control (QA/QC) protocols, including Data Quality Objectives (DQOs), have been developed and are maintained as essential elements of air monitoring as directed by the RREMP. The QA requirements established for the monitoring program include the use of sample packages to thoroughly document each sampling event, rigorous management of databases, and completion of essential training. The program also provides for the stringent oversight of external analytical laboratories and internal data validation, verification, and review. Routine QC samples (e.g., duplicates, blanks, and spikes) are also incorporated into the analytical suites on a frequent basis. The reader is directed to Section 17.0 for a thorough discussion of QA protocols and procedures utilized for radiological air monitoring.

2.1.2.4 Data Reporting

The annual average concentration for each radionuclide at each sampling location is presented in data tables in the following results section. The annual average concentration for each radionuclide was calculated from the uncensored analytical results for individual samples, in that those values less than the sample-specific MDC were included in the calculation. A column is included in each table indicating the percentage of the analytical results that were greater than the MDC.

Annual average concentrations are also expressed in the tables as percentages of the CL (second column of Table 2-1). In graphs of concentration data, the CL or some percentage of the CL is included as a green horizontal line so the reader can easily visualize the results in comparison to the CL. The CL for each radionuclide was used in all tables and graphs instead of the DCG as it was always the lesser of the two for those radionuclides for which these limits differed.

For convenience in reporting, all values shown in the tables in the following results section are formatted to a greater number of digits (three or more) than can be justified by the accuracy of the measurements, which is two significant figures (e.g., 2500, 25, 2.5, or 0.025).

2.1.3 Results

This section presents the concentrations of airborne radionuclides and gross alpha and beta radioactivity in air samples collected in 2003. Multiple-year trends for radionuclides of interest (Pu and tritium) are also presented. The results are presented first, grouped by analytes, for all environmental samplers (Section 2.1.3.1). The final subsections present the 2003 sampling results for just the six critical receptor samples to show compliance with NESHAP limits (Section 2.1.3.2) and for the stack sampler at the Jasper facility (Section 2.1.3.3).

2.1.3.1 Environmental Samplers

The 2003 results from all air samplers are shown in tables and graphs below. No graphs for ^{238}Pu and ^{137}Cs are included because very few of the results for these analyses were above the sample-specific MDCs. In the graphs, a horizontal green line for the CL is shown for reference only and not to demonstrate compliance with NESHAP dose limits. The assessment of compliance is based upon annual average concentrations, not upon the single sample results shown in the figures.

There were no radioactive emissions from NTS operations in 2003. Therefore, all radionuclide concentrations in the 2003 air samples shown in the tables and graphs are attributed to the resuspension of legacy contamination in surface soils and to the evaporation and transpiration of tritium from the soil and plants at the sites of past nuclear tests.

2.1.3.1.1 Americium-241

During 2003, only 29 percent of all the air samples contained detectable concentrations of ^{241}Am (Table 2-2). This is down from 39 percent in 2002. The percentage of samples above their MDCs were lower than last year at each location except at Little Feller N. The average concentration of ^{241}Am across all sites was 7.6 x 10^{-18} µCi/mL (0.28 µBq/m^3). The highest mean concentration occurred at U-3ah/at S (24 x 10^{-18} µCi/mL [0.89 µBq/m^3]), which is only 1.3 percent of the CL. Both the proportion of measurements exceeding their MDCs and the site-wide averages were lower this year than over the past three years.

Peaks in ^{241}Am concentrations throughout the year occurred at five locations: BJY, U-3ah/at N, U-3ah/at S, Bunker 9-300, and Sedan N (Figure 2-2). The annual mean decreased substantially from the 2002 level at U-3ah/at N and Bunker 9-300, whereas it increased moderately at U-3ah/at S. All of these locations were near or in areas with legacy soil contamination.

Table 2-2. Concentrations of Am-241 in air samples collected in 2003

			^{241}Am (x 10^{-18} µCi/mL)							
NTS Area	Location	Number of Samples	Mean	% of CL [(a)]	Median	Std [(b)]	Min [(c)]	Max [(d)]	Mean MDC	% > MDC
1	BJY	12	11.68	0.6	2.36	24.81	0.13	86.85	8.61	25.0
3	U-3ah/at N	13	17.27	0.9	11.31	13.47	3.12	39.05	8.99	46.2
3	U-3ah/at S	12	24.01	1.3	14.77	27.55	2.17	104.97	10.49	70.8
3	U-3bh N	12	8.09	0.4	4.28	9.71	-2.19	28.82	11.65	33.3
3	U-3bh S	12	7.45	0.4	7.42	2.67	2.94	11.06	7.74	50.0
5	DoD	12	2.56	0.1	2.24	2.91	-1.76	7.27	9.46	8.3
5	Sugar Bunker N	12	2.72	0.1	1.72	2.86	-0.88	7.57	9.43	0.0
6	Yucca	12	3.56	0.2	3.30	3.23	-1.25	10.03	8.18	20.8
9	Bunker 9-300	12	15.34	0.8	11.56	11.69	2.68	41.35	7.96	66.7
10	Gate 700 South	12	3.99	0.2	1.58	4.81	0.00	14.96	10.09	8.3
10	Sedan N	12	9.27	0.5	5.72	12.53	0.00	46.47	8.88	33.3
16	3545 Substation	12	3.48	0.2	3.06	3.87	-1.37	10.23	8.85	20.8
18	Little Feller 2 N	12	4.36	0.2	4.22	4.17	-1.78	14.03	8.32	41.7
20	Gate 20-2P	5	4.36	0.2	1.22	6.59	-0.53	15.70	8.13	20.0
20	Schooner	12	3.64	0.2	2.06	4.02	-1.21	12.98	10.14	16.7
23	Mercury Track	12	5.44	0.3	3.04	5.42	0.00	16.84	8.03	16.7
25	Guard Station 510	12	4.41	0.2	3.31	3.85	0.00	11.21	7.45	25.0
27	ABLE Site	9	3.59	0.2	4.53	3.62	-1.34	8.74	8.98	0.0
27	JASPER Stack	5	1.99	0.1	8.80	36.77	-54.35	39.53	105.06	0.0
	All Onsite Locations	**212**	**7.59**	**0.4**	**4.46**	**13.12**	**-54.35**	**104.97**	**11.26**	**29.0**

Blue shading indicates those stations which are EPA approved critical receptor samplers

Orange shading indicates the point-source sampler station

No shading indicates those stations which are environmental samplers

Green shading indicates that some percentage of samples had concentrations above the sample specific MDC

(a) CL is the NESHAP Concentration Level for Environmental Compliance (see Table 2-1)

(b) Standard deviation

(c) Minimum

(d) Maximum

Note: The CL for ^{241}Am is 1,900 x 10^{-18} µCi/mL when expressed in the same units as the data in this table.

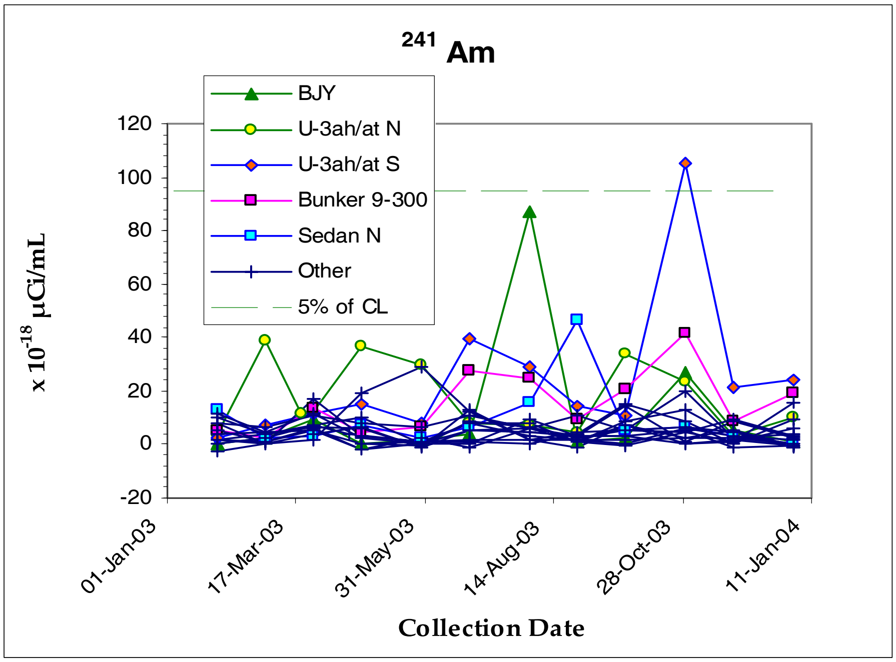


Figure 2-2. Concentrations of Am-241 in air samples collected in 2003

2.1.3.1.2 Cesium-137

Cs-137 was measured above the MDC in samples from only one location, Bunker 9-300 in Area 9 (Table 2-3) where there are known legacy deposits of radionuclides from past nuclear tests. As in previous years, ^{137}Cs is only occasionally detected in the monthly air sample composites. All concentration means were below or near zero, similar to 2002. No graph for ^{137}Cs concentrations is included because the majority of values were below detection.

Table 2-3. Concentrations of Cs-137 in air samples collected in 2003

NTS Area	Location	Number of Samples	^{137}Cs (x 10^{-15} µCi/mL) Mean	% of CL (a)	Median	Std (b)	Min (c)	Max (d)	Mean MDC	% > MDC
1	BJY	11	-0.25	-1.3	-0.187	0.227	-0.673	0.023	0.613	0
3	U-3ah/at N	11	-0.091	-0.5	-0.16	0.286	-0.418	0.449	0.672	0
3	U-3ah/at Ss	12	-0.16	-0.8	-0.191	0.332	-0.727	0.342	0.749	0
3	U-3bh N	12	-0.066	-0.3	-0.112	0.217	-0.37	0.268	0.779	0
3	U-3bh S	12	-0.099	-0.5	0.058	0.442	-1.178	0.347	0.667	0
5	DoD	12	-0.092	-0.5	-0.141	0.141	-0.283	0.15	0.615	0
5	Sugar Bunker N	12	-0.311	-1.6	-0.069	0.814	-2.835	0.169	0.729	0
6	Yucca	12	-0.092	-0.5	-0.079	0.206	-0.376	0.233	0.604	0
9	Bunker 9-300	12	0.030	0.2	0.006	0.362	-0.481	0.862	0.607	8.3
10	Gate 700 South	11	-0.136	-0.7	-0.011	0.376	-0.965	0.482	0.648	0
10	Sedan N	12	-0.065	-0.3	0.065	0.271	-0.44	0.262	0.683	0
16	3545 Substation	12	-0.184	-1	-0.128	0.45	-1.353	0.513	0.637	0
18	Little Feller 2 N	12	-0.035	-0.2	0.036	0.227	-0.533	0.216	0.606	0

Table 2-3. (continued)

NTS Area	Location	Number of Samples	^{137}Cs (x 10^{-15} μCi/mL) Mean	% of CL (a)	Median	Std (b)	Min (c)	Max (d)	Mean MDC	% > MDC
20	Gate 20-2P	4	-0.06	-0.3	-0.024	0.09	-0.193	0	0.666	0
20	Schooner	12	-0.22	-1.2	-0.164	0.38	-1.212	0.299	0.6	0
23	Mercury Track	10	-0.142	-0.7	-0.051	0.242	-0.599	0.153	0.615	0
25	Guard Station 510	11	-0.136	-0.7	-0.028	0.422	-1.242	0.288	0.622	0
27	ABLE Site	9	0.031	0.2	-0.075	0.34	-0.346	0.809	0.621	0
27	JASPER Stack	7	-0.513	-2.7	-0.562	4.023	-5.517	6.207	6.637	0
	All On-site Locations	**206**	**-0.132**	**-0.7**	**-0.087**	**0.778**	**-5.517**	**6.207**	**0.856**	**1**

Blue shading indicates those stations which are EPA approved critical receptor samplers

Orange shading indicates the point-source sampler station

No shading indicates those stations which are environmental samplers

Green shading indicates that some percentage of samples had concentrations above the sample specific MDC

(a) CL is the NESHAP Concentration Level for Environmental Compliance (see Table 2-1)

(b) Standard deviation

(c) Minimum

(d) Maximum

2.1.3.1.3 Plutonium Isotopes

Pu-238 was detected above the MDC in at least one sample from 11 locations (Table 2-4). The proportion of samples with concentrations above the MDC was approximately the same as that in 2001 and 2002. The U-3ah/at N and S locations had the highest proportion of samples above the MDC (35 and 25 percent, respectively) and also the highest mean concentrations which were only 0.2 percent of the CL. No graph for ^{238}Pu concentrations is included because the majority of the sample concentrations were below the MDCs.

Table 2-4. Concentrations of Pu-238 in air samples collected in 2003

NTS Area	Location	Number of Samples	^{238}Pu (x 10^{-18} μCi/mL) Mean	% of CL (a)	Median	Std (b)	Min (c)	Max (d)	Mean MDC	% > MDC
1	BJY	12	3.517	0.2	1.530	6.626	-0.909	20.623	7.353	16.7
3	U-3ah/at N	13	3.589	0.2	2.152	2.792	0.000	9.018	5.853	34.6
3	U-3ah/at S	12	3.916	0.2	2.324	4.683	-3.103	12.019	9.582	25.0
3	U-3bh N	12	2.576	0.1	1.840	5.103	-5.537	15.599	9.210	16.7
3	U-3bh S	12	2.300	0.1	1.634	2.084	0.000	6.223	5.733	8.3
5	DoD	12	0.692	0.0	0.000	1.688	-0.739	4.691	7.379	8.3
5	Sugar Bunker N	12	3.805	0.2	0.598	9.668	-1.352	33.864	10.126	8.3
6	Yucca	12	4.391	0.2	1.942	7.824	-3.079	22.478	11.651	12.5
9	Bunker 9-300	12	1.597	0.1	1.367	3.618	-4.139	10.504	9.351	16.7
10	Gate 700 South	12	0.520	0.0	0.000	3.249	-4.261	8.795	8.253	8.3

Table 2-4. (continued)

NTS Area	Location	Number of Samples	^{238}Pu (x 10^{-18} μCi/mL) Mean	% of CL (a)	Median	Std (b)	Min (c)	Max (d)	Mean MDC	% > MDC
10	Sedan N	12	2.454	0.1	1.937	2.317	-0.767	6.730	7.178	0.0
16	3545 Substation	12	-0.186	0.0	-0.329	1.169	-1.624	2.437	9.897	0.0
18	Little Feller 2 N	12	0.565	0.0	0.782	2.565	-4.449	4.495	8.200	0.0
20	Gate 20-2P	5	0.953	0.0	0.899	1.945	-1.691	3.286	9.196	0.0
20	Schooner	12	1.725	0.1	1.620	2.849	-3.893	6.135	11.127	0.0
23	Mercury Track	12	-0.441	0.0	0.000	1.476	-3.033	2.458	8.521	0.0
25	Guard Station 510	12	2.927	0.1	1.516	5.246	-4.135	14.392	9.309	8.3
27	ABLE Site	9	0.500	0.0	0.490	1.887	-2.679	4.055	8.504	0.0
27	JASPER Stack	6	22.136	1.1	2.487	47.131	15.692	103.999	96.962	0.0
	All Onsite Locations	**213**	**2.596**	**0.1**	**1.280**	**9.131**	**15.692**	**103.999**	**11.149**	**9.4**

Blue shading indicates those stations which are EPA approved critical receptor samplers

Orange shading indicates the point-source sampler station

No shading indicates those stations which are environmental samplers

Green shading indicates that some percentage of samples had concentrations above the sample specific MDC

(a) CL is the NESHAP Concentration Level for Environmental Compliance (see Table 2-1)

(b) Standard deviation

(c) Minimum

(d) Maximum

Note: The CL for ^{238}Pu is 2,100 x 10^{-18} μCi/mL when expressed in the same units as the data in this table.

The proportion of $^{239+240}$Pu results above the MDC were higher (54 percent) in 2003 (Table 2-5) than in 2002 and 2001 (48 and 42 percent, respectively). Those locations at which 100 percent of the air samples contained $^{239+240}$Pu above detection included U-3ah/at N, U-3ah/at S, U-3bh N, U-3bh S, and Bunker 9-300. In 2002, this occurred only at U-ah/at S and Bunker 9-300. Generally, the proportion of $^{239+240}$Pu results above MDC is greater than 50 percent at those air sampling locations that are in areas where $^{239+240}$Pu is in the surface soil (see Figure 2-1 and Table 2-5). The $^{239+240}$Pu continues to be detected while most other radionuclides are not, due to their more rapid radioactive decay and absorption into the soil. Due to the long half-life of ^{239}Pu (~24,000 years) and its insolubility in water, its presence in soil and resuspension into the air will continue to decrease slowly with time.

The annual mean $^{239+240}$Pu concentrations for most locations were less than last year, as reflected by the site-wide mean of 38 x 10^{-18} μCi/mL (1.4 μBq/m^3) in 2003 compared to 55 x 10^{-18} μCi/mL (2.0 μBq/m^3) for 2002. The location with the highest mean concentration (160 x 10^{-18} μCi/m^3 [5.9 μBq/m^3]) was at U-3ah/at S, which was only 7.9 percent of the CL.

Table 2-5. Concentrations of Pu-239+240 in air samples collected in 2003

			$^{239+240}$Pu (x 10^{-18} µCi/mL)							
NTS Area	Location	Number of Samples	Mean	% of CL [a]	Median	Std [b]	Min [c]	Max [d]	Mean MDC	% > MDC
1	BJY	12	78.21	3.9	11.37	155.39	0.00	444.77	9.90	58.3
3	U-3ah/at N	13	108.77	5.4	69.14	80.80	29.69	257.37	7.22	100.0
3	U-3ah/at S	12	157.93	7.9	108.12	199.56	37.75	774.56	9.40	100.0
3	U-3bh N	12	52.22	2.6	38.05	47.35	13.57	184.28	9.70	100.0
3	U-3bh S	12	42.68	2.1	34.32	31.44	14.48	130.41	9.85	100.0
5	DoD	12	8.91	0.4	5.58	9.54	0.00	32.33	8.13	54.2
5	Sugar Bunker N	12	16.16	0.8	5.15	38.47	-3.35	137.08	8.99	50.0
6	Yucca	12	20.40	1.0	5.71	45.57	0.00	163.69	9.87	33.3
9	Bunker 9-300	12	96.24	4.8	68.15	75.19	18.13	246.71	9.04	100.0
10	Gate 700 South	12	8.01	0.4	3.79	11.32	0.29	42.20	7.28	29.2
10	Sedan N	12	43.84	2.2	22.89	48.97	5.87	172.82	9.50	66.7
16	3545 Substation	12	5.91	0.3	3.96	8.15	-0.47	29.78	7.69	25.0
18	Little Feller 2 N	12	6.68	0.3	6.22	5.77	-1.23	17.51	8.12	33.3
20	Gate 20-2P	5	1.17	0.1	1.09	2.06	-1.23	3.42	5.98	0.0
20	Schooner	12	7.25	0.4	3.06	14.74	-0.02	53.50	8.10	25.0
23	Mercury Track	12	6.24	0.3	4.65	5.41	-1.10	13.94	10.06	25.0
25	Guard Station 510	12	6.70	0.3	3.94	6.97	0.00	21.59	8.27	41.7
27	ABLE Site	9	1.63	0.1	1.75	1.52	-1.07	3.30	7.44	0.0
27	JASPER Stack	7	15.45	0.8	10.89	43.44	-26.36	103.99	123.49	0.0
	All Onsite Locations	**214**	**38.46**	**1.9**	**9.80**	**80.38**	**-26.36**	**774.56**	**12.44**	**53.7**

Blue shading indicates those stations which are EPA approved critical receptor samplers
Orange shading indicates the point-source sampler station
No shading indicates those stations which are environmental samplers
Green shading indicates that some percentage of samples had concentrations above the sample specific MDC
(a) CL is the NESHAP Concentration Level for Environmental Compliance (see Table 2-1)
(b) Standard deviation
(c) Minimum
(d) Maximum
Note: The CL for $^{239+240}$Pu is 2,000 x 10^{-18} µCi/mL when expressed in the same units as the data in this table.

The highest concentrations of $^{239+240}$Pu in 2003 occurred at the following five locations: BJY, U-3ah/at N, U-3ah/at S, Bunker 9-300, and Sedan N (Table 2-5 and Figure 2-3). The peaks in $^{239+240}$Pu concentrations and the peaks for ^{241}Am occurred on the same dates for most of these locations. This is expected because ^{241}Am is the daughter-product of ^{241}Pu which is present with the $^{239+240}$Pu used in past nuclear tests. Due to the differences in half-lives between the ^{241}Pu (14.4 years) and the ^{241}Am (433 years), the concentrations of ^{241}Am in NTS soil will increase gradually with time for about 80 years, after which it will begin decreasing.

Figure 2-4 shows the long-term trends in annual mean concentrations of $^{239+240}$Pu at 43 locations having at least fourteen years of data. The concentration lines for each air sampling station are color coded by the station's geographical location within one of nine NTS Area Groups. This plot shows a steady decrease in air-borne $^{239+240}$Pu over the past three decades at most locations. The locations with the slightest long-term decreases are the same as those with the highest means in 2003.

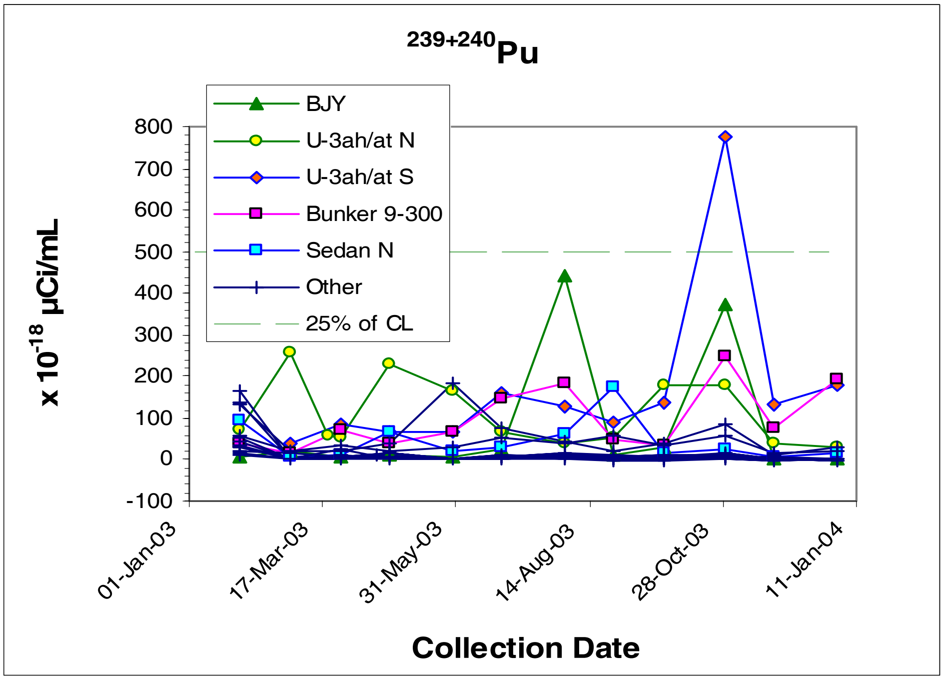


Figure 2-3. Concentrations of Pu-239+240 in air samples collected in 2003

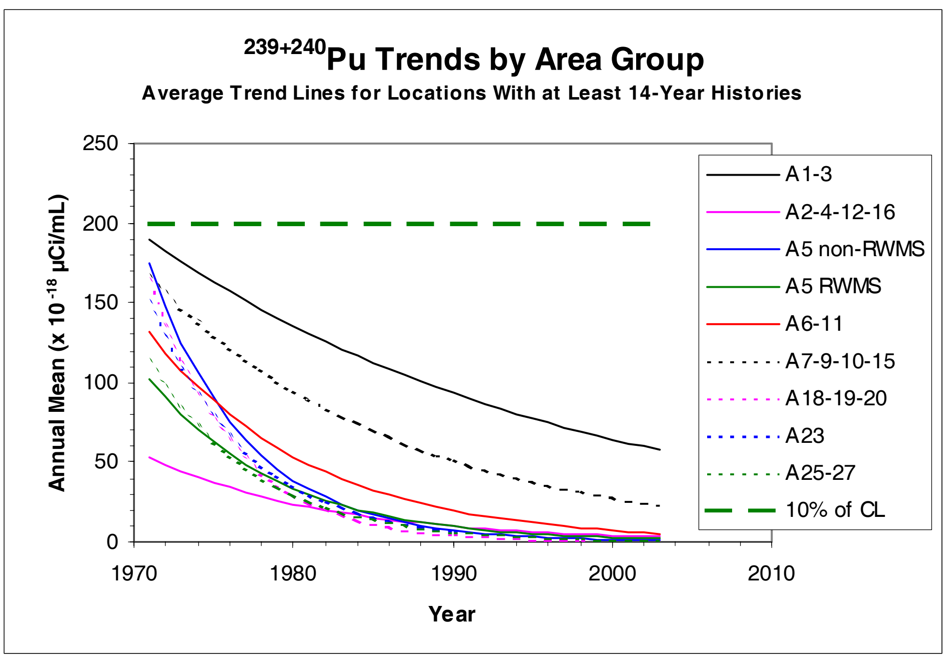


Figure 2-4. Average long-term trends in airborne Pu-239+240 by location on the NTS

2.1.3.1.4 Uranium Isotopes

The annual mean concentrations for each of the uranium isotopes (Table 2-6) showed little change from those for last year. The proportion of air samples containing uranium at levels above detection were 80 to 100 percent for $^{233,234}U$ and ^{238}U, whereas they were only 0 to 38 percent for $^{235,236}U$.

The uranium isotopes measured above their MDCs (Table 2-6) are attributed to naturally-occurring uranium in the soil which has become resuspended. This was determined by calculating the ratio of the annual average concentration of ^{238}U to that of the other uranium isotopes for all sampling locations and then comparing the ratios to those for natural uranium (Table 2-7). Ratios greater than those shown for natural uranium (~0.93 and 21) would be an indication that the air samples contain uranium from human activities (i.e., depleted uranium). The $^{238}U/^{235,236}U$ ratios from sampling results were lower than the ratios for naturally-occurring uranium, possibly due to the greater number of $^{235+236}U$ concentrations that were below or near the MDC.

Table 2-6. Concentrations of uranium isotopes in air samples collected in 2003

NTS Area	Location	Number of Samples	Mean	% of CL [(a)]	Median	Std [(b)]	Min [(c)]	Max [(d)]	Mean MDC	% > MDC
			$^{233+234}U$ by Chemistry (x 10^{-15} µCi/mL)							
6	Yucca	12	0.086	1.2	0.087	0.016	0.060	0.115	0.014	100.0
16	3545 Substation	12	0.088	1.2	0.078	0.024	0.065	0.135	0.014	100.0
20	Gate 20-2P	5	0.073	1.0	0.089	0.028	0.033	0.096	0.015	100.0
25	Guard Station 510	12	0.085	1.2	0.089	0.028	0.009	0.128	0.017	91.7
27	ABLE Site	9	0.085	1.2	0.086	0.009	0.070	0.098	0.016	100.0
	All Onsite Locations	**50**	**0.085**	**1.2**	**0.088**	**0.021**	**0.009**	**0.135**	**0.015**	**98.0**
			$^{235+236}U$ by Chemistry (x 10^{-15} µCi/mL)							
6	Yucca	12	0.0085	0.1	0.0070	0.0054	0.0000	0.0167	0.0105	37.5
16	3545 Substation	12	0.0083	0.1	0.0059	0.0083	0.0020	0.0295	0.0141	20.8
20	Gate 20-2P	5	0.0035	0.0	0.0041	0.0051	0.0041	0.0100	0.0125	0.0
25	Guard Station 510	12	0.0076	0.1	0.0075	0.0046	0.0003	0.0143	0.0145	20.8
27	ABLE Site	9	0.0082	0.1	0.0097	0.0055	0.0000	0.0159	0.0146	11.1
	All Onsite Locations	**50**	**0.0077**	**0.1**	**0.0061**	**0.0060**	**0.0041**	**0.0295**	**0.0130**	**21.0**
			^{238}U by Chemistry (x 10^{-15} µCi/mL)							
6	Yucca	12	0.086	1.0	0.086	0.013	0.065	0.105	0.012	100.0
16	3545 Substation	12	0.085	1.0	0.089	0.014	0.056	0.107	0.013	100.0
20	Gate 20-2P	5	0.061	0.7	0.071	0.025	0.018	0.080	0.010	80.0
25	Guard Station 510	12	0.085	1.0	0.080	0.032	0.013	0.122	0.013	91.7
27	ABLE Site	9	0.083	1.0	0.079	0.013	0.071	0.105	0.016	100.0
	All Onsite Locations	**50**	**0.082**	**1.0**	**0.081**	**0.021**	**0.013**	**0.122**	**0.012**	**96.0**

Blue shading indicates those stations which are EPA approved critical receptor samplers
No shading indicates those stations which are environmental samplers
Green shading indicates that some percentage of samples had concentrations above the sample specific MDC
(a) CL is the NESHAP Concentration Level for Environmental Compliance (see Table 2-1)
(b) Standard deviation
(c) Minimum
(d) Maximum

Table 2-7. Ratios of uranium isotopes in air samples collected near NTS locations where uranium was detected above the MDC

NTS Area	Location	Ratios of Uranium Isotopes in Air Samples $^{238}U/^{233,234}U$	$^{238}U/^{235,236}U$
6	Yucca	1	10
16	3545 Substation	1	10
20	Gate 20-2P	0.8	18
25	Guard Station 510	1	11
27	ABLE Site	1	10
Ratios of Natural Uranium Isotopes[(a)]		**~0.93**	**~21**

Blue shading indicates those stations which are EPA approved critical receptor samplers

(a) Calculated from percent abundances occurring naturally (Brown et al., 1986). Ratios greater than these would indicate the presence of depleted uranium.

2.1.3.1.5 Tritium

Detectable tritium was observed in all air samples collected at the Sedan and Schooner craters and at E Tunnel Pond 2 (Table 2-8). The tritium found at these locations comes primarily from the tritium used in nuclear testing devices. During the detonations, the tritium was oxidized forming tritiated water which was entrained in the ejecta from the cratering experiments at Sedan and Schooner and in the rubble formed in the various shafts of E Tunnel. At Sedan and Schooner, the tritiated moisture evaporates and transpires from the soil and vegetation in these areas. At the E Tunnel ponds, the tritiated water continues to flow out of the tunnel and evaporates into the air. Figure 2-5 shows the variation of measured tritium concentrations in air throughout the year.

The highest annual mean concentration of tritium was at Schooner (420×10^{-6} pCi/mL [16 Bq/m^3]), where the sampler is located only 269 m from the crater and surrounded by ejecta from the crater. This concentration is only 28 percent of the CL. The data for Schooner are plotted in Figure 2-5 at one-tenth their actual values so that the details at other locations may be seen. As in the past, the higher measurements occurred at Schooner and Sedan. The concentrations at all locations followed the same pattern observed in past years: increasing during the summer months and decreasing in the fall. This follows the rise and fall of the temperature and the influence of rainfall (DOE, 2003b).

Figure 2-6 shows the annual means for nineteen air sample locations with at least a seven-year history between 1988 and 2003. The data from 1982 through 1987 (dotted lines), taken from previous annual reports, were in some cases reported as "< *xxx*", in which *xxx* was an average of values that included the "less than" values as well as actual measurements above the MDCs. Beginning with the 1988 data (solid lines) actual measurements were reported, whether above or below their MDCs. Locations are color-coded into Area Groups consisting of adjacent NTS Areas. As shown by this figure, the annual concentration averages of tritium in air were decreasing during the years 1982 to 1992 and continued the decrease more gradually from then to the present time.

Table 2-8. Concentrations of tritium in air samples collected in 2003

			^3H Concentration (x 10^{-6} pCi/mL)							
NTS Area	Location	Number of Samples	Mean	% of CL [(a)]	Median	Std [(b)]	Min [(c)]	Max [(d)]	Mean MDC	% > MDC
1	BJY	26	1.34	0.1	1.16	0.97	-0.65	3.16	1.12	59.6
5	DoD	25	0.83	0.1	0.44	1.00	-0.63	3.58	1.26	16.0
5	RWMS 4 Northeast	12	1.89	0.1	1.61	1.21	0.17	4.03	1.09	79.2
5	Sugar Bunker N	26	1.12	0.1	0.86	0.80	0.09	3.58	1.19	57.7
6	Yucca	26	0.80	0.1	0.85	0.78	-0.42	3.65	1.19	30.8
9	Bunker 9-300	26	3.24	0.2	2.83	2.24	0.56	7.27	1.09	96.2
10	Gate 700 South	26	0.99	0.1	0.61	0.90	0.00	3.48	1.13	32.7
10	Sedan N	26	13.67	0.9	11.01	9.92	3.03	34.21	1.13	100.0
12	E Tunnel Pond 2	25	5.41	0.4	5.66	3.07	1.23	11.66	1.12	100.0
16	3545 Substation	26	0.72	0.0	0.48	0.87	-0.41	3.57	1.24	26.9
18	Little Feller 2 N	25	0.46	0.0	0.40	0.62	-0.88	1.80	1.08	16.0
20	Gate 20-2P	11	0.66	0.0	0.49	0.65	-0.24	1.77	1.11	27.3
20	Schooner	25	419.69	28.0	241.10	387.05	32.29	985.48	1.56	100.0
23	Mercury Track	25	0.52	0.0	0.48	0.94	-2.28	3.05	1.24	24.0
25	Guard Station 510	26	0.52	0.0	0.30	0.77	-0.64	2.63	1.26	23.1
	All Onsite Locations	**356**	**31.70**	**2.1**	**1.05**	**146.80**	**-2.28**	**985.48**	**1.19**	**52.7**

Blue shading indicates those stations which are EPA approved critical receptor samplers

No shading indicates those stations which are environmental samplers

Green shading indicates that some percentage of samples had concentrations above the sample specific MDC

(a) CL is the NESHAP Concentration Level for Environmental Compliance (see Table 2-1)

(b) Standard deviation (c) Minimum (d) Maximum

Note: The CL for ^3H is 1,500 x 10^{-6} pCi/mL when expressed in the same units as the data in this table.

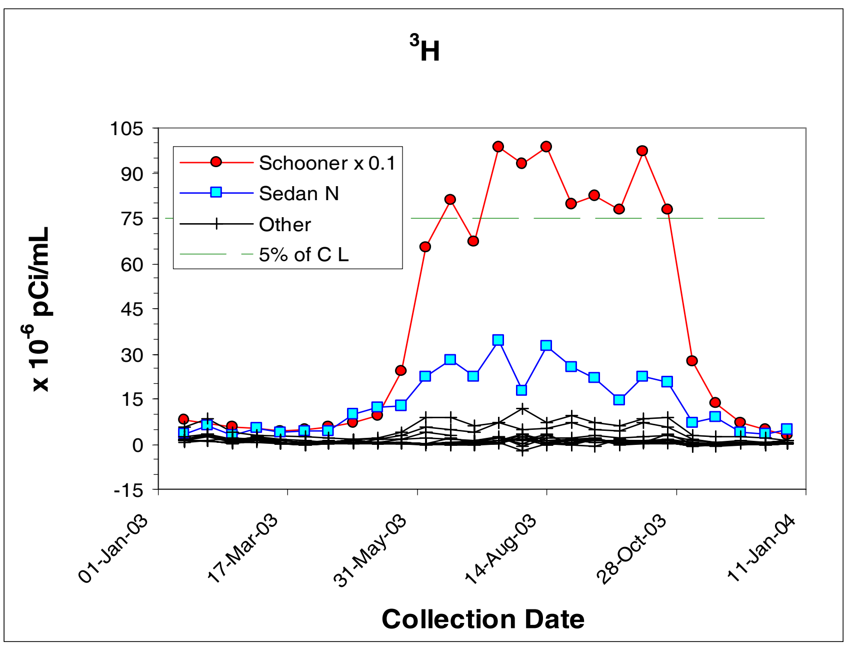


Figure 2-5. Concentrations of tritium in air samples collected in 2003

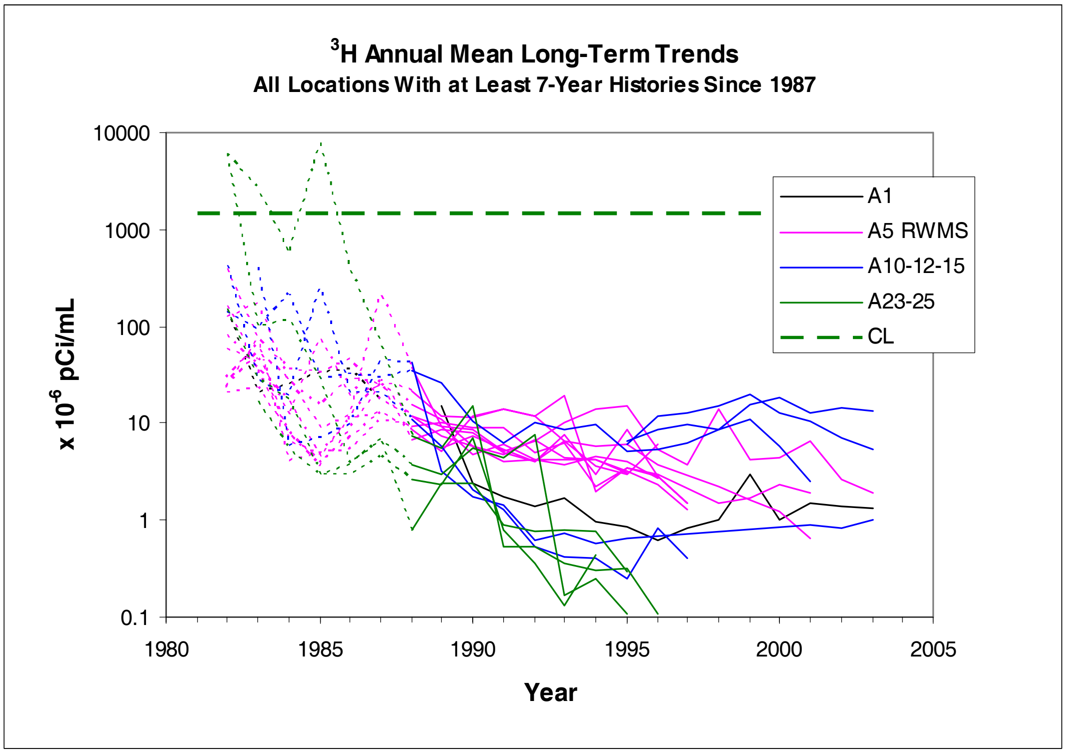


Figure 2-6. Average long-term trends in tritium at locations on the NTS having at least 7 years of data

2.1.3.1.6 Gross Alpha and Gross Beta

The concentrations of gross alpha and gross beta radioactivity in air samples collected from all environmental samplers in 2003 are shown in Tables 2-9 and 2-10 and Figures 2-7 and 2-8. Since these radioactivities include naturally-occurring uranium isotopes, ^{40}K, and ^{7}Be, no reference to a CL is appropriate. These analyses are useful in that they can be performed by BN personnel at NTS five days after collection to identify any increasing trends requiring investigation.

As shown in Figures 2-7 and 2-8, the concentrations of both gross alpha and gross beta have a cyclical variation similar to what has been observed in the past. The locations of peak values at DoD, U-3bh N, BJY, Sugar Bunker N, and Bunker 9-300 identified on the figures, are at locations near or in areas of legacy deposits of radionuclides in and on the soil. Peak values at these same five locations have been measured during previous years. No increasing trend in gross alpha or beta radioactivity was observed for any location.

Table 2-9. Gross alpha radioactivity in air samples collected in 2003

			Gross Alpha (x 10^{-15} μCi/mL)						
NTS Area	Location	Number of Samples	Mean	Median	Std [(a)]	Min [(b)]	Max [(c)]	Mean MDC	% > MDC
1	BJY	52	4.111	3.696	2.810	-2.228	12.006	3.077	73.1
3	U-3ah/at N	52	5.651	5.547	2.636	0.824	13.747	3.100	87.5
3	U-3ah/at S	48	6.397	5.757	3.400	0.163	19.857	3.488	87.5
3	U-3bh N	50	4.825	4.669	2.954	-0.492	14.501	3.794	66.0
3	U-3bh S	51	4.424	4.602	2.051	-0.137	9.287	3.064	78.4
5	DoD	52	4.354	4.161	2.646	-0.122	14.470	3.083	71.2
5	Sugar Bunker N	48	5.646	5.663	2.779	0.000	15.492	3.214	87.5
6	Yucca	52	4.425	3.969	2.496	0.166	12.411	3.082	72.1
9	Bunker 9-300	52	4.045	3.487	2.412	-0.947	9.176	3.083	67.3
10	Gate 700 South	51	3.665	3.518	2.032	0.402	7.583	3.083	58.8
10	Sedan N	50	3.814	3.612	2.385	-1.112	12.651	3.356	60.0
16	3545 Substation	51	3.686	3.218	2.327	-0.403	9.380	3.041	52.0
18	Little Feller 2 N	51	3.750	3.704	2.405	-1.342	10.754	3.051	56.9
20	Gate 20-2P	21	2.726	2.570	1.618	-0.544	5.502	3.273	42.9
20	Schooner	49	3.832	3.537	2.386	-0.270	11.116	3.000	59.2
23	Mercury Track	51	3.763	3.706	2.278	-1.526	10.637	3.105	66.7
25	Guard Station 510	51	4.304	3.788	2.464	0.487	10.764	3.107	70.6
27	ABLE Site	39	3.822	3.422	1.975	0.166	8.105	3.160	64.1
27	JASPER Stack	23	-0.123	0.000	7.643	-10.895	22.391	28.724	0.0
	All Onsite Locations	**894**	**4.227**	**3.935**	**2.927**	**-10.895**	**22.391**	**3.828**	**67.0**

Blue shading indicates those stations which are EPA approved critical receptor samplers

Orange shading indicates the point-source sampler station

No shading indicates those stations which are environmental samplers

Green shading indicates that some percentage of samples had concentrations above the sample specific MDC

(a) Standard deviation

(b) Minimum

(c) Maximum

Table 2-10. Gross beta radioactivity in air samples collected in 2003

NTS Area	Location	Number of Samples	Gross Beta (x 10^{-15} µCi/mL) Mean	Median	Std [(a)]	Min [(b)]	Max [(c)]	Mean MDC	% > MDC
1	BJY	52	18.865	18.553	6.572	0.229	31.091	3.062	98.1
3	U-3ah/at N	52	19.855	20.027	5.694	7.097	29.242	3.085	100.0
3	U-3ah/at S	48	20.220	19.613	5.589	6.672	30.612	3.471	100.0
3	U-3bh N	50	19.315	18.845	5.597	6.326	32.228	3.774	100.0
3	U-3bh S	51	18.879	18.873	5.863	4.236	30.686	3.057	98.0
5	DoD	52	20.590	20.770	6.078	9.566	31.380	3.068	100.0
5	Sugar Bunker N	48	21.791	23.118	5.893	9.030	31.571	3.194	100.0
6	Yucca	52	20.452	20.334	6.265	7.579	34.178	3.066	100.0
9	Bunker 9-300	52	18.655	18.212	6.096	3.943	33.036	3.068	98.1
10	Gate 700 South	51	18.438	18.008	5.519	6.865	30.062	3.067	100.0
10	Sedan N	50	18.517	18.082	6.567	-4.618	31.791	3.340	98.0
16	3545 Substation	51	17.321	17.414	5.997	1.952	28.226	3.025	98.0
18	Little Feller 2 N	51	17.734	17.706	6.023	3.133	31.199	3.034	98.0
20	Gate 20-2P	21	17.112	17.976	5.585	3.956	25.817	3.273	95.2
20	Schooner	49	17.819	18.237	5.502	5.938	29.532	2.991	100.0
23	Mercury Track	51	19.477	19.728	5.948	10.412	30.834	3.090	100.0
25	Guard Station 510	51	20.770	20.772	6.274	8.402	37.103	3.093	100.0
27	ABLE Site	39	19.495	19.509	5.942	4.846	30.237	3.159	97.4
27	JASPER Stack	23	-8.803	-3.293	23.531	-96.057	20.082	28.724	0.0
	All Onsite Locations	**894**	**18.523**	**18.820**	**8.297**	**-96.057**	**37.103**	**3.814**	**96.5**

Blue shading indicates those stations which are EPA approved critical receptor samplers

Orange shading indicates the point-source sampler station

No shading indicates those stations which are environmental samplers

Green shading indicates that some percentage of samples had concentrations above the sample specific MDC

(a) Standard deviation

(b) Minimum

(c) Maximum

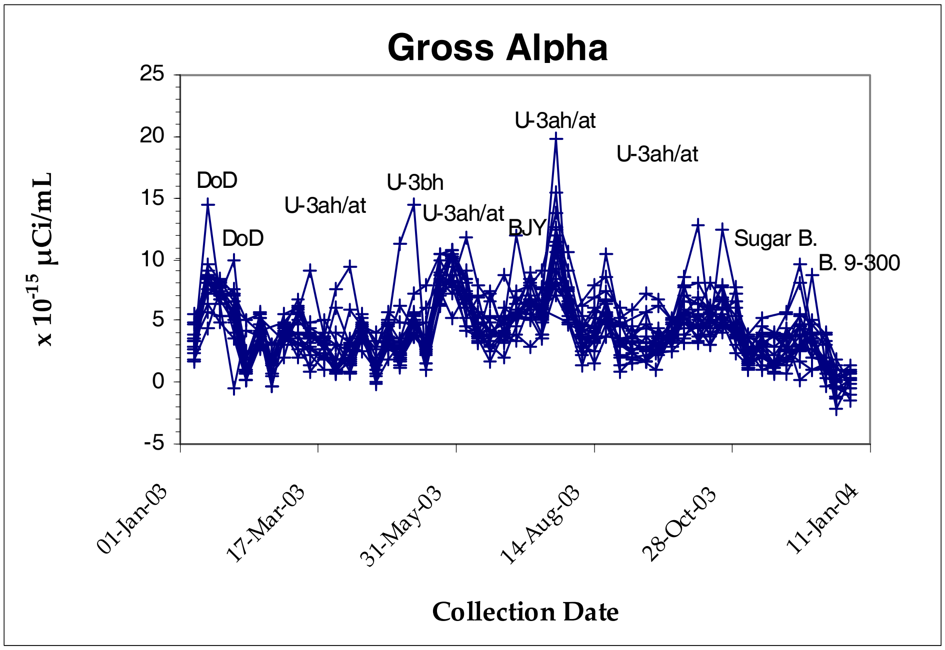


Figure 2-7. Gross alpha radioactivity in air samples collected in 2003

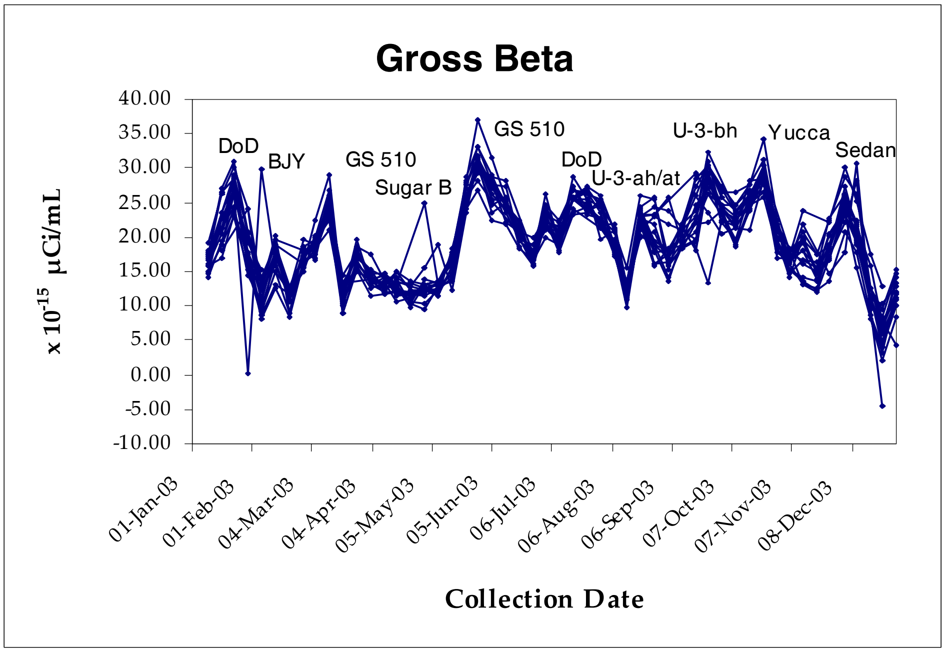


Figure 2-8. Gross beta radioactivity in air samples collected in 2003

2.1.3.2 Critical Receptor Samplers

The following radionuclides were detected at three or more of the critical receptor samplers: ^{241}Am, ^{238}Pu, $^{239+240}$Pu, $^{233+234}$U, $^{235+236}$U, ^{238}U, and ^{3}H (tritium) (see Tables 2-2, 2-4, 2-5, 2-6, and 2-8, respectively). All concentrations of these radionuclides were well below the CLs. The uranium isotopes are attributed to naturally-occurring uranium (see Section 2.1.3.1.4). The concentration of each measured radionuclide (excluding uranium) at each of the six critical receptor samplers was divided by its respective CL (see Table 2-1) to obtain a "fraction of CL". These fractions were then summed for each location. The sum of these fractions at each critical receptor sampler is less than 1.0 (Table 2-11) and shows that the NESHAP dose limit to the public of 10 mrem/yr was not exceeded.

Table 2-11. Sum of percents of compliance levels for radionuclides detected at critical receptor samplers

Radionuclides Included in Sum of Percents[(a)]	NTS Area	Location	Sum of Fractions of Compliance Levels (CLs)
^{241}Am, ^{238}Pu, $^{239+240}$Pu, ^{3}H	6	Yucca	.015
	10	Gate 700 South	.007
	16	3545 Substation	.006
	20	Schooner	.286[(b)]
	23	Mercury	.007
	25	Guard Station 510	.006

(a) $^{233+234}$U, $^{235+236}$U, and ^{238}U are not included in sum of percents. All uranium detected in air particulate samples were determined to be naturally-occurring, based on their isotopic ratios.

(b) This equates to a hypothetical receptor at this location receiving a CEDE of 2.9 mrem/yr.

2.1.3.3 Point-Source (Stack) Sampler

The 2003 air samples from the stack sampler at the JASPER facility contained no man-made radionuclides above their MDCs (see Tables 2-2 through 2-9). The HEPA filters at the facility appeared to function as intended. No radionuclide emission rate or offsite dose was calculated, therefore, for this potential NTS radiation source (see Section 7.0).

2.1.4 Environmental Impact

The concentrations of man-made radionuclides in air on the NTS were all less than the regulatory concentration limits specified by federal regulations. Long-term trends of $^{239+240}$Pu and tritium in air continue to show a decline with time. All radionuclides detected by environmental monitoring appear to be from legacy deposits of radioactivity on and in the soil from past nuclear tests. There was no significant contribution to radioactive air emissions from NTS operational facilities in 2003.

2.2 Non-Radiological Air Quality Assessment

2.2.1 Goals and Compliance Measures

Non-radiological air quality assessments[1] are conducted to document compliance with current state of Nevada air quality permits that regulate specific operations or facilities on the NTS. The state of Nevada has adopted the CAA standards which include NESHAP, National Ambient Air Quality Standards (NAAQS), and New Source Performance Standards (NSPS) (see Section 1.1.1). Therefore, requirements set forth in the NTS air permits issued by the state are in compliance with these national standards. Specifically omitted from this section is NESHAP compliance for radionuclide emissions, as these were presented in Section 2.1.3.2. Assessments, facility/equipment monitoring, record-keeping, and reporting activities related to air quality on the NTS are conducted by BN ECD specifically to:

- Ensure that NTS operations comply with all the requirements of current air quality permits issued by the state of Nevada for NTS operations.
- Ensure that air emissions of criteria pollutants (sulfur dioxide [SO_2]), nitrogen oxides[NO_X], carbon monoxide [CO], ozone, lead [Pb], and particulate matter [PM]) do not exceed limits established under NAAQS.
- Ensure that NTS operations comply with the asbestos abatement reporting requirements under NESHAP.
- Document usage of ozone-depleting substances (ODS) to comply with Title VI of the CAA.

BN ECD personnel monitor the following compliance measures as required by air quality permits for the operation of specific facilities and/or pieces of equipment on the NTS:

- Tons of emissions of each criteria pollutant produced annually
- Gallons of fuel burned annually
- Hours of operation of equipment per year
- Monthly opacity readings
- Rate at which aggregate and concrete is produced
- Amount of asbestos in existing structures removed or scheduled for removal

2.2.2 Methods

There are three current NTS air quality permits (see Section 1.12, Table 1-12). They include:

- AP9711-0549 for over 30 facilities/pieces of equipment in Areas 1, 3, 5, 6, 12, and 23
- AP9711-0556 for the HSC in Area 5
- AP9711-0814 for the (Tactical Demilitarization Development Project) TaDD Facility in Area 11

NTS facilities that are regulated by air permits must adhere to the recordkeeping and operational requirements specified in the permits. Compliance is verified by conducting periodic site walk-downs, observations of equipment while in operation, and a review of the records associated with each permitted facility.

Along with each air quality permit issued, there is an Air Emissions Inventory which lists all permitted facilities/equipment and the quantities of criteria pollutants as well as (Hazardous Air Pollutants) HAPs that each facility/piece of equipment would emit annually if it were operated for the maximum number of hours specified in the air permit. These quantities are known as the "Potential to Emit" (PTE). Lead is considered a HAP as well as a criteria pollutant. Emissions from lead are reported as part of the total HAPs emissions rather than as a separate

[1]The word "assessment" versus "monitoring" is used in this section. Adherence to most non-radiological air quality standards on the NTS does not require field collection and analysis of air samples (activities called "monitoring" in this report). Instead, adherence to NTS air quality permits for non-radiological emissions usually involves the review of records, gathering of operational information, and calculations of emissions.

criteria pollutant. Compliance with permits involves documenting that the PTE for all facilities/equipment is not exceeded. A description of the various activities performed or measures tracked in order to meet permit requirements are described below.

2.2.2.1 Emissions of Criteria Air Pollutants and Hazardous Air Pollutants

Quantities of emissions of criteria pollutants and non-radiological HAPs produced by each permitted facility are determined through calculations that take into account the number of operating hours, number of gallons of fuel burned, number of tons of material that were produced, and emission factors. Emission factors are representative values that relate the quantity of a pollutant released to the atmosphere to an activity associated with the release of that pollutant. These factors are generally expressed as the weight of the pollutant divided by a unit weight, volume, distance or duration of the activity emitting the pollutant, e.g., pounds of particulates emitted per ton of aggregate material produced. Emission factors have been developed for many different types of industries and activities and are published by the EPA in a two-volume document known as the *Compilation of Air Pollutant Emission Factors* (EPA, 1995). This document is updated on a continuing basis and is recognized by regulatory agencies as an industry standard. The emission factors that were used in the NTS air quality operating permits are derived from this source.

Each year, the state issues to NNSA/NSO, as an air quality permit holder, *Actual Production/Emissions Reporting Forms* for each of the NTS air permits. These forms are used to report the actual hours of operation, gallons of fuel burned, etc., for each permitted facility/piece of equipment listed on each air quality permit. Using this data and emission factors furnished by the state, emissions of the criteria pollutants are calculated and the emissions reported along with the other required information mentioned above. The forms are completed by BN ECD personnel and returned to NNSA/NSO for submittal to the state. The state uses the information from the report to determine annual maintenance and emissions fees and to document compliance with emission limits.

Quantities of criteria pollutants produced by open burns are not required to be calculated. However, submittal of an Open Burn Variance form is required by the state prior to each burn. An exception to this is the Open Burn Variance for fire extinguisher training, which is valid for one year and covers approximately 60 fire extinguisher training sessions conducted throughout the year.

2.2.2.2 Production Rates/Hours of Operation

Compliance with operational parameters such as production rates and hours of operation is verified through an examination of the data generated by each facility owner for the annual report to the state. The number of hours that equipment operates throughout a year is determined by reading meters that are located on each piece of equipment. Permit requirements specific to each piece of equipment dictate the frequency in which readings are obtained. Production rates for construction facilities such as the aggregate-producing plant are calculated using the hours of operation and amount of material produced. Logbooks are maintained to record this information. Gallons of fuel used are calculated using industry standards and the hours of operation, or simply by recording tank levels each time that the tank is filled.

2.2.2.3 Opacity Readings

Under Title 40 CFR, Part 60, personnel that conduct visible emissions evaluations to satisfy the opacity requirements for a facility or piece of equipment must be certified semi-annually by a qualified organization. A form similar to one appearing in Title 40 CFR, Part 60 for conducting visible emissions evaluations is used to record and document the readings. The form requires that weather conditions, wind speeds and other factors that could affect the readings be recorded. Visual readings are taken every 15 seconds. A minimum of 24 consecutive readings is required for a valid reading. The average of the 24 readings must not exceed the permit-specified limit (20 percent for NAAQS, 10 percent for NSPS) to remain in compliance. Readings are only required to be obtained once during the month that the equipment is used. No readings are required during the month(s) that the equipment is not used.

2.2.2.4 HSC Reporting

The NTS air quality operating permit for the HSC requires, in addition to annual reporting, the submittal of test plans and final analysis reports to the state for each chemical release. Test plans provide detailed information regarding the types and quantities of chemicals to be released, a description of how they will be released, and environmental and chemical hazards. The HSC, by its nature as a research facility, provides no air quality controls. The impact of the chemical releases is minimized by controlling the amount and duration of each release. When chemical release tests are conducted, plumes pass through an instrument array and impacts are confined to a defined area. Predictions of impacts for each test are reliable because of extensive meteorological data that is available on wind direction, wind speed, standard deviation of wind direction, vertical turbulence, temperature, humidity, and barometric pressure. In turn, post-release monitoring is used to document the degree of actual impact. Following each release, a completion report is submitted that documents the test dates, chemicals, and quantities that were actually released.

2.2.2.5 TaDD Reporting

The TaDD is located in Area 11 at the NTS. This facility was developed as a prototype of a portable burn facility to dispose of unneeded Shillelagh tactical military rocket motors. As such, an air quality operating permit was required because of the emissions generated during each burn. Emissions are controlled by a baghouse, HEPA, and ultra high efficiency filters. Permit requirements include annual reporting of hours of operation and emissions and an opacity limit of 20 percent.

2.2.2.6 ODS Recordkeeping

ODS recordkeeping requirements applicable to NTS operations include maintaining, for a minimum of three years, evidence of technician certification, recycling/recovery equipment approval, and servicing records for appliances containing 22.7 kilograms (50 pounds) or more of refrigerant. Compliance with recordkeeping and certification requirements for the use and disposition of ODS is verified through periodic assessments. The assessments include a records review and interviews with managers and technicians associated with the use, disposition, and purchase of refrigerants. Under Section 608 of the CAA, EPA may conduct random inspections to determine compliance.

2.2.2.7 Asbestos Abatement

Asbestos abatement plans are made annually which estimate the quantities of asbestos-containing materials that are scheduled for removal during the next calendar year. These projections are submitted to EPA in an Annual Asbestos Abatement Notification Form. If quantities actually removed exceed 79.2 linear meters or 14.9 square meters (260 linear feet or 160 square feet), then EPA is notified by submitting a Notification of Demolition and Renovation Form. The recordkeeping requirements for asbestos abatement activities on the NTS include maintaining the following records for the following number of years:

- Asbestos air and bulk sampling data records (collected during asbestos removal projects) up to 75 years
- Asbestos abatement plans up to 25 years
- Operations and Maintenance activity records up to 75 years
- Location-specific records of asbestos-containing materials for a minimum of 75 years

Compliance with recordkeeping requirements is verified through periodic assessments. The assessments include a records review and interviews with managers and technicians associated with asbestos abatement. State assessments/audits are performed periodically.

2.2.3 Results

2.2.3.1 Emissions of Criteria Air Pollutants and Hazardous Air Pollutants

Records that were examined for permitted facilities and equipment indicated that all operational parameters were being properly tracked. Table 2-12 presents the calculated tons of emissions of criteria pollutants regulated under permits from those NTS facilities that were operational during 2003. The maximum allowable emissions (i.e., the PTE) for each facility are also shown in Table 2-12 and were derived from the limits set forth in the NTS air quality permits. Approximately 12.9 mtons (14.3 tons) of criteria pollutants were emitted from NTS facilities and equipment during 2003. The majority of these emissions were nitrogen oxides from fuel burned by diesel fired generators. No emission limits were exceeded.

Table 2-12. Tons of criteria air pollutant emissions released on the NTS in 2003

	Calculated Tons[a] of Emissions for Calendar Year 2003									
	Particulate Matter (PM10)[b]		Carbon Monoxide (CO)		Nitrogen Oxide (NOx)		Sulfur Dioxide (SO2)		Volatile Organic Compounds (VOC)	
Facility	**Actual**	**PTE[c]**	**Actual**	**PTE**	**Actual**	**PTE**	**Actual**	**PTE**	**Actual**	**PTE**
Wet Aggregate Plant	0.78	6.14	NA [d]	NA	NA	NA	NA	NA	NA	NA
Area 1 Concrete Batch Plant	0.03	2.04	NA	NA	NA	NA	NA	NA	NA	NA
Cementing Equipment	0.52	18.54	NA	NA	NA	NA	NA	NA	NA	NA
Portable Cement Bins	0.01	3.06	NA	NA	NA	NA	NA	NA	NA	NA
Boilers	0.15	0.61	0.42	1.35	1.5	5.41	0.32	1.15	0.02	0.06
Incinerator (propane fired)	0	0.03	0	0	0	0.02	0	0	0	0
Diesel Fired Compressors	0.11	0.54	0.3	1.66	1.51	7.72	0.1	0.51	0.12	0.61
Diesel Fired Generators	0.79	3.34	1.07	10.24	5.1	17.87	0.34	3.13	0.37	2.16
Laboratory Hoods	NA	NA	NA	NA	NA	NA	NA	NA	0.01	2
Bulk Gasoline Storage Tank	NA	NA	NA	NA	NA	NA	NA	NA	0.69	3.92
Bulk Diesel Fuel Storage Tank	NA	NA	NA	NA	NA	NA	NA	NA	0	0.02
Total	**2.39**	**34.3**	**1.79**	**13.25**	**8.11**	**31.02**	**0.76**	**4.79**	**1.21**	**8.77**
Total 2003 Actual Emissions	**14.26**									

(a) For mtons, multiply tons by 0.9072

(b) Particulate matter equal to or less than 10 microns in diameter

(c) PTE = potential to emit; the quanitity of criteria pollutant that each facility/piece of equipment would emit annually if it were operated for the maximum number of hours and at the maximum production rates specified in the air permit.

(d) Not applicable because the permit does not regulate the emissions of this pollutant for this facility

Table 2-13 is a summary of tons of air pollutants released on the NTS since 1995. These numbers were derived from the Actual Production/Emissions Reporting Forms that are required to be submitted to the state annually. Prior to calendar year (CY) 2000, HAPS were not included in the Reporting Forms. HAPS are now reported, but for only a few of the facilities. Specific HAPS are not identified in the Reporting Forms. The quantity of HAPS released in 2003, as calculated in the Reporting Forms, was 0 (Table 2-13).

The *Calendar Year 2003 Actual Production/Emissions Reporting Form,* containing the calculated emission totals for 2003 was submitted to the Nevada Division of Environmental Protection on February 24, 2004, prior to its due date of March 1.

Table 2-13. Tons of air pollutants released on the NTS since 1995

	Total Emissions (tons/yr)[a]								
Pollutant	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Particulate Matter (PM10)[b]	4.53	2.89	1.67	1.11	1.7	1.46	2.05	3.61	2.39
Carbon Monoxide (CO)	0.21	0.04	5.28	1.85	1.87	2.76	4.84	4.6	1.79
Nitrogen Oxides (NOx)	1.56	0.16	19.79	7.57	8.07	12.75	22.23	21.09	8.11
Sulfur Dioxide (SO2)	1.47	0.3	0.85	0.37	0.42	0.98	1.68	1.62	0.76
Volatile Organic Compounds (VOC)	19.87	2.82	0.94	11.76	1.99	1.89	2.01	2.1	1.21
Hazardous Air Pollutants (HAPS)	0	0	0	0	0	0.01	0.03	0.01	0

(a) For mtons, multiply tons by 0.9072
(b) Particulate matter equal to or less than 10 microns in diameter

2.2.3.2 Production Rates/Hours of Operation

Production rates and hours of operation were computed for all permitted facilities as an interim step in order to calculate the tons of air pollutants emitted in 2003, as shown in Table 2-12 above. The records examined for all permitted equipment and facilities indicated that the production rates, hours of operation, and gallons of fuel used by each were within the specified permit limits.

2.2.3.3 Opacity Readings

During 2003, four BN personnel were certified by Carl Koontz Associates to conduct visible emissions evaluations (i.e., opacity readings). Opacity readings were obtained for the following NTS permitted facilities regulated under the NAAQS opacity limit of 20 percent: Area 23 Incinerator, Area 1 Concrete Batch Plant, Area 1 Wet Aggregate Plant, Area 23 Boiler, Area 1 Storage Silos, and the Portable Field. Readings for these facilities ranged from 0 to 10 percent, all below the air quality permit limits of 20 percent.

Opacity readings were obtained once a month for a portion of the Area 1 Wet Aggregate Plant which is regulated under the stricter NSPS opacity limit of 10 percent. Opacities were found to be within the 10 percent limit.

One evaluation was performed for a small chemical release at Test Cell C in Area 26. Test Cell C is a non-permitted facility for such releases, and permission from the state was required and obtained prior to conducting the release. The opacities from this facility ranged from 15 to 20 percent.

2.2.3.4 HSC Reporting

In 2003, four chemical tests consisting of 17 releases were conducted at the HSC. They included:

- Divine Invader Test Series (2 releases)
- Roadrunner II Test (4 releases)
- Quail Project (3 releases)
- DuPont Fuming Acids Mitigation Workshop (8 releases)

A completion report was submitted to NNSA/NSO for transmittal to the Nevada Division of Environmental Protection's Bureau of Air Pollution Control at the conclusion of each test. Table 2-14 summarizes the quantities of all chemicals released during all 2003 tests.

Table 2-14. Pounds of chemicals released during tests conducted in 2003 at the HSC

Chemical	State in Container	Total Amount Released (lbs)[(a)]
Chlorosulfonic acid	Liquid	2,457
Methyl phosphonic dichloride	Liquid	22
Dipropylene glycol methyl ether	Liquid	5,228
Dimethyl methylphosphonate	Liquid	3,183
Nitrous oxide	Gas	40
Oleum	Liquid	2,545
Sulfur hexafluoride, pure	Gas	230
Thiodiglycol	Liquid	533
Thionyl chloride	Liquid	32

(a) 1lb = 0.456 kilograms

2.2.3.5 TaDD Reporting

The TaDD facility has not been used due to lack of funding, and in 2003 the Shillelagh missiles that would have been burned at this facility were removed from the NTS. Thus, no opacity readings have been acquired and no emissions reported.

2.2.3.6 ODS Recordkeeping

From an assessment conducted in CY 2002, it was determined that the regulatory requirements of Title VI (Section 608) of the CAA for the protection of stratospheric ozone were generally being met. No assessment was conducted in CY 2003. An ODS Management Plan is scheduled to be written in 2004 to develop and implement a program and procedures to maximize the use of safe alternatives to ODS due to their required phaseout.

2.2.3.7 Asbestos Abatement

An Annual Asbestos Abatement Notification Form was submitted to the EPA in November 2002 which projected that 45.7 linear meters (150 linear feet) and 18.6 square meters (200 square feet) of asbestos-containing material would be removed from NTS facilities in 2003. During 2003, the actual amounts of asbestos-containing materials that were removed included those from the old steam plant in Mercury and the old Mercury theatre as shown below:

- 92.9 square meters (1,000 square feet) of transite board
- 61 linear meters (200 linear feet) of thermal system insulation
- 74.3 square meters (800 square feet) of sprayed-on insulation

The EPA was notified of these activities because the quantities of asbestos-containing material removed exceeded EPA's notification threshold of 79.2 linear meters or 14.9 square meters (260 linear feet or 160 square feet). All other asbestos abatement activities throughout the NTS complex were minor in scope, involving the removal of amounts below the reporting threshold. Asbestos abatement records continued to be maintained as required.

2.2.4 Environmental Impact

Air emissions produced by NTS operations and activities during CY 2003 were within regulatory limits and had little, if any, impact to air quality on the NTS and at offsite locations. Emissions of pollutants for CY 2003 were significantly less than those generated during the heightened activity that occurred in the years prior to the nuclear weapons testing moratorium.

Impacts of the chemical releases during tests at the HSC are minimized by controlling the amount and duration of each release. Biological monitoring at the HSC is performed whenever there is a risk of significant exposure to downwind plants and animals from the planned tests (see Section 12.5). BN biologists review all chemical release test plans to determine the level of field monitoring needed for each test. To date, chemical releases at the HSC have used such small quantities (when dispersed into the air), that downwind test-specific monitoring has not been necessary. No measurable impacts to downwind plants or animals have been observed.

3.0 Radiological and Non-Radiological Water Monitoring

This chapter presents both radiological and non-radiological monitoring results for surface water and groundwater conducted by Bechtel Nevada (BN) on and off the Nevada Test Site (NTS). Surface water and groundwater includes natural springs, drinking water, non-potable groundwater, and water discharged into domestic and wastewater systems on the NTS. Several BN programs or projects are involved with water monitoring and include: (1) routine radiological monitoring conducted by BN Environmental Technical Services (ETS) under the Routine Radiological Environmental Monitoring Plan (RREMP) (DOE, 2003b), (2) water quality assessments of permitted water systems conducted by BN Environmental Compliance Department (ECD), and (3) water sampling and analysis conducted by the Underground Test Area (UGTA) Project. Water quality assessments are driven by the need to comply with applicable state and federal regulations (see Section 1.2) as well as by the desire to address the concerns of stakeholders who reside within the vicinity of the NTS. Section 3.1 of this chapter addresses only radiological water monitoring.

Data presented in Section 3.1 are limited to the concentrations of radioactivity in water samples. These data are then used to calculate radiological dose to the general public, via drinking water, in the vicinity of the NTS. The reader is directed to Section 7.0 (Radiological Dose Assessment) of this Nevada Test Site Environmental Report (NTSER) where the calculated dose from drinking water is presented.

An oversight monitoring program has been established by U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) to independently monitor radionuclide contamination of offsite springs and water supply systems. This independent oversight program is managed by the Desert Research Institute (DRI). DRI's 2003 monitoring results for surface and groundwater are presented in Section 5.7 of this NTSER.

Section 3.2 of this chapter presents the results of non-radiological water monitoring of drinking water, domestic and industrial waste waters on the NTS. Non-radiological water monitoring is also conducted to comply with state and federal water regulations (see Section 1.2).

3.1 Radiological Surface Water and Groundwater Monitoring

There have been 828 underground nuclear tests conducted at the NTS. Approximately one third of these tests were detonated near or below the water table (DOE, 1996; DOE, 2000b). This legacy of nuclear testing has resulted in the contamination of groundwater in some areas. The Federal Facility Agreement and Consent Order (FFACO) established Corrective Action Units (CAUs) that delineated and defined areas of concern for groundwater contamination on the NTS (DOE, 1996). Figure 3-1 shows the locations of underground nuclear tests and areas of potential groundwater contamination. To safeguard the public's health and safety and comply with applicable federal, state, and local environmental protection regulations as well as the U.S. Department of Energy (DOE) directives, groundwater on and near the NTS is monitored for radioactivity. Monitoring in the past has been conducted by the U.S. Public Health Service, U.S. Geological Survey (USGS), the U.S. Environmental Protection Agency (EPA), and others. In 1998, BN was tasked by NNSA/NSO to establish and manage an NTS integrated and comprehensive radiological environmental monitoring program. The RREMP (DOE, 2003b), was prepared and describes groundwater monitoring objectives, regulatory drivers, and quality assurance protocols.

3.1.1 Goals and Compliance Measures

The goal of radiological water monitoring is to determine if concentrations of radionuclides in groundwater and in surface water bodies at the NTS and its vicinity pose a threat to public health or the environment. Specifically, the monitoring program collects and analyses water samples to meet the following objectives:

- Determine if radionuclide concentrations in on and offsite water supply wells exceed the safe drinking water standards established by the EPA under the Safe Drinking Water Act and the dose limits to the general public established by DOE Order 5400.5. (See Section 7.0 for calculated dose).
- Determine if radionuclide concentrations in surface water from NTS natural springs and from bodies of water on the NTS result in the exposure of terrestrial and aquatic animals to doses which exceed those established by DOE (DOE-STD-1153-2002) to protect wildlife populations. (See Section 7.0 for calculated dose).

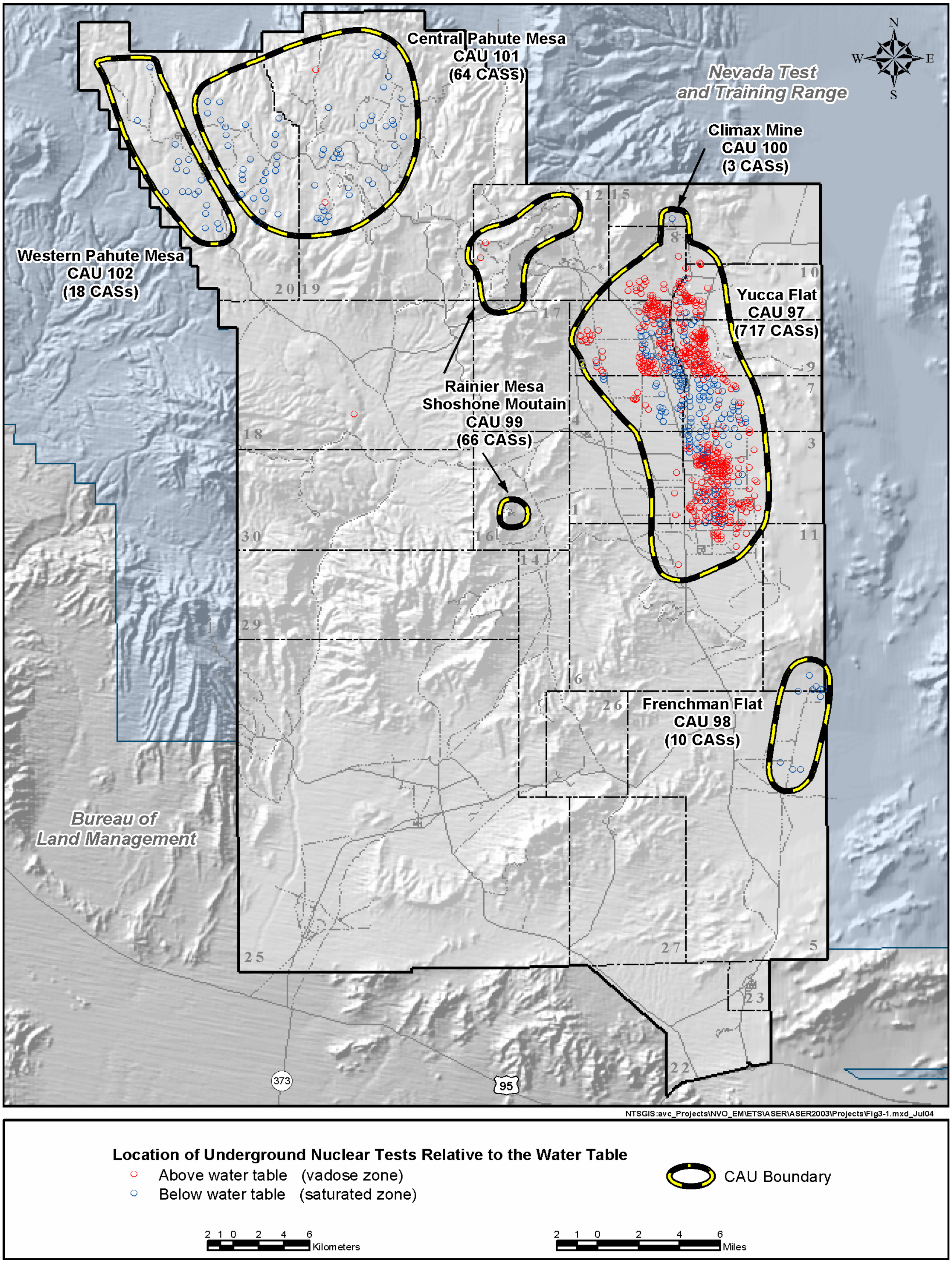


Figure 3-1. Areas of potential groundwater contamination on the NTS

- Determine if permitted facilities on the NTS are in compliance with permit discharge limits for radionuclides.
- Determine if radionuclide concentrations in offsite natural springs and from on and offsite non-potable water wells (monitoring wells), including those within CAUs, indicate that past or present NNSA/NSO activities have an impact on the environment. Often, strict drinking water standards are used as a monitoring action level for this determination.

The RREMP outlines the goal and objectives listed above. In addition to RREMP-driven monitoring, the UGTA Project (see Section 13.0) collects data from wells to define groundwater flow rates and direction to determine the nature and location of aquifers. Data from these studies are used to determine whether or not radionuclides resulting from nuclear testing have moved appreciable distances from the original test location. Groundwater or vadose zone sampling and radiological analysis results for 2003 from UGTA wells are also presented in this section of the NTSER along with RREMP monitoring results (see Section 3.1.5).

The measures for radiological water monitoring in 2003 were concentrations of the following analytes:

- ^{241}Am
- ^{14}C
- Gamma-emitting radionuclides
- Gross alpha radioactivity
- Gross beta radioactivity
- ^{238}Pu, and $^{239+240}$Pu
- ^{226}Ra and ^{228}Ra
- ^{90}Sr
- ^{99}Tc
- Tritium (^{3}H)
- Uranium isotopes

The selection of analytes for groundwater monitoring are based on the radiological source term from historical nuclear testing, regulatory/permit requirements, and characterization needs. The isotopic inventory remaining from nuclear testing is presented in the most recent environmental impact statement for NTS activities (DOE, 1996c) and a recent Lawrence Livermore National Laboratory (LLNL) document (Smith, 2001). Many of the radioactive species generated from subsurface testing have very short half-lives, sorb strongly onto the solid phase or are bound into what is termed "melt glass" and are not available for groundwater transport in the near term (Smith, 1993; Smith et al., 1995). Tritium (^{3}H) is the radioactive species created in the greatest quantities and is widely believed to be one of the most mobile. Tritium is therefore the primary target analyte and represents the greatest concern to users of groundwater on and around the NTS for at least the next 100 years due to its high mobility and concentration (DOE, 1996c; International Technology [IT], 1997).

Tritium analyses are done on all water samples. Analyses for gross alpha, gross beta, and gamma-emitting radionuclides are also conducted on all water samples as rapid screening measures. Gross alpha and gross beta radioactivity include activity from both natural and potential man-made radionuclides but are used as indicators of radionuclide contamination. Naturally-occurring deposits of certain minerals in water can contribute to both alpha (e.g., isotopes of uranium and ^{226}Ra) and beta (e.g., ^{228}Ra and ^{40}K) radiation. The analyses for gamma-emitting radionuclides by gamma spectroscopy can identify the presence of specific man-made radionuclides (e.g., ^{241}Am, ^{137}Cs, ^{60}Co, ^{152}Eu, and ^{154}Eu), as well as natural radionuclides (e.g., ^{228}Ac, ^{212}Pb, ^{40}K, ^{235}U, and ^{234}Th). Specific analyses for ^{238}Pu, $^{239+240}$Pu, ^{226}Ra, ^{228}Ra, ^{14}C , ^{90}Sr, ^{99}Tc, ^{241}Am, and uranium isotopes were performed on selected water samples to help characterize sampled locations. Water analyses also included chemical parameters to characterize the groundwater system, but these measures are not reported in the NTSER.

3.1.2 Methods

3.1.2.1 Monitoring Locations

The NTS groundwater monitoring network consists of a variety of monitoring locations that include onsite supply wells, domestic offsite wells, wells specifically designed to monitor groundwater, natural springs, containment ponds, and point of opportunity locations. The groundwater locations sampled in 2003 are presented in Figures 3-2 and 3-3. The NTS groundwater monitoring sites are located in a complex hydrogeologic setting as described in Appendix A, Section A.5. The predicted groundwater flow paths are also presented in Figures 3-2 and 3-3.

A network of 45 wells were sampled in 2003 (Figure 3-2) and consisted of:

- 21 offsite wells
- 10 onsite potable water supply wells (nine of which are permitted)
- 14 onsite monitoring wells (3 are compliance wells for the Area 5 RWMS and 1 is a compliance well for the Area 23 sewage lagoon)

Current surface water monitoring locations sampled in 2003 on and off the NTS (Figure 3-3) include:

- 6 offsite springs
- 1 NTS operations-related containment pond system (E Tunnel ponds)
- 3 onsite sewage lagoons

Several UGTA wells were sampled and analyzed for radionuclides in 2003 under the UGTA program (see Section 13.0). These wells do not comprise the RREMP network of groundwater wells, but they are briefly discussed in Section 3.1.4 below.

3.1.2.2 Water Sampling/Analysis

Water sampling methods are based, in part, on the characteristics and configurations of the sample locations. For example, wells with dedicated pumps may simply be sampled from the associated plumbing (e.g., spigots) at the wellhead, while wells without pumps may be sampled via a wireline bailer or a portable pumping system. Grab samples (discrete samples with respect to space and time) are typically obtained from the springs.

Some of the monitoring program wells are constructed with multiple strings of casing/tubing or multiple completion zones comprised of discrete intervals of slotted casing which access different horizons of the penetrated hydrostratigraphic units. Multiple-depth samples were obtained from four wells with such configurations in 2003:

- 615 and 679 m (2,017 and 2,228 ft) below ground surface (bgs) in ER-6-1
- 590, 622, 649, and 701 m (1,935, 2,040, 2,130, and 2,300 ft) bgs in HTH #1
- 518 and 649 m (1,700 and 2,130 ft) bgs in UE-18r
- 475 and 608 m (1,560 and 1,994 ft) bgs in PM-3

Sampling frequencies and requisite analyses for routine radiological water monitoring are based on the location and type of the sampling point as defined in the RREMP (DOE, 2003b). During each monitoring year, not every water sample is analyzed for every analyte as per the design criteria of the RREMP. In 2003, tritium, gross alpha, gross beta, ^{238}Pu, $^{239+240}$Pu, and gamma spectroscopy analyses were performed on all samples. Analyses for the other listed radionuclides were performed only on specific subsets of groundwater, spring, onsite containment pond, and sewage lagoon samples based on the probability of their existence at the sampled location or whether they have been screened for previously at that location.

To achieve a sufficiently low detection limit, the analyses for most tritium samples were conducted after the samples underwent an enrichment process. The enrichment process concentrates tritium in a sample to provide an effective minimum detectable concentration (MDC) (see Glossary, Appendix D) of approximately 20 pCi/L. The MDC for standard (non-enriched) tritium analyses typically ranges from 200-400 pCi/L.

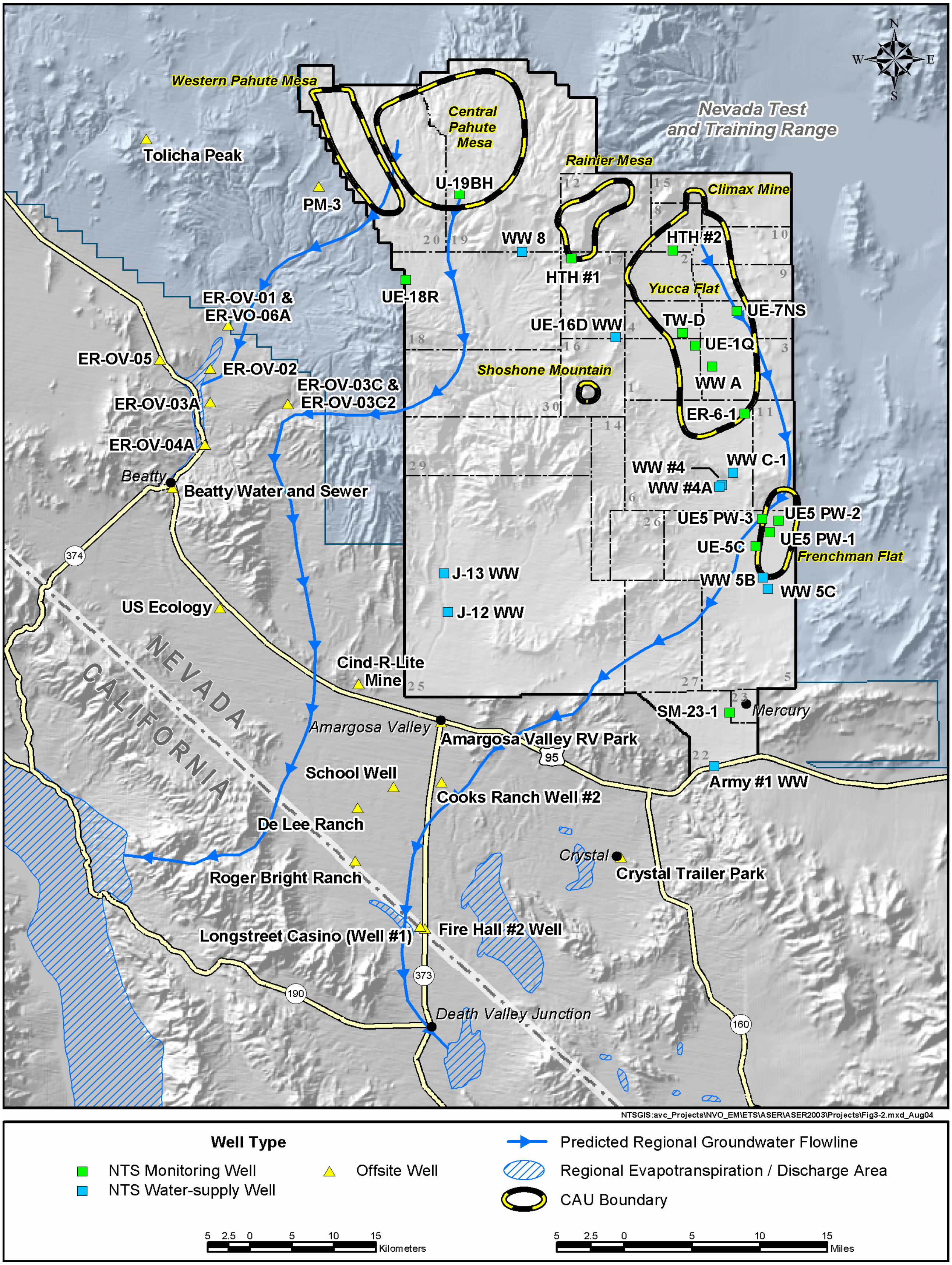


Figure 3-2. 2003 RREMP groundwater monitoring locations on and off the NTS

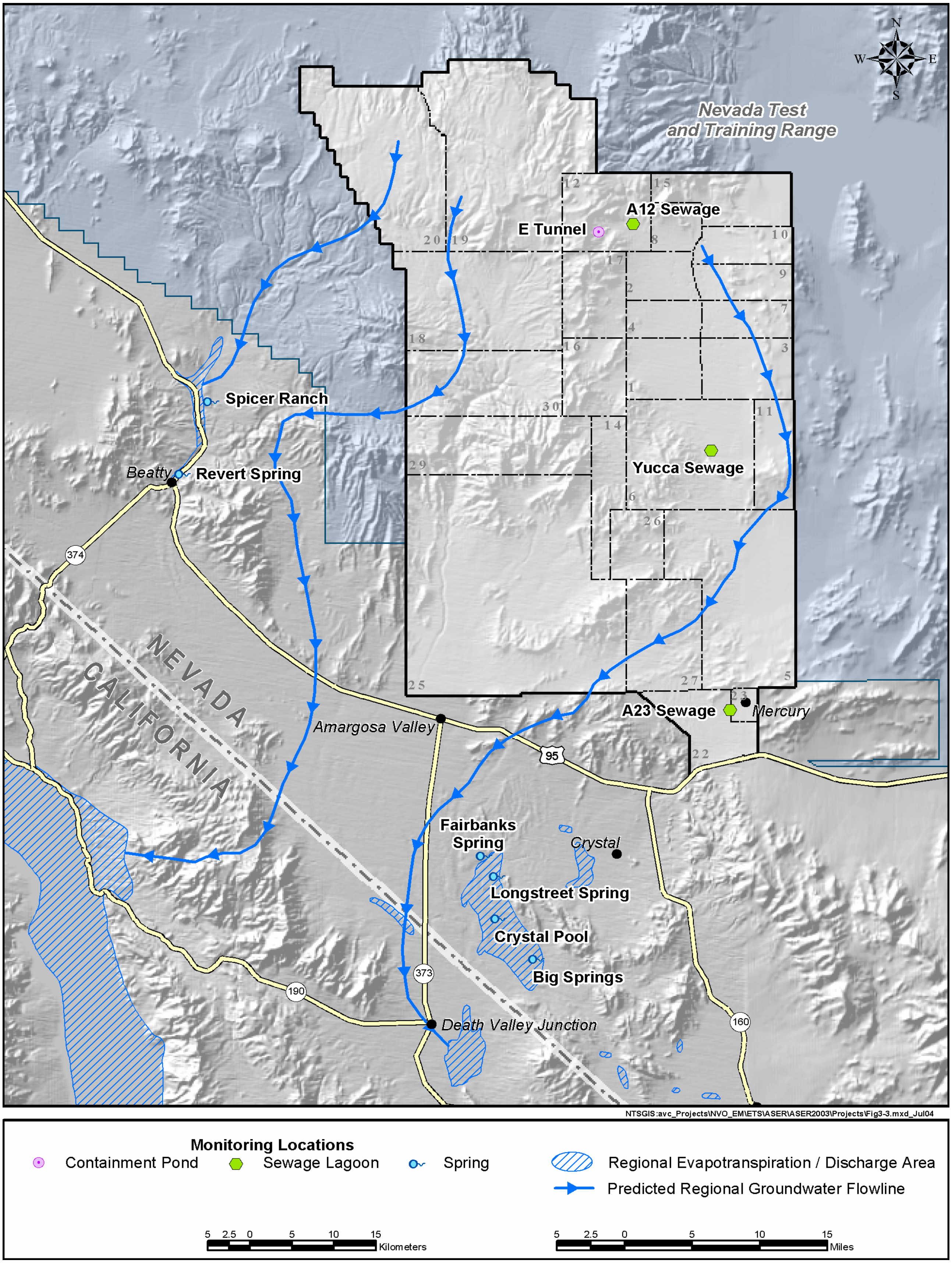


Figure 3-3. 2003 RREMP surface water monitoring locations on and off the NTS

3.1.2.3 Data Quality

Quality Assurance and Quality Control (QA/QC) protocols, including Data Quality Objectives, have been developed and are maintained as essential elements of water monitoring as directed by the RREMP. The QA requirements established for the monitoring program include the use of sample packages to thoroughly document each sampling event, rigorous management of databases, and completion of essential training. The program also provides for the stringent oversight of external analytical laboratories and internal data validation, verification, and review. Routine QC samples (e.g., duplicates, blanks, and spikes) are also incorporated into the analytical suites on a frequent basis. The reader is directed to Section 17.0 for a thorough discussion of QA protocols and procedures utilized for radiological water monitoring.

3.1.2.4 Data Reporting

Each water sample is analyzed for a potentially very large suite of radionuclides based on the analytes listed in Section 3.1.1 above. The following results section presents only concentrations that were above the MDC for gamma-emitting radionuclides, plutonium, ^{14}C, ^{90}Sr, and ^{99}Tc. Concentration values of gross alpha, gross beta, tritium, ^{226}Ra, and ^{228}Ra, whether they are below or above the sample-specific MDCs, are presented for all water samples in the data tables.

The uncertainty values presented in the data tables of this chapter represent the counting uncertainty (or "error") of the analytical method. This does not include the uncertainty associated with the preparation and concentration of tritium which is estimated to be up to 20 percent. Therefore, it is important to note that the total or system error associated with the enrichment and analysis process for tritium samples is somewhat higher than the uncertainty values presented in the data tables.

3.1.3 Results

3.1.3.1 Offsite Wells

The offsite sampling locations included private domestic wells, community wells, and NNSA/NSO wells related to NTS activities. The 2003 data indicate that groundwater at the offsite locations has not been impacted by NTS nuclear testing operations. All of the tritium results for the offsite wells were less than the MDC except for the Beatty Water and Sewer well, which was barely above the sample-specific MDC (Table 3-1). The radiological analytes that were principally detectable in 2003 were gross alpha and gross beta. No man-made radionuclides were detected by gamma spectroscopy in any of the water samples.

ER-OV-01 and ER-OV-02, had gross alpha levels above the EPA established 15 pi/L maximum contaminant level (MCL) in drinking water. These two offsite monitoring wells do not supply drinking water. These wells produce water from a volcanic aquifer that may have relatively higher quantities of natural alpha-yielding elements in the host rock. The gross alpha levels are attributed to the decay of naturally-occurring uranium and local variation in mineralogy due to hydrothermal alteration in the volcanic host rock.

3.1.3.2 Offsite Springs

Four of the six offsite springs sampled (Big Springs, Crystal Pool, Fairbanks Spring, and Longstreet Spring) (see Figure 3-3) are located within the Ash Meadows National Wildlife Refuge, which is located approximately 6 km (3.7 mi) south-southwest of the NTS. With respect to the regional groundwater flow system, Ash Meadows is hydrologically downgradient of the NTS and serves as a discharge area. The two other springs sampled (Spicer Ranch Spring and Revert Spring) are near Beatty, Nevada.

Table 3-1. Gross alpha, gross beta, and tritium analysis results for offsite wells in 2003

Monitoring Location	Date Sampled	Gross α ± Uncertainty[(a)] (MDC) (pCi/L)[(b)]				Gross β ± Uncertainty (MDC) (pCi/L)[(c)]				³H ± Uncertainty (MDC) (pCi/L)[(d)]			
Amargosa Valley RV Park	8/20/2003	0.617	±	0.873	(1.81)	2.39	±	1.24	(2.30)	-10.4	±	16.5	(27.8)
Beatty Water and Sewer	8/6/2003	11.1	±	2.20	(1.28)	9.58	±	1.99	(1.84)	29.9	±	15.3	(23.9)
Cind-R-Lite Mine	8/6/2003	3.75	±	0.920	(0.864)	3.67	±	1.05	(1.33)	9.44	±	14.5	(24.1)
Cooks Ranch Well #2	8/20/2003	1.39	±	0.921	(1.50)	11.6	±	2.31	(2.06)	-20.1	±	16.3	(27.5)
Crystal Trailer Park	8/20/2003	2.20	±	0.863	(1.20)	6.76	±	1.53	(1.74)	-10.9	±	16.6	(28.0)
De Lee Ranch	8/20/2003	1.42	±	0.939	(1.59)	5.60	±	1.61	(2.30)	-13.2	±	16.5	(27.8)
ER-OV-01	6/23/2003	15.0	±	4.63	(2.77)	4.89	±	1.77	(1.77)	18.3	±	12.8	(20.5)
ER-OV-01 FD[(e)]	6/23/2003	16.8	±	5.02	(3.02)	6.25	±	2.01	(1.91)	NA[(f)]			
ER-OV-02	6/24/2003	24.4	±	6.32	(3.95)	2.79	±	1.89	(2.11)	6.66	±	15.5	(26.0)
ER-OV-02 FD	6/24/2003	23.8	±	6.15	(3.53)	2.50	±	1.90	(2.17)	NA			
ER-OV-03A	6/24/2003	12.9	±	3.99	(3.08)	2.19	±	1.58	(1.89)	0.972	±	11.6	(19.7)
ER-OV-03A FD	6/24/2003	12.9	±	4.22	(2.64)	2.44	±	1.50	(1.76)	NA			
ER-OV-03C	6/25/2003	13.1	±	4.38	(2.91)	6.73	±	2.01	(1.91)	12.3	±	13.0	(21.2)
ER-OV-03C2	6/25/2003	10.8	±	3.95	(3.08)	3.64	±	1.72	(2.00)	20.8	±	13.9	(22.1)
ER-OV-04A	7/15/2003	8.42	±	6.44	(8.88)	6.60	±	4.27	(5.81)	20.1	±	14.4	(23.0)
ER-OV-05	7/15/2003	11.4	±	7.08	(8.61)	8.64	±	4.26	(5.28)	-8.49	±	15.4	(25.9)
ER-OV-06A	6/23/2003	11.7	±	3.95	(3.27)	7.22	±	2.02	(1.91)	4.30	±	13.0	(21.7)
Fire Hall #2 Well	8/20/2003	1.63	±	0.989	(1.60)	11.0	±	2.18	(1.95)	8.34	±	16.9	(27.9)
Longstreet Casino Well #1	8/20/2003	0.872	±	0.633	(1.05)	9.27	±	1.78	(1.46)	-16.1	±	16.2	(27.3)
PM-3 (1,560 ft bgs)	12/10/2003	9.61	±	1.91	(1.12)	22.2	±	3.80	(1.75)	-11.9	±	12.1	(21.6)
PM-3 FD (1,560 ft bgs)	12/10/2003	NA				NA				-7.14	±	13.0	(22.7)
PM-3 (1,994 ft bgs)	12/10/2003	5.85	±	1.49	(1.43)	11.3	±	2.38	(2.26)	-4.88	±	12.7	(22.1)
Roger Bright Ranch	8/20/2003	4.12	±	1.44	(1.87)	13.4	±	2.70	(2.45)	-7.86	±	16.0	(27.0)
School Well	8/20/2003	1.92	±	0.733	(0.986)	10.2	±	1.91	(1.40)	-6.84	±	16.8	(28.3)
Tolicha Peak	8/6/2003	2.84	±	1.60	(2.56)	4.89	±	1.79	(2.91)	7.05	±	14.2	(23.6)
US Ecology	8/6/2003	3.56	±	1.22	(1.50)	10.1	±	2.23	(2.26)	21.9	±	14.7	(23.4)
US Ecology FD	8/6/2003	NA				NA				-1.80	±	13.7	(23.6)

Green shaded results are considered detected (result is greater than the sample specific MDC)

Yellow shaded results are any which are equal to or greater than the EPA-designated levels shown below for each analyte:

(a) ± 2 standard deviations

(b) The EPA established MCL in drinking water for gross alpha (α) is 15 pCi/L

(c) The EPA "Level of Concern" in drinking water for gross beta (β) is 50 pCi/L

(d) The EPA established MCL in drinking water for tritium (^{3}H) is 20,000 pCi/L

(e) FD = field duplicate sample

(f) NA = Specific analysis was not run on the sample

Detectable concentrations of gross alpha and gross beta were present in water collected from the springs, although their concentrations were below limits EPA has established for drinking water (Table 3-2). No detectable concentrations of tritium were found in any of the samples (Table 3-2). No man-made gamma-emitting radionuclides were detected. The low measurable gross alpha and gross beta radioactivity in the spring waters is likely from natural sources.

Table 3-2. Gross alpha, gross beta, and tritium analysis results for offsite springs in 2003

Monitoring Location	Date Sampled	Gross α ± Uncertainty[a] (MDC) (pCi/L)[b]	Gross β ± Uncertainty (MDC) (pCi/L)[c]	^{3}H ± Uncertainty (MDC) (pCi/L)[d]
Big Springs	8/13/2003	1.95 ± 0.688 (0.877)	6.31 ± 0.851 (1.16)	-6.74 ± 16.5 (27.9)
Big Springs FD[e]	8/13/2003	NA[f]	NA	-2.66 ± 15.9 (26.7)
Crystal Pool	8/13/2003	2.13 ± 0.673 (0.856)	10.1 ± 1.02 (1.30)	-2.34 ± 16.3 (27.4)
Fairbanks Spring	8/13/2003	2.37 ± 0.848 (0.928)	7.08 ± 1.08 (1.55)	0.799 ± 16.8 (28.1)
Longstreet Spring	8/13/2003	3.27 ± 0.760 (0.705)	7.00 ± 0.843 (1.13)	15.4 ± 17.1 (27.8)
Revert Spring	8/6/2003	4.80 ± 0.905 (0.702)	5.19 ± 0.754 (1.10)	-5.42 ± 16.2 (27.2)
Spicer Ranch Spring	8/6/2003	4.86 ± 0.927 (0.827)	6.72 ± 0.846 (1.19)	-9.55 ± 16.3 (27.4)
Spicer Ranch Spring FD	8/6/2003	NA	NA	-5.14 ± 16.5 (27.7)

Green shaded results are considered detected (result is greater than the sample specific MDC)
(a) ± 2 standard deviations
(b) The EPA established maximum contaminant level (MCL) in drinking water for gross alpha (α) is 15 pCi/L
(c) The EPA "Level of Concern" in drinking water for gross beta (β) is 50 pCi/L
(d) The EPA established MCL in drinking water for tritium (^{3}H) is 20,000 pCi/L
(e) FD = field duplicate sample
(f) NA = Specific analysis was not run on the sample

3.1.3.3 NTS Potable Water Supply Wells

The 2003 data continue to indicate that subsurface nuclear testing has not impacted the NTS potable water supply network. All of the water samples from the supply wells had non-detectable concentrations of tritium (Table 3-3).

WW-C1 (also known as Water Well C-1) had a history of validated tritium detections because this well was injected with approximately 0.1 to 0.2 curies of tritium in 1962 by a researcher conducting a tracer test (Lyles, 1990). Since 1994, annually-averaged tritium concentrations in WW-C1 have continued to occur below the MDC (see Figure 3-4 in Section 3.1.3.4 below).

The radiological analytes that were principally detectable in 2003 were gross alpha and gross beta radioactivity which likely represent the presence of naturally-occurring radionuclides since there was a general lack of corresponding detectable man-made radionuclides in the samples. Very low, yet detectable, concentrations of naturally-occurring ^{226}Ra and ^{226}Ra were also observed (Table 3-3). None of these detectable radiological analytes exceeded EPA established Levels of Concern or their established MCLs for drinking water.

No man-made gamma-emitting radionuclides were detected in potable supply well samples.

3.1.3.4 NTS Monitoring Wells

Analytical results from the network of onsite monitoring wells (see Figure 3-2) indicate that migration of radionuclides from the underground test areas is not significant. Tritium in most of the 2003 samples was not detectable (Table 3-4). Only three onsite monitoring wells, U-19BH, UE-7NS, and WW A, had detectable concentrations of tritium, but the results were well below the federal MCL of 20,000 pCi/L (Table 3-4). Each of these wells is located within 1 km (0.6 mi) of historical underground nuclear tests.

Table 3-3. Gross alpha, gross beta, tritium, and radium analysis results for NTS potable water supply wells

Monitoring Location and Date Sampled	Gross α ± Uncertainty[a] (MDC) (pCi/L)[b]	Gross β ± Uncertainty (MDC) (pCi/L)[c]	^{3}H ± Uncertainty (MDC) (pCi/L)[d]	^{226}Ra ± Uncertainty (MDC) (pCi/L)[e]	^{228}Ra ± Uncertainty (MDC) (pCi/L)[f]
Army#1 WW					
1/29/2003	4.16 ± 1.32 (1.36)	5.45 ± 0.709 (1.78)	-12.7 ± 13.6 (23.9)	0.323 ± 0.225 (0.290)	-0.008 ± 0.735 (0.368)
4/30/2003	1.95 ± 1.20 (1.82)	6.03 ± 1.90 (2.68)	-7.08 ± 14.2 (24.7)	0.320 ± 0.205 (0.213)	0.530 ± 0.740 (0.470)
7/2/2003	4.18 ± 0.787 (0.546)	5.80 ± 0.532 (0.542)	-20.0 ± 15.4 (25.8)	-0.0498 ± 0.0977 (0.268)	0.619 ± 0.663 (0.389)
10/8/2003	4.17 ± 1.39 (1.77)	6.48 ± 1.63 (2.11)	7.47 ± 15.1 (24.9)	0.810 ± 0.430 (0.540)	0.451 ± 0.668 (0.358)
10/8/2003 FD[g]	NA[h]	NA	-2.72 ± 14.8 (24.1)	NA	NA
J-12 WW					
1/29/2003	1.77 ± 0.730 (0.791)	4.90 ± 0.582 (1.76)	6.60 ± 14.2 (23.6)	0.129 ± 0.167 (0.277)	0.480 ± 0.633 (0.347)
4/30/2003	0.740 ± 0.642 (1.02)	4.05 ± 1.25 (1.74)	-5.69 ± 14.5 (25.0)	0.299 ± 0.285 (0.433)	0.060 ± 0.770 (0.460)
7/2/2003	0.101 ± 0.424 (0.740)	1.85 ± 0.371 (0.514)	-4.56 ± 15.3 (25.7)	0.0222 ± 0.144 (0.291)	0.299 ± 0.928 (0.512)
10/8/2003	0.475 ± 0.753 (1.55)	5.16 ± 1.44 (2.08)	2.73 ± 15.0 (24.9)	-0.600 ± 0.330 (0.700)	0.087 ± 0.645 (0.306)
J-13 WW[i]					
1/29/2003	2.00 ± 1.17 (1.95)	3.33 ± 0.714 (2.10)	-9.57 ± 13.2 (23.0)	0.106 ± 0.194 (0.347)	-0.161 ± 0.575 (0.283)
10/8/2003	0.651 ± 0.710 (1.39)	3.91 ± 1.26 (1.98)	5.64 ± 15.1 (24.9)	-0.260 ± 0.370 (0.710)	0.044 ± 0.585 (0.275)
UE-16D WW					
1/28/2003	5.41 ± 1.12 (0.786)	6.25 ± 0.893 (1.17)	3.16 ± 17.2 (29.0)	1.23 ± 0.383 (0.288)	0.776 ± 0.818 (0.456)
1/28/2003 FD	NA	NA	-2.72 ± 15.5 (26.6)	NA	NA
4/29/2003	5.97 ± 1.57 (1.53)	6.37 ± 1.97 (2.76)	-5.50 ± 14.1 (24.3)	1.25 ± 0.477 (0.320)	0.250 ± 0.710 (0.440)
7/1/2003	5.06 ± 1.49 (1.83)	5.34 ± 0.975 (1.31)	-3.30 ± 15.4 (25.9)	1.32 ± 0.389 (0.300)	0.955 ± 0.738 (0.453)
10/7/2003	3.80 ± 1.34 (1.61)	6.28 ± 1.72 (2.40)	6.92 ± 15.1 (24.9)	1.92 ± 0.710 (0.660)	0.211 ± 0.589 (0.292)
WW#4					
1/28/2003	9.59 ± 1.69 (1.47)	6.20 ± 0.805 (1.62)	-5.04 ± 15.4 (26.4)	0.0250 ± 0.177 (0.353)	1.03 ± 0.914 (0.524)
4/29/2003	5.17 ± 1.44 (1.56)	4.17 ± 1.55 (2.29)	-18.3 ± 13.4 (24.2)	0.158 ± 0.233 (0.393)	0.13 ± 0.700 (0.420)
4/29/2003 FD	NA	NA	-19.4 ± 13.2 (24.0)	NA	NA
7/1/2003	5.90 ± 0.888 (0.753)	4.27 ± 0.431 (0.423)	-12.6 ± 15.5 (26.2)	0.301 ± 0.241 (0.353)	0.769 ± 0.875 (0.507)
10/7/2003	5.07 ± 1.45 (1.47)	4.82 ± 1.42 (2.09)	2.41 ± 14.2 (23.6)	0.310 ± 0.260 (0.360)	0.0098 ± 0.683 (0.319)
WW#4A					
1/28/2003	10.2 ± 1.78 (1.74)	6.50 ± 0.884 (1.85)	9.98 ± 16.0 (26.5)	0.105 ± 0.206 (0.370)	0.176 ± 0.837 (0.428)
4/29/2003	5.70 ± 1.49 (1.45)	5.25 ± 1.58 (2.17)	-26.4 ± 13.4 (24.8)	0.131 ± 0.139 (0.202)	0.480 ± 0.730 (0.450)
7/1/2003	5.68 ± 1.27 (0.984)	5.95 ± 0.722 (0.730)	-0.367 ± 15.5 (25.8)	0.0433 ± 0.159 (0.305)	0.768 ± 0.859 (0.502)
10/7/2003	7.34 ± 1.80 (1.39)	6.65 ± 1.65 (2.12)	4.99 ± 15.9 (26.3)	0.180 ± 0.260 (0.430)	0.172 ± 0.730 (0.352)
WW#5B					
1/28/2003	4.21 ± 1.25 (1.16)	6.21 ± 0.669 (1.78)	10.3 ± 16.2 (26.8)	-0.0232 ± 0.151 (0.327)	-0.304 ± 0.995 (0.492)
4/29/2003	1.37 ± 1.05 (1.64)	10.3 ± 2.34 (2.78)	-16.1 ± 13.6 (24.5)	0.203 ± 0.243 (0.394)	0.00 ± 0.800 (0.480)
7/1/2003	4.13 ± 1.13 (0.908)	9.49 ± 0.853 (0.819)	-7.15 ± 15.8 (26.5)	-0.0664 ± 0.097 (0.266)	0.0367 ± 1.01 (0.544)
7/1/2003 FD	NA	NA	-0.375 ± 15.8 (26.4)	NA	NA
10/7/2003	8.24 ± 2.02 (1.62)	7.53 ± 1.76 (2.09)	-5.75 ± 15.6 (26.3)	-0.360 ± 0.510 (0.980)	-0.0362 ± 0.683 (0.317)
WW#5C					
1/28/2003	4.25 ± 1.36 (1.47)	4.80 ± 0.670 (1.79)	-3.66 ± 15.0 (25.6)	0.0710 ± 0.123 (0.220)	-0.160 ± 0.998 (0.498)
4/29/2003	4.21 ± 1.12 (1.32)	6.42 ± 1.38 (1.64)	-17.4 ± 14.0 (25.0)	0.0000 ± 0.251 (0.495)	0.020 ± 0.720 (0.430)
7/1/2003	4.93 ± 1.23 (1.08)	6.92 ± 0.806 (0.883)	-6.63 ± 15.0 (25.3)	0.129 ± 0.147 (0.232)	-0.106 ± 0.687 (0.363)
10/7/2003	6.04 ± 1.32 (1.05)	5.59 ± 1.30 (1.42)	8.62 ± 16.0 (26.3)	0.0200 ± 0.160 (0.320)	0.0375 ± 0.701 (0.329)
10/7/2003 FD	NA	NA	8.77 ± 16.2 (26.7)	NA	NA
WW-C1					
1/28/2003	2.06 ± 1.04 (1.48)	2.78 ± 0.570 (1.51)	7.40 ± 16.3 (27.1)	1.51 ± 0.415 (0.331)	1.29 ± 0.782 (0.490)
4/29/2003	8.23 ± 1.78 (1.69)	14.4 ± 2.60 (2.51)	-12.6 ± 14.2 (25.2)	1.51 ± 0.582 (0.522)	0.820 ± 0.820 (0.530)
7/1/2003	13.1 ± 2.99 (2.81)	14.5 ± 1.95 (2.25)	-0.723 ± 15.3 (25.5)	1.52 ± 0.404 (0.264)	0.990 ± 0.635 (0.399)
10/7/2003	12.8 ± 2.47 (1.33)	13.7 ± 2.57 (1.91)	16.0 ± 14.7 (23.6)	0.690 ± 0.550 (0.830)	0.666 ± 0.620 (0.376)
WW-8					
1/28/2003	0.807 ± 0.467 (0.656)	2.72 ± 0.626 (1.12)	-6.32 ± 16.3 (28.1)	0.526 ± 0.254 (0.244)	0.163 ± 0.932 (0.476)
4/29/2003	0.819 ± 0.763 (1.24)	2.18 ± 1.27 (2.03)	-14.5 ± 13.7 (24.3)	-0.0261 ± 0.170 (0.368)	0.320 ± 0.870 (0.530)
7/1/2003	-0.390 ± 0.480 (0.907)	1.41 ± 0.473 (0.719)	-7.73 ± 15.4 (25.9)	0.0241 ± 0.106 (0.224)	0.636 ± 0.786 (0.459)
10/7/2003	0.536 ± 0.934 (1.94)	3.22 ± 1.20 (2.01)	-1.82 ± 14.9 (24.9)	0.480 ± 0.380 (0.570)	-0.0187 ± 0.637 (0.296)

Green shaded results are considered detected (result is greater than the sample specific MDC)

(a) See Glossary, Appendix D for a definition of uncertainty
± 2 standard deviations
(b) The EPA established maximum contaminant level (MCL) in drinking water for gross alpha (α) is 15 pCi/L
(c) The EPA "Level of Concern" in drinking water for gross beta (β) is 50 pCi/L
(d) The EPA established MCL in drinking water for tritium (^{3}H) is 20,000 pCi/L
(e) The EPA established MCL in drinking water for ^{226}Ra + ^{228}Ra is 5 pCi/L
(f) FD = field duplicate sample
(g) NA = Specific analysis was not run on the sample
(h) Not analyzed in sample
(i) J-13 Water Well was not operational for a period of time

Table 3-4. Gross alpha, gross beta, and tritium analysis results for NTS monitoring wells in 2003

Monitoring Location	Date Sampled	Gross α ± Uncertainty[a] (MDC) (pCi/L)[b]	Gross β ± Uncertainty (MDC) (pCi/L)[c]	^3H ± Uncertainty (MDC) (pCi/L)[d]
ER-6-1 (2,017 ft bgs)	2/18/2003	3.00 ± 1.17 (1.55)	13.9 ± 2.54 (2.38)	1.25 ± 14.6 (24.8)
ER-6-1 (2,228 ft bgs)	2/18/2003	1.87 ± 1.06 (1.56)	12.4 ± 2.46 (2.56)	3.30 ± 14.4 (24.2)
ER-6-1 (2,228 ft bgs) FD[e]	2/18/2003	NA[f]	NA	6.07 ± 13.7 (22.7)
HTH #1 (1,935 ft bgs)	3/12/2003	2.14 ± 0.928 (1.16)	1.46 ± 1.22 (2.00)	-0.627 ± 11.2 (19.2)
HTH #1 (2,040 ft bgs)	3/12/2003	1.10 ± 0.925 (1.45)	0.463 ± 1.23 (2.10)	5.12 ± 21.9 (37.0)
HTH #1 (2,040 ft bgs) FD	3/12/2003	NA	NA	-4.33 ± 10.5 (18.3)
HTH #1 (2,130 ft bgs)	3/12/2003	0.916 ± 0.833 (1.31)	1.47 ± 1.23 (2.01)	-5.96 ± 10.7 (18.8)
HTH #1 (2,300 ft bgs)	3/12/2003	1.81 ± 1.08 (1.56)	0.830 ± 1.26 (2.12)	0.914 ± 11.1 (18.8)
HTH #2 (Water Well 2)	1/28/2003	3.23 ± 1.16 (1.37)	6.61 ± 1.67 (2.05)	-3.61 ± 11.1 (19.4)
HTH #2 (Water Well 2) FD	1/28/2003	NA	NA	-5.00 ± 11.7 (20.4)
SM-23-1[g]	3/24/2003	4.20 ± 1.05 (1.14)	8.80 ± 1.69 (1.76)	-3.24 ± 10.8 (18.7)
TW-D	1/28/2003	0.613 ± 0.819 (1.37)	6.58 ± 1.77 (2.25)	3.39 ± 14.8 (25.0)
TW-D FD	1/28/2003	NA	NA	-2.12 ± 12.1 (20.8)
U-19BH	4/23/2003	NA	NA	38.2 ± 11.7 (17.2)
U-19BH	4/23/2003	NA	NA	32.7 ± 12.3 (18.5)
UE-18R (1,700 ft bgs)	4/22/2003	8.41 ± 1.98 (1.42)	2.40 ± 0.912 (1.70)	3.56 ± 10.8 (18.2)
UE-18R (2,130 ft bgs)	4/22/2003	16.4 ± 2.91 (2.04)	4.85 ± 1.12 (1.83)	0.147 ± 10.5 (18.0)
UE-1Q	1/21/2003	4.77 ± 1.16 (1.04)	10.3 ± 1.88 (1.75)	7.75 ± 12.5 (20.7)
UE-1Q FD	1/21/2003	NA	NA	8.80 ± 24.7 (4.4)
UE-1Q	9/3/2003	1.60 ± 0.881 (1.44)	6.34 ± 1.67 (2.31)	-7.45 ± 13.0 (22.6)
UE-5C (Water Well)	1/28/2003	3.40 ± 1.29 (1.85)	3.56 ± 0.732 (1.84)	-12.1 ± 14.7 (25.7)
UE5PW-1[h]	4/15/2003	3.60 ± 1.39 (1.61)	7.17 ± 2.07 (2.71)	-1.13 ± 10.1 (17.3)
UE5PW-1	10/22/2003	NA	NA NA	2.70 ± 14.7 (24.8)
UE5PW-1 FD	10/22/2003	NA	NA NA	-0.797 ± 13.9 (23.8)
UE5PW-2[h]	4/15/2003	3.93 ± 1.17 (1.23)	7.00 ± 1.56 (1.79)	-3.64 ± 10.3 (17.9)
UE5PW-2 FD	4/15/2003	NA	NA NA	-6.80 ± 10.3 (18.1)
UE5PW-2	10/22/2003	NA	NA	11.2 ± 14.9 (24.4)
UE5PW-3[h]	4/15/2003	4.25 ± 1.56 (1.81)	5.15 ± 1.85 (2.65)	1.62 ± 10.6 (18.1)
UE5PW-3	10/21/2003	NA	NA	0.404 ± 14.1 (24.1)
UE-7NS	2/19/2003	0.640 ± 0.608 (0.984)	3.83 ± 1.15 (1.62)	133 ± 17.9 (22.7)
UE-7NS FD	2/19/2003	NA	NA	156 ± 19.8 (24.5)
Well A (USGS Water Well A)	1/29/2003	0.470 ± 0.661 (1.11)	6.90 ± 1.63 (2.01)	510 ± 26.0 (19.1)

Green shaded results are considered detected (result is greater than the sample specific MDC)

(a) ± 2 standard deviations
(b) The EPA established MCL in drinking water for gross alpha is 15 pCi/L
(c) The EPA "Level of Concern" in drinking water for gross beta (β) is 50 pCi/L
(d) The EPA established MCL in drinking water for tritium (^3H) is 20,000 pCi/L
(e) FD = field duplicate sample
(f) NA = Gross α and Gross β were not run on these FD samples
(g) Compliance well for Area 23 sewage lagoon
(h) Compliance well for validation of Area 5 RWMS performance assessment criteria

Well U-19BH – this well is located in the Central Pahute Mesa CAU. It is an inventory emplacement borehole. There were several nuclear detonations conducted near U-19BH, but the source of the tritium in the borehole is unclear. Previous investigations suggest that the water in the well originates from a perched aquifer, but identifying the likely source of tritium is difficult due to a lack of data regarding the perched system (Brikowski et al., 1993). The results from a tracer test conducted in the well indicate that there is minimal flow across the borehole (Brikowski et al., 1993). The lack of measurable flow in the well suggests that the chemistry of the water sampled from the borehole may not be representative of the aquifer. The data are provided as a point of interest due to the detection of tritium.

Well UE-7NS – this well is located in the Yucca Flat CAU and was drilled 137 m (449 ft) from the Bourbon underground nuclear test (U-7n) which was conducted in 1967. This well was routinely sampled between 1978 and 1987, with the resumption of sampling in 1991. In 2003, tritium concentrations of 133 and 156 pCi/L were detected from this well. These results are consistent with the trend of decreasing concentrations observed in recent years (Figure 3-4). Well UE-7NS is the second known location on the NTS where the regionally-important lower carbonate aquifer (LCA) has been impacted by radionuclides from nuclear testing (Smith et al., 1999). The first location where the LCA has been impacted by radionuclides from nuclear testing is Well UE-2CE. Well UE-2CE is located less the 200 m (656 ft) from the NASH test, which was conducted in Yucca Flat in 1967. Well UE-2CE is not currently configured for routine sampling.

Well WW-A (also known as USGS Water Well A) – this well is completed in alluvium in the Yucca Flat CAU (see Figure 3-2). It is located within 1 km (0.6 mi) of 14 underground nuclear tests in Yucca Flat, most of which appear to be upgradient of the well. The well has had measurable tritium since the late 1980s. The marked increase between 1985 and 1999 suggests inflow of tritium to this well from the HAYMAKER underground nuclear test (U-3aus) conducted in 1962 which is 524 m (1,720 ft) north of Well WW-A. This well which supplied non-potable water for construction was shut down in the early 1990s. The concentrations measured in 2003 at WW-A indicate a slight downward trend since 1999 (Figure 3-4).

Very low, yet detectable, concentrations of ^{226}Ra and ^{226}Ra were also observed in water samples from wells SM-23-1 and UE-5C. These were the only two monitoring wells tested for ^{226}Ra and ^{228}Ra (Table 3-5). These radium isotopes were far below their EPA (MCLs) for drinking water.

No radionuclides were detected at concentrations above their respective MDCs by gamma spectroscopy analyses in any of the NTS monitoring wells in 2003.

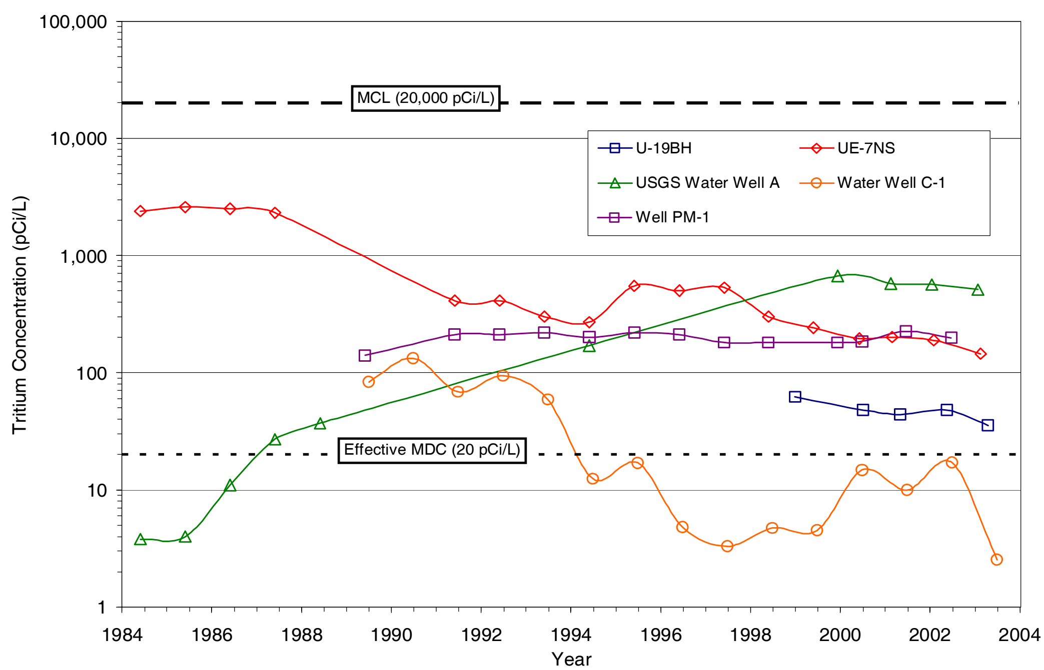


Figure 3-4. Concentrations of tritium in wells with a history of detectable levels

Table 3-5. Detectable concentrations of radium isotopes in NTS monitoring wells sampled in 2003

Monitoring Location	Date Sampled	^{226}Ra ± Uncertainty[(a)] (MDC) (pCi/L)				^{228}Ra ± Uncertainty (MDC) (pCi/L)			
SM-23-1	3/24/2003	0.501	±	0.279	(0.346)	2.37	±	0.72	(0.882)
UE-5C (Water Well)	1/28/2003	0.357	±	0.212	(0.237)	1.08	±	0.55	(0.984)

The EPA established MCL in drinking water for ^{226}Ra + ^{228}Ra is 5 pCi/L

(a) ± 2 standard deviations

3.1.3.5 NTS E Tunnel Ponds

Five primary basins were constructed to collect and hold water discharged from the onsite E Tunnels in Area 12 where nuclear testing was conducted in the past (see Figures 3-3 and 6-4). The water is perched groundwater that has percolated through fractures in the tunnel system. The Defense Threat Reduction Agency (DTRA) conducts monitoring of effluent waters from E Tunnel to determine if radionuclides and non-radiological contaminants exceed the allowable contaminant levels regulated under a state water pollution control permit (NEV 96021), which is issued to DTRA. During October, 2003, water was sampled from the tunnel effluent near where water is discharged, from the pond influent (which at the time was flowing into Pond 2), and from Ponds 2 and 5 themselves. Sediment was also sampled from the basins of Ponds 2, 4, and 5. Effluent water was analyzed by DTRA for tritium, gross alpha, and gross beta (Table 3-6). All other samples were analyzed by BN for tritium (water samples only), gamma-emitting radionuclides, uranium, plutonium, ^{90}Sr, and ^{241}Am (Table 3-7).

The majority of samples had radionuclide concentrations above minimum detectable concentrations (MDC) (Table 3-7). While tritium concentrations in tunnel effluent were elevated, they were about 12 percent lower than the limit allowed under permit NEV 96021 for that discharge system (Table 3-6). Tritium was found in all pond inlet and pond water samples at concentrations analogous to previous years' samples except the sample from Pond 5, which was approximately one third lower. This was probably due to the fact that Pond 5 did not receive tunnel effluent during 2003 and precipitation diluted the original concentration. Concentrations of ^{90}Sr, ^{137}Cs, plutonium, and ^{241}Am were also at levels comparable with the past two years. In samples for which it was analyzed, uranium was detected in both water and sediment samples, but was determined to be naturally-occurring, based on the activity ratios of ^{238}U/^{235}U and ^{238}U/$^{233+234}$U not being different from 20 and 1, respectively (PHS, 1970).

Due to the elevated concentrations of radionuclides in the containment ponds, they are fenced and posted with radiological warning signs. Given that the ponds are available to wildlife, game animals are also sampled under RREMP monitoring to assess the potential radiological dose to humans via ingestion of game animals and to evaluate radiological impacts to wildlife (see Section 6.0 and Section 7.0).

Table 3-6. Radiological results for E Tunnel Pond effluent pertaining to Water Pollution Control Permit NEV 96021

Parameter	Permit Threshold/Permissible Limit	Average Measured Value
Tritium	1,000,000 pCi/L	885,000 pCi/L
Gross Alpha	35.1 pCi/L	12.75 pCi/L
Gross Beta	101 pCi/L	54.45 pCi/L

Source: *Water Pollution Control Permit NEV 96021 Quarterly Monitoring Report and Annual Summary Report for E Tunnel Waste Water Disposal System* (DTRA, 2003)

Table 3-7. Routine radiological water monitoring results for E-Tunnel Ponds in 2003

Sample	^{3}H ± Uncertainty[a] (MDC)	^{90}Sr ± Uncertainty (MDC)	^{137}Cs ± Uncertainty (MDC)	^{238}Pu ± Uncertainty (MDC)	$^{239/240}Pu$ ± Uncertainty (MDC)	^{241}Am ± Uncertainty (MDC)
Water - Concentration units are pCi/L						
Influent (Pond 2)	828,000 ± 126,000 (1,820)	0.76 ± 0.37 (0.63)	43.10 ± 9.37 (6.67)	0.438 ± 0.179 (0.036)	4.960 ± 1.170 (0.036)	0.242 ± 0.061 (0.017)
Pond 2	815,000 ± 125,000 (2,050)	0.34 ± 0.31 (0.63)	20.70 ± 6.20 (6.89)	0.223 ± 0.104 (0.068)	4.280 ± 0.930 (0.068)	0.144 ± 0.064 (0.041)
Pond 2 FD[b]	833,000 ± 127,000 (1,830)	0.69 ± 0.35 (0.60)	22.20 ± 6.40 (6.91)	0.181 ± 0.090 (0.063)	2.570 ± 0.574 (0.023)	0.234 ± 0.066 (0.008)
Pond 5	528,000 ± 80,700 (1,640)	1.49 ± 0.51 (0.63)	13.30 ± 5.39 (7.04)	0.081 ± 0.078 (0.100)	0.770 ± 0.265 (0.099)	0.170 ± 0.056 (0.025)
Sediment - Concentration units are pCi/g						
Pond 2	NA[c]	0.37 ± 0.29 (0.57)	54.10 ± 9.10 (0.50)	0.737 ± 0.159 (0.018)	2.170 ± 0.401 (0.009)	0.456 ± 0.111 (0.010)
Pond 2 FD	NA	0.26 ± 0.26 (0.53)	44.40 ± 7.40 (0.30)	0.535 ± 0.125 (0.010)	2.040 ± 0.381 (0.010)	0.454 ± 0.108 (0.009)
Pond 4	NA	3.30 ± 0.91 (0.64)	95.40 ± 15.90 (0.43)	0.399 ± 0.101 (0.023)	3.660 ± 0.652 (0.023)	0.433 ± 0.106 (0.009)
Pond 5	NA	3.30 ± 0.90 (0.60)	60.30 ± 10.00 (0.33)	0.111 ± 0.045 (0.023)	1.430 ± 0.279 (0.026)	0.192 ± 0.061 (0.010)

Green shaded results are considered detected (result greater than the sample specific MDC)

(a) ± 2 standard deviations
(b) FD = Field duplicate
(c) Not applicable: tritium is not measured in samples which do not contain water

3.1.3.6 NTS Sewage Lagoons

Each sewage lagoon at the NTS is part of a closed system used for the evaporative treatment of sanitary sewage. In recent years, sewage storage and treatment at the NTS has transitioned from lagoons to septic systems at several locations. A few permitted sewage lagoons remain: Area 6 Yucca, Area 12 Camp, and Area 23 Mercury. The permits for these lagoons do not require that the water or sediments be monitored for radioactivity (see Section 3.2.4 below). However, to more completely demonstrate the proper management of effluents on the NTS, limited radiological analyses are conducted for these lagoons. Due to periods of inactivity and limited fluid, the Area 12 Camp lagoon is only sampled intermittently.

The lagoon water samples were analyzed for tritium using standard (un-enriched) analyses and by gamma spectroscopy for other radionuclides. No tritium was detected at concentrations above their MDCs in the lagoon water samples (Table 3-8).

Table 3-8. Tritium water monitoring results for NTS sewage lagoons in 2003

Monitoring Location	Date Sampled	^3H ± Uncertainty[(a)] (MDC) (pCi/L)			
Area 6 Yucca	4/9/2003	16	±	210	(352)
	7/1/2003	169	±	219	(357)
	10/1/2003	-151	±	120	(218)
Area 12 Camp	7/1/2003	-17	±	213	(357)
Area 23 Mercury	4/9/2003	-171	±	206	(352)
	7/1/2003	-93.9	±	211	(357)
	10/1/2003	-34	±	130	(225)

(a) ± 2 standard deviations

3.1.4 UGTA Wells

Preliminary (pre-development) groundwater characterization samples were collected from each of three newly drilled wells: ER-12-2, ER-7-1, and ER-2-1 (Figure 3-5). Tritium was noted at Well ER-2-1 during drilling in the vadose zone at 328.0 to 490.7 m (1,076 to 1,610 ft) and again in the saturated section at 743.7 to 765.0 m (2,440 to 2,510 ft) depth. Activity levels were less than 8,700 pCi/L in these two intervals, and returned to background levels elsewhere. The amount of tritium detected (less than one-half the Safe Drinking Water Act level) was much less than expected. No other radionuclides above background have been identified to date in groundwater produced from Well ER-2-1. All fluids produced during the construction of Well ER-2-1 were contained in two lined sumps.

Groundwater characterization samples were also collected from Wells ER-5-4#2 and ER-6-1#2 following hydraulic testing activities. The UGTA Project also sampled eight characterization wells drilled in 1999 for the Western Pahute Mesa – Oasis Valley study area. The wells sampled included: ER-EC-1, ER-EC-2A, ER-EC-4, ER-EC-5, ER-EC-6, ER-EC-7, ER-EC-8, and ER-18-2 (Figure 3-5). No tritium or other man-made radionuclides were detected while drilling (except as noted at Well ER-2-1) or sampling any of these wells. The data are maintained in updated versions of the UGTA Project geochemical database by Stoller-Navarro Joint Venture, Las Vegas, NV.

In 2003, the UGTA Program sampled four post-shot/cavity wells, or "Hot Wells": U-4t PS#3A, U-19q PS#1D, U-19v PS#1DS, and U-20n PS#1DDH (Figure 3-5). These wells access cavities from the underground nuclear tests GASCON, CAMEBERT, ALMENDRO, and CHESHIRE, respectively. A multi-agency team consisting of personnel from the USGS, Los Alamos National Laboratory (LANL), and LLNL collected fluid samples at these wells using a downhole sampling pump.

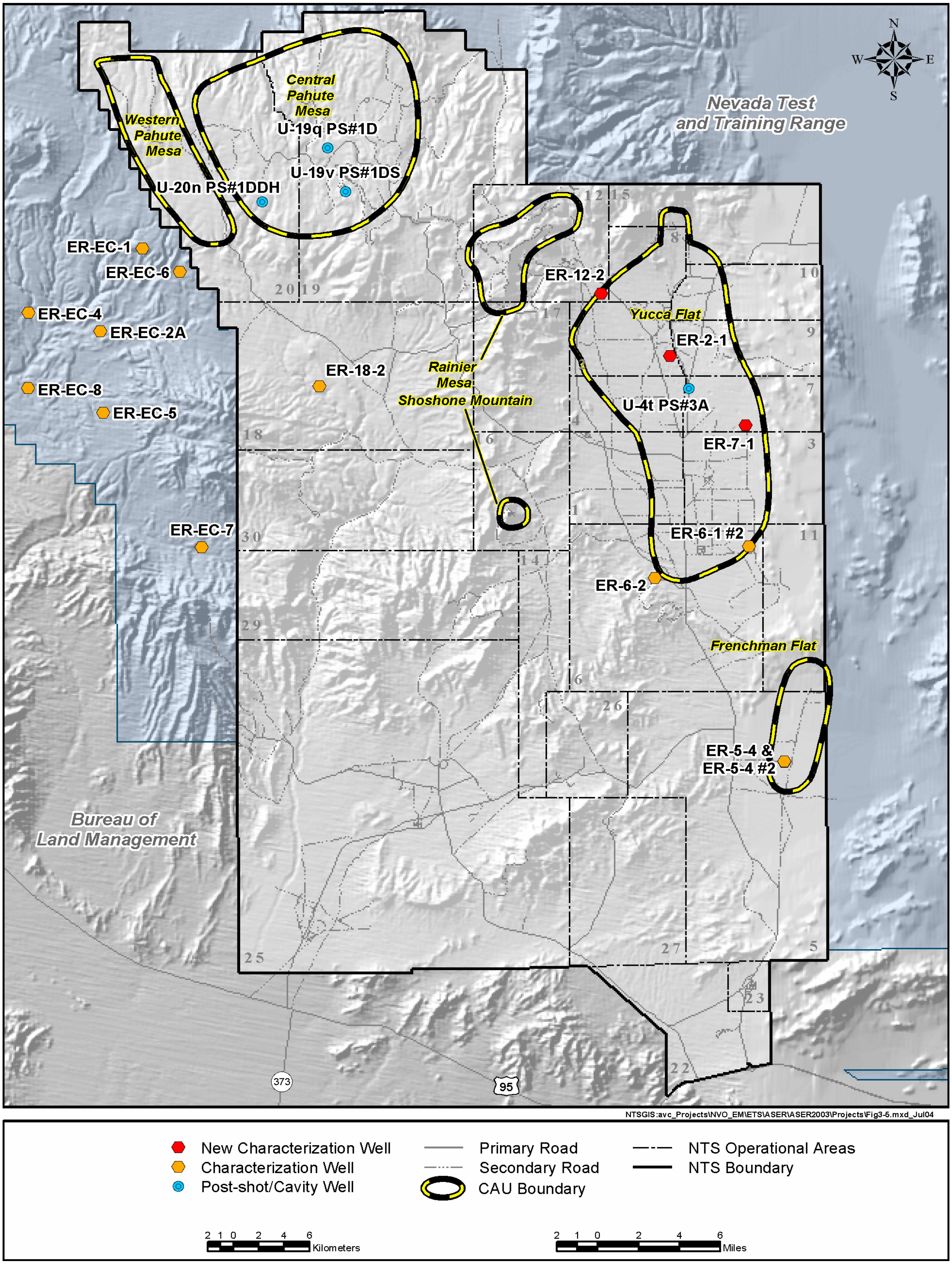


Figure 3-5. Wells recently drilled or sampled for the UGTA Project

The wells access the target test cavities via perforated casing. During sample collection, field parameters, including temperature, pH, and conductivity were measured. Samples were then analyzed for selected radionuclides as well as gross alpha and gross beta. In general, preliminary results show expected levels of radionuclides for post-shot wells. Final laboratory analytical results for these wells are pending. Preliminary analyses indicate that tritium concentrations ranged from 200,000 pCi/L to 160,000,000 pCi/L. The results of this year's "hot well" sampling effort will support the NNSA's continuing efforts to create a long-term monitoring program for wells in or near underground nuclear test cavities. The program objectives are to characterize the hydrologic source term and evaluate the decay and potential migration of radionuclides through monitoring at or near the source.

3.1.5 Environmental Impact

All but four groundwater samples had tritium levels below detectable levels. Groundwater from three onsite monitoring wells (U-19BH, UE-7NS, and Well WW-A which have histories of detectable tritium levels, and had detectable levels of tritium in 2003. These three wells are located in close proximity to underground test. The Beatty Water and Sewer offsite wells had a low but detectable tritium level but there was no evidence of any other detectable man-made radionuclides. The tritium data provides no evidence that radionuclides have traveled significant distances from underground testing areas to offsite water supply wells.

Most groundwater samples had gross alpha and beta levels above detection limits but below the EPA MCL for drinking water. The samples from two offsite monitoring wells (ER-OV-01 and ER-OV-02) exceeded the drinking water standard. The measured gross alpha and beta levels in these wells, however, are attributed to the decay of naturally-occurring radioactive elements particularly in volcanic host rock.

3.2 Non-Radiological Drinking Water and Wastewater Monitoring

3.2.1 Goals

The quality of drinking water and wastewater on the NTS is regulated by federal and state laws. In addition, the design, construction, operation, and maintenance of many of the drinking water and wastewater systems on the NTS are regulated under state permits. BN is tasked with ensuring that such systems meet all the applicable water quality standards and permit requirements. BN personnel conduct field water sampling, perform assessments, and maintain documentation to ensure compliance. This section describes the assessment or field monitoring methods and results used to accomplish this task. Specifically omitted from this section are assessment methods related to monitoring radionuclides in drinking water on and off the NTS, as these are presented in the preceding Section 3.1.3.1 and Section 3.1.3.3, respectively. Monitoring reported in this section is conducted specifically to:

- Ensure that the operation of the NTS public water systems (PWS) and private water systems provide high quality drinking water to workers and visitors of the NTS.
- Determine if NTS PWS are operated in accordance with the requirements in Nevada Administrative Code (NAC) 445A under permits issued by the Nevada State Health Division, Bureau of Health Protection Services (BHPS).
- Determine if the operation of commercial septic systems to process domestic wastewater on the NTS meets operational standards in accordance with the requirements NAC 445A under permits issued by BHPS.
- Determine if the operation of industrial wastewater systems on the NTS meets operational standards of federal and state regulations as prescribed under the GNEV93001 state permit issued by the Nevada Division of Environmental Protection (NDEP).

3.2.2 Drinking Water Monitoring

3.2.2.1 Methods

A network of nine permitted wells supplies the potable water needs of NTS operations (Figure 3-6). NNSA/NSO operates three public water systems (PWSs) (Figure 3-6) and four private water systems. The PWSs are operated in accordance with the requirements in NAC 445A under permits issued by BHPS, which are renewed annually. The private water systems are not subject to NAC 445A.

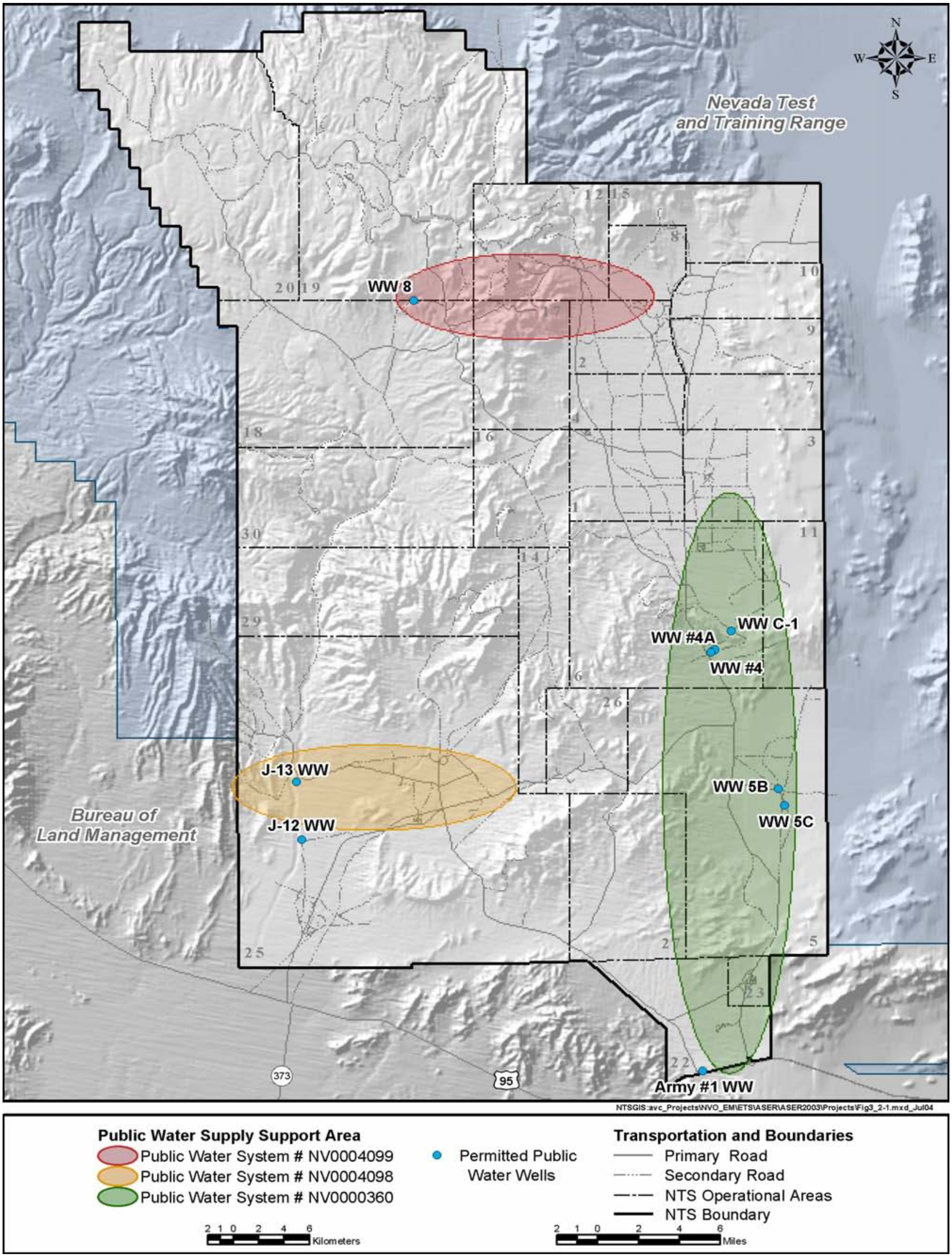


Figure 3-6. Drinking water system on the NTS

Sampling for Water Quality of PWS and Permitted Water Hauling Trucks – The three PWS must meet water quality standards for coliform bacteria, nitrates, nitrites, lead, copper, and fluoride. The PWS must also meet other standards and conditions listed in the regulations relating to design, operation, and maintenance. For work locations at the NTS that are not part of a public water system, NNSA/NSO hauls potable water for use in decontamination and sanitation. The NTS uses two water tanker trucks, which are permitted by the BHPS to haul water to a public water system. Normal use of these trucks involves hauling to private water systems and to hand-washing stations at construction sites, activities which are not subject to permitting. NNSA/NSO, however, retains the permits in case of emergency. These permits are also renewed annually. The two permitted potable water hauling trucks are subject to water quality standards for coliform bacteria.

Table 3-9 lists the water quality parameters monitored, sample locations, and sample frequencies. The largest PWS (Area 23 and 6) serves the main work areas of the NTS. It was monitored monthly for coliform bacteria at seven locations within the distribution systems approved by the BHPS. The two smaller systems (Area 12 and Area 25) were monitored quarterly for coliform bacteria. At all building locations, the sampling point for coliform bacteria is one of the sinks within one of the building's bathrooms. Monitoring for other contaminants took place at the six points of entry to the PWSs. Although not required by regulation or permit, the private water systems were monitored quarterly for coliform bacteria to ensure safe drinking water. All potable water hauling trucks were monitored monthly for coliform bacteria.

All water samples were collected in accordance with accepted practices, and the analyses were performed by state-approved laboratories. Approved analytical methods listed in NAC 445A and Title 40 Code of Federal Regulations (CFR) 141 were used by the laboratories.

Table 3-9. Water quality monitoring parameters and sampling design for NTS public drinking water systems

PWS	Contaminant	2003 Monitoring Requirement	Monitoring Locations
Area 23 and 6	Coliform Bacteria	36 samples (3/month)	Buildings 5-7, 6-624, 6-900, 22-1, 23-710, 23-777, 23-1103
	Nitrates	4 samples (1/entry point)	Entry points (Army Well Tank, Mercury Tank, 4/4a Tank, C-1 Wellhead)
Area 12	Coliform Bacteria	4 samples (1/quarter)	Building 12-45
	Nitrates	1 sample	Entry point (Area 12 Tank)
	Lead and Copper	5 samples	Buildings 12-23, 12-31, 12-35, 12-30, 12-928
Area 25	Coliform Bacteria	4 samples (1/quarter)	Building 25-4320
	Nitrates	1 sample	Entry point (J-11 Tank)
	Total Nitrates and Nitrites	1 sample	Entry point (J-11 Tank)
	Fluoride	2 samples (1/well)	Well J-12, Well J-13
Water Hauling Truck 84846	Coliform Bacteria	12 samples (1/month)	From water tank on truck after filling at Area 6 potable water fill stand
Water Hauling Truck 84847	Coliform Bacteria	12 samples (1/month)	From water tank on truck after filling at Area 6 potable water fill stand

Sanitary Survey of PWS and Inspection of Permitted Water Hauling Trucks – The BHPS conducts a periodic sanitary survey of the permitted PWS. A sanitary survey consists of an inspection of the wells, tanks, and other visible portions of the PWS to ensure that they are maintained in a sanitary configuration. As non-community water systems, the minimum survey frequency for a sanitary survey is five years. The BHPS has been performing the survey more frequently, however. The BHPS inspects the two water hauling trucks annually at the time of permit renewal to make sure they still meet the requirements of NAC 445A.

3.2.2.2 Results

Water Sampling and Analysis – In 2003, monitoring results indicated that the PWS and the permitted water hauling trucks complied with drinking water quality standards (Table 3-10). In Area 25, only Well J-12 was monitored for fluoride. The submersible pump in Well J-13 failed in April 2003 and it was taken out of service for the remainder of 2003.

Table 3-10. Water quality analysis results for NTS public drinking water systems in 2003

Contaminant	Maximum Contaminant Level	Result
Coliform Bacteria - Public Water System/ Permitted Hauling Truck	**1 sample w/ coliforms present/month**	
PWS - Area 23 and 6		Absent in all samples
PWS - Area 12		Absent in all samples
PWS - Area 25		Absent in all samples
Water Hauling Truck 84846		Absent in all samples
Water Hauling Truck 84847		Absent in all samples
Coliform Bacteria - Private Water System	**NA** (a)	
JASPER compound		Absent in all samples
U3ah/at complex		Absent in all samples
Area 6 Weather Station		Absent in all samples
G Tunnel office		Absent in all samples
Nitrates	**10.0 mg/L**	
PWS - Area 23 and 6		0.31 – 4.0 mg/L (b)
PWS - Area 12		1.2 mg/L
PWS - Area 25		1.9 mg/L
Lead	**0.015 mg/L**	
PWS - Area 12		.0135 mg/L
Copper	**1.3 mg/L**	
PWS - Area 12		.094 mg/L
Total Nitrates and Nitrites	**10.0 mg/L**	
PWS - Area 25		2.1 mg/L
Fluoride	**4.0 mg/L**	
PWS - Area 25 (Well J-12 only)		1.8 mg/L

(a) Not applicable because it is a non-permitted private water system
(b) Lowest and highest concentration of contaminant among samples analyzed

BHPS Surveys and Inspections – The BHPS did not conduct a sanitary survey of the PWS in 2003. Their last sanitary survey took place in 2002. BHPS conducted an annual inspection of the permitted water hauling trucks at the time of permit renewal and no findings were noted.

3.2.3 Domestic Wastewater Monitoring

3.2.3.1 Methods

To obtain a permit for a proposed new NTS septic system, an assessment is conducted to ensure that the sources producing discharges are domestic in nature. ECD and the Nevada State Health Division conduct this assessment. After the design of a new system is completed, a permit package is submitted through NNSA/NSO to the BHPS. Subsequent to state approval, a "permit to construct" is issued. At the completion of construction, the state conducts a final inspection. Upon approval, the state issues a "permit to operate."

Existing septic systems that are not permitted may be permitted by submitting a narrative describing facility operations, flow test results, tank and leach field sizing, engineering drawings, personnel numbers, existing flow (volume) information, and a fixture count. The application is reviewed by the state and an onsite inspection is conducted by BHPS. Approval results in the issuance of a "permit to operate."

There are seven active commercial septic systems on the NTS (Figure 3-7) which are periodically inspected by BN for sediment loading and are pumped as required. A state permitted septic pumping contractor is used. The state conducts onsite inspections of pumper trucks and pumping contractor operations.

BN personnel perform management assessments of permitted facilities and services to determine and document adherence to permit conditions. The assessments are performed according to existing directives and procedures.

3.2.3.2 Results

In 2003, the following compliance actions relating to domestic wastewater on the NTS occurred:

- One new septic system was permitted for the Area 5 Radioactive Waste Management Complex (Permit NY-1106).
- Septic system design was initiated for the U1a Complex and Area 12 -910. The final permit package submittals will be completed in 2004.
- Septic tank pumping contractor permit renewal (Permit NY-17-03318), septic tank pump truck permit renewals (Permits NY-17-03313, NY-17-03315, NY-17-03317, and NY-17-06838), and a septic tanker renewal (Permit NY-17-06839) were permits approved by the state and renewed in September 2003.
- Septic system assessments were performed at the Area 6 LANL (Permit NY-1090) and the Area 25 Central Support Facilities and Reactor Control Point Systems (Permits NY-1085 and 1086). The septic system assessment performed in Area 6 resulted in no findings. The Area 25 assessment resulted in four findings:

    (1) Changes in permit conditions had occurred since the last inspection conducted in August 2002. These changes were forwarded to NNSA/NSO for transmittal to the state before the assessment report was issued.

    (2) A potential discharge pathway (to the septic tank) was identified in a paint storage area. Since an NNSA contractor did not occupy this facility, the finding was reported to NNSA for transmittal to the tenant organization. The assessor also notified the tenant organization during the assessment.

    (3) It was determined that non-commercial systems were not being inspected periodically for sediment loading. This finding was entered into the corrective action tracking system for resolution.

    (4) Photographic processing chemicals were found in a vacated building. This process had not been noted in a previous assessment conducted in 2001. The chemicals were removed and disposed before the assessment report was issued.

3.2.4 Industrial Wastewater

3.2.4.1 Methods and Results

Industrial discharges on the NTS were limited to three operating sewage lagoon systems in 2003: Area 6 Yucca Lake, Area 12 Camp, and Area 23 Mercury (these lagoon systems also receive domestic wastewater) (Figure 3-7). The Area 6 Yucca Lake system consists of two primary lagoons and two secondary lagoons. All lagoons in this system are lined

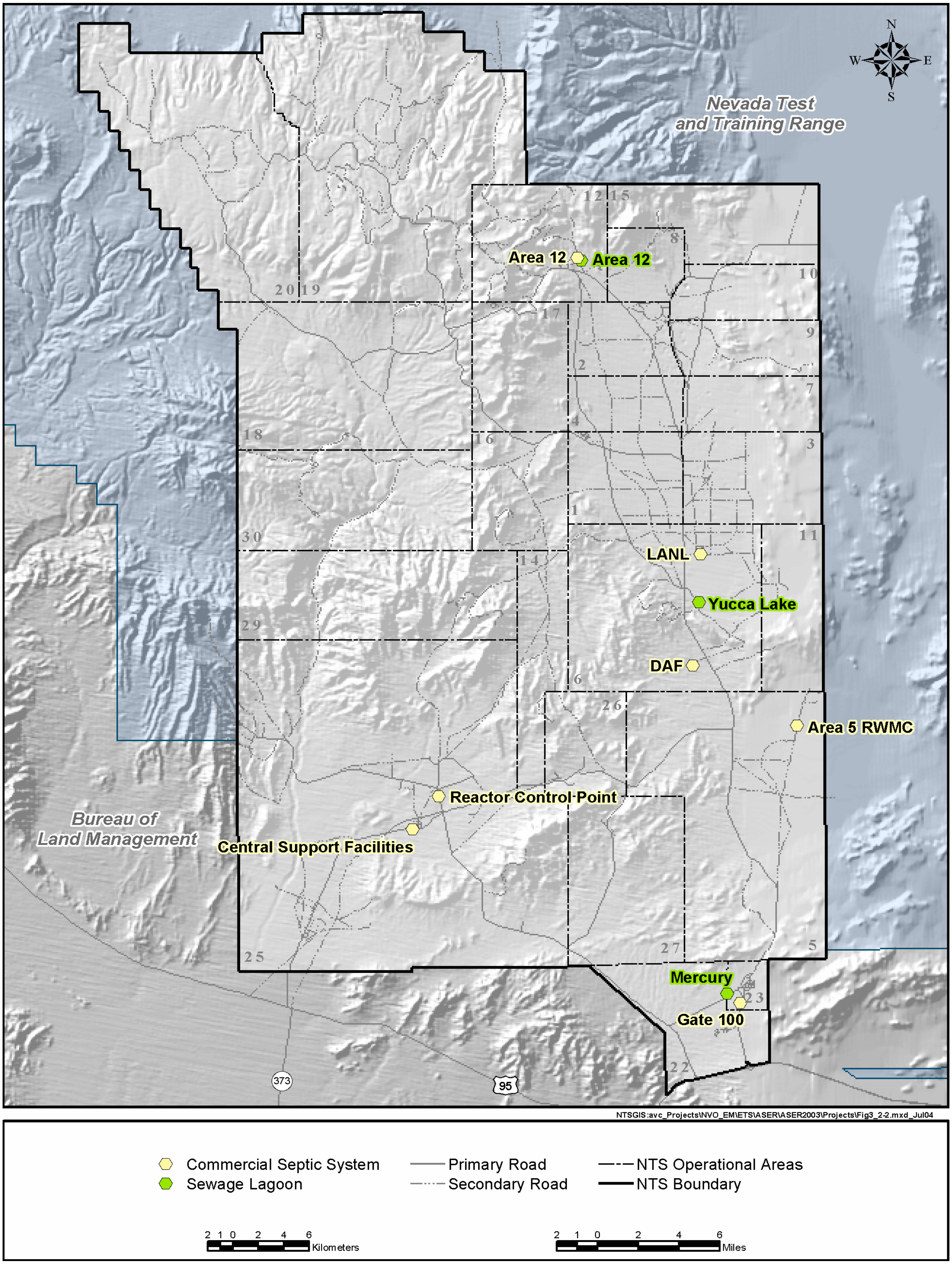


Figure 3-7. Active permitted sewage disposal systems on the NTS

using compacted native soils that meet the state requirements for transmissivity (10-7cm/sec). This system is monitored quarterly for influent quality and annually for influent toxicity.

The Area 12 Camp system consists of four primary lagoons and five secondary lagoons. All lagoons in this system are lined using compacted native soils that meet the state requirements for transmissivity. This system is monitored quarterly for influent quality and annually for influent toxicity. The sewage that normally flows to this system was diverted to a permitted septic system (Permit NY-1089) in the fourth quarter of 2003 because of low flow.

The Area 23 Mercury system consists of one primary lagoon and three infiltration basins. All lagoons in this system are unlined, and the groundwater well SM-23-1 is monitored for this system. Monitoring is conducted quarterly for influent quality and annually for influent toxicity and groundwater contamination.

The locations where water samples were collected for analysis within each sewage system include:

- Each influent headwork for systems where there is direct access to influent flows
- Each pond near the lagoon's inlet for systems where there is no direct access to influent flows
- Each infiltration basin at a place where a sample most closely representing the infiltrating waste water can be collected
- Each groundwater monitoring well or alternative-monitoring device

Composite samples are flow-weighted (10 hours) at the Area 6 Yucca Lake and Area 23 Mercury systems which are equipped with an ultrasonic flow meter. At Area 12 Camp, where there are no flow meters, but automatic sampling equipment is used, composite samples are time-weighted (8 hours) when the facility is active.

All water samples were collected in accordance with accepted practices, and the analyses were performed by state-approved laboratories. Approved analytical methods listed in NAC 445A and Title 40 CFR 141 were used by the laboratories.

3.2.4.1.1 Quarterly Analysis of Influent Water Quality

A composite sample from each influent headwork was collected quarterly and the composite sample was analyzed for three parameters: 5-day biological oxygen demand (BOD 5), total suspended solids (TSS), and pH (Table 3-11). The compliance limits for these parameters are established under Water Pollution Control General Permit GNEV93001 and are shown in Table 3-11. All quarterly monitoring of BOD 5, TSS, and pH for sewage system influent waters were within permit limits in 2003.

Table 3-11. Water quality analysis results for NTS sewage lagoon influent waters in 2003

		Minimum and Maximum Values from Quarterly Samples		
Parameter	**Units**	**Area 6 Yucca**	**Area 12 Camp[(a)]**	**Area 23 Mercury**
BOD 5	mg/L	19 - 200	91 - 230	100 - 310
BOD 5 Permit Limit		No Limit	No Limit	No Limit
BOD 5 Mean Daily Load [(b)]	kg/day	0.620 – 4.94	0.432 – 2.10	13.5 – 67.5
BOD 5 Mean Daily Load Limit		8.66	54.2	172
TSS	mg/L	19.8 - 541	91 - 178	54.3 - 340
TSS Permit Limit		No Limit	No Limit	No Limit
pH	S.U.	7.75 – 8.46	7.64 - 8.9	7.63 – 8.02
pH Permit Limit		6.0 – 9.0	6.0 – 9.0	6.0 – 9.0

(a) Area 12 Camp was dry the 2nd quarter of 2003, values shown are for only 3 samples collected for influent water quality

(b) BOD 5 Mean Daily Load in kg/day = (mg/L BOD x L/day Average Flow x 3.785)/10^6.

3.2.4.1.2 Annual Analysis of Toxicity of Sewage Lagoon Pond Waters

A grab sample from the Area 23 Mercury primary lagoon and an equal-volume composite sample from the two Area 6 Yucca Lake primary lagoons were collected in April. No samples were collected from the Area 12 Camp ponds for influent toxicity because the sewage that normally flows to the Area 12 Camp system was diverted to a permitted septic system.

Each grab and composite sample was filtered, the solids discarded, and the filtrate analyzed directly, using those methods of analysis cited in EPA Publication SW-846. Each sample was analyzed for those contaminants listed in Table 3-12. The limits for the contaminants for annual monitoring are taken from 40 CFR 261.24, Table 1, Maximum Concentration of Contaminants for the Toxicity Characteristic. Annual monitoring of Area 6 Yucca Lake and Area 23 Mercury sewage lagoon waters adjacent to lagoon inlets showed that no contaminants exceeded permit limits (Table 3-12).

Table 3-12. Water toxicity analysis results for NTS sewage lagoon pond water in 2003

Contaminant	Limit[(a)] (mg/L)	Area 6 Yucca (mg/L)	Area 23 Mercury (mg/L)
Benzene	0.5	< 0.005	< 0.005
Carbon Tetrachloride	0.5	< 0.005	< 0.005
Chlordane	0.03	< 0.0001	< 0.0001
Chlorobenzene	100	< 0.005	< 0.005
Chloroform	6	< 0.005	< 0.005
Cresol (Total)	200	< 0.050	< 0.050
2,4-D	10	< 0.001	< 0.001
1,4-Dichlorobenzene	7.5	< 0.050	< 0.050
1,2-Dichloroethane	0.5	< 0.005	< 0.005
1,1-Dichlorethylene	0.7	< 0.005	< 0.005
2,4-Dinitrotoluene	0.13	< 0.050	< 0.050
Endrin	0.02	< 0.0001	< 0.0001
Heptachlor	0.008	< 0.0001	< 0.0001
Hexachlorobenzene	0.13	< 0.050	< 0.050
Hexachlorobutadiene	0.5	< 0.050	< 0.050
Hexachloroethane	3	< 0.050	< 0.050
Lindane	0.4	< 0.0001	< 0.0001
Methoxychlor	10	< 0.0005	< 0.0005
Methylethyl Ketone	200	< 0.010	< 0.010
Nitrobenzene	2	< 0.050	< 0.050
Pentachlorophenol	100	< 0.120	< 0.120
Pyridine	5	< 0.050	< 0.050
Tetrachloroethylene	0.7	< 0.005	< 0.005
Toxaphene	0.5	< 0.005	< 0.005
Trichloroethylene	0.5	< 0.005	< 0.005
2,4,5-Trichlorophenol	400	< 0.120	< 0.120
2,4,6-Trichlorophenol	2	< 0.050	< 0.050
2,4,5-TP (Silvex)	1	< 0.0005	< 0.0005
Vinyl Chloride	0.2	< 0.010	< 0.010
Arsenic	5	0.0091	0.0098
Barium	100	0.0395	0.0441
Cadmium	1	< 0.0004	< 0.0004
Chromium	5	0.0006	0.0012
Lead	5	< 0.0026	< 0.0026
Mercury	0.2	< 0.0001	0.0001
Selenium	1	< 0.0036	< 0.0036
Silver	5	0.0016	< 0.0008

(a) Source: 40 CFR 261.24, Table 1

3.2.4.1.3 Annual Analysis of Groundwater Monitoring Wells Associated With Sewage Lagoons

The Area 23 Mercury lagoons are the only lagoons required to have groundwater monitoring because the lagoons and infiltration basins are unlined. Since they are unlined, the mode of disposal is evaporation/infiltration. The monitoring well (SM-23-1) is sampled annually and analyzed for those contaminants/parameters listed in Table 3-13. The compliance limits are those prescribed under the Nevada Drinking Water Standards (NDWS). In 2003, samples were collected in the second quarter, and no concentration limits were exceeded (Table 3-13). This indicates that no toxic chemicals or radionuclides have leached into the groundwater from the Area 23 Mercury sewage lagoons.

Table 3-13. Groundwater analysis results for NTS groundwater monitoring well SM-23-1 in 2003

Contaminant/Parameter	NDWS Limit	Results
	(pCi/L):	
Adjusted Gross Alpha	15	4.5
Gross Beta/photon emitter	50	7.9
Tritium	20,000	-34.5 ± 97.5[(a)]
	(mg/L):	
Arsenic	0.05	0.0091
Cadmium	0.005	< 0.0004
Chloride	400	103
Chromium	0.1	0.0029
Copper	1.3	< 0.0006
Fluoride	4	1.6
Iron	0.6	0.0385
Lead	0.015	< 0.0026
Magnesium	150	25.8
Manganese	0.1	0.0010
Mercury	0.002	< 0.0001
Nitrate (Nitrogen)	10	5.1
pH (Hydrogen Ion Activity)	6.5 – 8.5 SU	7.52
Selenium	0.05	< 0.0036
Sulfate	500	99.6
Zinc	5	0.0574

Source: NDWS (NAC 445A.144)

(a) Results of un-enriched tritium analyses from General Engineering Laboratories. This value, therefore, differs from the tritium value reported in Table 3-4 analyzed by Sanford, Cohen, and Associates laboratory (an enriched analysis).

3.2.4.1.4 Sewage System Inspections

In addition to BN personnel monitoring the quality of the sewage water, as per the GNEV93001 state permit, the sewage system operators inspect active systems weekly and inactive lagoon systems quarterly. State inspections of active and inactive lagoon systems are conducted annually. Operators inspect for abnormal conditions, weeds, algae blooms, pond color, abnormal odors, dike erosion, burrowing animals, discharge from ponds or lagoons, depth of staff gauge, crest level, excess insect population, maintenance/repairs needed, and general conditions.

In 2003, there were three notable inspection findings. Area 6 Yucca Lake sewage lagoon experienced high flow during January and part of February. An investigation was conducted and it was discovered that a 5 cm (2 inch) water line had failed. The water line was repaired and flows returned to normal. Area 23 Mercury sewage lagoon experienced intermittent line blockage at the head works in June. The blockage was cleared and procedures were put in place to check and clean the line daily. Area 23 Mercury sewage lagoon experienced high flow during July. An investigation was conducted and it was discovered that cooling towers in Mercury were malfunctioning. The cooling towers were repaired and flows returned to normal.

NDEP conducted an annual inspection of active and inactive sewage lagoon systems on February 5 and 6, 2003. The inspection found no problems with the field maintenance program in keeping the lagoons, sites, and access roads functional. However, at the Area 6 Yucca Lake sewage lagoon, a false influent flow measurement that exceeded the maximum permitted design flow was obtained. This led to a late discovery of a malfunctioning flow meter. Corrective actions were completed and approved by NDEP in July 2003.

4.0 Direct Radiation Monitoring

DOE Orders 5400.5 and 435.1 have requirements to protect the public and environment from exposure to radiation (see Section 1.3). Energy from radionuclides present in the Nevada Test Site (NTS) environment can be deposited inside humans and animals through inhalation and ingestion. Sections 2.0 and 3.0 of this Nevada Test Site Environmental Report (NTSER) present the results of monitoring radionuclides in air and water on the NTS so as to estimate internal radiation dose to the public via inhalation and ingestion. Energy absorbed from radioactive materials residing outside the body results in an external dose. External dose is measured by the Direct Radiation Monitoring Program conducted by Bechtel Nevada (BN) Environmental Technical Services (ETS). This section presents the results of monitoring direct ionizing radiation on the NTS from all sources, including natural radioactivity from cosmic or terrestrial sources and from man-made radioactive sources. These data are then used to document and trend gamma radiation exposure rates (mR/hr) on the NTS.

Monitoring occurs at certain NTS areas which have elevated radiation levels as a result of either: (1) historical weapons testing, (2) current and past radioactive waste management activities, and (3) current operational activities that involve radioactive material or radiation-generating devices. A surveillance network of sampling locations has been established and the objectives and design of the network are described in detail in the Routine Radiological Environmental Monitoring Plan (RREMP) (DOE, 2003). This section describes briefly the RREMP goals, compliance measures, and methods, and presents the results of 2003 field sample collection and analysis.

An oversight monitoring program has been established by U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) to independently monitor direct radiation within communities adjacent to the NTS. This independent oversight program is managed by Desert Research Institute (DRI). DRI's 2003 direct radiation monitoring results are presented in Section 5.6.1.3 of this NTSER.

4.1 Goals and Compliance Measures

The goals of direct radiation monitoring are to assess the state of the external radiation environment, detect changes in that environment, and measure gamma radiation levels near potential exposure sites. DOE Order 450.1 states that environmental monitoring should be conducted to detect, characterize, and respond to releases from U.S. Department of Energy (DOE) activities, assess impacts, and estimate dispersal patterns in the environment. In addition, DOE Order 5400.5 states, "it is also an objective that potential exposures to members of the public be as low as is reasonably achievable (ALARA)." Specific objectives for direct radiation monitoring are to:

- Measure the potential external dose to a member of the public in order to determine if the total dose (internal and external combined) exceeds 100 mrem/yr, the total dose limit specified in DOE Order 5400.5.
- Determine if radiation levels from the Radioactive Waste Management Complex (RWMC) are likely to result in a dose exceeding the 25 mrem/yr (0.25 mSv/yr) dose limit to members of the public as specified in DOE M 435.1-1.
- Monitor operational activities involving radioactive material, radiation-generating devices, or accidental releases of radioactive material to ensure exposure to members of the public are kept ALARA as stated in DOE Order 5400.5.
- Determine if the absorbed radiation dose (from external radiation exposure) to NTS terrestrial plants and aquatic animals is less than 1 rad/day, and if the absorbed radiation dose to NTS terrestrial animals is less than 0.1 rad/day (the limits prescribed by DOE Order 5400.5 and DOE Standard DOE-STD-1153-2002).
- Determine the exposure rates through time at various soil contamination areas to fulfill the DOE Order 450.1 requirement to characterize releases in the environment.

It is important to note that all the dose limits listed above do not include the dose contribution from background radiation. Direct radiation monitoring is therefore necessary to assess the proportion of dose to the public which comes from background radiation versus NTS operations.

The measure of direct radiation is *exposure* to electromagnetic (gamma and X-ray) radiation. Electromagnetic radiation is able to travel long distances through air and to penetrate living tissue causing ionizations within the tissues of the body. In contrast, alpha and weak beta particles do not travel far in air (a few centimeters for alpha and about 10 m

(32.8 ft) for beta particles). Alpha particles only deposit negligible energy externally; they rarely penetrate the outer dead layer of skin, and beta particles are generally absorbed in the immediate layers of skin below the outer layer. Radiation exposure is usually measured in the unit milli-roentgen (mR), which is a measure of dose in terms of a specified number of ionizations in air. Generally, the dose resulting from an exposure from the most common external radionuclides can be approximated by equating a 1 mR *exposure* with a 1 mrem (0.01 mSv) *dose*.

4.2 Methods

Thermoluminescent dosimeters (TLDs) were used to measure ionizing radiation exposure from all sources, including natural and man-made radioactivity. The TLD used was the Panasonic UD-814AS, consisting of four elements housed in an air-tight, water-tight, ultraviolet-light-protected case. A slightly shielded lithium borate element was used to check low-energy radiation levels and the average of three calcium sulfate elements were used to measure penetrating gamma radiation.

A pair of TLDs are placed at 1 ± 0.3 m (28 to 51 in) above the ground surface at each monitoring location and are exchanged for analysis on a quarterly basis. In order to normalize all TLD locations on the NTS, and to lower the potential for shielding effects from TLD posts, all TLD stations were changed from metal posts or fence lines to plastic/fiberglass composite posts during 2003. The quarterly analysis of TLDs was performed using automated TLD readers that were calibrated and maintained by the BN Health Physics Department (HPD). Reference TLDs were exposed to 100 mR from a ^{137}Cs radiation source under very controlled conditions and were read with TLDs collected from the environment to scale their response.

4.2.1 TLD Locations

In 2003 there were a total of 107 active environmental TLD locations on the NTS (Figure 4-1). They included the following numbers and types of locations:

- Background (B) – 8 locations where radiation effects from NTS operations are negligible.
- Environmental 1 (E1) – 42 locations where there is no measurable added radioactivity from past operations but where the locations are of interest due to either (1) the presence of personnel or the public in the area or (2) the potential for receiving radiation exposure from a current operation.
- Environmental 2 (E2) – 35 locations where there is measurable added radioactivity from past operations and the locations are of interest due to (1) the potential for personnel to be in the area and (2) the need to monitor trends in exposure rates in the area.
- Waste Operations (WO) – 16 locations in and around the Radioactive Waste Management Sites in Areas 3 and 5.
- Control (C) – 6 locations spread between two buildings in Mercury. Control TLDs are kept in a stable environment and are used as a quality check of TLDs and the analysis process.

4.2.2 Data Quality

Quality Assurance (QA) and Quality Control protocols, including Data Quality Objectives, have been developed and are maintained as essential elements of direct radiation monitoring as directed by the RREMP. The QA requirements established for the monitoring program include the use of sample packages to thoroughly document each sampling event, rigorous management of databases, and completion of essential training. Agreement between the results provided by the pairs of TLDs at each location was very good, with an average relative percent difference between measurements of 0.93 percent for 2003. Quarterly results from Control TLDs were not significantly different from those of previous years and exhibited a coefficient of variation between quarters ranging from 4 to 9 percent. This variation is a measure of that associated with the TLD sampling process. HPD maintains certification through the U.S. Department of Energy Laboratory Accreditation Program for dosimetry.

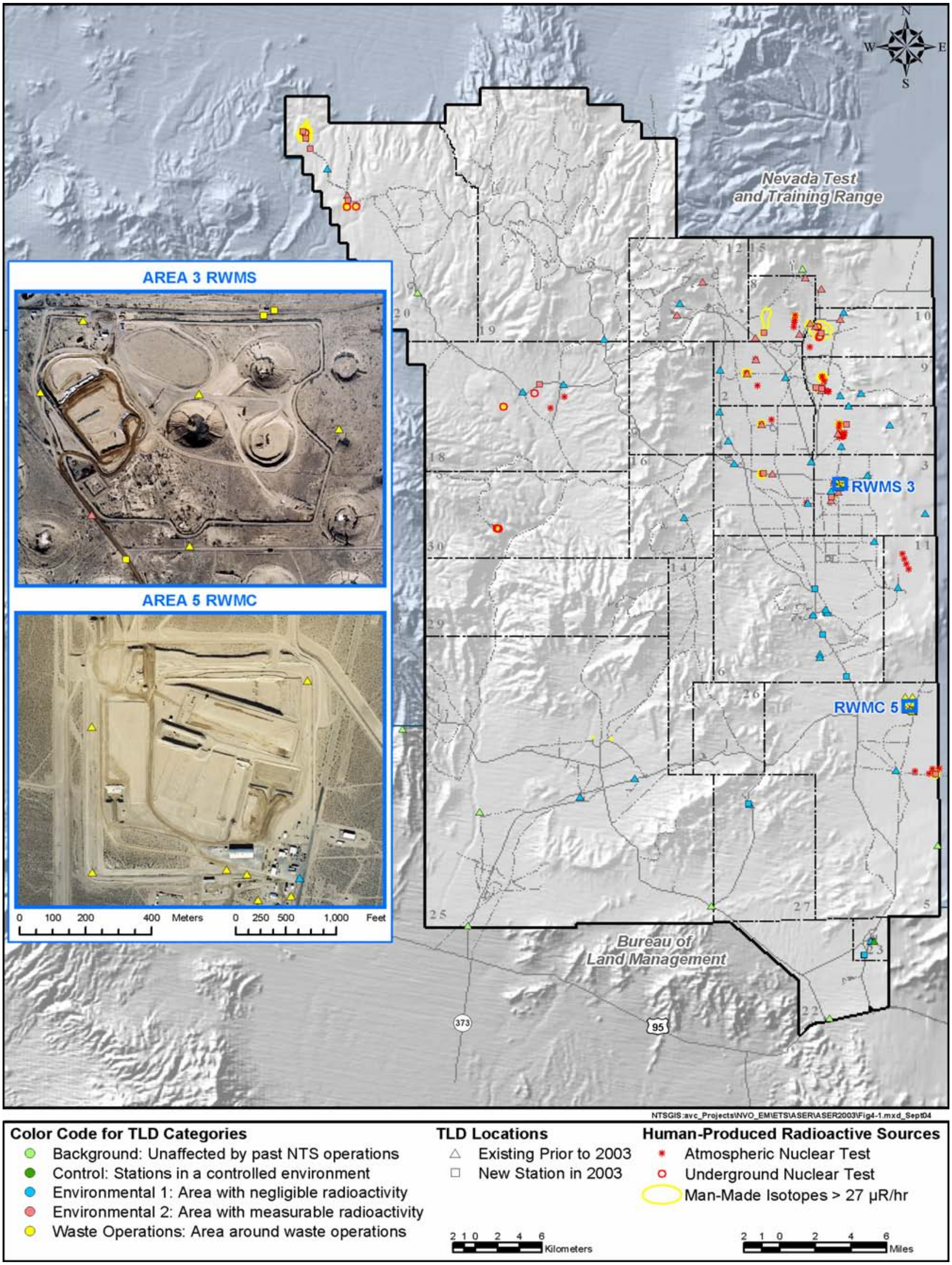


Figure 4-1. Location of TLDs on the NTS

4.2.3 Data Reporting

Direct radiation is reported as an exposure per unit of time. As the number of days per calendar quarter varies and the levels of direct radiation in the environment are relatively low, the radiation exposures measured with the TLDs are generally reported in mR per day (mR/d), determined by dividing the mR exposure per quarter by the number of days in the quarter. Annual exposures are used for comparison to federal regulations. Mean annual exposure rates are calculated by summing the four quarterly exposures per location, dividing by the total number of days in all four quarters, and then multiplying by the number of days in 2003 (365 days). Daily exposure rates can be calculated from results reported in Tables 4-1 and 4-2 by dividing by 365.

4.3 Results

Annual exposure rates for all TLD locations are summarized in Table 4-1 and Table 4-2. There were eight background TLD locations on the NTS. During 2003, the average exposure rate at those locations was 0.31 mR/d and ranged from 0.17 to 0.45 mR/d. All values reported in the following sections include the contribution from background unless it is specifically stated that it is a net exposure which would be the total exposure minus the contribution from background. Dose limits prescribed by DOE orders only apply to exposures above background levels.

Table 4-1. Annual external radiation exposure rates measured at TLD locations on the NTS in 2003

NTS Area	Location	Location Type[(a)]	Number of Samples	Annual Exposure Rate (mR/yr)				
				Mean[(b)]	Median	Std[(c)]	Min[(d)]	Max[(e)]
5	3.3 Mi SE of Aggregate Pit	B	4	65	63	5	62	74
15	U-15e Substation	B	4	108	112	10	93	115
20	Stake A-118	B	4	157	159	6	150	164
22	Army #1 Water Well	B	4	84	81	9	79	99
25	Gate 25-4-P	B	4	130	128	10	122	144
25	Guard Station 510	B	4	129	127	9	121	142
25	Jackass Flats & A-27 Roads	B	4	81	81	5	77	89
25	Yucca Mountain	B	4	138	140	6	131	143
23	Bldg 652, Rm 11 Pig, Center	C	4	25	25	2	23	27
23	Bldg 652, Rm 11 Pig, NE	C	4	26	26	2	24	28
23	Bldg 652, Rm 11 Pig, NW	C	4	26	26	2	23	28
23	Bldg 652, Rm 11 Pig, SE	C	4	25	25	1	24	26
23	Bldg 652, Rm 11 Pig, SW	C	4	26	26	2	24	27
23	Building 650 Dosimetry	C	4	60	59	5	56	68
1	BJY	E1	4	111	115	14	91	123
1	Sandbag Storage Hut	E1	4	113	115	9	102	123
1	Stake C-2	E1	4	117	114	7	113	128
2	Stake M-140	E1	4	132	130	9	125	146
2	Stake TH-58	E1	4	95	95	6	89	103
3	LANL Trailers	E1	3	125	128	7	117	130
3	Stake OB-20	E1	4	88	86	8	83	101
3	Well ER 3-1	E1	4	128	126	9	121	142
4	Stake TH-41	E1	4	113	113	8	105	124
4	Stake TH-48	E1	4	121	119	9	113	134
5	Bldg 5-31	E1	4	110	108	11	100	126
5	Water Well 5B	E1	4	113	111	9	105	126
6	CP-6	E1	4	72	70	7	66	83
6	DAF East	E1	4	91	90	8	85	102
6	DAF North	E1	2	101	101	0	100	101
6	DAF South	E1	2	130	130	0	130	131
6	DAF West	E1	4	82	81	7	77	92

Table 4-1. (continued)

NTS Area	Location	Location Type[a]	Number of Samples	Annual Exposure Rate (mR/yr) Mean[b]	Median	Std[b]	Min[c]	Max[d]
6	Decon Facility Northeast	E1	4	121	119	7	114	129
6	Decon Facility Southeast	E1	4	129	129	5	123	134
6	Stake OB-11.5	E1	4	128	127	6	122	136
6	Yucca Compliance	E1	2	89	89	1	89	89
6	Yucca Oil Storage	E1	4	100	97	10	93	115
7	Reitmann Seep	E1	4	130	130	4	125	134
7	Stake H-8	E1	4	128	126	9	122	141
9	Papoose Lake Road	E1	4	85	85	5	79	91
9	U-9cw South	E1	4	105	104	5	102	113
9	V & G Road Junction	E1	4	112	111	6	108	120
10	Gate 700 South	E1	4	133	132	6	129	143
11	Stake A-21	E1	4	133	132	6	128	142
12	Upper N Pond	E1	4	131	129	7	126	141
16	3545 Substation	E1	4	133	134	10	119	142
18	Stake A-83	E1	4	150	150	7	145	159
18	Stake F-11	E1	4	148	147	5	144	155
19	Stake P-41	E1	4	165	164	9	159	179
20	Stake J-41	E1	4	140	138	11	131	156
23	Gate 100 Truck Parking 1	E1	1	63	63	NA[f]	63	63
23	Gate 100 Truck Parking 2	E1	1	63	63	NA	63	63
23	Mercury Fitness Track	E1	4	70	68	18	57	95
25	Henre	E1	4	128	129	5	122	133
25	NRDS Warehouse	E1	4	125	122	8	119	137
27	Cafeteria	E1	4	112	110	10	105	128
27	Jasper-1	E1	4	113	111	9	106	127
1	Bunker 1-300	E2	4	121	123	8	110	128
1	T1	E2	2	439	437	36	412	462
2	Stake L-9	E2	4	178	176	9	172	191
2	Stake N-8	E2	4	634	632	20	616	658
3	Stake A-6.5	E2	4	144	142	9	138	157
3	T3	E2	2	414	413	17	401	425
3	T3 West	E2	2	399	397	23	381	414
3	T3A	E2	1	550	550	NA	550	550
3	T3B	E2	2	527	526	35	501	551
3	U-3co North	E2	3	346	218	11	204	226
3	U-3co South	E2	4	154	153	2	152	158
4	Stake A-9	E2	4	767	770	23	733	787
5	Frenchman Lake	E2	2	412	412	17	400	425
7	Bunker 7-300	E2	4	260	261	4	256	264
7	T7	E2	2	118	118	4	115	121
8	Baneberry 1	E2	2	432	430	30	409	452
8	Road 8-02	E2	4	128	128	4	125	134
8	Stake K-25	E2	4	107	108	3	104	111
8	Stake M-152	E2	4	167	167	9	159	179
9	B9A	E2	2	132	132	0	132	133
9	Bunker 9-300	E2	4	123	123	11	112	138
9	T9B	E2	2	576	577	16	565	588

Table 4-1. (continued)

NTS Area	Location	Location Type[(a)]	Number of Samples	Annual Exposure Rate (mR/yr) Mean[(b)]	Median	Std[(c)]	Min[(d)]	Max[(e)]
10	Circle & L Roads	E2	4	121	120	7	115	130
10	Sedan East Visitor Box	E2	4	132	131	7	125	142
10	Sedan West	E2	4	263	262	10	255	276
10	T10	E2	2	289	288	11	280	296
12	T-Tunnel #2 Pond	E2	4	262	267	12	245	271
12	Upper Haines Lake	E2	4	113	114	8	103	123
15	EPA Farm	E2	4	116	114	7	112	127
18	Johnnie Boy North	E2	2	140	140	5	136	143
20	Palanquin	E2	2	241	242	12	234	251
20	Schooner 1	E2	4	959	986	72	889	1045
20	Schooner 2	E2	2	333	336	57	297	377
20	Schooner 3	E2	2	152	153	25	136	171
20	Stake J-31	E2	4	178	179	7	171	184
3	A3 RWMS Center	WO	4	151	149	9	144	164
3	RWMS East	WO	4	150	148	8	144	162
3	RWMS North	WO	4	125	124	5	121	132
3	RWMS South	WO	4	429	423	25	411	466
3	RWMS West	WO	4	132	132	5	127	139
5	RWMS East Gate	WO	4	126	125	9	117	137
5	RWMS Expansion NE	WO	4	136	134	7	133	147
5	RWMS Expansion NW	WO	4	146	146	6	140	155
5	RWMS Northeast Corner	WO	4	123	122	6	118	131
5	RWMS Northwest Corner	WO	4	125	125	9	116	134
5	RWMS South Gate	WO	4	109	108	8	104	120
5	RWMS Southwest Corner	WO	4	126	123	9	122	140
5	WEF East	WO	4	124	122	6	121	133
5	WEF North	WO	4	120	119	6	117	129
5	WEF South	WO	4	124	124	4	120	130
5	WEF West	WO	4	129	127	9	123	144

(a) Location types:
- B = Background locations
- C = Control locations
- E1 = Environmental locations with exposure rates near background but monitored for potential for increased exposure rates due to NTS operations
- E2 = Environmental locations with measurable radioactivity from past operations, excluding those designated "WO"
- WO = Locations in or near waste operations

(b) Time weighted average
(c) Standard deviation
(d) Minimum value
(e) Maximum value
(f) Not applicable (no standard deviation could be calculated because there was only one measurement).

Table 4-2. Summary statistics for annual direct radiation exposure by TLD location type

Location Type	Number of Samples	Annual Exposure Rate (mR/yr) Mean	Median	Std[(a)]	Min[(b)]	Max[(c)]
Background (B)	32	112	118	31	62	164
Control (C)	24	31	26	13	23	68
Environmental 1 (E1)	155	116	120	23	57	179
Environmental 2 (E2)	108	287	179	227	103	1045
Waste Operations (WO)	64	149	129	75	104	466
All Locations	**386**	**165**	**126**	**150**	**23**	**1045**

(a) Standard deviation
(b) Minimum value
(c) Maximum value

4.3.1 Potential Exposure to the Public along the NTS Boundary

Most of the NTS is not accessible to the public and only the southern portions of the NTS boundary borders public land. Therefore, the only place the public has potential for exposure to direct radiation from the NTS is along the southern boundary.

Gate 100 is the primary entrance point to the NTS and the outer parking areas are accessible to the public. Trucks hauling radioactive materials, primarily low-level radioactive waste being shipped for disposal in the RWMC often park outside Gate 100 while waiting for entry to the NTS. Two TLD locations were established in October 2003 to monitor this truck parking area. The TLDs measured an exposure rate of 0.17 mR/d for the fourth quarter. This is at the lower range of the background measurements taken on the NTS and is lower than the 0.26 mR/d average exposure rate measured by the Community Environmental Monitoring Program in Las Vegas, NV, during 2003 (see Table 5-3). These data indicate that trucks hauling radioactive materials did not cause elevated exposure rates at this location over the monitoring period.

While the public only has access to the southern portions of the NTS borders, other people may have access to other boundaries of the NTS. The great majority of the NTS is bounded by the Nevada Test and Training Range (NTTR). Though military personnel on the NTTR are not members of the public, they are still subject to the 100 mrem/yr dose limits for members of the public unless they are classified as radiation workers. The only place a soil contamination area crosses a boundary with NTTR is in the Frenchman Lake region of Area 5 along the southeast boundary of the NTS. A TLD location was established in July 2003, near the NTS boundary in Frenchman Lake playa. The exposure rate measured was 1.15 mR/d during the third quarter and 1.16 mR/d during the fourth quarter. Subtracting the average background exposure for the NTS (0.31 mR/d) from the average of these measurements results in a net exposure rate of 0.85 mR/d from added man-made radioactivity. This would result in a net annual exposure of 310 mR/yr. This exposure rate would exceed the 100 mrem/y dose limit to a hypothetical person residing year-round at this location. However, there are no living quarters or full-time workers at this location.

4.3.2 Exposure Rates at Radioactive Waste Management Sites (RWMSs)

The Radioactive Waste Management Manual, DOE M 435.1-1 (DOE, 2001a), states that low-level waste disposal facilities shall be operated, maintained, and closed so that a reasonable expectation exists that dose to representative members of the public shall not exceed 25 mrem/yr (0.25 mSv/yr). Given that the RWMSs are located well within the NTS boundaries, there are no members of the public which could access these areas for significant periods of time. However, exposure rates are measured by TLDs located at the RWMSs to show the potential dose to a hypothetical person residing year-round at the RWMS.

4.3.2.1 Area 3 RWMS

The Area 3 RWMS is located on Yucca Flat. Between 1952 and 1972, 60 nuclear weapons tests were conducted within 400 meters of the Area 3 RWMS boundary. Fourteen of these tests were atmospheric tests which left radionuclide contaminated surface soil and, therefore, elevated radiation exposure rates across the area. Waste pits in the Area 3 RWMS are subsidence craters from seven subsurface tests that are being filled with low-level radioactive waste and covered with clean soil. The result of this is a lower exposure rate inside the Area 3 RWMS compared with the average exposure rate at the fence line or with that measured in the area from the fence line out to 2.2 km (1.4 mi).

Net average annual exposure rates surrounding the Area 3 RWMS are shown in Figure 4-2. The net exposure rate is the total measured minus the 0.31 mR/d average rate measured at NTS background locations. The external dose to a hypothetical person residing full time on the Area 3 RWMS would be about 152 percent of the 25 mrem dose limit specified in DOE Order M 435.1-1 (exposure of 38 mR/yr). A person residing at the Area 3 RWMS only during normal full-time work hours (40 hr/week x 52 weeks/yr = 2080 hours or 0.24 years) would be exposed to only 9 mR during 2003 (38 mR/yr x 0.24 yr).

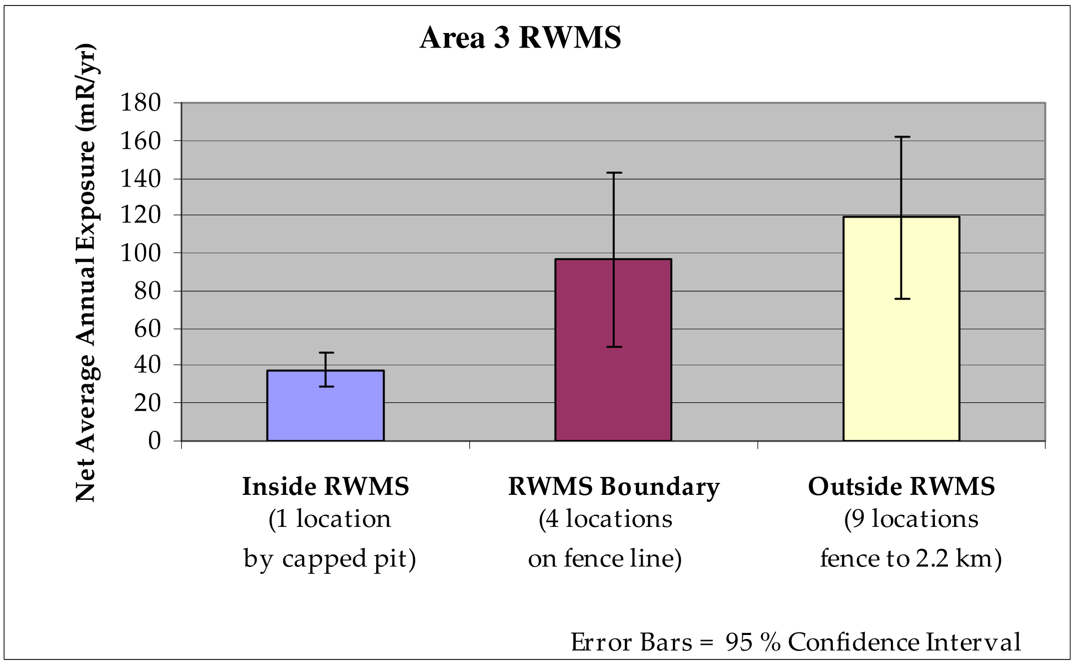


Figure 4-2. Average annual net exposure rates at the Area 3 RWMS during 2003

4.3.2.2 Area 5 RWMS

The Area 5 RWMS is located on the northern portion of Frenchman Flat. Ten underground nuclear weapons tests were conducted within 3 km (1.9 mi) of the Area 5 RMWS between 1965 and 1971. Nine of these released radioactivity to the surface which contribute to the exposure rates in the area. No nuclear weapons testing occurred within the boundaries of the Area 5 RWMS. During 2003, the net average annual exposure rate at the Area 5 RWMS boundary was 9 mR/yr. The net average of the three TLD locations closest to, but outside, of the Area 5 RWMS disposal area was 20 mR/yr (Figure 4-3). Two of these three locations were about 400 m (1, 312 ft) from the disposal areas while the third was about 5 km (3.1 mi) south-southeast of Area 5 RWMS. The external dose to a hypothetical person residing full-time at the boundary of Area 5 RWMS would be about 35 percent of the 25 mrem dose limit specified in DOE Manual 435.1-1. Because the exposure rates appear to be higher away from Area 5 RWMS compared with that at its boundary, it is likely that the clean soil used to cap waste pits actually lowers the exposure rate compared with the surrounding area.

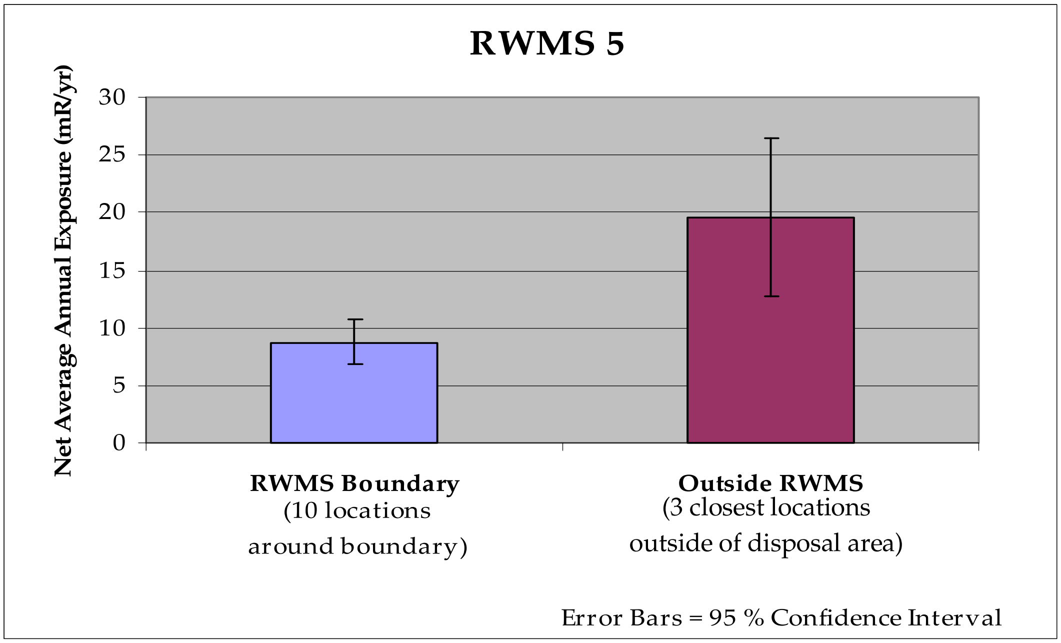


Figure 4-3. Average annual exposure rates at the Area 5 RWMS during 2003

4.3.3 Exposure Rates From NTS Operational Activities

During 2003 there were 42 TLDs located where NTS operations had the potential to produce elevated radiation exposure rates (E1 locations). The median exposure rate at these locations was 120 mR/yr, virtually the same as the average 118 mR/yr measured at background locations (Table 4-2, Figure 4-4). During 2003, NTS operations produced undetectable radiation exposure at monitoring locations close to those operations. The public, having no access to theses areas, received no direct radiation exposure from NTS operations during 2003.

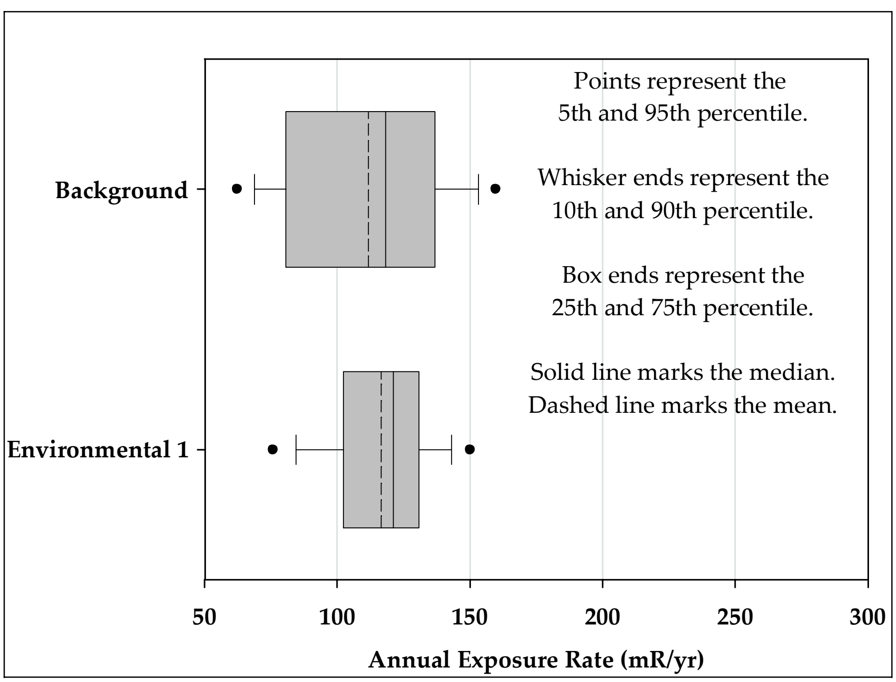


Figure 4-4. Annual exposure rates at Background and E1 locations on the NTS in 2003

4.3.4 Exposure to NTS Plants and Animals

The TLD location with the highest exposure rate (Schooner 1) had a maximum measurement of 2.86 mR/d during the second quarter of 2003. This relates to an external dose approximately 3 percent of the most limiting dose rate to biota (0.1 rad/day limit to terrestrial animals). Based on this, dose to plants and animals from external radiation exposure on the NTS is low compared with dose limits.

4.3.5 Exposure Rate Patterns in the Environment over Time

DOE Order 450.1 states that environmental monitoring should be conducted to characterize releases from DOE activities. Monitoring the exposure rates at locations of past releases on the NTS over time helps to do this. Small quarter-to-quarter changes are normally seen in exposure rates from all locations. During 2003, the first quarter measurements across all locations averaged around 10 percent higher than those of the other three quarters. This increase was statistically significant. Similar quarter-to-quarter differences have been noticed in previous years, although the third quarter has been significantly higher rather than the first quarter for the past three years. Because this is observed across all locations (including background locations), the reason for the differences are likely related to meteorological conditions.

Changes through time are displayed in Figure 4-5 for annual TLD measurements by location type for those locations which have been monitored for at least eleven years. The Schooner TLD locations, which have the highest exposure rates of any current TLD locations on the NTS, are not included in this figure because they were established in 2003. The two highest exposure rates shown in Figure 4-5, Stake A-9, and Stake N-8, are overall decreasing with a half-life of about 15 and 12 years, respectively. The next three highest exposure rates are from the Sedan West, T-Tunnel #2 Pond, and Bunker 7-300 locations, and are overall decreasing with a half-life of about 14, 13, and 22 years, respectively. All five of these locations are in the E2 category at known contaminated sites with the predominant photon-emitting radionuclides being ^{137}Cs, ^{60}Co, ^{152}Eu, and ^{241}Am. The observed decreases in exposure rates are due to the natural decay of radionuclides and to the dispersal of radionuclides in the environment. Exposure rates at all other locations have been relatively stable over time indicating little added radionuclides at those locations.

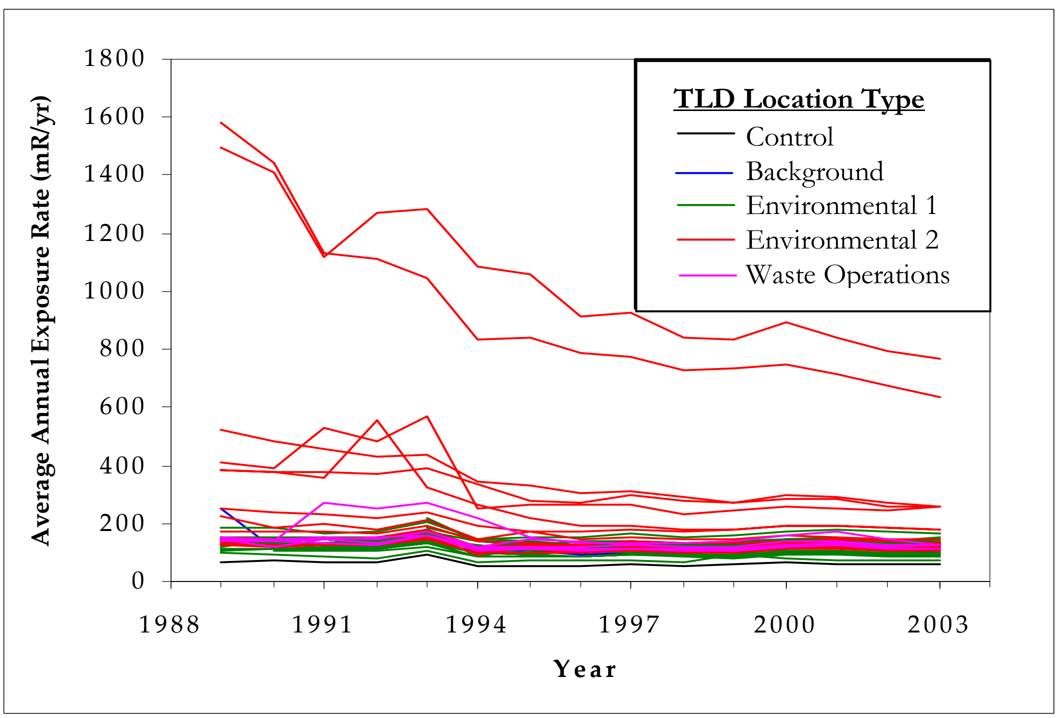


Figure 4-5. Trend in direct radiation exposure measured at TLD locations with at least eleven-year data histories

4.4 Environmental Impact

Direct radiation exposure to the public from NTS operations in 2003 was negligible. Areas accessible to the public had exposure rates virtually the same as background exposure rates. Radionuclides historically released to the environment on the NTS have resulted in localized elevated exposure rates. These areas are not open to the public nor are there personnel working in these areas. The exposure rates at the RWMSs appear to be lower inside, or at the boundary, compared with that outside the RWMSs. This is likely due to the presence of radionuclides released from historical testing distributed throughout the area around the RWMSs and clean soil used inside the RWMSs to cap waste pits. External dose to plants and animals at the location with the highest measured exposure rates was a small fraction of the dose limit to biota. There should be no detrimental effects to biota from external radiation exposure at these sites.

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5.0 Oversight Radiological Monitoring of Air and Water

5.1 Introduction

Community oversight for the (Nevada Test Site) NTS is provided through the Community Environmental Monitoring Program (CEMP), formerly the Community Technical Liaison Program (CTLP), whose mission is to monitor and communicate environmental data that are relevant to the safety and well-being of participating communities and their surrounding areas. Previously, the CEMP network functioned as a first line of offsite detection of potential radiation releases from underground nuclear tests, and it can be outfitted to fulfill this role again should underground testing ever resume. It currently exists as a non-regulatory public informational and outreach program, although quarterly reporting of monitoring data is furnished to the U.S. Environmental Protection Agency (EPA) Region IX as a supplemental requirement to NTS onsite monitoring. The CEMP is sponsored by the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO), and is administered and operated by the Desert Research Institute (DRI) of the University and Community College System of Nevada.

Monitored and collected data include, but are not necessarily limited to, background and airborne radiation data, meteorological data, and tritium concentrations in community and ranch drinking water wells. The network stations, located in Nevada and Utah, are managed by local citizens, many of them high school science teachers, whose routine tasks are to maintain the equipment, collect air filters, and route them to the DRI for analysis. These Community Environmental Monitors (CEMs) are also available to discuss the monitoring results with the public and to speak to community and school groups. DRI's responsibilities include maintaining the physical monitoring network through monthly visitations by environmental radiation monitoring specialists, who also participate in training and interfacing with CEMs and interacting with other local community members and organizations to provide information related to the monitoring data. DRI also provides public access to the monitoring data through maintenance of a project web site at <http://www.cemp.dri.edu/>.

5.2 Historical Background

In order to understand how the CEMP came into being, it is helpful to become familiar with some of the history of nuclear research, development, and monitoring in the United States. By 1949, the pace of nuclear weapons research and development had accelerated to the point that the identification of an on-continent testing area was a priority of the U.S. government. Factors of population density, weather, available labor pool, transportation, real estate available to the government, and security were taken into account in the attempt to identify a suitable location. In late 1950, President Truman signed the order establishing the Nevada Proving Grounds, which later became known as the NTS.

The Offsite Radiological Safety Program (ORSP) was established and in 1954 became the responsibility of the U.S. Public Health Service (PHS) through a memorandum of understanding between the U.S. Atomic Energy Commission (the predecessor of U.S. Department of Energy [DOE]) and the PHS. Major objectives of this program were to directly measure or to collect and analyze representative samples of air, water, foodstuffs, soil, biota, and other environmental media to:

- Assess and document radiation exposure to the public and the environmental radiological conditions of the offsite areas.
- Initiate actions needed to protect the health and safety of the public.
- Conduct a public information program in the offsite areas to assure the residents that all reasonable precautions to protect the public from radiation and other hazards associated with the nuclear testing program are being applied.
- Determine compliance with applicable guidelines and legal requirements.

In the 1950s, nuclear testing was not conducted year round, but in a series of tests requiring up to several months to complete. PHS officers were brought to Nevada to conduct the surveillance of each series. There were no permanent continuously operating environmental monitoring or sampling networks in operation. In 1959, national radiological health requirements were identified and the Southwestern Radiological Health Laboratory (SWRHL) was established in Las Vegas, Nevada. The SWRHL served as the western U.S. focal point for radiological research and surveillance and provided training programs for all states west of the Mississippi River including Alaska and Hawaii.

A nuclear testing moratorium was in effect for the United States (U.S.) and the Soviet Union from November 1, 1958 until September 1, 1961. The U.S. resumed testing on September 15, 1961. With the resumption of nuclear testing, the NTS went to year-round operation, and SWRHL became the PHS base of operations for the ORSP. At this time, PHS initiated the first network of continuously operating air samplers in the offsite areas.

The PHS continued the ORSP until 1970 when the EPA was created. In December 1970, responsibilities for offsite radiation safety, along with the SWRHL facilities, were transferred from the PHS to the EPA. The SWRHL acquired an expanded mission which included the development of monitoring techniques for a variety of environmental pollutants and conducting national environmental studies. To reflect its changing missions, SWRHL underwent several name changes until today it is the Environmental Monitoring Systems Laboratory (EMSL-LV). Within EMSL-LV, the Nuclear Radiation Assessment Division (NRD) was created to manage the ORSP.

In March 1979, the accident at the Three-Mile Island (TMI) Nuclear Power Generating Plant near Middletown, Pennsylvania occurred. EMSL-LV was requested to respond to this emergency. Personnel from EMSL-LV traveled to Pennsylvania. They established radiation monitoring and environmental sampling locations in the offsite areas surrounding TMI and a radioanalytical laboratory in the basement of the Pennsylvania State Health Department in Harrisburg, Pennsylvania.

The accident at TMI was a cause for much public concern and fostered a general distrust of the federal government. This distrust was still evident in the summer of 1980 when purging the nuclear reactor containment vessel of radiokrypton was planned. To increase credibility and to develop a method to communicate the status of the radiological conditions of the environment around TMI, the Citizen's Monitoring Program (CMP) was instituted. In each of the communities where the monitoring stations would be located, local officials nominated residents as station managers. State and federal participants selected the managers from the nominees. EPA provided and installed the continuous beta/gamma radiation exposure detector/recorder systems. The station managers were trained by the Pennsylvania State University and the Pennsylvania Department of Environmental Resources (DER). The managers independently analyzed the data they collected daily and reported it to their communities and the DER. The DER validated the data and reported it to the news media. The CMP, consisting of monitoring stations operated and managed by local residents, was very successful in reassuring the communities that radiation levels were being measured and accurately reported by the federal government. Since the creation of this program, similar independent community monitoring networks such as EFMR and TMI-Citizen's Monitoring Network have been established.

Because of the success of this program, it was proposed that a similar program be instituted in the communities around the NTS, where the U.S. was conducting its Nuclear Weapons Testing Program. Although the NRD had well-established monitoring stations already in place in these communities, the implementation of a similar community monitoring program would create monitoring stations located in highly visible locations where local residents would be aware of their presence, and have access to the radiological data and the station managers. Thus, 1981 saw the start of the Community Monitoring Program, a cooperative project of the DOE, DRI, and EPA, consisting of 15 monitoring stations located in the states of California, Nevada, and Utah.

The program has expanded and gone through several name changes, and today includes 26 monitoring stations in Nevada and Utah under the name CEMP. In 1999, technical administration of the CEMP was transitioned from EPA to DRI, and the stations were upgraded to include a full suite of meteorological instrumentation in addition to radiation monitoring sensors, state-of-the-art electronic data collectors, and communications hardware enabling updates several times daily to a publicly-accessible web page.

5.3 Monitoring Activities

Locations for monitoring stations are identified with special attention to placement in and near population centers with proximity to the NTS. In addition, special attention is given to population centers more distant which are located in areas downwind of the NTS according to prevailing winds. Stations may also be located in remote areas where ranching and farming activities are carried out. Routine monthly visits for maintenance are conducted by environmental radiation monitoring specialists. The emphasis of the CEMP is to monitor airborne radioactivity and weather conditions, and to make the results available to the public through local station managers (CEMs) and a publicly-accessible web site.

DRI employs CEMs, who are residents of the communities in which the stations occur, and an attempt is made to select respected members of the community who interface with the public on a regular basis, especially high school science teachers. Through workshops, the CEMs are trained to independently verify the results of the environmental monitoring and become knowledgeable spokespersons on subjects ranging from radiation detection to local environmental conditions. They are effective technical liaisons between local and federal entities, helping to identify the environmental concerns of people in their communities.

Instrumentation that records the airborne radioactivity and weather data is connected to a datalogger. Real-time radiation levels or weather conditions can immediately and easily be seen on a display on the front of the datalogger. The equipment array at each station has changed through time to reflect the various missions of the CEMP. For example, when the CEMP served as a first offsite detection of potential releases from underground nuclear tests, charcoal filters and noble gas samplers were part of the standard station equipment. Monitoring instrumentation at the stations is evaluated on an annual basis, and occasionally upgrades or additions are warranted to be appropriate. Monitoring stations are currently equipped with the following instrumentation:

Low-volume particulate air sampler – This instrument pulls approximately two cubic feet of air per minute (at standard temperature and pressure [STP]) through a glass-fiber paper filter. The filter collects the particles, which are then collected weekly and analyzed by an independent laboratory for alpha, beta, and gamma radioactivity.

Air flow totalizer – This instrument constantly monitors and sums the actual air flow rate and total volume through the particulate air samplers to provide accurate flow rates for filter analysis calculations.

Thermoluminescent dosimeter (TLD) – This instrument provides data on accumulated background-gamma radiation and is collected quarterly for analysis by an independent laboratory.

Exposure rate recorder – This instrument consists of a pressurized ion chamber detector (PIC), and provides continuous readings of gamma radiation exposure rates.

Weather instruments – These instruments include sensors to measure air temperature, humidity, wind speed and direction, solar radiation, barometric pressure, precipitation, and soil temperature and moisture data.

All instrumentation, with the exception of the particulate air sampler, is hardwired to the datalogger, which collects and stores the data at a default rate of 3-second intervals. All monitoring data are archived on the web site at <http://www.cemp.dri.edu/> and on compact disk-read only memory.

An additional monitoring task of the CEMP is to annually sample community and ranch drinking water well sources identified by the CEMs and perform radioisotopic analyses to detect for the presence and concentration of tritium. These analyses are performed at DRI's Tritium Laboratory in Reno and are reported annually in this NTSER.

Quality assurance for equipment maintenance and calibration and laboratory sample collection and collation is addressed in the CEMP Standard Operating Procedures (SOPs). Specific responsibilities of the environmental radiation monitoring specialists and CEMs are detailed in Task Responsibility Documents for each position. CEMs' responsibilities include monitoring the equipment, assisting with maintenance, and posting information on the program as well as analytical results. The CEMs are also part of the chain-of-custody for the air particulate samples, and are responsible for the weekly collection of air filters to be routed to DRI where they are prepared for submission to an independent laboratory for analysis.

5.4 Public Outreach

Public understanding of the CEMP and transparency of the monitoring results are important parts of the program's mission, so great attention has been paid to station location and accessibility, and making the results available. Communications equipment transmits collected data several times daily via direct internet connection, telephone line, cellular phone, or satellite to DRI's Western Regional Climate Center in Reno, Nevada. These data are automatically posted to a publicly-accessible web site at <http://www.cemp.dri.edu/>. Monthly summaries of these data are physically posted on bulletin boards at the monitoring stations. Quarterly reports of results of air filter and TLD analyses are provided to EPA Region IX as a required supplement to the NTS onsite monitoring network. An annual summary of the CEMP data is reported in this annual environmental report.

The CEMP endeavors to make presentations, both through local CEMs and DRI program administrators, at local community events, school classroom settings, and town hall meetings. An annual training workshop for the CEMs helps them remain current on program and NTS activities, the basic concepts of radiation, the station instrumentation, and prepares them to deal with public interactions and inquiries.

5.5 Participants

The CEMP is an integrated effort among federal and state agencies, and also includes members of the public in 19 communities and 7 ranch sites with stakeholder interest in past, present, and future NTS activities. Program participants represent the technical expertise available to address issues and problems identified in the program as well as issues of general concern to participating communities. Currently, participating communities and ranch sites (Figure 5-1) include:

Nevada Communities		Utah Communities	Ranches (Nevada)
Alamo	Indian Springs	Cedar City	Garden Valley*
Amargosa Valley	Las Vegas	Delta	Medlin's Ranch
Beatty	Overton	Milford	Nyala Ranch
Boulder City	Pahrump	St. George	Sarcobatus Flats
Caliente	Pioche		Stone Cabin Ranch
Ely	Rachel		Twin Springs
Goldfield	Tonopah		Warm Springs Summit
Henderson			

*Location of Garden Valley ranch not shown on Figure 5-1 at request of owner.

5.6 2003 Offsite Air Monitoring

During calendar year (CY) 2003 there were 26 CEMP stations managed by DRI which comprised the Air Surveillance Network (ASN) (Figure 5-1), including two new stations installed at Ely and Warm Springs Summit in the summer and fall of 2003, respectively. The ASN is composed of stations that include the various equipment-specific sampling networks described below. The CEMP station at Beatty, Nevada is shown in Figure 5-2.

CEMP Low-Volume Air Sampling Network – During CY 2003, the CEMP ASN included continuously operating low-volume particulate air-samplers located at 23 of the 26 CEMP station locations. No low-volume air samplers are located at Medlin's Ranch, Sarcobatus Flats, or Warm Springs Summit. Duplicate air samplers were collected from two routine ASN stations each week. The duplicate samplers are operated at randomly selected stations for three months (one calendar quarter) before being moved to a new location. One new station, located in Ely, Nevada, was added to the network in July of 2003. This re-established an important monitoring site that was removed prior to the program being administered by DRI.

The glass-fiber filters from the low-volume particulate samplers are collected by the CEMs, sent to DRI via the U.S. Postal Service, then prepared and forwarded to an independent laboratory to be analyzed for gross alpha and gross beta activity. Samples are held for a minimum of seven days after collection to allow for the decay of naturally-occurring radon progeny. Upon completion of the gross alpha/beta analyses, the filters are returned to DRI to be recompiled on a quarterly basis for gamma spectroscopy analysis.

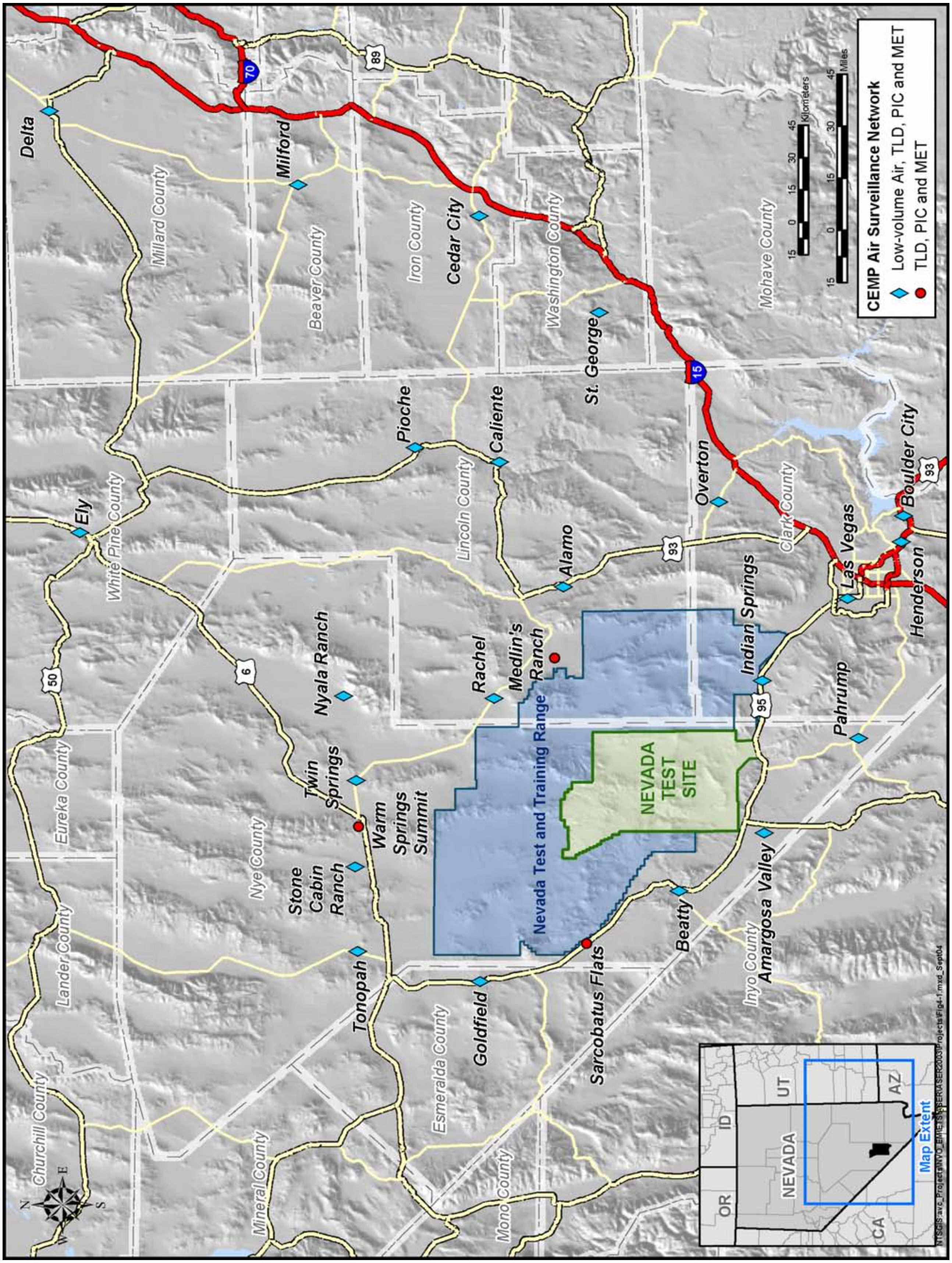

Figure 5-1. 2003 CEMP Air Surveillance Network

CEMP TLD Network – Thermoluminescent dosimetry is another of the essential components of environmental radiological assessments. This is used to determine both individual and population external exposure to ambient radiation from natural or artificial sources. In CY 2003, the TLD network consisted of fixed environmental TLDs at all 26 of the CEMP stations (see Figure 5-1). The TLD used was a Panasonic UD-814AS. Within the TLD, a slightly shielded lithium borate element is used to check low-energy radiation levels while three calcium sulfate elements are used to measure penetrating gamma radiation.

Figure 5-2. CEMP station at Beatty, Nevada

For quality assurance purposes, duplicate TLDs are deployed at three randomly-selected environmental stations. An average daily exposure rate was calculated for each quarterly exposure period. The average of the quarterly values was multiplied by 365.25 days to obtain the total annual exposure for each station.

CEMP PIC Network – The PIC measures gamma radiation exposure rates, and because of its sensitivity may detect low-level exposures that go undetected by other monitoring methods. PICs are in place at all 26 stations in the CEMP network (see Figure 5-1). The primary function of the PIC network is to detect changes in ambient gamma radiation due to human activities. In the absence of such activities, ambient gamma radiation rates naturally vary among locations reflecting differences in altitude (cosmic radiation), radioactivity in the soil (terrestrial radiation), and slight variations at a single location due to weather patterns. Since the addition of a full suite of meteorological instrumentation at the CEMP stations, variations in PIC readings caused by weather events such as precipitation or by changes in barometric pressure are more readily identified. These variations can be easily viewed by selecting the Time Series Graph link from the CEMP home page, < http://www.cemp.dri.edu/>, after selecting a desired station and then selecting the desired variables.

CEMP Meteorological (MET) Network – Because changing weather conditions can have a significant effect on measurable levels of background radiation, meteorological instrumentation is in place at each of the 26 CEMP stations. The MET network includes sensors that measure air temperature, humidity, wind speed and direction, solar radiation, barometric pressure, precipitation, and soil temperature and moisture data. All of these data can be observed real-time at the onsite station display, and archived data are accessible by accessing the CEMP home page at <http://www.cemp.dri.edu/>.

5.6.1 Air Particulate Sampling Results

A sample of airborne particulates from the CEMP ASN is collected by drawing air through a 2 in (5 cm) diameter glass-fiber filter at a constant flow rate of 2 cubic feet per minute (cfm) (86.6 liters (L)/min) at STP. The actual flow rate and volume is measured and recorded with an in-line air-flow calibrator. The particulate filter is mounted in a filter holder that faces downward at a height of 5 ft (1.5 m) above the ground. The total actual volume collected ranges from approximately 19,000 to 28,000 cubic feet (ft^3) (538 to 793 m^3) depending on the elevation of the station and changes in air temperature and/or pressure.

5.6.1.1 Gross Alpha and Gross Beta Results

Gross alpha and beta analysis in airborne particulate samples are used to screen for long-lived radionuclides in the air. The mean annual gross alpha activity across all sample locations was $1.8 \pm 0.5 \times 10^{-15}$ µCi/mL (67 ± 19 µBq/m^3) (Table 5-1). Most of the results for CY 2003 exceeded the analytical minimum detectable concentration (MDC) (see Glossary, Appendix D) and overall are similar to results from previous years. Figure 5-3 shows the long-term maximum, mean, and minimum alpha trend for the CEMP stations as a whole.

Table 5-1. Gross alpha results for the CEMP offsite Air Surveillance Network in 2003

Sampling Location	Number of Samples	Concentration (x 10^{-15} µCi/mL [37 µBq/m^3])			
		Maximum	Minimum	Mean	Standard Deviation
Alamo	50	4.8	0.7	2.1	1.1
Amargosa Valley	51	5.1	0.8	2.1	1.1
Beatty	51	5.1	0.5	2.1	1.3
Boulder City	52	7.3	0.7	3.2	1.3
Caliente	52	5.8	0.8	2.3	1.2
Cedar City	52	6.1	0.6	2.2	1.1
Delta	52	3.3	0.6	1.4	0.6
Ely	22	2.8	0.6	1.4	0.6
Garden Valley	52	3.1	0.4	1.3	0.5
Goldfield	52	3.1	0.5	1.4	0.7
Henderson	52	4.6	0.5	1.6	0.7
Indian Springs	46	3.4	0.5	1.4	0.6
Las Vegas	52	5.8	0.7	2.2	0.9
Milford	51	4.1	0.6	1.8	0.7
Nyala Ranch	51	2.3	0.3	1.1	0.4
Overton	52	3.8	0.5	2.1	0.8
Pahrump	52	4.5	0.5	1.5	0.7
Pioche	52	3.1	0.5	1.4	0.6
Rachel	50	4.8	0.6	1.6	0.8
Stone Cabin Ranch	52	4.8	0.7	2.6	1.1
St. George	51	4.7	0.6	1.5	0.7
Tonopah	48	5.2	0.5	1.5	0.7
Twin Springs	52	3.5	0.6	1.3	0.5
Overall Mean = $1.8 \pm 0.5 \times 10^{-15}$ µCi/mL					
Mean MDC = 0.5×10^{-15} µCi/mL		**Standard Deviation of Mean MDC = 0.05×10^{-15} µCi/mL**			

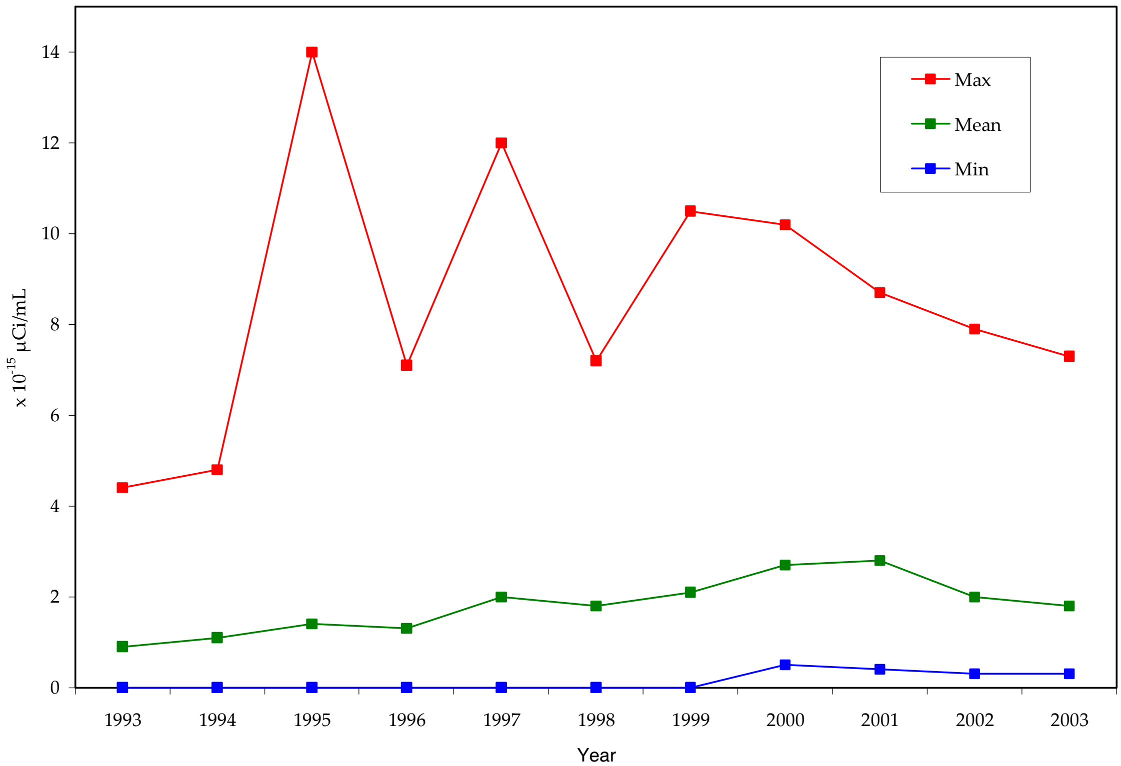

Figure 5-3. Historical trend for gross alpha analysis for all CEMP stations

The mean annual gross beta activity across all sample locations was 23.5 ± 2.0 x 10^{-15} µCi/mL (869.5 ± 74.0 µBq/m³ (Table 5-2). Most of these results also exceeded the MDC, and are similar to previous years' data. Figure 5-4 shows the long-term maximum, mean, and minimum beta trend for the CEMP stations as a whole.

Table 5-2. Gross beta results for the CEMP offsite Air Surveillance Network in 2003

Sampling Location	Number of Samples	Concentration (10^{-15} µCi/mL [37 µBq/m³]) Maximum	Minimum	Mean	Standard Deviation
Alamo	50	43.9	13.9	23.4	5.4
Amargosa Valley	51	40.1	14.3	25.3	6.3
Beatty	51	39.1	12.4	23.8	6.8
Boulder City	52	58.6	15.8	27.4	7.9
Caliente	52	48.4	14.1	24.2	6.1
Cedar City	52	54.8	11.9	23.1	6.9
Delta	52	59.7	13.5	24.1	7.5
Ely	22	30.7	14.6	21.3	4.7
Garden Valley	52	33.6	10.3	21.7	4.9
Goldfield	52	33.1	10.2	21.4	5.4
Henderson	52	45.0	13.3	27.0	16.0
Indian Springs	46	45.1	11.7	22.8	6.4
Las Vegas	52	43.1	13.8	24.5	6.7
Milford	51	53.2	14.5	25.6	7.5

Table 5-2. (continued)

Sampling Location	Number of Samples	Concentration (10^{-15} µCi/mL [37 µBq/m³]) Maximum	Minimum	Mean	Standard Deviation
Nyala	51	30.4	8.8	19.6	4.8
Overton	52	54.8	11.9	26.3	7.1
Pahrump	52	37.3	13.1	23.7	5.8
Pioche	52	39.4	11.8	21.6	5.3
Rachel	50	45.1	13.9	23.7	6.5
Stone Cabin	52	31.8	8.1	21.7	6.0
St. George	51	40.3	11.2	25.1	6.2
Tonopah	48	46.3	11.6	21.4	6.5
Twin Springs	52	37.9	11.6	22.9	6.3
Network Mean = 23.5 ± 2.0 x 10^{-15} µCi/mL					
Mean MDC = 1.1 x 10^{-15} µCi/mL		**Standard Deviation of Mean MDC = 0.7 x 10^{-15} µCi/mL**			

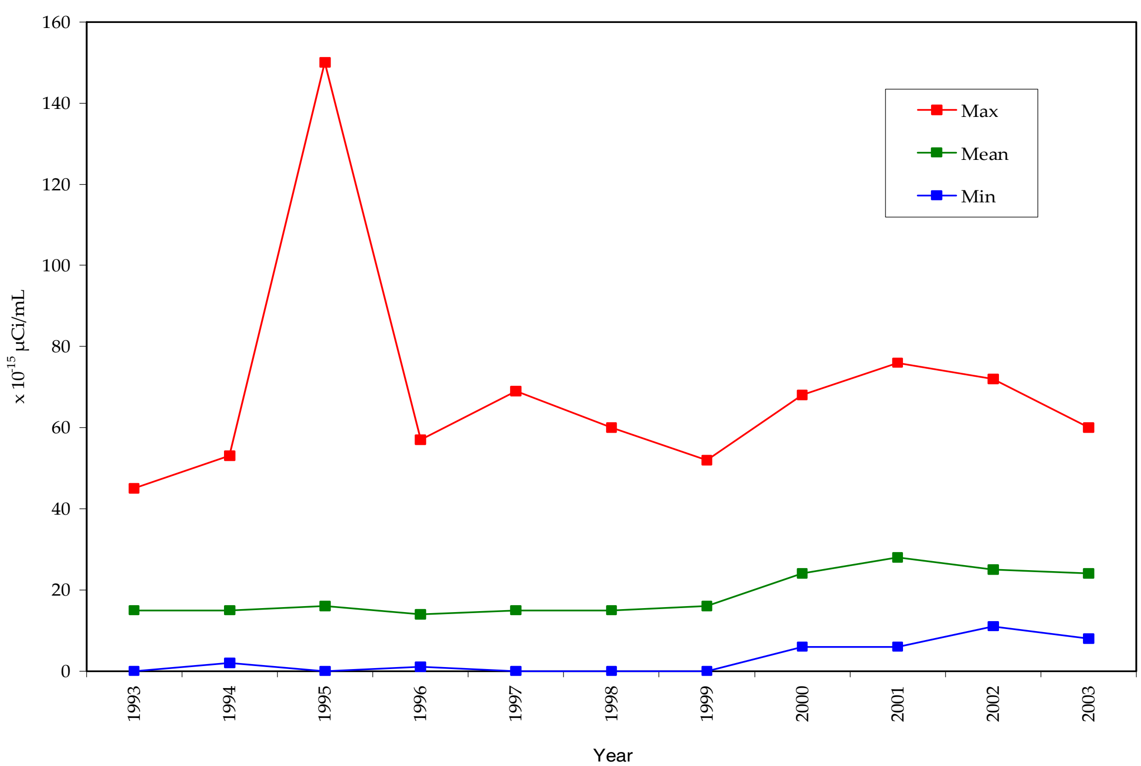

Figure 5-4. Historical trend for gross beta analysis for all CEMP stations

The overall gross alpha results show a generally increasing trend from 1993 to 2001 before trending downward the last two years. Likewise, the gross beta results show a similar trend beginning in 1998. These trends are also reflected by most of the stations on an individual basis. Although this trend merits further evaluation, it may likely be explained as being a result of persistent drought conditions throughout the southwest and Great Basin states. Drought in these regions has existed to varying degrees since 1996. These dry conditions could be directly responsible for an increase in suspended air particles collected by the air-sampling network. The apparent spikes in the maximum trend lines for gross alpha and beta are the result of a single analysis for that year. These analyses occurred prior to the CEMP being directed by DRI, so specific information is not available.

5.6.1.2 Gamma Spectroscopy Results

Gamma spectroscopy analysis was performed on all samples from the low-volume air-sampling network. The filters were combined by station on a quarterly basis after gross alpha/beta analysis. As in previous years, all samples were gamma spectrum negligible with respect to man-made radionuclides (i.e., gamma-emitting radionuclides were not detected). In most of the samples, naturally-occurring ^{7}Be was detected above the analytical MDC. This radionuclide is produced by cosmic ray interaction with nitrogen in the atmosphere. The mean annual activity for ^{7}Be for the sampling network was 70.3 $\pm$ 11.1 x 10^{-15} μCi/mL.

5.6.1.3 TLD Results

TLDs measure ionizing radiation from all sources, including natural radioactivity from cosmic or terrestrial sources and from man-made radioactive sources. The TLDs are mounted in a plexiglass holder approximately one meter above the ground, and are exchanged quarterly. TLD results are not presented for Warm Springs Summit because this new station was not installed until the last quarter of 2003. The total exposure for 2003 ranged from 87 mR (0.87 mSv) per year at Pahrump, Nevada, to 163 mR (1.63 mSv) at Twin Springs, Nevada, with a mean annual exposure of 120 mR (1.20 mSv) per year for all operating locations. Results are summarized in Table 5-3 and are consistent with previous years' data. Figure 5-5 shows the long-term trend for the CEMP stations as a whole.

Table 5-3. TLD monitoring results for CEMP offsite stations in 2003

Sampling Location	Number of Days	Daily Exposure (mR)			
		Maximum	Minimum	Mean	Total Annual Exposure (mR)
Alamo	366	0.3	0.21	0.28	103
Amargosa Valley	361	0.33	0.24	0.29	104
Beatty	364	0.44	0.42	0.43	157
Boulder City	369	0.32	0.27	0.30	110
Caliente	274	0.38	0.33	0.35	129
Cedar City	366	0.28	0.25	0.29	105
Delta	363	0.31	0.26	0.30	108
Ely	195	0.28	0.27	0.27	99
Garden Valley	365	0.4	0.36	0.38	138
Goldfield	365	0.35	0.32	0.34	124
Henderson	369	0.34	0.28	0.32	116
Indian Springs	272	0.3	0.26	0.28	103
Las Vegas	373	0.3	0.22	0.26	94
Medlin's Ranch	365	0.43	0.36	0.39	142
Milford	363	0.43	0.37	0.40	146
Nyala Ranch	365	0.33	0.3	0.31	114
Overton	369	0.27	0.24	0.26	95
Pahrump	361	0.26	0.22	0.24	87
Pioche	363	0.33	0.31	0.32	117
Rachel	366	0.4	0.37	0.38	140
Sarcobatus Flats	364	0.41	0.38	0.40	145
Stone Cabin Ranch	364	0.42	0.36	0.39	144
St. George	366	0.27	0.23	0.25	90
Tonopah	366	0.4	0.35	0.38	137
Twin Springs	365	0.48	0.41	0.38	163
Overall Annual Mean = 120 mR					

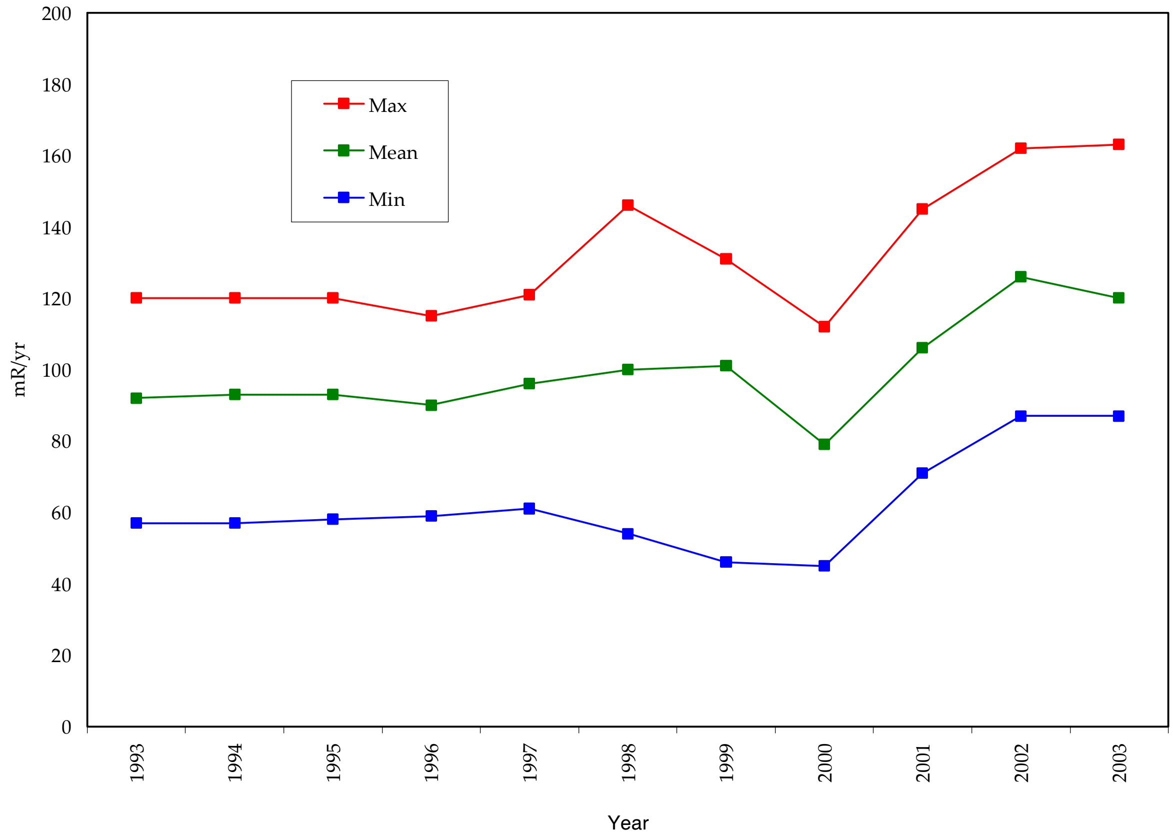

Figure 5-5. Historical Trend for TLD Analysis for All CEMP Stations

As with the gross alpha and beta results, the TLD data also shows a generally increasing trend from 1996 to 2002. This again may be consistent with drought conditions observed in the regions around the monitoring network. As the soil and underlying strata become drier due to lack of precipitation, the naturally-occurring radon may more easily escape into the atmosphere along with the increased suspended particle load. This could result in an increase in detectable natural radioactivity. As with the gross alpha and beta results, further evaluation is needed.

5.6.1.4 PIC Results

The PIC data presented in this section are based on daily averages of gamma exposure rates from each station. Table 5-4 contains the maximum, minimum, and standard deviation of daily averages for the periods during 2003 when telemetry data were available. It also shows the average gamma exposure rate for each station during the year, as well as the total mR/yr. The exposure rate ranged from 69.03 mR/yr (0.69 mSv) in Pahrump to 180.76 mR/yr (1.80 mSv) in Milford, Utah. Background levels of environmental gamma exposure rates in the United States (from combined effects of terrestrial and cosmic sources) vary between 49 and 247 mR/yr (BEIR III, 1980). Averages for selected regions of the United States were compiled by the EPA and are shown in Table 5-5. The annual exposure levels observed at the CEMP stations in 2003 are well within these United States background levels.

Table 5-4. PIC monitoring results for CEMP offsite stations in 2003

	Daily Average Gamma Exposure Rate (μR/hr)				Annual Exposure (mR/yr)
Sampling Location	**Maximum**	**Minimum**	**Mean**	**Standard Deviation**	
Alamo	13.37	12.02	12.70	0.17	111.21
Amargosa Valley	13.25	11.94	12.60	0.16	110.33
Beatty	19.08	16.56	17.82	0.55	156.10
Boulder City	15.29	14.07	14.68	0.16	128.60
Caliente	15.92	14.33	15.13	0.26	132.50
Cedar City	11.59	10.10	10.85	0.22	95.00
Delta	12.65	10.65	11.65	0.31	102.05
Ely[(a)]	13.73	10.66	12.20	0.32	106.83
Garden Valley	17.24	15.19	16.22	0.37	142.04
Goldfield	16.42	14.09	15.26	0.44	133.63
Henderson	16.02	14.59	15.31	0.27	134.07
Indian Springs	12.40	10.73	11.57	0.34	101.31
Las Vegas	10.04	8.83	9.43	0.18	82.64
Medlin's Ranch	17.68	15.48	16.58	0.39	145.24
Milford	23.26	18.01	20.64	0.93	180.76
Nyala Ranch	13.86	12.01	12.94	0.44	113.31
Overton	10.58	9.07	9.83	0.26	86.08
Pahrump	8.76	7.00	7.88	0.21	69.03
Pioche	19.03	13.66	16.35	0.62	143.18
Rachel	15.72	14.18	14.95	0.29	130.96
Sarcobatus Flats	18.84	16.71	17.78	0.26	155.71
Stone Cabin Ranch	18.32	16.10	17.21	0.50	150.76
St. George	10.21	8.70	9.45	0.28	82.81
Tonopah	17.24	15.07	16.16	0.30	141.52
Twin Springs	20.98	17.59	19.29	0.64	168.94
Warm Springs Summit[(b)]	20.08	18.62	19.35	0.38	169.51

(a) Ely station installed July 8, 2003.
(b) Warm Springs Summit station installed October 29, 2003.

Table 5-5. Average natural background radiation for selected U.S. cities (excluding radon)

City	Radiation (mR/yr)
Denver, CO	164.6
Tampa, FL	63.7
Portland, OR	86.7
Los Angeles, CA	73.6
St. Louis, MO	87.9
Rochester, NY	88.1
Wheeling, WV	111.9
Richmond, VA	64.1
New Orleans, LA	63.7
Fort Worth, TX	68.7

Source: <http://www.wrcc.dri.edu/cemp/Radiation.html.> "Radiation in Perspective," August 1990 (Access Date: 9/20/2004)

5.6.2 Environmental Impact

Results of analyses conducted on data obtained from the CEMP network of low-volume particulate air samplers, TLDs, and PICs showed no measurable evidence at CEMP station locations of offsite impact from radionuclides originating on the NTS. Activity observed in gross alpha and beta analyses of low-volume air sampler filters was consistent with previous years' results and are within the range of activity found in other communities of the United States which are not adjacent to man-made radiation sources. Also, no man-made gamma-emitting radionuclides were detected. Likewise, TLD and PIC results remained consistent with previous years' background levels and are well within average background levels observed in other parts of the United States (see Table 5-5).

Occasional elevated gamma readings (10–50 percent above normal average background) were always associated with precipitation events and/or low barometric pressure. Low barometric pressure can result in the release of naturally-occurring radon and its daughter products from the surrounding soil and rock substrates. Precipitation events can result in the "rainout" of globally-distributed radionuclides occurring as airborne particulates in the upper atmosphere. Figure 5-6, generated from the CEMP web site, illustrates an example of this phenomenon.

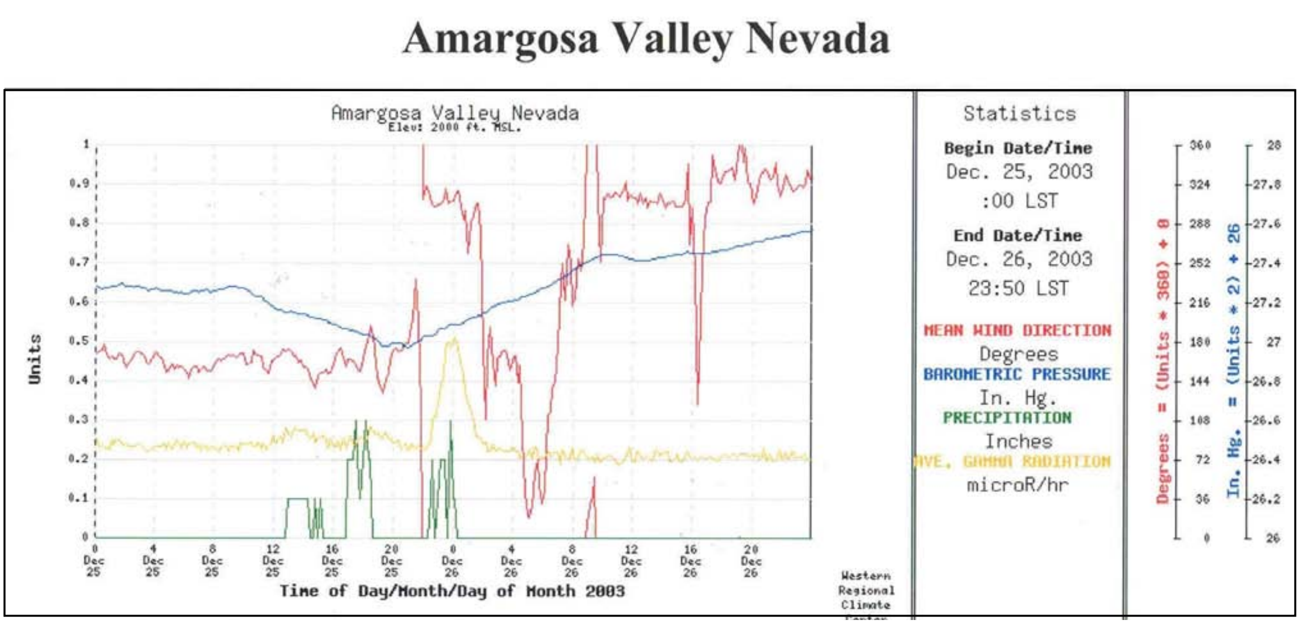

Figure 5-6. The effect of meteorological phenomena on background gamma readings

5.7 Offsite Surface and Groundwater Monitoring

The DRI was tasked by NNSA, during fiscal year 2003, to provide independent verification of the tritium activity within some of the offsite groundwater wells, municipal water supply systems, and springs used for water supplies in areas surrounding the NTS. Samples collected by DRI personnel provide, in some cases, a direct comparison to the results obtained by the RREMP presented in Section 3.1.

The sole analyte for this project was tritium. Tritium is one of the most abundant radionuclides generated by an underground nuclear test, and since it is a constituent of the water molecule itself, it is also one of the most mobile radionuclides.

5.7.1 Sample Locations and Methods

Four springs, 17 wells, and 3 water supply systems were sampled during the period of May 27 to June 25, 2003. Sample locations were selected based upon input from the CEMs and local ranch owners participating in the CEMP project. All wells were sampled utilizing downhole submersible pumps. Samples from water supply systems were collected via discharge from a faucet connected to that system. Springs were sampled by hand at the orifice, along surface drainage, or from the water supply system connected to the spring discharge. Each well was pumped a minimum of 5 to 15 minutes prior to sampling to purge water from the pump tubing and well annulus. This process ensured that the resultant sample was representative of local groundwater. Table 5-6 lists all of the sample points, their locations, the date they were sampled, and the sampling method. The locations of the sample points are also shown in Figure 5-7.

5.7.2 Procedures and Quality Assurance

DRI utilized several methods to ensure that radiological results reported herein conform to current quality assurance protocols (see Section 18.0 for a detailed description of the CEMP quality assurance program). This was achieved through the use of SOPs, field quality assurance samples, and laboratory quality assurance procedures. DRI's SOPs are detailed instructions that describe the method and materials, using step-by-step instructions, which are required to collect field water quality samples and protect the samples from tampering and environmental conditions that may alter their chemistry.

The second tier of quality assurance utilized on this project consisted of field quality assurance samples. The intent of these samples and procedures was to provide direct measures of the contribution of radioactive material that was derived from the bottles, sampling equipment, and the environment to the activity of tritium measured within the samples. Duplicate samples were collected to establish a measure of the repeatability of the analysis. Matrix spike duplicates were also collected to ensure no other parameters in the sample water were present that could cause erroneously high or low tritium values. Nine samples (37 percent of the sample load) were collected for the purposes of meeting field quality assurance requirements. Laboratory quality assurance controls consisted of the utilization of published laboratory techniques for the analysis of enriched tritium, method blanks, laboratory control samples, and laboratory duplicates. The laboratory quality assurance samples provide a measure of the accuracy and the confidence of the reported results.

Enriched tritium analyses were run on all water samples. The decision level (see Glossary, Appendix D) of tritium was 11pCi/L. This decision level is the result that must be exceeded before there is a 95 percent confidence that the sample contains radioactive material above background. The MDC (see Glossary, Appendix D) for tritium was 21 pCi/L. By comparison, Bechtel Nevada reports that the MDC for enriched tritium analyses for the RREMP water samples is approximately 20 pCi/L (see Section 3.1.2).

Table 5-6. CEMP water monitoring locations sampled in 2003

Monitoring Location Description	Latitude	Longitude	Date Sampled	Sample Collection Method
Adaven Springs	38 08.25	115 36.20	5/27/2003	By hand from stream discharging from spring orifice
Alamo city water supply system - source of water is municipal well field	37 21.74	115 10.15	6/3/2003	By hand from municiple water well
Amargosa Valley school well	36 34.17	116 27.65	6/24/2003	By hand at well head
Beatty Water and Sanitation - municipal well	36 54.94	116 45.65	6/4/2003	By hand at well head at utility headquarters
Boulder City – at Hemingway Park from municipal water distribution system	35 59.73	114 49.92	6/23/2003	By hand from a drinking fountain inside Hemingway Park
Caliente municipal water supply well	37 36.93	114 30.98	6/11/2003	By hand at well head
Cedar City municipal water supply well #7 located 10 mi west of town	37 39.40	113 13.14	6/10/2003	By hand at well head
Delta municipal well	39 21.59	112 34.69	6/11/2003	By hand at well head
Goldfield Municipal Water Supply well approximately 12 mi north of town	37 52.42	117 14.76	6/4/2003	By hand at well head
Henderson CCSN - source of water is municipal water system originating at Lake Mead	36 00.45	114 57.94	6/23/2003	By hand from faucet inside college building
Indian Springs municipal well	36 34.40	115 40.10	6/24/2003	By hand at well head
Las Vegas Valley Water District #103	36 13.56	115 15.08	6/25/2003	By hand at well head
Medlin's Ranch - spring located 11 miles west of ranch house	37 24.12	115 32.24	5/28/2003	By hand at kitchen faucet
Milford Municipal Well	38 22.97	113 01.18	6/10/2003	By hand at well head
Nyala Ranch Water Well	38 14.90	115 43.73	5/27/2003	By hand from front yard hose faucet at house
Overton water well located at Arrow Canyon ~ 10 mi west of town	36 44.07	114 44.87	6/25/2003	By hand at well head
Pahrump municipal well	36 11.46	115 58.25	6/24/2003	By hand at well head located near old Calvada Headquarters
Pioche municipal well located 1 mile east of town	37 56.97	114 25.76	6/11/2003	By hand at well head
Rachel - Little Ale Inn well	37 38.81	115 44.74	6/3/2003	By hand from bar faucet inside Lil Ale Inn Restaurant
Sarcobatus Flats well	37 16.78	117 01.91	6/4/2003	By hand at well head
St. George Gunlock Well Field Storage System	37 11.62	113 44.59	6/10/2003	By hand of composite well discharge entering storage system
Stone Cabin Ranch Spring	38 12.43	116 37.92	5/28/2003	By hand from kitchen faucet at ranch house
Tonopah Public Utilities well field located 10 miles from town	38 11.68	117 04.70	6/4/2003	By hand at well head
Twin Springs Ranch Spring	38 12.21	116 10.54	5/28/2003	By hand from front yard hose faucet at house

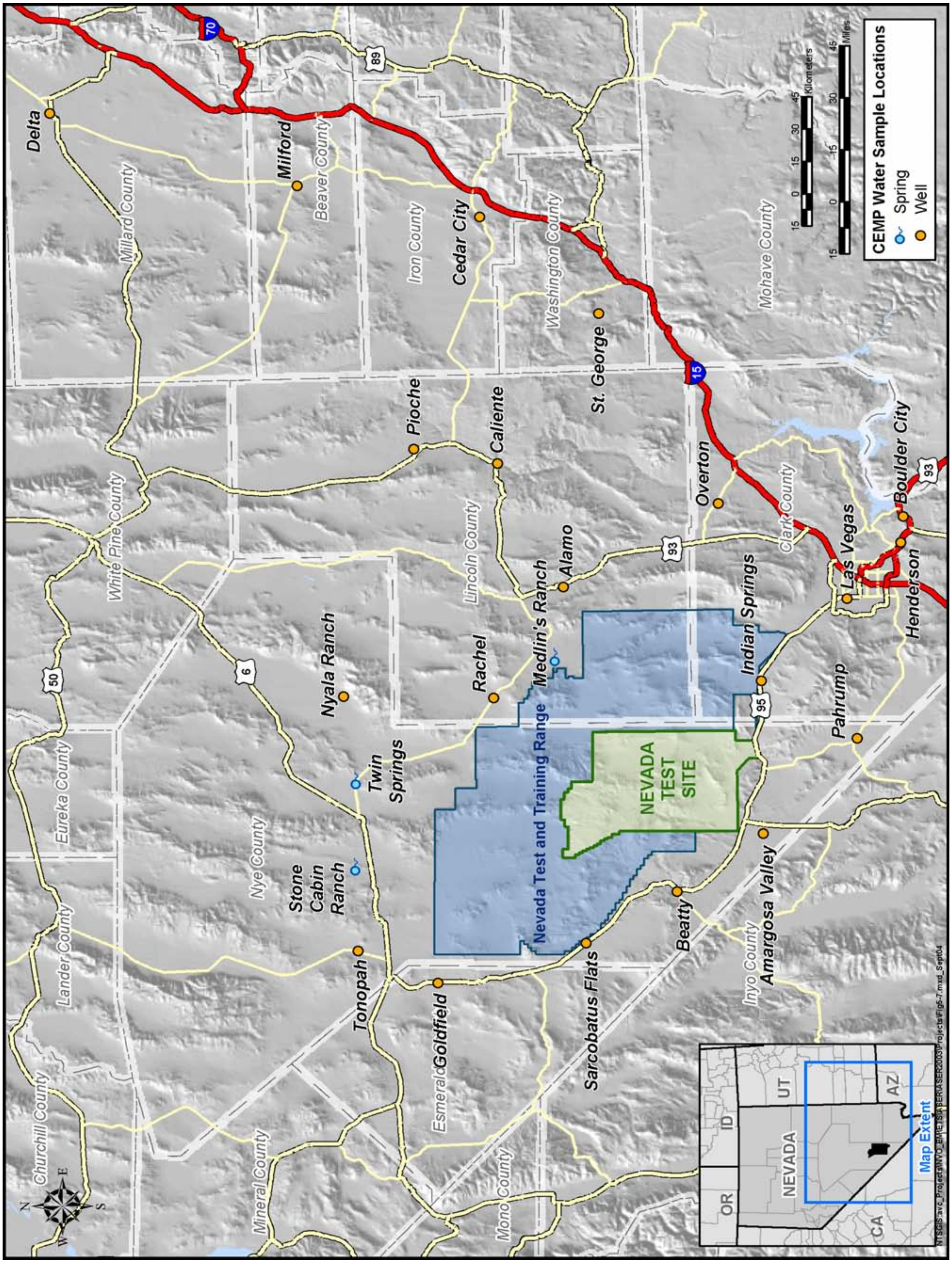

Figure 5-7. 2003 CEMP water monitoring locations

5.7.3 Results of Surface Water Monitoring from Springs

Measured tritium (3H) concentrations from the springs ranged from -1 to 16 pCi/L (Table 5-7). Three of the samples, Medlin's Ranch, Stone Cabin Ranch, and Twin Springs Ranch, yielded results that were indistinguishable from background (i.e., ≤ 11 pCi/L). The Adaven Springs sample result, at 16 ± 20 pCi/L, was statistically greater than background. All sample analyses were well below the safe drinking water limit of 20,000 pCi/L. Sample results for Adaven Springs, Medlin's Ranch, Stone Cabin Ranch, and Twin Springs Ranch were similar to results reported by DRI in the CY 2002 Annual Site Environmental Report (DOE, 2003c).

Table 5-7. Tritium analysis results for offsite surface water samples in 2003

Monitoring Location	**^{3}H ± Uncertainty[(a)] (pCi/L)**		
Adaven Springs	16	±	20
Medlin's Ranch - spring located 11 miles west of ranch house	9	±	22
Stone Cabin Ranch	3	±	24
Twin Springs Ranch	-1	±	14

(a) ± 2 standard deviations

5.7.4 Results of Groundwater Monitoring

The results for the 20 groundwater tritium analyses from the DRI Tritium Laboratory are presented in Table 5-8. The measured activities ranged from -9 to 35 pCi/L. All of the samples, with the exception of Henderson and Boulder City, yielded results that were statistically indistinguishable from background (≤11 pCi/L). Results from Henderson and Boulder City were statistically greater than background. The water in these samples originated from Lake Mead. Slightly elevated tritium activities in Lake Mead are well documented by previous investigations (DOE, 2002d; DOE, 2003c) and are due to residual tritium persisting in the environment that originated from global atmospheric nuclear testing. All sample analyses were well below the safe drinking water limit of 20,000 pCi/L. Trending of the data was not conducted due to the limited number of previously collected samples (two previous sets have been collected by DRI thus far). The only notable changes were at the Boulder City water treatment plant (from 27 ± 16 pCi/L in 2002 to 35 ± 28 pCi/L in 2003). The change in measured tritium activity at Boulder City is well within the range of uncertainty associated with the 2002 and 2003 analyses.

5.7.5 Environmental Impact

Results of the CEMP tritium analyses conducted on selected offsite groundwater wells and water supply systems surrounding the NTS showed no evidence of tritium migration offsite via groundwater. Most of the samples analyzed were below the decision level for tritium (11 pCi/L) (see Tables 5-7 and 5-8). The greatest observed activities, (27 pCi/L and 35 pCi/L from Henderson and Boulder City, respectively) were well below the safe drinking water standard of 20,000 pCi/L.

Table 5-8. CEMP water monitoring results for offsite wells in 2003

Monitoring Location	^3H ± Uncertainty[a] (pCi/L)
Alamo city	0 ± 26
Amargosa Valley	3 ± 14
Beatty	0 ± 18
Boulder City	35 ± 28
Caliente	5 ± 20
Cedar City	-4 ± 18
Delta	-1 ± 18
Goldfield	5 ± 16
Henderson	27 ± 20
Indian Springs	4 ± 22
Las Vegas	-2 ± 24
Milford	-2 ± 14
Nyala Ranch	-4 ± 18
Overton	2 ± 24
Pahrump	2 ± 22
Pioche	-1 ± 20
Rachel	-9 ± 16
Sarcobatus Flats	-7 ± 18
St. George	4 ± 16
Tonopah	4 ± 8

Green shaded results are considered detected (result greater than the MDC of 21 pCi/L)

(a) ± 2 standard deviations

6.0 Radiological Biota Monitoring

DOE Order 5400.5, "Radiation Protection of the Public and the Environment" requires that all U.S. Department of Energy (DOE) sites monitor radioactivity in the environment to ensure that the public does not receive a radiological dose greater than 100 mrem/yr from all pathways of exposure. The consumption, by members of the general public, of Nevada Test Site (NTS) game animals which may have elevated tissue concentrations of radionuclides is one of the pathways of radiation exposure which is assessed by Bechtel Nevada (BN) Environmental Technical Services (ETS) under the Routine Radiological Environmental Monitoring Plan (RREMP). Game animals and plants are sampled annually from known contaminated sites on the NTS to estimate hypothetical doses to hunters (i.e., the public) as well as to determine if NTS plants and animals themselves are exposed to radiation levels harmful to their populations. This section describes the biota monitoring program designed to meet all radiation protection regulations (see Section 1.3). It describes the methods, and results of field sampling and analyses in 2003.

6.1 Biota Monitoring Goals and Measures

Historical atmospheric nuclear weapons testing and outfalls from underground nuclear tests provide a source of radiation contamination and exposure to NTS plants and animals (biota). The primary objective of biota monitoring is to document that NTS operations do not cause a radiological dose to humans or biota which exceeds the limits prescribed by DOE. Specifically, samples of NTS plants and animals are collected and their tissues analyzed for the presence of radionuclides in order to:

- Determine if the potential dose to humans consuming game animals from the NTS is less than 100 mrem/yr (the limit prescribed by DOE Order 5400.5).
- Determine if the absorbed radiation dose to NTS terrestrial plants and aquatic animals is less than 1 rad/day, and if the absorbed radiation dose to NTS terrestrial animals is less than 0.1 rad/day (the limits prescribed by DOE Order 5400.5 and DOE Standard DOE-STD-1153-2002).

The following sections describe the basic design criteria for biota monitoring, the sampling and analysis methods, and the tissue analysis results for biota samples collected in 2003. The estimated dose, both to humans consuming game animals from the NTS, and to biota found in contaminated areas of the NTS are presented in Section 7.0.

6.2 Biota Monitoring Design

Current NTS land use precludes the harvest of plants or plant parts (e.g., pine nuts and wolf berries) for direct consumption by humans. Therefore, the ingestion of game animals is the primary potential biotic pathway for radionuclides from the NTS to the public. Game birds and game mammals that occur on the NTS are monitored because these mobile species may travel off the site and become available, through hunting, for consumption by the public. Monitoring of NTS vegetation is conducted to measure radionuclide uptake rates and the potential for radionuclide transfer through the food chain.

The RREMP (DOE, 2003b) specifies that the radionuclides to be monitored in NTS biota include tritium, ^{137}Cs, ^{241}Am, and $^{239+240}$Pu. During 2003, this was expanded to include ^{90}Sr and uranium to better characterize the sample locations. The study design for radiological monitoring of NTS biota is fully described in the RREMP. Below is a brief description of the species and sites selected for monitoring.

6.2.1 Species Selection

The goal for vegetation monitoring is to sample the most contaminated plants within the NTS environment. Contaminated plants are generally found inside demarcated radiological areas near the "ground zero" locations of historical above-ground nuclear tests. The plant species selected for sampling represent the most dominant plant life forms (e.g., trees, shrubs, herbs, or grasses) at these sites. Woody vegetation (i.e., shrubs versus forbs or grasses) is primarily selected for sampling because such vegetation is reported to have deeper penetrating roots and higher concentrations of tritium (Hunter and Kinnison, 1998). Additionally, this vegetation serves as a major source of browse for game animals that might eat such vegetation and potentially migrate offsite. Grasses and forbs are also sampled when present, however, because they are also a source of food for wildlife. Plant parts collected represent new growth over the past year.

Three criteria were used to determine which animal species to monitor. The first was that the species should have a relatively high probability of entering the human food chain. Second, the species should have a home range which overlaps a contaminated site and, as a result, have the potential for relatively high radionuclide body burdens from exposure to contaminated soil, air, water, or plants at the contaminated site. Thirdly, the selected species should be sufficiently abundant at a site to acquire an adequate tissue sample for laboratory analysis. These criteria limited the candidate game animals on the NTS to mourning doves (*Zenaida macroura*), chukar (*Alectoris chukar*), Gambel's quail (*Callipepla gambelii*), cottontail rabbits (*Sylvilagus audubonii*), and jackrabbits (*Lepus californicus*). Two species of large game animals also occur on the NTS: mule deer (*Odocoileus hemionus*) and pronghorn antelope (*Antilocapra americana*). Mule deer are known to move off of the mesas on the north end of the NTS in the winter into lower elevations on and off the NTS (Giles and Cooper, 1985). There is a possibility that pronghorn antelope may also leave the NTS and be available for hunting. Because of this, opportunistic sampling (e.g., sampling road-kills) of big game animals occurs.

Surface waters on the NTS consist of natural springs, containment ponds, and sewage lagoons. These contain aquatic animals, primarily invertebrates. Goldfish, golden shiners, and bluegills have been unofficially introduced into ponds associated with wells, and represent the only fish species known to occur on the NTS. There are also no native amphibians found on the NTS. Non-native bullfrogs occur in a few man-made ponds in Areas 3 and 6. There is no potential dose pathway directly from NTS aquatic animals to humans.

No aquatic invertebrates or non-native fish or amphibians were sampled for radionuclide tissue analyses. To assess dose to aquatic NTS organisms, a comparison of radionuclide concentrations in water and sediment to biota concentration guide values was performed. This assessment is presented in Section 7.2.

6.2.2 Site Selection

The monitoring design focuses on sampling those sites having the highest known concentrations of radionuclides in other media (e.g., soil and surface water) and sites that have relatively high densities of candidate game animals. Currently, five sites are selected for monitoring, and each site is sampled at least once every five years. These sites are E Tunnel Ponds, Palanquin, Sedan, T2, and Plutonium Valley (Figure 6-1). One control site is selected for each contaminated site which has similar biological and physical features. The control site is sampled to document radionuclide levels representative of background. Below is a brief description of the two sites monitored during 2003.

E Tunnel Ponds – The E Tunnel Ponds are located just southeast of Rainier Mesa in Area 12 in the northern part of the NTS at an elevation of 1,828 m (6,000 ft). Radionuclide contaminated water and soils occur at this site. The E Tunnel Ponds were constructed to collect and hold contaminated water (mainly from tritium) which drains out of E Tunnel where nuclear testing was conducted. The water is perched groundwater that has percolated through fractures in the tunnel system. Mourning doves occur at relatively high densities near these ponds. Camp 17 pond is the control site for E Tunnel Ponds, but this pond was not scheduled for sampling in 2003.

Palanquin – The Palanquin Crater site is located in Area 20 in the northwest portion of the NTS at an elevation of 1,890 m (6,200 ft). Palanquin was detonated on April 14, 1965 as part of the Plowshare project which tested the ability of nuclear weapons detonated below the surface to excavate large volumes of soil from the surface. The soils at the site are contaminated with fission products. A control area for the Palanquin Crater site is located about 6 km (3.7 mi) southeast of the crater in similar habitat (partially disturbed) in Area 20. Any one of the candidate game species is likely to be present at the crater and control sites.

6.3 Sampling Methods

During calendar year 2003, biota samples were successfully collected at all planned monitoring sites. Active sampling and trapping of biota took place July through August. Sample methods and the numbers and types of samples collected in 2003 are described below.

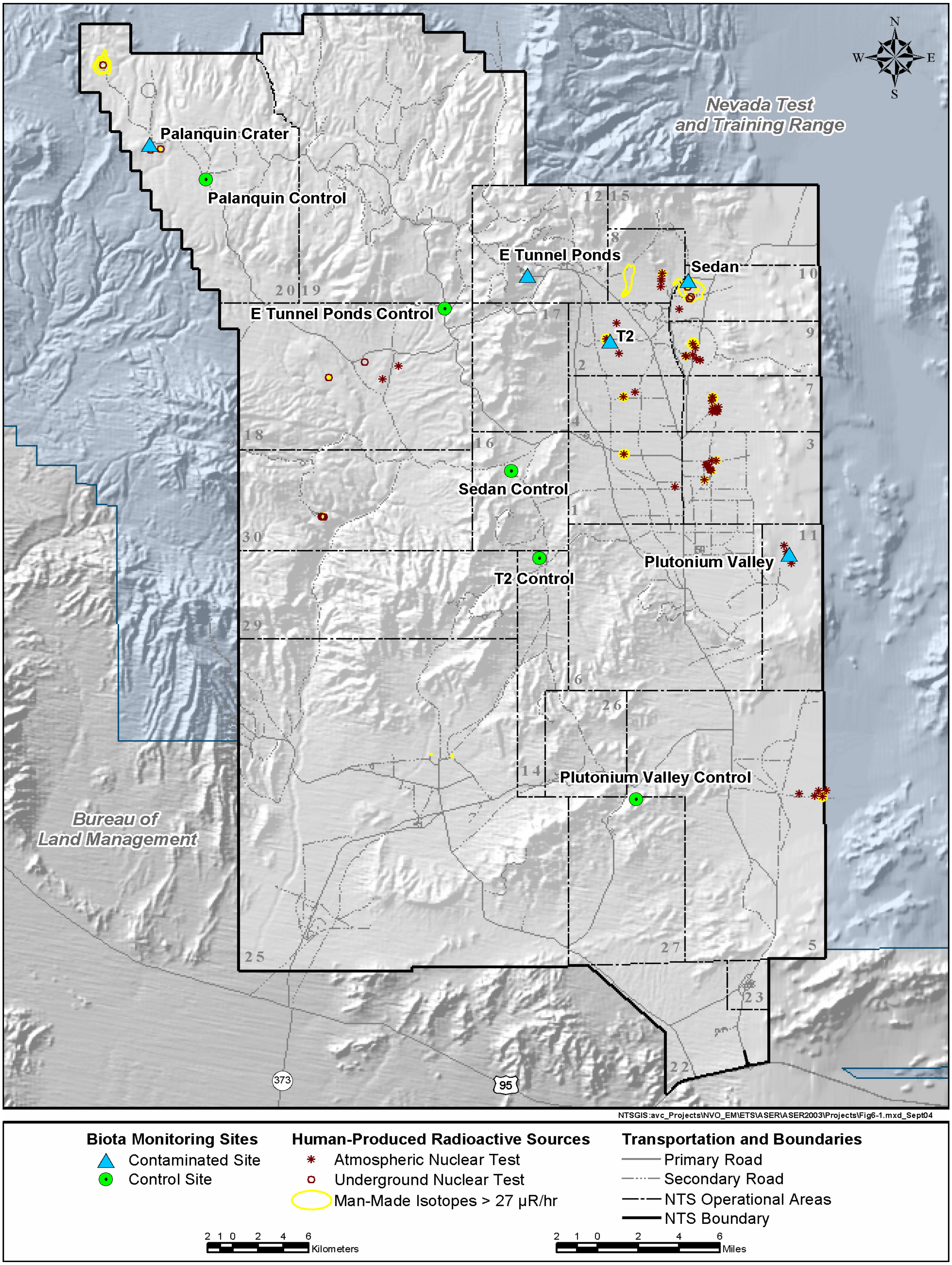

Figure 6-1. Radiological biota monitoring sites on the NTS

6.3.1 Plants

No plants were sampled at the E Tunnel site in 2003 because the data of interest was potential dose to humans consuming doves living near the E Tunnel Ponds. Vegetation was sampled at E Tunnel in 1999. Plant sampling at the Palanquin Crater and the Palanquin Control sites occurred on July 9, 2003. Photographs of these sites are shown in Figure 6-2 and Figure 6-3. Samples were taken of the dominant shrubs species, forbs, and grasses present at each site (Table 6-1).

At each site two samples, each consisting of about 300 to 500 grams (10.6 to 17.6 ounces) of fresh-weight plant material, were collected for each species sampled. A plant sample consisted of a composite of material from many plants of the same species in the area sampled. Only current year's growth was collected from each plant and consisted of new green leaves and stems. Green leaves and stems from shrubs and forbs were hand-plucked and stored in air-tight plastic bags. Rubber gloves were used by samplers and changed between each composite sample collected. Samples were labeled and stored in an ice chest. Within four hours of collection, the samples were delivered to the laboratory. Water was separated from plant samples by distillation for tritium analysis, and the dried plant tissues were submitted to a commercial laboratory to be analyzed for gamma-emitting radionuclides, ^{90}Sr, uranium, plutonium, and ^{241}Am.

Table 6-1. Plant species sampled at Palanquin Crater and Palanquin Control Site in 2003

Plant Common Name	Name Abbreviation[a]	Plant Scientific Name	Crater Site	Control Site
Basin big sagebrush	BBS	*Artemisia tridentata*	X	X
desert globemallow	DGM	*Sphaeralcea ambigua*	X	X
desert needlegrass	DNG	*Achnantherum speciosa*	X	X
four-wing saltbush	FWSB	*Atriplex canescens*	X	X
Mormon tea	MT	*Ephedra viridis*		X
Nevada jointfir	NJF	*Ephedra nevadensis*	X	
Rubber rabbitbrush	RRB	*Ericameria nauseosus*	X	X

(a) plant name abbreviation used in sample results table of this chapter (Table 6-2).

6.3.2 Animals

State and federal permits were secured to trap and analyze rabbits, Gambel's quail, chukar, and mourning doves during 2003 as well as to sample road-killed, large game animals. Animal trapping took place from July through August at the E Tunnel Ponds (Figure 6-4), Palanquin Crater, and Palanquin Control sites. Live-traps to collect game birds at the E Tunnel Ponds were run for four days. Live-traps for both game birds and rabbits were run at the Palanquin Crater and Control sites for 249 and 70 trap-nights, respectively. Opportunistic sampling of two pronghorn antelope road-kills (one male and one female) occurred in December on the Mercury Highway in south Frenchman Flat.

Three doves were trapped at all three sites sampled, and only one cottontail rabbit was trapped at the Palanquin Crater site. In the laboratory, each animal specimen was separated into two samples: a muscle tissue sample and a sample representing the whole body minus the portion of muscle. All samples were homogenized as much as possible using an industrial meat grinder and food processor. Water was distilled from the samples for tritium analysis and the dried tissue samples were submitted to a laboratory to be analyzed for gamma-emitting radionuclides, ^{90}Sr, uranium, plutonium, and ^{241}Am.

To document the general abundance of the candidate game species present during the collection period, three permanent 1-km (0.62-mi) transects were established in the vicinity of the Palanquin fenced radioactive material area to count jackrabbits, cottontail rabbits, mourning doves, chukar and Gambel's quail. The transects were walked one or two times on four dates between July 2 and September 11, 2003 for a total of six transects walked. No target species were observed on transects suggesting that these species were not abundant in this habitat during the summer, and that the risk of animal migration offsite and corresponding risk to humans from eating contaminated game was

Figure 6-2. Palanquin Crater biota sampling site

Figure 6-3. Palanquin Control biota sampling site

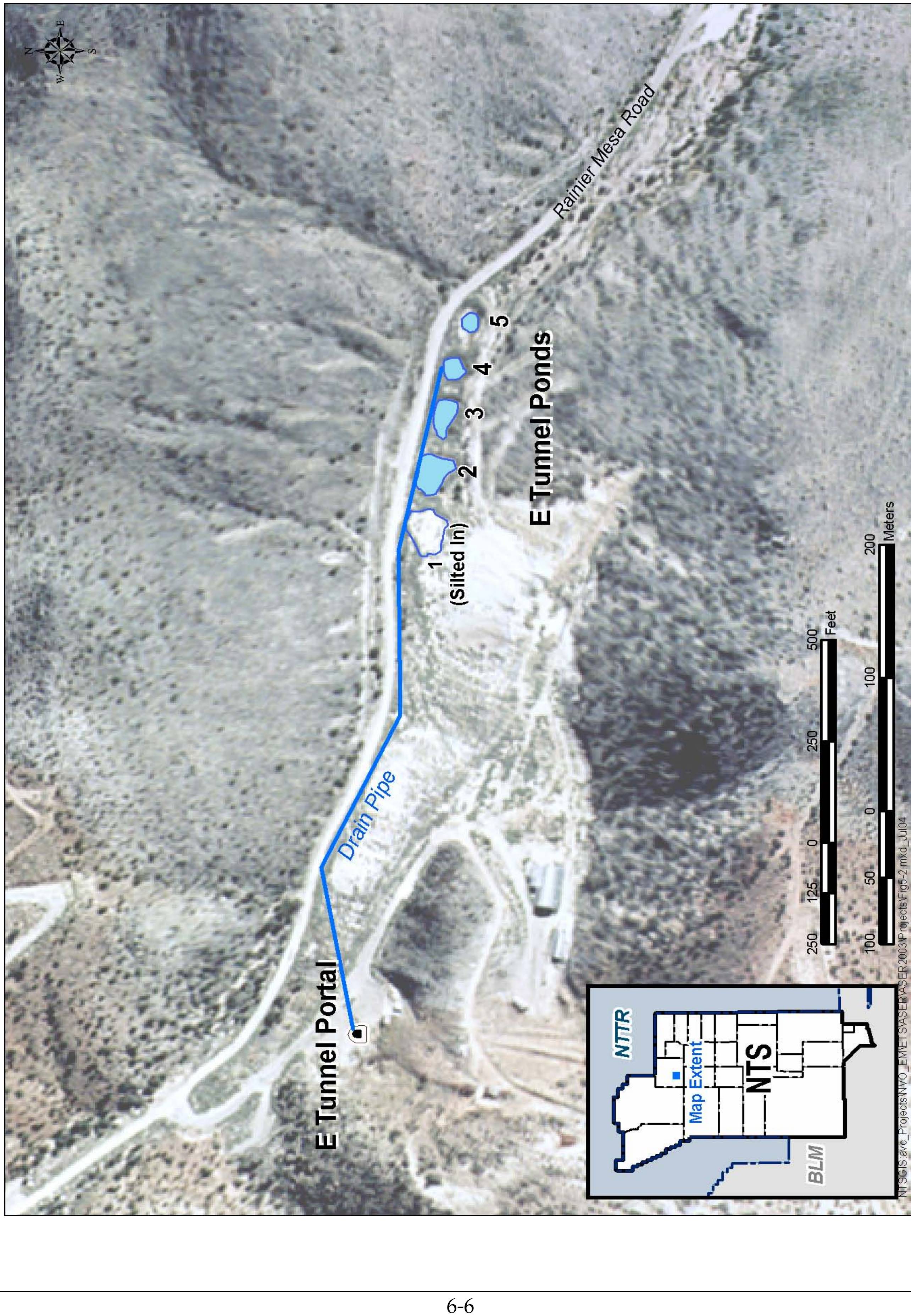

Figure 6-4. E Tunnel Ponds biota sampling site

very low. Mourning doves and a group of chukar, however, were detected by calls during trapping sessions, indicating that these species were present in the area in mid July through August. The number of target species recorded during 2003 were too low to calculate species density.

6.4 Results

6.4.1 Plants

Concentrations of man-made radionuclides detected in 2003 NTS plant samples are shown in Table 6-2. As expected, most all of the plant samples collected from the area adjacent to the Palanquin crater had detectable levels of radionuclides and those detectable concentrations were generally higher than those in plants taken from the control site 6 km (3.7 mi) away (Table 6-2). The exception to this was ^{137}Cs which was detected in a low percentage of samples from both locations. While two ^{137}Cs detections at Palanquin Control site were higher than the one ^{137}Cs detection at Palanquin Crater site, the detections occurred in only 17 and 8 percent of the samples from the two sites, respectively. Overall, the concentrations of ^{137}Cs in vegetation were not different between the two sites.

All uranium detected in plant samples was determined to be natural based on isotopic ratios of ^{234}U, ^{235}U, and ^{238}U. Tritium was not detected in any plant samples from the crater or control areas.

6.4.2 Animals

Concentrations of man-made radionuclides detected in 2003 NTS animal samples are listed in Table 6-3. All uranium detected in animal samples was determined to be natural based on isotopic ratios of ^{234}U, ^{235}U, and ^{238}U.

E Tunnel Doves – All three mourning doves collected near the E Tunnel Ponds contained elevated tritium concentrations ranging from 282,000 to 573,000 pCi/L (10,434 to 21,201 Bq/L). These elevated levels are similar to those reported in environmental reports over the past four years for E Tunnel doves, and are probably the result of doves drinking tritiated water from the ponds. In 2003, tritium concentrations in water from these ponds ranged from 528,000 to 885,000 pCi/L (19,536 to 32,745 Bq/L) (see Section 3.1.3.5, Tables 3-6 and 3-7). Other radionuclides were detected in the three doves from the E Tunnel area, albeit at low concentrations (Table 6-3).

Palanquin Crater and Control Doves – Only one of the three doves sampled at the Palanquin Crater site had a barely detectable concentration of tritium in the water distilled from the body portion of its tissue (portion without breast muscle tissue) (321 pCi/L or 11.9 Bq/L (sample specific minimum detectable concentration (MDC)=313 pCi/L or 11.6 Bq/L). In contrast, all three mourning doves sampled from the Palanquin Control site 6 km (3.7 mi) from the Palanquin crater contained detectable tritium; two of which were relatively high (Table 6-3). Mourning doves are highly mobile, but the presence of tritium in all doves sampled from the Palanquin Control site and the relatively high concentrations in two out of three of these sampled doves indicated that a tritium source existed close to the control site. The source appeared to be a containment pond (sump) for the Underground Test Area Project post-shot/cavity well U-20n PS#1DDH (see Figure 3-5) that is approximately 5 km (3.1 mi) southeast of the Palanquin Control site. This sump contained water with tritium at 42,000,000 pCi/L (1,554,000 Bq/L). At the time the control site was selected and sampled, this usually dry sump was not known to contain tritiated water.

Additional radionuclides detected in doves from the Palanquin Crater site were ^{90}Sr, ^{238}Pu, $^{239/240}$Pu, and ^{241}Am. One dove (#7) had all four of these in the whole body portion with the ^{238}Pu, $^{239/240}$Pu, and ^{241}Am being about two orders of magnitude higher than those detected in other animals sampled from this site. Because these radionuclides were not detected in the muscle portion of this dove, it is likely that the activity was associated with a relatively higher activity particle in the gut or on the external portion of the dove. One other dove from the crater site had low concentrations of $^{239/240}$Pu in both its muscle tissue and the rest of the body. The third dove from this location had low concentrations of $^{239/240}$Pu and ^{241}Am in its body sample (whole body minus breast muscle).

At the Palanquin Control site, ^{90}Sr was detected at low concentrations in the body sample of all three doves. Low concentrations of ^{137}Cs were also detected in muscle samples from two of the doves.

Palanquin Crater Cottontail – One cottontail rabbit was collected at the Palanquin Crater site. No man-made radionuclides were detected in its muscle tissue. However, low concentrations of tritium, ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239/240}$Pu, and ^{241}Am were detected in the body fraction excluding the muscle tissue.

Table 6-2. Radionuclide concentrations in NTS plants sampled in 2003

Sample	Radionuclide Concentrations ± Uncertainty[a]					
	^{3}H (pCi/L)[b]	^{90}Sr (pCi/g)[c]	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	$^{239/240}$Pu (pCi/g)	^{241}Am (pCi/g)
Palanquin Crater						
BBS #1	0 ± 214	0.35 ± 0.10	0.10 ± 0.09	0.0317 ± 0.0166	0.0808 ± 0.0206	0.0376 ± 0.0136
BBS #2	227 ± 215	0.39 ± 0.10	0.09 ± 0.04	0.0324 ± 0.0125	0.0657 ± 0.0176	0.0455 ± 0.0168
RRB #1	93.5 ± 201	0.13 ± 0.05	0.00 ± 0.08	0.0179 ± 0.0089	0.0324 ± 0.0124	0.0196 ± 0.0106
RRB #2	271 ± 203	0.09 ± 0.04	-0.04 ± 0.08	0.0139 ± 0.0091	0.0462 ± 0.0150	0.0112 ± 0.0092
DNG #1	182 ± 201	0.23 ± 0.09	0.08 ± 0.20	0.7240 ± 0.0910	1.1100 ± 0.1230	0.5110 ± 0.0646
DNG #2	90.3 ± 194	0.18 ± 0.07	0.01 ± 0.05	0.0848 ± 0.0208	0.2910 ± 0.0414	0.1240 ± 0.0250
FWS #1	29 ± 185	0.61 ± 0.17	0.01 ± 0.06	0.0190 ± 0.0088	0.0370 ± 0.0119	0.0202 ± 0.0085
FWS #2	123 ± 200	0.01 ± 0.04	0.01 ± 0.08	0.0572 ± 0.0174	0.1340 ± 0.0266	0.0505 ± 0.0173
DGM #1	90.7 ± 195	0.32 ± 0.10	0.03 ± 0.11	0.1440 ± 0.0265	0.3020 ± 0.0405	0.1240 ± 0.0264
DGM #2	30.5 ± 194	0.80 ± 0.18	0.05 ± 0.24	0.5720 ± 0.0601	1.3100 ± 0.1120	0.5700 ± 0.0711
NJF #1	-62.8 ± 195	0.34 ± 0.09	0.01 ± 0.03	0.0080 ± 0.0055	0.0208 ± 0.0102	0.0090 ± 0.0071
NJF #2	124 ± 201	0.44 ± 0.11	-0.01 ± 0.02	0.0103 ± 0.0098	0.0469 ± 0.0154	0.0210 ± 0.0094
Percent above MDC:	**0**	**92**	**8**	**92**	**100**	**83**
Palanquin Control						
BBS #1	-348 ± 181	0.11 ± 0.05	0.01 ± 0.03	0.0000 ± 0.0048	0.0020 ± 0.0061	0.0114 ± 0.0092
BBS #2	-417 ± 180	0.08 ± 0.05	0.00 ± 0.02	0.0010 ± 0.0044	-0.0020 ± 0.0048	0.0072 ± 0.0084
RRB #1	-185 ± 156	0.04 ± 0.04	-0.01 ± 0.03	0.0000 ± 0.0022	0.0000 ± 0.0031	0.0000 ± 0.0046
RRB #2	-217 ± 155	0.04 ± 0.04	-0.01 ± 0.08	-0.0001 ± 0.0071	0.0006 ± 0.0043	0.0015 ± 0.0048
DNG #1	-216 ± 155	0.08 ± 0.04	0.44 ± 0.61	0.0023 ± 0.0056	0.0175 ± 0.0105	0.0037 ± 0.0052
DNG #2	-154 ± 158	0.07 ± 0.05	0.41 ± 0.13	-0.0052 ± 0.0046	0.0093 ± 0.0074	0.0118 ± 0.0106
FWS #1	-458 ± 168	0.20 ± 0.07	0.03 ± 0.06	-0.0032 ± 0.0056	0.0053 ± 0.0076	0.0033 ± 0.0065
FWS #2	-469 ± 172	0.14 ± 0.07	0.00 ± 0.05	0.0025 ± 0.0080	0.0000 ± 0.0062	0.0046 ± 0.0085
DGM #1	-126 ± 163	0.06 ± 0.04	0.02 ± 0.07	0.0000 ± 0.0028	0.0051 ± 0.0060	0.0022 ± 0.0042
DGM #2	-181 ± 153	0.04 ± 0.04	1.34 ± 1.32	-0.0021 ± 0.0050	0.0011 ± 0.0074	0.0062 ± 0.0070
MT #1	-210 ± 150	0.20 ± 0.07	0.08 ± 0.13	0.0015 ± 0.0021	0.0076 ± 0.0063	0.0019 ± 0.0059
MT #2	-121 ± 157	0.20 ± 0.07	-0.04 ± 0.19	-0.0011 ± 0.0031	0.0000 ± 0.0081	0.0024 ± 0.0075
Percent above MDC:	**0**	**50**	**17**	**0**	**8**	**8**
Average MDC:	**359**	**0.29**	**0.31**	**0.0110**	**0.0136**	**0.0111**

Green shaded results are considered detected (result greater than the sample specific MDC)

(a) ± 2 standard deviations

(b) Concentration of ^{3}H in water distilled from the sample

(c) Concentrations are per gram dry weight of sample

Table 6-3. Radionuclide concentrations in NTS animals sampled in 2003

Sample	Radionuclide Concentrations ± Uncertainty[a]					
	^{3}H (pCi/L)[b]	^{90}Sr (pCi/g)[c]	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	$^{239/240}$Pu (pCi/g)	^{241}Am (pCi/g)
E Tunnel Ponds – Animals						
Dove #4 (breast)	282,000 ± 5,620	0.06 ± 0.06	0.17 ± 0.31	0.0013 ± 0.0025	-0.0064 ± 0.0083	0.0014 ± 0.0046
Dove #4 (body fraction)	275,000 ± 5,510	0.06 ± 0.04	0.22 ± 0.28	0.0012 ± 0.0062	0.0095 ± 0.0088	0.0114 ± 0.0105
Dove #5 (breast)	560,000 ± 11,000	0.02 ± 0.04	0.21 ± 0.23	0.0000 ± 0.0039	0.0056 ± 0.0067	-0.0016 ± 0.0069
Dove #5 (body fraction)	567,000 ± 11,100	0.05 ± 0.10	0.54 ± 0.48	0.0152 ± 0.0078	0.1340 ± 0.0258	0.0379 ± 0.0134
Dove #9 (breast)	573,000 ± 11,200	0.03 ± 0.12	0.59 ± 0.39	0.0054 ± 0.0064	0.0054 ± 0.0083	0.0041 ± 0.0081
Dove #9 (body fraction)	540,000 ± 10,500	0.22 ± 0.09	0.00 ± 0.35	0.0013 ± 0.0043	0.0265 ± 0.0167	0.0104 ± 0.0076
Palanquin Crater – Animals						
Dove #6 (breast)	29.8 ± 232	0.04 ± 0.07	-0.14 ± 0.27	-0.0047 ± 0.0065	0.0082 ± 0.0100	0.0129 ± 0.0081
Dove #6 (body fraction)	321 ± 196	0.04 ± 0.03	0.05 ± 0.22	0.0135 ± 0.0129	0.0269 ± 0.0122	0.0062 ± 0.0054
Dove #7 (breast)	94.1 ± 194	0.70 ± 0.61	0.44 ± 0.62	0.0013 ± 0.0025	0.0025 ± 0.0120	0.0052 ± 0.0063
Dove #7 (body fraction)	249 ± 204	0.33 ± 0.12	0.50 ± 0.50	1.8300 ± 0.1530	22.1000 ± 1.5400	9.2900 ± 0.8600
Dove #8 (breast)	186 ± 199	0.58 ± 0.44	0.08 ± 1.67	-0.0014 ± 0.0039	0.0263 ± 0.0132	0.0056 ± 0.0067
Dove #8 (body fraction)	324 ± 216	0.10 ± 0.16	0.14 ± 0.35	0.0027 ± 0.0065	0.0135 ± 0.0099	0.0079 ± 0.0082
Desert cottontail (muscle)	332 ± 231	0.21 ± 0.19	0.07 ± 0.11	0.0000 ± 0.0042	0.0000 ± 0.0072	0.0043 ± 0.0060
Desert cottontail (body fraction)	839 ± 232	0.76 ± 0.18	0.76 ± 0.29	0.0229 ± 0.0116	0.1220 ± 0.0270	0.0248 ± 0.0136
Palanquin Control – Animals						
Dove #1 (breast)	159 ± 254	3.82 ± 4.02	0.18 ± 0.27	0.0017 ± 0.0040	0.0050 ± 0.0052	0.0097 ± 0.0115
Dove #1 (body fraction)	626 ± 275	0.08 ± 0.04	-0.02 ± 0.20	-0.0034 ± 0.0087	0.0068 ± 0.0095	0.0080 ± 0.0096
Dove #2 (breast)	14,800,000 ± 291,000	-0.15 ± 0.61	0.47 ± 0.31	0.0000 ± 0.0035	0.0106 ± 0.0120	0.0072 ± 0.0085
Dove #2 (body fraction)	12,600,000 ± 251,000	0.06 ± 0.04	0.22 ± 0.91	0.0034 ± 0.0038	0.0134 ± 0.0108	0.0041 ± 0.0071
Dove #3 (breast)	17,500,000 ± 338,000	No Data	0.98 ± 0.35	-0.0013 ± 0.0056	0.0038 ± 0.0103	-0.0013 ± 0.0057
Dove #3 (body fraction)	16,800,000 ± 325,000	0.11 ± 0.04	0.25 ± 0.64	-0.0022 ± 0.0044	0.0056 ± 0.0105	0.0022 ± 0.0043
Area 5 Roadkill						
Pronghorn #1 (hind quarter muscle)	8 198	0.00 0.04	-0.09 0.10	-0.0017 0.0076	0.0017 0.0042	0.0033 0.0059
Pronghorn #2 (hind quarter muscle)	8 195	0.10 0.05	0.02 0.07	-0.0013 0.0036	-0.0034 0.0053	0.0038 0.0055
Average MDC :	**359**	**0.29**	**0.31**	**0.0110**	**0.0136**	**0.0111**

Green shaded results are considered detected (result greater than the sample specific MDC)

(a) ± 2 standard deviations

(b) Concentration of ^{3}H in water distilled from the sample

(c) Concentrations are per gram dry weight of the sample

Frenchman Flat Pronghorn Antelope – Muscle tissue from one of the two pronghorn antelope killed by a vehicle in Area 5, south Frenchman Flat, contained a detectable amount of ^{90}Sr just above the sample-specific MDC for this radionuclide. No other radionuclides were detected in the pronghorn antelope muscle samples.

6.5 Environmental Impact

As expected, radionuclides were detected in biota sampled near the Palanquin Crater and E Tunnel Ponds. These were locations associated with historic testing of nuclear weapons. Elevated levels of tritium were also found in two of three doves sampled from the Palanquin Control location and is believed to be from uptake of water pumped during 2003 from a post-shot well located about 5 km (3 mi) southeast of the control location. While these radionuclides were detected, they pose negligible risk to humans as the potential dose to a person hunting and consuming these animals was well below dose limits (≤ 0.3 percent of dose limits) to members of the public (see Section 7.2). Also, radionuclide concentrations were below levels considered harmful to the health of the plants or animals as the dose resulting from observed concentrations were less than 10 percent of dose limits set to protect populations of plants and animals (see Section 7.2).

7.0 Radiological Dose Assessment

DOE Order 450.1, "Environmental Protection Program" and DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (see Section 1.3) require U.S. Department of Energy (DOE) facilities to estimate the radiological dose to the general public and to plants and animals in the environment caused by past or present facility operations. This chapter uses data gathered in 2003 and radiation surveys in the past that inventoried the radionuclide content of Nevada Test Site (NTS) surface soils to estimate these radiological doses with the aid of mathematical models. The data used are presented in Chapters 2 through 6 of this environmental report and include the 2003 results for onsite compliance monitoring of air, water, and biota, and the offsite monitoring results of air and water conducted by the Desert Research Institute (DRI) under the Community Environmental Monitoring Program (CEMP). Estimated doses calculated and presented in this chapter must fall below the limits established by DOE in order to demonstrate that the general public and the environment are not exposed to hazardous levels of radioactivity from the NTS.

7.1 Radiological Dose to the Public

7.1.1 Goals and Compliance Measures

The goals for the dose assessment component of radiological monitoring are to show that:

- The maximum radiation dose to a member of the general public from airborne radionuclide emissions at the NTS did not exceed the standard of 10 mrem/yr as specified by 40 CFR Part 61, Subpart H.
- The total radiation dose that a member of the general public could receive from the NTS by all possible pathways (direct exposure, inhalation, ingestion of water and food) is less than the limit of 100 mrem/yr as established by DOE Order 5400.5.
- The radiation doses received by onsite biota are less than 1 rad/d (0.01 Gy/d) to aquatic animals and terrestrial plants, and less than 0.1 rad/d (1 mGy/d) to terrestrial animals, as specified in DOE-STD-1153-2002.

The compliance measures which are calculated in order to accomplish these goals are listed below. Their definitions and the methods by which they are obtained are described in the following subsection.

- Committed effective dose equivalent (CEDE) (see Glossary, Appendix D) for an offsite maximally exposed individual (MEI) from air emissions, in mrem/yr (or mSv/yr).
- CEDE for an offsite MEI from all pathways, in mrem/yr (or mSv/yr).
- Absorbed dose to onsite plants and animals, in rad/d.

7.1.2 Methods

Several steps are taken to compute radiological dose to the public from all pathways. Many sources of information and mathematical models are used. This section briefly describes these steps, identifies how field monitoring data interface with other NTS data sources (e.g., radionuclide inventory data, climatological data) to provide input to the mathematical models, identifies the mathematical models, and presents the results of each step.

7.1.2.1 Determining Human Exposure Pathways

As prescribed in the Routine Radiological Environmental Monitoring Plan (RREMP) (DOE, 2003b), Bechtel Nevada (BN) routinely samples air, groundwater, and biota to document the amount of radioactivity in these media and to provide data that can be used to assess the radiation dose received by the general public.

The pathways by which a member of the general public can receive a radiation dose resulting from past or present NTS operations include:

- Exposure of the body to direct radiation in the environment resulting from radionuclides being transported off the NTS by winds and deposited on the ground offsite.
- Inhalation of airborne radionuclide emissions transported offsite by wind.
- Ingestion of meat from migratory wild game animals which drink from surface waters and eat vegetation containing NTS-related radioactivity.
- Ingestion of water from underground aquifers containing radionuclides which have migrated from the sites of past underground nuclear tests.

Since the migration of radioactivity in groundwater has not been detected in the past or in 2003 (see Section 3.1), exposure through ingestion of water was not considered in the 2003 calculated dose to public. Air and biota monitoring results indicated there was a potential for offsite residents to receive a radiation dose from past or current activities on the NTS from the first three pathways.

7.1.2.2 Identifying Onsite Sources and Radionuclide Air Emission Rates

An atmospheric diffusion model called Clean Air Package 1988 (CAP88-PC) (Version 2.0) is used, according to Title 40 CFR, Part 61, Subpart H, for calculating the radiation CEDEs received by hypothetical offsite receptors from airborne emissions. To use this model, certain factors must be identified and quantified. Two of these factors include: (1) location of all potential sources of radioactive air emissions on the NTS, and (2) quantity of radionuclides released from these locations, in Ci/yr. These sources for calendar year (CY) 2003 were:

- Release of tritium during the calibration of equipment at Building CP-50.
- The re-suspension of surface soil contaminated by past nuclear testing at NTS.
- The evaporation of tritiated water discharged from post-shot wells and E Tunnel.
- The evaporation and transpiration of tritiated water from soil and vegetation, respectively at sites of past nuclear tests and from the Area 5 RWMC.

Table 7-1 presents the names of those locations which were potential sources of radioactive emissions in 2003. The radionuclide emission rates (in Ci/yr) at each site are also presented. Brief descriptions of the methods used for estimating these quantities are given in the table footnotes. More detailed descriptions of the methods and emission sources are reported in Grossman, 2004. Note that in the last row of the table, the total amounts of ^{241}Am and $^{239+240}Pu$ emissions from soil re-suspension are presented. They are the sum of emission rates computed (see footnote [d]) for each area of the NTS with surface contamination (Areas 1-11, 12, 13, 15, 16, 17, 18, 19, 20, and 30). Other radionuclides (^{60}Cs, ^{90}Sr, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, and ^{238}Pu), although found in surface soils by past radiation surveys, were not included because combined, they contributed only ten percent or less to the total dose of the MEI.

7.1.2.3 Calculating Dose to Humans from NTS Air Emissions

The radiation doses to offsite residents from airborne NTS emissions are estimated with the CAP88-PC software, Version 2.0. The following variables are entered into the software for each point/grouped source:

- Distance and appropriate compass sector for each populated location within 80 km (50 mi) of each emission source.
- The calculated annual radionuclide emission rates (Table 7-1).
- The estimated annual emission rates for each of the NTS areas with surface contamination (Areas 1-11, 12, 13, 15, 16, 17, 18, 19, 20, and 30) (shown summed for "Grouped NTS Areas" in Table 7-1).
- Wind data collected in 2003 from meteorological data acquisition stations (see Section 15.0) such as wind direction, frequency, and stability classification.

Table 7-1. Radiological atmospheric releases from NTS for CY 2003 used in theCAP88-PC model

Source	Radionuclide	Quantity (Ci)
Area 6 Building CP-50	^{3}H	0.00019[(a)]
Area 12 E Tunnel Ponds	^{3}H	13[(b)]
Well RNM#2S	^{3}H	36[(b)]
Well U-4u PS #2A	^{3}H	0.73[(b)]
Well U-19q PS #1D	^{3}H	0.47[(b)]
Well U-20n PS @1DDH	^{3}H	4.2[(b)]
Area 5 RWMS	^{3}H	5.9[(c)]
Area 10 Sedan	^{3}H	64[(c)]
Area 20 Schooner	^{3}H	190[(c)]
All Sources Total	^{3}H	314
Grouped NTS Areas Total	^{241}Am	0.047[(d)]
Grouped NTS Areas Total	$^{239+240}Pu$	0.29[(d)]

(a) Quantity of tritium gas released during the calibration of laboratory equipment.

(b) Estimated from tritium concentration in water discharged into containment ponds or open tanks, assuming all water was completely evaporated during the year.

(c) Estimated from calculations with CAP88-PC software and annual mean concentration of tritium in air measured by air sampling at a location near the emission source.

(d) Calculated from inventory of radionuclides in surface soil determined by Radionuclide Inventory and Distribution Program (DOE, 1991), a re-suspension model (NRC, 1983), and equation parameters derived at the NTS (DOE, 1992).

- A rural food source scenario (versus an urban scenario), which conservatively assumes that all food at the populated areas around the NTS was either home-produced or obtained from within the 80-km radius assessment area. The CAP88-PC software applies factors to estimate the deposition of airborne radionuclides onto crops and soil, their uptake into crops, and their transfer to milk and meat.

The variables referenced above were entered into the CAP88-PC model, and the CEDEs for an individual living within each populated area was computed for each emission source location on the NTS. The calculated CEDEs for each offsite populated area from each NTS source location were then summed to determine the annual total CEDEs at each offsite population area within 80 km of the emission sources.

Based on these calculations for CY 2003, the location of the MEI (the hypothetical individual receiving the highest offsite dose) was Cactus Springs, Nevada, where the CEDE was 0.10 mrem/yr (0.001 mSv/yr) (Figure 7-1). This dose is well below (1.0 percent of) the National Emission Standards for Hazardous Air Pollutant limit of 10 mrem/yr (0.1 mSv/yr) and is consistent with the estimates computed for past years (1996 to the present) (Figure 7-2).

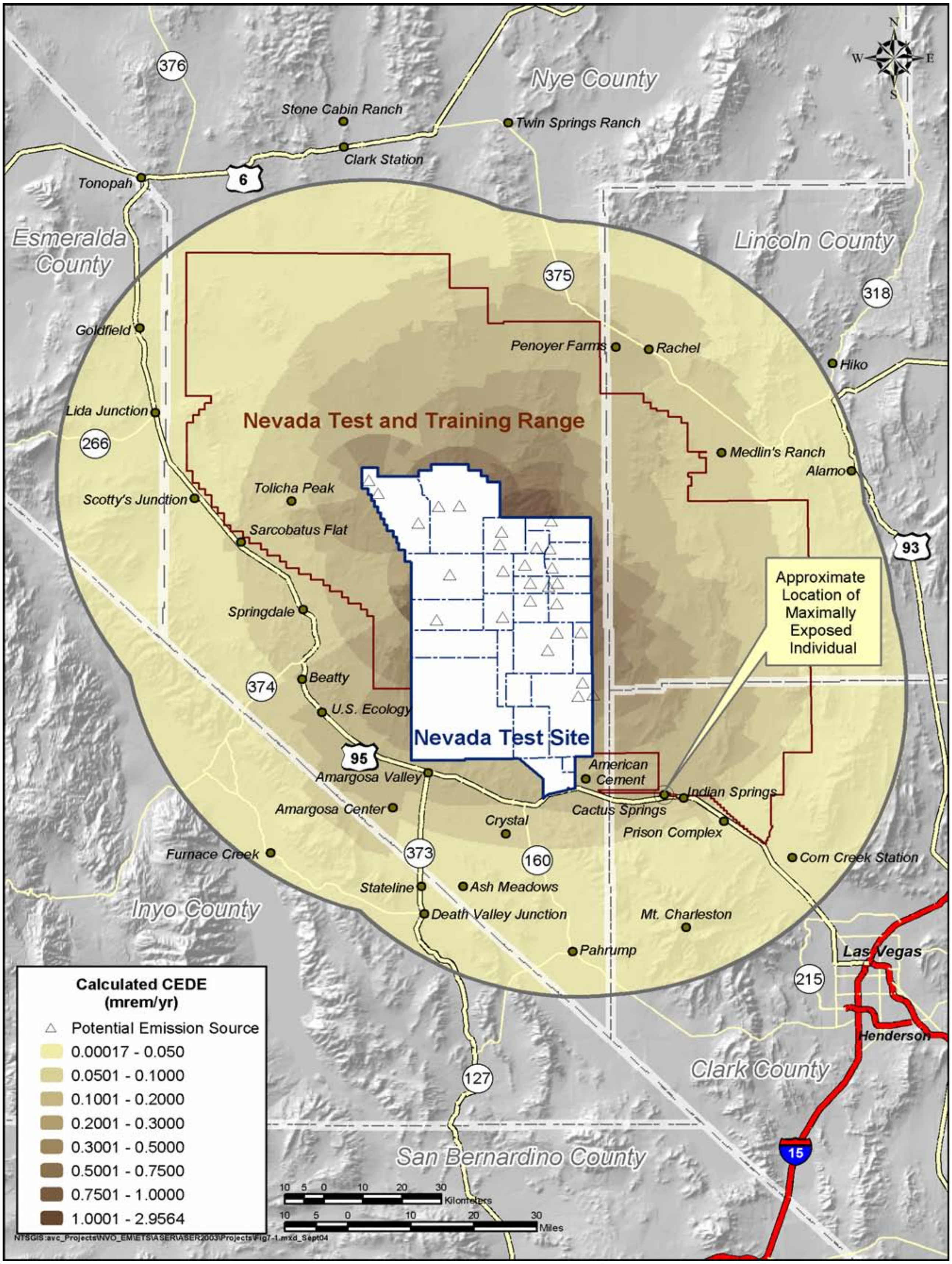

Figure 7-1. Map of the NTS showing annual CEDEs within 80 km of emission sources

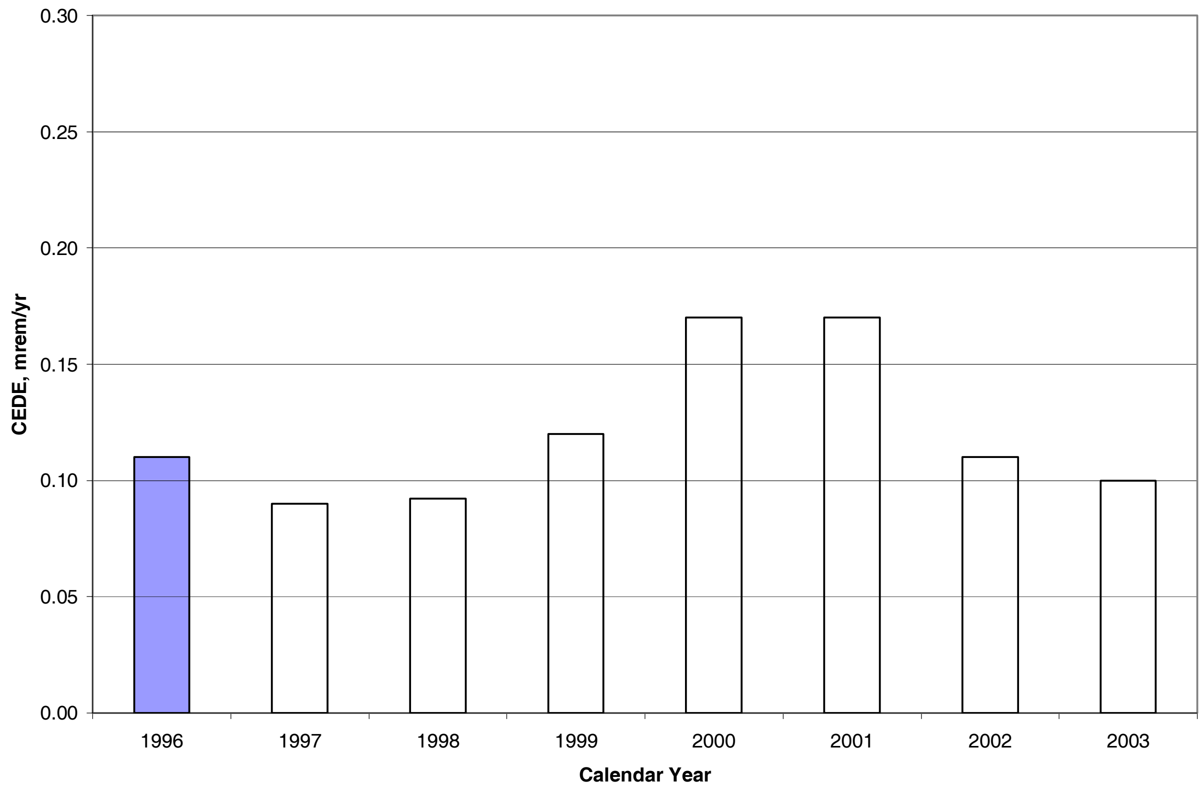

Figure 7-2. Radiation dose to MEI offsite who is not consuming game animals from the NTS

7.1.2.4 Calculating Dose to Humans from Ingestion of Wild Game from the NTS

Though there is little data suggesting that NTS small game animals travel offsite and become available to hunters, they are sampled on the NTS near contaminated areas as a conservative (worst case) estimate of the levels of radionuclides that hunters may consume if game animals did leave the NTS and were harvested. Radiation doses from the ingestion of game animals presented here are calculated from measurements of the radionuclide concentrations in game animals trapped in 2003 near sites where the soil, vegetation, and/or water sources are known to be contaminated with radioactivity from past nuclear tests (see Section 6.0).

The average concentrations of man-made radionuclides in the muscle tissue of mourning doves and pronghorn antelope sampled in 2003 from the NTS are shown in Table 7-2. Although a cottontail rabbit was sampled in 2003, no detectable levels of radionuclides were found in its muscle tissue (see Section 6.0). The following assumptions were made for calculating the dose to an individual eating game animals from the NTS:

- One individual consumed 20 doves and one antelope over the year. These numbers are based upon the current possession limit set for these species by the Nevada Division of Wildlife.
- Each game animal that an individual consumed contained the average concentration of radionuclides detected in muscle tissue for that species sampled.
- The amount of dove meat an individual consumed per animal was the average weight of the dove breast muscle samples.
- The amount of pronghorn meat consumed was 10 kg, which is within the range measured by Field, et al., 2003.
- The moisture content of game meat consumed was equivalent to the measured moisture content of the muscle tissue samples (Table 7-2).
- The CEDE was calculated using dose conversion factors (DOE, 1988) multiplied by the total activity estimated to be consumed for each of the detected radionuclides. The resultant potential doses from consuming mourning doves and pronghorn are shown in Table 7-2.

Table 7-2. Hypothetical dose to a human consuming mourning doves or pronghorn antelope from the NTS

Animal Sampled	Wet Weight of Consumed Muscle (g)	% by Weight of Water	Detected Radionuclides	Average Radionuclide Concentration		Dose Conversion Factors (mrem/pCi Consumed) [(a)]		CEDE (mrem)
E Tunnel Ponds								
Mourning dove	588[(b)]	74	^{3}H	472,000	pCi/L	0.000000063		0.013
			^{137}Cs	0.32	pCi/g (dry)	0.00005		0.002
							Total:	**0.015**
Palanquin								
Mourning dove	588[(b)]	74	$^{239/240}Pu$	0.012	pCi/g (dry)	0.0043		0.008
			^{241}Am	0.0079	pCi/g (dry)	0.0045		0.005
							Total:	**0.013**
Palanquin Control								
Mourning dove	588[(b)]	74	^{3}H	10,800,000	pCi/L	0.000000063		0.294
			^{137}Cs	0.54	pCi/g (dry)	0.00005		0.005
							Total:	**0.299**
Area 5 Road kill								
Pronghorn	10000[(c)]	73	^{90}Sr	0.19	pCi/g (dry)	0.00013		0.064
							Total:	**0.064**

(a) Dose conversion factors for human ingestion from DOE (1988)
(b) Assumed breast meat from 20 mourning doves were consumed and each breast weighed 29.4 g
(c) Assumed one pronghorn antelope was consumed and pronghorn muscle weight was 10 kg (Field, et al., 2003)

The highest of these committed doses (0.30 mrem/yr [0.003 mSv/yr]) is only about 0.3 percent of the annual dose limit for members of the public. To put this potential dose received from NTS game animals in perspective, the dose from naturally-occurring cosmic radiation generally increases approximately 0.5 mrem/yr for every 100 feet higher in altitude a person lives. A 0.3 mrem dose can be thought of as the increase in dose from natural radiation received by merely increasing the elevation at which one lives by about 60 feet.

7.1.3 Results

This section presents the calculation of radiological dose to the general public from all pathways of exposure that are possible for individuals residing near the NTS.

7.1.3.1 Total Offsite Dose to the Maximally Exposed Individual (MEI)

As mentioned in Section 7.1.2.3 above, the location of the MEI was Cactus Springs, Nevada, where the CEDE was 0.10 mrem/yr (0.001 mSv/yr) based on the CAPP88-PC model. This CEDE estimate for CY 2003 is consistent with the estimates from 1996 to the present (see Figure 7-2).

If the MEI at Cactus Springs was also a hunter harvesting and ingesting the Palanquin Control site mourning doves and the pronghorn mentioned in Section 7.1.2.4, the person would receive an estimated additional 0.36 mrem/yr (0.0036 mSv/yr) dose for a total CEDE of 0.46 mrem/yr (0.0046 mSv/yr).

This dose of 0.46 mrem/yr is the total offsite dose to the MEI due to NTS emissions given all feasible pathways of exposures. It is 0.46 percent of the DOE limit of 100 mrem/yr, and it is only 0.13 percent of the total dose the MEI would receive from natural background radiation (365 mrem/yr) (Figure 7-3).

Natural background radiation consists of cosmic radiation, terrestrial radiation, radiation from radionuclides (primarily ^{40}K) within the composition of the human body, and radiation from the inhalation of naturally-occurring radon and its progeny. The cosmic and terrestrial components of the background (125 mrem/yr) were estimated from the annual mean radiation exposure rate measured with a pressurized ion chamber (PIC) at Indian Springs (see Table 5-4) by the offsite CEMP (see Section 5.0). The radiation exposure in air measured by the PIC in units of mR/yr is approximately equivalent to the unit of mrem/yr for tissue. The portion of the background dose from the internally deposited naturally-occurring radionuclides and the radiation dose from the inhalation of radon and its daughters were estimated as 40 mrem/yr and 200 mrem/yr, respectively, using the approximations by the National Council on Radiation Protection (NCRP, 1996).

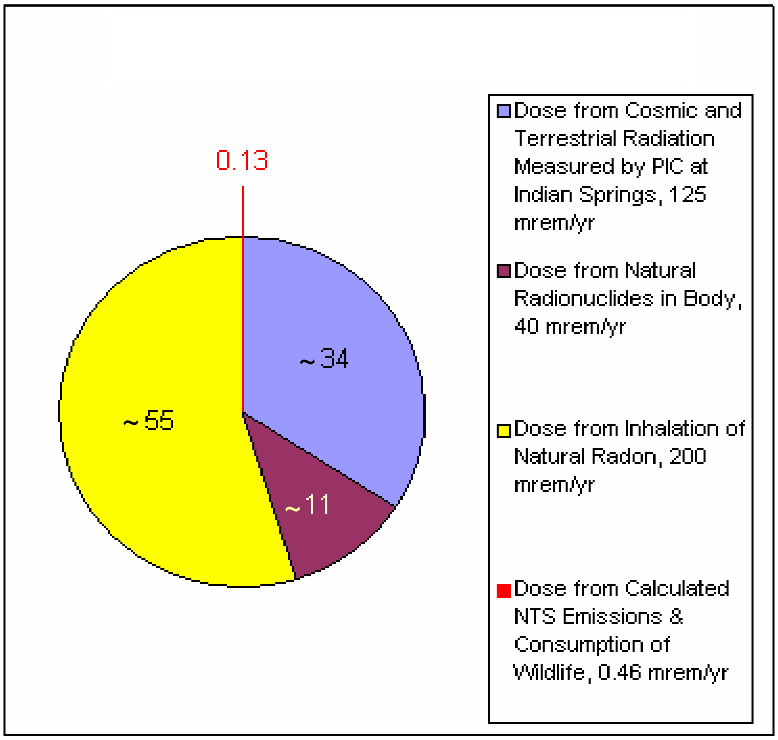

Figure 7-3. Comparison of radiation dose to MEI and the natural radiation background

7.1.3.2 Collective Population Dose

Approximately 38,154 persons live within an 80-km radius of the NTS (Hardcastle, 2003). The collective population dose (see Glossary, Appendix D) from NTS operations is the sum of the CEDEs to all individuals within the 80-km radius of the NTS (see Figure 7-1). The dose calculation does not include those working onsite. It is intended to calculate doses to residents at their homes. The 2003 collective population dose attributable to NTS operations to persons living within 80 km of the NTS was estimated to be 0.45 person-rem/yr (0.0045 person-Sv/yr) (Table 7-3). This population dose is comparable to the population dose of 0.42 person-rem reported for 2002 (DOE, 2003c).

Table 7-3. Radiological dose to the general public from 2003 NTS operations

Pathway	Dose to Maximally Exposed Individual (mrem/yr)	(mSv/yr)	Percent of DOE 100-mrem/yr Limit	Estimated Collective Population Dose[(a)] (person-rem/yr)	(person-Sv/yr)
Air	0.10	0.0010	0.10	0.45[(a)]	0.0045
Water	0	0	0	0	0
Wildlife	0.36	0.0036	0.36	U[(b)]	U
All Pathways	0.46	0.0046	0.46	0.45	0.0045

(a) Sum of radiation doses from all emission sources at each populated location within 80 km of emission sources multiplied by the population at each location, and then summed over all locations.

(b) Unable to make this estimate due to a lack of data on number of game animals harvested near the NTS by hunters in 2003.

7.2 Dose to Aquatic and Terrestrial Biota

On January 15, 2003, DOE Order 450.1, "Environmental Protection Program," was approved, replacing DOE Order 5400.1. The new order adds specific requirements for the protection of biota and requires DOE facilities to evaluate the potential impacts of radiation exposure to biota in the vicinity of DOE activities. The following radiological dose limits for biota are established by DOE (DOE, 2002a), such that dose rates equal to or less than these are expected to have no direct, observable effect on plant or animal reproduction:

- Dose limit to aquatic animals = 1 rad/day (0.01 Gy/day)
- Dose limit to terrestrial plants = 1 rad/day (0.01 Gy/day)
- Dose limit to terrestrial animals = 0.1 rad/day (1 mGy/day)

7.2.1 Goals and Compliance Measures

The goal for the biota dose assessment component of radiological monitoring is to evaluate the radiological dose to aquatic and terrestrial biota caused by past or current NTS activities. DOE Standard 1153-2002, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," (DOE, 2002a) was developed by DOE's Biota Dose Assessment Committee to assist in such an evaluation and to determine if the established dose limits shown above are exceeded at any DOE facility. This standard describes a graded approach for evaluating radiation doses to biota. The standard also provides concentration values for radionuclides in soil, water, and sediment that are to be used as a guide for determining if biota are receiving radiation doses that exceed the limits. These concentrations are called the Biota Concentration Guide (BCG) values. They are defined as the maximum concentration of a radionuclide that would not cause dose limits to be exceeded using very conservative uptake and exposure assumptions. The following measures or information are required by this graded approach for evaluating dose to biota on the NTS:

- Identification of terrestrial and aquatic habitats on the NTS that have radionuclides in soil, water, or sediment.
- Identification of terrestrial and aquatic biota on the NTS that occur in contaminated habitats and which are at risk of exposure.
- Measured or calculated radionuclide concentrations in soil, water, and sediment in contaminated habitats on the NTS that can be compared to BCG values to determine the potential for exceeding biota dose limits.
- Measured radionuclide concentrations in NTS biota, soil, water, and sediment in contaminated habitats on the NTS to estimate site-specific dose to biota.

7.2.2 Methods and Results

As in computing human radiological dose (Section 7.1), several steps are involved in evaluating radiological dose to biota. The graded approach outlined in DOE Standard 1153-2002 is a three-step process consisting of a data assembly step, a general screening step, and an analysis step. Furthermore, the analysis step consists of site-specific screening, site-specific analysis, and site-specific biota dose assessment. This section describes all of these steps (Table 7-4) and presents the results of each step conducted in 2003.

7.2.2.1 Data Assembly

The goal of the data assembly step is to define both aquatic and terrestrial biota dose evaluation areas (DEAs) on the NTS and the exposed biotic populations. Existing information on radiologically contaminated areas and biotic populations on the NTS were gathered and summarized. The bodies of water existing on the NTS during 2003 which were contaminated with radionuclides defined the aquatic DEAs. They included: two lined well sumps, one open tank, a drainage ditch (Cambric Ditch), and E Tunnel Ponds (Figure 7-4).

The two lined ponds, open tank, and Cambric Ditch all contained groundwater pumped from the following underground test area post-shot wells, respectively: U-19Q PS #1D, U-20N PS #1DDH, U-4U PS #2A, and RNM #2S. The E Tunnel Ponds contain groundwater as it drains from the E Tunnel system. Radiological monitoring data gathered at these water sources under the RREMP during 2003 were used to assess dose to biota at these aquatic DEAs.

Terrestrial DEAs on the NTS were defined as the historic survey areas established by the Radionuclide Inventory and Distribution Program (RIDP) from 1981 through 1986. RIDP compiled the most comprehensive data on radionuclide concentrations in NTS surface soil from a combination of field exposure rate measurements, field gamma spectroscopy measurements, aerial surveys of external exposure rate, and soil samples. Thirty-one soil contamination regions defined by RIDP (McArthur and Kordas, 1983; McArthur and Kordas, 1985; McArthur and Mead, 1987; McArthur and Mead, 1988; McArthur and Mead, 1989; McArthur, 1991) were used to define the NTS terrestrial DEAs (see Figure 7-4). RIDP radionuclide data from these 31 areas were used for comparison with the BCG values to assess potential dose to terrestrial biota residing in these areas.

To identify possible plant species that might occur within DEAs which could be at risk of radiation doses that exceed federal limits, existing information on the distribution of vegetation associations and dominant plant species were examined (Ostler, et al., 2000). Ostler, et al., described vegetation associations on the NTS near the vicinity of contaminated sites; however, the vegetation of areas with high radionuclide concentrations in which land access is restricted have not been well characterized in terms of the exact numbers of plant species and their abundance. Preliminary observations at many of these sites suggest that the most common plants present are annual invasive species such as red brome (*Bromus rubens*), cheat grass (*Bromus tectorum*), and tumble weed (*Salsola paulensis*).

To identify NTS aquatic and terrestrial animals within DEAs which may be at risk of radiation doses that exceed federal limits, existing information on the presence and location of known NTS animal species were examined (Wills and Ostler, 2001). No known aquatic vertebrates (i.e., amphibians or fish) or crustaceans (i.e., crayfish, shrimp) reside in the five aquatic DEAs identified in 2003. These waters or their bottom sediments have not been sampled, however, to identify the presence of aquatic invertebrates such as larval stages of insects or sediment-dwelling worms. Within the terrestrial DEAs, fossorial small mammals including rodents (e.g., mice, kangaroo rats, ground squirrels) comprise the most likely and most abundant species to be adversely affected. Fossorial animals are burrow-dwellers and those residing in the DEAs would spend much of their life burrowing in the contaminated soils and foraging on plants growing at these sites. There have been numerous studies characterizing biota within undisturbed and disturbed areas on the NTS, including areas affected by past nuclear tests (Wills and Ostler, 2001). The data compiled by these studies are being reviewed on an ongoing basis and will be incorporated into this data assembly phase as it evolves to give a clearer picture of biota radiological dose on the NTS.

Table 7-4. Summary of DOE's process for evaluating radiation dose to aquatic and terrestrial biota (as per DOE-STD-1153-2002)

Process Step	Process Step Description	Process Results That Require the Next Step of Evaluation
1) Data Assembly	Knowledge of radionuclide sources, plant and animal receptors, and routes of exposure is summarized. Existing data on radionuclide concentrations in soil, water, and sediment are assembled. Contaminated areas with sufficient data are identified as dose evaluation areas (DEAs).	There is sufficient existing data on site-related radionuclides in the environment and exposed biota to identify DEAs.
2) General Screening (Level 1 Screen)	Maximum measured radionuclide concentrations in soil, sediment, and water in DEAs are compared with BCG values for each radionuclide.	Sum of fractions of maximum radionuclide concentrations in soil, water, and sediment in a DEA divided by the BCG values is greater than 1.0.
3) Analysis		
a. Site-Specific Screening (Level 2 Screen)	Average radionuclide concentrations are used in place of maximum concentrations and screened against BCG values. Receptor residence time in a DEA is considered. More realistic, site-representative, lumped parameters (e.g., bioaccumulation factors) are used in place of default values.	Sum of fractions of average radionuclide concentrations in soil, water, and sediment in a DEA divided by the BCG values, taking into account residence time and realistic lumped model parameters, is greater than 1.0.
b. Site-Specific Analysis	More realistic, site-representative, parameters are used to represent uptake and dose estimation for specific receptors.	Sum of fractions of average radionuclide concentrations in soil, water, and sediment in a DEA divided by the BCG values, taking into account realistic specific model parameters, is greater than 1.0.
c. Site-Specific Biota Dose Assessment	An actual site-specific biota dose assessment is conducted.	

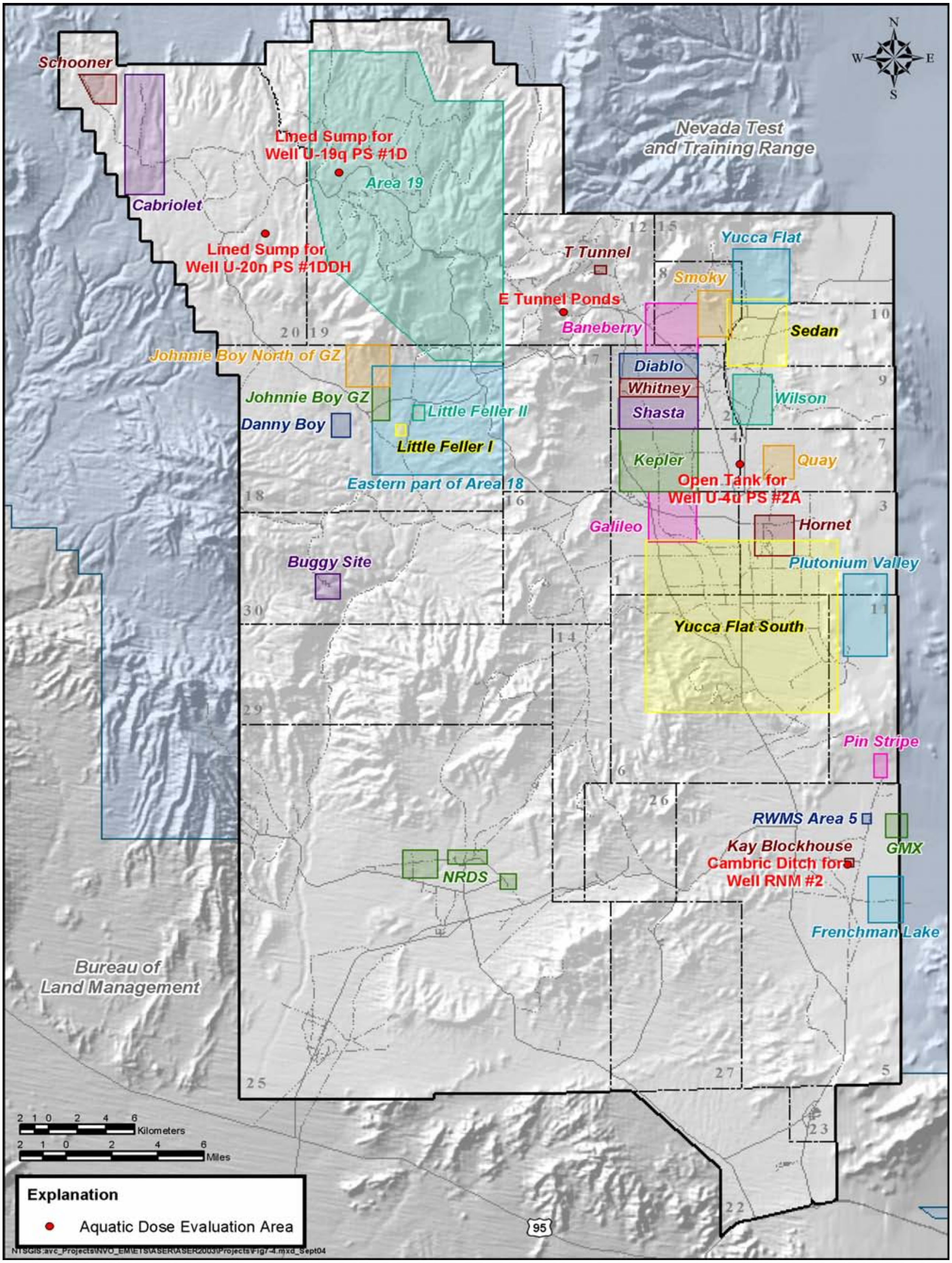

Figure 7-4. Terrestrial and aquatic dose evaluation areas for assessing potential dose to biota

7.2.2.2 General Screening: Level 1 Screen

The goal of General Screening is to determine whether the sum of the fractions of maximum radionuclide concentrations in soil, water, and sediment in a DEA divided by the BCG values are less than 1.0. For E Tunnel Ponds, results from water and sediment samples taken during 2003 were used (see Section 3.1.3.5). For terrestrial biota DEAs maximum radionuclide concentrations reported by the RIDP were used. If the maximum soil concentrations were reported on a per area basis (nCi/m^2), they were converted to gravimetric concentrations (pCi/g) using the assumptions that the soil density was 1.5 g/cm^3 and that radionuclides were distributed to a depth of 7 cm for ^{241}Am, ^{238}Pu, $^{239/240}$Pu, and to a depth of 11 cm for ^{90}Sr, ^{137}Cs, ^{152}Eu, ^{154}Eu, and ^{155}Eu. These depth distributions represent the average measured by the RIDP (McArthur, 1991). All RIDP reported values were adjusted to account for radioactive decay from the dates the samples were analyzed through January 1, 2003.

The Level 1 Screen was conducted by entering the maximum radionuclide concentrations into the RESRAD-BIOTA software (DOE, 2004). The RESRAD-BIOTA software then computed the fractions (maximum radionuclide concentration/BCG) and the sum of fractions (total fractions for all radionuclides). If the sum of fractions in a screen was less than 1.0 within a DEA, the absorbed dose to biota is expected to be less than the federal dose limits within that DEA.

The sums of fractions for the Level 1 Screen are listed in Table 7-5. Seven DEAs passed the Level 1 screen (Table 7-5; Figure 7-5). The estimated maximum dose to biota in these seven DEAs, therefore, is less than the federal dose limit of 1 rad/day (0.01 Gy/day) for plants and 0.1 rad/day (1 mGy/day) for animals.

The remaining terrestrial DEAs had sums of fractions greater than 1.0. These DEAs required Site-Specific Screening. The radionuclides primarily contributing to the failure of the Level 1 Screen for these DEAs were ^{137}Cs (in 96 percent of the DEAs), ^{90}Sr (in 84 percent), ^{241}Am (in 20 percent), and $^{238+239/240}$Pu (in 16 percent) (Table 7-5).

7.2.2.3 Site-Specific Screening: Level 2 Screen

The goal of Site-Specific Screening is to determine whether the sum of fractions of average radionuclide concentrations in soil, water, and sediment in a DEA divided by the BCG values are less than 1.0. For E Tunnel Ponds, results from water and sediment samples collected by BN ETS during 2003 were used (see Section 3.1.3.5). For the remaining aquatic DEAs, results from water samples collected by Underground Test Area Project personnel were used. No sediment samples were collected in 2003 at these four water sources. For terrestrial DEAs, average soil concentrations were determined by taking the inventory estimates from McArthur (1991) and distributing them over the entire RIDP survey region using the same assumptions used for converting maximum area concentrations to gravimetric (see Section 7.2.2.2 above).

The RESRAD-BIOTA software (DOE, 2004) was used for the Level 2 Screen in the same manner described above for the Level 1 Screen, only using average radionuclide concentrations instead of the maximums (see Section 7.2.2.2 above).

The sum of fractions from the Level 2 Screen are listed in Table 7-6. All DEAs, except Sedan, had a resultant value less than 1.0 and passed the screen (Table 7-6; Figure 7-5). The Sedan DEA had a value of 1.60. The radionuclides contributing to the Sedan DEA not passing the Level 2 Screen were ^{137}Cs and ^{90}Sr which had estimated average concentrations in soil which were 91 percent and 67 percent of associated BCG values, respectively.

An additional Level 2 Screen was conducted for NTS Areas 8 and 10 because they encompass the Sedan DEA (see Figure 7-4), and they contained outfall from the Sedan plowshare test which was outside the RIDP survey regions. Average soil concentrations were determined by taking the inventory estimates for NTS Areas 8 and 10 (McArthur, 1991) and distributing them over the entire NTS Areas 8 and 10, respectively. The resulting sums of fractions for these Level 2 Screens were 0.40 for Area 8 and 0.56 for Area 10 (Table 7-6), both below 1.0. These areas therefore passed the Level 2 Screen. The fact that averaging radionuclides over a larger area resulted in the passing of the Level 2 Screen underscores the importance of defining the boundaries of evaluation areas with respect to populations of biota. Future work will characterize biota in these areas to help better define the evaluation boundaries and future sampling will be conducted to verify the depth distribution assumptions and the resulting average radionuclide concentration estimates used in the screens.

Table 7-5. Results of the Level 1 Screen of dose evaluation areas (DEAs) on the NTS

Level 1 Screening (Using Maximum Radionuclide Concentrations)					
Dose Evaluation Area (DEA)	**NTS Area(s)**	**Area (km^2)**	**Soil Sum of Fractions**	**Water Sum of Fractions**	**Key Radionuclides Contributing to Failure (% of BCG)**
DEAs Passing Level 1 Screen					
Area 19 [(a)]	18, 19	384.1	0.18	NA	None
GMX [(a)]	5	1.0	0.27	NA	None
Johnnie Boy North of GZ [(b)]	18	7.3	0.14	NA	None
Kay Blockhouse [(a)]	5	0.4	0.04	NA	None
Plutonium Valley [(a)]	3, 11	8.8	0.34	NA	None
RWMS 5 [(a)]	5	0.4	0.10	NA	None
Yucca Flat [(a)]	8, 15	40.1	0.84	NA	None
DEAs Failing Level 1 Screen					
Baneberry [(c)]	2, 8, 12	13.5	60.71	NA	^{137}Cs (5150%), ^{90}Sr (906%)
Buggy Site [(a)]	30	0.8	43.67	NA	^{137}Cs (1390%), ^{90}Sr (2900%)
Cabriolet [(b)]	20	11.7	19.83	NA	^{137}Cs (1510%), ^{90}Sr (356%)
Danny Boy [(b)]	18	2.3	23.78	NA	^{137}Cs (1960%), ^{90}Sr (287%)
Diablo [(d)]	2	10.4	36.77	NA	^{137}Cs (1200%), ^{90}Sr (2460%)
E Tunnel Ponds [(e)]	12	0.01	0.04	1.05	^{137}Cs in water (101%)
East Part of Area 18 [(a)]	18	55.7	2.22	NA	^{241}Am (167%)
Frenchman Lake [(a)]	5	5.7	20.18	NA	^{137}Cs (1380%), ^{90}Sr (606%)
Galileo [(f)]	1	12.4	12.08	NA	^{137}Cs (846%), ^{90}Sr (302%)
Hornet [(c)]	3	22.0	14.32	NA	^{137}Cs (889%), ^{90}Sr (483%)
Johnnie Boy GZ [(b)]	18	3.0	17.75	NA	^{137}Cs (360%), ^{90}Sr (1410%)
Kepler [(d)]	4	25.1	23.02	NA	^{137}Cs (936%), ^{90}Sr (1290%)
Little Feller I [(b)]	18	1.6	15.21	NA	^{241}Am (329%), ^{137}Cs (151%), ^{239}Pu (778%), ^{90}Sr (262%)
Little Feller II [(b)]	18	0.8	9.60	NA	^{241}Am (167%), ^{137}Cs (137%), ^{239}Pu (428%), ^{90}Sr (228%)
Near T tunnel [(a)]	12	0.4	23.80	NA	^{137}Cs (2350%)
NRDS [(a)]	25	2.3	7.81	NA	^{137}Cs (409%), ^{90}Sr (368%)
Pin Stripe [(a)]	11	1.6	1.29	NA	^{137}Cs (89%), ^{90}Sr (40%)
Quay [(c)]	7	17.4	15.46	NA	^{137}Cs (520%), ^{90}Sr (876%)
Schooner [(b)]	20	4.4	3.71	NA	^{137}Cs (155%), ^{90}Sr (128%)
Sedan [(c)]	8, 10	19.9	253.12	NA	^{241}Am (6140%), ^{137}Cs (1920%), ^{239}Pu (16300%), ^{90}Sr (939%)
Shasta [(d)]	2	12.7	14.28	NA	^{137}Cs (430%), ^{90}Sr (992%)
Smoky [(c)]	8	8.5	304.98	NA	^{241}Am (5750%), ^{137}Cs (467%), ^{239}Pu (23200%), ^{90}Sr (1060%)
Whitney [(d)]	2	7.0	22.35	NA	^{137}Cs (895%), ^{90}Sr (1280%)
Wilson [(c)]	9	19.4	5.85	NA	^{137}Cs (445%), ^{90}Sr (88%)
Yucca Flat South [(c)]	1, 3, 6	115.3	3.07	NA	^{137}Cs (300%)

NA = not applicable
Maximum values taken from: (a) McArthur and Mead, 1989; (b) McArthur and Mead, 1988; (c) McArthur and Mead, 1987; (d) McArthur and Kordas, 1985; (e) samples collected in 2003; (f) McArthur and Kordas, 1983.

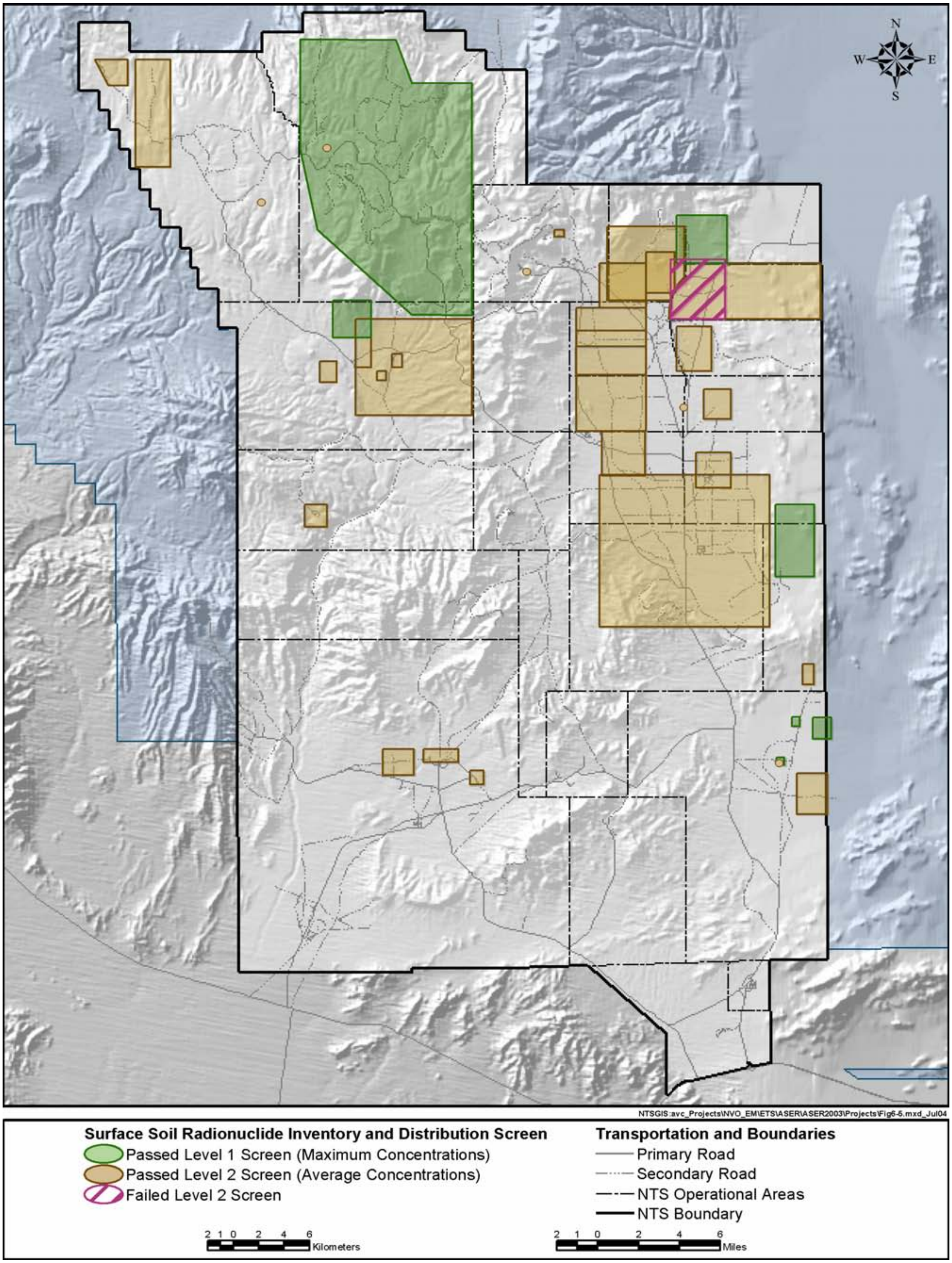

Figure 7-5. Results of Level 1 and Level 2 Screens for dose evaluation areas on the NTS

Table 7-6. Results of the Level 2 Screen of dose evaluation areas (DEAs) on the NTS

Level 2 Screening (Using Average Radionuclide Concentrations[a])					
Dose Evaluation Area (DEA)	**NTS Area(s)**	**Area (km^2)**	**Soil Sum of Fractions**	**Water Sum of Fractions**	**Key Radionuclides Contributing to Failure (% of BCG)**
<u>DEAs Passing Level 2 Screen</u>					
Area 19 (a)	18, 19	384.1	0.04	NA	None
Baneberry(a)	2, 8, 12	13.5	0.52	NA	None
Buggy Site (a)	30	0.8	0.93	NA	None
Cabriolet (a)	20	11.7	0.18	NA	None
Cambric Ditch (b)	5	0.1	NA	0.00	None
Danny Boy (a)	18	2.3	0.36	NA	None
Diablo (a)	2	10.4	0.53	NA	None
E Tunnel Ponds(b)	12	0.01	0.02	0.61	None
East Part of Area 18 (a)	18	55.7	0.06	NA	None
Frenchman Lake (a)	5	5.7	0.06	NA	None
Galileo (a)	1	12.4	0.20	NA	None
GMX (a)	5	1.0	0.01	NA	None
Hornet (a)	3	22.0	0.34	NA	None
Johnnie Boy GZ & N. of GZ (a)	18	10.3	0.25	NA	None
Kay Blockhouse (a)	5	0.4	0.01	NA	None
Kepler (a)	4	25.1	0.21	NA	None
Little Feller I (a)	18	1.6	0.15	NA	None
Little Feller II (a)	18	0.8	0.30	NA	None
Near T tunnel (a)	12	0.4	0.00	NA	None
NRDS (a)	25	2.3	0.04	NA	None
Pin Stripe (a)	11	1.6	0.05	NA	None
Plutonium Valley (a)	3, 11	8.8	0.02	NA	None
Quay (a)	7	17.4	0.11	NA	None
RWMS 5 (a)	5	0.4	0.01	NA	None
Schooner (a)	20	4.4	0.17	NA	None
Shasta (a)	2	12.7	0.60	NA	None
Smoky (a)	8	8.5	0.76	NA	None
Well U-4u PS #2A (b)	4	<0.1	NA	0.11	None
Well U-19q PS #1D (b)	19	<0.1	NA	0.05	None
Well U-20n PS #1DDH (b)	20	<0.1	NA	0.18	None
Whitney (a)	2	7.0	0.45	NA	None
Wilson (a)	9	19.4	0.22	NA	None
Yucca Flat (a)	8, 15	40.1	0.23	NA	None
Yucca Flat South (a)	1, 3, 6	115.3	0.02	NA	None
NTS Area 8 (a)	8	35.9	0.40	NA	None
NTS Area 10 (a)	10	52.1	0.56	NA	None
<u>DEAs Failing Level 2 Screen</u>					
Sedan (a)	8, 10	19.9	1.60	NA	^{137}Cs (91%), ^{90}Sr (67%)

NA = not applicable

(a) Average values taken from inventory of radionuclides (McArthur, 1991)

(b) Average of samples collected in 2003

7.2.2.4 Site-Specific Analysis

The goal of Site-Specific Analysis is to determine if the sum of fractions of average radionuclide concentrations in soil, water, and sediment in a DEA divided by the BCG values is greater than 1.0. This step differs from the Level 2 Screen in that more realistic and site-representative parameters are to be used for uptake and dose estimations for specific animal species. The default terrestrial animal modeled in RESRAD-BIOTA for both the Level 1 and 2 Screens is the deer mouse (*Peromyscus maniculatus*), which is probably analogous to any one of the numerous small mammal rodent species likely to be the most exposed animals in the DEAs. Because of this, the parameters used for the dose estimation in the screening process are likely site-representative, so no site-specific analyses were made in this assessment. Field surveys will be conducted in the future to better characterize both plant and animal species within the DEAs, including their abundance, period of use, and other important life history parameters that will be used to verify, or revise site-specific screens. Characterization efforts may be phased over several years to ensure that sufficient resources are available to characterize DEAs consistent with the graded approach required under DOE Order 450.1.

7.2.2.5 Site-Specific Biota Dose Assessment

Most of the graded approach for assessing dose to biota is based on radionuclide concentrations in soil, water, and sediment. The site-specific biota dose assessment phase; however, centers on the actual collection and analysis of biota from DEAs. This section presents estimates of site-specific doses to biota sampled in DEAs during 2003.

Also included are site-specific doses to plants in the Sedan DEA because of this site's failure to pass the Level 2 Screen. Vegetation sampled for radioanalysis from the Sedan DEA in 2000 were used. No animals have been sampled from this DEA in over 10 years.

During 2003, animal samples were collected from two contaminated sites. These sites included: (1) the Palanquin plowshare test site in the Cabriolet DEA (see Figure 7-4), and (2) the E Tunnel Ponds inside the E Tunnel Ponds DEA. Plant samples were collected in 2003 from the Palanquin site, but not the E Tunnel Ponds site. Sampling methods and radionuclide concentrations in these 2003 samples are presented in Section 6.0 of this report. In 2000, vegetation was sampled in the Sedan area (DOE, 2001b); however, no animals have been collected from the Sedan DEA in the past 10 years.

Internal and external dose coefficient factors discussed in the graded approach methodology (Section 2, Module 3 of DOE, 2002a) were used with the measured concentrations to obtain dose rate estimates for both plants and animals. The external dose rate was estimated by summing the product of average concentrations in soil and the external dose coefficients (DOE, 2002a) for each detected radionuclide. The internal dose rates for biota were estimated by summing the product of average concentrations of radionuclides detected in the biota samples and the internal dose factors (DOE, 2002a). The external dose rate estimate was then added to the internal estimate to obtain a total dose rate estimate for plants and animals.

Average doses were estimated to be 0.008 rad/day (0.08 mGy/day) for animals and 0.002 rad/day (0.02 mGy/day) for plants near the Palanquin plowshare test in the Cabriolet DEA (Table 7-7). Internal dose was higher than external dose; about 95 percent and 83 percent of the estimated dose to animals and plants, respectively, came from internally deposited radionuclides. The estimated dose rates are 8 percent and 0.2 percent of the dose limits for terrestrial animals and plants, respectively. These results support the Level 2 Screen pass of the Cabriolet DEA. For doves residing at the E Tunnel Ponds, average doses were estimated to be 0.002 rad/day (0.02 mGy/day) which is 2 percent of the dose limits to terrestrial animals and supports the Level 2 Screen pass of the E Tunnel Ponds.

Dose rates to vegetation sampled in the Sedan DEA during 2000 were estimated to be 0.002 rad/day (0.02 mGy/day) (Table 7-7) of which 95 percent was from external radiation. This is a dose rate 0.2 percent of the limit to terrestrial plants. It is likely that radionuclide concentrations in animals taken from the same location would also not exceed dose limits. Future sampling of small mammals in the Sedan area will be conducted to estimate their radiological dose rate.

Table 7-7. Site-specific dose assessment results for terrestrial plants and animals sampled on the NTS

	Estimated Radiological Dose (rad/day)			
DEA	**Animals**		**Plants**	
Cabriolet	Palanquin doves [(a)]	0.008	Palanquin vegetation [(b)]	0.002
E Tunnel Ponds	E Tunnel pond doves	0.002	(*not sampled in 2003*)	-
Sedan	(*not sampled in last 10 yrs*)	-	Sedan vegetation [(c)]	0.002
DOE Dose Limit		**0.1**		**1.0**

(a) See Table 6-3 of this report

(b) See Table 6-1 of this report

(c) See DOE (2001b)

7.2.3 Environmental Impact

The estimated radiological doses to biota within DEAs examined on the NTS in 2003 do not exceed the federal dose limits. Based on this graded approach, plants and animals on the NTS are not expected to be exposed to significantly large radiological doses that may be detrimental to their populations.

Further work is required; however, to refine this dose assessment especially in DEAs which may contain populations of biota that have home range sizes much smaller than the area of the DEAs they occur in. This potential disparity in animal home range sizes and DEA sizes (defined by the RIDP survey area boundaries) may mean that some NTS animals are exposed to higher or lower radionuclide levels in soils or plants than what was estimated using the RIDP data this year. For example, there are fairy shrimp which stay buried in the dried playa sediments in Frenchman Lake and then emerge when the playa fills with surface runoff from rainstorms. The Frenchman Lake DEA defined by the RIDP survey area boundary encompasses a much larger area than just the dried lake bed. The radionuclide concentrations reported by RIDP for soils in this DEA may therefore not be representative of concentrations found in the playa sediments that shrimp burrow into and which define the true boundary of this ephemeral aquatic DEA.

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8.0 Waste Management and Environmental Restoration

Several federal and state regulations govern the safe management; storage; and disposal of radioactive, hazardous, and solid wastes generated or received on the Nevada Test Site (NTS) for the purpose of protecting the environment and the public (see Section 1.4). This section describes both the waste management and environmental restoration operations conducted under the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) Environmental Management Program. The overall goals of the Program are to: (1) manage and safely dispose of low-level radioactive waste (LLW), mixed low-level radioactive waste (MW), and hazardous waste generated by NNSA/NSO and U.S. Department of Defense (DoD) operations, and (2) characterize and remediate historic sites contaminated by NNSA/NSO testing activities. This section also summarizes the program's 2003 activities which were performed to meet all applicable environmental protection regulations and state permit requirements.

8.1 Radioactive Waste Management

8.1.1 Program Goal

DOE Order 435.1 "*Radioactive Waste Management*"requires that U.S. Department of Energy (DOE) radioactive waste management activities shall be systematically planned, documented, executed, and evaluated. Radioactive waste is managed to:

- Protect the public from exposure to radiation from radioactive materials
- Protect the environment
- Protect workers
- Comply with applicable federal, state, and local laws and regulations and with applicable Executive Orders and other DOE directives

The major tasks within Radioactive Waste Management include:

- Characterization of LLW and MW that has been generated by the DOE within the state of Nevada.
- Disposal of LLW and MW at the Radioactive Waste Management Complex (RWMC) comprised of the Area 5 Radioactive Waste Management Site (RWMS) and the Area 3 RWMS.
- Characterization, visual examination, and repackaging of transuranic (TRU) waste at the Waste Examination Facility (WEF) at the RWMC.
- Loading of TRU waste at the Mobile Loading Unit (MLU) for shipment to the Waste Isolation Pilot Plant (WIPP) at Carlsbad New Mexico.

8.1.2 Description of Operations

8.1.2.1 Characterization of LLW and MW

Waste Generator Services (WGS) characterizes LLW and MW generated by the DOE within Nevada, primarily at the NTS. Characterization is performed utilizing either knowledge of the generating process, or sampling and analysis. Following the complete characterization of a waste stream, a Waste Profile is completed for approval by an appropriate disposal facility. The Waste Profile delineates the complete pedigree of the waste, including but not limited to: a description of the waste generating process, physical and chemical characteristics, radioactive isotopes and their quantities, and detailed packaging information. The WGS then packs and ships approved waste streams in accordance with Department of Transportation requirements to either the Area 3 or Area 5 RWMS or to an offsite treatment, storage, and disposal facility.

8.1.2.2 Disposal of LLW and MW

The RWMC operates as a Category II Nuclear Facility. The RWMC, which includes the Area 3 and the Area 5 RWMSs, is designed and operated to perform three functions:

- Dispose of LLW from NNSA/NSO activities performed on and off the NTS and from other offsite generators in the state of Nevada.
- Dispose of DOE LLW from around the complex, primarily from the cleanup of sites associated with the manufacture of weapons components.
- Dispose of MW from onsite NNSA/NSO activities.

All generators of waste streams must first request to dispose of waste, submit a request to NNSA/NSO requesting to ship waste to the NTS for disposal, submit profiles characterizing specific waste streams, meet the NTS Radioactive Waste Acceptance Criteria, and receive programmatic approval for disposal by NNSA/NSO. The NTS Radioactive Waste Acceptance Criteria are based on how well the site is predicted to perform in containing radioactive waste and ensuring that the environment (including air and groundwater) and the public will not be exposed to significant radiation. The NNSA/NSO assesses and predicts the long-term performance of LLW disposal sites by conducting a Performance Assessment (PA). A PA is a systematic analysis of the potential risks posed by a waste disposal site to the public and to the environment. PA and Composite Analysis (CA) documents are developed as a result of the assessment. The RWMC receives LLW generated within the DOE complex from numerous DOE sites across the United States, LLW from DoD sites which carry a national security classification, and MW generated within the state of Nevada for disposal or indefinite storage.

Disposal consists of placing waste in various sealed containers in unlined cells and trenches. Soil backfill is applied over the waste in a single lift, which is approximately 2.4 m (8 ft) thick as rows of containers reach approximately 1.2 m (4 ft) below the original grade.

Area 5 RWMS – This site includes 81 hectares (200 acres) of existing and proposed disposal cells for burial of both LLW and MW, and approximately 202 hectares (500 acres) of land available for future radioactive disposal cells. Waste disposal at the Area 5 RWMS has occurred in a 37 hectare (92 acre) portion of the site since the early 1960s. The Area 5 RWMS consists of 27 Disposal Cells (pits and trenches) and 13 Greater Confinement Disposal (GCD) boreholes as identified below:

- 29 Disposal Cells:
  4 active which receive standard LLW
  1 active and permitted to receive asbestos-form LLW (P06U)
  1 active and permitted by the state to receive MW (P03U)
  4 inactive (open but have not received any waste)
  19 closed (containing waste and backfilled) containing LLW

- 13 GCD Boreholes:
  4 inactive (open but have not received any waste)
  4 closed containing TRU waste
  5 closed containing LLW

This site is used for disposal of waste in drums or boxes. Existing cells are expected to be filled and closed by 2010, and new cells extending to the north and west are expected to close by 2021. LLW and MW disposal services are expected to continue at Area 5 RWMS as long as the DOE complex requires disposal of wastes from the weapons program.

Area 3 RWMS – This facility consists of seven craters making up five disposal cells. Each subsidence crater was created by an underground weapons test. This site is used for disposal of bulk LLW waste, such as soils or debris, and waste in large cargo containers. Disposal operations at the Area 3 RWMS began in the late 1960s. The site consists of the following seven craters. Waste disposal services at Area 3 RWMS will continue as long as the DOE requires such services.

- 3 Active Disposal Cells:
  U3ah/at
  U3bh

- 2 Closed Cells:
  U3ax/bl
- 2 Undeveloped Cells:
  U3az
  U3bg

8.1.2.3 TRU Waste Operations

The Transuranic Pad Cover Building (TPCB) at the Area 5 RWMC is a Resource Conservation and Recovery Act (RCRA) Part B interim status facility designed for the safe storage of TRU waste which was generated by Lawrence Livermore National Laboratory in the 1970s. The TPCB accepts no other TRU wastes for interim storage. The TPCB stores TRU waste until it is characterized, visually examined, and repackaged at the WEF at the Area 5 RWMC. Once repackaged, the TRU waste is loaded at the Mobile Loading Unit (MLU) for shipment to the WIPP at Carlsbad New Mexico. Current agreements between NNSA/NSO and WIPP plan for TRU waste shipments to be completed by March 2005.

8.1.2.4 Maintenance of Key Documents

Below are listed the key documents which must be current and in place at each RWMS for disposal operations to occur:

- Disposal Authorization Statement (DAS)
- Performance Assessment (PA)
- Composite Analysis (CA)
- NTS Waste Acceptance Criteria (NTSWAC)
- Integrated Closure and Monitoring Plan (ICMP)
- Auditable Safety Analysis (ASA)

8.1.2.5 Assessments

Assessments are conducted at the RWMC in accordance with Bechtel Nevada (BN) Procedure OP-NOPS.003, *Nuclear Operations Conduct of Operations*. Schedules for BN management self-assessments (MSAs) are included in the Support Execution Plans for each facility. In addition to the MSAs performed internally at the RWMC, there are assessments performed periodically by other BN organizations, NNSA/NSO, and the Defense Nuclear Facilities Safety Board. The results of each assessment are logged in the BN tracking system for DOE/NSO known as CaWeb. Assessments are performed monthly.

8.1.2.6 Environmental Monitoring

There are three groundwater wells which are monitored to verify the performance of the Area 5 RWMS, as specified in the *Performance Assessment for Area 5 RWMS*, Revision 2.1 (PA). They are wells UE5 PW-1, UE5 PW-2, and UE5 PW-3, and comprise 3 of the 14 onsite monitoring wells sampled periodically for radionuclide analyses of groundwater. These wells are sampled to determine if the groundwater remains protected from buried radioactive wastes. The reader is directed to Section 3.1 where the methods and results of groundwater sampling in 2003, which includes wells UE5 PW-1, UE5 PW-2, and UE5 PW-3, are presented.

Monitoring of the vadose zone (unsaturated zone above the water table) is conducted at the RWMC in addition to groundwater monitoring to demonstrate that: (1) the PA assumptions at the RWMSs are valid regarding the hydrologic conceptual models used, including soil water contents, and upward and downward flux rates; and (2) that there is negligible infiltration of precipitation into zones of buried waste at the RWMSs. Vadose zone monitoring (VZM) offers many advantages over groundwater monitoring including detecting potential problems long before groundwater resources would be impacted, allowing corrective actions to be made early, and being less expensive than groundwater monitoring.

Water balance measurements for VZM are obtained by the following activities:

- **Meteorological monitoring** – conducted to measure precipitation (the driving force for downward flow) and to calculate potential evapotranspiration (the driving force for upward flow).
- **Weighing and draining lysimeters** – used to measure infiltration, soil water redistribution, bare-soil evaporation, evapotranspiration, and deep drainage.
- **Neutron logging through access tubes** – conducted to measure infiltration, soil water redistribution, and monitor a large spatial area (in some locations to depths of hundreds of feet).
- **Automated VZM systems with *in situ* sensors** (e.g., time domain reflectometry probes, and heat dissipation probes) – used to measure soil water content and soil water potential over a large spatial area, but usually to a limited depth.
- **Soil-gas sampling for tritium** – conducted to confirm PA assumptions and transport coefficients.

8.1.3 2003 Activities and Status

8.1.3.1 Characterization of LLW and MW

In 2003, the LLW and MW were characterized by WGS for the following waste stream categories:

- Correction Action Unit (CAU) 407, Tonopah Test Range (TTR) Solid Soil
- Area 25 Reactor Maintenance, Assembly and Disassembly (R-MAD) Decontamination Facility Waste
- Sealed Sources
- Radioactive Material
- Compactible Trash

8.1.3.2 Disposal of LLW and MW

In FY 2003, the Area 5 RWMS received shipments containing 34,631 m^3 (45,295 yd^3) of LLW for disposal. The Area 3 RWMS received shipments containing 57,108 m^3 (74,694 yd^3) of LLW. The majority of disposed LLW was shipped from offsite. A total of only 871 m^3 (1,139 yd^3) of LLW disposed in 2003 were generated onsite.

In FY 2003, the Area 5 RWMS disposed of only 0.37 m^3 (0.48 yd^3) of MW at Pit 3 Mixed Waste Disposal Unit (P03U).

8.1.3.3 TRU Waste Operations

In 2003, TRU wastes stored at the TPCB continued to be characterized, visually inspected, repackaged, loaded, and shipped for disposal to the WIPP site.

8.1.3.4 Maintenance of Key Documents

In 2003, the following key documents were maintained, created, or revised:

- NTS Waste Acceptance Criteria, Revision 5, October 2003
- This document was revised in October to incorporate the transition of the RWMC from a Radiological Facility to a Category II Nuclear Facility.
- Disposal Authorization Statement for Area 5 RWMS, December 2000
- Disposal Authorization Statement for Area 3 RWMS, October 1999
- Performance Assessment for Area 5 RWMS, Revision 2.1, January 1998
- Composite Analysis for Area 5 RWMS, February 2000
- Performance Assessment/Composite Analysis for Area 3 RWMS, Revision 2.1, October 2000
- Integrated Closure and Monitoring Plan for the Area 3 and 5 RWMSs, September 2001

- Documented Safety Analysis (DSA) for the NTS Area 5 RWMC, Revision 0, October 2002
- DSA for the NTS Area 3 RWMS, Revision 0, April 2003
- The above two DSA documents were prepared to replace the ASA for the Area 3 and 5 RWMSs, August 2000 as a consequence of the transition to a Category II Nuclear Facility.
- Technical Safety Requirements (TSRs) for the Area 5 RWMC LLW Activities, Revision 2, April 2003
- TSR for the Area 5 RWMC TRU Waste Activities, Revision 2, April 2003
- TSR for the Area 3 RWMS, Revision 0, April 2003
- The above three TSR documents were prepared to implement the new DSAs.

8.1.3.5 Assessments

Self-assessments were conducted monthly at the RWMC.

8.1.3.6 Environmental Monitoring

Groundwater samples were collected and analyzed from wells UE5 PW-1, UE5 PW-2, and UE5 PW-3 at the Area 5 RWMS. None of the water samples had detectable levels of tritium or of other radionuclides that would be present in the LLW or MW within the site's disposal cells. The reader is directed to Section 3.1.3 where 2003 water analysis results are presented for all groundwater monitoring wells.

All VZM conducted in 2003 for the RWMC continued to demonstrate that there is negligible infiltration of precipitation into zones of buried waste at the RWMC and that the performance criteria of the waste disposal cells are being met to prevent contamination of groundwater and the environment. A few components of the VZM monitoring program implemented in 2003 are presented below. For more details on the program refer to the NTS 2002 Waste Management Monitoring Report Area 3 and Area 5 Radioactive Waste Management Sites (BN, 2003).

8.1.3.6.1 Area 3 RWMS Drainage Lysimeter Facility

In December 2000, a Drainage Lysimeter Facility was constructed approximately 15 m (50 ft) northwest of the closed U-3ax/bl disposal unit at the Area 3 RWMS. The facility consists of eight cylindrical drainage lysimeters. Each lysimeter is 3.1 m (10.0 ft) in diameter and 2.4 m (8.0 ft) deep and has been filled with the same native soil used to cap the closed disposal unit. Each lysimeter is instrumented with an array of eight Time Domain Reflectometry (TDR) sensors to measure soil water content and eight heat dissipation probe (HDP) sensors to measure soil water potential and temperature. The facility is also used to evaluate the effectiveness of different surface treatments of monolayer-evapotranspiration covers to retard the infiltration of precipitation. Different surface treatments, including bare (no vegetation), invasive plant species, and native vegetation (seeded), have been dedicated to pairs of lysimeters.

In 2003, an automated irrigation system was constructed and deployed over the southern portion of four lysimeters (B, D, F, and H) to apply double the volume of natural rainfall events. By effectively inducing three times natural precipitation, shallow subsurface responses under a scenario of climate change will be assessed. Lysimeters E and F were reseeded in late 2002. Subsequently, they were periodically watered from late January through April 2003 to facilitate the establishment of the seedlings. These seedlings did not establish in the spring because of drought in the region. Therefore, additional efforts to reseed the two lysimeters were conducted in November 2003.

The data acquired to date at this facility indicate that the vegetated lysimeters remain much drier than the bare soil lysimeters, indicating that even limited densities of vegetation are effective in removing water from the shallow subsurface.

8.1.3.6.2 Area 5 RWMS Weighing Lysimeter Facility

A Weighing Lysimeter Facility, comprised of two precision lysimeters, was constructed in 1993-94 approximately 400 m (1,300 ft) southwest of the Area 5 RWMS. Each lysimeter consists of a steel box that is 2.0 m (6.6 ft) deep and has a surface area of 2.0 m x 4.0 m (6.6 ft x 13.1 ft). Both lysimeters were filled with the same native soil used to construct operational covers and closure caps at the Area 5 RWMS. Both lysimeters are mounted on sensitive scales, with the weight of each lysimeter being continuously monitored using an electronic loadcell. Each lysimeter was initially instrumented with ten thermocouple psychrometers (TCPs) for soil temperature measurements and with eight TDRs. Data from the TCPs proved to be problematic as they only provided reliable data within a limited pressure range. Data acquisition from the TCPs ceased after a lightning strike permanently damaged the TCP logging system in July 1999. Subsequently, HDPs were installed in June 2001 as more reliable sensors. The TDRs installed in 1993-94 were three-wire prototypes that required extensive processing of the raw data waveforms. This resulted in intensive data management and processing and ultimately provided unreliable data over time. Processing of the waveforms from these TDRs was terminated in 2002.

The north lysimeter is vegetated with native plant species at the approximate density (i.e., canopy cover) of the surrounding desert (~15 percent canopy cover). The south lysimeter is kept bare to simulate the bare operational waste covers at the Area 5 RWMS. The facility has been in continuous operation since its inception in 1994 and has provided data to support the assumptions made in the PA and CA for each RWMS and to justify other NTS closure covers (DOE, 2000b and c).

Data acquired from the lysimeters indicate that water is efficiently removed from each lysimeter, but also that the vegetated lysimeter is considerably drier than the bare-soil lysimeter despite the paucity of plants in the vegetated lysimeter. No drainage has ever been observed from either lysimeter indicating that precipation does not percolate to the bottom lysimeters. All precipitation is either evaporated, transpired by plants, or stored in the top 2 m (6.6 ft) of soil.

8.1.3.6.3 Area 5 RWMS Automated Monitoring

Since late 1998, continuous monitoring of the waste cell covers and floors at the Area 5 RWMS using automated data-acquisition systems has been conducted. Instrumentation and sensors, including over 50 TDRs and 16 thermistors, have been deployed to continuously monitor the floor and operational cover of Pit 3 (P03U), the floor and operational cover of Pit 5 (P05U), and the cover of Pit 4 (P04U). Due to operational requirements, the data leads to the sensors in the floor of Pit 3 were cut in January 2002.

The Area 5 RWMS automated VZM indicates that groundwater recharge is not occurring under current climatic conditions and that no water from precipitation is percolating to the waste zone. No water movement was observed in the floor of Pit 5 and no wetting fronts percolated below 1.5 m (4.9 ft) in the operational covers.

8.1.3.6.4 RWMS Supplemental Automated Monitoring

Additional automated data-acquisition stations are maintained to provide ancillary data in the support of the more direct monitoring of RWMS disposal units and the lysimeters in Areas 3 and 5. These stations include meteorological towers that continuously measure precipitation, air temperature, humidity, wind, solar radiation, and additional parameters. Data are also obtained from a flume north of the Area 3 RWMS and one northwest of the Area 5 RWMS for assessing, in part, the potential for surface water runoff near the RWMSs. An automated system has also been deployed within a subsidence crater in Area 3 (U3-bw) to study the potential for infiltration into the underlying chimney.

8.2 Hazardous Waste Management

Non-radioactive hazardous wastes (HW) regulated under RCRA are generated at the NTS from a broad range of activities including onsite laboratories, paint shops, vehicle maintenance, communications and photo operations, and environmental restoration of historic contaminated sites (see Section 8.3 below). All non-radioactive HW are presently transported to approved offsite RCRA HW treatment, storage, and disposal facilities. Nevada has issued a RCRA Hazardous Waste Operating Permit to NNSA/NSO for operation of the Hazardous Waste Storage Unit

(HWSU) in Area 5. The permit allows NNSA/NSO to store non-radioactive HW in containers on a pad designed for the safe storage of wastes that have been generated at the NTS. The HWSU is a pre-fabricated, rigid steel framed, roofed shelter which is permitted to store a maximum of 61,600 liters (16,280 gallons) of approved waste at a time. Non-radioactive HW generated at BN restoration sites off the NTS (e.g., at TTR) or generated at the North Las Vegas facility are direct-shipped to approved disposal facilities.

The RCRA Hazardous Waste Operating Permit also covers operations at the Explosive Ordnance Disposal Unit in Area 11. Conventional explosive wastes are generated at the NTS from tunnel operations, the NTS firing range, the resident national laboratories, and other activities. The permit allows NNSA/NSO to treat explosive ordnance wastes, which are hazardous wastes as defined under 40 Code of Federal Regulations (CFR) (Sections 261.21, 261.23, 261.24, and 261.33), by open detonation in a specially constructed and managed area designed for the safe and effective treatment of explosive HW. The permit allows a maximum of 45.4 kg (100 lbs) of approved waste to be detonated at a time, not to exceed one detonation event per hour.

The RCRA Hazardous Waste Operating Permit also covers the disposal of mixed wastes generated from NTS activities (such as environmental remediation) at the Pit 3 Mixed Waste Disposal Unit located at the Area 5 RWMS.

The amounts of waste managed at each of these three permitted units are tracked and reported to the state in quarterly reports. NNSA/NSO pays fees to the state based on the number of tons of waste managed.

In 2003, a total of 529.3 metric tons (mtons) (583 tons) of non-radioactive HW were managed on the NTS, and most (518.9 mtons [572 tons]) of this waste came from cleanup activities at environmental remediation sites (see Section 8.3 below). Much of the wastes generated from NTS cleanup activities, however, were bulk shipments (i.e., dump trucks, rolloff boxes) which were direct-shipped from their point-of-generation. The HWSU only manages packaged (non-bulk) hazardous waste. Table 8-1 shows the mtons (tons) of non-radioactive HW which came to the HWSU, were temporarily stored there, and then shipped offsite in 2003. The table also shows the quantities of waste disposed of at the two permitted disposal units in 2003. The weight of wastes managed at each unit per quarter were reported to the state. No HW storage or disposal limits were exceeded in 2003.

Table 8-1. Hazardous waste stored or disposed at the NTS in 2003

Permitted Unit	Waste Managed
Hazardous Waste Storage Unit	23.46 mtons (25.86 tons)
Explosive Ordnance Disposal Unit	0 kg
Pit 3 Mixed Waste Disposal Unit (P03U)	0.37 m^3 (0.48 yd^3)

8.3 Underground Storage Tank (USTs) Management

By 1998, the NTS UST program met all regulatory compliance schedules for the reporting, upgrading, or removal of documented USTs. The NNSA/NSO operates one deferred UST and three excluded USTs at the Device Assembly Facility. The NNSA/NSO also maintains a fully-regulated UST at the Area 6 helicopter pad which is not in service.

8.4 Environmental Restoration - Remediation of Historic Contaminated Sites

8.4.1 Program Goal

In April 1996, the DOE, DoD, and the state of Nevada entered into a Federal Facilities Agreement and Consent Order (FFACO) to address the environmental restoration of historic contaminated sites at the NTS, parts of TTR, parts of the Nellis Air Force Range (now known as the Nevada Test and Training Range [NTTR], the Central Nevada Test Area, and the Project Shoal Area. These sites, known as Corrective Action Sites (CASs), may be contaminated with both radioactive and non-radioactive wastes. Appendix VI of the FFACO describes the strategy that will be employed to plan, implement, and complete environmental corrective actions at facilities where nuclear-related operations were conducted. Stoller-Navarro Joint Venture conducts site characterization activities, while BN Environmental Restoration conducts site remediation.

8.4.2 Description of Operations

8.4.2.1 Corrective Action Strategy

The corrective action strategy is based on four steps: (1) identifying the CASs, (2) grouping the CASs into CAUs, (3) prioritizing the CAUs for funding and work, and (4) implementing the corrective action investigations (CAIs) and/or corrective actions, as applicable. CASs are broadly organized into the following four categories based on the source of contamination:

- Industrial Sites – CASs located on the NTS and TTR where activities were conducted that supported nuclear testing activities
- Underground Test Area (UGTA) Sites – CASs located where most underground nuclear test have resulted or might result in local or regional impacts to groundwater resources
- Soil Sites – CASs where tests have resulted in extensive surface and/or shallow subsurface contamination
- Nevada Off-Sites – Additional CASs associated with underground nuclear testing at the Project Shoal Area and the Central Nevada Test Area located in northern and central Nevada, respectively

Identifying CASs – The first step in the strategy is to identify CASs potentially requiring CAIs and/or corrective actions. As CASs are identified, a literature search may be completed and each CAS is verified on aerial photographs or in the field to confirm its condition and location. A data repository has been created containing or referencing all information currently available for each CAS.

Grouping CASs into CAUs – A CAU may have several CASs or only one. In addition to the four categories noted above, criteria for grouping CASs into CAUs include the following:

- Potential source of contamination
- Agency responsible for cleanup of the CAS
- Function of the CAS, and therefore, the nature of the contamination
- Geographic proximity of CASs to one another
- Potential for investigation or cleanup of grouped CASs to be accomplished within a similar time frame

Implementing Correction Action Investigations and/or Corrective Actions – When a CAU is assigned priority and funding, environmental restoration activities follow a formal work process beginning with a Data Quality Objectives (DQO) meeting between the NNSA/NSO, the Defense Threat Reduction Agency, NDEP, and contractors. The DQO process is a strategic planning approach based on the scientific method used to plan data collection activities to ensure that the data collected will provide sufficient and reliable information to identify, evaluate, and technically defend the recommended corrective actions. If existing information about the nature and extent of contamination at the CASs in question is insufficient to evaluate and select preferred corrective actions, a CAI will be conducted. A Corrective Action Investigation Plan (CAIP) is prepared that provides a conceptual model of the site and defines how the site is to be characterized in conformance with the DQO process.

Site characterization is carried out in the field and documented in a Corrective Action Decision Document (CADD). This document provides the information that either confirms the conceptual model or modifies it. If suitable information is available to make a decision, a remedial alternative is selected from several alternatives identified for analysis that best provides site closure. In some instances, additional site characterization may be required before the CADD can be prepared.

If a site requires remediation, a Corrective Action Plan (CAP) is prepared that provides the necessary design and other information on the method of remediation. A CAP includes the proposed methods to be used to close a site, quality control measures, waste management strategy, design drawings (when appropriate), verification sampling strategies (for clean closures), and other information necessary to perform the closure. Some sites also require a Post Closure Plan as the site or parts of the site are closed in place. Information on inspections and monitoring are provided in an Annual Post Closure Monitoring Report.

Once the closure has been completed, a Closure Report is prepared. This report provides information on the work performed, results of verification sampling, as-built drawings, waste management, etc. Some sites are closed under the Streamlined Approach for Environmental Restoration (SAFER) process. These sites typically have suitable information available and can be remediated under a shorter schedule. A SAFER plan is prepared providing the methods to be used to close the site. After closure, a SAFER closure report is prepared that documents the work performed.

The NDEP is a participant throughout the remediation process. The Community Advisory Board is also kept informed by NNSA/NSO of the progress made. The Board's comments are strongly considered before final prioritization of corrective actions. In addition, a public participation working group made up of representatives from DOE, DoD, the State of Nevada, and the Community Advisory Board meets twice each year to discuss upcoming environmental restoration activities and the level of public involvement required. These meetings focus on the quarterly progress reports and priority-setting activities established under the FFACO.

8.4.2.2 Post-Closure Monitoring and Inspections

There are nine sites on the NTS for which remediation was indicated or completed under RCRA regulations prior to enactment of the FFACO. Eight have been closed and are referred to as historic RCRA closure units. For the ninth site, the Area 5 Retired Mixed Waste Pits and Trenches, NDEP has determined that NNSO/NSA shall close the site (in the future) subject to the conditions of 40 CFR 265.310. Three of the eight RCRA closure units require no further post-closure monitoring (Area 23 Building 650 Leachfield, Area 6 Steam Cleaning Effluent Ponds, and Area 2 U-2bu Subsidence Crater). Two of the eight closed units require periodic site inspections only (Area 2 Bitcutter Containment, Area 6 Decon Pond), and three require post-closure inspections as well as VZM. These three sites and the methods of VZM required by state permit are:

CAU 91, Area 3 U-3fi Injection Well – Neutron logging of the ER-3-3 Borehole will be conducted and analyzed quarterly. Annual reports of Post-Closure Monitoring and Inspections shall include monthly precipitation data and be issued to the NDEP by the last day of February each reporting year. VZM will be conducted to detect statistically significant changes in raw neutron counts exceeding an action level of 200 counts in the residual raw neutron count. Data analysis will be based on the calculated residual raw neutron counts, obtained by subtracting the first year average (baseline values) raw neutron count from the quarterly raw neutron count on a depth basis within the regulated interval of 73.1 meters (240 feet) to 82.3 meters (270 feet) below ground surface.

CAU 110, U-3ax/bl Subsidence Crater – Post-closure inspections will be done on a quarterly basis and will consist of visual observations to check that the cover is intact. The U-3ax/bl Subsidence Crater cover is designed to limit infiltration into the disposal unit and is monitored using TDR soil water content sensors buried at various depths within the waste cover to provide water content profile data. The soil water content profile data is used to demonstrate whether the cover is performing as expected.

CAU 112, Area 23 Hazardous Waste Trenches – Soil moisture monitoring shall be collected and analyzed biannually (January and July) and site inspections shall be conducted quarterly. Soil moisture data shall be obtained from 30 neutron access tubes specified in the permit. Annual reports of post-closure monitoring shall include monthly precipitation data for the reporting period and shall be submitted to NDEP by the last day of January.

8.4.3 2003 Activities and Status

8.4.3.1 Corrective Actions

Table 8-2 lists all CAUs for which some step of the site remediation process was completed in calendar year 2003. All 2003 milestones were met. A total of 81 CASs were closed, either under the SAFER process or the standard closure process. For DOE UGTA CAUs, 2003 milestones included field well sampling, well development, model development, and data documentation and evaluations (Table 8-2).

Table 8-2. Environmental restoration activities conducted in 2003

CAU	CAU Description	Number of CASs	Milestone	Due Date	Date Submitted
		DTRA Industrial Sites			
475	Area 12 P-Tunnel Muckpile	1	CAIP	9/30/2003	2/19/2003
478	Area 12 T-Tunnel Ponds	1	CAIP	9/30/2003	2/27/2003
480	Area 12 N-Tunnel Ponds	1	CAIP	9/30/2003	2/26/2003
482	Area 15 U15a/e Muckpiles and Ponds	3	CADD	9/30/2003	9/22/2003
		DTRA/DOE - Industrial Sites			
383	Area 12 E-Tunnel Sites	3	CAIP	1/30/2004	12/22/2003
		DOE Industrial Sites			
322	Areas 1 & 3 Release Sites and Injection Wells	3	CAIP	7/21/2003	7/16/2003
335	Area 6 Injection Well and Drain Pit	3	Closure Report	8/29/2003	8/5/2003
346	Areas 8, 10 Housekeeping Sites	14	Closure Report	9/30/2003	9/5/2003
350	Miscellaneous Housekeeping Sites	8	Closure Report	6/30/2003	6/13/2003
351	Areas 16, 18, 29, 30 Housekeeping Sites	13	Closure Report	8/29/2003	7/31/2003
352	Areas 19, 20 Housekeeping Sites	21	Closure Report	5/30/2003	5/27/2003
355	Area 2 Cellars/Mud Pits	15	SAFER Plan	1/31/2003	1/10/2003
			Closure Report	8/31/2004	11/20/2003
357	Mud Pits and Waste Dump	14	SAFER Plan	6/30/2003	6/25/2003
394	Areas 12, 18, and 29 Spill/Release Sites	6	Closure Report	9/30/2003	9/26/2003
396	Area 20 Spill Sites	4	SAFER Plan	4/30/2003	4/17/2003
536	Area 3 Release Site	1	CAIP	7/21/2003	6/26/2003
5	Landfills	8	CADD	10/31/2003	10/24/2003
113	Area 25 R-MAD Facility	1	Closure Report	4/30/2003	4/22/2003
127	Areas 25 and 26 Storage Tanks	12	CADD	9/30/2003	9/26/2003
140	Waste Dumps, Burn Pits, and Storage Area	9	CADD	11/28/2003	10/14/2003
165	Area 25 and 26 Dry Well and Washdown Areas	8	CADD	4/30/2003	4/17/2003
168	Area 25 and 26 Contaminated Materials and Waste Dumps	12	CADD	9/30/2003	8/7/2003
176	Areas 5, 6, and 11 Housekeeping Sites	9	Closure Report	4/30/2003	4/17/2003
214	Bunkers and Storage Areas	9	CAIP	5/30/2003	5/16/2003
262	Area 25 Septic Systems and UDP	9	Closure Report	5/30/2003	5/14/2003

Table 8-2. (continued)

CAU	CAU Description	Number of CASs	Milestone	Due Date	Date Submitted
		DOE Industrial Sites, cont.			
271	Areas 25, 26, and 27 Septic Systems	15	CAP	6/30/2003	6/13/2003
330	Areas 6, 22, and 23 Tanks and Spill Sites	4	Closure Report	9/30/2003	8/8/2003
398	Area 25 Spill Sites	13	Closure Report	2/28/2003	2/21/2003
410	Waste Disposal Trenches (TTR)	5	Closure Report		12/22/2003
			CADD	12/30/2003	12/22/2003
425	Area 9 Main Lake Construction Debris Disposal Area (TTR)	1	Closure Report	4/1/2003	2/21/2003
490	Station 44 Burn Area (TTR)	4	Closure Report	4/30/2003	4/17/2003
516	Septic Systems and Discharge Points	6	CAIP	5/30/2003	5/8/2003
523	Housekeeping Waste	15	Closure Report	12/31/2003	12/2/2003
528	Polychlorinated Biphenyls Contamination	1	CAIP	6/30/2003	5/16/2003
529	Area 25 Contaminated Materials	1	CAIP	4/30/2003	3/6/2003
		DOE UGTA Sites			
97	Yucca Flat/Climax Mine	720	Submit draft Contaminant Boundary Phase I Modeling Approach/Strategy	4/30/2004	3/18/2003
			Initiate well development, testing & sampling activities in Yucca Flat	7/31/2003	4/24/2003
			Complete the resurvey of measuring points in Yucca Flat to improve accuracy of previous measurements	9/30/2003	9/5/2003
98	Frenchman Flat	10	Complete well development and aquifer testing activities in Frenchman Flat	9/30/2003	9/18/2003
99	Rainier/Shoshone	66	Initiate Value of Information Analysis	12/31/2003	12/3/2003
101	Central Pahute Mesa	64	Submit draft Phase I Hydrologic Data Documentation Package	7/31/2003	4/3/2003
102	Western Pahute Mesa	18	Submit draft Phase I Hydrologic Data Documentation Package	7/31/2003	4/3/2003
			Submit draft Phase I Hydrologic Data Documentation Package	7/31/2003	4/3/2003

8.4.3.2 Post-Closure Monitoring and Inspections

All required VZM and inspections of closed sites were conducted in 2003 as specified by RCRA permit or by each site's closure report. VZM results for the RCRA closure sites CAU 91, CAU 110, and CAU 112 indicated that surface water is not migrating into buried wastes. VZM reports were submitted to the state prior to their due dates.

A list of all sites at which physical inspections were conducted in 2003 included:

CAU 90 Area 2 Bitcutter Containment
CAU 91 Area 3 U-3fi Injection Well
CAU 92 Area 6 Decon Pond Facility
CAU 110 Area 3 U-3ax/bl Subsidence Crater
CAU 112 Area 23 Hazardous Waste Trenches
CAU 143 Area 25 Contaminated Waste Dumps
CAU 261 Area 25 Test Cell A Leachfield System
CAU 333 U-3auS Disposal Site
CAU 339 Area 12 Fleet Operations Steam Cleaning Effluent
CAU 342 Mercury Fire Training Pit
CAU 400 Bomblet Pit and Five Points Landfill (TTR)
CAU 404 Roller Coaster Lagoons and Trench (TTR)
CAU 407 Roller Coaster RadSafe Area (TTR)
CAU 417 Central Nevada Test Area -Surface
CAU 424 Area 3 Landfill Complexes (TTR)
CAU 426 Cactus Spring Waste Trenches (TTR)
CAU 427 Area 3 Septic Waste Systems 2, 6 (TTR)

8.5 Solid/Sanitary Waste Management

8.5.1 Description of Operations

The NTS has three landfills for solid waste disposal which are regulated and permitted by the state (see Table 1-12 for list of permits). No liquids, hazardous waste, or radioactive waste are accepted in these landfills. They include:

- Area 6 Hydrocarbon Disposal Site – accepts hydrocarbon-contaminated wastes, such as soil and absorbents.
- Area 9 U10c Solid Waste Disposal Site – designated for industrial waste such as construction and demolition debris.
- Area 23 Solid Waste Disposal Site – accepts municipal-type wastes such as food waste and office waste. Regulated asbestos-containing material is also permitted in a special section. The permit allows disposal of no more than an average of 20 tons/day at this site.

These landfills are designed, constructed, operated, maintained, and monitored in adherence to the requirements of their state-issued permits. The Nevada Department of Environmental Protection visually inspects the landfills and checks the records on an annual basis to ensure compliance with the permits.

The NTS also has three state-permitted sewage lagoons that receive domestic wastewater (sanitary waste) as well as industrial discharges. The names of these sewage lagoon systems are:

- Area 6 Yucca Lake
- Area 12 Camp
- Area 23 Mercury

These sewage lagoons are operated by BN Waste Management, as are the solid waste landfills. The operations and monitoring requirements for these sewage lagoons, however, are specified by Nevada water pollution control regulations. Because of this, the discussion of their operations and monitoring of their water and sediments are presented in Section 3.2.4, within the section on non-radiological water monitoring.

A groundwater monitoring well in Area 23 called SM-23-1 is monitored periodically under Nevada permit requirements for both the Area 23 Solid Waste Disposal Site and the Area 23 Mercury sewage lagoons. The purpose of monitoring is to demonstrate that waste from these systems is not reaching the groundwater. Well SM-23-1 is monitored once every five years for the Area 23 Solid Waste Disposal Site and once a year for the Area 23 Mercury sewage lagoons.

The vadose zone (unsaturated zone of soil above the water table) is monitored at two of the permitted sanitary landfills: the Area 9 U10c Solid Waste Disposal Site and the Area 6 Hydrocarbon Disposal Site. This monitoring is performed in lieu of groundwater monitoring for the purpose of demonstrating that contaminants from the landfills are not leaching into the groundwater. Semiannual reports with the monitoring data, rainfall data, and conclusions are sent to the state, as specified in the landfill permits.

8.5.2 2003 Activities

The amount of waste disposed of in each solid waste landfill is shown in Table 8-3. An average of 4 tons/day was disposed at the Area 23 landfill, well within permit limits. State inspections of permitted landfills were conducted in February 2003. No compliance issues were noted.

Table 8-3. Quantity of solid wastes disposed in NTS landfills in CY 2003

Metric Tons (Tons) of Waste		
Area 6 Hydrocarbon Disposal Site	**Area 9 U10c Solid Waste Disposal Site**	**Area 23 Solid Waste Disposal Site**
5,439 (5,995)	13,190 (14,540)	1,460 (1,609)

Water from well SM-23-1 was last sampled in 2002 for the purpose of monitoring the Area 23 Solid Waste Disposal Site, and is not scheduled for sampling again until 2007. This well was sampled, however, in 2003 to satisfy permit requirements for the Area 23 Mercury sewage lagoons (see Sections 3.1.3.4 and 3.2.4.1.3).

VZM of the Area 6 and Area 9 landfills in 2003 indicated that there was no soil moisture migration, and therefore no waste leachate migration to the water table.

The following reports were prepared in 2003 to comply with state permits for solid waste operations on the NTS:

- *Biannual Neutron Monitoring Report for the Nevada Test Site Area 9 10c and Area 6 Hydrocarbon Landfills*
- *January – June 2003 Biannual Solid Waste Disposal Site Report for the Nevada Test Site Area 23 Sanitary Landfill*
- *July – December 2003 Biannual Solid Waste Disposal Site Report for The Nevada Test Site Area 23 Sanitary Landfill*
- *2003 Annual Solid Waste Disposal Site Report for the Nevada Test Site Area 6 Hydrocarbon Landfill and Area 9 U10c Landfills*

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9.0 Hazardous Materials Control and Management

Hazardous materials used or stored on the Nevada Test Site (NTS) are controlled and managed through the use of a Hazardous Substance Inventory database. Bechtel Nevada (BN) and all other U.S. Department of Energy, National Nuclear Security Administration (NNSA/NSO) subcontractors who use or store hazardous materials utilize this database and are required to comply with the operational and reporting requirements of the Toxic Substances Control Act (TSCA); Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); the Emergency Planning and Community Right-to-Know Act (EPCRA); and the Nevada Chemical Catastrophe Act (see Section 1.5). This section describes the 2003 activities which were conducted on the NTS to control and manage hazardous materials.

9.1 Goals and Compliance Measures

Requirements and responsibilities for the use and management of hazardous/toxic chemicals are provided in company documents. The goal is to minimize the adverse effects of improper use, storage or management of hazardous/toxic chemicals and ensure compliance with applicable state and federal regulations. The following reports/assessment activities are prepared/performed to document compliance with these regulations:

- Use of Hazardous Substance Inventory database
- Annual TSCA report
- FIFRA management assessments
- Annual EPCRA Toxic Release Inventory (TRI) Report, Form R
- Nevada Combined Agency Report
- Nevada Division of Environmental Protection (NDEP)-Chemical Accident Prevention Program (CAPP) Annual Registration Form
- Use of electronic hazardous material tracking database called HAZTRAK

9.2 Methods and 2003 Activities

Chemicals to be purchased are subject to a requisition compliance review process. BN's Environmental Compliance Department personnel review each chemical purchase to ensure that restricted chemicals are not purchased when less hazardous chemical substitutes are commercially available.

9.2.1 TSCA Program

The TSCA program consists mainly of properly characterizing, storing and disposing of various polychlorinated biphenyl (PCB) wastes generated through remediation and maintenance activities. The remediation waste is generated by BN and Stoller-Navarro Joint Venture at Corrective Action Sites during environmental restoration activities (see Section 8.4) and during maintenance activities and building decontamination and decommissioning activities performed by BN. These activities can generate PCB contaminated fluids and bulk product waste containing PCBs. There are no known pieces of PCB-containing equipment on the NTS.

On May 22, 2003, an Annual Report was sent from NNSA/NSO to U.S. Environmental Protection Agency (EPA) Region IX which reported the quantity of hydraulic oil containing PCBs that were generated during a site remediation project and were disposed of offsite during 2002.

In 2003 during remediation activities at the Reactor Maintenance, Assembly and Disassembly Building in Area 25, PCB oil was discovered in a hydraulic system. The hydraulic oil was drained into twelve 55-gallon drums and shipped offsite for disposal. No other PCB materials were generated by remediation or site operations in 2003. On March 22, 2004, an Annual Report was generated for calendar year 2003, but was not sent to outside regulators.

There were no TSCA inspections by outside regulators performed at the NTS in 2003.

9.2.2 FIFRA Program

On the NTS, both registered and non-registered pesticides are applied under the direction of a state of Nevada certified applicator. This service is provided by BN Solid Waste Operations, which manages the FIFRA program. The following procedures are followed to ensure FIFRA compliance: (1) requisitions for purchases of restricted use pesticides are screened, (2) operating procedures for handling, storing and application of pesticide products are reviewed, (3) appropriate Commercial Category (Industrial) certification for the application of restricted use pesticides is maintained, and (4) facility inspections for unauthorized pesticide storage/use are conducted. Pesticide applications in food service facilities are subcontracted to state-certified vendors.

In 2003, no restricted use pesticides were purchased. Formulations purchased in prior years that became restricted use in 2003, were applied to eliminate these items from the pesticide inventory. The Solid Waste Operations procedure for pesticide application was updated in 2003, and training was provided to affected personnel. Certifications were kept current in 2003 for Industrial Category application(s) of restricted use pesticides. Facility inspections were conducted in Area 6, Area 23, Area 12 and Area 25 and indicated that there were no restricted use pesticides being used or stored in violation of federal/state requirements. There was no FIFRA inspection by an outside regulator during 2003.

9.2.3 EPCRA Program

In response to the EPCRA requirements, all chemicals that are purchased are entered into a hazardous substance inventory database and assigned specific hazard classifications (e.g., corrosive liquid, flammable, diesel fuel). Annually, this database is updated to show the maximum amount of chemicals that was present in each building at all of the NTS facilities. This information is then used to complete the Nevada Combined Agency (NCA) Report. This report provides the state, community, and local emergency planning commissions with the maximum amount of any chemical, based on its hazard classification, present at any given time during the preceding year. This report also provides the commissions with new chemicals or chemical classes that were not previously on site. The State Fire Marshall then issues a permit to store hazardous chemicals to each facility.

In 2003, the chemical inventory at NTS facilities was updated and submitted to the state in the NCA Report on March 5, 2004. No extremely hazardous substance (EHS) was present at any NTS facilities in quantities that were reportable to the state. No accidental or unplanned release of an EHS occurred on the NTS in 2003.

The hazardous substance inventory database is also used to complete the TRI Report, Form R. This report provides EPA and the State Emergency Response Commission information on any toxic chemical that enters the environment above a given threshold. It also provides these agencies with the amounts of toxic chemicals that are recycled. NNSA/NSO submitted this report for calendar year 2003 to EPA on June 23, 2004. Lead was the only listed toxic chemical released into the environment in 2003 that was reportable. The source is lead ammunition used at the Mercury firing range. A total of 1.95 tons (1.77 mtons) of lead was released at the firing range.

There were no EPCRA inspections by outside regulators performed at the NTS in 2003.

HAZTRAK is a tracking system that monitors hazardous materials while they are in transit. When a truck transporting hazardous material enters the NTS, all information concerning the load is entered into the tracking system. Once the delivery is complete, the information provided at the time of entry is removed from the tracking system.

9.2.4 Nevada Chemical Catastrophe Prevention Act

If EHSs are stored in quantities which exceed threshold quantities established by the NDEP, then NNSA/NSO submits a report notifying the state. During 2003, 3,192 kg (7,037 lbs) of oleum was stored and 1,154 kg (2,545 lbs) were released at the HSC in Area 5 as part of a planned chemical release test. These quantities exceed the CAPP threshold for oleum of 454 kg (1,000 lbs) and was reported in the NDEP-CAPP Annual Registration Form submitted to NDEP on July 15, 2004.

10.0 Pollution Prevention and Waste Minimization

The U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) Pollution Prevention (P2) and Waste Minimization (WM) initiatives establish a process to reduce the volume and toxicity of waste generated by the NNSA/NSO and ensure that proposed methods of treatment, storage, and disposal of waste minimize potential threats to human health and the environment. These initiatives also address the requirements of several federal and state regulations applicable to operations on the Nevada Test Site (NTS) (see Section 1.7). The following information provides an overview of the P2/WM goals, major accomplishments during the reporting year, a comparison of the current year's waste generation to prior years, a description of efforts undertaken during the year to reduce the volume and toxicity of waste generated by the NNSA/NSO, and a description of the Secretary of Energy's P2 Goals and NNSA/NSO's status towards reaching those goals.

10.1 P2 and WM Goals and Components

It is the priority of NNSA/NSO to minimize the generation, release, and disposal of pollutants to the environment by implementing cost-effective P2 technologies, practices, and policies. A commitment to P2 minimizes the impact on the environment, improves the safety of operations, improves energy efficiency, and promotes the sustainable use of natural resources. This commitment includes providing adequate administrative and financial materials on a continuing basis to ensure goals are achieved.

Source Reduction – When economically feasible, source reduction is the preferred method of handling waste, followed by reuse and recycling, treatment, and as a last resort, landfill disposal. NNSA/NSO's Integrated Safety Management System requires that every project address waste minimization issues during the planning phase and ensure that adequate funds are allocated to perform any identified waste minimization activities.

To minimize the generation of waste, project managers are required to incorporate waste minimization into the planning phase of their projects. Waste generating processes must be assessed to determine if the waste can be economically reduced or eliminated. Waste minimization activities that are determined to be cost effective should be incorporated into the project plan and adequate funding allocated to ensure their implementation.

Recycling – For wastes that have already been generated, an aggressive recycling program is maintained. Items recycled through the NNSA/NSO recycling program include paper, cardboard, aluminum cans, toner cartridges, inkjet cartridges, tires, used oil, food waste from the cafeteria, plastic, scrap metal, rechargeable batteries, lead-acid batteries, alkaline batteries, fluorescent light bulbs, mercury lamps, metal hydride lamps, sodium lamps, and electronic media (diskettes, audio and video tapes, backup tapes, reel-to-reel tapes, etc.).

An effective method for reuse is the coordination of the Material Exchange Program. Created in 1998, the Material Exchange Program has diverted over 184 metric tons (mtons) (202.8 tons) of supplies, chemicals, and equipment from landfills. Unwanted chemicals, supplies, and equipment are made available through electronic mail or postings on the intranet Material Exchange Database so that individuals in need can obtain the items at no cost. These materials are destined for disposal, either as solid or hazardous waste, as a result of process modification, discontinued use, or shelf life expiration. Rather than disposing of these items, the majority of them are provided to other employees for their intended purpose, thus avoiding disposal costs and costs for new purchases. If items are not placed with another user, they can be returned to the vendor for recycle/reuse, or given to other U.S. Department of Energy (DOE) sites, other government agencies, or local schools.

As required by Resource Conservation and Recovery Act (RCRA), Section 42 USC 6962, the NNSA/NSO maintains an Affirmative Procurement process that stimulates a market for recycled content products and closes the loop on recycling. RCRA section 42 USC 6962 requires the U.S. Environmental Protection Agency (EPA) to develop a list of items containing recycled materials that should be purchased. The EPA is also required to determine what the minimum content of recycled material should be for each item. Once this EPA-designated list was developed, federal facilities were required to ensure that a process was in place for purchasing the EPA-designated items containing the minimum content of recycled materials. Executive Order (EO) 13101 "Greening the Government through Waste Prevention, Recycling and Federal Acquisition" went one step further and requires federal facilities to ensure that 100 percent of purchases of items from the EPA-designated list contain recycled materials at the specified minimum content. Of the items NNSA/NSO currently purchases from the EPA-designated list, about 86 percent of those purchases contain recycled materials.

Assessments – Pollution Prevention Assessments are conducted twice a year. These assessments look at facilities or processes throughout the complex and focus on what waste streams are generated, what waste minimization activities are practiced, if there is room for improvement, and if these activities are tracked and reported in order to document that a waste minimization program is in place and operating as required. The assessments also look for new P2 opportunities.

Employee and Public Awareness – The NNSA/NSO P2 and WM initiatives also include an employee and public awareness program. Awareness of P2/WM issues is accomplished by dissemination of articles through both electronic mail and the NNSA/NSO site newsletters, the maintenance of a P2/WM intranet website, employee training courses, and participation at employee and community events. These activities are intended to increase awareness of P2/WM and environmental issues and point out the importance of P2/WM for improving environmental conditions in the workplace and community.

10.2 Major P2/WM Accomplishments in 2003

- Decommissioned buildings destined for disassembly and disposal were donated or sold to other agencies/schools that disassemble and remove the buildings from the NTS for reuse at new offsite locations. This waste minimization effort diverted approximately 11.4 mtons (12.6 tons) of waste from the NTS landfills.
- Corrective Action Unit (CAU) 271 – Environmental Restoration segregated 39.7 mtons (43.8 tons) of clean soil from soil impacted by hydrocarbons or PCBs, using the clean soil as backfill for the excavation.
- The Explosive Ordnance Disposal Unit (EODU) transferred 1.02 mtons (1.1 tons) of old explosives, destined for treatment/disposal, to the Counter Terrorism Operations Support (CTOS) group for use in training exercises.
- The Bechtel Nevada (BN) Payroll Department began posting pay stub information on the intranet, eliminating the need to print pay stubs on check stock and mail them to employees. This effort keeps approximately 1.1 mtons (1.2 tons) of check stock annually from ending up in local landfills.
- The Bulk Fuel Facility in Area 23 was demolished in February, 2003. The facility, which had not been used for years, consisted of two 500,000 gallon (1,893 m^3) above-ground storage tanks, associated piping, pumps, and a fuel stand. The tanks were cut into pieces and sold to a metal recycling company, saving about 400 cubic yards (306 m^3) of landfill space.
- Environmental Restoration recycled 21.3 mtons (47,000 pounds) of radioactively contaminated lead solids via the DOE Oak Ridge Office (DOE/ORO) Assets Utilization Program.
- The Material Exchange Program reused 2.34 mtons (2.58 tons) of solid waste and 0.03 mtons (0.033 tons) of hazardous waste in 2003.
- During 2003, BN Engineering has aided water conservation by specifying low flow fixtures in restrooms/showers for ten facilities (nine new and one renovation) which included dormitories, shops, offices, and a classroom building. Energy conservation was aided by replacing failed exterior insulation on two existing buildings at the NTS. In planning for a more active role in future projects, Engineering issued procedure OP-CENG.012, Sustainable Design, on May 23, 2003. This procedure provides a process to apply sustainable design principles to the siting, design, and construction of new facilities (buildings and infrastructure). Additionally, a BN employee was appointed as a point of contact for the Engineering Practices Working Group for participation in the U.S. Green Building Council Leadership in Energy and Environmental Design (LEED) program. Future projects currently under consideration for design under the LEED program are new facilities for the TA-18 Project, replacement of the Mercury and Area 6 Fire Stations at the NTS, and modifications to Buildings B3 and A1 in Las Vegas.

10.3 Waste Generation in 2003 Compared To Prior Years

For the purpose of comparison, the waste generation activities are presented in two source categories: routine waste and cleanup waste. Routine waste is operational waste generated from routine activities, both ongoing and new. Cleanup waste is waste generated from clean-up activities including investigation, site characterization, remediation from Environmental Restoration (ER) projects, and Deactivation and Disposal projects.

Table 10-1 compares radioactive waste generated on site in calendar year (CY) 2003 with prior years. NNSA/NSO has not routinely generated radioactive waste, except for an occasional one-time generation. With the addition of the JASPER and ATLAS Projects, routine radioactive waste will be generated in the future. Clean-up radioactive waste has increased since 2000 due to an accelerated clean-up schedule for ER and D&D projects.

Table 10-1. Volume of radioactive waste generated by year

	Radioactive Waste Generated (m^3)[(a)]		
Calendar Year	**Routine**	**Clean-up**	**Total**
2003	0.23	647.2	647.4
2002	0	1,270.3	1,270.3
2001	0	354.4	354.1
2000	0.46	67.1	67.6

(a) m^3 = Cubic meters; 1 m^3 = 1.3 cubic yards (yd^3)

Routine hazardous waste fluctuated slightly up and down over the past three years (Table 10-2). Clean-up hazardous waste has increased, primarily due to the accelerated clean-up schedule for ER and D&D projects.

Table 10-2. Mass of hazardous waste generated by year

	Hazardous Waste Generated (mtons)[(a)]		
Calendar Year	**Routine**	**Clean-up**	**Total**
2003	10.4	518.9	529.3
2002	7.0	127.5	134.5
2001	10.2	1.6	11.8
2000	24.5	22.5	47.0

(a) 1 mton = 1.1 ton

Routine solid waste has shown an increase over the past three years (Table 10-3), mainly due to an increase of routine solid waste generated by new projects and an accelerated clean-up schedule. Solid clean-up wastes have increased, primarily due to the accelerated clean-up schedule for ER and D&D projects.

Table 10-3. Mass of solid waste generated by year

	Solid Waste Generated (mtons)[(a)]		
Calendar Year	**Routine**	**Clean-up**	**Total**
2003	4,502	16,975	21,477
2002	3,305	14,006	17,311
2001	1,622	8,145	9,767
2000	4,401	4,381	8,782

(a) 1 mton = 1.1 ton

10.4 Waste Reductions in 2003 Compared To Prior Years

P2/WM techniques and practices are implemented for all activities that may generate waste. These P2/WM activities result in reductions to the volume and/or toxicity of waste actually generated on site. Table 10-4 compares the amounts of radioactive, hazardous, and solid wastes reduced in CY 2003 to prior years.

Table 10-4. Volume of waste reduced through P2/WM activities by year

Calendar Year	Radioactive Waste Reduced (m^3)[(a)]	Hazardous Waste Reduced (mtons)[(b)]	Solid Waste Reduced (mtons)
2003	40.0	207.3	1,547.2
2002	63.2	177.2	904.2
2001	79.6	123.5	799.0

(a) 1 m^3 = 1.3 yd^3

(b) 1 mton = 1.1 ton

Table 10-5 shows a summary of the estimated volume reductions of radioactive, hazardous, and solid waste accomplished during CY 2003, through implementation of P2/WM activities. An estimated 52.3 yd^3 (40 m^3) reduction of radioactive waste; a 228 ton (207 mton) reduction of hazardous waste including RCRA, Toxic Substance Control Act, and state-regulated hazardous waste; and a 1,705 ton (1,547 mton) reduction of solid waste (sanitary waste) occurred in CY 2003.

Table 10-5. Volume of waste reduced through P2/WM activities in 2003

Waste Minimization Activity	Activity	Volume Reduction
Radioactive Waste		**(m^3)[(a)]**
Recycle/Reuse	ER recycled 47,000 (21.3 mtons) pounds of radioactively contaminated lead solids via DOE/ORO Assets Utilization Program.	**40**
Hazardous Waste		**(mtons)[(b)]**
Source Reduction	CAU 271 – ER segregated 87,524 pounds (39.7 mtons) of clean soil from soil impacted by hydrocarbons or PCBs, using the clean soil as backfill for the excavation.	39.7
Recycle/Reuse	Bulk used oil was sent to an offsite vendor for recycle.	134.8
Recycle/Reuse	Lead scrap metal was sold for reuse/recycle.	18.6
Recycle/Reuse	Lead acid batteries were shipped to an offsite vendor for recycle.	9.1
Recycle/Reuse	Spent fluorescent light bulbs, mercury lamps, metal hydride lamps, and sodium lamps were sent to an offsite vendor for recycle.	3
Recycle/Reuse	The EODU transferred 2,260 pounds (1 mton) of old explosives, destined for treatment/disposal, to the CTOS group for use in training exercises.	1
Recycle/Reuse	Lead tire weights were reused instead of being disposed as hazardous waste.	0.9
Recycle/Reuse	Rechargeable batteries were sent to an offsite vendor for recycle.	0.1
Recycle/Reuse	Hazardous chemicals were relocated to new users through the Material Exchange program, diverting them from landfill disposal.	0.1
Total		**207.3**

Table 10-5. (continued)

Waste Minimization Activity	Activity	Volume Reduction
Solid Waste		**(mtons)[(b)]**
Recycle/Reuse	Scrap ferrous metal was sold to a vendor for recycle.	748.4
Recycle/Reuse	Mixed paper and cardboard was sent offsite for recycle.	562.2
Recycle/Reuse	Scrap non-ferrous metal was sold to a vendor for recycle.	108.1
Recycle/Reuse	Food waste from the cafeterias was sent offsite to be reused as pig feed for a local pig farmer.	62.5
Recycle/Reuse	Shipping materials including pallets, styrofoam, bubble wrap, and shipping containers were reused.	27.9
Recycle/Reuse	Tires were sent to a vendor for recycle.	19.9
Recycle/Reuse	Decommissioned buildings destined for disassembly and disposal were donated or sold to other agencies/schools that disassemble and remove the buildings from the site for reuse.	11.4
Recycle/Reuse	Non-hazardous chemicals, equipment, and supplies were relocated to new users through the Material Exchange program, diverting them from landfill disposal.	2.3
Recycle/Reuse	Spent toner cartridges were sent offsite for recycle.	2.1
Recycle/Reuse	Aluminum cans were sent offsite for recycle.	0.9
Recycle/Reuse	Electronic media was sent offsite for recycle.	0.7
Recycle/Reuse	Alkaline batteries were sent to a vendor for recycle.	0.5
Recycle/Reuse	Number 1 Plastic was sent offsite for recycle.	0.3
Total		**1,547.20**

(a) 1 m^3 = 1.3 yd^3

(b) 1 mton = 1.1 ton

10.5 Secretary of Energy's P2/WM Leadership Goals

On November 12, 1999, the Secretary of Energy set numerous pollution prevention and energy efficiency goals that each DOE Site is required to meet. The following are the P2/WM goals:

- Reduce waste from routine operations by 2005, using a 1993 baseline, for the following waste types:
  - Hazardous by 90 percent
  - Low Level Radioactive by 80 percent
  - Low Level Mixed Radioactive by 80 percent
  - Transuranic (TRU) by 80 percent
- Reduce solid waste from routine operations by 75 percent by 2005 and 80 percent by 2010, using a 1993 baseline.
- Reduce releases of toxic chemicals subject to Toxic Chemical Release Inventory (TRI) reporting by 90 percent by 2005, using a 1993 baseline.
- Reduce waste resulting from cleanup, stabilization, and decommissioning activities by 10 percent on an annual basis.
- Recycle 45 percent of solid waste from all operations by 2005 and 50 percent by 2010.
- Increase purchases of EPA-designated items with recycled content to 100 percent, except when not available competitively at a reasonable price or if items do not meet performance standards.

NNSA/NSO generated 11.5 tons (10.4 mtons) of hazardous waste in CY 2003 as part of routine operations. Using the 1993 baseline of 4,105 tons (3,724 mtons), NNSA/NSO reduced hazardous waste by 99.6 percent. Therefore, NNSA/NSO has already met the 2005 goal of 90 percent. The 1993 baselines for low level radioactive, low level mixed radioactive, and TRU waste were all 0 m^3. However, the new JASPER and ATLAS projects will generate routine radioactive wastes in the future. As long as these projects generate routine radioactive waste, NNSA/NSO will not be able to meet the goals for these waste types.

The routine solid waste generated by the NNSA/NSO in CY 2003 was 4,963 tons (4,502 mtons). Using the 1993 baseline of 15,140 tons (13,735 mtons), NNSA/NSO reduced solid waste by 68 percent during CY 2003. The 2005 goal is 75 percent.

In 1993, NNSA/NSO released 0 pounds of chemicals subject to TRI reporting into the environment. Effective January 1, 2001, the EPA lowered the reporting threshold for lead. With this lower threshold limit, NNSA/NSO had releases of lead generated from lead bullets at the Wackenhut Services, Inc. (WSI) firing range that now have to be reported. NNSA/NSO will not be able to meet the TRI release goal as long as the WSI firing range continues to use lead bullets. In CY 2003, 1.95 tons (1.77 metric tons) of lead were released at the firing range.

The NNSA/NSO generated 19,998 tons (18,142 mtons) of radioactive, hazardous, and solid waste from cleanup operations at the NTS. Additionally, 1,065 tons (966 mtons) were recycled, amounting to 5 percent reduction in cleanup waste. The goal for recycling all cleanup waste is 10 percent annually. The low percentage of waste recycled is mainly due to large volumes of wastes generated by ER projects and wastes associated with the D&D projects that get disposed at the NTS landfills.

In CY 2003, the solid waste generated by all operations (routine and cleanup activities) was 23,674 tons (21,477 mtons). NNSA/NSO recycled 1,705 tons (1,547 mtons) of solid waste, or about 7 percent of the solid waste generated. The 2005 goal is 45 percent. Almost 18,739 tons (17,000 mtons) of solid waste were generated due to the accelerated cleanup schedule at the NTS where numerous buildings were decommissioned and dismantled. The majority of this D&D waste was disposed at the solid waste landfill at the NTS, inflating the waste generation totals and lowering the percentage of solid waste recycled.

EO13101 requires that 100 percent of purchases of items found on the EPA-designated list be purchased containing recycled materials. In CY 2003, 86 percent of NNSA/NSO's purchases of EPA-designated items contained recycled materials.

The tabulated summary of NTS progress towards meeting these leadership goals, as discussed above, are presented in Chapter 1.0, Compliance Summary (Table 1-7b).

11.0 Historic Preservation and Cultural Resources Management

U.S. Department of Energy (DOE) Order 450.1 "*Environmental Protection Program*," requires cultural resources compliance and monitoring for activities and programs conducted at the Nevada Test Site (NTS) (see Section 1.8). The Cultural Resources Management (CRM) program has been established and is implemented by the Desert Research Institute (DRI) on the NTS to meet this requirement. The CRM program is designed to:

- Ensure compliance with all regulations pertaining to cultural resources on the NTS
- Inventory and manage cultural resources on the NTS
- Provide information that can be used to evaluate the potential impacts of proposed projects and programs to cultural resources on the NTS

In order to achieve these goals and meet federal and state requirements, the CRM is multi-faceted and contains the following major components: (1) surveys, inventories, and historical evaluations, (2) curation of archaeological collections; and (3) the American Indian Program. The guidance for the CRM work is provided in the *Cultural Resources Management Plan for the Nevada Test Site* (Drollinger et al., 2002). Historic preservation personnel and archaeologists of DRI who meet the Secretary of the Interior standards conduct the work and the archaeological efforts are permitted under the Archeological Resources Protection Act (ARPA).

11.1 Cultural Resources Surveys, Inventories, Historic Evaluations, and Associated Activities

11.1.1 Goals and Compliance Measures

Cultural resources surveys are conducted at the NTS to meet the requirements of the National Historic Preservation Act (NHPA) and the ARPA. The surveys are completed prior to proposed projects that may disturb or otherwise alter the environment. The following information is maintained in databases:

- Number of cultural resources surveys conducted
- Location of each survey
- Number of acres surveyed at each project location
- Types of cultural resources identified at each project location
- Number of cultural resources determined eligible to the National Register of Historic Places (NRHP)
- Number of eligible properties avoided by project activities
- Number of cultural resources requiring mitigation to address an adverse effect
- Final report on results

11.1.2 Methods

The geographical scope of a project is determined before surveys, inventories, or historical evaluations proceed. After the location and the size of the area have been defined, archival research is conducted to obtain relevant background data to guide the development of a research design for the cultural resources work. Relevant data include the results of previous cultural resources surveys, known sites, historic information, and individuals with knowledge of prior activities in the area and, in the case of historic evaluations, building plans and maps. Some of the sources investigated are the DRI records for the NTS, the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) Nuclear Testing Archive, the Technical Library, and Archives and Records Center.

Generally, for field surveys of project areas, the archaeologists walk parallel pedestrian transects at 30-m (98-ft) intervals over the entire project area. Data are recorded on forms to be analyzed and evaluated after completion of the fieldwork. Data collected for cultural resources surveys and inventories are the dimensions of the area, environmental setting (geology, geomorphology, and botany), and existing construction (e.g., roads, power poles, etc.). When cultural resources are identified, information on each is recorded and includes the location of the resource, the size of the resource area, the type of resource, types of artifacts (when applicable), and a detailed description. Mapping is done with hand-held global positioning units, electronic distance measurers, and other measuring devices, such as measuring tapes and calipers. For evaluations of historic structures, buildings, or objects, the layout of the structure is mapped and an architectural description is prepared. Photographs of the resources are taken at the time of survey.

After the fieldwork, the data are organized, analyzed and then put into a report format. Cultural resources site information is entered on Intermountain Antiquities Site Forms and maps are drawn of the sites. At that time, decisions are made regarding the significance of the cultural resources and statements are included regarding whether or not the cultural resource meets the eligibility requirements for the NRHP. If an eligible site or structure is within or adjacent to a proposed project location, the effort is made to relocate the project away from the site, so that the project will not impact the resource. When a project cannot be relocated and will impact an eligible site or structure, then it usually is determined that the project will have an adverse effect on the resource. This information is presented in the report. Data management activities involve entering the survey and cultural resources information into a Geographical Information System. The final report is sent to the Nevada State Historic Preservation Office (SHPO) for review and concurrence.

A determination of adverse effect requires preparation and implementation of a mitigation plan in consultation with the SHPO and the Advisory Council on Historic Preservation. Mitigation actions vary and for archaeological sites often include systematic collection of artifacts, excavation and detailed recording of the site area, and consultation with the Consolidated Group of Tribal Organizations. The results of the work are detailed in a technical report. For structures, consultation also includes the National Park Service and mitigation normally involves preparing Historic American Building Survey and Historic American Engineering Record documentation.

11.1.3 Results

Cultural Resources Surveys – In 2003, three surveys were conducted for proposed projects: Phoebus 1A Arc and Kiwi Transient Nuclear Test Arc Project Areas, the Soil Stabilization Demonstration Project Area, and the Horned Viper Project Areas. Seven prehistoric archaeological sites were located within these project areas. During earlier surveys, three of these sites had been determined eligible to the National Register and the site forms for these sites were updated with current information. One new site was identified and determined eligible to the National Register and three did not meet the eligibility requirements. The eligible sites were avoided by project activities.

A cultural resources survey and monitoring effort was conducted at the location of the Egg Point Wildfire in Area 12. Most of the fire zone had been surveyed several years ago. The area that was not surveyed was examined for cultural resources and no new sites were located by this effort. The fire was near or crossed six known National Register eligible sites. All six prehistoric archaeology sites are intact and retain their integrity. Another prehistoric archaeology site, previously determined ineligible for the National Register, was relocated. As a result of the removal of the vegetation, more of the site was visible and it was re-evaluated and determined eligible to the National Register.

Cultural Resources Inventories – There were two cultural resources inventories conducted in 2003. The ongoing survey and inventory of the prehistoric and historic remains at Tippipah Spring continued in 2003, and the survey of the historic nuclear testing structures on Yucca Dry Lake was completed. A Yucca Lake Historic District was proposed for National Register eligibility. The district contains 22 structures and 8 features with 15 of these properties contributing to the district.

Evaluations of Historic Structures – Two historic evaluations were conducted in 2003. Kay Blockhouse, the instrumentation bunker for the first atmospheric test at the NTS had previously been determined ineligible to the National Register. The location was re-examined and re-evaluated and its status has been changed to a property eligible to the National Register. The train cars at the Radioactive Material Storage Facility were evaluated for eligibility. These cars were used in the nuclear rocket testing program from the late 1950s to early 1970s and some contain superstructures designed specifically for the tests. The facility and the cars were determined eligible to the National Register.

As summarized in Table 11-1, a total of 1,487 hectares (3,674 acres) were examined during cultural resources surveys, inventories, and historic evaluations. Thirteen prehistoric and historic sites were examined, with four eligible to the National Register. Twenty-three nuclear testing related structures were recorded, with one determined eligible and 15 contributing to a historic district.

Table 11-1. Summary data for cultural resources surveys, inventories, and historic evaluations conducted in 2003

Survey/Inventory/Historic Evaluation	Prehistoric/Historic Sites Found	Structures Evaluated	Sites Determined NRHP Eligible	Area Surveyed	
				Acres	Hectares
Phoebus and Kiwi	4	0	2	200.00	80.94
Soil Stabilization	0	0	0	13.10	5.30
Horned Viper	1	0	0	123.60	50.02
Egg Point Wildfire	6	0	1	85.05	34.42
Tippipah Spring	1	0	1	50.00	20.23
Yucca Lake HD	0	22	15	3,060.00	1,238.34
Kay Blockhouse	0	1	1	0.05	0.02
Train Cars	1	0	0	142.00	57.47
Total	13	23	20	3,673.80	1,486.73

Adverse Effect Assessments and Mitigation Activities – There were no determinations of adverse effect to cultural resources in 2003. No mitigation activities were undertaken or were in progress.

Results from Other Cultural Resources Activities – General reconnaissance surveys, without systematic field recording, were also conducted in 2003 for three projects. They included one well location, several Corrective Action Sites (CASs), and NTS buildings no longer used and scheduled for demolition. The well location was near the historic mining town of Wahmonie. It was determined through a field examination of the area that the well and associated activities were within a previously-disturbed zone for which a cultural resources survey report had been prepared in the 1990s. Numerous CASs have been identified on the NTS for remediation or cleanup and some of these have historical value. Descriptions and photographs of proposed CASs were reviewed and some warranted field examination. After a visual examination of the areas, several were determined to have historic value related to nuclear testing and to be left in place for future recording efforts. Buildings proposed for demolition or removal were visited and photographed with historic evaluation work pending for several. Also, the technical report on the Bower Cabin was finalized.

11.1.4 Reports

Four survey and monitoring reports, two historical evaluations, two technical reports, and two letter reports were completed and are listed in Table 11-2. Site location information is protected from public distribution and those reports containing such data are not available to the public. Technical reports can be obtained from the DOE's Office of Scientific and Technical Information at email address <http://www.osti.gov/bridge>.

The data on NTS archaeological activities also were provided to DOE Headquarters in the formal Archeology Questionnaire for transmittal to the Secretary of the Interior and, ultimately, the U.S. Congress as part of the federal agency archaeology report.

Table 11-2. Short reports, historical evaluations, technical reports, and letter reports prepared in 2003

Project	Report No.	Author(s)
Phoebus 1A Arc and Kiwi Transient Nuclear Test Arc	SR060903-1	Drollinger H. and B.A. Holz 2003
Soil Stabilization Demonstration	SR070903-1	Jones R.C. 2003b
Horned Viper	SR102703-1	Jones, R.C. 2003d
Egg Point Wildfire Near Tongue Wash	SR032703-1	Holz, B.A. and C.M. Beck 2003
Yucca Lake Historic District	TR# 102	Jones, R.C., C.M. Beck, and B.A. Holz 2003
Historical Evaluation of Kay Blockhouse	SR030703-1	Jones, R.C. 2003a
Historical Evaluation of Train Cars	SR052003-1	Drollinger, H. 2003a
Bower Cabin	TR# 100	Drollinger, H. 2003b
Horn Silver Mine Drilling Project	LR100603-1	Jones R.C. 2003c
Corrective Action Sites	LK110603-1	Holz, B.A., C.M. Beck, and H. Drollinger 2003

11.2 Curation

11.2.1 Goals and Requirements

The NHPA requires that archaeological collections and associated records be maintained at professional standards and the specific requirements are delineated in 36 Code of Feder Regulations (CFR) Part 79, Curation of federally-owned and Administered Archeological Collections. Requirements for curation of the NTS archaeological collection include the following:

- Maintain a catalog of the items in the NTS collection
- Package the NTS collection in materials that meet archival standards (e.g., acid-free boxes)
- Store the NTS collection and records in a facility that is secure and has environmental controls
- Establish and follow curation procedures for the NTS collection and facility
- Comply with the Native American Graves Protection and Repatriation Act

11.2.2 Ongoing Activities

In the 1990s, the NNSA/NSO completed the required inventory and summary of NTS cultural materials accessioned into the NTS Archaeological Collection and distributed the inventory list and summary to the tribes affiliated with the NTS and adjacent lands. Consultations followed, and all artifacts the tribes requested were repatriated to the American Indian tribal groups. This process was completed in 2002, but will be repeated for any new additions to the NTS collection in the future. The known locations of American Indian human remains at the NTS continued to be protected from NTS activities in 2003.

The NTS Archaeological Collection contains over 400,000 artifacts and is curated in accordance with 36 CFR Part 79. For the past decade these materials and the associated records have been housed in a remote facility. In 2003, the artifacts were moved into a newly constructed building that provides additional security and environmental controls for the collection. Archaeologists, American Indians, NNSA/NSO personnel, and facilities staff worked on the move from the remote facility to the new building. The boxes of artifacts were logged in and out of the facilities and the move was accomplished without incident. Following the relocation of the artifacts, a draft of new curation procedures was completed and distributed for review.

11.3 American Indian Program

11.3.1 Goals

The NNSA/NSO has had an active American Indian Program since the late 1980s. The function of the program is to conduct consultations between NNSA/NSO and NTS-affiliated American Indian tribes. Such consultation occurs through the Consolidated Group of Tribes and Organizations (CGTO). The CGTO is comprised of 16 groups of Southern Paiute, Western Shoshone, and Owens Valley Paiute-Shoshone, and one Pan-Indian organization: the Las Vegas Indian Center (see Table 11-3 for a list of participants in the CGTO). A history of this program is contained in *American Indians and the Nevada Test Site, A Model of Research and Consultation* (Stoffle et al., 2001). The goals of the program are to:

- Provide a forum of the CGTO to express and discuss issues of importance
- Provide the CGTO with opportunities to actively participate in decisions that involve places and locations that hold significance for them
- Involve the CGTO in the curation and display of American Indian artifacts
- Enable the CGTO and its constituency to practice their religious and traditional activities

Table 11-3. Culturally affiliated tribes and organizations in the CGTO

Ethnic Group	Tribe/Band
Southern Paiute	Chemehuevi Indian Tribe Colorado River Indian Tribes Kaibab Paiute Tribe Las Vegas Paiute Tribe Moapa Paiute Tribe Paiute Indian Tribe of Utah Pahrump Band of Paiutes
Western Shoshone	Duckwater Shoshone Tribe Ely Shoshone Tribe Timbisha Shoshone Tribe Yomba Shoshone Tribe
Owens Valley Paiute-Shoshone	Benton Paiute-Shoshone Tribe Big Pine Paiute Tribe Bishop Paiute Tribe Fort Independence Indian Tribe Lone Pine Paiute-Shoshone Tribe
Pan-Indian Organization	Las Vegas Indian Center

11.3.2 2003 Activities

In May 2003, a 2.5-day meeting was held with the CGTO at the NTS. Discussion topics at the meeting focused on American Indian history research, artifacts, site treatments, Traditional Cultural Properties, and the NTS Historical Foundation and Museum. The recommendations reached at the meeting included continuance of research on American Indian history, decisions regarding the handling and display of artifacts, concurrence with the handling of sites near activities, development of a Traditional Cultural Property study, and the creation of a sub-group to meet with the Atomic Testing Museum (ATM) staff to work towards creating an American Indian exhibit based on CGTO input. One day of the meeting was spent visiting areas of interest as Traditional Cultural Properties. Also discussed was the impending move of the NTS artifact collection to a new facility and the preference to have involvement in this move.

The Museum Sub-Group met twice with the director and exhibit planners for the ATM regarding exhibit content. Work on this project will continue into 2004 with consultation between the Museum and the sub-group until the exhibit design is finalized. The artifact collection was moved with involvement from the CGTO. Requests were made by American Indians to conduct ceremonies and these requests were honored by NNSA/NSO.

12.0 Ecological Monitoring

U.S. Department of Energy (DOE) Order 450.1 "*Environmental Protection Program,*" requires ecological monitoring and biological compliance support for activities and programs conducted at the Nevada Test Site (NTS). The Ecological Monitoring and Compliance Program (EMAC) provides this support. EMAC is designed to:

- Ensure compliance with all state and federal regulations (see Section 1.9) and stakeholder commitments pertaining to NTS flora, fauna, and sensitive vegetation and wildlife habitats including wetlands
- Delineate NTS ecosystems
- Provide ecological information that can be used to evaluate the potential impacts of proposed projects and programs on NTS ecosystems

The major sub-programs and tasks within EMAC include: (1) the Desert Tortoise Compliance Program, (2) biological surveys at proposed construction sites, (3) ecosystem mapping and data management, (4) monitoring of sensitive species and habitats, (5) the Habitat Restoration Program, and (6) biological impact monitoring at the Hazardous Materials Spill Center (HSC). A brief description of these program components and their 2003 accomplishments are provided below, and more detailed information may be found in published fiscal year EMAC reports which are distributed to several state and federal natural resource agencies (e.g., Bechtel [BN], 2003). These annual reports are available electronically at <http://www.osti.gov/bridge>.

12.1 Desert Tortoise Compliance Program

The desert tortoise occurs within the southern one-third of the NTS at fairly low estimated densities (Figure 12-1). This species is listed as threatened under the Endangered Species Act. In December 1995, U.S. Department of Energy, National Nuclear Security Administration Site Office (NNSA/NSO) completed consultation with the U.S. Fish and Wildlife Service (FWS) concerning the effects of NNSA/NSO activities on the desert tortoise, as described in the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE, 1996). A final Biological Opinion (Opinion) (FWS, 1996) was received from the FWS in August 1996. The Opinion concluded that the proposed activities on the NTS were not likely to jeopardize the continued existence of the Mojave population of the species and that no critical habitat would be destroyed or adversely modified. All terms and conditions listed in the Opinion must be followed when activities are conducted within the range of the desert tortoise on the NTS.

12.1.1 Goals and Compliance Measures

The Desert Tortoise Program within EMAC was developed to implement the terms and conditions of the Opinion, to document compliance actions taken by NNSA/NSO, and to assist NNSA/NSO in FWS consultations. The compliance measures which are monitored include:

- Number of tortoises accidentally injured or killed due to NTS activities
- Number of tortoises captured and displaced from project sites
- Number of tortoises injured or killed on NTS paved roads
- Number of total acres of desert tortoise habitat disturbed by NTS construction
- Adherence to 23 operational terms and conditions of the Opinion

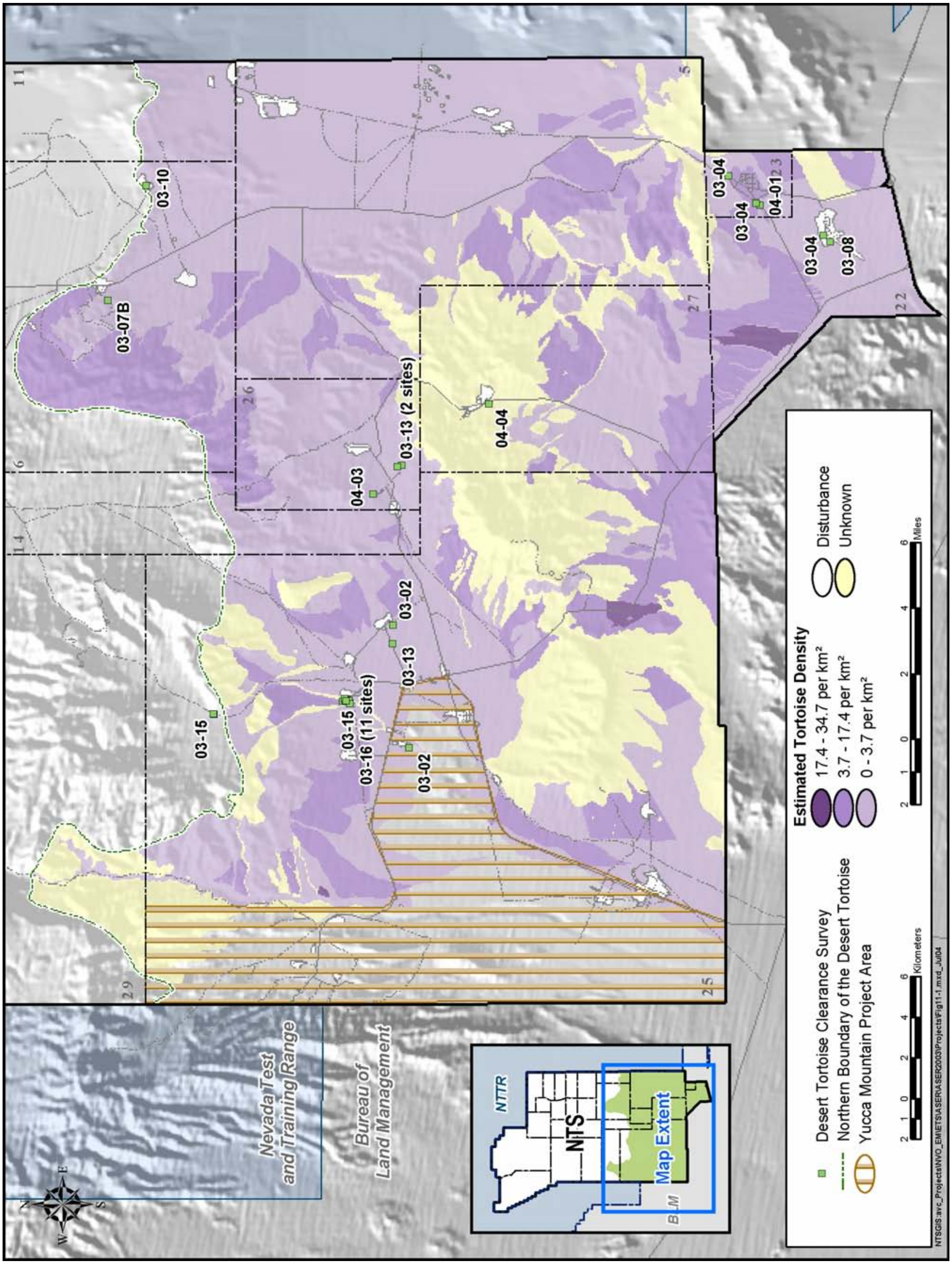

Figure 12-1. Desert tortoise distribution and abundance on the NTS and locations of clearance surveys conducted in 2003

12.1.2 Methods

Proposed projects on the NTS are subjected to a National Environmental Policy Act (NEPA) review process. If a proposed project may disturb native vegetation, soils, or wildlife, biologists are informed of the project. Biologists conduct desert tortoise clearance surveys prior to construction for all projects that will disturb desert tortoise habitat. They follow written survey procedures which incorporate those terms and conditions of the Opinion that must be performed by qualified biologists. A database is maintained to document survey results and compliance to the Opinion's terms and conditions.

Biologists train one or more onsite project personnel to become an environmental monitor (EM) as specified by the Opinion. EMs monitor the land-disturbing activities at a project site and document that the project is complying with the Opinion.

Biologists estimate the acreage of tortoise habitat disturbed by each project by conducting post-activity surveys. Post-activity surveys are not conducted if viable tortoise habitat is not found within the project area boundaries during the clearance survey and if the EM documents that the project stayed within its proposed boundaries. Hand-held global positioning satellite (GPS) units are used to record the field coordinates defining the boundary of all disturbed areas and then Geographic Information System (GIS) computer software is used to calculate the acres disturbed.

12.1.3 Results

In 2003, biologists conducted desert tortoise clearance surveys at 27 sites for 11 proposed projects (Table 12-1; see Figure 12-1). One inactive tortoise burrow was found and flagged (Project Number 03-10). The flagged tortoise burrow was avoided during surface disturbing activities. Five tortoise burrows were observed and avoided during surveys for off-road driving for Project 03-16. On-site construction monitoring was conducted by a designated EM at all sites, where required.

Table 12-1. Land-disturbing projects conducted in desert tortoise habitat in 2003

Project Number	Project Name	Tortoise Sign Found	Tortoise Habitat Disturbed	
			Acres	Hectares
03-02	Area 25 Septic Systems and Underground Discharge Point Closure (CAU 262) (2 sites)	None	0.35	0.14
03-04	Areas 6, 22, 23 Tanks and Spill Sites Closure (CAU 330) (3 sites)	None	1.51	0.61
03-07b	Turnaround for Building Demolition	None	0.09	0.04
03-08	Area 22 Desert Rock Runway Lighting System Renovation	None	0.17	0.07
03-10	Cleanup of Old WSI Firing Range	1 inactive burrow	0	0
03-13	Cleanup of R-MAD Yard and Port Gaston (3 sites)	None	0	0
03-15	Cleanup of Topopah Wash Military Firing Range (2 sites)	None	0	0
03-16	Characterization of Area 25 Contaminated Wash and Land Parcels (CAU 259) (11 sites)	5 tortoise burrows avoided along off-road routes	0.97	0.39
04-01	Jackass Flats Road Barbed Wire Cleanup	None	0.005	0.002
04-03	Characterization at Horn Silver Mine	None	0.50	0.20
04-04	Clean Closure of Areas 25, 26, and 27 Septic Systems (CAU 271)	None	TBD	TBD
	Total		**3.59**	**1.45**

Post-activity surveys to quantify the acreage of tortoise habitat actually disturbed were conducted for seven projects at a total of twelve sites. Only 1.45 hectares (3.59 acres) of tortoise habitat were disturbed in 2003 (Table 12-1). No desert tortoises were accidentally injured or killed, nor were any captured or displaced from project sites. A cumulative total of 88.1 hectares (217.71 acres) of tortoise habitat on the NTS has been disturbed since the desert tortoise was listed as threatened in 1992. A mitigation fee for the loss of 101 hectares (250 acres) of habitat was prepaid in 1992 into the Desert Tortoise Habitat Conservation Fund Number 236-8290. During 2003, none of the threshold levels established by the FWS for the compliance measures listed above were exceeded (see Table 1-9).

In January 2004, NNSA/NSO Environment, Safety and Health Division submitted a report to the FWS Southern Nevada Field Office that summarized tortoise compliance activities conducted on the NTS from January 1 through December 31, 2003.

12.1.4 Other Significant Activities Related to Desert Tortoise Compliance

Field Sampling to Update NTS Tortoise Abundance Map – The Opinion includes a tortoise abundance map which delineates areas of none-to-very-low, low, and moderate tortoise abundance based on the results of past transect surveys. As per the Opinion, tortoise clearance surveys and onsite construction monitoring are optional in none-to-very-low abundance areas, but are required in areas of higher or unknown tortoise abundance. The Opinion allows for updates of this map as better data become available. During August, biologists began to sample areas of unknown tortoise abundance. Twenty-eight transects totaling 54.8 km (34.0 mi) were sampled (BN, 2003).

Preparation of Habitat Revegetation Plan for Tortoise Habitat – Mitigation for the loss of tortoise habitat is required under the terms and conditions of the Opinion. The Opinion requires either payment for habitat disturbed or the revegetation of disturbed habitat. Since 1992, NNSA/NSO has been using the balance of $81,000 that NNSA/NSO pre-paid for the future disturbance of 101 hectares (250 acres) of tortoise habitat on the NTS. This fund is almost depleted. In 2003, biologists developed a plan to revegetate tortoise habitat whenever it is reasonable and prudent. This plan was submitted to the FWS for concurrence.

12.2 Biological Surveys

12.2.1 Goals and Compliance Measures

Biological surveys are performed at proposed project sites where land disturbance will occur. The goal is to minimize adverse effects of land disturbance on wetlands, sensitive plant and animal species and their associated habitat, and on important biological resources (i.e., nest sites, active burrows). Biological surveys comply with the terms and conditions of the Opinion and with the mitigation measures specified in the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE, 1996) and its final Record of Decision.

Sensitive species include those protected under state or federal regulations which are known or suspected to occur on the NTS. They include 22 plants and 34 animals (Tables 12-2, 12-3, and 12-4). Important biological resources include such things as cover sites, nest or burrow sites, roost sites, wetlands, or water sources important to sensitive species.

The following measures are documented:

- Number of biological surveys conducted
- Number of hectares/acres surveyed per proposed project
- Types and numbers of important species and biological resources found
- Mitigation recommendations and actions taken to protect species/resources

Table 12-2. Sensitive plants which are known to occur on or adjacent to the NTS

Flowering Plant Species	**Common Name**	**Status[(a)]**
Arctomecon merriamii	White bearpoppy	SOC, W, IA
Astragalus beatleyae	Beatley's milkvetch	SOC , W, A
Astragalus funereus	Black woolypod	SOC, W, A
Astragalus oopherus var. *clokeyanus*	Clokey's egg milkvetch	SOC, W, A
Camissonia megalantha	Cane Spring suncup	SOC, W, IA
Cymopterus ripleyi	Ripley's springparsley	SOC, W, IA
Eriogonum concinnum	Darin's buckwheat	W, A
Eriogonum heermannii var. *clokeyi*	Clokey's buckwheat	W, A
Frasera albicaulis var. *modocensis*	Modoc elkweed	SOC, W, IA
Galium hilendiae ssp. *kingstonense*	Kingston Mountain bedstraw	SOC, W, IA
Hulsea vestita ssp. *inyoensis*	Inyo hulsea	W, IA
Ivesia arizonica var. *saxosa*	Whitefeather ivesia	W, A
Lathyrus hitchcockianus	Hitchcock's peavine	W, A
Penstemon pahutensis	Pahute penstemon	SOC, W, IA
Phacelia beatleyae	Beatley's phacelia	SOC , W, A
Phacelia mustelina	Weasel phacelia	W, IA
Phacelia parishii	Parish's phacelia	SOC, W, IA
Moss Species		
Crossidiium seriatum	Seriate crossidium	W, E
Didymodon nevadensis	Gold Butte moss	W, E
Entosthodon planoconvexus	Planoconvex enthosthodon	W, E
Grimmia Americana	American grimmia	W, E
Trichostomum sweetie	Sweet trichostomum	W, E

(a) Status Codes:

Endangered Species Act, FWS
SOC - Species of concern

Nevada Natural Heritage Program
W - Watch list

Long-term Plant Monitoring Status on NTS
A - Active ; IA - Inactive; E - Evaluate

Table 12-3. Sensitive reptiles and birds which are known to occur on or adjacent to the NTS

Reptile Species	Common Names	Status (a)
Gopherus agassizii	Desert tortoise	LT, NPT
Sauromalus obesus	Chuckwalla	SOC
Bird Species(b)		
Athene cunicularia hypugea	Western burrowing owl	SOC, P
Alectoris chukar	Chukar	G
Aquila chrysaetos	Golden eagle	BE, P
Buteo regalis	Ferruginous hawk	SOC, P
Callipepla gambelii	Gambel's quail	G
Charadrius montanus	Mountain plover	PT, P
Chlidonias niger	Black Tern	SOC
Empidonax wrightii	Gray flycatcher	SOC
Falco peregrinus anatum	American peregrine falcon	<LE, P
Haliaeetus leucocephalus	Bald eagle	LT-PD, BE, P
Ixobrychus exillis hesperis	Western least bittern	SOC, P
Phainopepla nitens	Phainopepla	SOC
Phasianus colchicus	Ring-necked pheasant	G
Plegadis chihi	White-faced ibis	SOC, P

(a) Status Codes:

Endangered Species Act, FWS

<LE - Formerly listed as endangered; LT - Listed as threatened; PD - Proposed for delisting; PT - Proposed for listing as threatened; SOC - Species of concern

U.S. Department of Interior

BE - Protected under the Bald Eagle Protection Act

State of Nevada

G - Regulated as game; NPT - Protected as threatened; P - Protected bird

(b) Does not include all bird species that are protected by the Migratory Bird Treaty Act or by the state. Additionally, there are 26 birds which have been observed on the NTS, which are all protected by the state.

Table 12-4. Sensitive mammals which are known to occur on or adjacent to the NTS

Mammal Species	Common Name	Status[(a)]
Antilocapra americana	Pronghorn antelope	G
Corynorhinus townsendii pallescens	Townsend's big-eared bat	SOC
Equus asinus	Burro	H&B
Equus caballus	Horse	H&B
Euderma maculatum	Spotted bat	SOC, NPT
Felis concolor	Mountain lion	G
Lynx rufus	Bobcat	F
Myotis ciliolabrum	Small-footed myotis	SOC
Myotis evotis	Long-eared myotis	SOC
Myotis thysanodes	Fringed myotis	SOC
Myotis volans	Long-legged myotis	SOC
Myotis yumanensis	Yuma myotis	SOC
Ovis canadensis nelsoni	Desert bighorn sheep	G
Odocoileus hemionus	Mule deer	G
Sylvilagus audubonii	Audubon's cottontail	G
Sylvilagus nuttallii	Nuttall's cottontail	G
Urocyon cinereoargenteus	Gray fox	F
Vulpes velox macrotis	Kit fox	F

(a) Status Codes:

Endangered Species Act, FWS

SOC - Species of concern

U.S. Department of Interior

H&B – Protected under Wild Free Roaming Horse and Burro Act

State of Nevada

F - Regulated as fur-bearer; G - Regulated as game; NPT - Protected as threatened

12.2.2 Methods

Proposed projects are subjected to a NEPA review process, and biologists are notified of projects that may disturb native vegetation, soils, or wildlife. Biologists conduct surveys for projects prior to land-disturbing activities following written survey procedures. The locations of sensitive species and important resources found are recorded and flagged in the field for avoidance. Hand-held GPS units are used to record the boundary coordinates of all project areas surveyed. GIS computer software is then used to calculate, from the field coordinates, the acres surveyed and to overlay the surveyed areas onto existing vegetation and habitat maps of the NTS. A database is maintained to document survey results. Survey reports are written, providing project personnel with feasible mitigation measures to avoid or lessen impacts to such species and resources. The design and/or location of projects are altered whenever possible and if required under the Opinion.

12.2.3 Results

Surveys for the following 18 projects at 290 different sites were conducted throughout the NTS in 2003:

- Area 25 Septic Systems and Underground Discharge Point Closure (Correction Action Unit [CAU] 262) – 2 sites
- Borehole Management (plugging existing boreholes) – 141 sites
- Areas 6, 22, and 23 Tanks and Spill Sites Closure (CAU 330) – 3 sites
- Building Demolitions – 113 buildings, 1 land-disturbance sites
- Area 22 Desert Rock Runway Lighting System Renovation – 1 site
- Unicorn Subcritical Experiment – 1 site
- Cleanup of Area 6 Wackenhut Services, Inc. (WSI) Firing Range – 1 site
- Installation of Surface Laid Power Cables – 2 sites
- Legacy Rehabilitation Demarcation at SMOKEY Event – 1 site
- Cleanup of Reactor Maintenance, Assembly and Disassembly (R-MAD) Yard and Port Gaston – 3 sites
- CHANCELLOR Post-Shot Drill Back – 1 site
- Cleanup of Topopah Wash Military Firing Range – 2 sites
- Characterization of Area 25 Contaminated Wash and Land Parcels (CAU 259) – 12 sites
- Areas 18 and 19 Borrow Pit Reactivation – 2 sites
- Jackass Flats Road Barbed Wire Cleanup – 1 site
- Characterization at Horn Silver Mine (CAU 527) – 1 site
- U1a Leachfield – 1 site
- Clean Closure of Areas 25, 26, and 27 Septic Systems (CAU 271) – 1 site

The summary of survey results are shown in Table 12-5. No wetlands, no important species, and no important biological resources were impacted by these projects.

Table 12-5. Summary of 2003 biological survey results

Measure	Result
Number of biological surveys conducted	290 for 18 projects
Area surveyed	Total: 116.40 ha (287.62 ac) Undisturbed habitat: 48.11 ha (118.88 ac) Previously-disturbed habitat: 68.29 ha (168.74 ac)
Important species/biological resources found	21 inactive nests of migratory birds 1 possible bat roost 1 inactive tortoise burrow 23 inactive predator burrows
Mitigation actions taken	Inactive tortoise burrow avoided Bird nests removed prior to building demolitions Potential bat roost left undisturbed

12.3 Sensitive Species and Habitat Monitoring

12.3.1 Goals and Measures

Over the last three decades, NNSA/NSO has taken an active role in collecting or supporting the collection of information on the status of sensitive plants and animals and their habitat on the NTS and has produced numerous documents reporting their occurrence, distribution, and susceptibility to threats on the NTS (see *Ecology of the Nevada Test Site: An Annotated Bibliography* [Wills and Ostler, 2001]). In 1998, NNSA/NSO prepared a Resource Management Plan (DOE, 1998). One of the many natural resources goals stated in the plan is to protect and conserve sensitive plant and animal species found on the NTS and to minimize cumulative impacts to those species as a result of NNSA/NSO activities. The EMAC goals of species and habitat monitoring on the NTS are to:

- Ensure that impacts caused directly by NTS projects can be detected, quantified, and managed so that a species' occurrence on the NTS is not threatened by such projects.
- Ensure adherence to state and federal regulations aimed at protecting wild horses, migratory birds, wetlands, and wildlife habitat.

Data collected for monitored species include:

- Distribution on the NTS
- Relative abundance, density, or population size on the NTS
- Susceptibility to threats from NTS projects
- Location of nest burrows, nests, or roost sites of sensitive animals
- Location of preferred habitats
- Incidence and cause of mortality

12.3.2 2003 Activities

In 2003, the major accomplishments under this EMAC task are presented below. Detailed descriptions of these actions and results can be found in BN, 2003.

Sensitive Plants – Six known population locations of *Phacelia beatleyae* and three of *Astragalus funereus* were visited to record plant abundance (Figure 12-2). Approximately 100 – 800 individual *P. beatleyae* plants were found at each of the six sites monitored, although numbers were lower than had been reported from previous years. The numbers found in 2003 seem commensurate with the amount of precipitation each site received. *A. funereus* was absent at two of the three sites monitored. This may not indicate a decline of this species on the NTS, but an effect of the continued drought in the southwest. When climatic conditions which favor *A. funereus* growth and reproduction occur, surveys will be conducted again so an accurate assessment of the status of this species can be made.

Sensitive Bats – Night monitoring surveys for bats were conducted at 22 sites (Figure 12-3) to identify the distribution of sensitive bat species and to identify bat roost sites. Nine species of bats were documented at 21 of the 22 sites monitored. One maternity roost (at Climax Mine Adit 1) and one day roost (at Oak Spring Middle Basin Adit 1) of the Townsend's big-eared bat (*Corynorhinus townsendii pallescens*) were identified (Figure 12-3). Three day-roosts and eight night-roost/foraging sites used by multiple bat species were also identified.

Wild Horses – An annual horse census was conducted by driving selected roads along the boundaries of the suspected annual horse range in the northern portion of the NTS. Thirty adult horses and five foals were counted in 2003. From 1995 the feral horse population has declined (Figure 12-4). The decline is mainly the result of poor foal survival and no immigration of new adults. Over the past ten years, the causes of mortality among adult horses, when observed, have included unknown causes (four), predation (one), collisions with vehicles (two), and drowning (one). Among young horses (1-2 year olds), two have died from unknown causes and one presumably from dehydration at a dried up spring.

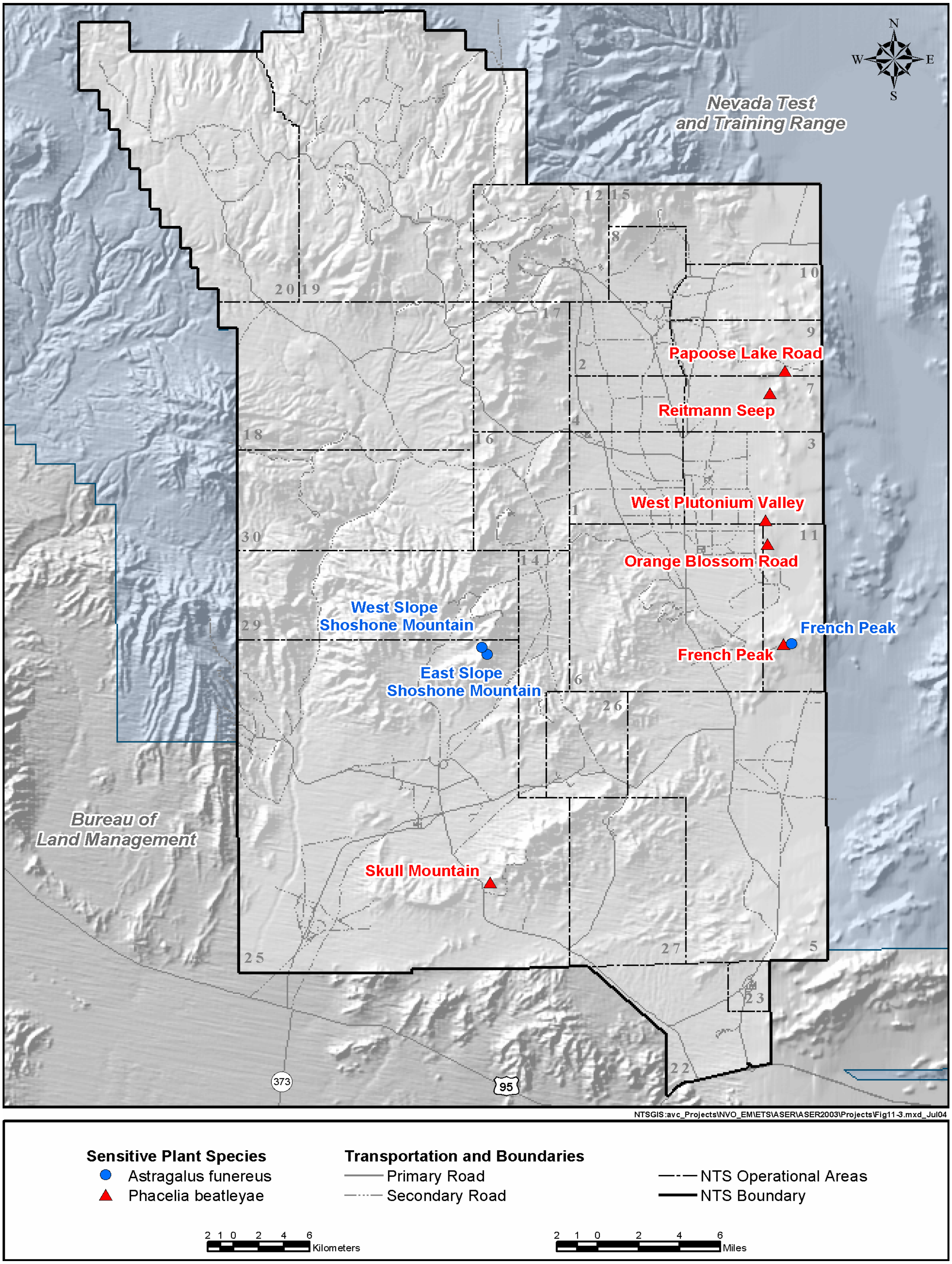

Figure 12-2. Sensitive plant populations monitored on the NTS in 2003

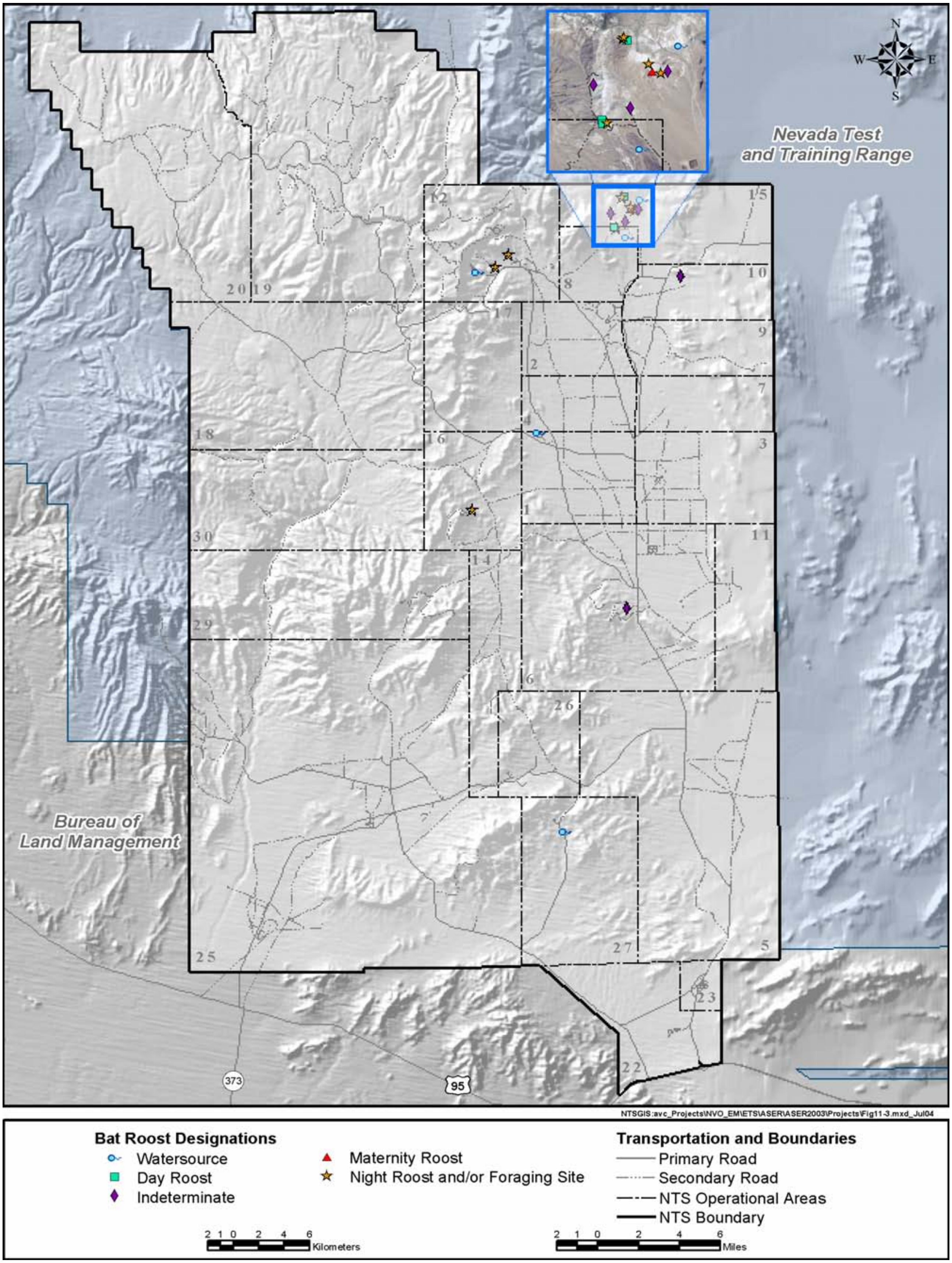

Figure 12-3. Sites monitored on the NTS for bat use in 2003 and roost site designations

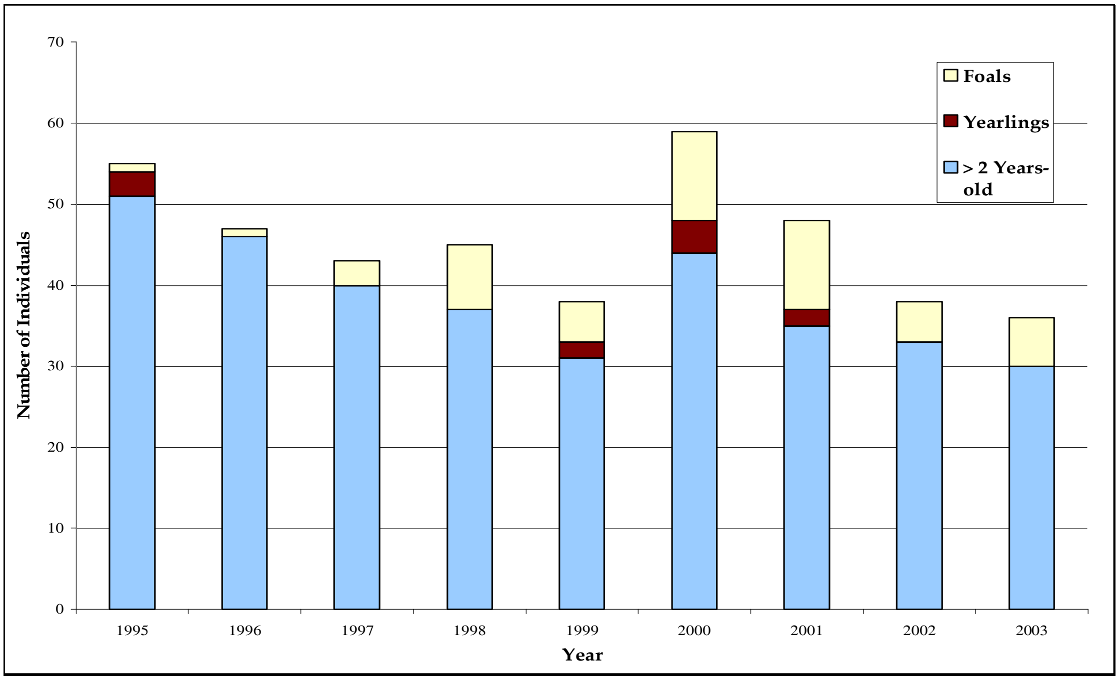

Figure 12-4. Number of wild horses observed by age category

Migratory Birds – No field surveys for any species of migratory birds were conducted this year. However, a database was updated that stores all sightings of dead birds reported by NTS workers or observed by biologists. All but 2 of the 239 bird species observed on the NTS are migratory birds protected under the Migratory Bird Treaty Act. In 2003, 35 birds were found dead (Table 12-6). The majority (30) were mourning doves found at man-made water sources that were either killed by predators or died from trichomoniasis. The great-horned owl and red-tailed hawk found electrocuted, are state protected birds of prey.

Table 12-6. Number of migratory bird deaths reported on the NTS in 2003

Species	Cause of Death				
	Electrocution	Roadkill	Predation	Disease	Unknown
Chukar (*Alectoris chukar*)		1			
Great-horned owl (*Buteo jamaicensis*)	1				
Loggerhead shrike (*Lanius ludovicianus*)		1			
Mourning dove (*Zenaida macroura*)			15	15	
Red-tailed hawk (*Buteo jamaicensis*)	1				
Say's phoebe (*Sayornis saya*)					1

The overall reported number of bird deaths on the NTS related directly to NTS activities is low and the causes are varied (Figure 12-5). The major cause of recorded deaths is natural predation and disease among mourning doves. No feasible mitigation actions were identified in 2003 that may reduce the incidence of bird mortality on the NTS.

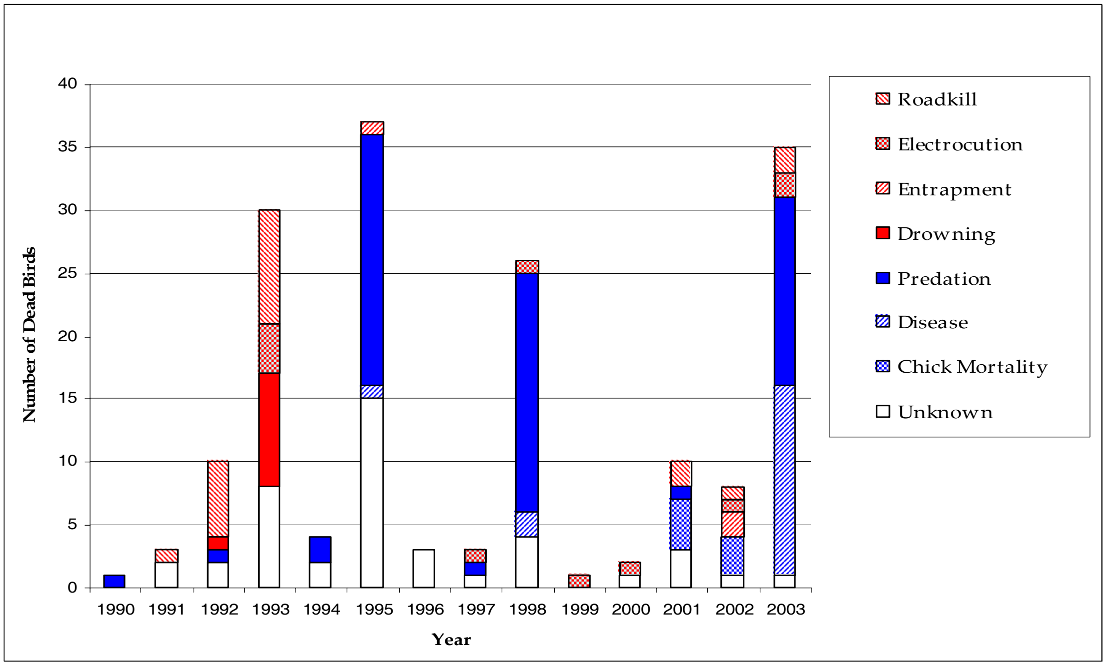

Figure 12-5. Number of bird deaths recorded on the NTS by year and by cause

The document *Ecology of the Western Burrowing Owl on the Nevada Test Site* (Hall et al., 2003) was completed in 2003. The report summarizes the results of more than four years of field data collected on the NTS regarding this species. The western burrowing owl is a migratory bird and is also an FWS-designated species of concern which resides and breeds on the NTS. A section of the report addresses current NTS management practices for this bird which have been adjusted in response to the ecological information gathered.

Natural and Human-Made Water Sources – Monitoring data collected in 2003 included: (1) surface area and surface flow of natural water sources, (2) description of disturbances observed at natural water sources, (3) species of wildlife observed at natural and man-made water sources, and (4) description of dead animals or animal remains found at water sources. Thirteen wetlands were visited at least once during 2003. Disturbances noted were trampling and grazing of vegetation by horses at four sites. No NNSA/NSO projects disturbed these natural water sources. Thirty-nine plastic-lined sumps, 34 unlined well ponds, and 4 radioactive containment ponds were monitored in 2003. About 30 dead mourning doves were detected. These deaths were from predation and disease. Dirt ramps have been installed during previous years in many plastic-lined sumps to allow entrapped animals to escape. No state-protected or un-protected animals were observed dead at any plastic-lined sumps in 2003.

12.4 Habitat Restoration Monitoring Program

12.4.1 Goals and Measures

The native vegetation and wildlife habitat at disturbed NTS sites are sometimes restored by seeding and/or planting native plant species. This effort is called revegetation. NNSA/NSO evaluates revegetation as a potential method to stabilize soils at a site based on site size, future use, nature of soils, annual precipitation, slope, aspect, and site location (DOE, 1996). Revegetation supports the intent of Executive Order 13112 *Invasive Species* which is to prevent the introduction and spread of invasive (non-native) species and restore native species to disturbed sites. To date, the majority of NNSA/NSO projects for which revegetation has been pursued are abandoned industrial or nuclear test support sites that have been characterized and remediated under the Environmental Restoration (ER) Program. Also, the ER Program has funded revegetation of soil cover caps to protect against soil erosion and water percolation into buried waste. In 2003, a wildfire burn site in Area 12 (Egg Point Wildfire site) was revegetated to help minimize soil erosion and the invasion of non-native species which would make the site more prone to future wildland fires. In addition to conducting all revegetation efforts on the NTS, the Habitat Restoration Monitoring Program conducts short- and long-term monitoring of revegetated sites. The summary of this program's goals are to:

- Design and implement site-specific revegetation plans at approved disturbed sites
- Monitor the short- and long-term outcome of revegetation efforts
- Monitor the long-term outcome of natural vegetation succession at disturbed sites where revegetation has not occurred
- Develop a site-wide habitat restoration plan based on evaluations of past revegetation efforts, natural succession processes, and wildlife habitat requirements
- Monitor the effectiveness of revegetation to restore wildlife habitat

The field measures routinely used to monitor both revegetation success and the status of natural succession at sites include:

- Plant density
- Percent survival
- Plant cover (percent of ground covered by living plant material) by species or by plant type (e.g., annual grasses, forbs)
- Presence of wildlife species and their sign (e.g., burrows, scat, ant mounds)

12.4.2 2003 Activities

The Egg Point Wildfire burned approximately 121 hectares (300 acres) in Area 12 on August 16, 2002. The fire encompassed vegetation within the following three vegetation associations, as per Ostler, et al., (2000): Blackbrush-Nevada Jointfir, Singleleaf Pinyon-Black Sagebrush, and Rubber Rabbitbrush-Nevada Jointfir. The majority of plant cover was lost but there did not appear to be any significant direct impacts to wildlife or to any sensitive plant or animal species. The Nevada Test Site Wildland Fire Management Plan (BN, 2002) prescribes the rehabilitation of land after a fire, mainly for the prevention of future wildland fires, and secondarily for erosion control. Revegetation of the site began in November 2002 and was completed in March 2003. A total of 1,681 kg (3,705 lb) of bulk native seed of 14 different species was distributed over the site. Rocky steep areas with little, if any, soil were not seeded. The total area seeded is estimated to be 93 - 101 hectares (230 - 250 acres). About 5,000 transplants of native shrubs were planted along drainages.

Vegetation monitoring of the burn site was conducted in June 2003. Monitoring focused on assessing the success of seed germination and plant establishment on the steep upper slopes and the lower slopes and bottoms. Plant density of seeded species on the burn site was low. The continued drought conditions on the NTS and throughout the southwest have not been favorable for seed germination and plant growth. On the lower and upper slopes, total plant density was 5.73 and 8.09 plants/m^2 (plants per square meter) (0.53 and 0.75 plants/ft^2) respectively. However, only a small portion of these were seeded species. The majority of the other plants were invasive annuals, primarily *Bromus rubens* (red brome) and *B. tectorum* (cheatgrass). Seeded species may emerge during future growing seasons as soil moisture is replenished. Transplant areas were sampled to determine transplant survival. Five months after planting, the overall survival of all transplants sampled was 75 percent.

12.5 Biological Monitoring of the HSC

12.5.1 Goals and Measures

Biological monitoring at the HSC on the playa of Frenchman Lake in Area 5 will be performed as an EMAC task whenever there is a risk of significant exposure to downwind plants and animals from the planned test releases of hazardous materials. The Desert National Wildlife Refuge lies just east of the NTS border approximately 5 km (3 mi) downwind from the HSC. Biological monitoring of HSC tests is a requirement of the facility's Programmatic Environmental Assessment (DOE, 2002c). An unpublished BN document titled *Biological Monitoring Plan for Hazardous Materials Testing at the Liquefied Gaseous Fuels Spill Test Facility on the Nevada Test Site* prepared in 1996 and updated in 2002 describes how field surveys will be conducted to meet the following two goals: (1) document significant impacts of chemical testing on plants and animals and (2) verify that HSC operations comply with the National Wildlife Refuge Administration Act (see Section 1.9). Monitoring will entail sampling established transects both downwind and upwind of the HSC. The parameters to be measured whenever transects must be sampled will include:

- Number and type of dead animals observed
- Number and type of wildlife observed
- Presence of observed vegetation damage

12.5.2 Methods

Biologists are tasked to review all chemical release test plans to determine the level of field monitoring needed. The level of monitoring is determined by the ecological exposure risk of each proposed test. Risk is ranked into three qualitative categories: minimal, moderate, and high. Under minimal risk there would be nondetectable levels of released chemicals at the playa edge as verified by air sampling instruments. At moderate risk, there would be a probability that released chemicals will contact biota downwind. High risk tests would potentially expose downwind biota to potentially damaging concentrations of chemicals. For tests classified as minimal risk, no biotic monitoring is conducted. For tests classified as moderate and high risk, field sampling along established transects downwind and upwind would be conducted before and after testing. Details of the risk assessment review process and of the levels of biological monitoring performed for each risk level are described in the biological monitoring plan. Chemical releases at the HSC use such small quantities that downwind test-specific monitoring has not been necessary.

Biologists conduct baseline sampling of all transects three times a year regardless if biological monitoring is needed for chemical spill tests. This sampling documents representative baseline conditions during the spring (period of maximum plant growth), summer (period of declining growth and increasing plant stress), and winter (period of plant dormancy) and will document any long-term and/or cumulative impacts of testing that would not be detected otherwise. It also documents any adverse ecological effects from natural phenomenon such as drought and freezing which may be observed along downwind transects and erroneously attributed to HSC operations.

12.5.3 Results

Chemical spill test plans for the following five tests were reviewed in 2003 and determined to be minimal risk tests requiring no field monitoring:

- Ground Truth Engineering Tests
- Divine Invader Test Series
- DuPont Fuming Acids Mitigation Workshop
- Quail Project
- Roadrunner II Test

Baseline monitoring was conducted at established control and treatment transects in February and August. This sampling noted the condition of plants and the presence of wildlife sign during the period of vegetative dormancy. No differences in biota were noted along downwind (treatment) versus upwind (control) transects. Noticeable cumulative impacts on biota from HSC testing have not been observed. Baseline monitoring data are made available to neighboring land managers upon request.

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Supportive Environmental Programs and Activities

All photos: the Sugarloaves, Area 17, 1985

13.0 Underground Test Area Project

The Underground Test Area (UGTA) Project is the largest project in the Environmental Restoration Division and addresses groundwater contamination resulting from past underground nuclear testing conducted in shafts and tunnels by the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) on the Nevada Test Site (NTS). From 1951 to 1992, more than 800 underground nuclear tests were conducted at the NTS (U.S. Department of Energy [DOE], 2000). Most of these tests were conducted hundreds of feet above the groundwater table, however, over 200 of the tests were within or near the water table. This underground testing was limited to specific areas of the NTS including Pahute Mesa, Rainier Mesa, Shoshone Mountain, Frenchman Flat, and Yucca Flat.

The UGTA Project collects data to define groundwater flow rates and direction to determine the nature and location of aquifers (geologic formation of permeable rock containing or conducting groundwater). In addition, project team members gather information regarding the hydrology and geology of the area under investigation. Data from these studies will help determine whether or not radionuclides resulting from nuclear testing have moved appreciable distances from the original test location. Numerous surface and subsurface investigations are ongoing to ensure that these issues are addressed.

Surface investigations include:

- Evaluating discharges from springs located downgradient of the NTS
- Assessing surface geology

Subsurface investigations include:

- Drilling deep wells to access groundwater hundreds to thousands of feet below the surface
- Sampling groundwater to test for any radioactive contaminants
- Assessing NTS hydrology and subsurface geology to determine possible groundwater flow direction

13.1 New Drilling

The UGTA Project initiated a hydrogeologic investigation well drilling program for the Yucca Flat Corrective Action Unit (CAU) in 2002 (International Technology [IT], 2002). This drilling initiative included five new characterization wells. In 2003 the UGTA Project drilled and completed the last three wells of this drilling initiative: ER-12-2, located in northwestern Yucca Flat; ER-7-1, located in eastern Yucca Flat; and ER-2-1, located in central Yucca Flat (see Section 3.1.3.4, Figure 3-5).

Well ER-12-2 – Drilling activities at Well ER-12-2 began in December of 2002 and continued into calendar year 2003. The well was drilled to a total depth of 2,097 m (6,881 ft) and completed in Mississippian-age clastic rocks (the "upper clastic confining unit, or UCCU", see Appendix A, Section A.5.3.2 for explanation of the hydrostratigraphic units presented here). The primary uses of Well ER-12-2 are to provide data that constrain models of groundwater flow into Yucca Flat from the northwest and to constrain the hydrogeologic framework model in this area of sparse subsurface data.

Well ER-7-1 – This well, located in eastern Yucca Flat, was completed in February of 2003 at a total depth of 762 m (2,500 ft) in Paleozoic-age carbonate rocks (the regional "lower carbonate aquifer", or LCA). The primary use of Well ER-7-1 is to evaluate the LCA down-gradient from an underground nuclear test conducted close to the LCA. The well also provides information that will enhance the understanding of the hydrogeology of eastern Yucca Flat and help define hydraulic and hydrochemical parameters in the LCA.

Well ER-2-1 – This well, located in central Yucca Flat, was the last characterization well in the Yucca Flat drilling initiative. It was completed in March of 2003 at a total depth of 792 m (2,600 ft) in zeolitic bedded tuffs (the "tuff confining unit", or TCU). The primary use of Well ER-2-1 is to characterize the radiological and physical environment near underground nuclear tests conducted in a saturated volcanic aquifer setting. The goal of this drilling and hydrogeologic investigation program is to collect additional subsurface geologic and hydrologic data in the Yucca Flat CAU (see Section 3.1.4, Figure 3-5), where shaft and tunnel nuclear tests were conducted between 1957 and 1992 (DOE, 2000). Data from these wells will allow for more accurate modeling of groundwater flow and radionuclide migration in this former test area. Some of the new wells may also function as long-term monitoring wells. Well construction information and hydrologic and geologic data for these recent UGTA wells will be published in separate reports by Bechtel Nevada (BN) for NNSA/NSO in 2004.

13.2 Aquifer Tests

Well development and hydrological testing were conducted at five wells in 2003; Wells ER-2-1, ER-5-4, ER-6-1#2, ER-7-1, and ER-12-2. Multi-well aquifer tests were conducted at Wells ER-5-4#2 and ER-6-1#2 in 2003. Well ER-6-1#2 will be part of a multi-well tracer experiment designed to enhance understanding of the hydraulic properties of the lower carbonate aquifer. Data from initial pump tests and tracer experiments are being analyzed. Well development and hydrologic testing activities will be published in separate reports by Stoller-Navarro Joint Venture for NNSA/NSO in 2004.

13.3 Groundwater Sampling

UGTA groundwater samples collected in 2003 included the following:

- Preliminary (pre-development) characterization samples from the newly drilled wells ER-12-2, ER-7-1, and ER-2-1
- Characterization samples from Wells ER-5-4#2 and ER-6-1#2 following hydraulic testing activities
- Characterization samples from eight characterization wells drilled in 1999 for the Western Pahute Mesa-Oasis Valley study area: ER-EC-1, ER-EC-2A, ER-EC-4, ER-EC-5, ER-EC-6, ER-EC-7, ER-EC-8, and ER-18-2
- Samples from four post-shot/cavity wells, or "Hot Wells": U-4t PS#3A, U-19q PS#1D, U-19v PS#1DS, and U-20n PS#1DDH

The results of sampling in 2003 are presented in Section 3.1.4 of this NTSER along with all other radiological groundwater monitoring results.

13.4 Geophysical Studies

In October, November, and December 2003, the U.S. Geological Survey collected Magnetotelluric (MT) data at 52 sites in Yucca Flat. This MT survey included a series of sites in generally west to east transects across Yucca Flat and Control Point (CP) Basin. Briefly, MT is an electromagnetic sounding technique that measures naturally-occurring electric and magnetic fields in the earth's crust (Christopherson, 1998). These measurements can be compiled and processed to infer resistivity of the rocks in the subsurface to several kilometers depth. The natural source of MT fields is lightening discharge (perhaps many hundreds to thousands of miles away), and magnetospheric current systems generated by an interaction of solar wind and the earth's magnetic field (Appendix A of Schenkel et al., 1999).

The Yucca Flat MT data were collected primarily to provide insights regarding the pre-Tertiary stratigraphy and structure in Yucca Flat. Of particular interest was the presence and extent of the UCCU and the CP Thrust Fault. Data from this study will be used to enhance the three-dimensional (3D) hydrostratigraphic framework model of the Yucca Flat CAU.

13.5 3D Hydrostratigraphic Framework Models

A regional 3D computer groundwater model (IT, 1996) has already been developed to identify any immediate risk and to provide a basis for developing more detailed models of specific NTS test areas designated as individual CAUs. The regional model constituted Phase I of the UGTA project. The CAU-specific models, of which up to four are planned (geographically covering each of the six former NTS testing areas), comprise Phase II. To date, two have been built: Frenchman Flat (IT, 1998) and the Pahute Mesa-Oasis Valley model (BN, 2002a). An enhanced model for

Frenchman Flat and a Yucca Flat model are in progress. The more detailed CAU-specific groundwater-flow and contaminant-transport models will be used to determine contaminant boundaries based on the maximum extent of contaminant migration. The results of the individual CAU groundwater models will be used to refine the Routine Radiological Environmental Monitoring Plan monitoring network to ensure public health and safety.

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14.0 Hydrologic Resources Management Program

The primary responsibility of the Hydrologic Resources Management Program (HRMP) is to provide U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) with hydrologic data and information on groundwater supplies to support ongoing activities and to assist in planning new uses for the Nevada Test Site (NTS). The main objective of this program is to provide a sound technical basis for NTS groundwater use decisions regarding the quality and quantity of water resources available on and around the NTS on a long-term scale.

14.1 Program Goals

The goal of the HRMP is to support national security operations at the NTS by the investigation of site hydrology, radionuclide migration, and protection of NTS water resources. The HRMP meets this goal through long-term research activities including data collection, analysis, evaluation, modeling, and documentation. These activities provide reliable information for decision-making on groundwater utilization, stewardship, and environmental protection. Research and technology development activities essential to the achievement of these goals are an integral part of the HRMP.

14.2 Program Activities

Results of program activities are available as technical reports and documents. Project participants also disseminate information and transfer technologies through publication in technical reports and peer-reviewed journals, presentations at professional meetings and symposia, and educational outreach activities.

14.2.1 Hydrology and Radionuclide Investigations for Operations

The HRMP assists NNSA/NSO in maintaining capabilities in hydrology and radiochemistry to support test readiness and science-based stockpile stewardship through applied field and laboratory studies of the occurrence, distribution, and movement of radionuclides in groundwater at the NTS. Scientific expertise is utilized in the assembly, analysis, and evaluation of data to produce requested hydrologic and radionuclide information. State of Nevada regulations require NNSA/NSO to provide detailed information on hydrologic conditions of the NTS. At the request of NNSA/NSO management, the HRMP gathers, analyzes, and transfers science-based information to the state of Nevada and other external customers.

Hydrologic services, provided upon request to NNSA/NSO programs, include depth-to-groundwater estimates, water level measurements, containment evaluations, and determining emplacement hole integrity. Technology development projects and research investigations are conducted to address gaps in the capabilities and knowledge required to support safe conduct of operations for stockpile stewardship, nuclear test readiness, and national security. Previous and current activities include:

- Determining the steady state and transient hydrologic conditions in the subsurface, such as location of groundwater table, perched water zones, and regions of enhanced permeability.
- Using and developing state-of-the-art radiochemical instrumentation to analyze rocks and water samples in order to predict the fate and transport of radioactive isotopes deposited from subsurface experiments.
- Achieving a more fundamental understanding of chemical fractionation in underground nuclear tests through sample analysis and experimentation.
- Investigating the subsurface geology and fracture propagation in the vicinity of underground nuclear tests for containment issues.
- Building public confidence by conducting public and government outreach and education programs on the hydrologic environment and impact of nuclear testing on water resources at the NTS.
- Investigating the free water and bound water relationships in boreholes and cores.

14.2.2 Long-Term Groundwater Stewardship

A major element of the HRMP mission is the protection and long-term stewardship of NTS groundwater resources. A range of activities, including monitoring of groundwater levels, quality and consumption; monitoring well evaluation; and maintaining a wellhead protection program, are conducted to accomplish this element. HRMP supports groundwater flow model development for both the Death Valley Region (which includes the NTS) and for the NTS and will continue to support refinement of these models. Based upon hydrologic investigations and modeling, HRMP will evaluate proposed new groundwater uses on and near the NTS for their potential impacts on NTS groundwater reserves, quality, flow paths, and radionuclide migration. The HRMP protects NTS groundwater by implementing a well installation and maintenance program to ensure:

- Reliability of the potable water supply.
- Optimal location, design, and construction of new potable water wells.
- Long-term reliability of monitoring wells to supply representative water samples.
- Integrity of emplacement and groundwater boreholes.

The HRMP also provides assistance to NNSA/NSO regarding the impact of NTS water usage on offsite water supplies and springs, such as Devil's Hole. In addition, the HRMP assists in addressing compliance issues and is responsive to the needs of NNSA/NSO that result from state and federal regulations not within the purview of other programs, or which may be well-addressed by the capabilities of the HRMP. For example, implementation of the Safe Drinking Water Act dictates substantial compliance efforts both on and outside the boundaries of the NTS, a process to which HRMP can provide valuable support.

HRMP also has a groundwater review and advice capability with a unique NTS perspective that is invaluable to NNSA/NSO. HRMP scientists conduct competent, informed, and independent reviews of NNSA/NSO groundwater-related program documents prior to their release to extensive regulatory and public scrutiny. This capability enhances both the protection of NTS groundwater resources and the accuracy and credibility of NNSA/NSO program documentation.

15.0 Meteorological Monitoring

15.1 Meteorological Monitoring Goals

Meteorological and climatological data are collected on the Nevada Test Site (NTS) by the Air Resources Laboratory, Special Operations and Research Division (ARL/SORD). Data are collected through the Meteorological Data Acquisition (MEDA) system, a network of approximately 30 mobile meteorological towers located primarily on the NTS. The MEDA system became operational in 1981, replacing an older system. MEDA is used to measure, transmit, and display vital meteorological data to SORD meteorologists and U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) customers. These data are used daily for operational support to a wide variety of projects on the NTS and form the climatological database for the NTS. Additional uses for the database are for safety analysis reports, emergency response activities, radioactive waste remediation projects, environmental reports, and consequence assessments.

15.2 MEDA Station Locations

A standard MEDA unit consists of an enclosed trailer, a portable 10 m (32.8 ft) tower, an electric generator (when needed), a microprocessor, and a microwave radio transmitter. An example of a MEDA unit is shown in Figure 15-1. Locations of the MEDA stations at the time of the preparation of this report are shown in Figure 15-2. All towers were sited according to standards set by the Federal Meteorological Handbook No. 1 (NOAA, 1995) and the World Meteorological Organization (WMO, 2002) so as not to be influenced by natural or man-made obstructions, or by heat dissipation and generation systems. MEDA station locations are based on the following criteria: (1) availability of power, (2) access by road, (3) line-of-sight to a microwave repeater, and (4) project support. The primary goal of the network is to provide details in the surface wind field for emergency response activities related to the transport and dispersion of hazardous materials.

Figure 15-1. Example of a typical MEDA station with 10 meter tower

15.3 MEDA Station Instrumentation

MEDA station instrumentation is located on booms oriented into the prevailing wind direction and at a minimum distance of two tower widths from the tower. Wind

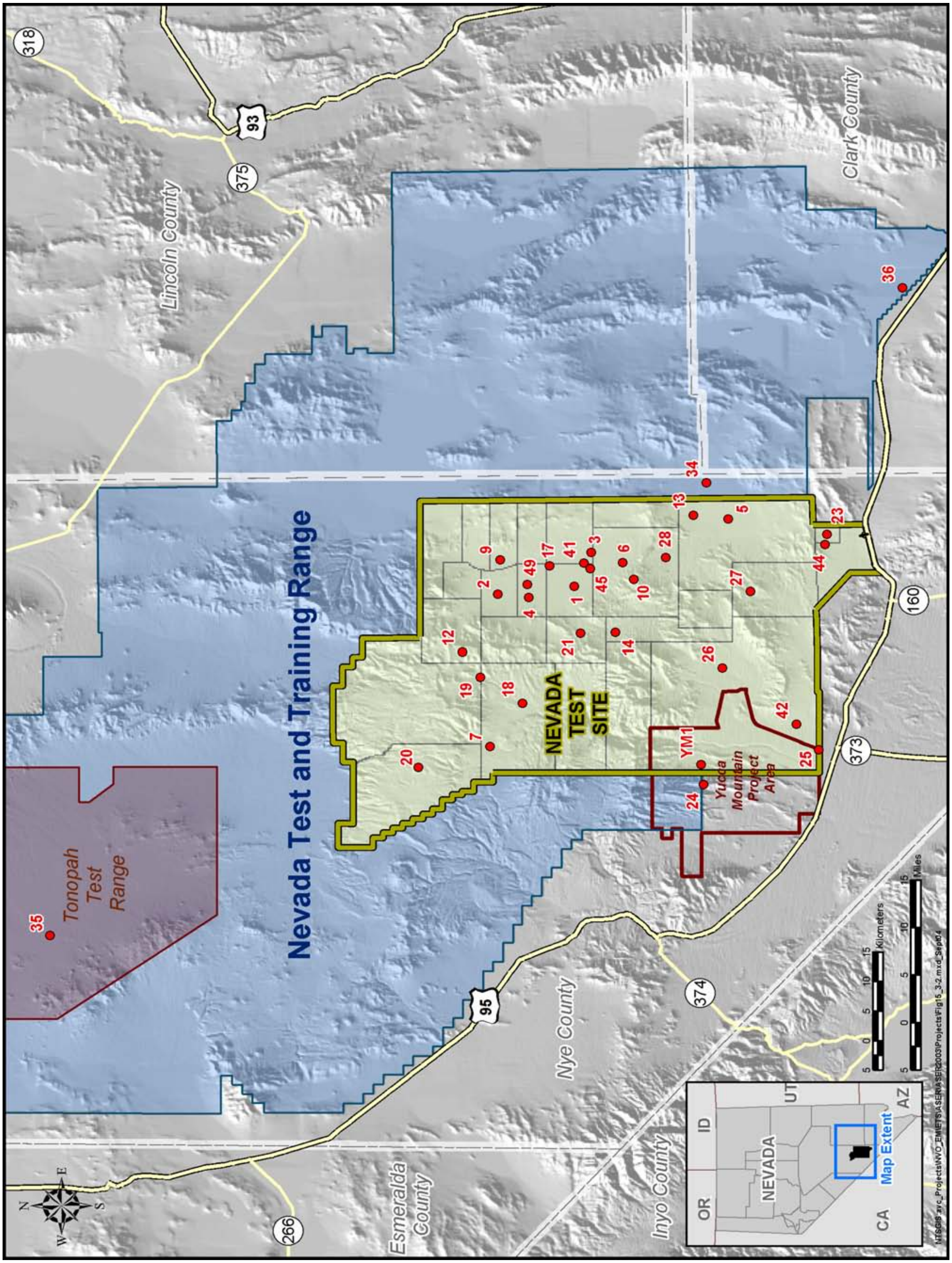

Figure 15-2. MEDA station locations on and near the NTS

direction and speed are measured at the 10-m level according to ANS/ANSI 3.11 (American Nuclear Society, 2000). Ambient temperature, relative humidity, and atmospheric pressure measurements are taken at approximately the 2-m level so as to be within the surface boundary layer. The observations are collected and transmitted every 15 minutes on the quarter hours. Wind data are 5-min averages of speed and direction. The peak wind speed is the fastest instantaneous gust measured within the 15-min time interval. Temperature, relative humidity, and pressure are instantaneous measurements.

15.4 Rain Gauge Network

ARL/SORD also operates and maintains a climatological rain gauge network on the NTS. This network consists of 17 Belford Series 5-780 Universal Precipitation Gauges (Figure 15-3). These are strip chart recorders that are read at least every 30 days. Once read and checked, the data are entered into the SORD precipitation climatological database. Data are recorded as daily totals. Under special circumstance, 1- to 3-hour totals can be obtained.

15.5 Data Access

The meteorological parameters measured at each station are listed on the SORD website <http://www.sord.nv.doe.gov> along with other information. MEDA data are also processed and archived in the ARL/SORD climatological database. Climatological data summaries are posted on the ARL/SORD website under the "Climate" section. SORD meteorologists provide specially tailored climatological summaries by request through NNSA/NSO. Wind data from the MEDA stations are used each year to calculate radiological doses from NTS air emissions to members of the public residing near the NTS (see Section 7.1.2.3).

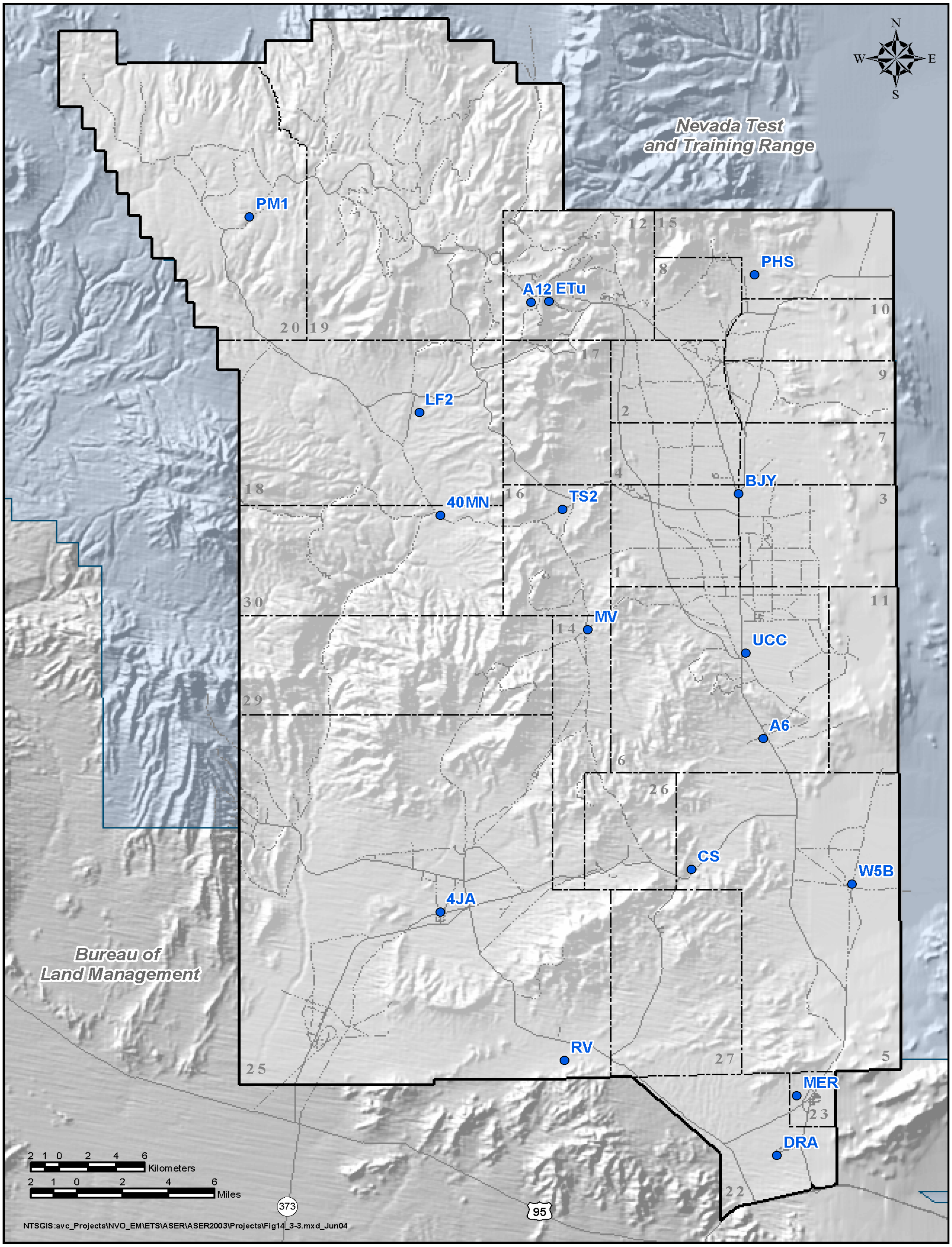

Figure 15-3. Climatological rain gauge network on the NTS

16.0 Environmental Management System

Bechtel Nevada's (BN's) Environmental Management System (EMS) is modeled after ISO 14001 while needing to satisfy U.S. Department of Energy (DOE) Order 450.1. BN Process Description PD-0442.001, "Environmental Management System Description," discusses how each of the seventeen elements of ISO 14001 is addressed, including controlling documents and organizations. This EMS Description is not a procedure, but is a roadmap to all the environmental processes and governing documents in the different EMS elements. The EMS Description will be revised in 2004 to reflect system improvements, updated procedures, and the blending in of the DOE Order 450.1 requirements. BN has an existing Environmental Policy that will also need to be updated to reference Order 450.1 as a driver and model for the environmental program. During 2003, progress was made in the areas of aspect identification and mitigation, identification and implementation of regulatory changes, addressing environmental issues in work control and execution plans, and overall awareness of the EMS.

After DOE Order 450.1 was approved in 2003, BN evaluated the Order and identified requirements that were not fully implemented. These were primarily in the pollution prevention areas, where DOE funding has been greatly reduced in the last few years. There are also areas such as resource protection from wildland and operational fires that are not traditionally thought of as environmental programs that will now need to be included in the EMS. A table is being prepared that lists all the requirements in the Order and identifies how each requirement is met and what organization is responsible for implementation or oversight.

A key goal of the new Order is to incorporate the EMS program into the existing Integrated Safety Management System (ISMS). This will require the ISMS Program Plan to be updated to specify that the EMS and Order 450.1 are the method by which the environmental part of ISMS is implemented. An example of how this is being accomplished is that the BN procedure and form for performing a hazard analysis for a new work activity is being modified to include environmental aspects. BN has identified its significant environmental aspects and is in the process of adding them and their respective mitigating actions to the hazard analysis form. This form that people are already used to completing for safety and health issues will soon better incorporate environmental issues. Identifying potential environmental impacts and mitigating them in the planning phase of doing work is the single most important part of a successful EMS. Goal setting is also included in the planning phase of performing work. Each year BN has several environmental goals identified in the Contractor Performance and Fee Award Program. These are measurable goals where performance is tracked and reported to ensure the maximum change for successful completion. Affirmative Procurement goals are also tracked and reported annually.

Work will continue to strengthen the EMS program. All the elements of ISO 14001 and DOE Order 450.1 are already in place to some degree, so full integration of EMS into ISMS, and full implementation of 450.1 should be complete by the deadline of December 31, 2005.

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17.0 Compliance Quality Assurance Program

The Quality Assurance Program (QAP) ensures that all environmental monitoring data meet quality assurance and quality control requirements in compliance with U.S. Department of Energy (DOE) Order 414.1A Change 1 *Quality Assurance*. Samples are collected and analyzed in accordance with standard operating procedures that are designed to ensure samples are representative and data are reliable and defensible. Quality control in the analytical laboratories is maintained through instrument calibration, efficiency and background checks, and testing for precision and accuracy. Data are validated as required by project-specific objectives before they are used to support decision making. Specifically, the Routine Radiological Environmental Monitoring Plan (RREMP) (DOE, 2003b) provides a formalized process to ensure that all sampling and analytical objectives are appropriate, economically feasible, reliable, and defensible. Elements of the QAP include the following:

- **Data and Measurement Quality Objectives are developed** to ensure that clear goals and objectives are established for data collection, analyses, and projected data use.
- **A Sampling Plan is developed** to ensure that an appropriate plan of action is developed to execute scope in accordance with DOE, administrative, or legal requirements such as environmental, safety, and health concerns.
- **Laboratory Sample Analyses are implemented** to ensure that analysis of samples for required parameters meet Bechtel Nevada (BN), customer, and regulatory-defined requirements.
- **Data Management Procedures are used** to ensure that all data are readily retrievable, protected through a system of checks and balances, and defensibly archived.
- **Data Review and Systematic Assessments are made** to ensure that analytical data quality are improved and enhanced, and to adequately assess procedures, identify nonconforming items, implement corrective actions, monitor for corrective action effectiveness, and provide feedback and lessons learned.

A discussion of these program elements follows together with the results of the 2003 QAP assessment.

17.1 Data and Measurement Quality Objectives

The Data Quality Objectives (DQOs) process is a strategic planning approach that is used to plan for a data collection activity. It provides a systematic process for defining the criteria that a data collection design should satisfy, including when to collect samples, where to collect samples, the tolerable level of decision errors for the study, and how many samples to collect.

The Measurement Quality Objectives (MQOs) can generally be considered as the DQOs for the analytical process. The MQOs provide direction to the laboratory concerning performance objectives or requirements for specific method performance characteristics. Default MQOs are established in the subcontract, but may be altered on a project-by-project basis in order to satisfy the DQOs. MQOs may generally be described in terms of precision, accuracy, representativeness, completeness, and comparability requirements. The following discussion includes brief statements on these terms as they apply to the overall monitoring effort to provide correlation with laboratory efforts. The RREMP (DOE, 2003b) provides additional discussions on monitoring, precision, accuracy, representativeness, completeness, and comparability.

17.1.1 Precision

Precision refers to "the degree of mutual agreement characteristic of independent measurements as the result of repeated application of the process under specified conditions" (Taylor 1987). Practically, precision is determined by comparing the results obtained from performing the sample analysis on split samples, or on duplicate samples taken at the same time from the same location, maintaining sampling and analytical conditions as nearly identical as possible. Precision related to the overall monitoring effort is evaluated by comparing results for field duplicate samples of particulates in air, tritiated water vapor, Thermoluminescent Dosimeters (TLDs), and some water samples. Precision related to laboratory operations is evaluated by comparing laboratory duplicates/replicates with established control limits. The laboratory is directed in the subcontract to establish and maintain precision control limits for various matrices and analytes. Control limits may be specified in the subcontract or by the specific method, but are more commonly generated and maintained by the laboratory in order to develop controls specific to their operations. In most cases however, laboratory specific limits should not be less stringent than those published in the standard methods.

17.1.2 Accuracy

Accuracy refers to "the degree of agreement of a measured value with the true or expected value of the quantity of concern" (Taylor, 1987), and may be defined as the ratio of the measured value divided by the true value, expressed as a percent. Accuracy related to the overall monitoring effort is evaluated by comparing field sample results with historic data to determine whether the data points fall within acceptable statistical trends, or other criteria. Accuracy related to laboratory operations is monitored by performing measurements and evaluating results of control samples of known composition which contain the analytes of interest. The control samples are analyzed using the same sample preparation and analytical methods as employed for the project samples. The subcontract provides the required control limits or directs the laboratory to establish control limits. Control limits may be specified by the specific method, but may be generated and maintained by the laboratory in order to develop controls specific to their operations. In cases where a laboratory is authorized to establish in-house limits, they can not be less stringent than those published in the standard methods. Compliance with accuracy control limits is usually required in order for further analysis to be performed.

17.1.3 Representativeness

Representativeness is the degree to which a sample is truly representative of the sampled medium (i.e., the degree to which measured analytical concentrations represent the concentrations in the medium being sampled) (Stanley and Verner 1985). Representativeness from a sample collection standpoint is managed through sampling plan design and execution in order to ensure the process collects a sample which is representative of the source material. Representativeness related to laboratory operations is managed primarily through direction to the laboratory, for example if the sample is a heterogeneous matrix (soil, sludge, solids, etc.), it should be homogenized prior to aliquoting for preparation or analysis. Water samples are generally considered homogeneous unless observation suggests otherwise. Individual air samples, as a function of the collection media, cannot be homogenized by the laboratory. Composite air samples are necessarily homogenized by the laboratory during the preparation process. Field sample duplicate or replicate analyses are additional controls allowing determination of representativeness.

17.1.4 Comparability

Comparability refers to "the confidence with which one data set can be compared to another" (Stanley and Verner, 1985). Comparability from an overall monitoring perspective is ensured by sampling design, sample collection and handling, laboratory analyses, and data review which are performed in accordance with established Organization Instructions (OIs) and Procedures and standardized methodologies. Comparability regarding laboratory operations is managed through direction to the laboratory which requires that standard methods will be used when available. When a standard method is not available, or when analytes may be determined by multiple techniques, equivalent quality assurance (QA) controls must be applied and more attention should be paid to review in order to draw conclusions on comparability.

17.2 Sampling Plan

Quality assurance in field operations includes development of an execution sampling plan, sampling assessments, surveillances, and oversight. Key elements of this plan include: (1) development of a Sample Package, (2) data management, and (3) appropriate training.

17.2.1 Sample Packages

Sample Packages are prepared that contains the data quality objectives, execution sampling plan or statement of work (SOW), organizational instructions, and field logs. Sample packages must be prepared prior to conducting any sampling and may include the following items:

Checklists to include:

  - Routing list showing all personnel who must review and approve the sample package
  - Pre-job and post-job checklists which describe personal protective equipment, safety, etc.
  - Sample package task lead summary
  - Requested analyses
  - Performance evaluation or certification for all labs that do the requested analyses
  - Signature page which documents signatures of all personnel associated with the work
- Field Logs for all samples required to be taken
- Work Package includes the "Traveler" sheet (a work notification and authorization tool) if required
- Specific, detailed Work Instructions
- Material Safety Data Sheets for all chemicals that are being used for the job
- Authorization Basis Documents that would include Execution Plans (Facility, Project, Support) that apply to the sampling effort as well as Real Estate/Operations Permits that identify the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office real property assets and operations involved in the sampling effort
- Chains-of-Custody

This managed approach to sampling ensures that the sampling is traceable and enhances the value of the final results available to project managers. The sample package also ensures that the sampler is prepared for the sampling event. The manager or QA Officer routinely performs assessments or surveillances of each type of sampling event to ensure that samplers are adhering to the OIs and sampling protocol and that the OIs represent what is actually being done.

17.2.2 Database Support

Database support includes the Bechtel Environmental Integrated Data Management System (BEIDMS) for field data and laboratory results. Completed Sample Packages, analysis results, data review checklists, etc., are optically scanned and entered into the Optix Data Base to enhance accessibility to these documents. The Optix system is used for scanning, long term storage, and retrieval of the Sample Package as a graphic image. Data obtained in the course of executing field operations are entered in the Sample Package during field work and in the BEIDMS after completion of the field activities.

17.2.3 Training

Bechtel Nevada ensures that all personnel are properly trained and qualified prior to doing work under the RREMP. A matrix is maintained to identify training required for each individual and their current status. It is checked prior to each sampling episode to ensure that personnel are qualified to do the work and job-specific training requirements are checked by the field sampling supervisor prior to assignment of personnel to sampling jobs.

17.3 Laboratory Sample Analyses

Because much of the laboratory sample analyses not done internally, but through subcontracts for laboratory services, Bechtel Nevada ensures DOE Order 414.1A, "Quality Assurance" requirements are met by structuring subcontracts for services that emphasize quality assurance. This is accomplished through a multifaceted approach that focuses on three areas: (1) Procurement, (2) Initial and Continuing Assessment, and (3) a Laboratory Quality Assurance Plan (LQAP).

17.3.1 Procurement

Laboratory services are procured through subcontract. The subcontract specifies the requirements and technical specifications needed to determine compliance with those requirements and to evaluate overall performance of the subcontractor. Subcontracts are established through a competitive bid process and a formal request for proposal

(RFP) process. It is awarded on a "best value" basis. The RFP generally requires a prospective vendor to submit in a proposal. Successful proposals include:

- All procedures pertinent to subcontract scope
- An Environmental, Safety and Health Plan
- Examples of deliverables, both hardcopies and electronic copies
- Proficiency Testing (PT) results from previous years of participation in recognized PT programs
- Resumes of those conducting the work
- A description of the facility or its design
- Accreditations and certifications
- Licenses
- Audits performed within the last year by the DOE Consolidated Audit Program (DOECAP) (formerly DOE Environmental Management CAP), other DOE sites, or other audits (DoD, etc.) covering comparable scope and acceptable to BN
- Past performance surveys
- A LQAP
- Pricing

Proposal evaluations are conducted and scored as detailed in the RFP. Pricing evaluation is performed by the procurement representative and is a separate operation from the technical evaluation. The BN technical evaluation team does not receive pricing information and performs the evaluation based solely on technical capability, in this way ensuring that the technical evaluation is not biased by pricing.

17.3.2 Initial and Continuing Assessment

An initial assessment is made during the RFP process above, including a pre-award audit. If an acceptable audit has not been performed within the past year, BN will consider performing an audit (or participating in an DOECAP audit) of those laboratories awarded the contract. However, in no instance does BN initiate work with a laboratory without approval of BN personnel authorized for ensuring acceptable vendors. A continuing assessment consists of the ongoing monitoring of a laboratory's performance against the contract terms and conditions, of which the technical specifications are a part. Tasks supporting continuing assessment are:

- Tracking schedule compliance
- Review of analytical data deliverables (Appendix F of DOE, 2003b)
- Conducting regular audits or participating in evaluation of DOECAP audit products
- Monitoring for continued successful participation in proficiency testing (PT) programs. The subcontract established with the laboratory requires or suggests participation in the following PT programs:
  - National Institute of Standards and Technology Radiochemistry Intercomparison Program
  - Studies equivalent to the former Environmental Protection Agency Water Pollution and -Water Supply programs which support certification by the state of Nevada for analyses performed in support of Clean Water Act and Safe Drinking Water Act monitoring
- Monitoring of the lab's adherence to the LQAP

17.3.3 Laboratory Quality Assurance Plan

Each laboratory must develop a Laboratory Quality Assurance Plan (LQAP). The LQAP is a statement of the laboratory's policies and approach to the implementation of DOE Order 414.1A for ensuring the generation of quality data. Elements of the plan include: (1) the LQAP requirements, (2) LQAP management responsibilities, and (3) additional subcontract requirements.

17.3.3.1 LQAP Requirements

LQAP requirements include the following elements:

- Establishes that senior management shall be responsible for the scope of the LQAP and implementing, assessing, and continually improving an effective quality system
- Designates an individual responsible for developing, implementing, and routinely monitoring the LQAP program
- Describes the organizational structure, functional responsibilities, levels of authority, and interfaces for those managing, performing, and assessing the work
- Defines the organization's policies regarding, and its commitment to, ethical standards, client confidentiality, and the implementation of safety and quality standards
- Establishes that line management shall be responsible for achieving quality in specific activities
- Establishes that all personnel, including samplers, field analysts, laboratory technicians, scientists, researchers, principal investigators, operators, craftspeople, clerical/support staff, and internal auditors shall retain responsibility for the quality of their work.
- Establishes that regulatory actions toward the organization or its parent corporation shall be reported immediately to cognizant management and affected clients. This includes actions, such as suspension of contracts with other federal agencies, notices of investigations, and legal actions against the organization or its personnel
- Establishes that functional responsibilities shall include the following activities as a minimum:
  - Participating with the client for planning and developing analytical work scope
  - Training and personnel development
  - Preparing, reviewing, approving, and issuing instructions, procedures, schedules, and procurement documents; identifying and controlling hardware and software
  - Managing and operating facilities
  - Calibrating and controlling the equipment used to measure and test
  - Conducting investigations and improving methods
  - Acquiring, evaluating, and reporting data
  - Performing maintenance, repair, and improvements
  - Controlling records

17.3.3.2 LQAP Management Responsibilities

QA and/or Quality Control (QC) positions shall report to the highest level of management (e.g., manager or director). The QA program identifies personnel positions that are given the responsibility and authority to do the following:

- Stop unsatisfactory work. The plan shall identify the chain of command through which any employee may initiate a stop-work order where detrimental ethical, contractual, quality, safety, or health conditions exist
- Initiate action to prevent reporting laboratory results from a measurement system that is out of control
- Prevent further reporting of measurements until corrective action has been completed
- Identify any method or procedure that poses quality problems
- Recommend, initiate, or provide solutions through designated channels, and monitor effectiveness of corrective actions

17.3.3.3 Additional Subcontract Requirements

Additional requirements are placed on the laboratory through the subcontract. Compliance with these requirements is verified through Initial and Continuing Assessment. These requirements include the following items.

Personnel Training and Qualification – The Laboratory organization shall be clearly structured with well-defined responsibilities for each individual in the management system. This system shall ensure that sufficient resources are maintained to perform the requirements specified in the subcontract. Personnel performing services specified by the subcontract SOW and personnel performing quality assurance activities shall receive suitable and timely indoctrination and training in such things as technical skills, laboratory analytical methods, QC procedures, safety policies, and waste management practices and essential elements of the QA Program prior to performing work. Records of the indoctrination and training shall include descriptions of the training provided, attendance sheets, training logs, and personnel training records.

Quality Improvement – A system shall be established and implemented to identify, document, correct, and prevent quality problems, and this system shall be subject to ongoing documented review by management to assess its effectiveness.

Documents and Records – Activities affecting quality shall be prescribed by documented instructions, procedures, or drawings that include quantitative or qualitative acceptance criteria that can be used to determine whether activities are satisfactorily accomplished. Revisions to instructions, procedures, and drawings that affect the process or are technical in nature shall receive the same level of review and approval by the affected parties as the original document. Editorial changes may be made to instructions, procedures, and drawings without review and approval. Document control shall include measures by which documentation can be controlled, tracked, and updated in a timely manner to ensure that applicability and correctness are established. Control measures shall be used to ensure that documents are reviewed for adequacy, approved for release by authorized personnel, and distributed to and used at the location of the prescribed activity.

Work Processes – Work shall be performed to established technical standards and administrative controls. Work shall be performed under controlled conditions using approved instructions, procedures, or instructions. Analytical procedures shall be listed by method number and matrix. Any method variances employed by the laboratory shall be documented. The laboratory shall specify protocols for reporting any incident that delays sample processing for a period of time, affects holding times, or delays work, and also specify the corrective action implemented. Examples of forms used to document out-of-control events are to be provided in the LQAP.

Analysis of QC Samples and Documentation – A summary of QC procedures and documentation to be employed in the day-to-day operation of the laboratory shall be included. The discussion will emphasize the following as they relate to the different QC levels:

- Analysis of method and reagent blanks.
- Analysis of duplicates, spiked samples, spiked laboratory blanks, and reference or control standards such as U.S. Environmental Protection Agency, National Institute of Standards and Technology, or other recognized authority check standards.
- The criteria used to establish warning and control limits for the above types of QC samples.
- Documentation and examples of control data and control charts.
- The frequency of analyzing blanks and other QC samples.
- How data from QC samples are reported and reviewed.
- Who reviews and makes decisions relative to QC data.

Procurement – A process shall be established and implemented to control purchased items and services; this process shall be subject to ongoing review by management to assess its effectiveness. Subcontract documents require that suppliers of all tiers comply with technical and quality assurance requirements, including but not limited to, standards, measuring and test equipment, calibration services, and analytical test activities. Contracted items and services that have the potential to affect the quality of analytical tests shall be controlled to ensure conformance with contractual requirements. Such control shall include one or more of the following: Source evaluation and selection (pre-performance/pre-award survey), source verification, audit, and examination of items or services before use. The procurement documents shall specify the quality system elements for which the supplier is responsible and how the supplier's conformance to the customer's requirements will be verified. Procurement documents shall be reviewed for accuracy and completeness by qualified personnel prior to release. Changes to procurement documents shall receive the same level of review and approval as the original documents.

Inspection and Acceptance Testing – Inspection and acceptance testing of specified items, services and processes shall be conducted using established acceptance and performance criteria. Equipment used for inspection and tests shall be calibrated and maintained. There shall be a current list of available (on hand) equipment types, models, and years and a general description of the facility. General information shall be included as to who performs major, preventative, and day-to-day equipment maintenance and how it is documented. A schedule of preventive maintenance activities shall be developed and the performance of preventive maintenance shall be documented. A documented inventory of critical spare parts and/or equipment necessary to minimize the downtime of measurement systems related to analytical test samples that have a holding time of 48 hours or less shall be maintained. A documented evaluation of the usage of such inventory shall be performed at least annually. Control processes shall be maintained for all instrument spikes, replicates/splits, blanks, and other standards.

Management Assessment – A method shall be established whereby management with executive authority assesses the adequacy of the QAP at least annually to ensure its continuing suitability and effectiveness in satisfying the requirements of the SOW and the supplier's stated policies and objectives. The method shall include provisions for reporting the results of management assessments, including the distribution of those reports. Problems that hinder the organization from achieving its objectives shall be identified and corrected.

Independent Assessment – Designated persons or organizations shall be responsible for ensuring that an appropriate QAP is established and for verifying that activities affecting the quality of the services specified in the SOW have been correctly performed. Such person or organization shall have sufficient authority, access to work areas, and organizational freedom necessary to independently assess all activities affecting quality and to report the results of such assessments. Persons conducting independent assessments shall be technically qualified and knowledgeable in the areas assessed. Assessment results shall be documented, reported to and reviewed by the level of management with authority to affect any necessary corrective actions. Assessments shall be conducted of subcontractors that perform work affecting the integrity of analytical results and to assure continued conformance to contractual requirements.

17.4 Data Management Procedures

The RREMP describes the need for environmental data and the details of the collection and analysis of environmental data to support various drivers at the NTS. A data management system is essential for understanding and sustaining the quality of data collected under the program, allowing programs to identify data gaps or data requirements for other environmental efforts, and eliminating unnecessary duplication of data collection efforts. Because decisions are based on environmental data, and the effectiveness of operations is measured at least in part by environmental data, reliable and accurate records of defensible environmental data are essential. Detailed records that must be kept include temporal, spatial, numerical, geotechnical, chemical, and radiological data, and all sampling and analytical procedures used. Failure to maintain these records in a secure but accessible form may result in exposure to legal challenges and the inability to respond to demands from regulators and third parties.

BEIDMS is a hierarchical relational database management system developed by Bechtel Environmental, Inc. that is designed to achieve standardization and integrity in managing environmental data. The primary objective of BEIDMS is to store and manage unclassified environmental data which are directly or indirectly tied to field sampling events. This includes information on construction, analytical, geotechnical, and field parameters at the NTS. Database integrity and security are enforced through the assignment of role memberships and the provision of available menu items.

17.5 Data Review and Systematic Assessments

The final element of the process-based QA is the review of data and systematic assessments than can be used to evaluate data quality and usability. Four components of this review and assessment are: data checks, data verification, data validation, and data quality assessment. A description of these components follows.

17.5.1 Data Checks

Data checks are conducted to ensure accuracy and consistency of field operations data collection prior to and upon data entry into the BEIDMS.

17.5.2 Data Verification

Data verification is defined as a subcontract compliance and completeness review to ensure that all laboratory data and sample documentation are present and complete. Sample preservation, sample temperature, chain-of-custody, and other field sampling documentation shall also be reviewed during the verification process. Data verification ensures that the reported results entered in BEIDMS correctly represent the sampling and/or analyses performed and includes evaluation of quality control sample results. A Tier I review form and/or a Verification Checklist is completed for all data packages.

17.5.3 Data Validation

Data validation is the process of reviewing a body of analytical data to determine if it meets the data quality criteria defined in OIs. Data validation ensures that the reported results correctly represent the sampling and analyses performed, determines the validity of the reported results, and assigns data qualifiers (or "flags"), if required. The process of data validation consists of:

- Evaluating the quality of the data to ensure that all project requirements are met
- Determining the impact on data quality of those requirements that were not met
- Verifying compliance with QA requirements
- Checking QC values against defined limits
- Applying qualifiers to analytical results in BEIDMS for the purpose of defining the limitations in use of the reviewed data
- Documenting the results of the data validation

It is the goal to conduct data validation on 20 percent of laboratory data (10 percent using laboratory reported calibration data, QC results, and sample results; and 10 percent recalculating the laboratory results using submitted raw data to verify laboratory reported results). OIs and Procedures, applicable project specific work plans, field sampling plans, Quality Assurance Project Plans, analytical method references, and laboratory SOW may all be used in the process of data validation. Documentation of data validation includes: checklists, qualifier assignment, and summary forms.

17.5.4 Data Quality Assessment

Data Quality Assessment (DQA) is the scientific evaluation of data to determine if data obtained from environmental data operations are of the right type, quality, and quantity to support their intended use. DQA requires a systematic review against pre-established criteria to verify that the data are valid for their intended use. DQA is conducted by the technical lead and is the final review performed.

The overall effectiveness of the QA program is determined through systematic assessments and surveillances of the plan execution work flow (e.g., sampling plan development and execution, chain of custody, sample receiving, shipping, subcontract laboratory analytical activities, and data review) as well as the program requirements. Deficiencies are addressed on assessment/surveillance checklist, and if warranted will be tracked for corrective action and disposition (e.g., using the CaWeb Issues Tracking System).

17.6 Results

A brief discussion of the 2003 results for field duplicates, laboratory control samples, blank analysis, and interlaboratory comparison studies are provided within this section. Summary tables are also included. Based on implementation and evaluation of the QA/QC program and the results presented below, it can be concluded that the analytical data reported in the Nevada Test Site Environmental Report 2003 are reliable and of high quality.

17.6.1 Field Duplicates

Field duplicates are used to evaluate the precision of the data. A field duplicate is a sample collected, handled, and analyzed in the same fashion as the primary sample. The Relative Percent Difference (RPD) between the field duplicate result and corresponding field sample result is a measure of the variability in the process caused by the sampling uncertainty (matrix heterogeneity, collection variables, etc.) and measurement uncertainty (field and laboratory) used to derive the final result. The average absolute RPD, expressed as a percentage, was determined and listed in Table 17-1.

Table 17-1. Summary of field duplicate samples for compliance monitoring in 2003

Analysis	Matrix	Number of Samples Reported[(a)]	Number of Samples Reported above MDC[(b)]	Average Absolute RPD of those above MDC (%)[(c)]
Gross Alpha	Air	102	66	19.9
Gross Beta	Air	102	102	8.37
^{241}Am	Air	15	3	35.6
$^{239+240}$Pu	Air	24	9	39.3
^{7}Be	Air	24	24	4.77
^{3}H	Air	51	35	18.2
^{234}U	Air	9	9	28.4
^{238}U	Air	9	9	18.2
^{3}H	Water	21	2	20.7
Gross Alpha	Water	3	3	4.6
Gross Beta	Water	3	3	15.4
TLDs	Ambient	425	425	3.13

(a) Represents the number of field duplicates reported for the purpose of monitoring precision. If an associated field sample was not processed, the field duplicate was not included in this table.

(b) Represents the number of field duplicate - field sample result sets reported above the minimum detectable concentration (MDC). MDC is not applicable for TLDs. If either the field samples or its duplicate was reported below MDC, the precision was not determined.

(c) Reflects the Average Absolute RPD calculated for those field duplicates reported above the detection limit.

The Absolute RPD calculation is as follows:

$$Absolute\ RPD = \frac{|FD - FS|}{(FD + FS)/2} X\ 100$$

Where: FD = Field Duplicate result
FS = Field Sample result

17.6.2 Laboratory Control Samples

Laboratory control samples (LCS) are used to evaluate analytical accuracy by the subcontract laboratory. The analytical accuracy is the degree of agreement of a measured value with the true or expected value. Samples of known concentration are analyzed using the same methods as used for the project samples. The results are determined as the measured value divided by the true value, expressed as a percent. To be considered valid, the results must fall within established control limits (or percentage range) for further analyses to be performed. The LCS results obtained for samples analyzed in 2003 are summarized in Table 17-2. The LCS results were satisfactory with no more than one result being out of control for any given analysis or matrix category for the year.

Table 17-2. Summary of laboratory control samples (LCS) for compliance monitoring in 2003

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits[(a)]
$^{239+240}$Pu	Air	8	6
^{241}Am	Air	7	7
^{137}Ce	Air	6	5

Table 17-2. (continued)

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits[(a)]
Gross Alpha	Water	9	9
Gross Beta	Water	8	8
$^{239+240}$Pu	Water	14	14
Tritium	Water	43	42
^{90}Sr	Water	2	2
^{226}Ra	Water	3	3
^{228}Ra	Water	3	3
^{241}Am	Water	12	12
^{137}Ce	Water	17	16
^{60}Co	Water	9	9
^{90}Sr	Soil	7	7
$^{239+240}$Pu	Soil	10	10
^{241}241	Soil	6	6
^{137}Ce	Soil	9	9

(a) Control limits are as follows: 80 to 120 percent for gross alpha and beta; 84 to 114 percent for gamma (^{137}Cs, ^{60}Co, ^{241}Am); and 80 to 120 percent for tritium.

17.6.3 Blank Analysis

Blank analysis and control samples are used to evaluate overall laboratory procedures including sample preparation and instrument performance. Laboratory blank sample analyses are essentially the opposite of control samples discussed in Section 17.6.2. These samples do not contain any of the analyte of interest. Results of these analyses are expected to be 'zero', or more accurately, below the detection limit of a specific procedure. The laboratory blank sample results obtained for 2003 are summarized in Table 17-3. The laboratory blank results were satisfactory with no more than one result being out of control for any given analysis/matrix category for the year with the exception of $^{239+240}$Pu in air which had 28 of 32 analyses which were satisfactory.

Table 17-3. Summary of laboratory blank samples for compliance monitoring in 2003

Analysis	Matrix	Number of Blank Results Reported	Number Within Control Limits[(a)]
Gamma	Air	22	22
$^{239+240}$Pu	Air	32	28
Gamma	Water	26	25
Gross Alpha	Water	21	21
Gross Beta	Water	21	21
$^{239+240}$Pu	Water	16	15
Tritium	Water	87	86
^{90}Sr	Water	3	3
^{226}Ra	Water	5	5
^{228}Ra	Water	5	4
Gamma	Soil	25	24
Gross Alpha	Soil	1	1

Table 17-3. (continued)

Analysis	Matrix	Number of Blank Results Reported	Number Within Control Limits[(a)]
Gross Beta	Soil	1	1
^{90}Sr	Soil	11	11
$^{239+240}Pu$	Soil	18	17

(a) Control limit is less than MDC

17.6.4 Interlaboratory Comparison Studies

The interlaboratory comparison sample results obtained for 2003 are summarized in Tables 17-4 and 17-5. Table 17-4 shows the summary of interlaboratory comparison sample results for the Subcontracted Radiochemistry Laboratory. The Subcontractor participated in the InterLaB RadCheMTM Proficiency Testing Program directed by Environmental Resource Associates, the QAP administered by the Environmental Measurements Laboratory (EML), and the Mixed Analyte Performance Evaluation Program (MAPEP) conducted by Idaho National Engineering and Environmental Laboratory. The Subcontractor performed very well during the year by passing 100 out of 105 parameters analyzed. Table 17-5 shows the summary of interlaboratory comparison sample results for the BN in-house Dosimetry Group. This internal evaluation was based on National Voluntary Laboratory Accreditation Program (NVLAP) criteria. The Dosimetry Group participated in the Battelle Pacific Northwest National Laboratory performance evaluation study program during the course of the year. The Dosimetry Group performed very well during the year by passing 60 out of 60 TLDs analyzed.

Table 17-4. Summary of interlaboratory comparison samples of the subcontract radiochemistry laboratories for compliance monitoring in 2003

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[(a)]
	ERA Results		
Gross Alpha	Water	7	7
Gross Beta	Water	7	7
Gamma	Water	7	7
Tritium	Water	3	2
^{90}Sr	Water	7	7
^{226}Ra	Water	7	7
^{228}Ra	Water	7	7
	EML Results		
Gross Alpha	Air	7	7
Gross Beta	Air	7	7
$^{239+240}Pu$	Air	7	7
Gamma	Air	7	7
Gross Alpha	Water	7	3
Gross Beta	Water	7	7
$^{239+240}Pu$	Water	7	7
Gamma	Water	7	7
Gamma	Soil	7	7
$^{239+240}Pu$	Soil	7	7
^{90}Sr	Soil	7	7
Gamma	Vegetation	7	7

Table 17-4. (continued)

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[a]
		ERA Results	
$^{239+240}Pu$	Vegetation	7	7
^{90}Sr	Vegetation	7	7
		MAPEP Results	
Gamma	Water	5	5
$^{239+240}Pu$	Water	5	5
^{90}Sr	Water	5	5
Gamma	Soil	5	5
$^{239+240}Pu$	Soil	5	5
^{90}Sr	Soil	5	5

(a) Control limits are determined by the individual interlaboratory comparison study

Table 17-5. Summary of interlaboratory comparison TLD samples for the subcontract dosimetry group in 2003

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[a]
TLDs	Ambient Radiation	60	60

(a) Based upon NVLAP criteria; absolute value of the bias plus one standard deviation < 0.3.

18.0 Oversight Quality Assurance Program for CEMP

The Community Environmental Monitoring Program (CEMP) Quality Assurance Program Plan (QAPP) was followed for the collection and analysis of radiological air and water data presented in Section 5.0 of this Nevada Test Site Environmental Report (NTSER). The CEMP QAPP ensures compliance with U.S. Department of Energy (DOE) Order 414.1A Change 1 which implements a quality management system ensuring the generation and use of quality data. This QAPP addresses the following items previously defined in Section 17.0:

- Data Quality Objectives (DQOs)
- Sampling plan development appropriate to satisfy the DQOs
- Environmental health and safety
- Sampling plan execution
- Sample analyses
- Data review
- Continuous improvement

18.1 Data Quality Objectives (DQOs)

The DQO process is a strategic planning approach that is used to plan data collection activities. It provides a systematic process for defining the criteria that a data collection design should satisfy. These criteria include when and where samples should be collected, how many samples to collect, and the tolerable level of decision errors for the study. DQOs are unique to the specific data collection or monitoring activity, and are further explained in Appendices A through E of DOE, 2003b.

18.2 Measurement Quality Objectives (MQOs)

MQOs are basically equivalent to DQOs for analytical processes. The MQOs provide direction to the laboratory concerning performance objectives or requirements for specific method performance characteristics. Default MQOs are established in the subcontract, but may be altered in order to satisfy changes in the DQOs. The MQOs for the CEMP project are described in terms of precision, accuracy, representativeness, completeness, and comparability requirements. These terms are defined and discussed in Section 17.1 (Compliance Quality Assurance Program), for onsite activities.

18.3 Sampling QA Program

Quality Assurance (QA) in field operations for the CEMP includes sampling assessments, surveillances, and oversight of the following supporting elements:

- The sampling plan, data quality objectives, and field data sheets accompanying the sample package
- Database support for field and laboratory results, including systems for long-term storage and retrieval
- A training program to ensure that qualified personnel are available to perform required tasks

  Sample packages include the following items:

- Station manager checklist confirming all observable information pertinent to sample collection
- An Air Surveillance Network Sample Data Form documenting air sampler parameters, collection dates and times, and total sample volumes collected
- Chains-of-Custody

This managed approach to sampling ensures that the sampling is traceable and enhances the value of the final data available to the project manager. The sample package also ensures that the station manager Community Environmental Monitor (CEM) (see Section 5.0 for description of CEMs) has followed proper procedures for sample collection. The CEMP Project Manager or QA Officer routinely performs assessments of the station managers and field monitors to ensure that standard operating procedures and sampling protocol are being followed properly.

Data obtained in the course of executing field operations are entered in the documentation accompanying the sample package during sample collection and in the CEMP database along with analytical results upon their receipt and evaluation.

Completed sample packages are kept as hard copy in file archives. Analytical reports are kept as hard copy in file archives as well as Compact Disk-Read Only Memory by calendar year. Analytical reports and databases are protected and maintained in accordance with Desert Research Institutes (DRI's) Computer Protection Program.

18.4 Laboratory QA Oversight

CEMP ensures that DOE Order 414.1A, "Quality Assurance" requirements are met with respect to laboratory services through review of the vendor laboratory policies formalized in a Laboratory Quality Assurance Plan (LQAP). CEMP is assured of obtaining quality data from laboratory services through a multifaceted approach involving specific procurement protocols, the conduct of quality assessments, and requirements for selected laboratories to have an acceptable QA program. These elements are discussed below.

18.4.1 Procurement

Laboratory services are procured through subcontract. The subcontract establishes the technical specifications required of the laboratory and provides the basis for determining compliance with those requirements and evaluating overall performance. The subcontract is awarded on a "best value" basis as determined by pre-award audits. The prospective vendor is required to provide a review package to CEMP that includes the following items:

- All procedures pertinent to subcontract scope
- EH&S Plan
- LQAP
- Example deliverables (hard copy and/or electronic)
- Proficiency Testing (PT) results from the previous year from recognized PT programs
- Resumes
- Facility design/description
- Accreditations and certifications
- Licenses
- Audits performed by an acceptable DOE program covering comparable scope
- Past performance surveys
- Pricing

CEMP evaluates the review package in terms of technical capability. Vendor selection is based solely on these capabilities and not biased by pricing.

18.4.2 Initial and Continuing Assessment

An initial assessment of a laboratory is managed through the procurement process above, including a pre-award audit. Pre-award audits are conducted by CEMP (usually by the CEMP QA Officer). In no instance shall CEMP initiate work with a laboratory without approval of the CEMP program manager.

A continuing assessment of a selected laboratory involves ongoing monitoring of a laboratory's performance against the contract terms and conditions, of which technical specifications are a part. Tasks supporting continuing assessment are:

- Tracking schedule compliance
- Review of analytical data deliverables
- Monitoring of the lab's adherence to the LQAP
- Conducting regular audits
- Monitoring for continued successful participation in approved PT programs

18.4.3 Laboratory QA Program

The laboratory policies and approach to the implementation of DOE Order 414.1A must be verified in a LQAP prepared by the laboratory. The elements of a LQAP required for the CEMP are identical to those required by Bechtel Nevada for onsite monitoring, and are described in Section 17.3.3 (LQAP).

18.5 Data Review

Essential components of process-based QA are data checks, verification, validation, and data quality assessment to evaluate data quality and usability.

Data Checks – Data checks are conducted to ensure accuracy and consistency of field data collection operations prior to and upon data entry into CEMP databases and data management systems.

Data Verification – Data verification is defined as a subcontract compliance and completeness review to ensure that all laboratory data and sample documentation are present and complete. Sample preservation, chain-of-custody, and other field sampling documentation shall be reviewed during the verification process. Data verification ensures that the reported results entered in CEMP databases correctly represent the sampling and/or analyses performed and includes evaluation of quality control (QC) sample results.

Data Validation – Data validation is the process of reviewing a body of analytical data to determine if it meets the data quality criteria defined in operating instructions (OIs). Data validation ensures that the reported results correctly represent the sampling and/or analyses performed, determines the validity of the reported results, and assigns data qualifiers (or "flags"), if required. The process of data validation consists of:

- Evaluating the quality of the data to ensure that all project requirements are met
- Determining the impact on data quality of those requirements if they are not met
- Verifying compliance with QA requirements
- Checking QC values against defined limits
- Appling qualifiers to analytical results in the CEMP databases for the purposes of defining the limitations in the use of the reviewed data

OIs/Procedures, applicable project specific work plans, field sampling plans, QAPPs, analytical method references, and laboratory Statements of Work may all be used in the process of data validation. Documentation of data validation includes checklists, qualifier assignments, and summary forms.

Data Quality Assessment – Data Quality Assessment (DQA) is the scientific evaluation of data to determine if the data obtained from environmental data operations are of the right type, quality, and quantity to support their intended use. DQA review is a systematic review against pre-established criteria to verify that the data are valid for their intended use.

18.6 QA Program Assessments

The overall effectiveness of the QA program is determined through management and independent assessment as defined in the CEMP QAPP. These assessments evaluate the plan execution work-flow (sampling plan development and execution, chain-of-custody, sample receiving, shipping, subcontract laboratory analytical activities, and data review) as well as program requirements as it pertains to the organization.

18.7 2003 Sample QA Results

Quality assurance procedures were performed by the CEMP, including the laboratories responsible for sample analyses. These assessments ensure that sample collection procedures, analytical techniques, and data provided by the subcontracted laboratories comply with CEMP requirements. Data was provided by Severn Trent Laboratories (gross alpha/beta and gamma spectroscopy data), Global Dosimetry Solutions (thermoluminescent dosimeter [TLD] data), and DRI (tritium data). A brief discussion of the 2003 results for field duplicates, laboratory control samples, blank analysis, and interlaboratory comparison studies are provided along with summary tables within this section. The 2003 CEMP radiological air and water monitoring data themselves are presented in Section 5.0.

18.7.1 Field Duplicates (Precision)

A field duplicate is a sample collected, handled, and analyzed following the same procedures as the primary sample. The Relative Percent Difference (RPD) between the field duplicate result and the corresponding field sample result is a measure of the variability in the process caused by the sampling uncertainty (matrix heterogeneity, collection variables, etc.) and measurement uncertainty (field and laboratory) used to arrive at a final result. The average absolute RPD, expressed as a percentage, was determined for the calendar year 2003 samples and is listed in Table 18-1. An RPD of zero indicates a perfect duplication of results of the duplicate pair, whereas an RPD >100 percent generally indicates that a duplicate pair falls beyond QA requirements and are not considered valid for use in data interpretation. These samples are further evaluated to determine the reason for QA failure and if any corrective actions are required. Overall, the RPD values for all analyses indicate very good results.

Table 18-1. Summary of field duplicate samples for oversight monitoring in 2003

Analysis	Matrix	Number of Samples Reported[a]	Number of Samples Reported above MDC[b]	Average Absolute RPD of those above MDC (%)[c]
Gross Alpha	Air	106	105	28.1
Gross Beta	Air	106	106	9.9
Gamma - Beryllium-7	Air	8	4	16.4
Tritium	Water	4	1	11.1
TLDs	Ambient Radiation	12	12	4.8

(a) Represents the number of field duplicates reported for the purpose of monitoring precision. If an associated field sample was not processed, the field duplicate was not included in this table.

(b) Represents the number of field duplicate - field sample result sets reported above the minimum detectable concentration (MDC) (MDC is not applicable for TLDs). If either the field sample or its duplicate was reported below the detection limit, the precision was not determined.

(c) Reflects the Average Absolute RPD calculated for those field duplicates reported above the MDC.

The Absolute RPD calculation is as follows:

$$Absolute\ RPD = \frac{|FD - FS|}{(FD + FS)/2} \times 100$$

Where: FD = Field Duplicate result
FS = Field Sample result

18.7.2 Laboratory Control Samples (Accuracy)

Laboratory control samples (a.k.a. matrix spikes) are performed by the subcontract laboratory to evaluate analytical accuracy, which is the degree of agreement of a measured value with the true or expected value. Samples of known concentration are analyzed using the same methods as employed for the project samples. The results are determined as the measured value divided by the true value, expressed as a percent. To be considered valid, the results must fall within established control limits (or percentage range) for further analyses to be performed. The laboratory control samples (LCS) results obtained for 2003 are summarized in Table 18-2. The LCS results were satisfactory with only one sample (<1 percent) outside of control parameters each for gross alpha and gross beta for the air sample matrix.

Table 18-2. Summary of laboratory control samples (LCS) for oversight monitoring in 2003

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits[(a)]
Gross Alpha	Air	104	103
Gross Beta	Air	104	103
Gamma	Air	24	24
Tritium	Water	2	2

(a) Control limits are as follows: 80 to 120 percent for gross alpha and beta; 84 to 114 percent for gamma (^{137}Cs, ^{60}Co, ^{241}Am); 80 to 120 for tritium.

18.7.3 Blank Analysis

Laboratory blank sample analyses are essentially the opposite of control samples discussed in Section 18.7.2. These samples do not contain any of the analyte of interest. Results of these analyses are expected to be 'zero', or more accurately, below the MDC of a specific procedure. Blank analysis and control samples are used to evaluate overall laboratory procedures including sample preparation and instrument performance. The laboratory blank sample results obtained for 2003 are summarized in Table 18-3. The laboratory blank results were satisfactory with only one gross alpha sample (<1 percent) sample being outside of control parameters for the air sample matrix.

Table 18-3. Summary of laboratory blank samples for oversight monitoring in 2003

Analysis	Matrix	Number of Blank Results Reported	Number Within Control Limits[(a)]
Gross Alpha	Air	104	103
Gross Beta	Air	104	104
Gamma	Air	8	8
Tritium	Water	4	4

(a) Control limit is less than the MDC.

18.7.4 Interlaboratory Comparison Studies

Interlaboratory comparison studies are conducted by the subcontracted laboratories to evaluate their performance relative to other laboratories providing the same service. These types of samples are commonly known as 'blind' samples, in which the expected values are known only to the program conducting the study. The analyses are evaluated, and if found satisfactory, the laboratory is certified that its procedures produce reliable results. The interlaboratory comparison sample results obtained for 2003 are summarized in Tables 18-4 and 18-5. Note: the DRI tritium laboratory did not participate in any of these programs.

Table 18-4 shows the summary of interlaboratory comparison sample results for the Subcontract Radiochemistry Laboratory. The Laboratory participated in the Quality Assurance Program administered by the Environmental Measurements Laboratory (EML) for gross alpha, gross beta, and gamma analyses. The subcontractor performed very well during the year by passing all of the parameters analyzed.

Table 18-5 shows the summary of the in-house performance evaluation results conducted by the Subcontract Dosimetry Group. This internal evaluation was based on National Voluntary Laboratory Accreditation Program (NVLAP) criteria and was performed biannually. The Dosimetry Group performed very well during the year passing 20 out of 20 TLDs analyzed.

Table 18-4. Summary of interlaboratory comparison samples of the subcontract radiochemistry laboratory for oversight monitoring in 2003

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[(a)]
		EML Results	
Gross Alpha	Air	2	2
Gross Beta	Air	2	2
Gamma	Air	2	2

(a) Control limits are determined by the individual interlaboratory comparison study.

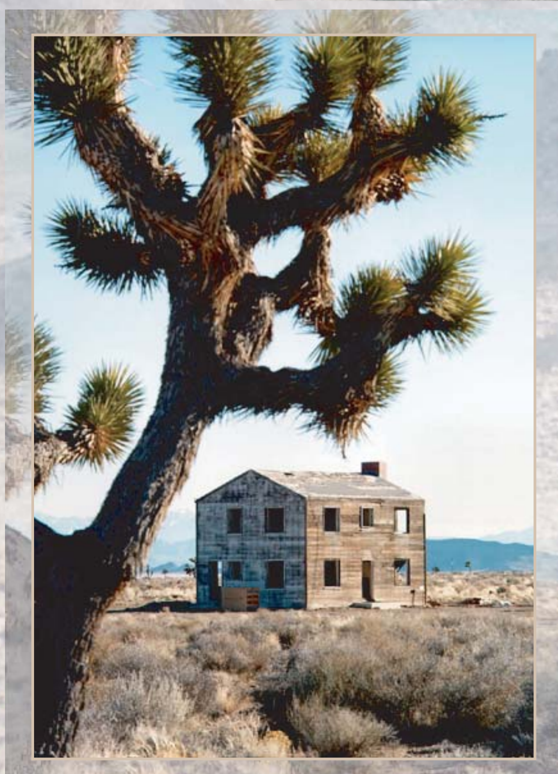
Table 18-5. Summary of interlaboratory comparison TLD samples of the subcontract dosimetry group for compliance monitoring in 2003

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[(a)]
TLDs	Ambient Radiation	20	20

(a) Based upon NVLAP criteria; absolute value of the bias plus one standard deviation < 0.3.

Historic cabin at Tippipah Spring, Area 16, 1986

Appendices



Apple II frame house, Area 1, 1986

Mercury, looking east, 1986

Appendix A
Nevada Test Site Description

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Appendix A: Nevada Test Site Description

This appendix provides a general description of the Nevada Test Site (NTS). Included are subsections that summarize the site's topographic setting, and the known climatic, geological, hydrological, and ecological features and conditions which characterize the NTS. The subsections are meant to aid the reader in understanding the complex physical and biological environment of the NTS. An adequate knowledge of the site's environment is necessary to assess the environmental impacts of new projects, design and implement environmental monitoring activities for current site operations, and assess the impacts of site operations on the public residing in the vicinity of the NTS. The NTS environment contributes to several key features of the site which afford protection to the inhabitants of adjacent areas from potential exposure to radioactivity or other contaminants resulting from NTS operations. These key features include the general remote location of the NTS, restricted access, extended wind transport times, the great depths to slow-moving groundwater, little or no surface water, and low population density. This appendix complements the annual summary of monitoring program activities and dose assessments presented in the main body of this report.

Aerial view of Rainer Mesa, the highest terrain on the NTS (Date Unknown)

A.1 NTS Location and Facilities

The NTS is located in Nye County in south-central Nevada (Figure A-1). The southeast corner of the NTS is about 88 km (55 mi) northwest of the center of Las Vegas in Clark County. By highway, it is about 105 km (65 mi) from the center of Las Vegas to Mercury. Mercury, located at the southern end of the NTS, is the main base camp for worker housing and administrative operations for the NTS.

The NTS encompasses about 3,561 km² (1,375 mi²). It varies from 46 to 56 km (28 to 35 mi) in width from west to east and from 64 to 88 km (40 to 55 mi) from north to south. The NTS is surrounded on all sides by federal lands. As shown in Figure A-1, the NTS is bordered on the north and west by the Nevada Test and Training Range (NTTR) (previously known as the Nellis Air Force Range), on the east by an area used by both the NTTR and the Desert National Wildlife Range (DNWR), and on the south by Bureau of Land Management lands. The combination of the NTTR and the NTS represents one of the larger unpopulated land areas in the United States, comprising some 14,200 km² (5,470 mi²). Figure A-2 shows the general layout of the NTS, including the location of major facilities and the numbered operational areas of the NTS referred to in this report. The geographical areas previously used for nuclear testing are also shown in Figure A-2.

Aerial view of Yucca Flat showing subsidence craters formed during underground nuclear test, Yucca Lake Playa, and Spring Mountains in the background (Date Unknown)

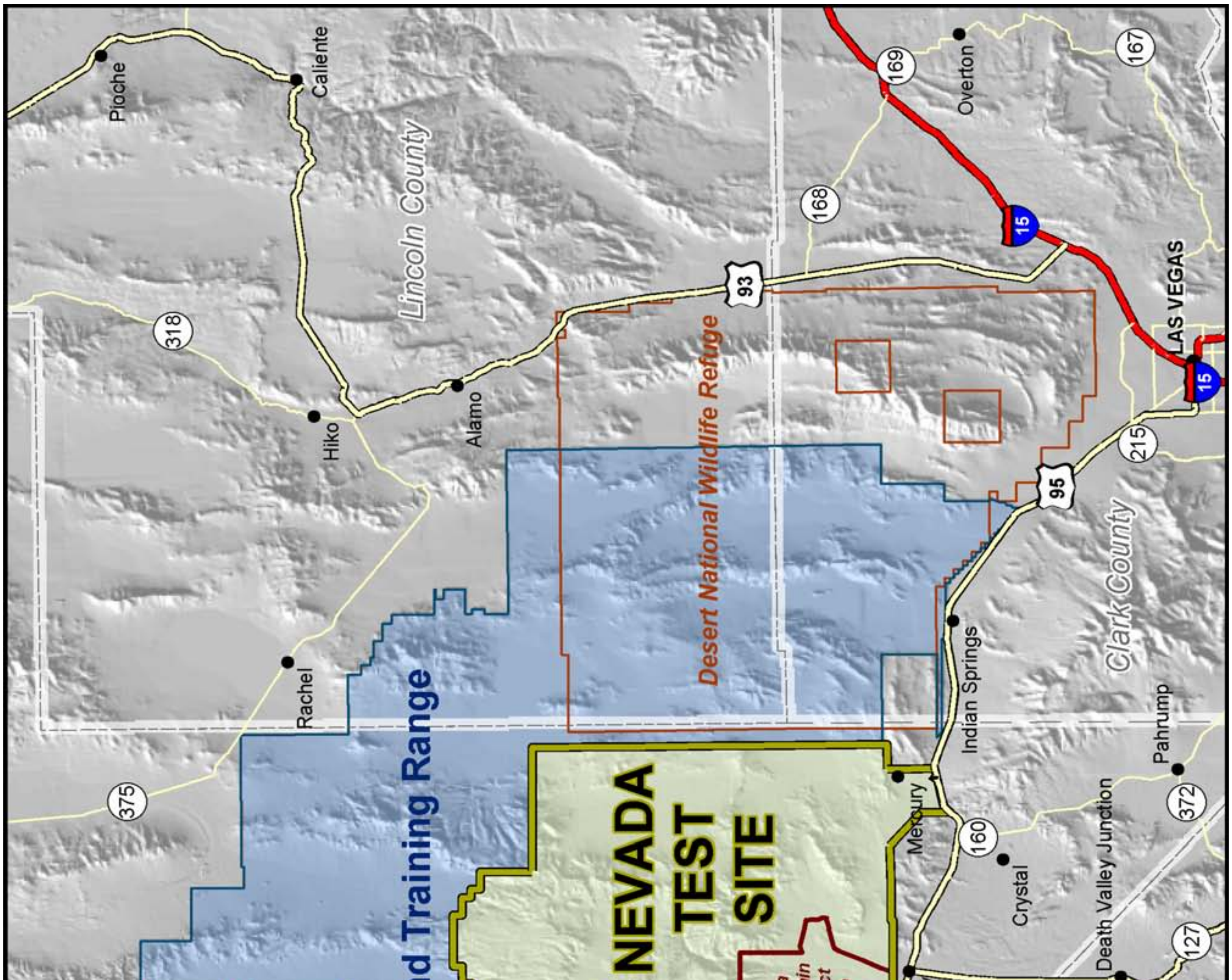


Figure A-1. NTS vicinity map

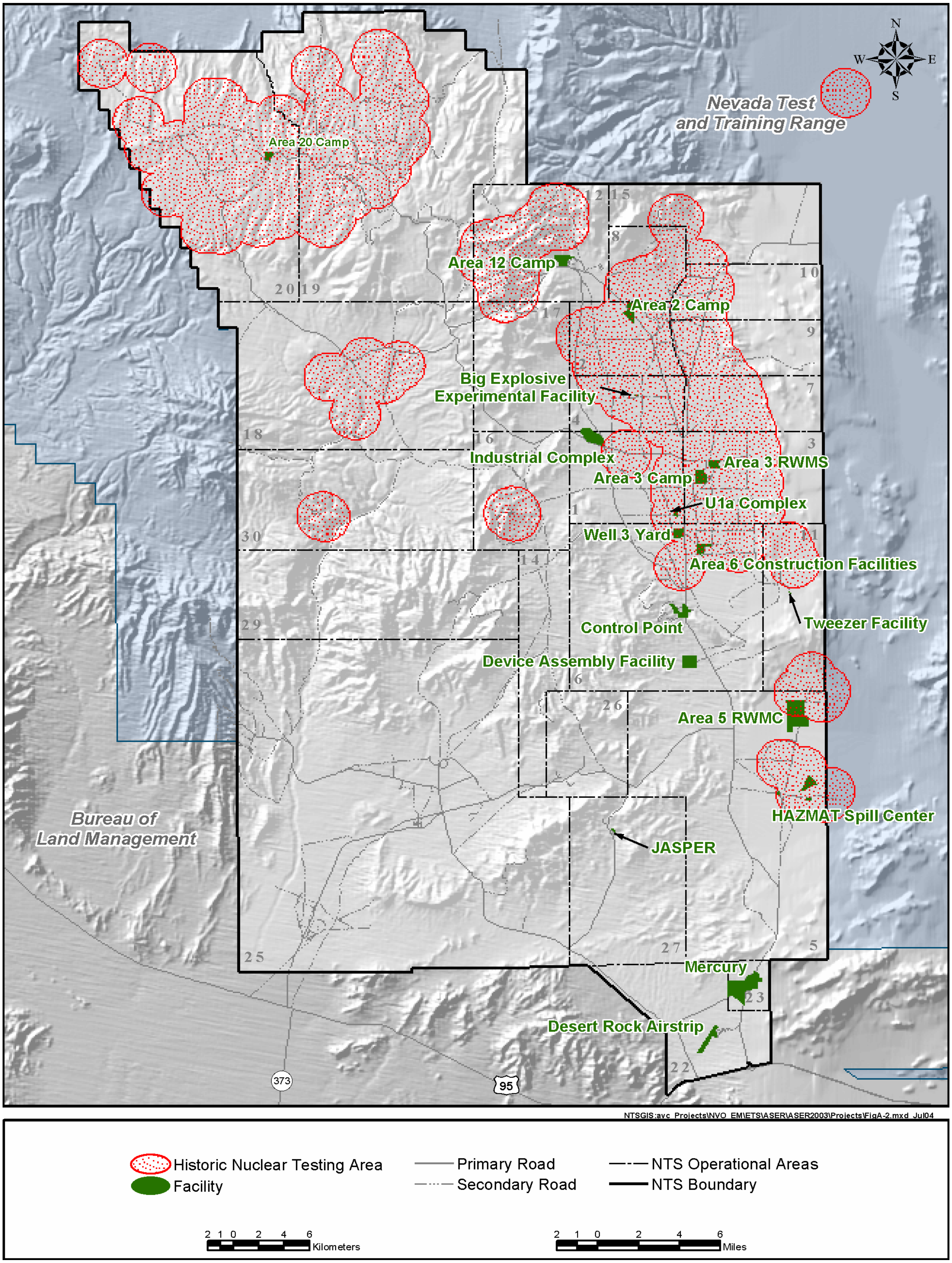


Figure A-2. NTS operational areas, principal facilities, and past nuclear testing areas

A.2 Demography

The population of the area surrounding the NTS is predominantly rural. The population estimates for Nevada communities has been estimated by the Nevada State Demographer Office (NSDO) up through July 1, 2003 (Hardcastle, 2004). The annual population estimate for Nevada counties, cities, and unincorporated towns is 2,296,566, with all but 675,818 residing in Clark County. The total population estimate for Nye County is 36,651 and includes the communities of Amargosa Valley (1,169), Beatty (1,079), Gabbs (314), Manhattan (135), Pahrump (28,847), Round Mountain (784), and Tonopah (2,481). The largest of the Nye County communities is Pahrump Valley, which is approximately 50 mi (80 km) south of the NTS Control Point facility, which is near the center of the NTS (see Figure A-2). Neighboring Lincoln County to the east of the NTS includes a few small communities including Alamo (428), Panaca (541), and Pioche (659). Neighboring Clark County is the major population center of Nevada and has an estimated total population of 1,620,748.

The Mojave Desert of California, which includes Death Valley National Park, lies along the southwestern border of Nevada. This area is still predominantly rural; however, tourism at Death Valley National Park swells the population to more than 5,000 on any particular day during holiday periods during mild weather.

The extreme southwestern region of Utah is more developed than the adjacent portion of Nevada. The population estimates for Utah communities are based on the 2000 Census data and were obtained from University of Utah websites (University of Utah, 2004). The largest community is St. George, located 220 km (137 mi) east of the NTS, with a population of 49,621. The next largest town, Cedar City, is located 280 km (174 mi) east-northeast of the NTS and has a population of 20,527.

The extreme northwestern region of Arizona is mostly rangeland, except for that portion in the Lake Mead recreation area. In addition, several small communities lie along the Colorado River. The largest towns in the area are Bullhead City, 165 km (103 mi) south-southeast of the NTS, with a population estimate of 35,410, and Kingman, located 280 km (174 mi) southeast of the NTS, with a population estimate of 22,045 (July 1, 2002 population estimates, Arizona Department of Economic Security, 2004).

The offsite population density within an 80-km radius of all emission sources of radioactivity on the NTS is about 1.0 persons/km^2 (2.6 persons/mi^2). In comparison, the 48 contiguous states have a population density of about 38 persons/km^2 (U.S. Census Bureau, 2003).

A.3 Physiography

The NTS is located in the southern part of the Great Basin, the northern-most sub-province of the Basin and Range Physiographic Province (Figure A-3). The Great Basin is a vast area of North America which is bounded by the Sierra Nevada on the west, the Colorado Plateau and the Wasatch Range on the east, the Columbia Plateau on the north, and the Sonoran Desert on the south. The Great Basin covers a small portion of eastern California, southeastern Oregon, southern Idaho, western Utah, and most of Nevada.

The NTS terrain is typical of much of the Basin and Range Physiographic Province, characterized by mostly tilted, fault-bounded blocks that are as much as 80 km (50 mi) long and 24 km (15 mi) wide. These features are modified locally by the Las Vegas Shear Zone (a component of the Walker Lane regional structural belt) in the southern part of the NTS, and by resurgent calderas of the Southwest Nevada Volcanic Field (SWNVF). The land forms and topography of the NTS area reflect the complex geology and its location in the arid Mojave Desert.

The principal valleys within the NTS are Frenchman Flat, Yucca Flat, and Jackass Flats (Figure A-4). Both Yucca and Frenchman Flat are topographically closed and contain dry lake beds, or playas, at their lowest elevations. Jackass Flats is topographically open, and surface water from this basin flows off the NTS via the Fortymile Wash. The dominant highlands of the NTS are Pahute Mesa and Rainier Mesa (high volcanic plateaus), Timber Mountain (a resurgent dome of the Timber Mountain caldera complex), and Shoshone Mountain. In general, the slopes of the highland areas are steep and dissected, and the slopes in the lowland areas are gentle and less eroded. The lowest elevation on the NTS is 823 m (2,700 ft) in Jackass Flats in the southeast, and the highest elevation is 2,341 m (7,680 ft) on Rainier Mesa in the north-central region.

The topography of the NTS has been altered by historic DOE actions, particularly underground nuclear testing. The principal effect of testing has been the creation of numerous collapse sinks (“craters”) in Yucca Flat basin and a lesser number of “craters” on Pahute and Rainier Mesas. Shallow detonations were also performed during Project Plowshare to determine the potential uses of nuclear devices for large-scale excavation. Lesser alterations of the natural topography of the NTS have occurred as a result of road building, sand and gravel mining, underground mining prior to the creation of the NTS, and the construction of waste disposal areas, flood controls, and drainage improvements.

Aerial view of Fortymile Canyon (Date Unknown)

Figure A-3. Basin and Range Physiographic Province and Great Basin Hydrologic Province

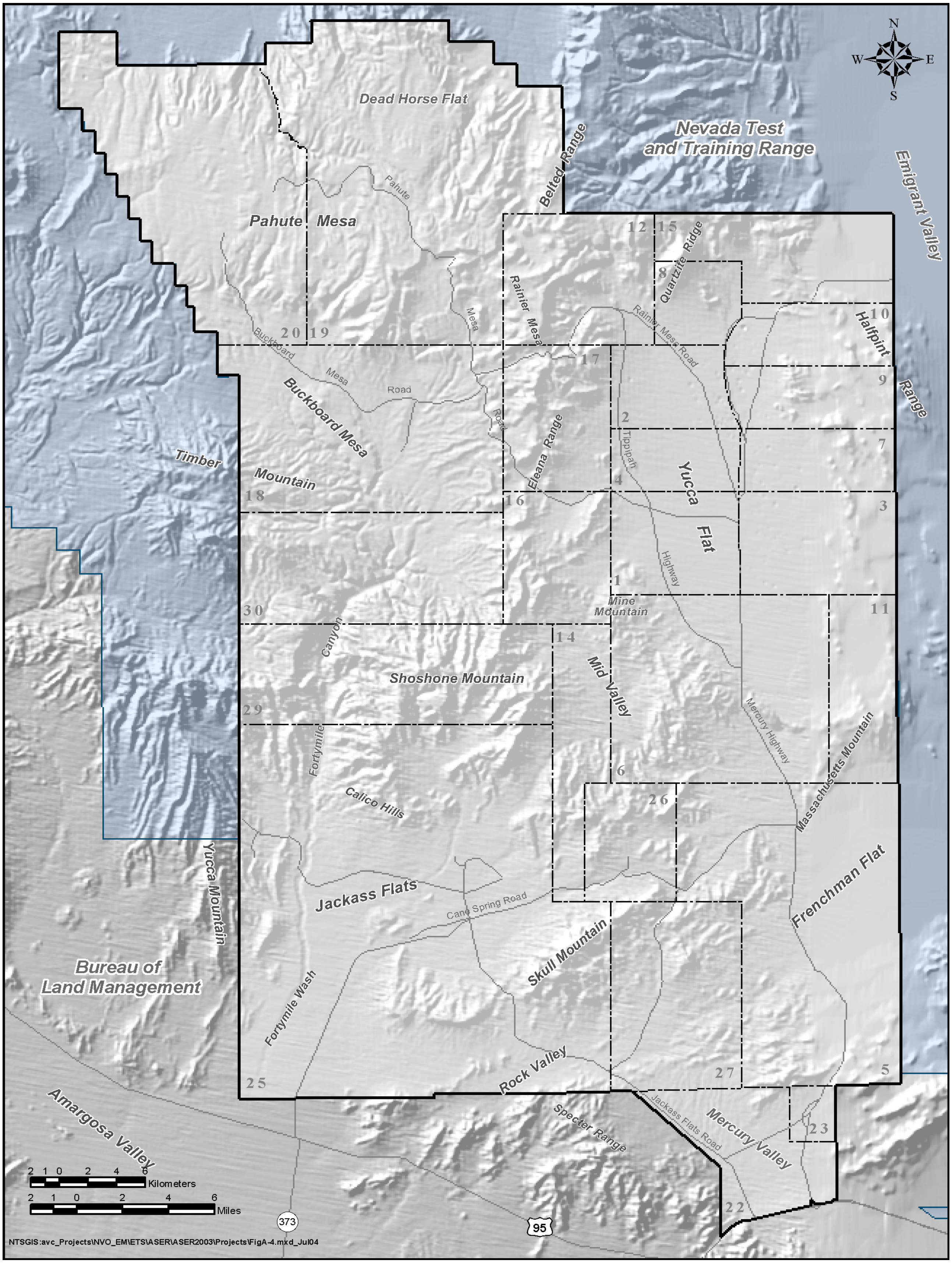


Figure A-4. Major topographic features of the NTS

A.4 Geology

The following subsections present an overview of the geologic setting of the NTS and vicinity, including summary descriptions of the stratigraphy and structure.

A.4.1 Geologic Setting

The NTS area is geologically complex, with at least six Tertiary-age calderas nearby, many relatively young basin-and-range-style normal faults, and Mesozoic-age thrust faults and intrusive bodies, all superimposed on a basement complex of highly deformed Proterozoic and Paleozoic-age sedimentary and metasedimentary rocks. Geologic units exposed at the surface in the NTS area can be categorized as approximately 40 percent alluvium-filled basins and 20 percent Paleozoic and uppermost Precambrian sedimentary rocks; the remainder is Tertiary-age volcanic rocks, and a few intrusive masses (Orkild, 1983b; Slate et al., 1999). A generalized geologic map of the NTS area is given in Figure A-5.

The NTS area is dominated by Tertiary-age volcanic rocks formed from materials that were erupted from various vents in the SWNVF, located on and adjacent to the northwestern part of the NTS (Figure A-5). At least six major calderas have been identified in this multi-caldera silicic volcanic field (Byers et al., 1976). The calderas formed by the voluminous eruption of zoned ash-flow tuffs between 16 and 7.5 million years ago (Ma) (Sawyer et al., 1994). From oldest to youngest the calderas are: Grouse Canyon, Area 20, Claim Canyon, Rainier Mesa, Ammonia Tanks, and Black Mountain calderas. A comprehensive review of past studies and the evolution of concepts on calderas of the SWNVF during the period from 1960 to 1988 is presented in Byers et al., 1989.

The volcanic rocks are covered in many areas by a variety of late Tertiary and Quaternary surficial deposits. These younger deposits consist of alluvium, colluvium, eolian (wind-blown sand) deposits, spring deposits, basalt lavas, lacustrine (fresh-water lake) deposits, and playa deposits.

The area includes more than 300 described Tertiary-age volcanic units (Warren et al., 2000a; 2003). As a matter of practicality, some units are grouped together, especially those of limited areal extent or thickness. Table A-1 presents most of the Tertiary volcanic units useful in characterizing the subsurface at the NTS.

Underlying the Tertiary volcanic rocks are Paleozoic and Proterozoic sedimentary rocks including dolomite, limestone, quartzite, and argillite, some of which form the primary regional aquifer and the regional hydrologic "basement" (Table A-2). During Precambrian and Paleozoic time, as much as 10,000 m (32,800 ft) of marine sediments were deposited in the NTS region (Cole, 1997). The only surface exposure of Mesozoic-age rocks in the NTS area are granitic intrusive masses, the Gold Meadows Stock north of Rainier Mesa (Snyder, 1977; Gibbons et al.,1963), and the Climax Stock located at the extreme north end of Yucca Flat (Maldonado, 1977; Barnes et al., 1963) (Figure A-5).

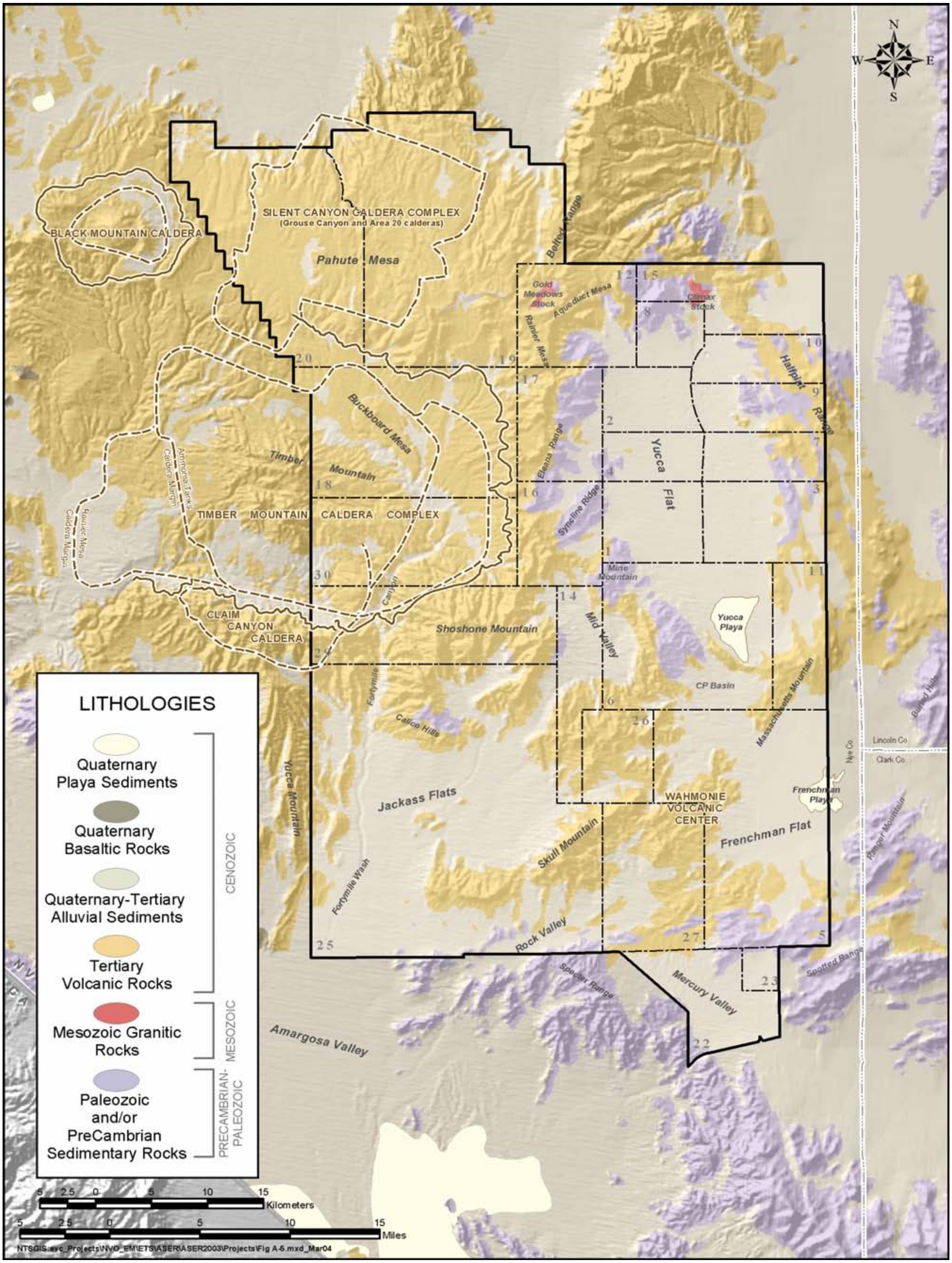


Figure A-5. Generalized geologic map of the NTS and vicinity

Table A-1. Quaternary and tertiary stratigraphic units of the NTS and vicinity

Stratigraphic Assemblages and Major Units[a, b]	Volcanic Sources[c]
Quaternary or Tertiary Sediments Young alluvium (Qay) Playa (Qp) Quaternary - Tertiary colluvium (QTc) Middle alluvium (Qam) Eolian sand (QTe) Quaternary-Tertiary alluvium (QTa) Quaternary Basalts (Qby) Pliocene Basalts (Typ) Tertiary alluvium (Tgy)	Not applicable
Miocene Basalt and Rhyolite Thirsty Canyon and Younger Basalts (Tyb) Rhyolite of Obsidian Butte (Tyr)	Several discrete sources
Tertiary Sediments Late synvolcanic sedimentary rocks (Tgm) Caldera moat-filling sedimentary deposits (Tgc) Younger landslide and sedimentary breccia (Tgyx)	Not applicable
Thirsty Canyon Group (Tt) Gold Flat Tuff (Ttg) Trachyte of Hidden Cliff (Tth) Trachytic rocks of Pillar Spring and Yellow Cleft (Tts) Trail Ridge Tuff (Ttt) Pahute Mesa and Rocket Wash Tuffs (Ttp) Comendite of Ribbon Cliff (Ttc)	Black Mountain Caldera
Volcanics of Fortymile Canyon (Tf) Rhyolite of Boundary Butte (Tfu) Post-Timber Mountain Basaltic Rocks (Tft) Trachyte of Donovan Mountain (Tfn) Rhyolite of Shoshone Mountain (Tfs) Lavas of Dome Mountain (Tfd) Younger intrusive rocks (Tiy) Rhyolite of Rainbow Mountain (Tfr) Beatty Wash Formation (Tfb) Tuff of Leadfield Road (Tfl) Rhyolite of Fleur-de-lis Ranch (Tff)	Several discrete vent areas in and around the Timber Mountain caldera complex

Table A-1. (continued)

Stratigraphic Assemblages and Major Units[a, b]	Volcanic Sources[c]
Timber Mountain Group (Tm)	Timber Mountain Caldera Complex
Trachyte of East Cat Canyon (Tmay)	
Tuff of Buttonhook Wash (Tmaw)	
Ammonia Tanks Tuff (Tma)	Ammonia Tanks Caldera
Bedded Ammonia Tanks Tuff (Tmab)	
Timber Mountain landslide breccia (Tmx)	
Rhyolite of Tannenbaum Hill (Tmat)	
Basalt of Tierra (Tmt)	Rainier Mesa Caldera
Rainier Mesa Tuff (Tmr)	
Rhyolite of Fluorspur Canyon (Tmrf)	
Tuff of Holmes Road (Tmrh)	
Landslide or eruptive breccia (Tmrx)	
Rhyolite of Windy Wash (Tmw)	
Transitional Timber Mountain rhyolites (Tmn)	
Paintbrush Group (Tp)	Claim Canyon Caldera
Rhyolite of Benham (Tpb)	
Post-Tiva Canyon rhyolites (Tpu)	
Paintbrush caldera-collapse breccias (Tpx)	
Tiva Canyon Tuff (Tpc)	Claim Canyon Caldera
Yucca Mountain Tuff (Tpy)	Unknown
Rhyolite of Delirium Canyon (Tpd)	
Rhyolite of Echo Peak (Tpe)	
Middle Paintbrush Group rhyolites (Tpm)	
Pah Canyon Tuff (Tpp)	
Rhyolite of Silent Canyon (Tpr)	
Topopah Spring Tuff (Tpt)	Unknown
Calico Hills Formation (Th; formerly Tac)	Unknown
Wahmonie Formation (Tw)	Wahmonie Volcanic Center
Crater Flat Group (Tc)	Silent Canyon Caldera Complex
Rhyolite of Inlet (Tci)	
Prow Pass Tuff (Tcp)	
Rhyolite of Kearsarage (Tcpk)	Area 20 Caldera
Andesite of Grimy Gulch (Tcg)	
Bullfrog Tuff (Tcb)	
Rhyolites in the Crater Flat Group (Tcr)	
Tram Tuff (Tct)	
Belted Range Group (Tb)	Grouse Canyon Caldera
Deadhorse Flat Formation (Tbd)	
Grouse Canyon Tuff (Tbg)	
Comendite of Split Range (Tbgs)	
Comendite of Quartet Dome (Tbq)	

Table A-1. (continued)

Stratigraphic Assemblages and Major Units[a, b]	Volcanic Sources[c]
Tram Ridge Group (Tr) Lithic Ridge Tuff (Trl) Dikes of Tram Ridge (Trd) Rhyolite of Picture Rock (Trr)	Uncertain
Tunnel Formation (Tn) 4 Member (Tn4) 3 Member (Tn3)	Uncertain
Volcanics of Quartz Mountain (Tq) Tuff of Sleeping Butte (Tqs) Hornblende-bearing rhyolite of Quartz Mountain(Tqh) Tuff of Tolicha Peak (Tqt) Early rhyolite of Quartz Mountain (Tqe) Dacite of Mount Helen (Tqm)	Uncertain
Volcanics of Big Dome (Tu) Comendite of Ochre Ridge (Tuo) Tub Spring Tuff (Tub) Comendite of Emigrant Valley (Tue)	Unknown
Volcanics of Oak Spring Butte (To) Tunnel bed 2 (Ton2) Yucca Flat Tuff (Toy) Tunnel bed 1 (Ton1) Redrock Valley Tuff (Tor) Tuff of Twin Peaks (Tot)	Unknown
Older Volcanics (Tqo)	Unknown
Paleocolluvium (Tl)	N/A

(a) Compiled from Wahl et al. (1997) and Ferguson et al. (1994).
(b) Letters in parentheses are stratigraphic unit map symbols.
(c) Sources, where known, from Sawyer et al. (1994)
Refer to Table A-2 for lists of Mesozoic, Paleozoic, and Precambrian sedimentary rock formations.

Table A-2. Pre-tertiary stratigraphic units of the NTS and vicinity

Map Unit	Stratigraphic Unit Map Symbol	Stratigraphic Thickness Feet	Stratigraphic Thickness Meters	Dominant Lithology
Gold Meadows Stock Climax Stock	Kgg Kgc	N/A	N/A	Quartz monzonite Granodiorite
Tippipah Limestone (correlative with the Bird Spring Formation)	PPt	3,500	1,070	Limestone
Chainman Shale and Eleana Formation	Mc MDe	4,000	1,220	Shale, argillite, and quartzite
Guilmette Formation	Dg	1,400	430	Limestone
Simonson Dolomite	Ds	1,100	330	Dolomite
Sevy Dolomite	DSs	690	210	Dolomite
Laketown Dolomite	Sl	650	200	Dolomite
Ely Spring Dolomite	Oes	340	105	Dolomite
Eureka Quartzite	Oe	400	125	Quartzite
Antelope Valley Limestone	Oa	1,530	466	Limestone
Ninemile Formation	On	335	102	Limestone
Goodwin Limestone	Og	685	209	Limestone
Nopah Formation	Cn	2,050	620	Limestone
Bonanza King Formation	Cb	4,350	1,330	Limestone/dolomite
Carrara Formation (upper)	Cc	925	280	Limestone
Carrara Formation (lower)	Cc	925	280	Shale/Siltstone
Zabriskie Quartzite	Cz	200	60	Quartzite
Wood Canyon Formation	CZw	2,300	700	Micaceous quartzite
Stirling Quartzite	Zs	2,900	890	Quartzite
Johnnie Formation	Zj	3,000	914	Quartzite/siltstone/limestone

(Stratigraphic units and lithologies adapted from Cole, 1992)

A.4.2 Stratigraphy

In order to confidently characterize the geology at the NTS, geoscientists must start from a well understood stratigraphic system. Refinement of the stratigraphy of the area was a continuous process during the decades in which geoscientists associated with the Weapons Testing Program (WTP) worked to understand the complex volcanic setting (documented by Byers et al., 1989). The need to develop detailed geologic models in support of the Underground Test Area (UGTA) Project (see Section 13) intensified this process, and the recognition of smaller and smaller distinct volcanic units permitted a greater understanding of the three-dimensional configuration of the various types of rocks, which has been incorporated into the geologic framework. Efforts to understand the structure and stratigraphy of the non-volcanic rocks (pre-Tertiary) have also continued to a lesser degree (Cole, 1997; Cole and Cashman, 1999; Cashman and Trexler, 1991; Trexler et al., 2003). The most widespread and significant Quaternary and Tertiary (mainly volcanic) units of the NTS area are listed in Table A-1. Refer to Table A-2 for a list of Mesozoic (granitic), Paleozoic (sedimentary), and Precambrian (sedimentary and metamorphic) stratigraphic units.

A.4.3 Structural Controls

Geologic structures are an important component of the hydrogeology of the area. Structures define the geometric configuration of the area, including the distribution, thickness, and orientation of units. Synvolcanic structures, including caldera faults and some normal faults had strong influence on depositional patterns of many of the units. The juxtaposition of units with different hydrologic properties across faults may have significant hydrogeologic consequences. Also, faults may act as either conduits or barriers of groundwater flow, depending on the difference in permeability between a fault zone and the surrounding rocks. This is partially determined by whether the fault zone is characterized by open fractures, or if it is associated with fine-grained gouge or increased alteration.

Five main types of structural features exist in the area:

- Thrust faults (e.g., Belted Range and CP thrusts).
- Normal faults (e.g., Yucca and West Greeley faults).
- Transverse faults and structural zones (e.g., Rock Valley and Cane Spring faults).
- Calderas (e.g., Timber Mountain and Silent Canyon caldera complexes).
- Detachment faults (e.g., Fluorspar Canyon - Bullfrog Hills detachment fault).

The Belted Range thrust fault is the principle pre-Tertiary structure in the NTS region and thus, controls the distribution of pre-Tertiary rocks in the area. The fault can be traced or inferred from Bare Mountain just south of the southwest corner of the NTS area to the northern Belted Range, just north of the NTS, a distance of more than 130 km (81 mi). It is an eastward-directed thrust fault that generally places late Proterozoic to early Cambrian rocks over rocks as young as Mississippian. Several imbricate thrust faults occur east of the main thrust fault. Deformation related to the Belted Range thrust fault occurred sometime between 100 and 250 Ma. Lesser thrusts of similar age are mapped in the area (e.g., the CP and Spotted Range thrusts).

Normal faults in the area are related mainly to basin-and-range extension (e.g., Yucca fault in Yucca Flat and West Greeley fault on Pahute Mesa). Most of them likely developed during and after the main phase of volcanic activity of the SWNVF (Sawyer et al., 1994). The majority of these faults are northwest-to northeast-striking, high angle faults. However, the exact locations, amount of offset along the faults, and character of the faults become increasingly uncertain with depth.

Calderas are probably the most hydrogeologically important features in the NTS area. Volcano-tectonic and geomorphic processes related to caldera development, result in abrupt and dramatic lithologic and thickness changes across caldera margins. Consequently, caldera margins (i.e., faults) separate regions with considerably different hydrogeologic character.

A.5 Hydrology

The hydrologic character of the NTS and vicinity reflects the region's arid climatic conditions and complex geology (D'Agnese et al., 1997). The hydrology of the NTS has been extensively studied for over 40 years (DOE, 1996), and numerous scientific reports and large databases are available (refer to cited references for more detailed information). The following subsections present an overview of the hydrologic setting of the NTS and vicinity, including summary descriptions of surface water and groundwater, hydrogeologic framework, and brief descriptions of the hydrogeology for each of the idle underground test areas on the NTS. The reader is directed to Section 13.5 in the main body of this document for a discussion of the hydrogeologic modeling efforts conducted under the UGTA Project.

A.5.1 Surface Water

The NTS is located within the Great Basin, a closed hydrographic province that comprises several closed hydrographic basins (Figure A-6). The closed hydrographic basins of the NTS (most notably Yucca and Frenchman Flats) are subbasins of the Great Basin. Streams in the region are ephemeral, flowing only in response to precipitation events or snowmelt. Runoff is conveyed through normally dry washes toward the lowest areas of the closed hydrographic subbasins, and collects on playas. Two playas (seasonally dry lakes) occur on the NTS: Frenchman Lake and Yucca Lake, which lie in Frenchman and Yucca Flats, respectively. While water may stand on the playas for a few weeks before evaporating, the playas are dry most of the year. Surface water may leave the NTS in only a few places, such as Fortymile Canyon in the southwestern NTS.

Springs that emanate from local perched groundwater systems are the only natural sources of perennial surface water in the region. There are 24 known springs or seeps on the NTS (Hansen et al., 1997; BN, 1999) (Figure A-7). Spring discharge rates are low, ranging from 0.014 to 2.2 liters/sec (0.22 to 35 gallons/minute) (IT, 1997). Most water discharged from springs travels only a short distance from the source before evaporating or infiltrating into the ground. The springs are important sources of water for wildlife, but they are too small to be of use as a public water supply source.

Other surface waters on the NTS include man-made impoundments constructed at several locations throughout the NTS to support various operations. These are numerous, and include open industrial reservoirs, containment ponds, and sewage lagoons (DOE, 2003). Surface water is not a source of drinking water on the NTS.

A.5.2 Groundwater

The NTS is located within the Death Valley regional groundwater flow system, one of the major hydrologic subdivisions of the southern Great Basin (Waddell et al., 1984; Laczniak et al., 1996). Groundwater in southern Nevada is conveyed within several flow-system subbasins within the Death Valley regional flow system (a subbasin is defined as the area that contributes water to a major surface discharge area [Laczniak, et al., 1996]). Three principal groundwater subbasins, named for their down-gradient discharge areas, have been identified within the NTS region: the Ash Meadows, Oasis Valley, and Alkali Flat-Furnace Creek Ranch subbasins (Waddell et al., 1984) (Figure A-8).

The groundwater-bearing rocks at the NTS have been classified into several hydrogeologic units (HGUs; see Section A.5.3 below), of which the most important is the lower carbonate aquifer, a thick sequence of Paleozoic carbonate rock. This unit extends throughout the subsurface of central and southeastern Nevada, and is considered to be a regional aquifer (Winograd and Thordarson, 1975; Laczniak, et al., 1996; IT, 1996a). Various volcanic and alluvial aquifers are also locally important as water sources.

The depth to groundwater in wells at the NTS varies from about 210 m (690 ft) below the land surface under the Frenchman Flat playa in the southeastern NTS, to more than 610 m (2,000 ft) below the land surface in the northwestern NTS, beneath Pahute Mesa (Lock et al., 2003; Bright et al., 2000; IT, 1996b; Reiner et al., 1995; O'Hagan and Laczniak, 1996; Robie et al., 1995). Perched groundwater (isolated lenses of water lying above the regional groundwater level) occurs locally throughout the NTS, mainly within the volcanic rocks.

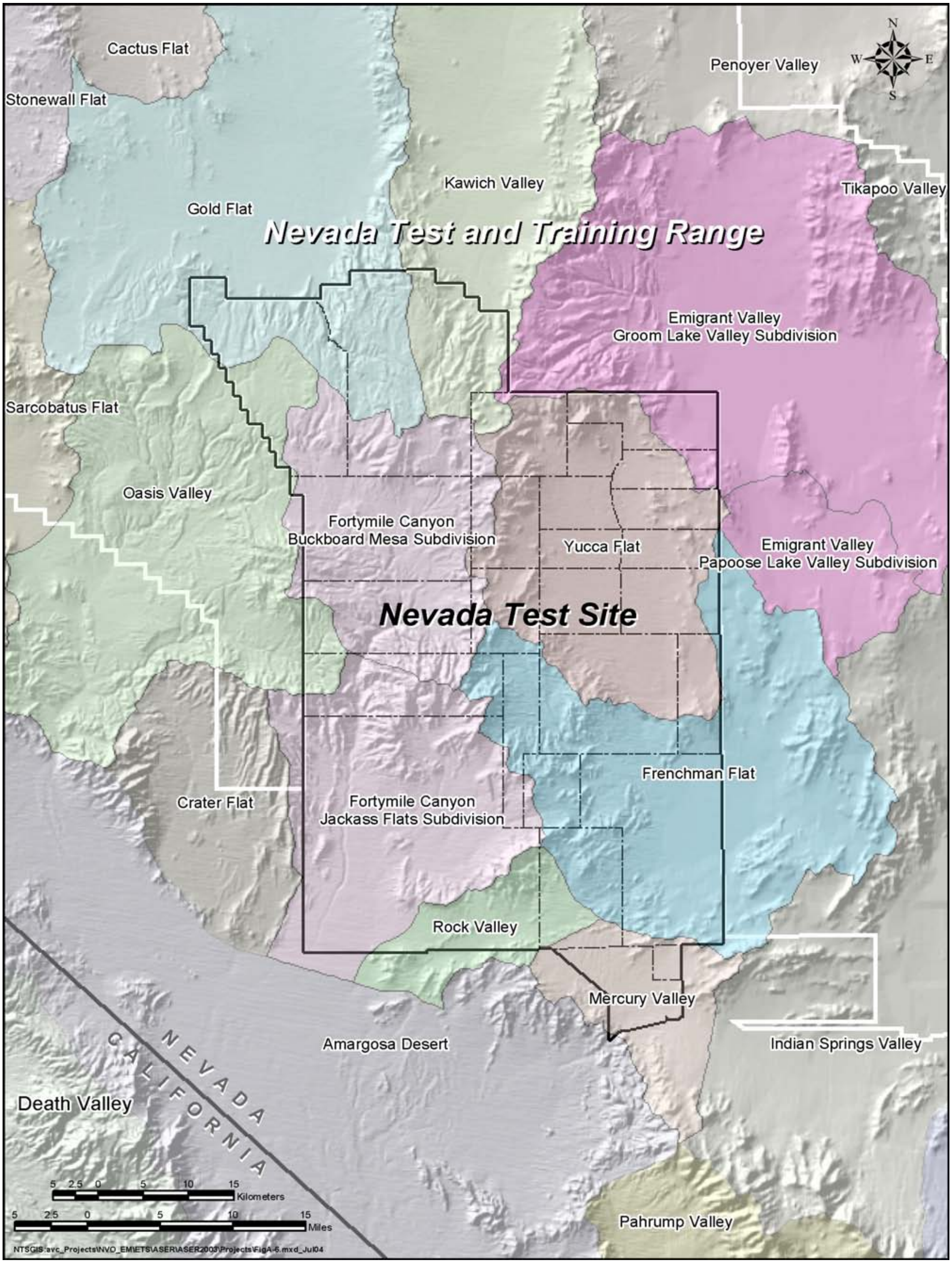


Figure A-6. Closed hydrographic subbasins on the NTS

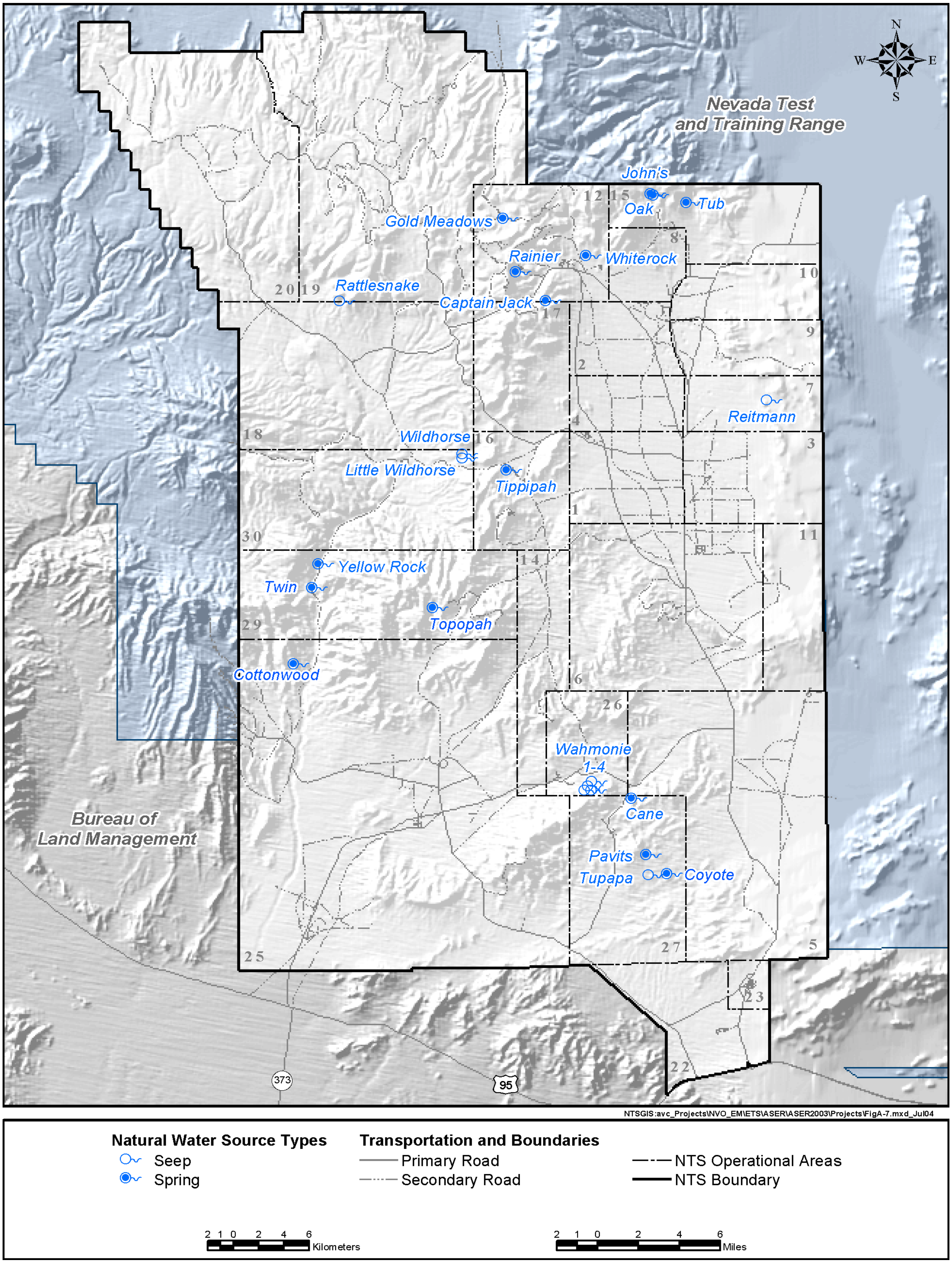


Figure A-7. Natural springs and seeps on the NTS

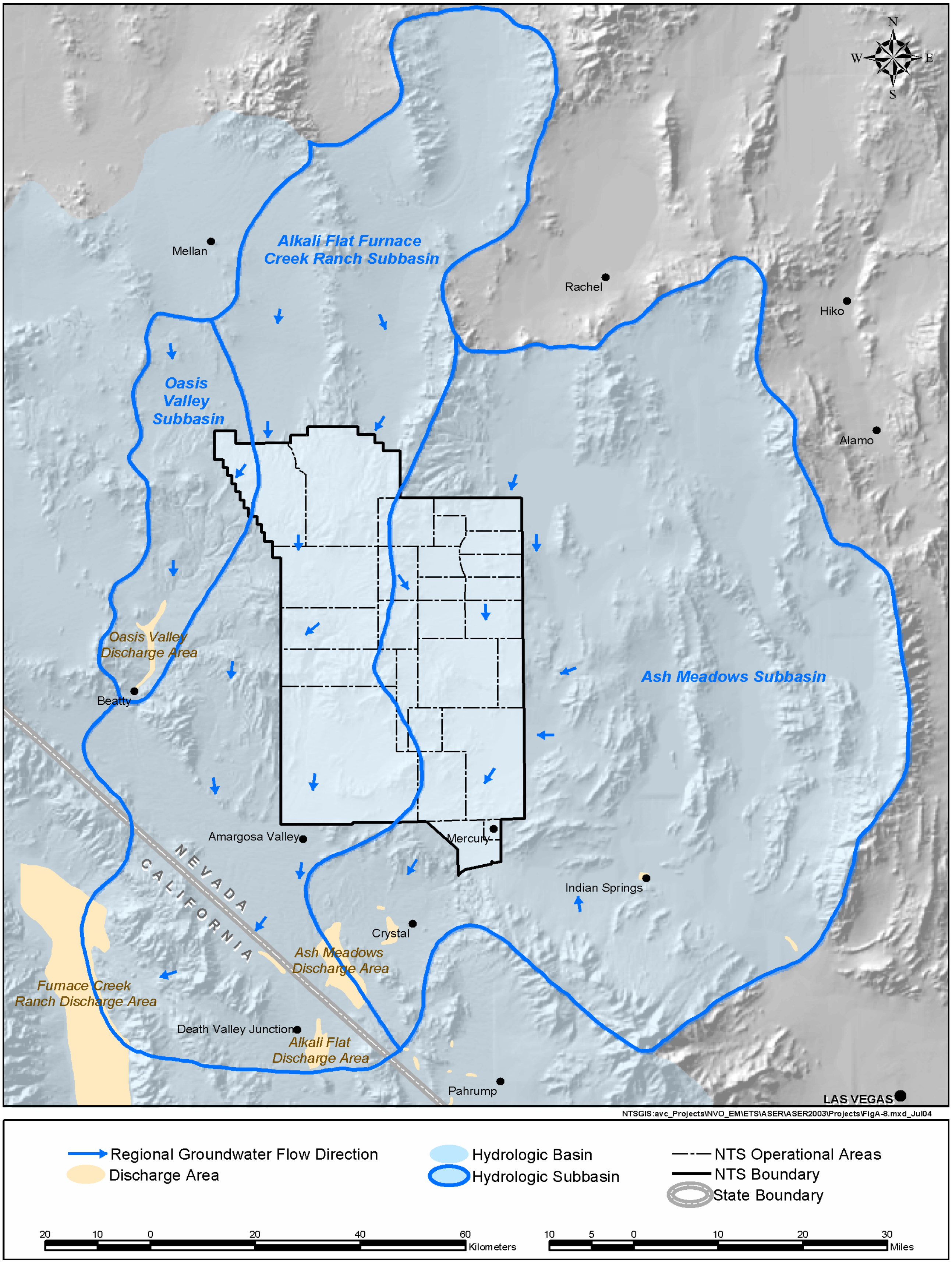


Figure A-8. Groundwater subbasins of the NTS and vicinity

Recharge areas for the Death Valley groundwater system are the higher mountain ranges of central and southern Nevada, where there can be significant precipitation and snowmelt. Groundwater flow is generally from these upland areas to natural discharge areas in the south and southwest. Groundwater at the NTS is also derived from underflow from basins up-gradient of the area (Harrill et al., 1988). The direction of groundwater flow may locally be influenced by structure, rock type, or other geologic conditions. Based on existing water-level data (Reiner et al., 1995; Hale et al., 1995; IT, 1996b; DOE, 2003) and flow models (IT, 1996a; D'Agnese et al., 1997) the general groundwater flow direction within major water-bearing units beneath the NTS is to the south and southwest.

Most of the natural discharge from the Death Valley flow system is via transpiration by plants or evaporation from soil and playas in the Amargosa Desert and Death Valley. Groundwater discharge at the NTS is minor, consisting of small springs which drain perched water lenses and artificial discharge at a limited number of water supply wells.

Groundwater is the only local source of potable water on the NTS. The nine supply wells that make up the NTS water system and the other supply wells for the various water systems in the area (town of Beatty, small mines, and local ranches) produce water for human and industrial use from the carbonate, volcanic, and alluvial aquifers. Water chemistry varies from a sodium-potassium-bicarbonate type to a calcium-magnesium-carbonate type, depending on the mineralogical composition of the aquifer source. Groundwater quality within aquifers of the NTS is generally acceptable for drinking water and industrial and agricultural uses (Chapman, 1994), and meets Safe Drinking Water Act standards (Chapman and Lyles, 1993; Rose et al., 1997; BN, 2003).

A.5.3 Hydrogeologic Framework for the NTS and Vicinity

When the need for testing nuclear devices underground was recognized in the 1950s, among the first concerns was the effect testing would have on the groundwater of the area. One of the earliest nuclear tests conducted below the groundwater table (the BILBY test conducted in 1963) was designed in part to study explosion effects on groundwater and the movement in groundwater of radioactive byproducts from the explosion (Hale et al., 1963; Garber, 1971). Since that time additional studies at various scales have been conducted to aid in the understanding of groundwater flow at the NTS. The current understanding of the regional groundwater flow at the NTS is derived from work by Winograd and Thordarson (1975), which was summarized and updated by Laczniak et al. (1996), and has further been developed by the UGTA Project hydrogeologic modeling team (IT, 1996a, 1998; BN, 2002a). See Section 7 for a description of the UGTA Project.

Winograd and Thordarson (1975) established a hydrogeologic framework, incorporating the work of Blankennagel and Weir (1973) who defined the first hydrogeologic units (HGUs) to address the complex hydraulic properties of volcanic rocks. HGUs are used to categorize lithologic units according to their ability to transmit groundwater, which is mainly a function of their primary lithologic properties, degree of fracturing, and secondary mineral alteration. Hydrostratigraphic units (HSUs) for the NTS volcanic rocks were first defined during the UGTA modeling initiative (IT, 1996a). HSUs are groupings of contiguous stratigraphic units that have a particular hydrogeologic character, such as aquifer (unit through which water moves readily) or confining unit (unit that generally is impermeable to water movement). The concept of HSUs is very useful in volcanic terrains where stratigraphic units can vary greatly in hydrologic character both laterally and vertically.

The rocks of the NTS have been classified for hydrologic modeling using this two-level classification scheme in which HGUs are grouped to form HSUs (IT, 1996a). An HSU may consist of several HGUs but is defined so that a single general type of HGU dominates (for example, mostly welded-tuff and vitric-tuff aquifers or mostly tuff confining units).

A.5.3.1 Hydrogeologic Units

All the rocks of the NTS and vicinity can be classified as one of ten HGUs, which include the alluvial aquifer, a playa confining unit, four volcanic HGUs, two intrusive units, and two HGUs that represent the pre-Tertiary rocks (Table A-3).

Table A-3. Hydrogeologic units of the NTS area

Hydrogeologic Unit	Typical Lithologies	Hydrologic Significance
Alluvial Aquifer (AA)	Unconsolidated to partially consolidated gravelly sand, eolian sand, and colluvium; thin, basalt flows of limited extent	Has characteristics of a highly conductive aquifer, but less so where lenses of clay-rich paleocolluvium or playa deposits are present.
Welded-Tuff Aquifer (WTA)	Welded ash-flow tuff; vitric to devitrified	Degree of welding greatly affects interstitial porosity (less porosity as degree of welding increases) and permeability (greater fracture permeability as degree of welding increases).
Vitric-Tuff Aquifer (VTA)	Bedded tuff; ash-fall and reworked tuff; vitric	Constitutes a volumetrically minor hydrogeologic unit. Generally does not extend far below the static water level due to tendency to become zeolitized (which drastically reduces permeability) under saturated conditions. Significant interstitial porosity (20 to 40 percent). Generally insignificant fracture permeability.
Lava-Flow Aquifer (LFA)	Rhyolite lava flows; includes flow breccias (commonly at base) and pumiceous zones (commonly at top)	Generally a caldera-filling unit. Hydrologically complex; wide range of transmissivities; fracture density and interstitial porosity differ with lithologic variations.
Tuff Confining Unit (TCU)	Zeolitized bedded tuff with interbedded, but less significant, zeolitized, nonwelded to partially welded ash-flow tuff	May be saturated but measured transmissivities are very low. May cause accumulation of perched and/or semi-perched water in overlying units.
Intracaldera Intrusive Confining Unit (IICU)	Highly altered, highly injected/intruded country rock and granitic material	Assumed to be impermeable. Conceptually underlies each of the SWNVF calderas and Calico Hills.
Granite Confining Unit (GCU)	Granodiorite, quartz monzonite	Relatively impermeable; forms local bulbous stocks, north of Rainier Mesa and Yucca Flat; may contain perched water.
Clastic Confining Unit (CCU)	Argillite, siltstone, quartzite	Clay-rich rocks are relatively impermeable; more siliceous rocks are fractured, but with fracture porosity generally sealed due to secondary mineralization.
Carbonate Aquifer (CA)	Dolomite, limestone	Transmissivity values differ greatly and are directly dependent on fracture frequency.

Note: Adapted from BN (2002a).

The deposits of alluvium (alluvial aquifer) fill the main basins of the NTS, and generally consist of a loosely consolidated mixture of boulders, gravel, and sand derived from volcanic and Paleozoic sedimentary rocks (Slate et al., 1999). The finest sediments can be deposited as playa deposits (or dry lake beds) in some closed basins (e.g., Yucca and Frenchman Flats). Because of their silty/clayey nature these fine-grained units tend to behave hydrologically as confining units (restrictive of groundwater flow).

The volcanic rocks of the NTS and vicinity can be categorized into four HGUs based on primary lithologic properties, degree of fracturing, and secondary mineral alteration. In general, the altered (typically zeolitized, but hydrothermally altered near caldera margins) volcanic rocks act as confining units (tuff confining unit), and the unaltered rocks form aquifers. The volcanic aquifer units can be further divided into welded-tuff aquifers or vitric-tuff aquifers (depending upon the degree of welding) and lava-flow aquifers. The denser rocks (welded ash-flow tuffs and lava flows) tend to fracture more readily, and therefore have relatively high permeability (Blankennagel and Weir, 1973; Winograd and Thordarson, 1975; Laczniak et al., 1996; IT, 1997, 1996c; Prothro and Drellack, 1997).

The pre-Tertiary sedimentary rocks at the NTS and vicinity are also categorized as aquifer or confining unit HGUs based on lithology. The silicic clastic rocks (quartzite, siltstone, shale) tend to be aquitards or confining units, while the carbonates (limestone and dolomite) tend to be aquifers (Winograd and Thordarson, 1975; Laczniak et al., 1996). The granite confining unit is considered to behave as a confining unit due to low primary porosity and low permeability, and because most fractures are probably filled with secondary minerals (Walker, 1962).

A.5.3.2 Hydrostratigraphic Units

The rocks at the NTS and vicinity are grouped into roughly 60 HSUs. The more important and widespread HSUs in the area are discussed separately below, from oldest to youngest. Additional information regarding other HSUs is summarized in tables introduced in Section A.5.5 below where the hydrogeology of Yucca and Frenchman Flats, and Pahute and Rainier Mesas UGTAs at the NTS is addressed. Additional information can be found in the documentation packages for the UGTA CAU-scale hydrogeologic models (IT, 1996a; 1998; Gonzales and Drellack, 1999; and BN, 2002a).

Lower Clastic Confining Unit (LCCU) – The Proterozoic to Middle-Cambrian-age rocks are largely quartzite and silica-cemented siltstone. Although these rocks are brittle and commonly fractured, secondary mineralization seems to have greatly reduced formation permeability (Winograd and Thordarson, 1975). These units make up the LCCU, which is considered to be the regional hydrologic basement (IT, 1996a). The LCCU is interpreted to underlie the entire region, except at the calderas. Where it is in a structurally high position, the LCCU may act as a barrier to deep regional groundwater flow.

Lower Carbonate Aquifer (LCA) – The LCA consists of thick sequences of Middle Cambrian through Upper Devonian carbonate rocks. This HSU serves as the regional aquifer for most of southern Nevada and locally may be as thick as 5,000 m (16,400 ft) (Cole, 1997; Cole and Cashman, 1999). The LCA is present under most of the area, except where the LCCU is structurally high and at the calderas. Transmissivities of these rocks differ from place to place, apparently reflecting the observed differences in fracture and fault densities and characteristics (Winograd and Thordarson, 1975).

Upper Clastic Confining Unit (UCCU) – Upper Devonian and Mississippian silicic clastic rocks in the NTS vicinity are assigned to the Eleana Formation and the Chainman Shale (Trexler et al., 2003; Cashman and Trexler, 1991; Trexler et al., 1996). Both formations are grouped into the UCCU. At the NTS this HSU is found mainly within a north-south band along the western portion of Yucca Flat. It is a significant confining unit and in many places forms the footwall of the Belted Range and Control Point (CP) thrust faults.

Lower Carbonate Aquifer, Upper Thrust Plate (LCA3) – Cambrian through Devonian, mostly carbonate rocks that occur in the hanging wall of the Belted Range and CP thrust faults are designated as LCA3. These rocks are equivalent stratigraphically to the LCA, but are structurally separated from the LCA by the Belted Range thrust fault. The LCA3 is patchily distributed as remnant thrust blocks, particularly along the western and southern sides of Yucca Flat (at Mine Mountain and the CP Hills), at Calico Hills, and at Bare Mountain.

Mesozoic Granite Confining Unit (MGCU) – The Mesozoic era is represented at the NTS only by intrusive igneous rocks. Cretaceous-age granitic rocks are exposed at two locations: in northern Yucca Flat, at the Climax Stock; and the Gold Meadows Stock, which lies 12.9 km (8 mi) west of the Climax Stock, just north of Rainier Mesa (Snyder, 1977; Bath et al., 1983) (Figure A-5). The two are probably related in both source and time and are believed to be connected at depth (Jachens, 1999). Because of its low intergranular porosity and permeability, and the lack of inter-connecting fractures (Walker, 1962), the MGCU is considered a confining unit. The Climax and Gold Meadows intrusives are grouped into the MGCU HSU.

Tertiary and Quaternary Hydrostratigraphic Units – Tertiary-and Quaternary-age strata at the NTS are organized into dozens of HSUs. Nearly all are of volcanic origin, except the alluvial aquifer, which is the uppermost HSU. These rocks are important because (1) most of the underground nuclear tests at the NTS were conducted in these units, (2) they constitute a large percentage of the rocks in the area, and (3) they are inherently complex and heterogeneous. As pointed out in Section A.5.3.1, the volcanic rocks are divided into aquifer or confining units according to lithology and secondary alteration. More detailed information can be found in the documentation packages for the UGTA CAU-scale hydrogeologic models (IT, 1996a, 1998; Gonzales and Drellack, 1999; BN, 2002a).

Alluvial Aquifer (AA) – The alluvium throughout most of the NTS is a loosely consolidated mixture of detritus derived from silicic volcanic and Paleozoic-age sedimentary rocks, ranging in particle size from clay to boulders. Sediment deposition is largely in the form of alluvial fans (debris flows, sheet wash, and braided streams) which coalesce to form discontinuous, gradational, and poorly sorted deposits. Eolian sand, playa deposits, and rare basalt flows are also present within the alluvial section of some valleys. The alluvium thickness in major valleys (e.g., Frenchman Flat and Yucca Flat) generally ranges from about 30 m (100 ft) to more than 1,128 m (3700 ft) in the deepest subbasins. The AA HSU is restricted primarily to the basins of the NTS. However, because the water table in the vicinity is moderately deep, the alluvium is generally unsaturated, except in the deep subbasins of some valleys. These sediments are porous and thus, have high storage coefficients. Hydraulic conductivity may also be high, particularly in the coarser, gravelly beds.

A.5.4 General Hydraulic Characteristics of NTS Rocks

Volcanic rocks typically are extremely variable in lithologic character both laterally and vertically. The characteristics of rocks that control the density and character of fractures are the primary determinants of their hydraulic properties, and most hydraulic heterogeneity ultimately is related to fracture characteristics such as fracture density, openness, orientation, and other properties. Secondary fracture-filling minerals can drastically obstruct the flow through or effectively seal an otherwise transmissive formation (Drellack et al., 1997; IT, 1996c). Fracture density typically increases with proximity to faults, potentially increasing the hydraulic conductivity of the formation, however, the hydrologic properties of faults, per se, are not well known. Limited data suggest that the full spectrum of hydraulic properties, from barrier to conduit, may be possible (Blankennagel and Weir, 1973; Faunt, 1998).

Table A-4 includes a brief summary of the hydrologic properties of NTS HGUs. The lowest transmissivity values in volcanic rocks at the NTS are typically associated with non-welded ash-flow tuff and bedded tuff (air-fall and reworked tuffs). Although interstitial porosity may be high, the interconnectivity of the pore space is poor, and these relatively incompetent rocks tend not to support open fractures. Secondary alteration of these tuffs (most commonly, zeolitization) ultimately yields a very impermeable unit. As described in Section A.5.3.1, these zeolitized tuffs are considered to be confining units. The equivalent unaltered bedded and non-welded tuffs are considered to be vitric-tuff aquifers, and have intermediate transmissivities.

In general, the most transmissive rocks tend to be moderately to densely welded ash-flow tuffs (welded-tuff aquifer), rhyolite lava flows (lava-flow aquifer), and carbonate rocks (limestone and dolomite). Although their interstitial porosity is low, these competent lithologies tend to be highly fractured, and groundwater flow through these rocks is largely through an interconnected network of fractures (Blankennagel and Weir, 1973; GeoTrans, 1995).

Underground nuclear explosions affect hydraulic properties of the geologic medium creating both long-term and short-term effects. Effects include enhanced permeability from shock-induced fractures, the formation of vertical conduits (e.g., collapse chimneys), and elevated water levels (mounding and over-pressurization of saturated low-permeability units). However, these effects tend to be localized (Borg, et al., 1976; Brikowski, 1991; Allen et al., 1997).

Table A-4. Summary of hydrologic properties for hydrogeologic units at the NTS

Hydrogeologic Unit[a]			Fracture Density[b, c]	Relative Hydraulic Conductivity[c]
Alluvial Aquifer			Very low	Moderate to very high
Vitric-Tuff Aquifer			Low	Low to moderate
Welded-Tuff Aquifer			Moderate to high	Moderate to very high
Lava-Flow Aquifer [d]	Pumiceous Lava	Vitric	Low	Low to moderate
		Zeolitic	Low	Very low
	Stony Lava and Vitrophyre		Moderate to high	Moderate to very high
	Flow Breccia		Low to moderate	Low to moderate
Tuff Confining Unit			Low	Very low
Intrusive Confining Unit			Low to moderate	Very low
Granite Confining Unit			Low to moderate	Very low
Carbonate Aquifer			Low to high (variable)	Low to very high
Clastic Confining Unit			Moderate	Very low to low [e]

(a) Refer to Table A-3 for hydrogeologic nomenclature.

(b) Including primary (cooling joints in tuffs) and secondary (tectonic) fractures.

(c) The values presented are the authors' qualitative estimates based on data from published (IT [1996c] and Blankennagel and Weir [1973], Winograd and Thordarson [1975]) and unpublished sources (i.e., numerous Los Alamos and Lawrence Livermore National Laboratory drill-hole characterization reports).

(d) Abstracted from Prothro and Drellack (1997).

(e) Fractures tend to be sealed by the presence of secondary minerals.

Note: Adapted from BN (2002c).

A.5.5 Hydrogeology of the NTS Underground Test Areas

Most NTS underground nuclear detonations were conducted in three main UGTAs: (1) Yucca Flat, (2) Pahute Mesa, and (3) Rainier Mesa (including Aqueduct Mesa). Underground tests in Yucca Flat and Pahute Mesa typically were conducted in vertical drill holes, whereas almost all tests conducted in Rainier Mesa were tunnel emplacements. A total of 85 underground tests (85 detonations) were conducted on Pahute Mesa, including 18 high-yield detonations (200 kilotons [kt] or more). Rainier Mesa hosted 61 underground tests (62 detonations), almost all of which were relatively low-yield (generally less than 20 kt) tunnel-based weapons-effects tests. Yucca Flat was the most extensively used UGTA, hosting 659 underground tests (747 detonations), four of which were high-yield detonations (200 kilotons or more) (Allen et al., 1997).

In addition to the three main UGTAs, underground nuclear tests were conducted in Frenchman Flat (ten tests), Shoshone Mountain (six tests), the Oak Spring Butte/Climax Mine area (three tests), the Buckboard Mesa area (three tests), and Dome Mountain (one test with five detonations) (Allen et al., 1997). It should be noted that these totals include nine cratering tests (13 total detonations) conducted in various areas of the NTS. Table A-5 is a synopsis of information about each UGTA at the NTS, and Figure A-9 shows the aerial distribution of underground nuclear tests conducted at the NTS.

Table A-5. Information summary of NTS underground nuclear tests

Physiographic Area	NTS Area(s)	Total Underground[a] Tests	Total Underground[a] Detonations	Test Dates[a]	Depth of Burial Range	Overburden Media	Comments
Yucca Flat	1, 2, 3, 4, 6, 7, 8, 9, 10	659	747	1951 - 1992	27 - 1219 m (89 - 3999 ft)	Alluvium/playa, Volcanic tuff, Paleozoic rocks	Various test types and yields; almost all were vertical emplacements above and below static water level; includes 4 high-yield[b] detonations.
Pahute Mesa	19, 20	85	85	1965 - 1992	31 - 1452 m (100 - 4765 ft)	Alluvium, (thin) volcanic tuffs and lavas	Almost all were large-diameter vertical emplacements above and below static water level; includes 18 high-yield detonations.
Rainier/Aqueduct Mesa	12	61	62	1957 - 1992	61 - 640 m (200 - 2100 ft)	Tuffs with welded tuff caprock (little or no alluvium)	Two vertical emplacements; all others were horizontal tunnel emplacements above static water level; mostly low-yield[c] U.S. Department of Defense weapons effects tests.
Frenchman Flat	5, 11	10	10	1965 - 1971	179 - 296 m (587 - 971 ft)	Mostly alluvium, minor volcanic tuff	Various emplacement configurations, both above and below static water level.
Shoshone Mtn.	16	6	6	1962 - 1971	244 - 640 m (800 - 2100 ft)	Bedded tuff	Tunnel-based low-yield weapons effects and Vela Uniform tests.
Oak Spring Butte (Climax Area)	15	3	3	1962 - 1966	229 - 351 m (750 - 1150 ft)	Granite	Three tests above static water level. (HARD HAT, TINY TOT, and PILE DRIVER).
Buckboard Mesa	18	3	3	1962 - 1964	≤ 27 m (90 ft)	Basaltic lavas	Shallow, low-yield experiments (SULKY, JOHNNIE BOY[d] and DANNY BOY); all were above static water level.
Dome Mountain	30	1	5	03/12/1968	50 m (165 ft)	Mafic lava	BUGGY (A, B, C, D, and E); Plowshare cratering test of five-detonation horizontal salvo; all above static water level.

(a) Source: U.S. Department of Energy (2000b).

(b) High-yield detonations – detonations more than 200 kilotons, or detonations described with an upper yield range of at least 200 kilotons.

(c) Low-yield detonations – detonations less than 20 kilotons.

(d) JOHNNIE BOY was detonated at a depth of 1.75 ft (essentially a surface burst) approximately one mile east of Buckboard Mesa.

Source: Allen, et al., 1997.

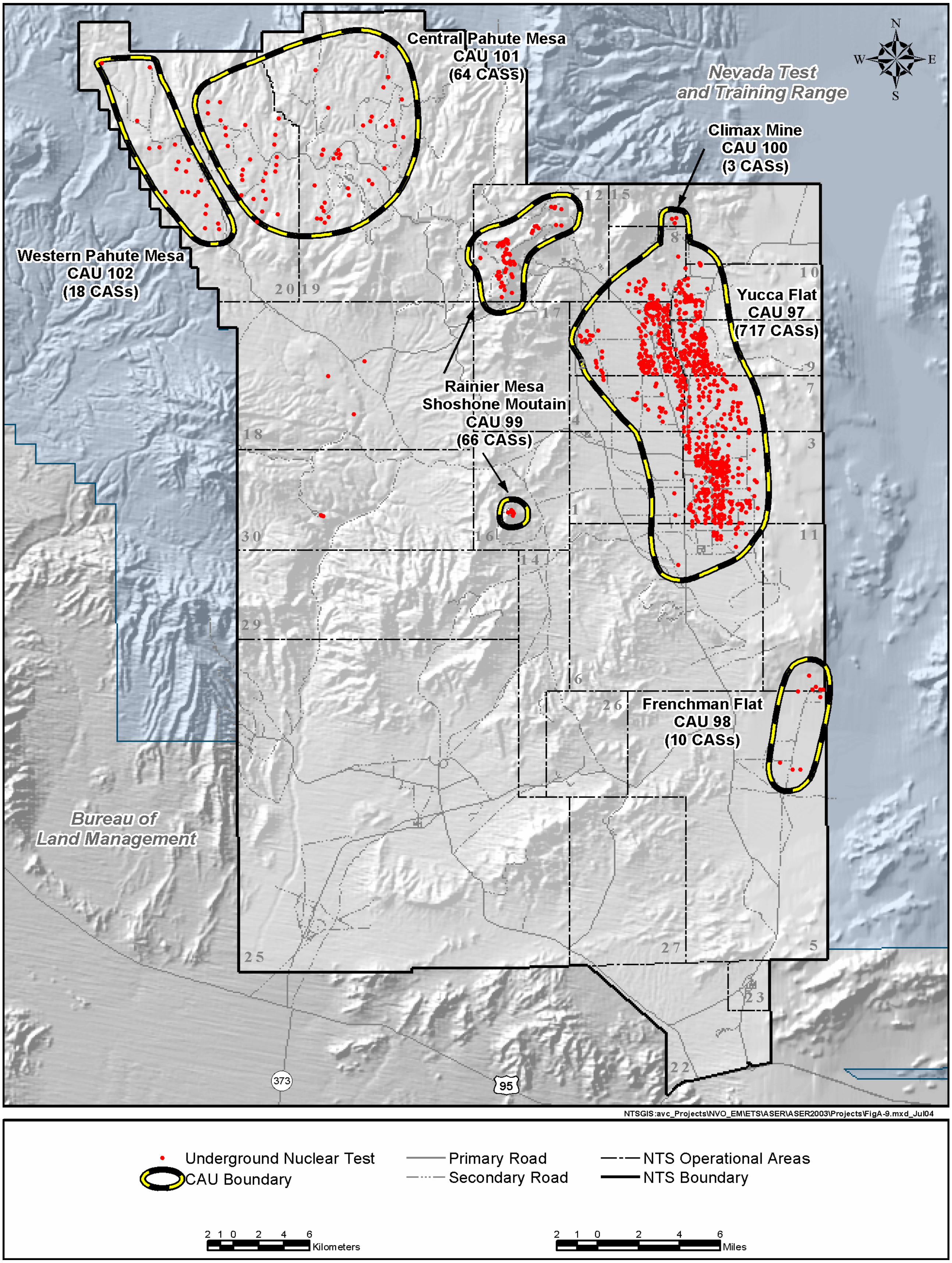


Figure A-9. Location of Corrective Action Units and Corrective Action Sites on the NTS

The location of each underground nuclear test is classified as a Corrective Action Site (CAS). These in turn have been grouped into six Corrective Action Units (CAUs), according to the Federal Facilities Agreement and Consent Order (FFACO, 1996) between the DOE and the state of Nevada. In general, the CAUs relate to the geographical UGTAs on the NTS (see Figure A-9).

The hydrogeology of the four main NTS UGTAs is summarized in the following subsections. For detailed stratigraphic descriptions of geologic units at the NTS (including each of the UGTAs) see Sawyer et al. (1994) and Slate et al. (1999).

A.5.5.1 Frenchman Flat Underground Test Area

The Frenchman Flat CAU consists of ten CASs located in the northern part of NTS Area 5 and southern part of Area 11 (see Figure A-9). The detonations were conducted in vertical emplacement holes and two mined shafts. Nearly all the tests were conducted in alluvium above the water table.

Physiography – Frenchman Flat is a closed intermontane basin located in the southeastern portion of the NTS. It is bounded on the north by Massachusetts Mountain and the Halfpint Range, on the east by the Buried Hills, on the south by the Spotted Range, and on the west by the Wahmonie volcanic center (see Figure A-5). The sparsely vegetated valley floor slopes gently toward a central playa lakebed. Ground-level elevations range from 938 m (3,078 ft) above sea level at the playa, to over 1,463 m (4,800 ft) in the nearby surrounding mountains.

Geology Overview – The stratigraphic section for Frenchman Flat consists of (from oldest to youngest) Proterozoic and Paleozoic clastic and carbonate rocks, Tertiary sedimentary and tuffaceous sedimentary rocks, Tertiary volcanic rocks, and Quaternary and Tertiary alluvium (Slate et al., 1999). In the northernmost portion of Frenchman Flat, the middle to upper Miocene volcanic rocks that erupted from calderas located to the northwest of Frenchman Flat unconformably overlie Ordovician-age carbonate and clastic rocks. To the south, these volcanic units, including the Ammonia Tanks Tuff, Rainier Mesa Tuff, Topopah Spring Formation, and Crater Flat Group, either thin considerably, interfinger with coeval sedimentary rocks, or pinch out together (IT, 1998b). Upper-middle Miocene tuffs, lavas, and debris flows from the Wahmonie volcanic center located just west of Frenchman Flat dominate the volcanic section beneath the western portion of the valley. To the south and southeast, most of the volcanic units are absent and Oligocene to middle Miocene sedimentary and tuffaceous sedimentary rocks, which unconformably overlie the Paleozoic rocks in the southern portion of Frenchman Flat, dominate the Tertiary section (Prothro and Drellack, 1997). In most of the Frenchman Flat area, upper Miocene to Holocene alluvium covers the older sedimentary and volcanic rocks (Slate et al., 1999). Alluvium thicknesses range from a thin veneer along the valley edges to perhaps as much as 1,158 m (3,800 ft) in north central Frenchman Flat.

Structural Setting – The structural geology of Frenchman Flat is complex. During the late Mesozoic era, the region was subjected to compressional deformation, which resulted in folding, thrusting, uplift, and erosion of the pre-Tertiary rocks (Barnes et al., 1982). Approximately 16 Ma, the region underwent extensional deformation, during which the present basin-and-range topography was developed, and the Frenchman Flat basin was formed (Ekren et al., 1968). In the immediate vicinity of Frenchman Flat, extensional deformation has produced northeast-trending, left-lateral strike-slip faults and generally north-trending normal faults that displace the Tertiary and pre-Tertiary rocks. Beneath Frenchman Flat, major west-dipping normal faults merge and are probably contemporaneous with strike-slip faults beneath the southern portion of the basin (Grauch and Hudson, 1995). Movement along the faults has created a relatively deep, east-dipping, half-graben basin elongated in a northeasterly direction (Figure A-10).

Hydrogeology Overview – The hydrogeology of Frenchman Flat is fairly complex, but is typical of the NTS area. Many of the HGU-and HSU-building blocks developed for the NTS vicinity are applicable to the Frenchman Flat basin. The strata in the Frenchman Flat area have been subdivided into five Tertiary-age HSUs (including the Quaternary/Tertiary alluvium) and three pre-Tertiary HSUs to serve as layers for the UGTA Frenchman Flat CAU groundwater model (IT, 1998b). In descending order these units are: the AA, the Timber Mountain aquifer (TMA), the Wahmonie confining unit (WCU), the tuff confining unit (TCU), the volcaniclastic confining unit (VCU), the LCA, and the LCCU (Table A-6).

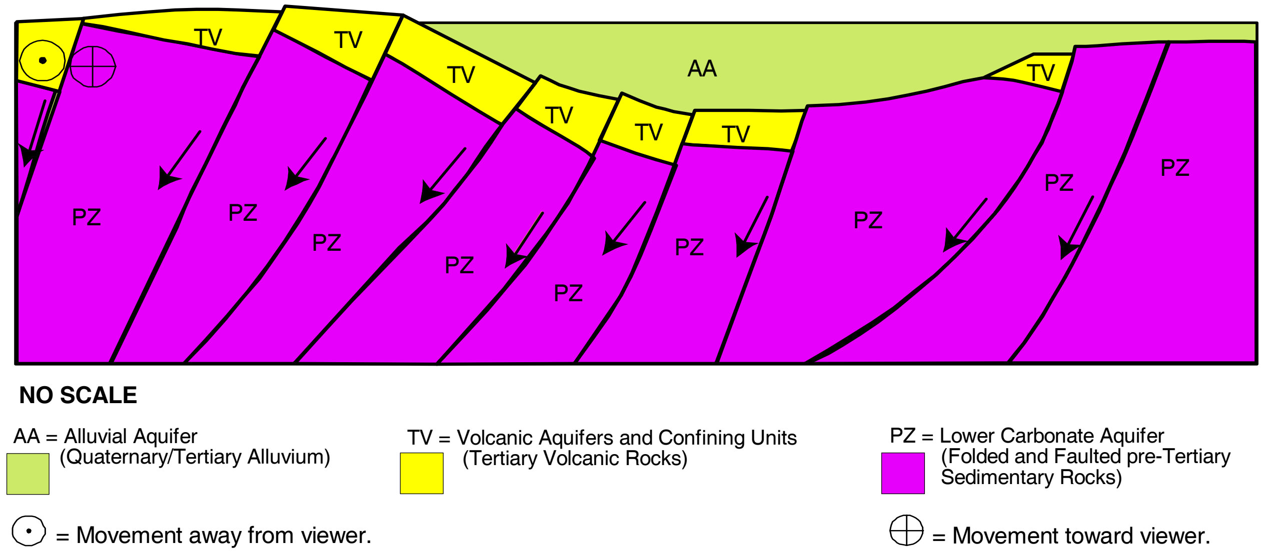


Figure A-10. Conceptual east-west cross section through Frenchman Flat

Table A-6. Hydrostratigraphic units of the Frenchman Flat underground test area

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Unit[(a)]	Typical Lithologies
Alluvial Aquifer (AA)	AA, minor LFA	Alluvium (gravelly sand); also includes relatively thin basalt flow in northern Frenchman Flat and playa deposits in south-central part of basin
Timber Mountain Aquifer (TMA)	WTA, VTA	Welded ash-flow tuff and related nonwelded and air-fall tuffs; vitric to devitrified
Wahmonie Volcanic Confining Unit (WVCU)	TCU, minor LFA	Air-fall and reworked tuffs; debris and breccia flows; minor intercalated lava flows. Typically altered: zeolitic to argillic
Tuff Confining Unit (TCU)	TCU	Zeolitic bedded tuffs, with interbedded but less significant zeolitic, nonwelded to partially welded ash-flow tuffs
Volcaniclastic Confining Unit (VCU)	TCU, minor AA	Diverse assemblage of interbedded volcanic and sedimentary rocks including tuffs, shale, tuffaceous and argillaceous sandstones, conglomerates, minor limestones
Upper Clastic Confining Unit (UCCU)	CCU	Argillite, quartzite; present only in northwest portion of model in the CP Basin
Lower Carbonate Aquifer (LCA)	CA	Dolomite and limestone; the “regional aquifer”
Lower Clastic Confining Unit (LCCU)	CCU	Quartzites and siltstones; the “hydrologic basement”

(a) See Table A-3 for descriptions of hydrogeologic units.

Note: Adapted from IT, 1998b.

Water–level Elevation and Groundwater Flow Direction – The depth to the static water level (SWL) in Frenchman Flat ranges from 210 m (690 ft) near the central playa to more than 350 m (1,150 ft) at the northern end of the valley. The SWL is generally located within the AA, TMA, WVCU, or TCU. In the deeper, central portions of the basin, more than half of the alluvium section is saturated. Water-level elevation data in the AA indicate a very flat water table (Blout et al., 1994; IT, 1998b).

Water-level data for the LCA in the southern part of the NTS are limited, but indicate a fairly low gradient in the Yucca Flat, Frenchman Flat, and Jackass Flats areas. This gentle gradient implies a high degree of hydraulic continuity within the aquifer, presumably due to high fracture permeability (Laczniak et al., 1996). Furthermore, the similarity of the water levels measured in Paleozoic rocks (LCA) in Yucca Flat and Frenchman Flat implies that, at least for deep interbasin flow, there is no groundwater barrier between the two basins. Inferred regional groundwater flow through Frenchman Flat is to the south-southwest toward discharge areas in Ash Meadows (see Figure A-8). An increasing westward flow vector in southern NTS may be due to preferential flow paths subparallel to the northeast-trending Rock Valley fault (Grauch and Hudson, 1995) and/or a northward gradient from the Spring Mountain recharge area (IT, 1996a; b).

Groundwater elevation measurements for wells completed in the AA and TMA are higher than those in the underlying LCA (IT, 1996b; 1998b). This implies a downward gradient. This apparent semi-perched condition is believed to be due to the presence of intervening TCU and VCU units.

A.5.5.2 Yucca Flat/Climax Mine Underground Test Area

The Yucca Flat/Climax Mine CAU consists of several hundreds of CASs located in NTS Areas 1, 2, 3, 4, 6, 7, 8, 9, 10, and three CASs located in Area 15 (see Figure A-9). These tests were typically conducted in vertical emplacement holes and a few related tunnels (see Table A-5).

The Yucca Flat and Climax Mine UGTAs were originally defined as two separate CAUs (CAU 97 and CAU 100) in the FFACO (1996) because the geologic frameworks of the two areas are distinctly different. The Yucca Flat underground nuclear tests were conducted in alluvial, volcanic, and carbonate rocks, whereas the Climax Mine tests were conducted in an igneous intrusion in northern Yucca Flat. However, particle-tracking simulations performed during the regional evaluation (IT, 1997) indicated that the local Climax Mine groundwater flow system merges into the much larger Yucca Flat groundwater flow system during the 1,000-year time period of interest, so the two areas were combined into the single CAU 97.

Yucca Flat was the most heavily used UGTA on the NTS (see Figure A-9). The alluvium and tuff formations provide many characteristics advantageous to the containment of nuclear explosions. They are easily mined or drilled. The high-porosity overburden (alluvium and vitric tuffs) will accept and depressurize any gas which might escape the blast cavity. The deeper tuffs are zeolitized, which creates a nearly impermeable confining unit. The zeolites also have absorptive and "molecular sieve" attributes which severely restrict or prevent the migration of radionuclides. The deep water table (greater than 503 m [1,650 ft] depth) provides additional operational and environmental benefits.

This section provides brief descriptions of the geologic and hydrogeologic setting of the Yucca Flat/Climax Mine UGTA, as well as a discussion of the hydrostratigraphic framework. This summary was compiled from various sources, including BN (2001a), Gonzales and Drellack (1999), Winograd and Thordarson (1975), Laczniak et al., (1996), Byers et al., (1989), and Cole (1997) where additional information can be found.

Physiography – Yucca Flat is a topographically closed basin with a playa at its southern end. The geomorphology of Yucca Flat is typical of the arid, inter-mountain basins found throughout the Basin and Range province of Nevada and adjoining states. Faulted and tilted blocks of Tertiary-age volcanic rocks and underlying Precambrian and Paleozoic sedimentary rocks form low ranges around the basin (see Figure A-5). These rocks also compose the "basement" of the basin, which is now covered by alluvium.

Ground elevation in the Yucca Flat area ranges from about 1,195 m (3,920 ft) above mean sea level at Yucca Lake (playa) in the southern portion to about 1,463 m (4,800 ft) in the northern portion of the valley. The highest portions of the surrounding mountains and hills range from less than 1,500 m (5,000 ft) in the south to over 2,316 m (7,600 ft) at Rainier Mesa in the northwest corner of the area. Yucca Flat is bounded by the Halfpint Range to the east; by Rainier Mesa and the Belted Range to the north; by the Eleana Range and Mine Mountain to the west; and by the CP Hills, CP Hogback, and Massachusetts Mountain to the south.

Geology Overview – The Precambrian and Paleozoic rocks of the NTS area consist of approximately 11,300 m (37,000 ft) of carbonate and silicic clastic rocks (Cole, 1997). These rocks were severely deformed by compressional movements during Mesozoic time, which resulted in the formation of folds and thrust faults (e.g., Belted Range and CP thrust faults). During the middle Late Cretaceous, granitic bodies (such as the Climax stock in northern Yucca Flat) intruded these deformed rocks (Maldonado, 1977; Houser and Poole, 1960).

Twenty-two pre-Tertiary formations (including the Mesozoic granitic intrusives) have been recognized in the Yucca Flat region (see Table A-2). These rocks range in age from Precambrian to Cretaceous and represent primarily carbonate and silicic shallow-to deep-water sedimentation near a continental margin. Some of these units are widespread throughout southern Nevada and California, though complex structural deformation has created many uncertainties in determining the geometric relationships of these units around Yucca Flat.

During Cenozoic time, the sedimentary and intrusive rocks were buried by thick sections of volcanic material deposited in several eruptive cycles from source areas in the SWNVF. The Cenozoic stratigraphy of the Yucca Flat area, though not structurally complicated, is very complex. Most of the volcanic rocks of the Yucca Flat area were deposited during many eruptive cycles of the SWNVF (see Section A.4.1). The source areas of most units (Volcanics of Oak Spring Butte, Tunnel Formation, Belted Range Group, Crater Flat Group, Calico Hills Formation, Paintbrush Group, and Timber Mountain Group) are located to the west and northwest of Yucca Flat; the Wahmonie source area is located southwest of Yucca Flat. Table A-1 lists the Tertiary stratigraphic units common to the Yucca Flat basin.

The volcanic rocks include primarily ash-flow tuffs, ash-fall tuffs, and reworked tuffs, whose thicknesses and extents vary partly due to the irregularity of the underlying depositional surface, and partly due to the presence of topographic barriers and windows between Yucca Flat and the source areas to the north and west.

Over the last several million years, gradual erosion of the highlands that surround Yucca Flat has deposited a thick blanket of alluvium on the tuff section. The alluvium in Yucca Flat and throughout most of the NTS is a loosely consolidated mixture of detritus derived from silicic volcanic and Paleozoic sedimentary rocks, ranging in particle size from clay to boulders. Sediment deposition is largely in the form of alluvial fans (debris flows, sheet wash, and braided streams) which coalesce to form discontinuous, gradational, and poorly sorted deposits. Eolian sand, playa deposits, and rare basalt flows are also present within the alluvium section of Yucca Flat. The alluvium thickness in Yucca Flat generally ranges from about 30 m (100 ft) to over 914 m (3,000 ft) (Drellack and Thompson, 1990).

Structural Setting – The structure of the pre-Tertiary rocks in Yucca Flat is complex and poorly known (Cole, 1997), but it is important because the pre-Tertiary section is very thick and extensive and includes units which form regional aquifers. The main pre-Tertiary structures in the Yucca Flat area are related to the east-vergent Belted Range thrust fault which has placed Late Proterozoic to Cambrian-age rocks over rocks as young as Late Mississippian (Cole, 1997; Cole and Cashman, 1999). In several places along the western and southern portions of Yucca Flat, east-vergent structures related to the Belted Range thrust were deformed by younger west-vergent structural activity (Cole and Cashman, 1999). This west-vergent deformation is related to the CP thrust fault which also placed Cambrian and Ordovician rocks over Mississippian and Pennsylvanian-age rocks beneath western Yucca Flat (Caskey and Schweickert, 1992).

Large-scale normal faulting began in Yucca Flat in response to regional extensional movements near the end of this period of volcanism. This faulting formed the Yucca Flat basin, and as fault movement continued, blocks between faults were down-dropped and tilted, creating subbasins within the Yucca Flat basin.

Over the last several million years, gradual erosion of the highlands that surround Yucca Flat has deposited a thick blanket of alluvium on the tuff section. The thickness of the alluvium in the Yucca Flat basin varies as a function of the topography of the underlying deposits and due to continuing movements along faults during alluvium deposition.

The major basin-forming faults generally strike in a northerly direction, and relative offset is typically down to the east (e.g., Yucca, Topgallant, and Carpetbag faults). Movement along the Yucca fault in central Yucca Flat indicates deformation in the area has continued into the Holocene (Hudson, 1992). Specific details regarding these faults are lacking because of the propensity to avoid inferred and known faults during drilling of emplacement holes for underground nuclear tests.

The configuration of the Yucca Flat basin is illustrated on the generalized west-east cross section shown in Figure A-11. The cross section is simplified to show the positions of only the primary lithostratigraphic units in the region. This cross section provides a conceptual illustration of the irregular Precambrian and Paleozoic rocks overlain by the Tertiary volcanic units, and the basin-filling alluvium at the surface. The main Tertiary-age, basin-forming large-scale normal faults are also shown.

Hydrogeologic Overview – All the rocks of the Yucca Flat underground test area can be classified as one of eight HGUs (see Table A-3), which include the AA, four volcanic HGUs, an intrusive unit, and two HGUs that represent the pre-Tertiary rocks.

The strata in Yucca Flat have been subdivided into eleven Tertiary-age HSUs (including the Tertiary/Quaternary alluvium), one Mesozoic intrusive HSU, and six Paleozoic HSUs (Gonzales and Drellack, 1999). These units are listed in Table A-7, and several of the more important HSUs are discussed in the following paragraphs. The alluvium and pre-Tertiary HSUs in Yucca Flat are as defined in Section A.5.3.2.

The hydrostratigraphy for the Tertiary-age volcanic rocks in Yucca Flat can be simplified into two categories: zeolitic tuff confining units and (non-zeolitic) volcanic aquifers.

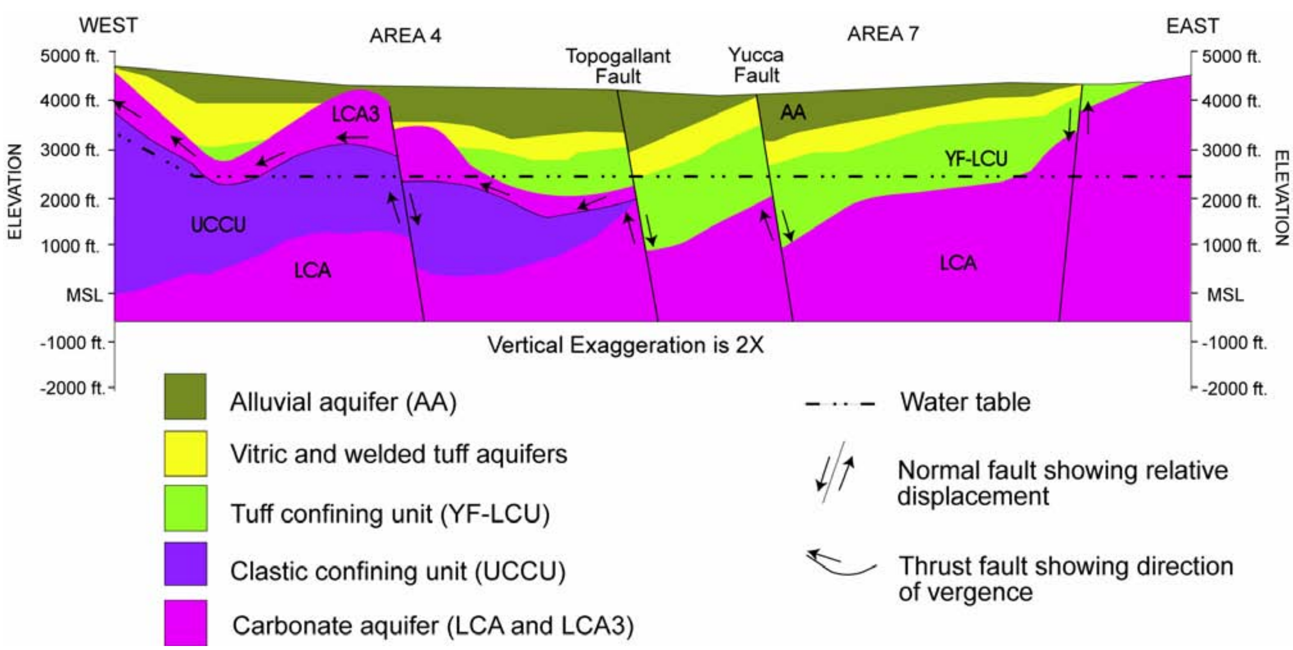


Figure A-11. Generalized west-east hydrogeologic cross section through central Yucca Flat

Table A-7. Hydrostratigraphic units of the Yucca Flat underground test area

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Units[(a)]	Typical Lithologies
Alluvial Aquifer (AA)	AA, minor LFA	Alluvium (gravelly sand); also includes one or more thin basalt flows, playa deposits and eolian sands
Timber Mountain Upper Vitric-Tuff Aquifer (TM-UVTA)	WTA, VTA	Includes vitric nonwelded ash-flow and bedded tuff
Timber Mountain Welded-Tuff Aquifer (TM-WTA)	WTA	Partially to densely welded ash-flow tuff; vitric to devitrified
Timber Mountain Lower Vitric-Tuff Aquifer (TM-LVTA)	VTA	Nonwelded ash-flow and bedded tuff; vitric
Yucca Flat Upper Confining Unit (YF-UCU)	TCU	Zeolitic bedded tuff
Topopah Spring Aquifer (TSA)	WTA	Welded ash-flow tuff; present only in extreme southern Yucca Flat
Belted Range Aquifer (BRA)	WTA	Welded ash-flow tuff
Belted Range Confining Unit (BRCU)	TCU	Zeolitic bedded tuffs
Pre-Grouse Canyon Tuff Lava-Flow Aquifer (Pre-Tbg-LFA)	LFA	Lava flow
Tub Spring Aquifer (TUBA)	WTA	Welded ash-flow tuff
Yucca Flat Lower Confining Unit (YF-LCU)	TCU	Zeolitic bedded tuffs with interbedded but less significant zeolitic, nonwelded to partially welded ash-flow tuffs
Mesozoic Granite Confining Unit (MGCU)	GCU	Granodiorite and quartz monzonite
Upper Carbonate Aquifer (UCA)	CA	Limestone
Lower Carbonate Aquifer - Yucca Flat Upper Plate (LCA3)	CA	Limestone and dolomite
Lower Clastic Confining Unit - Yucca Flat Upper Plate (LCCU1)	CCU	Quartzite and siltstone
Upper Clastic Confining Unit (UCCU)	CCU	Argillite and quartzite
Lower Carbonate Aquifer (LCA)	CA	Dolomite and limestone; "regional aquifer"
Lower Clastic Confining Unit (LCCU)	CCU	Quartzite and siltstone; "hydrologic basement"

(a) See Table A-3 for description of hydrogeologic units.

Note: Adapted from Gonzales and Drellack, 1999.

The Yucca Flat lower confining unit (YF-LCU) is an important HSU in the Yucca Flat region (stratigraphically similar to the TCU in Frenchman Flat) because it separates the volcanic aquifer units from the underlying regional LCA. Almost all zeolitized tuff units in Yucca Flat are grouped within the YF-LCU, which comprises mainly zeolitized bedded tuff (air-fall tuff, with minor reworked tuff). The YF-LCU is saturated in much of Yucca Flat; however, measured transmissivities are very low.

The YF-LCU is generally present in the eastern two-thirds of Yucca Flat. It is absent over the major structural highs, where the volcanic rocks have been removed by erosion. Areas where the YF-LCU is absent include the "Paleozoic bench" in the western portion of the basin. In northern Yucca Flat the YF-LCU tends to be confined to the structural subbasins. Outside the subbasins and around the edges of Yucca Flat the volcanic rocks are thinner and are not zeolitized.

The unaltered volcanic rocks of Yucca Flat are divided into three Timber Mountain HSUs. The hydrogeology of this part of the geologic section is complicated by the presence of one or more ash-flow tuff units that are quite variable in properties both vertically and laterally.

The Timber Mountain Group includes ash-flow tuffs that might be either welded-tuff aquifers or vitric-tuff aquifers, depending on the degree of welding (refer to Sections A.5.3.1 and A.5.3.2). In Yucca Flat these units are generally present in the central portions of the basin. They can be saturated in the deepest structural subbasins.

The AA is confined primarily to the basins of the NTS. However, because the water table in the vicinity is moderately deep, the alluvium is generally unsaturated, except in the deep sub-basins of some valleys. These sediments are porous, and thus, have high storage coefficients. Transmissivities may also be high, particularly in the coarser, gravelly beds.

The more recent large-scale extensional faulting in the Yucca Flat area is significant from both hydrologic and containment perspectives because the faults have profoundly affected the hydrogeology of the Tertiary volcanic units by controlling to a large extent their alteration potential and final geometry. In addition, the faults themselves may facilitate flow of high-pressure gases from nearby explosion cavities and of potentially contaminated groundwater from sources in the younger rocks into the underlying regional aquifers. Final geometry of formations may be such that rocks of very different properties are now juxtaposed (i.e., a Paleozoic carbonate scarp).

Water-level Elevation and Groundwater Flow Direction – Water-level data are abundant for Yucca Flat, as a result of more than thirty years of drilling in the area in support of the weapons testing program. However, water-level data for the surrounding areas are scarce. These data are listed in the potentiometric data package prepared for the UGTA regional-scale groundwater model (IT, 1996b; Hale et al., 1995).

The SWL in the Yucca Flat basin is relatively deep, ranging in depth from about 183 m (600 ft) in extreme western Yucca Flat to more than 580 m (1,900 ft) in north-central Yucca Flat (Laczniak et al., 1996; Hale et al., 1995). Elevation of the water table in Yucca Flat varies from 1,340 m (4,400 ft) in the north (western Emigrant Valley) to 730 m (2,400 ft) at the southern end of Yucca Flat (Laczniak et al., 1996; Hale et al., 1995). Throughout much of the Yucca Flat area, the SWL typically is located within the lower portion of the volcanic section, in the YF-LCU. Beneath the hills surrounding Yucca Flat, the SWL can be within the Paleozoic-age units, while in the deeper structural subbasins of Yucca Flat, the Timber Mountain Tuff and the lower portion of the alluvium are also saturated.

Fluid levels measured in wells completed in the AA and volcanic units in the eastern two-thirds of Yucca Flat are typically about 20 m (70 ft) higher than in wells completed in the LCA (Winograd and Thordarson, 1975; IT, 1996b). The hydrogeology of these units suggests that the higher elevation of the water table in the overlying Tertiary rocks is related to the presence of low permeability zeolitized tuffs of the YF-LCU (aquitard) between the Paleozoic and Tertiary aquifers. Detailed water-level data indicate the existence of a groundwater trough along the axis of the valley. The semi-perched water within the alluvial aquifer and volcanic aquifers eventually moves downward to the carbonate aquifer in the central portion of the valley.

Water-level elevations in western Yucca Flat are also well above the regional water level. The hydrology of western Yucca Flat is influenced by the presence of the Mississippian clastic rocks, which directly underlie the carbonate aquifer of the upper plate of the CP thrust (locally present), AA, and volcanic rocks west of the Topgallant fault. This geometry is a contributing factor in the development of higher (semi-perched) water levels in this area. The Climax Stock also bears perched water (Walker, 1962; Laczniak et al., 1996) well above the regional water level.

The present structural interpretation for Yucca Flat depicts the LCCU at great depth, except in the northeast corner of the study area. The Zabriskie Quartzite and Wood Canyon Formation, which are both classified as clastic confining units, are exposed in the northern portion of the Halfpint Range. The high structural position of the LCCU there (and in combination with the Climax Stock) may be responsible for the steep hydrologic gradient observed between western Emigrant Valley and Yucca Flat.

Based on the existing data and as interpreted from the UGTA regional-scale groundwater flow model (DOE, 1997c), the overall groundwater flow direction in Yucca Flat is to the south and southwest (see Figure A-8). Groundwater ultimately discharges at Franklin Lake Playa to the south and Death Valley to the southwest.

A.5.5.3 Pahute Mesa Underground Test Area

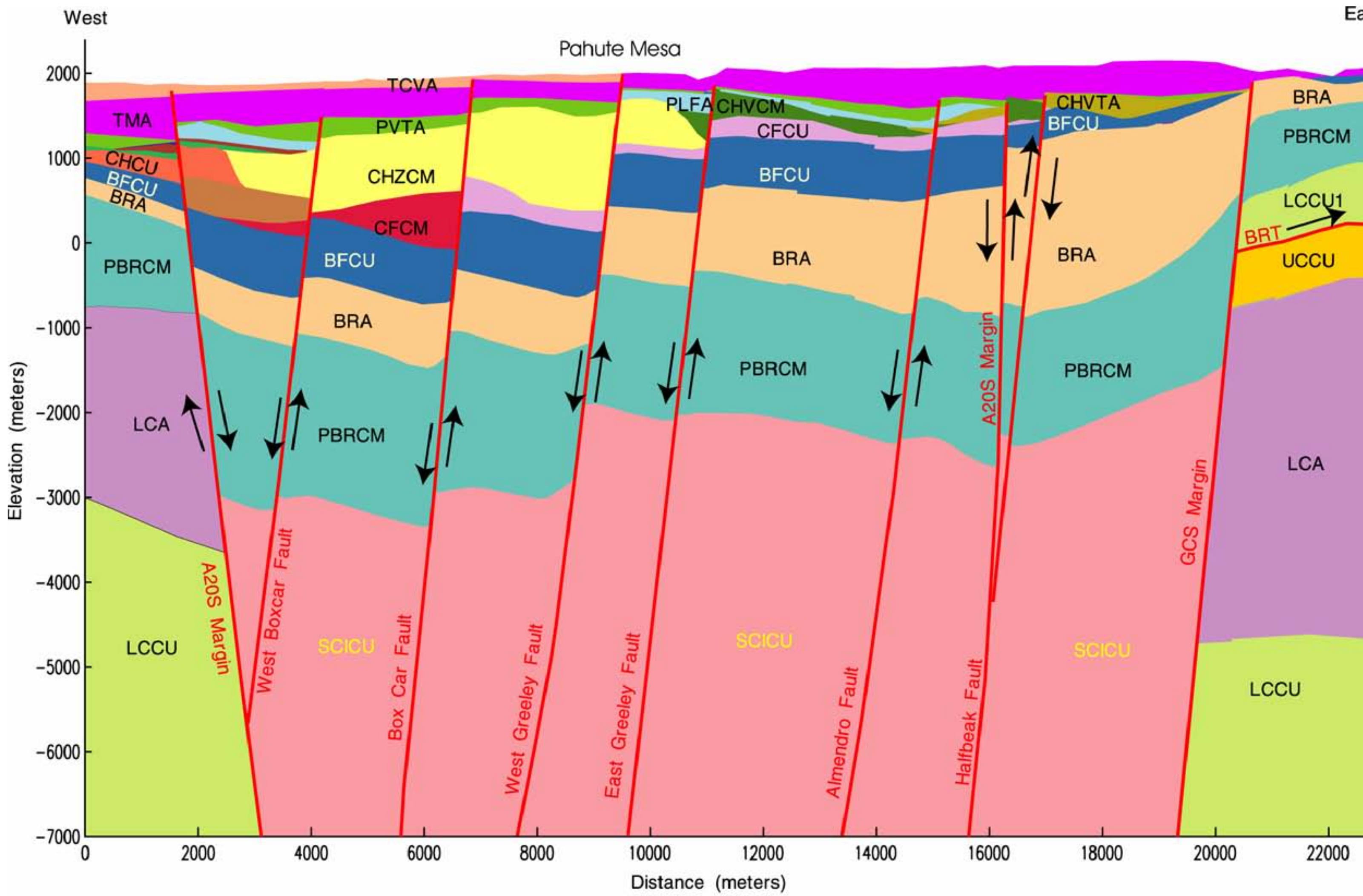
This section provides descriptions of the geologic and hydrologic settings of the Pahute Mesa UGTA. This summary was compiled from various sources, including BN (2002a and b), Winograd and Thordarson (1975), Laczniak et al., (1996), Byers et al. (1976; 1989), and Cole (1997). Additional information can be found in these documents. For detailed stratigraphic descriptions see Sawyer et al., (1994) and Slate et al., (1999).

The Western and Central Pahute Mesa CAUs, encompassing Areas 19 and 20 of the NTS, were the site of 85 underground nuclear tests (DOE, 2000b) (see Figure A-9). These detonations were all conducted in vertical emplacement holes (see Table A-5). The Western Pahute Mesa CAU is separated from the Central Pahute Mesa by the Boxcar fault and is distinguished by a relative abundance of tritium (IT, 1999b). For hydrogeologic studies and modeling purposes, these two CAUs are treated together.

Hydrogeologically, these CAUs are considered to be part of a larger region that includes areas both within and outside the boundaries of the NTS, designated as the Pahute Mesa-Oasis Valley (PM-OV) study area. Because most of the underground nuclear tests at Pahute Mesa were conducted near or below the static water level, test-related contaminants are available for transport via a groundwater flow system that may extend to discharge areas in Oasis Valley. So, like the UGTAs of Frenchman Flat and Yucca Flat, a CAU-scale hydrostratigraphic framework model has been developed for the PM-OV study area to support modeling of groundwater flow and contaminant transport for the UGTA Project (BN, 2002c).

Physiography – Pahute Mesa is a structurally high volcanic plateau in the northwest corner of the NTS (see Figure A-5). Ground-level elevations in the area range from below 1,650 m (5,400 ft) off the mesa to the north and south, to over 2,135 m (7,000 ft) in eastern Pahute Mesa. Pahute Mesa proper is composed of flat-topped buttes and mesas separated by deep canyons. This physiographic feature covers most of NTS Areas 19 and 20, which are the second most utilized testing real estate at the NTS. Consequently, there are numerous drill holes which provide a substantial amount of subsurface geologic and hydrologic information (BN, 2002a; Warren et al., 2000a and b).

Geology Overview – Borehole and geophysical data from Pahute Mesa indicate the presence of several nested calderas which produced thick sequences of rhyolite tuffs and lavas. The older calderas are buried by ash-flow units produced from younger calderas. Most of eastern Pahute Mesa is capped by the voluminous Ammonia Tanks and Rainier Mesa ash-flow tuff units which erupted from the Timber Mountain Caldera, located immediately to the south of Pahute Mesa (Byers et al., 1976). The western portion is capped by ash-flows of the Thirsty Canyon Group from the Black Mountain caldera. A typical geologic cross section for Pahute Mesa is presented in Figure A-12. For a more detailed geologic summary, see Ferguson, et al., (1994), Sawyer, et al., (1994), Warren, et al., (2000b), and BN (2002a).



A20S - Area 20 Caldera Structural Margin
BRT - Belted Range Thrust
GCS - Grouse Canyon Structural Margin

See Section A.5.3.2 of this appendix for definitions of hydrostratigraphic units.
1.5 x vertical exaggeration

Figure A-12. Generalized hydrostratigraphic cross section through the Silent Canyon complex, Pahute Mesa

The most widespread and significant Quaternary and Tertiary (mainly volcanic) units of the Pahute Mesa area are listed in Table A-1. Refer to Table A-2 for a list of Mesozoic (granitic), Paleozoic (sedimentary), and Precambrian (sedimentary and metamorphic) stratigraphic units.

Underlying the Tertiary-age volcanic rocks (exclusive of the caldera complexes) are Paleozoic and Proterozoic sedimentary rocks consisting of dolomite, limestone, quartzite, and argillite. During Precambrian and Paleozoic time, as much as 10,000 m (32,800 ft) of these marine sediments were deposited in the NTS region (Cole, 1997). For detailed stratigraphic descriptions of these rocks see Slate et al. (1999). The only occurrence of Mesozoic age rocks in the Pahute Mesa area is the Gold Meadows Stock, a granitic intrusive mass located at the eastern edge of Pahute Mesa, north of Rainier Mesa (Snyder, 1977; Gibbons et al., 1963).

The Silent Canyon caldera complex (SCCC) lies beneath Pahute Mesa. This complex contains the oldest known calderas within the SWNVF, and is completely buried by volcanic rocks erupted from younger nearby calderas. It was first identified from gravity observations that indicated a deep basin below the topographically high Pahute Mesa. Subsequent drilling on Pahute Mesa indicated that the complex consists of at least two nested calderas, the Grouse Canyon caldera and younger Area 20 caldera (13.7 and 13.25 Ma, respectively; Sawyer et al., 1994). For more information on the SCCC, see Ferguson et al., (1994), which is a comprehensive study of the caldera complex based on analysis of gravity, seismic refraction, drill hole, and surface geologic data.

Like the SCCC, the Timber Mountain caldera complex (TMCC) consists of two nested calderas, the Rainier Mesa caldera and younger Ammonia Tanks caldera, 11.6 and 11.45 Ma, respectively (Sawyer et al., 1994). However, unlike the SCCC, the TMCC has exceptional topographic expression, consisting of an exposed topographic margin for more than half its circumference and a well exposed central resurgent dome (Timber Mountain, the most conspicuous geologic feature in the western part of the NTS). The complex truncates the older Claim Canyon caldera (12.7 Ma; Sawyer et al., 1994) which is further to the south. The calderas of the TMCC are the sources for the Rainier Mesa and Ammonia Tanks Tuffs which form important and extensive stratigraphic units at the NTS and vicinity.

The Black Mountain caldera is a relatively small caldera in the northwest portion of the Pahute Mesa area. It is the youngest caldera in the area, formed as a result of the eruption, 9.4 Ma, of tuffs assigned to the Thirsty Canyon Group (Sawyer et al., 1994).

Deep gravity lows and the demonstrated great thickness of tuffs in the Pahute Mesa area suggest the presence of older buried calderas. These calderas would pre-date the Grouse Canyon caldera and thus, could be the source of some of the pre-Belted Range units.

Structural Setting – The structural setting of the Pahute Mesa area is dominated by the calderas described in the previous paragraphs. Several other structural features are considered to be significant factors in the hydrology, including the Belted Range thrust fault (see Section A.4.3), numerous normal faults related mainly to basin-and-range extension, and transverse faults and structural zones. However, many of these features are buried, and their presence is inferred from drilling and geophysical data. A typical geologic cross section for Pahute Mesa is presented in Figure A-12. For a more detailed geologic summary, see Ferguson et al., (1994); Sawyer et al., (1994); and BN (2002c).

Hydrogeology Overview – The hydrogeology of Pahute Mesa is complex. The thick section of volcanic rocks comprises a wide variety of lithologies that range in hydraulic character from aquifer to aquitard. The presence of several calderas and tectonic faulting further complicate the area, placing the various lithologic units in juxtaposition and blocking or enhancing the flow of groundwater in a variety of ways.

The general hydrogeologic framework for Pahute Mesa and vicinity was established in the early 1970s by USGS geoscientists (Blankennagel and Weir, 1973; Winograd and Thordarson, 1975). As described in Section A.5.3, their work has provided the foundation for most subsequent hydrogeologic studies at the NTS (IT, 1996a; BN, 2002c).

All the rocks in the PM-OV study area can be classified as one of nine HGUs, which include the AA, three volcanic HGUs, two intrusive units, and two HGUs that represent the pre-Tertiary rocks (see Table A-3).

The rocks within the PM-OV study area are grouped into 44 HSUs for the UGTA CAU-scale hydrogeology framework model (Table A-8). The volcanic units are organized into 37 HSUs that include 13 aquifers, 13 confining units, and 11 composite units (comprising a mixture of hydraulically variable units). The underlying pre-Tertiary rocks are divided into six HSUs, including two aquifers and four confining units. HSUs that are common to several CAUs at the NTS are briefly discussed in Section A.5.2.

Table A-8. Hydrostratigraphic units of the Pahute Mesa-Oasis Valley area

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Unit(s)[a]	Typical Lithologies
Alluvial Aquifer (AA)	AA	Alluvium (gravelly sand); also includes eolian sand
Younger Volcanic Composite Unit (YVCM)	LFA, WTA, VTA	Basalt, welded and nonwelded ash-flow tuff
Thirsty Canyon Volcanic Aquifer (TCVA)	WTA, LFA, lesser VTA	Partially to densely welded ash-flow tuff; vitric to devitrified
Detached Volcanics Composite Unit (DVCM)	WTA, LFA, TCU	Complex distribution of welded ash-flow tuff, lava, and zeolitic bedded tuff
Fortymile Canyon Composite Unit (FCCM)	LFA, TCU, lesser WTA	Lava flows and associated tuffs
Timber Mountain Composite Unit (TMCM)	TCU (altered tuffs, lavas) and unaltered WTA and lesser LFA	Densely welded ash-flow tuff; includes lava flows, and minor debris flows.
Tannenbaum Hill Lava-Flow Aquifer (THLFA)	LFA	Rhyolitic lava
Tannenbaum Hill Composite Unit (THCM)	Mostly TCU lesser WTA	Zeolitic tuff and vitric, nonwelded to welded ash-flow tuffs
Timber Mountain Aquifer (TMA)	Mostly WTA, minor VTA	Partially to densely welded ash-flow tuff; vitric to devitrified
Subcaldera Volcanic Confining Unit (SCVCU)	TCU	Probably highly altered volcanic rocks and intruded sedimentary rocks beneath each caldera
Fluorspar Canyon Confining Unit (FCCU)	TCU	Zeolitic bedded tuff
Windy Wash Aquifer (WWA)	LFA	Rhyolitic lava
Paintbrush Composite Unit (PCM)	WTA, LFA, TCU	Welded ash-flow tuffs, rhyolitic lava and minor associated bedded tuffs
Paintbrush Vitric-tuff Aquifer (PVTA)	VTA	Vitric, nonwelded and bedded tuff
Benham Aquifer (BA)	LFA	Rhyolitic lava
Upper Paintbrush Confining Unit (UPCU)	TCU	Zeolitic, nonwelded and bedded tuff

Table A-8. (continued)

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Unit(s)[(a)]	Typical Lithologies
Tiva Canyon Aquifer (TCA)	WTA	Welded ash-flow tuff
Paintbrush Lava-Flow Aquifer (PLFA)	LFA	Lava; moderately to densely welded ash-flow tuff
Lower Paintbrush Confining Unit (LPCU)	TCU	Zeolitic nonwelded and bedded tuff
Topopah Spring Aquifer (TSA)	WTA	Welded ash-flow tuff
Yucca Mountain Crater Flat Composite Unit (YMCFCM)	LFA, WTA, TCU	Lava; welded ash-flow tuff; zeolitic, bedded tuff
Calico Hills Vitric-tuff Aquifer (CHVTA)	VTA	Vitric, nonwelded tuff
Calico Hills Vitric Composite Unit (CHVCM)	VTA, LFA	Partially to densely welded ash-flow tuff; vitric to devitrified
Calico Hills Zeolitized Composite Unit (CHZCM)	LFA, TCU	Rhyolitic lava and zeolitic nonwelded tuff
Calico Hills Confining Unit (CHCU)	Mostly TCU, minor LFA	Zeolitic nonwelded tuff; minor lava
Inlet Aquifer (IA)	LFA	Lava
Crater Flat Composite Unit (CFCM)	Mostly LFA, intercalated with TCU	Lava and welded ash-flow tuff
Crater Flat Confining Unit (CFCU)	TCU	Zeolitic nonwelded and bedded tuff
Kearsarge Aquifer (KA)	LFA	Lava
Bullfrog Confining Unit (BCU)	TCU	Zeolitic, nonwelded tuff
Belted Range Aquifer (BRA)	LFA and WTA, with lesser TCU	Lava and welded ash-flow tuff
Pre-Belted Range Composite Unit (PBRCM)	TCU, WTA , LFA	Zeolitic bedded tuffs with interbedded but less significant zeolitic, nonwelded to partially welded ash-flow tuffs

Table A-8. (continued)

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Unit(s)[(a)]	Typical Lithologies
Black Mountain Intrusive Confining Unit (BMICU)	IICU	These units are presumed to be present beneath the calderas of the SWNVF. Their actual character is unknown, but they may be igneous intrusive rocks or older volcanic and pre-Tertiary sedimentary rocks intruded to varying degrees by igneous rocks.
Ammonia Tanks Intrusive Confining Unit (ATICU)	IICU	
Rainier Mesa Intrusive Confining Unit (RMICU)	IICU	
Claim Canyon Intrusive Confining Unit (CCICU)	IICU	
Calico Hills Intrusive Confining Unit (CHICU)	IICU	
Silent Canyon Intrusive Confining Unit (SCICU)	IICU	
Mesozoic Granite Confining Unit (MGCU)	GCU	Granodiorite and quartz monzonite; Gold Meadows Stock
Lower Carbonate Aquifer-Thrust Plate (LCA3)	CA	Limestone and dolomite
Lower Clastic Confining Unit Thrust Plate (LCCU1)	CCU	Quartzite and siltstone
Upper Clastic Confining Unit (UCCU)	CCU	Argillite and quartzite
Lower Carbonate Aquifer (LCA)	CA	Dolomite and limestone; "regional aquifer"
Lower Clastic Confining Unit (LCCU)	CCU	Quartzite and siltstone; "hydrologic basement"

(a) See Table A-3 for definitions of hydrogeologic units.
Note: Adapted from BN, 2002c.

Water–level Elevation and Groundwater Flow Direction – Water-level data are relatively abundant for the Pahute Mesa UGTA as a result of more than thirty years of drilling in the area in support of the weapons testing program. However, water-level data for the outlying areas to the west and south are sparse. These data are listed in the potentiometric data package prepared for the UGTA regional-scale groundwater flow model (IT, 1996b) and the Pahute Mesa water table map (O'Hagan and Laczniak, 1996).

The SWL at Pahute Mesa is relatively deep, at about 640 m (2,100 ft) below the ground surface. Groundwater flow at Pahute Mesa is driven by recharge in the east and subsurface inflow from the north. Local groundwater flow is influenced by the discontinuous nature of the volcanic aquifers and the resultant geometry created by overlapping caldera complexes and high angle basin and range faults (Laczniak et al., 1996). Potentiometric data indicate that groundwater flow direction is to the southwest toward discharge areas in Oasis Valley and ultimately Death Valley (see Figure A-8).

A.5.5.4 Rainier Mesa/Shoshone Mountain

The Rainier Mesa/Shoshone Mountain CAU consists of 61 CASs on Rainier Mesa and six on Shoshone Mountain, which are located in NTS Areas 12 and 16 respectively (see Figure A-9). Together, these two mesas constitute the third major area utilized for underground testing of nuclear weapons at the NTS between 1957 and 1992. Underground nuclear tests were conducted in horizontal, mined tunnels within these mesas, and two tests were conducted in vertical drill holes. All tests were conducted above the regional water table. Underground geologic mapping data from the numerous tunnel complexes, and lithologic and geophysical data from dozens of exploratory drill holes, provide a wealth of geologic and hydrologic information for this relatively small underground test area.

Physiography – The Rainier Mesa underground test area includes Rainier Mesa proper and the contiguous Aqueduct Mesa. Rainier Mesa and Aqueduct Mesa form the southern extension of the northeast trending Belted Range (see Figure A-5). This high volcanic plateau cuts diagonally across Area 12 in the north-central portion of the NTS. Ground-level elevations on Rainier Mesa are generally over 2,225 m (7,300 ft). The highest point on the NTS, 2,341 m (7,679 ft), is on Rainier Mesa. Aqueduct Mesa has slightly rougher and lower terrain, generally above 1,920 m (6,300 ft) in elevation. The edge of the mesas drop off quite spectacularly on the west, south and east sides.

Shoshone Mountain is located about 20 km (12 mi) south of Rainier Mesa. It is located in the middle of the NTS, at the west end of Syncline Ridge (see Figure A-5). Ground-level elevations range from 1,707 to 2,012 m (5,600 to 6,600 ft), but are generally above 1,830 m (6,000 ft). Tippipah Point, above the old Area 16 tunnels, has an elevation of 2,015 m (6,612 ft).

Geology Overview – Both Rainer Mesa and Aqueduct Mesa are composed of Miocene age air-fall and ash-flow tuffs, which erupted from nearby calderas to the west and southwest. As in Yucca Flat, these silicic volcanic tuffs were deposited unconformably on an irregular pre-Tertiary (upper Precambrian and Paleozoic) surface of sedimentary rocks (Gibbons et al., 1963; Orkild, 1963) and Mesozoic granitic rocks (at Rainier Mesa only). The stratigraphic units and lithologies are similar to those present in the subsurface of Yucca Flat (see Section A.5.5.2). Most of Rainier Mesa and Shoshone Mountain consist of zeolitized bedded tuff, though the upper part of this section is unaltered (vitric) in some areas. At both locations, the bedded tuffs are capped by a thick layer of welded ash-flow tuff. The Tertiary stratigraphic units and lithologies are similar to those present in the subsurface of Yucca Flat (see Section A.5.5.2).

Structural Setting – The geologic structure of the volcanic rocks of the Rainier Mesa is well documented. Several high-angle, normal faults have been mapped in the volcanic rocks. Faults with greater than about 30 m (100 ft) of displacement are notably absent in the volcanic rocks of Rainier Mesa. At Shoshone Mountain several faults have been mapped, but in general the structure is less well known there than at Rainier Mesa. The structure of the pre-Tertiary section at both locations is poorly known, though some workers speculate that the trace of the Belted Range thrust fault is present in the pre-Tertiary rocks beneath Rainier Mesa. A broad synclinal feature mapped at the surface and in the tuffs of Rainier Mesa/Aqueduct Mesa may reflect a paleo-topographic low beneath the tuffs (Figure A-13), but the exact character of this feature is unknown.

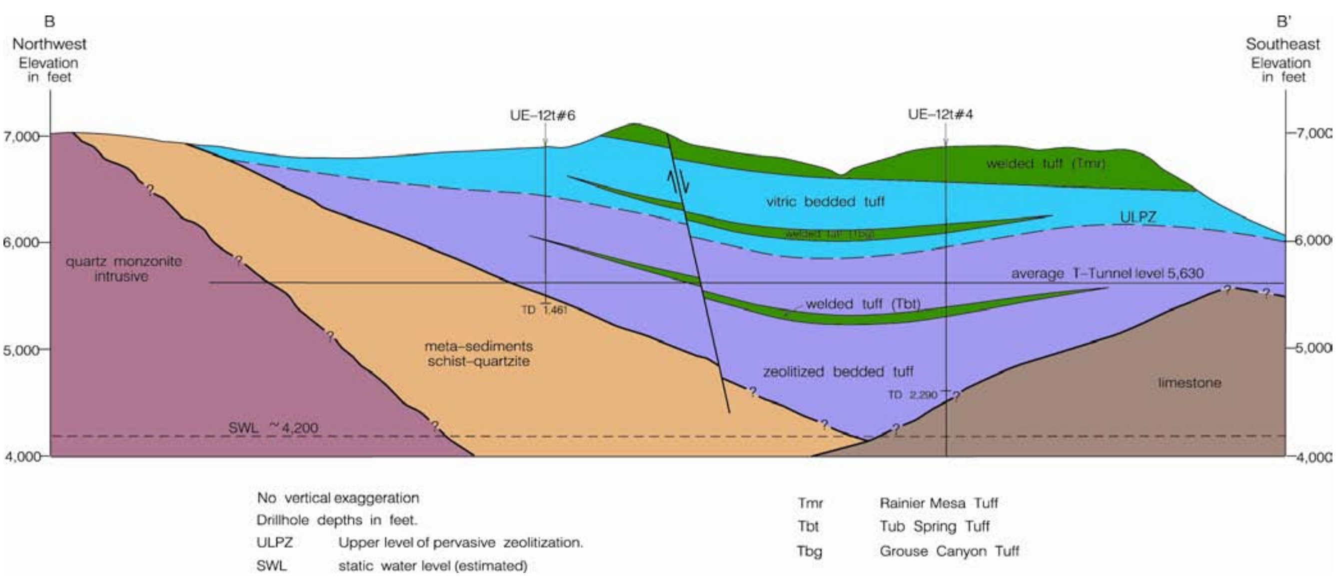


Figure A-13. Generalized hydrostratigraphic cross section through Aqueduct Mesa

Hydrogeology Overview – Construction of UGTA CAU-scale hydrogeology models for the Rainier Mesa and Shoshone Mountain UGTAs has not yet begun. However, HGUs and HSUs in the Rainier Mesa and Shoshone Mountain area are expected to be similar to those defined for the Yucca Flat area (see Table A-7).

The hydrostratigraphy of the pre-Tertiary section is unknown at Shoshone Mountain, and is poorly known at Rainier Mesa. At Rainier Mesa, granitic rocks (related to the nearby Gold Meadows Stock), carbonate rocks, silicic sedimentary rocks such as siltstone, and metamorphic rocks such as quartzite and schist have been encountered beneath the tuff section in the few existing drill holes that penetrate through the tuff section. This variability is indicative of the complex geology of the pre-Tertiary section.

Most of the tests in Shoshone Mountain and Rainier Mesa tunnels were conducted in the tuff confining unit, though a few were conducted in vitric bedded tuff higher in the stratigraphic section.

Water–level Elevation and Groundwater Flow Direction – The regional water level at Rainier Mesa is not well known, but is estimated to be at an elevation of approximately 1,280 m (4,200 ft) in the pre-Tertiary carbonate rocks that underlie the volcanic section. This is approximately 300 m (1,000 ft) below the average elevation of test locations in Rainier Mesa. The SWL, where measured in a few drill holes at Rainier Mesa, is at an elevation of about 1,847 m (6,060 ft). This anomalously high water level relative to the regional water level reflects the presence of water perched above the regional aquifer within the tuff confining unit (Walker 1962; Laczniak et al., 1996). Abundant water is present in the fracture systems of some of the tunnel complexes at Rainier Mesa. This water currently is permitted to flow from U12e Tunnel (also known as E Tunnel); however, water has filled the open drifts behind barriers built near the portals of U12n and U12t Tunnels.

The water level elevation at Shoshone Mountain is not known. No water was encountered during mining at Shoshone Mountain.

Regional groundwater flow from Rainier Mesa may be directed either toward Yucca Flat or, because of the intervening UCCU, to the south toward the Alkali Flat discharge area (see Figure A-8). The groundwater flow direction beneath Shoshone Mountain is probably southward.

A.5.6 Conclusion

The hydrogeology of the NTS and vicinity is complex and varied. Yet, the remote location, alluvial and volcanic geology, and deep water table of the NTS provided a favorable setting for conducting and containing underground nuclear tests. Its arid climate and its setting in a region of closed hydrographic basins also are factors in stabilizing residual surficial contamination from atmospheric testing, and are considered positive environmental attributes for existing radioactive waste management sites.

Average groundwater flow velocities at the NTS are generally slow, and flow paths to discharge areas or potential receptors (domestic and public water supply wells) are long. The water table for local aquifers in the valleys and the underlying regional carbonate aquifer are relatively flat. The zeolitic volcanic formation (TCU) separating the shallower alluvial and volcanic aquifers and the regional carbonate aquifer (LCA) appears to be a viable aquitard. Consequently, both vertical and horizontal flow velocities are low. Additionally, carbon-14 dates for water from NTS aquifers are on the order of 10,000 to 40,000 years old (Rose et al., 1997). Thus, there is considerable residence time in the aquifers, allowing contaminant attenuating processes such as matrix diffusion, sorption, and natural decay, to operate.

A.6 Climatology

The NTS is located in the extreme south-western corner of the Great Basin. Consequently, the climate is arid with limited precipitation, low humidity, intense solar radiation and large daily temperature ranges. The climatological data presented below were developed from the meteorological data network that has been located on the NTS for many years (see Section 15).

A.6.1 Precipitation

Two fundamental physical processes drive precipitation events on the NTS: those resulting from cool-season, mid-tropospheric cyclones and those resulting from summertime convection. Cool-season precipitation is usually light and can consist of rain or snow. Although light, winter precipitation events can last for several days and result in significant precipitation totals per winter storm; especially in January and February. Summer is thunderstorm season. Precipitation from thunderstorms is usually light; however, some storms are associated with very heavy rain, flash floods, intense cloud-to-ground (CG) lightning, and strong surface winds. Thunderstorms generally occur in July and August when moist tropical air can flow from the south-eastern North Pacific Ocean and spread over the desert southwest. This seasonal event is referred to as the south-western monsoon. The winter-summer precipitation mechanisms produce a bi-modal annual precipitation cycle. Figure A-14 shows patterns of mean monthly precipitation recorded from six MEDA stations on the NTS over the past 40+ years (see Figure 15-2 for location of MEDA stations). Mean annual precipitation totals on the NTS range from nearly 33 cm (13 in) over the high terrain in the north-western part of the NTS to less than 12.7 cm (5 in) in Frenchman Flat. However, inter-annual variations can be great. For example, 24.6 cm (9.67 in) occurred in Frenchman Flat in 1998 and 68 cm (26.79 in) fell on Rainier Mesa in 1978. Annual totals of less than 2.54 cm (1.0 in) have occurred on the lower elevations of the NTS. Daily precipitation totals can also be large and can range from 5 cm to over 8.89 cm (2.0 to over 3.5 in). The greatest daily precipitation event on the NTS was 9.22 cm (3.63 in), which was measured at Mercury on August 18, 1983. A storm-total precipitation amount of 8.89 cm (3.5 in) is a 100-year, 24-hour, extreme precipitation event. Daily totals of 2 – 3 in (5.1 – 7.6 cm) have been measured at several sites on the NTS (Randerson, 1997).

Snow can fall on the NTS anytime between October and May. In Yucca Flat, the greatest daily snow depth measured is 25.4 cm (10 in) in January 1974. The greatest daily depth measured at Desert Rock is 15.2 cm (6 in) in February 1987. Maximum daily totals of 38.1 to 50.8 cm (15 to 20 in) or more can occur on Pahute and Rainier Mesas.

Hail, sleet, freezing rain, and fog are rare on the NTS. Only 24 hailstorms were observed in Yucca Flat between 1957 and 1978. Hail and sleet can cover the ground briefly following intense thunderstorms.

A.6.2 Temperature

As is typical of an arid climate, the NTS experiences large daily, as well as annual, ranges in temperature. Moreover, temperatures vary with elevation. Sites 1,524 m (5,000 ft) above mean sea level can be quite cold in the winter and fairly mild during the summer months. At lower elevations, summertime temperatures can frequently exceed 37.7°C (100ºF). In the dry lakebeds, daily temperature ranges can be 4.4°C to 15.6°C (40ºF to 60ºF) with very cold morning temperatures in the winter and very hot temperatures in the summer. These temperature characteristics are clearly shown in Figure A-15. These annual temperature plots describe the temperature extremes and normal maximums and minimums throughout the year at different locations on the NTS (see Figure 15.2 for location of MEDA stations).

In Frenchman Flat, the average daily temperature minimum and maximum for January is -4.4°C to 13.3°C (24ºF to 56ºF) while in July it is 16.7°C to 38.9°C (62ºF to 102ºF). By contrast, on Pahute Mesa the minimum and maximum temperature for January is -3.9°C to 5°C (25ºF to 41ºF) and for July, 16.11°C to 28.9°C (61ºF to 84ºF). The highest maximum temperature measured on the NTS is 46.1°C (115ºF) in Frenchman Flat, near Well 5B, in July 1998 and in Jackass Flats near Lathrop Gate in July 2002. The coldest minimum temperature measured on the NTS is -25.6°C (-14ºF) in Yucca Flat in December 1967. The temperature extremes at Mercury are -11.7°C (11ºF) to 45°C (113ºF).

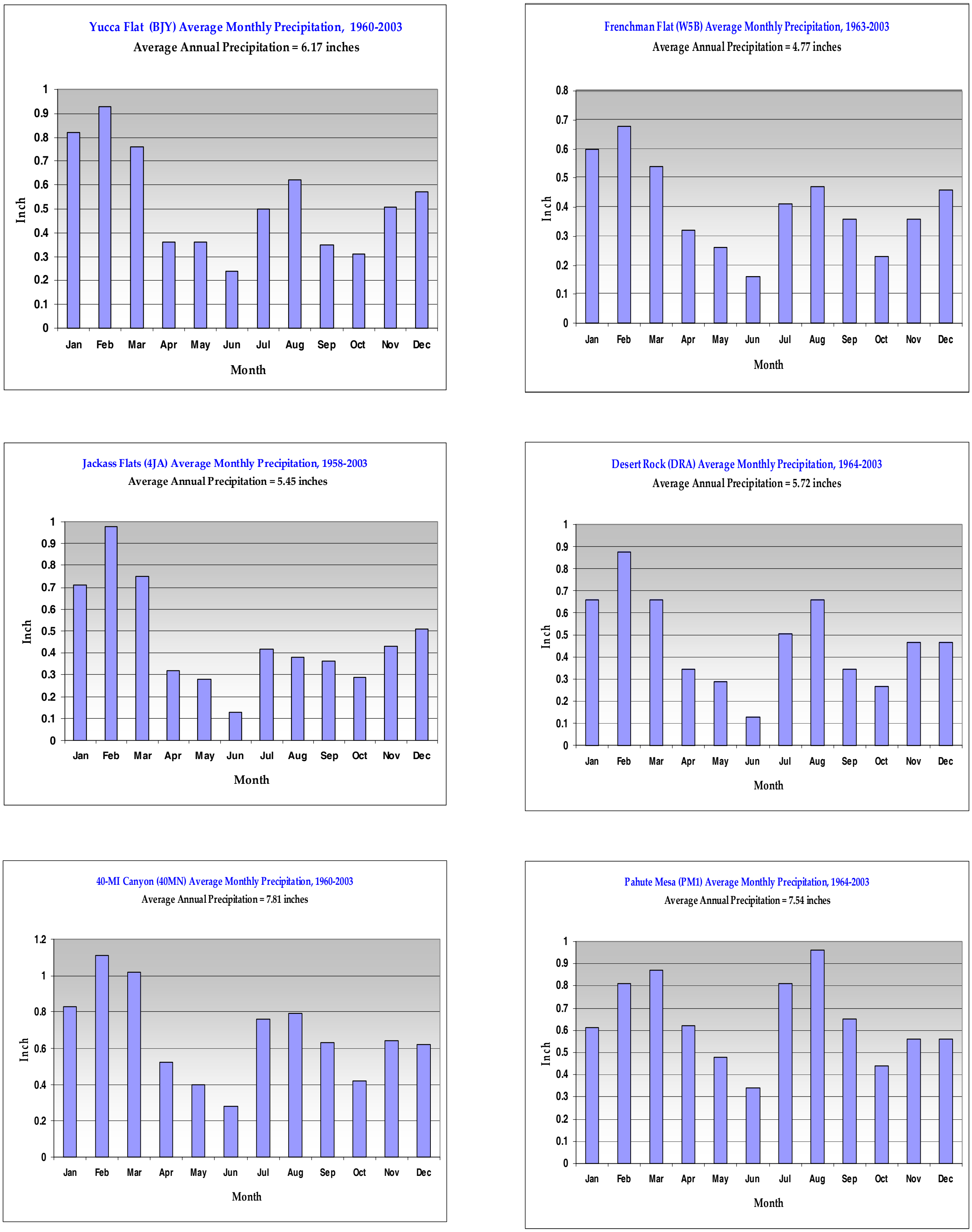


Figure A-14. Mean monthly precipitation at six NTS MEDA stations

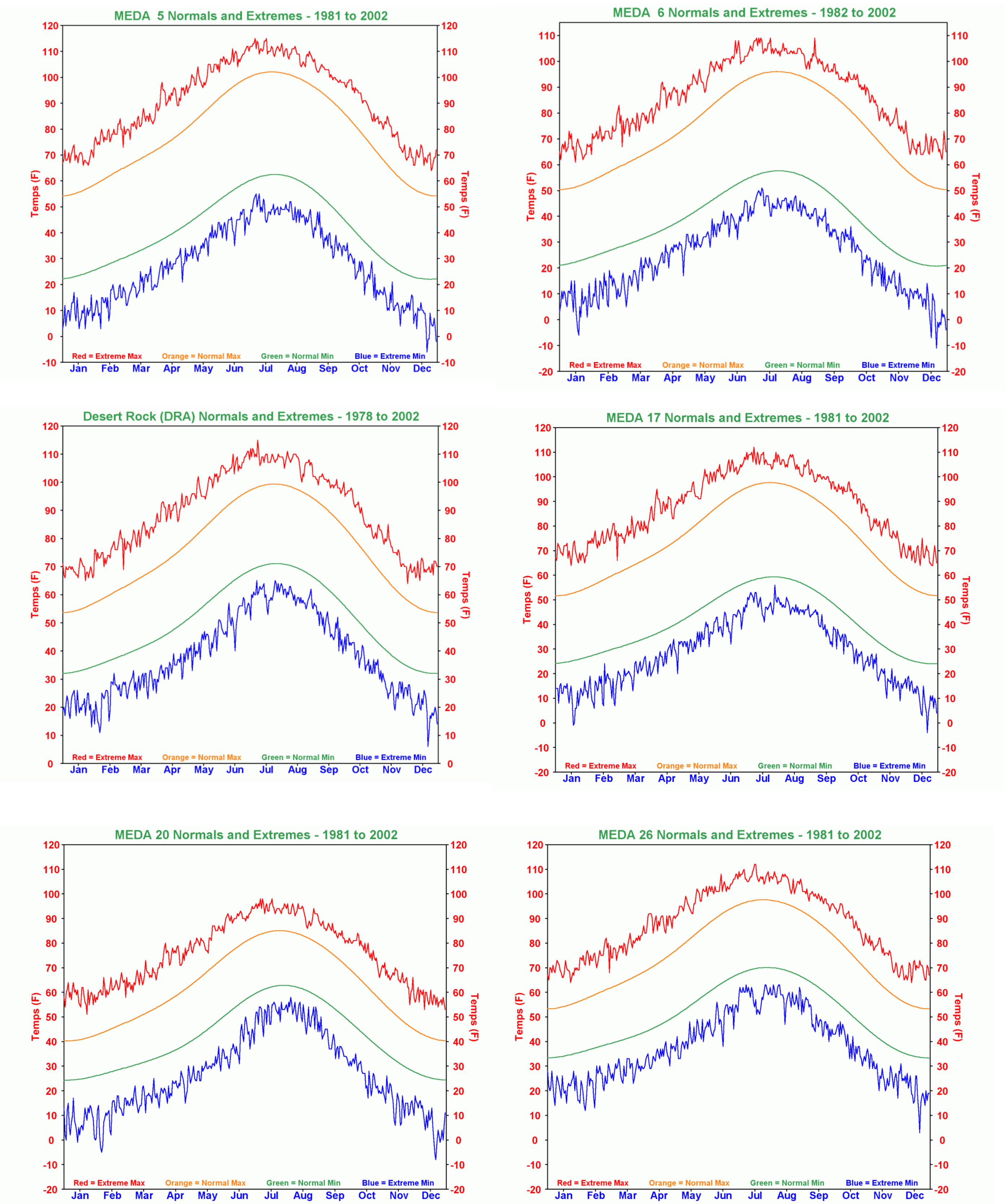


Figure A-15. Temperature extremes and normal maximums and minimum at six NTS MEDA stations

A.6.3 Wind

Complex topography, such as that on the NTS, can influence wind speeds and directions. Furthermore, there is a seasonal as well as strong daily periodicity to local wind conditions. For example, in Yucca Flat, during the summer months, the wind direction is usually northerly (from the north) from 10 p.m. Pacific Daylight Time (PDT) to 8 a.m. PDT and southerly from 10 a.m. PDT to 8 p.m. PDT. However, in January the winds are generally from the north from 6 p.m. Pacific Standard Time (PST) to 11 a.m. PST with some southerly winds developing between 11:00 a.m. PST and 5:00 p.m. PST. March through June tend to experience the fastest average wind speeds [12.9 to 19.3 kmh] (8 to 12 mph) with the faster speeds occurring at the higher elevations. Peak wind gusts of 80.5 to 112.7 kmh (50 to 70 mph) have occurred throughout the NTS. Peak winds at Mercury have been as high as 84 mph during a spring wind storm. Frenchman Flat experienced wind gusts to 112.7 kmh (70 mph) during the same windstorm. The peak wind speeds measured on the NTS are above 145 kmh (90 mph) on the high terrain with maximums of 146 kmh (91 mph) at Yucca Mountain Ridge-top, 148 kmh (92 mph) at the Monastery (MEDA station 10) in Area-6, and 151 kmh (94 mph) in Area-12 on Radio Hill.

Wind speed and direction data has been summarized for all the MEDA stations on the NTS. These climatological summaries are referred to as wind roses. Wind roses representing data collected from the early 1980s through 2002 for six stations on the NTS are shown in Figure A-16. This figure describes the strong seasonal and diurnal effects on the surface air flow pattern across the NTS. In general, winter and pre-sunrise winds tend to be northerly while summer and afternoon flow tends to be southerly. Terrain also contributes to determining wind direction.

A.6.4 Relative Humidity

The air over the NTS tends to be dry. On average, June is the driest month with humidity ranging from 10 percent to 35 percent. Humidity readings of 35 percent to 70 percent are common in the winter. The reason for this variability is that relative humidity is temperature dependent. The relative humidity tends to be higher with cold temperatures and lower with hot temperatures. Consequently there is not only a seasonal variation but also a marked diurnal rhythm with this parameter. Early in the morning the humidity ranges from 25 percent to 70 percent and in mid-afternoon it is in the 10 percent to 40 percent range, with the larger readings occurring in winter. Humidity readings of more than 75 percent are not common on the NTS.

A.6.5 Severe Weather Phenomena

Wind speeds in excess of 97 kmh (60 mph) occur annually. Additional severe weather in the region includes occasional severe thunderstorms, lightning, hail, and dust storms. Severe thunderstorms may produce high precipitation rates that may create localized flash flooding. Few tornadoes have been observed in the region and are not considered a significant threat.

CG lightning can occur throughout the year, but occurs primarily between June and September. Maximum CG lightning activity on the NTS occurs between 1 p.m. and 4 p.m. PDT while minimum activity occurs between 8 a.m. and 9 a.m. PDT. For safety analyses, the mean annual flash density on the NTS is 0.4 flashes per square kilometer (fl/km^2). Randerson and Sanders (2002) have characterized CG lightning activity on the NTS.

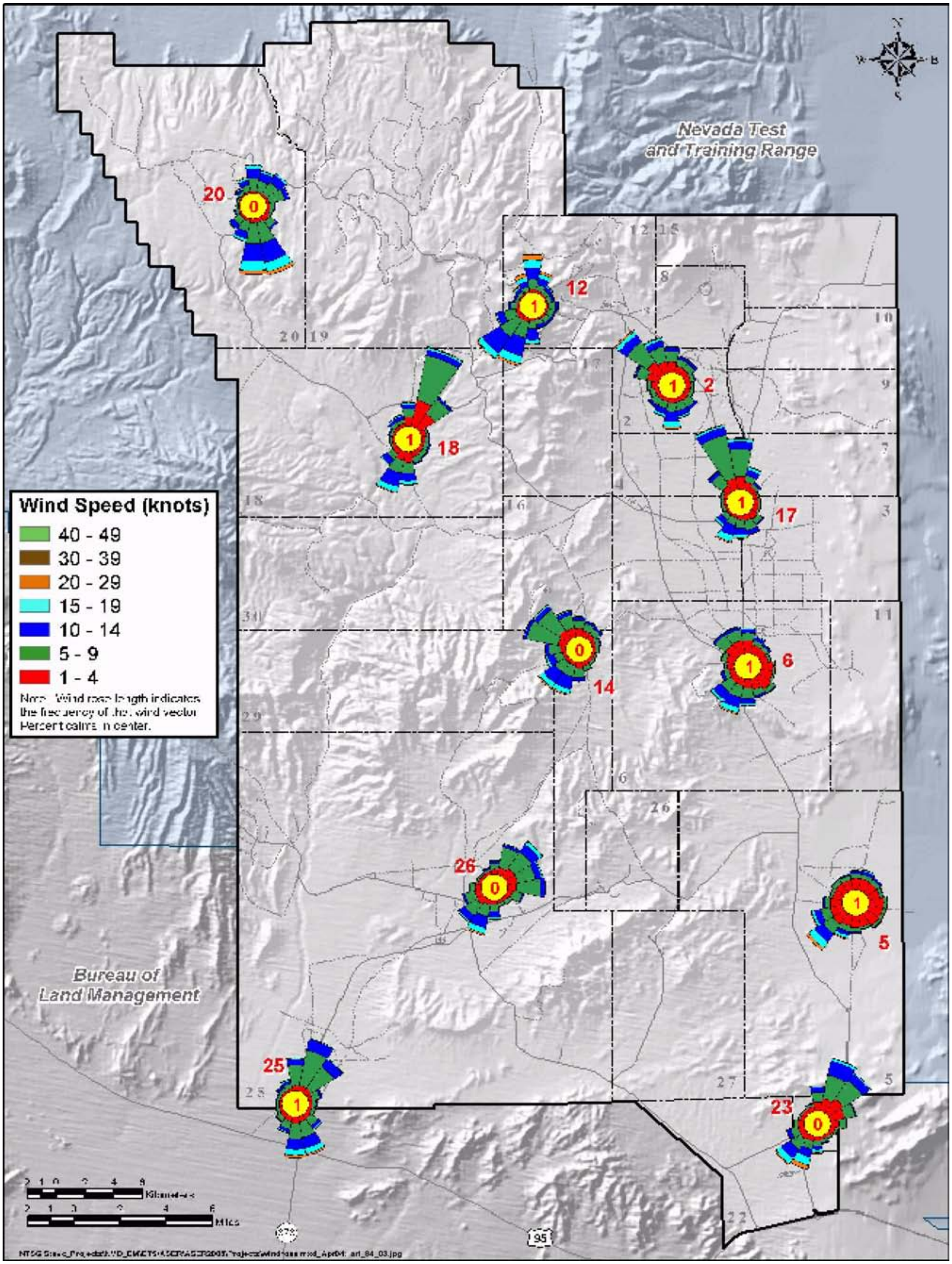


Figure A-16. Annual climatological wind rose patterns at 11 NTS MEDA stations from wind data gathered 1984 to 2003

A.7 Ecology

The NTS lies on the transition between the Mojave and Great Basin deserts. As a result, elements of both deserts are found in a diverse and complex flora and fauna (Ostler et al., 2000; Wills and Ostler 2001).

A.7.1 Flora

A total of 752 taxa of vascular plants have been collected in ten major vegetation alliances (Figure A-17). Twenty vegetation associations from among the alliances have been identified and mapped. Distributions of the Mojave Desert, Transition Zone, and Great Basin Desert vegetation alliances and associations are linked to temperature extremes, precipitation, and soil conditions.

Vegetation associations characteristic of the Mojave Desert occur over the southern third of the NTS, on bajadas and mountain ranges at elevations below about 1,219 m (4,000 ft) (Figure A-17). Creosote bush (*Larrea tridentata*) is the dominant shrub within these associations. Creosote bush associations are absent from habitats where the mean minimum air temperature is below -1.9°C (28.5° F) or the extreme minimum is less than -17.2°C (1° F). It is also limited to zones with an average rainfall of 18.3 cm (7.2 in) or less (Beatley, 1974). Between elevations of 1,219 to 1,524 m (4,000 to 5,000 ft), transitional vegetation associations exist, and the largest and most important is the blackbrush – Nevada jointfir (*Coleogyne ramosissima-Ephedra nevadensis*) Shrubland Association which covers 21.6 percent of the total area of the NTS (Ostler et al., 2000). Above 1,524 m (5,000 ft,) the vegetation mosaic is characteristic of the Great Basin Desert. Throughout the central and northwestern mountains of the NTS, the dominant shrub species are basin big sagebrush (*Artemisia tridentata*) and black sagebrush (*Artemisia nova*). The distribution of Great Basin Desert associations appears to be limited by mean maximum temperature and by minimum rainfall tolerances of the cold desert species (Beatley, 1975).

Above 1,828 m (6,000 ft), singleleaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*) mix with the sagebrush association where there is suitable moisture for these trees. Tree densities on the NTS are often not high enough to create closed canopies, but rather, an open woodland type with a mix of shrub and tree cover.

There are no plants on the NTS which are listed as threatened or endangered under the Endangered Species Act. However, there are 11 vascular plant species on the NTS which the FWS considers to be "species of concern" and there are another six vascular plants and five mosses that are considered species to watch by the Nevada Natural Heritage Program (see Table 12-2). Species of concern are those which the FWS recognizes may have conservation needs, though there is not enough information to warrant their listing. Federal agencies are encouraged to consider these species when evaluating environmental impacts of their activities. Through past field survey efforts over multiple years, population locations of the 11 plant species of concern have been mapped on the NTS (Figure A-18), and these species continue to be monitored under the Ecological Monitoring and Compliance Program (see Section 12).

A.7.2 Fauna

At least 1,163 taxa of invertebrates within the phylum Arthropoda have been identified on the NTS. Seventy-eight percent of the known arthropods are insects. Ants, termites, and ground-dwelling beetles are probably the most important groups of insects as regards distribution, abundance, and functional roles. No native fish species occur on the NTS, although non-native goldfish, golden shiners, and bluegills have been unofficially introduced into a few man-made ponds. The non-native bullfrog is the only amphibian that is known to occur on the NTS.

Among reptiles, the desert tortoise, 16 lizard species, and 17 snake species are known to occur on the NTS (Wills and Ostler, 2001). The rich reptile fauna is partly due to the overlapping ranges of plant species characteristic of the Mojave and Great Basin Deserts. The most abundant, widely distributed lizards include the side-blotched lizard (*Uta stansburiana*), western whiptail (*Cnemidophorus tigris*), desert horned lizard (*Phrynosoma platyrhinos*), and desert spiny lizard (*Sceloporus graciosus*). The western shovel-nosed snake (*Chionactis occipitalis*) is the most common snake on the NTS, and there are four species of poisonous snakes. They include the Mohave Desert sidewinder (*Crotalus cerastes*), Panamint rattlesnake (*Crotalus mitchellii*), night snake (*Hypsiglena torquata*), and Sonoran lyre snake (*Trimorphodon biscutatus*).

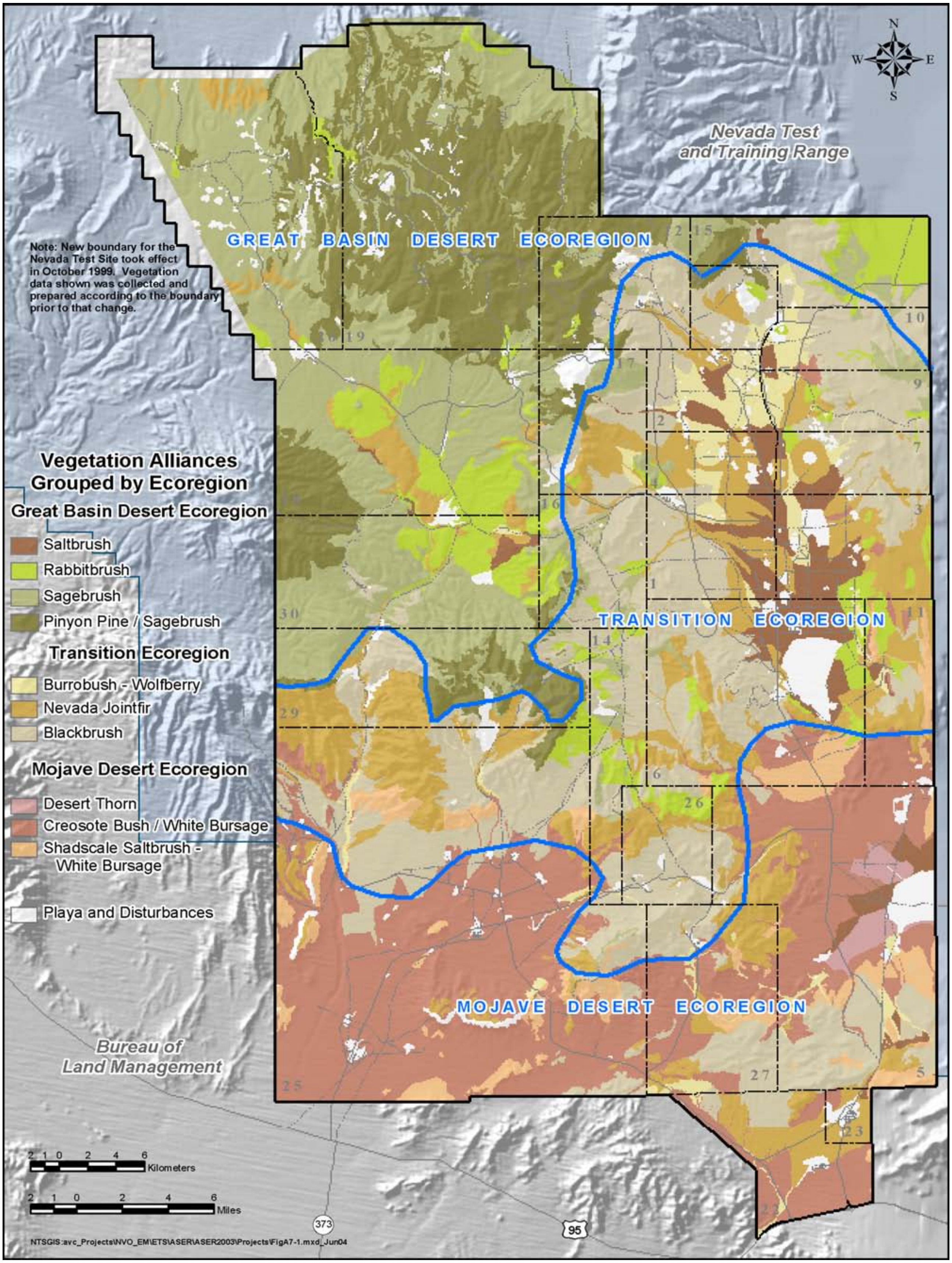


Figure A-17. Distribution of plant alliances on the NTS

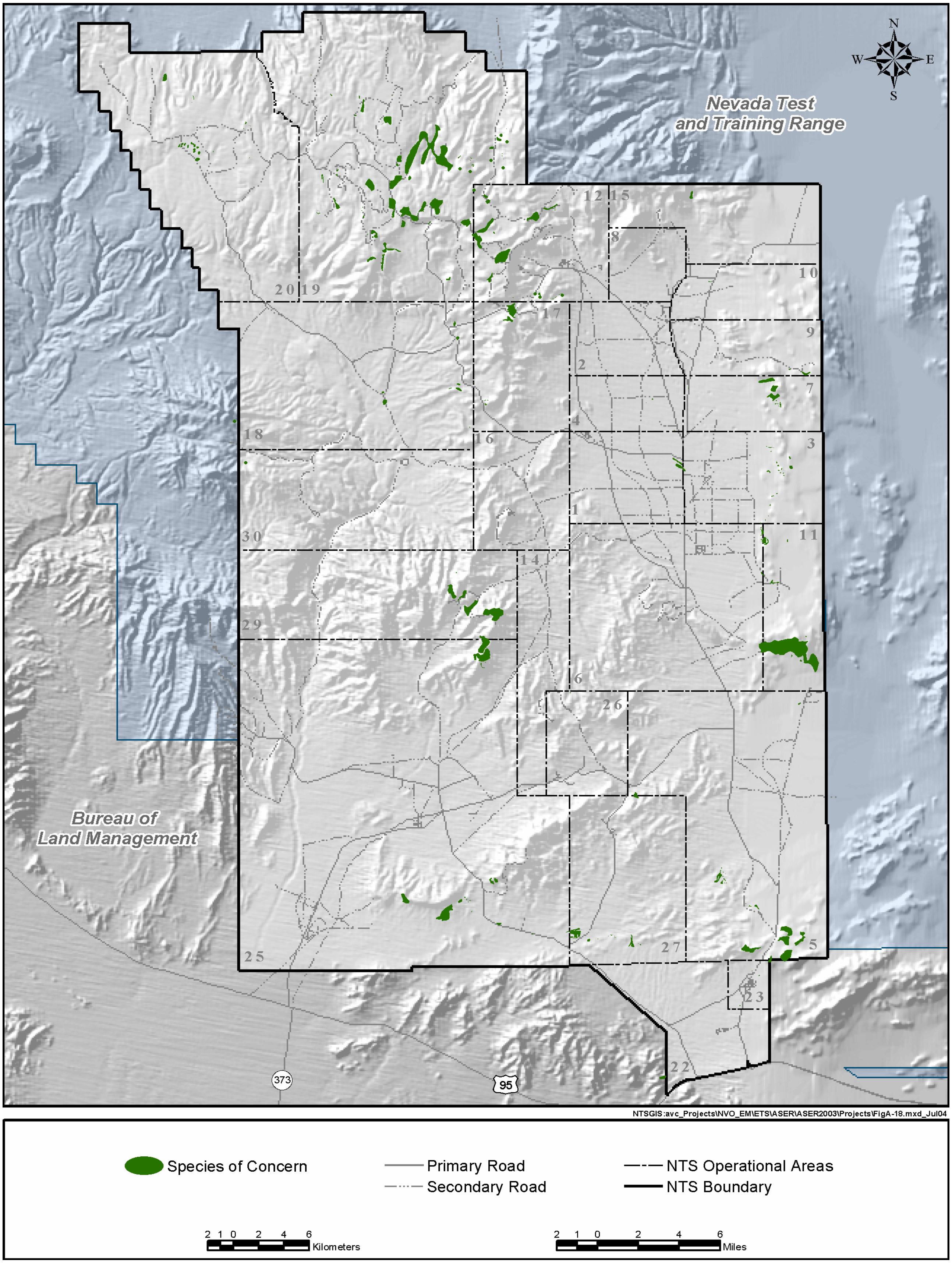


Figure A-18. Known locations of plant species of concern on the NTS

There are records of 239 species of birds observed on the NTS (Wills and Ostler, 2001). Approximately 80 percent of the bird species are migrants or seasonal residents. Eight species of raptors (birds of prey) are known to breed on the NTS (BN, 2002b). They include the golden eagle (*Aquila chrysaetos*), long-eared owl (*Asia otus*), red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*Buteo swainsoni*), prairie falcon (*Falco mexicanus*), American kestrel (*Falco sparverius*), western burrowing owl (*Athene cunicularia hypugea*), and the barn owl (*Tyto alba*).

There are 44 terrestrial mammals and 15 bat species that are known to occur on the NTS. Rodents account for about 40 percent of the known mammals, and in terms of distribution and relative abundance, are the most important group of mammals on the NTS (Wills and Ostler, 2001). There is an apparent correlation between production by winter annual plants and reproduction in desert rodents on the NTS. Larger mammals on the site include: black-tailed jackrabbit, desert and Nuttall's cottontails, feral horses, mule deer, pronghorn antelope, coyote, kit fox, badger, bobcat, and mountain lion. Mule deer herds occur mainly on the high mesas and surrounding bajadas. Small numbers of wild horses and pronghorn antelope range over small areas of the NTS. Bighorn sheep and burros are thought to be rare visitors.

The desert tortoise (*Gopherus agassizii*) is the only resident species found on the NTS which is listed as threatened under the Endangered Species Act. Habitat of the desert tortoise is in the southern third of the NTS (see Figure 12-1). The bald eagle is a threatened bird which is a rare migrant on the site. No other threatened or endangered animal is known to occur on the NTS. Virtually all birds on the NTS are protected by federal legislation under the Migratory Bird Treaty Act and/or by the state of Nevada. Most non-rodent mammals of the NTS are protected by the state of Nevada and managed as either game or furbearing mammals, and seven bats on the NTS are considered species of concern by the FWS (see Tables 12-2, 12-3, and 12-4).

A.7.3 Natural Water Sources

Important biological communities on the NTS are those associated with springs or other natural sources of water. They are rare, localized habitats that are important to regional wildlife and to isolated populations of water-loving plants and aquatic organisms. There are 30 natural water sources on the NTS which include 15 springs, 9 seeps, 4 tank sites (natural rock depressions that catch and hold surface runoff), and 2 ephemeral ponds (Hansen et al., 1997; BN, 1998; 1999) (Figure A-19).

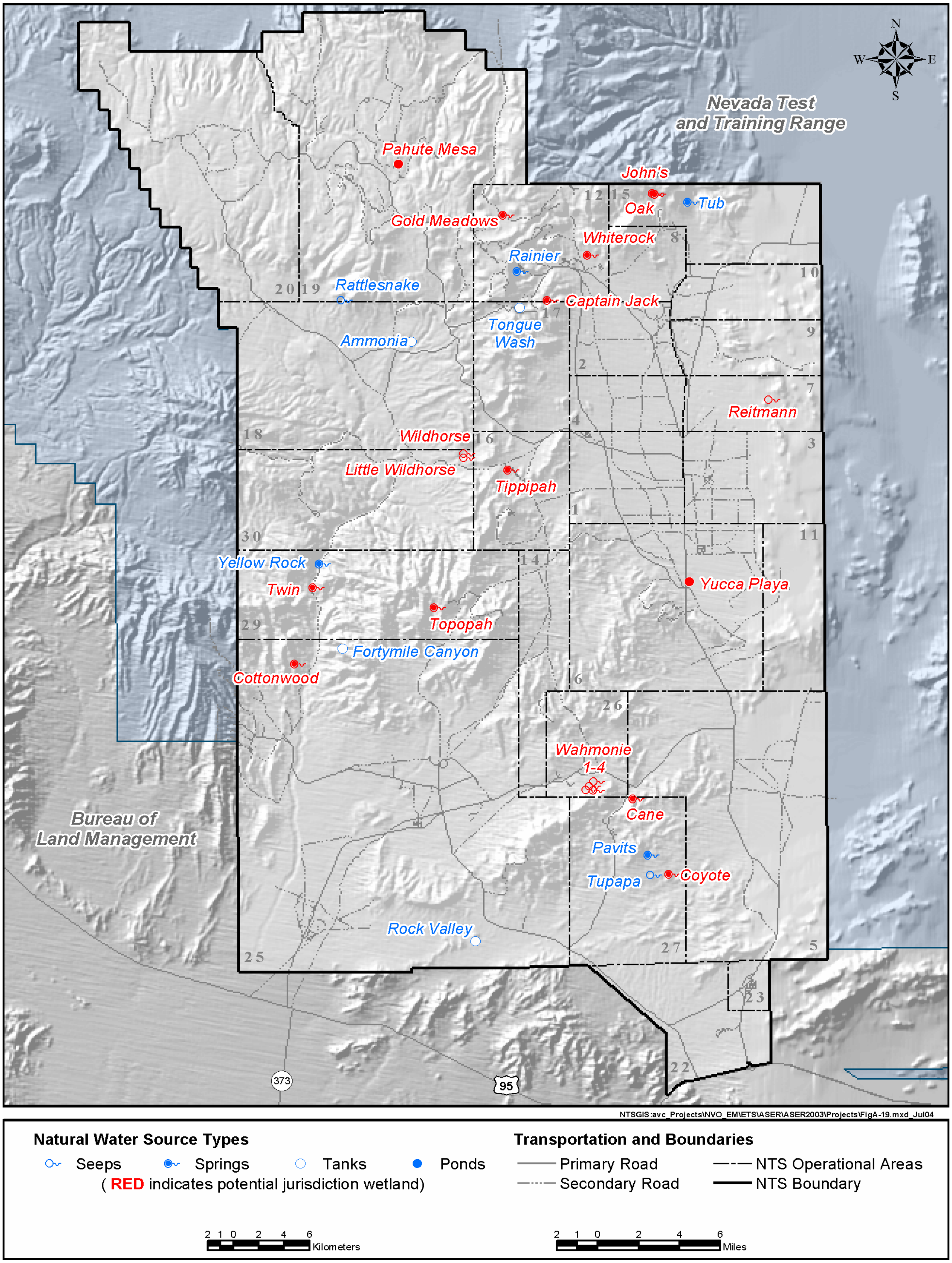


Figure A-19. Natural water sources on the NTS

A.8 Cultural Resources

A.8.1 Cultural Resources Investigations on the NTS

Few cultural resources investigations were performed from the 1940s to the 1960s on what is now the NTS. Earlier explorers did visit the area, such as O.S. Lodwick in the 1900s and Mark R. Harrington of the Heye Museum of the American Indian in the 1920s, but the visits were brief, and no in-depth studies were attempted. The work conducted by S.M. Wheeler in 1940 is the first serious investigation, resulting in some prominent sites being recorded (Winslow, 1996). Wheeler and a small party, including his wife, supported by the Nevada State Parks Commission, were guided by Roscoe J. Wright, a.k.a. "Death Valley Curley," a local miner, into the Fortymile Canyon region with the specific purpose of investigating archaeological sites (Figure A-20). The party spent only a few days in the area, however, and only briefly described the cultural resources they found. In 1955, Richard Shutler (1961:11), seeking evidence of pueblo ruins, was the next archaeologist to visit and record sites in the same general area of Fortymile Canyon as well as on Timber Mountain. He was guided by Bill Martin, a Shoshone from Beatty. Frederick C.V. Worman (1965, 1966, 1967, 1969), a zoologist and a vocational archaeologist employed by Los Alamos National Laboratory, and Donald Tuohy (1965), an archaeologist from the Nevada State Museum, conducted limited surveys and excavations during the 1960s. These investigations were typically salvage archaeology in response to an Atomic Energy Commission (AEC) directive regarding the preservation and protection of antiquities on AEC lands. It was not until the late 1970s with stronger federal laws and regulations concerning cultural resources that systematic archaeological investigations on the NTS were carried out on a regular basis. DRI became the cultural resources support contractor at this time and ever since has performed numerous surveys and data recovery efforts (Figure A-21), as well as records keeping and curation of artifacts. Lately, historical evaluations of NTS structures and buildings have become part of the program in documenting a significant period in the local and national history regarding nuclear testing and the Cold War era (Figure A-22).

Figure A-20. Example of an archaeological site found in Fortymile Canyon. This a rock art site probably 2,000 to 4,000 years old (1996 Photo).

Figure A-21. DRI archaeologist at an archaeological excavation of a prehistoric site on Pahute Mesa. The site is probably from the middle to late Holocene period (1992 Photo).

Figure A-22. Building 400, a camera station for photographing atmospheric tests, at Area 6 Control Point built in 1951 and demolished in 2003. One of the first buildings constructed on the NTS to support weapons testing activities (2003 Photo).

A.8.2 Paleo-Indian Period

The oldest cultural remains discovered on the NTS are Clovis style projectile point fragments dating to the Paleo-Indian period, ca. 12,000 to 10,000 years before present (BP). One was found along an alluvial terrace of Fortymile Wash near Yucca Mountain (Reno, 1985) and a second at the upper reaches of the Fortymile drainage system near Rattlesnake Ridge at the west base of Rainier Mesa (Jones and Edwards, 1994). The basic economic strategy for the Paleo-Indian was hunting of big game and a predominant use of lacustrine-marsh areas around late Pleistocene and early Holocene pluvial lakes (Madsen, 1982; Warren and Crabtree, 1986). Pluvial lakes were a result of cooler temperatures and higher annual precipitation characteristic of this time (Grayson, 1993). No evidence is available, however, to indicate that the basins on the NTS supported pluvial lakes as in other nearby valleys, such as Groom Lake east of the NTS and the Kawich, Gold Flat, and Mud lakes to the north (Grayson, 1993: Table 5-2; Mifflin and Wheat, 1979). The Fortymile Canyon drainage, where the Clovis points were found, may have been used as a travel route between highland and lowland areas or, as proposed by Pippin (1998a), part of a hunting territory where certain animals such as deer and elk could be found.

A.8.3 Early Holocene Period

A general broadening in the types of resources being exploited from a variety of environments occurs during the early Holocene, ca. 10,000 to 7,500 BP, and includes aquatic and small animals as well as plants (Grayson, 1993). Initially, lakes and marshes still abounded overall, but the climate began to change to one more dry and by 8,000 BP most of the standing bodies of water were gone (Grayson, 1993). Consequently, the woodlands began to move upslope to be replaced by sagebrush or bursage and creosote bush (Grayson, 1993).

Most cultural activities still appear to be restricted to the lower elevations, however (cf. Haynes, 1996; cf. Reno, et al., 1989); and Pippin (1998a) indicates that only short term hunting forays, originating from the lower elevations, occurred in the higher elevations of the NTS. This is similar to the pattern described for the eastern Great Basin (Madsen, 1982).

A.8.4 Middle Holocene Period

The period from ca. 7,500 to 4,500 BP is marked by increased aridity, and a hotter and dryer climate compared to the previous episode and to that of today (Antevs, 1948; Miller and Wigand, 1994). Some evidence suggests that entire areas were abandoned. For example, Warren and Crabtree (1986) contend that the people living in the Mojave Desert at this time were ill-adapted to the arid conditions because so few sites have been found, and of those sites, they appear to represent short-term activities with low artifact densities indicative of a highly mobile lifestyle. They suggest that the people may have aggregated at the margins of the desert near springs and other dependable water sources and only briefly entered the more arid localities during times of greater effective moisture. Few sites have been found in the Great Basin dating to this period as well. Grayson (1993) indicates the higher elevation zones are becoming an important part of the subsistence base and coincides with the upward movement in elevation of the woodlands. Pippin (1998a) also notes this change on the NTS, but he sees the cultural response as an intensification and expansion of the areas previously exploited and not in the relocation of residential bases to the uplands.

A.8.5 Late Holocene Period

The period from ca. 4,500 to 1,900 BP is generally known for cooler and wetter conditions. Subsequent periods fluctuated between dry and wet episodes, with the most notable arid periods from 1,900 to 1,000 BP and 700 to 500 BP (Miller and Wigand, 1994). A pattern of heavy winter precipitation began after 500 BP, but average temperatures have gradually increased since the end of the Little Ice Age about 150 years ago. Culturally, there is an increase in the number of sites and a broadening of the subsistence base (Grayson, 1993; Lyneis, 1982). A shift in the settlement pattern is made in some areas of the southern Great Basin to comparatively large, semi-sedentary communities on valley floors accompanied by a more frequent use of the highlands. An increase in the frequency of milling implements indicates a greater reliance on seeds than previously practiced (Warren and Crabtree, 1986).

Evidence at higher elevations on the NTS supports the contention that highland resources were an important part of the subsistence base, and quite likely, logistical seasonal movements between resource zones were being practiced (Pippin, 1998a:). Rock features interpreted as food caches begin to appear within the woodlands (Pippin, 1998a:). Examples of projectile points from this period found by DRI archaeologists on the NTS are shown in Figure A-23. One of the most conspicuous technological changes is the introduction of the bow and arrow, ca. 1,500 BP. Madsen (1986a:) suggests that the advent of this implement may have led to increased efficiency in hunting to where the animal populations were significantly reduced, resulting in a greater dependence by the people on plant resources, such as pinyon and other seed plants. Another introduction was brownware pottery (Figure A-24), ca. 700 to 1,000 BP (Lockett and Pippin, 1990; Madsen, 1986b; Pippin, 1986; Rhode, 1994), indicating increased sedentism and a change in the way food was prepared and stored.

Figure A-23. Prehistoric projectile points from the NTS (1992 Photo)

Figure A-24. Brownware bowl recovered from archaeological excavations on Pahute Mesa (1992 Photo)

A.8.6 Ethnohistoric American Indian

Early explorers and immigrants in the southern Great Basin during the nineteenth century encountered widely scattered groups of Numic-speaking hunters and gatherers currently known as Southern Paiute (see Kelly and Fowler, 1986) and Western Shoshone (see Thomas et al., 1986). The areas traditionally claimed by these tribal entities encompassed a large region and were bound in territories of ethnic or political groups (Stoffle et al., 1990). Subsistence strategies revolved around movements between environmental zones within their territories (e.g., highlands and lowlands), according to the seasonal availability of food resources (Steward, 1938; cf. Wheat, 1967). The normal range was within 32 km (20 mi) of the primary residential base, but most resources could be found within a short distance of the main camp. Criteria for the location of the primary residential base was nearness to stored or cached foods, the availability of water, wood for fuel and house construction, and relatively warm winter temperatures like that found in canyon mouths or in the woodlands (Steward, 1938).

The communal group around Rainier Mesa and the southern end of the Belted Range ca. 1875-1880 was known as *Eso* (little hill) and had an estimated population of 42. This locale is at the boundaries of the traditional tribal lands for the Southern Paiute and Western Shoshone, and the *Eso* consisted of members from both tribes. The *Eso* were closely linked linguistically with people to the east, but maintained close relationships with groups all around them, particularly to the north and west. They established winter residential camps at Cane Spring, Captain Jack Spring, Oak Springs, Tippipah Springs (Figure A-25), Topopah Spring, White Rock Springs, and on Pahute and Rainier mesas. Another camp, though not located at a spring, was Ammonia Tanks.

One of the better known spring sites, Captain Jack Spring, is named after One-eyed Captain Jack, a Paiute who resided there at various times with his wife(s) during the late 1800s and early 1900s (Steward, 1938; Stoffle et al., 1990). He died in 1928 (Stoffle et al., 1990). At White Rock Springs lived Wandagwana, headman for the Eso. He directed the annual fall rabbit drive in Yucca Flat which was a time of regional interaction between the various camps and with more distant people. A fandango was usually held at *Wungiakuda* off the southeast edge of Pahute Mesa (see Johnson et al., 1999) lasting about five days, and provided opportunity for the exchange of goods and information. Sweat houses, also serving as places of integration for the local group, were located at White Rock Springs and at Oak Springs. They were used by both women and men for smoking, gambling, sweating, and as a dormitory.

Figure A-25. Overview of the Tippipah Springs Area (2004 Photo)

A.8.7 Historic Mining on and near the NTS

It was around the beginning of the twentieth century, when substantial gold and silver deposits were discovered, that the Euro American culture began to dominate this particular region of Nevada, with strikes at Tonopah, Goldfield, and Rhyolite (Elliott, 1966, 1973; McCracken, 1992; Zanjani, 1992). The overall population of Nevada doubled (Elliott, 1966; McCracken, 1992). The great mining boom was short-lived, however, and quickly entered the bust phase. By 1908, only four years after it began, mining in the Bullfrog district collapsed and the town of Rhyolite became one of the many ghost towns in the region. For Goldfield, production fell rapidly after 1911 (Zanjani, 1992), but the town still survives today, principally because it is the seat for Esmeralda County (Elliott, 1966). The decline for the Tonopah mining district was more gradual and had time to transform its primary economic base from mining to a supply center, albeit relatively small and limited, for the surrounding ranches, remaining mining districts, and military installations. The Las Vegas and Tonopah rail line lasted until 1918 and the rails were removed in 1919 (Myrick, 1963). Still evident on the NTS today are some of the abandoned ties reused for the construction of corrals and other structures at a number of the springs. Around the Beatty area the ties were used in some of the later mining operations for shoring (McCracken, 1992).

As mining explorations continued in the region, fanning out from the earlier strikes, small mining districts were founded, such as Tolicha in 1917 at the west end of Pahute Mesa (Lincoln, 1923) and the Bare Mountain district just west of the NTS (Cornwall, 1972; Lincoln, 1923, Tingley, 1984). Recorded as an archaeological site by Jones et al. (1996), the mining town of Wahmonie in the southern part of the NTS around Mine and Skull mountains was founded in 1928. The history of Wahmonie spans only a few years and was typical of the boom-and-bust cycle of the mining industry. The historic mining camp of Wahmonie is located about 10 km (6 mi) west of Cane Spring (McLane, 1995; Quade and Tingley, 1984). It grew to a small town with boarding houses, tent stores, and cafes. The Silver Dollar Saloon and the Northern Club were but two of the enterprises (Long, 1950). Most of the miners lived in small tents. George Wingfield, a well-known mine owner and banker in Nevada, became interested and incorporated the Wahmonie Mining Company. Soon, however, the strike was apparently not as rich as had first been thought and by early 1929 optimism faded and people began leaving Wahmonie. Small amounts of prospecting in the Wahmonie district continued into the 1930s and 1940s, but few ore deposits were ever discovered.

The earliest record of prospecting on what is now the NTS is the Oak Spring mining district centered around the northern edge of Oak Butte (Drollinger, 2002). Documents at the Recorder's Office in Tonopah indicate it was established by the late 1880s. The main objectives of these early mining activities were gold, silver, and chrysocolla, a green to blue mineral resembling turquoise. Lincoln (1923) indicates copper ore containing some silver was shipped in 1917 from the Horseshoe claim in the Oak Spring mining district, and that minor amounts of tungsten were also mined in the district. The Oak Spring district, although having relatively abundant water and wood sources, did not prove to be very productive overall.

B.M. Bower (a.k.a. Bertha Muzzy Sinclair), a noted author, with husband (Bud Cowan) and family, moved to Nevada from Los Angeles, California in 1920 and took up residence (Figure A-26) at a mining camp near Oak Spring (McLane, 1996) (see Figure A-19). An accomplished and prolific writer, B.M. Bower published a number of short stories and novels over a 40 year career, with some of them becoming the basis for early western-themed movies in Hollywood. She also served as a screenwriter on a couple of them. While living at the camp, Bower wrote 11 novels, incorporating some of the surrounding geographic features, such as Oak Butte and the camp itself, into a few of the stories. (Copies of several of her books have been made electronically available to the public by Project Gutenberg as Etext and can be downloaded at: <http://www.thalasson.com/gtn/gtnletB.htm#bowerbm>). The family also formed the El Picacho Mining Company, with B.M. Bower serving as the president, and filed assessment work for the claims from 1922 to 1928. The family moved to Las Vegas around 1926, but still worked the mining claims sporadically over the next couple years.

They eventually returned to California. Fittingly, in keeping with the theme for some of the novels, the abandoned camp was used in the early 1930s by outlaws from Utah and Arizona whose escapades were later featured in a Death Valley Days radio episode narrated by Ronald Reagan. B.M. Bower died in 1940 and was inducted into the Western Writers of America Hall of Fame in 1994.

Historically, demand of tungsten for use in weaponry was high during times of war (World Wars I and II and the Korean War) and fell during times of peace (Stager and Tingley, 1988). Correspondingly, so did the mining of tungsten in Nevada. Tungsten was discovered in the Oak Spring district and located as the Climax group in 1937 by V.A. Tamney (Kral, 1951; Stager and Tingley, 1988). Most operations ended when the area was closed with the founding of the bombing and gunnery range by the Federal government (Kral, 1951; Quade and Tingley, 1984; Stager and Tingley, 1988). Production was never fully established for these claims, however, and only samples totaling some 15 tons were processed in a nearby dry concentrating mill serving the Oak Spring district. The last known mining. operation at the Climax claims was from December 1956 to May 1957 involving a co-use agreement between George Tamney, W.A. Kinney, A.J. Wright, owners of the Climax Tungsten Corporation, and the AEC (McLane, 1996; Quade and Tingley, 1984). The agreement was terminated and no legal mining has since been conducted on the NTS.

Figure A-26. Bower cabin on the NTS (2001 Photo)

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Appendix B

Nevada Test Site Satellite Facilities

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Appendix B: Nevada Test Site Satellite Facilities

This appendix provides a general description of the three Nevada Test Site (NTS) satellite facilities which support work on the NTS and of all environmental monitoring and compliance activities conducted in 2003 related to these facilities. The NTS and these facilities are managed by the U.S. Department of Energy, National Nuclear Security Administration's Nevada Site Office (NNSA/NSO). They include the North Las Vegas Facility (NLVF), Cheyenne Las Vegas Facility (CLVF), and Remote Sensing Laboratory (RSL). They are all located in Clark County (Figure B-1).

B.1 North Las Vegas

The NLVF is a fenced complex comprised of 31 buildings which houses many of the NTS project management, diagnostic development and testing, design, engineering, and procurement. The 80-acre facility is located along Losee Road a short distance west of Interstate 15 (Figure B-1). The facility is buffered on the north, south, and east by general industrial zoning. The western border separates the property from fully developed, single-family residential-zoned property. The NLVF is a controlled-access facility.

The environmental compliance and monitoring activities associated with this facility include maintenance of two wastewater permits, five air quality operating permits for a variety of equipment, one hazardous materials permit (Table B-1); and monitoring of ambient gamma-emissions associated with stored sealed radiation sources to comply with radiation protection regulations.

Table B-1. Environmental permits for NLVF

Permit Number	Description	Expiration Date	Reporting
Wastewater Discharge			
VEH-112	NLVF Wastewater Contribution Permit	December 31, 2006	Annually
TNEV2003349	NLVF Temporary Well Test/Discharge Permit	November 6, 2003	Monthly
TNEV2003461	NLVF Temporary Well Test/Discharge Permit	May 21, 2004	Monthly
Air Quality			
A38701	A-16 Spray Paint Booth	None	Annually
A38703	A-5/B-5 Emergency Generators	None	Annually
A06503	Emergency Generator	None	Annually
A06505	B-1 Aluminum Sander	None	Annually
A06507	Tinco Dry Blaster	None	Annually
Hazardous Materials			
2287-5144	NLVF Hazardous Materials Permit	February 28, 2004	Annually

B.1.1 Compliance with Water Permits

Wastewater permits for NLVF include: (1) a Class II Wastewater Contribution Permit with the City of North Las Vegas (CNLV) for sewer discharges and (2) two temporary discharge permits to support groundwater characterization and dewatering issued by the Nevada Division of Environmental Protection (NDEP).

Discharges of sewage and industrial wastewater from the NLVF are required to meet permit limits set by the CNLV. These limits support the permit limits for the Publicly Owned Treatment Works (POTW) operated by the City of Las Vegas. Regulations for wastewater discharges are codified in the municipal codes for both cities. Groundwater discharges are state regulated by the NDEP, and are discharged through the CNLV stormwater collection system.

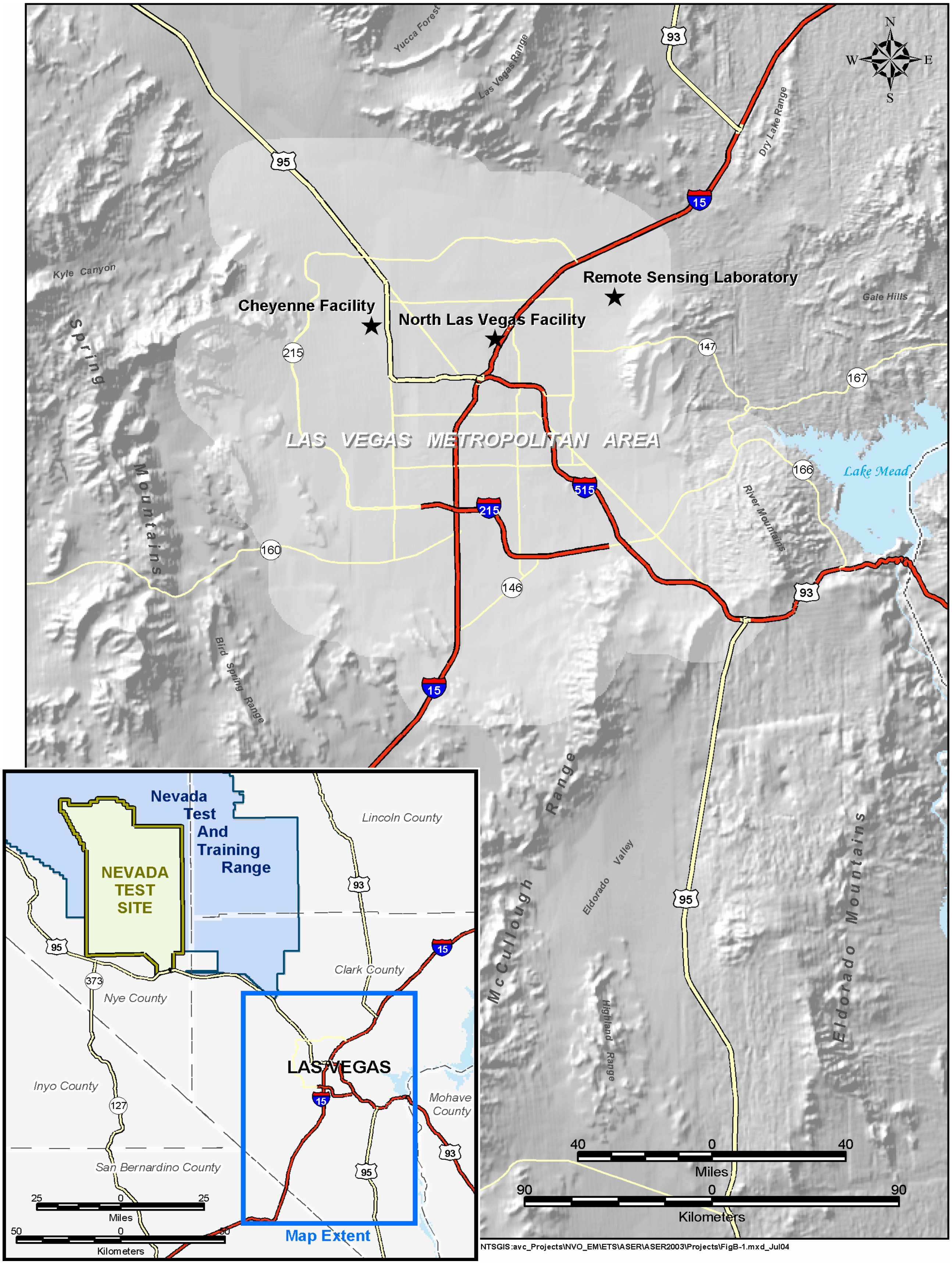

Figure B-1. Location of NTS satellite facilities

These discharges enter waters of the United States (Las Vegas Wash) under a National Pollutant Discharge Elimination System (NPDES) permit. In 2003, the NDEP issued two temporary permits (six-month duration) to NNSA/NSO. Sediment is the primary pollutant related to these discharges.

B.1.1.1 Wastewater Contribution Permit VEH-112

This permit specifies concentration limits for contaminants in domestic and industrial wastewater discharges. Self-monitoring and reporting of the levels of contaminants in sewage and industrial outfalls is conducted. In 2003, all water samples from NLVF outfalls and all sludge and liquid samples from the NLVF sand/oil interceptor contained contaminants below established permit limits (Table B-2). The majority of grab samples were below analytical detection limits. CNLV conducted an annual inspection on September 9, 2003, that resulted in no findings or corrective actions. In compliance with this permit, the following report summarizing wastewater monitoring was generated for NLVF operations and submitted October 3, 2003 to CNLV: *Self-Monitoring Report for the National Nuclear Security Administration's North Las Vegas Facility: Permit VEH-112*.

Table B-2. Results of 2003 monitoring at NLVF for Wastewater Contribution Permit VEH-112

Contaminant	Permit Limit (mg/L)	Outfall A (mg/L)	Outfall B (mg/L)	Outfall C2 (mg/L)
Barium	13.1	0.144	0.184	0.0836
BOD	600	56	200	24
Cadmium	0.15	< 0.0004	< 0.0004	0.003
Chromium (Hexavalent)	0.10	< 0.01	< 0.01	< 0.01
Chromium (Total)	5.60	0.001	0.0038	0.0198
Copper	0.60	0.169	0.50	0.108
Cyanide (Total)	19.9	< 0.02	0.29	< 0.02
Lead	0.20	< 0.0019	< 0.0019	0.0236
Nickel	1.10	0.0041	0.0037	0.0329
Oil & Grease (animal or vegetable)	250	4.1	7.7	2.9
pH (Standard Units)	5.0 – 11.0	8.64	8.70	8.31
Phenols	33.6	0.095	0.112	0.024
Phosphorus (Total)	14.0	2.5	7.2	0.62
Silver	2.70	< 0.0008	< 0.0008	< 0.0008
TDS	1200	214	480	403
TRPH	100	< 1.0	< 1.0	3.1
TSS	750	26.8	127	45
Zinc	8.20	0.152	0.336	0.262

B.1.1.1.2 NPDES Permits TNEV2003349 and TNEV2003461

These two permits apply to the groundwater characterization study and remedial dewatering operation which was conducted at the NLVF in 2003. The permits specify that monthly estimates of groundwater discharge volumes be reported for all wells being pumped for the study and that there be sediment controls on the waste stream which enters the storm water drains at the facility. These permit specifications were met in 2003.

B.1.2 Groundwater Control Study

Rising groundwater below Building A-1 at the NLVF intruded into the elevator pit in 1999. Between November 1999 and January 2001, the water level in a well installed in the basement of Building A-1 rose at the rate of 0.6 meters (m) (2 feet [ft]) per year (BN, 2001). Data collected during 2002 and 2003 show the rate of rise decreasing to less than 0.3 m (1 ft) per year (BN, 2003c). Sealing of the elevator pit and interim pumping at the nearby basement sump seems to have slowed the encroaching water. However, if this situation continues unchecked, it could jeopardize the integrity of deep-footed infrastructure (e.g., elevator pits, utility trenches, etc.).

B.1.2.1 Study Goals and Methods

In 2002 and 2003, Bechtel Nevada (BN) conducted a groundwater control study. This comprehensive investigation included the installation of 25 wells, soil and water sampling, hydrologic testing, and rudimentary modeling (BN, 2003). The goals of the study were to discover why the water table beneath Building A-1 was rising and to determine what remedial actions could be taken to protect the building. Prior to this investigation, details regarding the subsurface structure, geology and hydrology at the site were not well known.

Twenty-one monitoring wells and four hydrologic test wells were constructed at thirteen locations at the NLVF (Figure B-2). The hydrologic test wells have a larger diameter completion casing to accommodate a submersible pump employed during hydraulic testing. At all but one of the 13 sites (NLVF-4d), both a shallow and a deep well were drilled at the same drill site. At NLVF-4d, a previously-drilled monitoring well was used as the shallower companion well. The typical depth of each shallow well was about 12.2 m (40 ft). The typical depth of each deep well was about 41.1 m (135 ft).

To construct each pair of monitoring wells, a single 21.6-centimeter (cm) (8.5-inch [in.]) diameter hole was augered to the planned total depth. A single 5-cm (2-in) polyvinyl chloride (PVC) completion string with one isolated and gravel packed slotted interval was installed in each of the 21 new monitoring wells. Figure B-3 shows a cross section through a shallow and deep well pair of a typical monitoring site at the NLVF. The four hydrologic test wells are 34.3 cm (13.5 in.) in diameter and were completed with 10-cm (4-in) PVC and longer (3.0 to 6.1 m [10 to 20 ft]) screened intervals.

Measurements of physical properties (e.g., grain size, bulk density, and Atterberg limits) were determined for 67 split-spoon core samples collected from the 25 new wells. A full suite of water-chemistry analyses was preformed on groundwater samples collected at six wells (Table B-3). Hydraulic properties for the two alluvial aquifers were derived from step draw-down, constant-rate pumping, slug tests, and the physical properties measurements.

Groundwater characterization samples were collected from the two monitoring wells which are artesian, NLVF-1d and NLVF-3d, on July 24, 2002, and from monitoring wells NLVF-1s and NLVF-4d on March 26, 2003. Hydrologic Test Well NLVF-13s and the Building A-1 Basement Sump were sampled on August 26, 2003. The parameters analyzed include metals, ions, alkalinity, total dissolved solids, tritium, volatile organic compounds (including trihalomethanes), total organic carbon, coliform bacteria, turbidity, and the field parameters pH, temperature, and specific conductance. Based on the site hydrogeology, groundwater from these six wells is representative of the shallow groundwater beneath the NLVF.

B.1.2.2 Sample Analysis Results

Table B-3 presents the water analysis results obtained from the six wells sampled in 2002 and 2003. The water analysis results are maintained in the Bechtel Environmental Integrated Data Management System (BEIDMS) database. These studies indicate a complex hydrogeologic setting, and implicate multiple factors for the rise of the water table. The wells were drilled entirely in recent alluvial deposits consisting mainly of sand, silt and clay. The preliminary geologic interpretation of borehole data indicates that these fine-grained sediments represent a low energy, mid-valley alluvial and fluvial environment. Individual lithologic units are complexly interbedded and several normal faults have been mapped in the vicinity.

The near-surface (unconfined) water table at the NLVF was encountered in the depth range of 3.8 to 14.9 m (12.6 to 49 ft). Artesian water flow of 3.0 to 7.6 liters per minute (lpm) (0.8 to 2 gallons per minute [gpm]) was encountered at two wells. The water-table map (potentiometric surface) produced from these data shows a rather steep gradient to the southeast in the vicinity of Building A-1 (Figure B-4).

Water chemistry reveals that this water is not related to the near surface "nuisance water" commonly supplied by excessive irrigation, but is from a deeper alluvial aquifer. The hydrogeologic setting suggests that the source of this rising groundwater is water flowing upward along local faults from deeper confined aquifer(s) (Figure B-5). This condition is considered a long term adjustment that can be attributed to a combination of causes, including a seasonal water injection program and shifting of regional pumping centers away from the vicinity of the NLVF.

Figure B-2. Monitoring wells and hydrologic test wells constructed at North Las Vegas facility

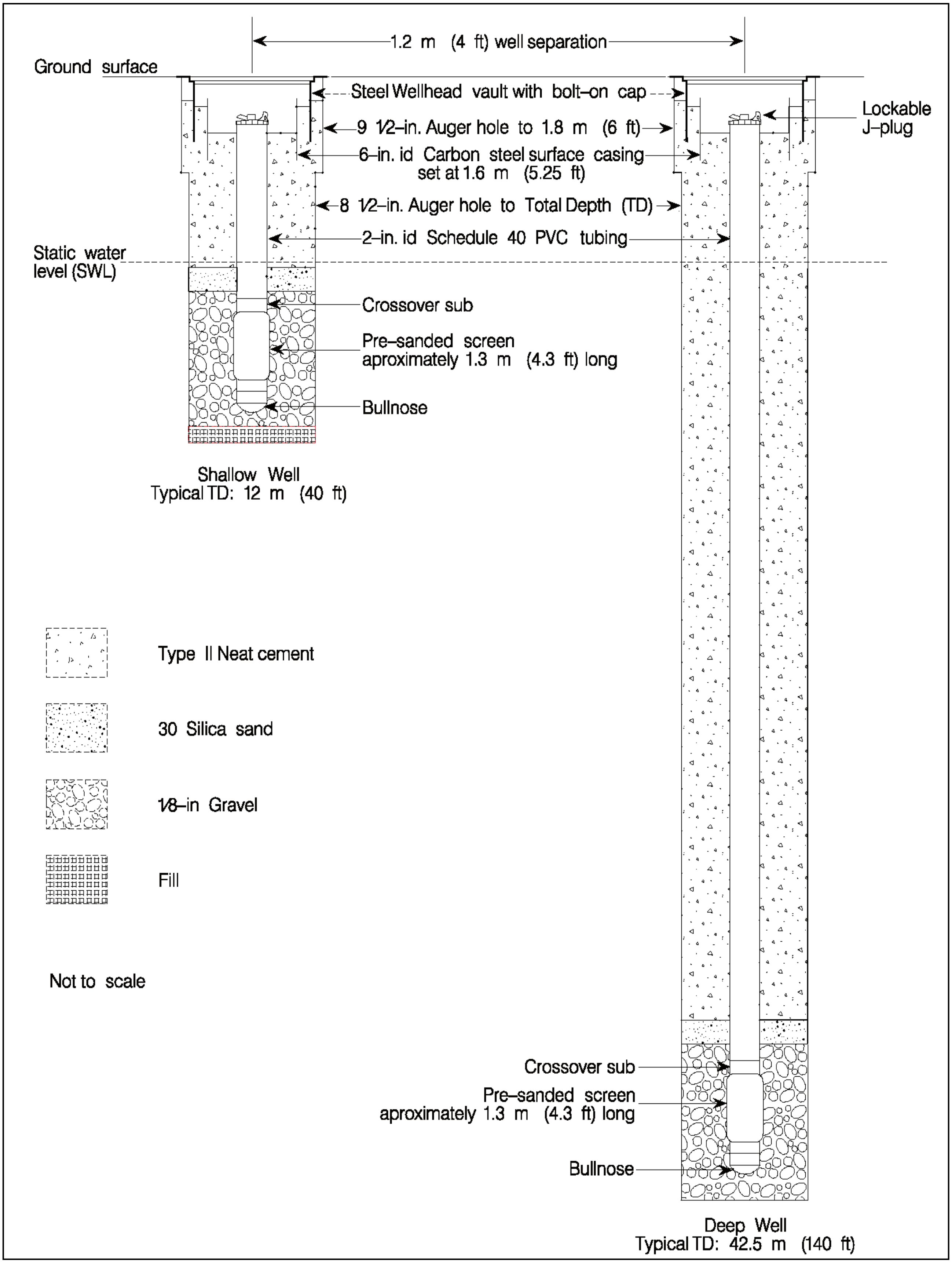

Figure B-3. Cross section through a shallow and deep well pair of a typical monitoring site at the NLVF

Table B-3. Chemical composition of water from selected NLVF wells

		NLVF Well					
Analysis/Analyte	**Units**	**NLVF-1d**	**NLVF-3d**	**NLVF-1s**	**NLVF-4d**	**NLVF-13s**	**A-1 Sump**[(a)]
Date sampled	mm/dd/yyyy	7/24/2002	7/24/2002	3/26/2003	3/26/2003	8/26/2003	8/26/2003
Depth interval[(b)]	feet	114.6-119	114.7-119	25.9-30.2	119.6-124	23.1-37.4	23.5-30.5
Aquifer (at completion)		UI[(c)]	UI	"NS"[(d)]	UI	"NS"	"NS"
Field Parameters							
pH	-	7.33	6.91	7.97	7.45	NA[(e)]	NA
Temperature	deg C[(f)]	25.6	24.7	29.2	30.4	NA	NA
Specific conductance	uS/cm[(g)]	555	305.8	382.4	481	NA	NA
Ions							
Cl	mg/L[(h)]	2.7	2.8	7.5	16.3	63.2	62.9
SO_4	mg/L	24.9	25.9	41.3	6.7	93.8	119
NH_4	mg/L	NA	NA	NA	NA	NA	NA
NO_3	mg/L	1.05	1.37	0.69/0.7	0.25	0.33	1.9
Metals							
Na	mg/L	9.34	10	11.6	19	29.7	34.3
K	mg/L	2.94	2.65	3.5	6.2	4.86	4.66
Ca	mg/L	21.8	21.1	26.8	40.8	48.6	42.6
F[(i)]	mg/L	0.28	0.26	0.28	2.9	0.31	0.27
Mg	mg/L	18.7	19.7	20.7	25.6	29.9	35.8
Alkalinity (Total)		NA	NA	NA	NA	NA	NA
Carbonate (CO_3)	mg/L	2	2	2	2	2	2
Bicarbonate (HCO_3)	mg/L	125	123	112	196	98.7	123
Residue/Filtrate (TDS)	mg/L	186	183	214	294	473	466
Turbidity	N.T.U.	0.24	ND	0.79	2.3		
TOC	mg/L	1.8	0.5	0.61	22.5	0.99	0.98
VOC	mg/L	ND[(j)]	ND	ND	ND	ND	ND
Oil & Grease	mg/L	ND	ND	ND	ND	ND	ND
Trihalomethanes (total)	mg/L	ND	ND	ND	ND	ND	ND
Coliform							
Total	% positive	absent	absent	present	present	present	absent
Fecal	# /100/mL	absent	absent	absent	absent	absent	absent
Tritium[(k)]	pCi/L[(l)]	82.8 [(m)]	38.1[(m)]	35.2/120[(m)]	68[(m)]	30.6[(m)]	1910

(a) Building A-1Basement Sump, BN, 2000.
(b) Screened interval as depth below ground level (includes 16.5 ft basement floor depth for A-1 Sump)
(c) UI – Upper intermediate aquifer
(d) "NS" Near surface aquifer
(e) degrees Centigrade
(f) microsiemens per centimeter
(g) NA – Not analyzed, or data not readily available
(h) milligrams per liter
(i) Floridation started March 2000 for the LVVWD municipal water supply
(j) ND – Not detected
(k) Analytical method = EPA 906.0
(l) picoCuries per liter
(m) Below minimum detectable concentration of 385 pCi/L

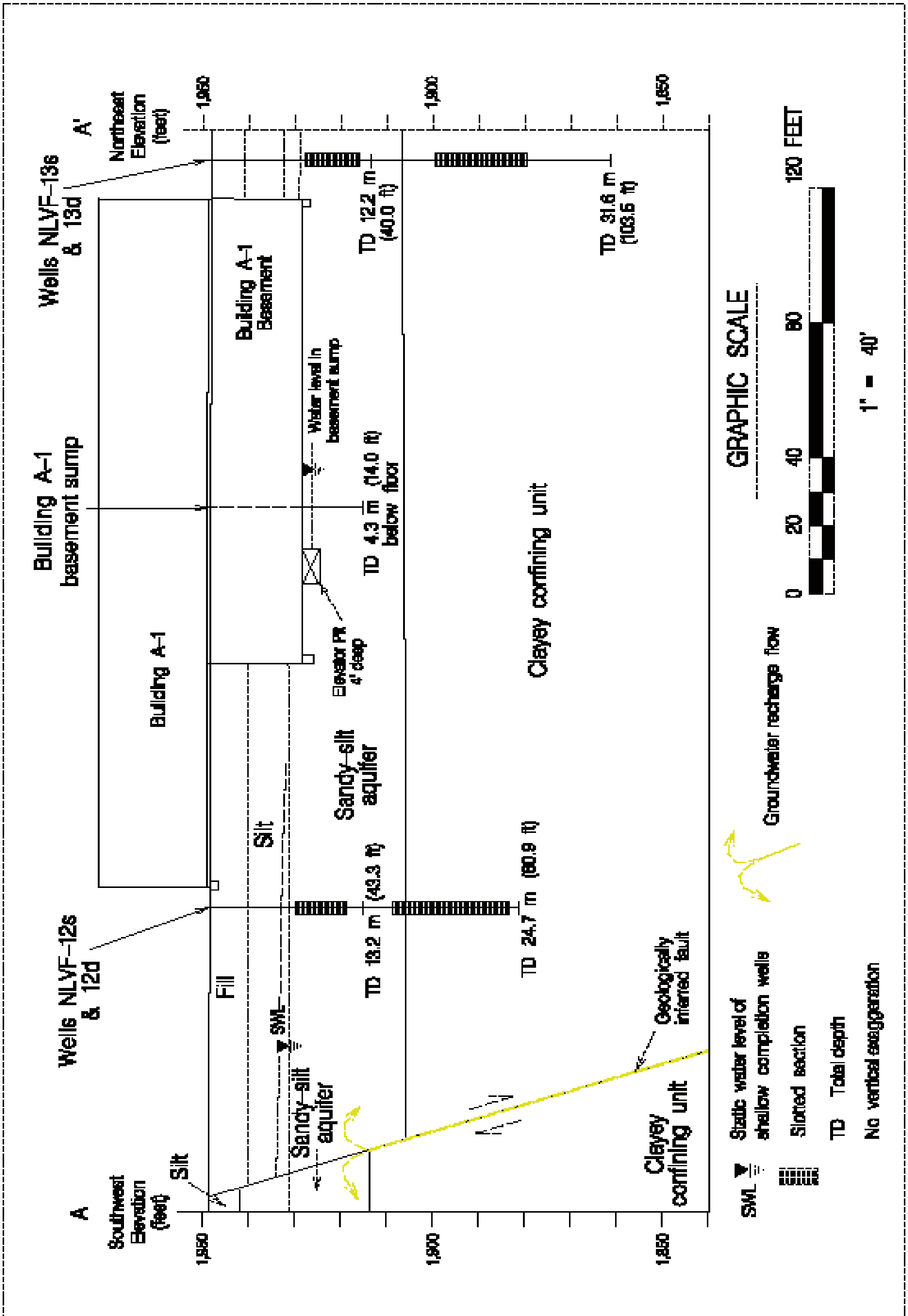

Figure B-4. Water table map of the North Las Vegas Facility

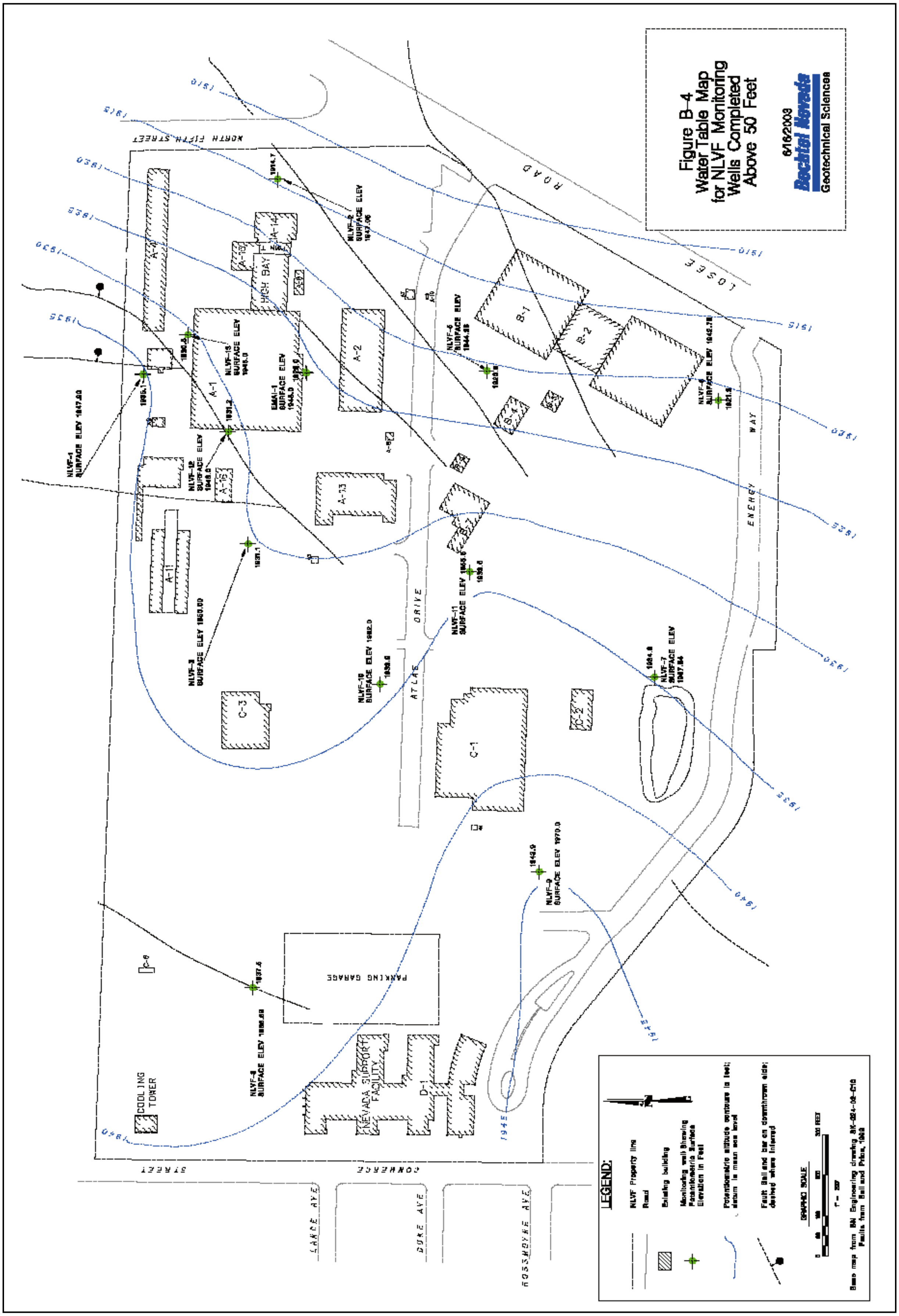

Figure B-5. Hydrogeologic setting for NLVF showing faults and aquifers

B.1.2.3 Future Work

The recommended remedial action for control of the groundwater level at the NLVF consists of converting the two shallow hydrologic testing wells installed around Building A-1 in FY 2003 into dewatering wells. The estimated pumping rate for the silty-sandy aquifer was determined to be only 3.8 to 7.6 lpm (1 to 2 gpm) per well. Pumping of the Building A-1 basement sump should continue until the dewatering wells come on-line.

In order to bring the dewatering operation on-line quickly, water initially would be disposed directly into the existing storm-water conveyance system. However, the long-range plan is to use the pumped water onsite for irrigation of landscape. Continued monitoring of water levels and water chemistry at selected wells is also planned. More detailed information regarding this project, including figures and data presentations, is reported in the summary report (BN, 2003c).

B.1.3 Compliance With Air Quality Permits

The NLVF is regulated for the emission of criteria pollutants and hazardous air pollutants (HAPs). They include sulfur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO), ozone, lead (Pb), particulate matter (PM), volatile organic compounds (VOC), and any of 189 defined HAPs. Air quality operating permits are maintained for a variety of equipment that includes: boilers, emergency generators, and a paint spray booth. There are no monitoring requirements associated with these permits. The air permits for the NLVF were issued in the mid-1980s and early 1990s through the Clark County Health District (CCHD). Permits are amended and revised only if the situation under which the permit has been issued changes. The permits have no expiration date and are renewed automatically each year upon payment of permit fees. The CCHD requires submittal of an annual emissions inventory. The estimated quantities of criteria air pollutants and HAPs emitted at the NLVF in 2003 are presented Table B-4.

Table B-4. Tons of criteria air pollutant and HAPs emissions estimated for NLVF in 2003

Facility at NLVF	Criteria Pollutant (Tons/yr)[(a)]					HAPs (Tons/yr)
	CO	NO_x	PM	SO_2	VOC	
Atlas Facility	0.076	0.285	0.009	0.005	0.008	0.00011
Losee Facility	0.068	0.317	0.022	0.021	0.026	0.0005
Nevada Support Facility	0.029	0.107	0.003	0.002	0.003	0.0001
Total	**0.173**	**0.709**	**0.034**	**0.028**	**0.037**	**0.0012**

(a) 1 ton equals 0.91 metric tons

B.1.4 Compliance with Hazardous Materials Regulations

In 2003, the chemical inventory at all NTS facilities was updated and submitted to the state in the Nevada Combined Agency (NCA) Report on March 5, 2004 as per the requirements of the Hazardous Materials Permit 2287-5144 (see Section 9.2.3 of this Nevada Test Site Environmental Report (NTSER) for description of content, purpose, and federal regulatory driver behind the NCA Report). No extremely hazardous substance (EHS) was present at the NLVF in quantities that were reportable to the state. No accidental or unplanned release of an EHS occurred at the NLVF in 2003.

B.1.5 Radiation Protection Regulations

DOE Order 5400.5, "Radiation Protection of the Public and the Environment" specifies that the radiological dose to a member of the public from external radiation must not exceed the 100 mrem/yr as a result of DOE activities. The facilities at NLVF which use radioactive sources or radiation producing equipment which have the potential to expose the general population or non-project personnel to direct radiation, are the Atlas A-1 Source Range and the Building

C-3 x-ray radiography operation. BN's Environmental Technical Services (ETS) conducts direct radiation monitoring at the site. ETS utilizes environmental dosimeters (thermoluminescent dosimeters [TLDs]) to monitor external gamma radiation exposure near the boundaries of these NLVF facilitities. The methods of TLD use and data analyses are described in Section 4.0 of this NTSER.

In 2003, two TLD stations were placed along the perimeter fence and one was placed in a control location. The resultant annual exposure rates estimated for those NLVF locations potentially accessible to the public are summarized in Table B-5. These exposures were all less than the 100 mrem/yr dose limit.

Table B-5. Results of 2003 direct radiation exposure monitoring at NLVF

		Gamma Exposure (mR/yr)				
Location	**Number of Samples**	**Mean**	**Median**	**Standard Deviation**	**Minimum**	**Maximum**
Control						76
North Fence of A-1	4	63	64	4	57	68
North Fence of Bldg C-3	4	64	64	5	57	72

B.2 Cheyenne Las Vegas Facility

The CLVF Facility is located at the Flynn Gallagher Corporate Center on West Cheyenne Avenue in northwest Las Vegas. It is comprised of five buildings which house engineering, procurement, and administrative functions. Access to the facility requires proper identification, badging, and a security access card. Facility and infrastructure maintenance is provided by the facility owner. No environmental monitoring or compliance activities are conducted at or for this facility.

B.3 Remote Sensing Laboratory

The RSL is approximately 13.7 km (8.5 mi) northeast of the Las Vegas city center, and approximately 11.3 km (7 mi) northeast of the NLV Facility. It occupies six facilities on approximately 14 secured hectares (35 acres) at the Nellis Air Force Base. The six NNSA/NSO facilities were constructed on property owned by the U.S. Air Force. There is a Memorandum of Agreement between the U.S. Air Force and the NNSA whereby the land belongs to the Air Force, but is under lease to the NNSA for 25 years (as of 1989) with an option for a 25-year extension. The facilities are owned by NNSA/NSO. The RSL provides emergency response resources for weapons-of-mass-destruction incidents. The laboratory also designs and field tests counter-terrorism/intelligence technologies and has the capability to assess environmental and facility conditions using complex radiation measurements and multi-spectral imaging technologies.

Environmental compliance and monitoring activities associated with this facility include maintenance of a wastewater contribution permit, six air quality permits, and a hazardous materials permit (Table B-6). Although sealed radiation sources are used for calibration at RSL, the public has no access to any area which may have elevated gamma radiation emitted by the sources. Therefore, no environmental TLD monitoring is conducted, only dosimetry monitoring to ensure protection of personnel who work within the facility.

Table B-6. Environmental permits for RSL

Permit Number	Description	Expiration Date	Reporting
Wastewater Discharge			
CCWRD-080	Industrial Wastewater Discharge Permit	June 30, 2005	March, May, September, December
Air Quality			
A34801	Boiler, Columbia, WL-180	None	March, June
A34802	Boiler, Columbia, WL-90	None	March, June
A34803	Water Heater, #2 Natl. BD	None	March, June
A34804(a)	Emergency Fire Control Pump Engine	None	June
A34804(b)	Emergency Generator, Cummins	None	June
A34805	Spray Paint Booth	None	June
Hazardous Materials			
2287-5144	NLVF Hazardous Materials Permit	February 28, 2004	Annually

B.3.1 Compliance with Wastewater Contribution Permit CCWRD-080

Discharges of wastewater from the RSL are required to meet permit limits set by the Clark County Water Reclamation District (CCWRD). These limits support the permit limits for the POTW operated by Clark County. The wastewater permit for this facility requires quarterly monitoring and reporting. Table B-7 presents the mean concentration of outfall measurements collected once per quarter in 2003. All contaminants in the outfall samples fell below permit limits. CCWRD also conducted two inspections of RSL in 2003. The inspections resulted in no findings or corrective actions for the facility.

Table B-7. Mean concentration of outfall measurements at RSL

Contaminant/Measure	Permit Limit	Outfall
	mg/L	
Ammonia	NL[(a)]	11.85
Cadmium	0.35	0.00236
Chromium (Total)	1.7	0.0023
Copper	3.36	0.208
Cyanide (Total)	1	0.033
Lead	0.99	0.0029
Nickel	10.08	0.0051
Phosphorus	NL	7.2
Silver	6.3	0.0256
TDS	NL	1143
TSS	NL	90.9
Zinc	23.06	0.425

Table B-7. (continued)

Contaminant/Measure	Permit Limit	Outfall
	Standard Units	
pH	5.0 – 11.0	8.05
	Degree Fahrenheit	
Temperature	140	60

(a) No limit listed on permit

B.3.2 Compliance with Air Quality Permits

The RSL is regulated for the emission of criteria pollutants and HAPs. Air quality operating permits are maintained for a variety of equipment (see Table B-6). There are no monitoring requirements associated with these permits. The air permits for RSL were issued in the mid-80's and early 90's through the CCHD. Permits are amended and revised only if the situation under which the permit has been issued changes. The permits have no expiration date and are renewed automatically each year upon payment of permit fees. The CCHD requires submittal of the annual emissions inventory (Table B-8).

Table B-8. Summary of Air Emissions for RSL-Nellis

Criteria Pollutant (Tons/yr)[a]					HAPs (Tons/yr)	Natural Gas Consumption (ft^3)
CO	NO_x	PM	SO_2	VOC		
0.271	0.494	0.031	0.01	0.026	0.0005	5,025,100

(a) 1 ton equals 0.91 metric tons

B.3.3 Compliance with Hazardous Materials Regulations

In 2003, the chemical inventory at all NTS facilities was updated and submitted to the state in the Nevada Combined Agency (NCA) Report on March 5, 2004 as per the requirements of the Hazardous Materials Permit 2287-5145 (see Section 9.2.3 of this NTSER for description of content, purpose, and federal regulatory driver behind the NCA Report). No extremely hazardous substance (EHS) was present at the RSL in quantities that were reportable to the state. No accidental or unplanned release of an EHS occurred at the RSL in 2003.

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Appendix C
Helpful Information

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Appendix C: Helpful Information

C.1 Scientific Notation

Scientific notation is used in this report to express very large or very small numbers. A very small number is expressed with a negative exponent, for example 2.0 x 10^{-5}. To convert this number from scientific notation to a more traditional number, the decimal point must be moved left by the number of places equal to the exponent (5 in this case). The number thus becomes 0.00002.

Very large numbers are expressed in scientific notation with a positive exponent. The decimal point should be moved to the right by the number of places equal to the exponent. The number 1,000,000,000 could be presented in scientific notation as 1.0 x 10^{9}.

C.2 Unit Prefixes

Units for very small and very large numbers are commonly expressed with a prefix. The prefix signifies the amount of the given unit. For example the prefix k, or kilo-, means 1,000 of a given unit. Thus 1 kg (kilogram) is 1,000 g (grams). Other prefixes used in this report are listed in Table C-1.

Table C-1. Unit prefixes

Prefix	Abbreviation	Meaning
mega-	M	1,000,000 (1 x 10^{6})
kilo-	k	1,000 (1 x 10^{3})
centi-	c	0.01 (1 x 10^{-2})
milli-	m	0.001 (1 x 10^{-3})
micro-	μ	0.000001 (1 x 10^{-6})
nano-	n	0.000,000,1 (1 x 10^{-9})
pico-	p	0.000,000,000,0001 (1 x 10^{-12})

C.3 Units of Radioactivity

Much of this report deals with levels of radioactivity in various environmental media. The basic unit of radioactivity used in this report is the curie (Ci) (Table C-2). The curie describes the amount of radioactivity present, and amounts are usually expressed in terms of fractions of curies in a given mass or volume (e.g., picocuries per liter). The curie is historically defined as the number of nuclear disintegrations that occur in 1 gram of the radionuclide radium-226, which are 37 billion nuclear disintegrations per second. For any other radionuclide, 1 Ci is the quantity of the radionuclide that decays at this same rate. Nuclear disintegrations produce spontaneous emissions of alpha or beta particles, gamma radiation, or combinations of these.

Table C-2. Units of radioactivity

Symbol	Name
Ci	curie
cpm	counts per minute
mCi	millicurie (1 x 10^{-3} Ci)
μCi	microcurie (1 x 10^{-6} Ci)
nCi	nanocurie (1 x 10^{-9} Ci)
pCi	picocurie (1 x 10^{-12} Ci)
aCi	attocurie (1 x 10^{-18} Ci)

C.4 Radiological Dose Units

The amount of ionizing radiation energy absorbed by a living organism is expressed in terms of radiological dose. Radiological dose in this report is usually written in terms of effective dose equivalent and reported numerically in units of millirem (mrem) (Table C-3). Millirem is a term that relates ionizing radiation to biological effect or risk to humans. A dose of 1 mrem has a biological effect similar to the dose received from an approximate 1-day exposure to natural background radiation. An acute (short-term) dose of 100,000 to 400,000 mrem can cause radiation sickness in humans. An acute dose of 400,000 to 500,000 mrem, if left untreated, results in death approximately 50 percent of the time. Exposure to lower amounts of radiation (1,000 mrem or less) produces no immediate observable effects, but long-term (delayed) effects are possible. The average person in the United States receives an annual dose of approximately 300 mrem from exposure to naturally produced radiation. Medical and dental x-rays and air travel add to this total.

Table C-3. Units of radiological dose

Symbol	Name
mrad	millirad (1 x 10^{-3} rad)
mrem	millirem (1 x 10^{-3} rem)
R	roentgen
mR	milliroentgen (1 x 10^{-3} R)
μR	microroentgen (1 x 10^{-6} R)

The unit "rad," for radiation absorbed dose, is also used in this report. The rad is a measure of the energy absorbed by any material, whereas a rem relates to both the amount of radiation energy absorbed by humans and its consequence. A roentgen (R) is a measure of radiation exposure. Generally speaking, one roentgen of exposure will result in an effective dose equivalent of 1 rem.

Additional information on radiation and dose terminology can be found in the Glossary (Appendix D). A list of the radionuclides discussed in this report, their symbols, and their half-lives are presented in the box below.

C.5 International System of Units for Radioactivity and Dose

In some instances in this report, radioactivity and radiological dose values are expressed in other units in addition to Ci and mrem. These units are the Becquerel (Bq) and the millisievert (mSv), respectively. The Bq and Sv belong to the International System of Units (SI), and their inclusion in this report is mandated by U.S. Department of Energy. SI units are the internationally accepted units and may eventually be the standard for reporting both radioactivity and radiation dose in the United States. One Bq is equivalent to one nuclear disintegration per second.

Table C-4. Conversion table for SI units

To Convert From	To	Multiply by
becquerel (Bq)	pCi	37
Curie (Ci)	Becquerel (Bq)	3.7 x 10⁹
gray (Gy)	Rad	100
mrem	msievert (mSv)	0.01
msievert (mSv)	Mrem	100
picocurie (pCi)	becquerel (Bq)	0.03704
rad	gray (Gy)	0.01
sievert (Sv)	rem	100

The unit of radiation absorbed dose (rad) has a corresponding SI unit called the gray (Gy). The roentgen measure of radiation exposure has no SI equivalent. Table C-4 provides the multiplication factors for converting to and from SI units.

C.6 Radionuclide Nomenclature

Radionuclides are frequently expressed with the one- or two-letter chemical symbol for the element. Radionuclides may have many different isotopes, which are shown by a superscript to the left of the symbol. This number is the atomic weight of the isotope (the number of protons and neutrons in the nucleus of the atom). Radionuclide symbols used in this report are shown in Table C-5 along with the half-life of each radionuclide. The half-life is the time required for one-half the radioactive atoms in a given amount of material to decay. For example, after one half-life, half of the original atoms will have decayed; after two half-lives, three-fourths of the original atoms will have decayed; and after three half-lives, seven-eighths of the original atoms will have decayed, and so on.

Table C-5. Radionuclides and their half-lives

Symbol	Radionuclide	Half-Life [(a)]	Symbol	Radionuclide	Half-Life [(a)]
^{241}Am	americium-241	432.2 yr	^{240}Pu	plutonium-240	6.5 x 10^3 yr
^{7}Be	beryllium-7	53.44 d	^{241}Pu	plutonium-241	14.4 yr
^{14}C	carbon-14	5,730 yr	$^{236+238}$Ra	radium-236+238	1.62 x 10^3 yr
^{134}Cs	cesium-134	2.1 yr	^{220}Rn	radon-220	56 s
^{137}Cs	cesium-137	30 yr	^{222}Rn	radon-222	3.8 d
^{51}Cr	chromium-51	27.7 d	^{103}Ru	ruthenum-103	39.3 d
^{60}Co	cobalt-60	5.3 yr	^{106}Ru	ruthenum-106	368.2 d
^{152}Eu	europium-152	13.3 yr	^{125}Sb	antimony-125	2.8 yr
^{154}Eu	europium-154	8.8 yr	^{113}Sn	tin-113	115 d
^{155}Eu	europium-155	5 yr	^{90}Sr	strontium-90	29.1 yr
^{3}H	tritium	12.35 yr	^{99}Tc	technetium-99	2.1 x 10^5 yr
^{129}I	iodine-129	1.6 x 10^7 yr	^{232}Th	thorium=131	1.4 x 10^{10} yr
^{131}I	iodine-131	8 d	U [(b)]	uranium total	- - - [(c)]
^{40}K	potassium-40	1.3 x 10^8yr	^{234}U	uranium-234	2.4 x 10^5 yr
^{85}Kr	krypton-85	10^7 yr	^{235}U	uranium-235	7 x 10^8 hr
^{212}Pb	lead-212	10.6 h	^{238}U	uranium-238	4.5 x 10^9 yr
^{238}Pu	plutonium-238	87.7 hr	^{65}Zn	zinc-65	243.9 d
^{239}Pu	plutonium-239	2.4 x 10^4 yr	^{95}Zr	zirconium-95	63.98 d

(a) From Shleien 1992.
(b) Total uranium may also be indicated by U-natural (U-nat) or U-mass.
(c) Natural uranium is a mixture dominated by ^{238}U, thus the half-life is approximately 4.5 x 10^9 years.

C.7 Units of Measurement

Both metric and non-metric units of measurement are used in this report. Metric system and U.S. customary units and their respective equivalents are shown in Table C-6.

Table C-6. Metric and U.S. customary unit equivalents

Metric unit	U.S. customary equivalent unit	U.S. customary unit	Metric equivalent unit
Length			
1 centimeter (cm)	0.39 inches (in)	1 inch (in)	2.54 centimeters (cm)
1 millimeter (mm)	0.039 inches (in)		25.4 millimeters (mm)
1 meter (m)	3.28 feet (ft)	1 foot (ft)	0.3048 meters (m)
	1.09 yards (yd)	1 yard (yd)	0.9144 meters (m)
1 kilometer (km)	0.62 miles (mi)	1 mile (mi)	1.6093 kilometers (km)
Volume			
1 liter (L)	0.26 gallons (gal)	1 gallon (gal)	3.7853 liters (L)
1 cubic meter (m3)	35.32 cubic feet (ft3)	1 cubic foot (ft3)	0.028 cubic meters (m3)
	1.35 cubic yards (yd3)	1 cubic yard (yd3)	0.765 cubic meters (m3)
Weight			
1 gram (g)	0.035 ounces (oz)	1 ounce (oz)	28.6 gram (g)
1 kilogram (kg)	2.21 pounds (lb)	1 pound (lb)	0.373 kilograms (kg)
1 metric ton (mton)	1.10 short ton (2000 pounds)	1 short ton (2000 pounds)	0.90718 metric ton (mton)
Geographic area			
1 hectare	2.47 acres	1 acre	0.40 hectares
Radioactivity			
1 becquerel (Bq)	2.7 x 10–11 curie (Ci)	1 curie (Ci)	3.7 x 10–10 becquerel (Bq)
Radiation dose			
1 rem	0.01 sievert (Sv)	1 sievert (Sv)	100 rem
Temperature			
°C = (°F–32)/1.8		°F = (°C x1.8) + 32	

C.8 Chemical and Elemental Nomenclature

The chemical contaminants discussed in this report are listed in Table C-7 along with their chemical (or elemental) names and their corresponding symbols.

Table C-7. Elemental and chemical constituent nomenclature

Symbol	Constituent	Symbol	Constituent	Symbol	Constituent	Symbol	Constituent
Ag	silver	$CHCI_3$	trichloromethane	K	potassium	Pb	lead
Al	aluminum	Cl^-	chloride	LiF	lithium fluoride	PO_4^{-3}	phosphate
As	arsenic	CN^-	cyanide	Mg	magnesium	P	phosphorus
B	boron	Cr^{+6}	chromium (species)	Mn	manganese	Sb	antimony
Ba	barium	Cr	chromium (total)	Mo	molybdenum	Se	selenium
Be	beryllium	CO_3^{-2}	carbonate	NH_3	ammonia	Si	silicon
Br	bromine	Co	cobalt	NH_4^+	ammonium	Sr	strontium
C	carbon	Cu	copper	N	nitrogen	SO_4^{-2}	sulfate
Ca	calcium	F	fluoride	Na	sodium	Ti	titanium
CaF_2	calcium fluoride	Fe	iron	Ni	nickel	TI	thallium
CCI_4	carbon tetrachloride	HCO_3	bicarbonate	NO_2^-	nitrite	V	vanadium
Cd	cadmium	Hg	mercury	NO_3^-	nitrate		

C.9 Uncertainty of Measurements

There is always uncertainty associated with the measurement of environmental contaminants. For radioactivity, a major source of uncertainty is the inherent randomness of radioactive decay events.

Uncertainty in analytical measurements is also the consequence of a series of minor, often unintentional or unavoidable, inaccuracies related to collecting and analyzing the samples. These inaccuracies could include errors associated with reading or recording the result, handling or processing the sample, calibrating the counting instrument, and numerical rounding.

The uncertainty of a measurement is denoted by following the result with an uncertainty value which is preceded by the plus-or-minus symbol, ±. This uncertainty value gives information on what the measurement might be if the same sample were analyzed again under identical conditions. The uncertainty value implies that approximately 95 percent of the time a recount or reanalysis of the same sample would give a value somewhere between the reported value minus the uncertainty value and the reported value plus the uncertainty value.

If the reported concentration of a given constituent is smaller than its associated uncertainty (e.g., 40 ± 200), the sample may not contain that constituent. Such low concentration values are considered to be below detection, meaning the concentration of the constituent in the sample is so low that it is undetected by the method and/or instrument.

C.10 Standard Error of the Mean

Just as individual values are accompanied by counting uncertainties, mean values (averages) are accompanied by uncertainty, known as the standard error of the mean (SE). The SE conveys how accurate of an estimate the mean value is based on the samples that were collected and analyzed. The ± value presented to the right of a mean value isequal to 2 x SE (2 multiplied by the SE). The ± value implies that approximately 95 percent of the time the next calculated mean will fall somewhere between the reported value minus the 2 x SE value and the reported value plus the 2 x SE value.

C.11 Median, Maximum, and Minimum Values

Median, maximum, and minimum values are reported in some sections of this report. A median value is the middle value when all the values are arranged in order of increasing or decreasing magnitude. For example, the median value in the series of numbers, 1 2 3 3 4 5 5 5 6, is 4. The maximum value would be 6 and the minimum value would be 1. Maximum, minimum, and median values are reported when there are too few analytical results to accurately determine the average with a ± statistical uncertainty.

C.12 Negative Radionuclide Concentrations

There is always a small amount of natural radiation in the environment. The instruments used in the laboratory to measure radioactivity in environmental media are sensitive enough to measure the natural, or background, radiation along with any contaminant radiation in a sample. To obtain a true measure of the contaminant level in a sample, the natural, or background, radiation level must be subtracted from the total amount of radioactivity measured by an instrument. Because of the randomness of radioactive emissions, and the very low concentrations of some contaminants, it is possible to obtain a background measurement that is larger than the actual contaminant measurement. When the larger background measurement is subtracted from the smaller contaminant measurement, a negative result is generated. The negative results are reported because they are essential when conducting statistical evaluations of the data.

C.13 Understanding Graphic Information

Graphs are useful when comparing numbers collected at several locations or at one location over time. Graphs make it easy to visualize differences in data where they exist. However, they may also lead to incorrect conclusions if they are not read correctly. The reader must consider the scale (linear or logarithmic), concentration units, and type of uncertainty used in graphs.

Some of the data graphed in this report are plotted using logarithmic, or compressed, scales. Logarithmic scales are useful when plotting two or more numbers that differ greatly in size. For example, a sample with a concentration of 5 grams per liter (g/L) would get lost at the bottom of the graph if plotted on a linear scale with a sample having a concentration of 1,000 g/L (Figure C-1). A logarithmic plot of these same two numbers allows the reader to see both data points clearly (Figure C-2).

The mean (average) and median (defined earlier) values graphed in this report have vertical lines extending above and below the data point. When used with a mean value, these lines (called error bars) indicate the amount of uncertainty in the reported result. The error bars in this report represent a 95 percent chance that the true mean is between the upper and lower ends of the error bar and a 5 percent chance that the true mean is either lower or higher than the error bar (this assumes the Normal statistical distribution of the data). For example, in Figure C-3, the first plotted mean is 2.0 ± 1.1, so there is a 95 percent chance that the true mean is between 0.9 and 3.1, a 2.5 percent chance that it is less than 0.9, and a 2.5 percent chance that it is greater than 3.1. Error bars are computed statistically, employing all of the information used to generate the mean value. These bars provide a quick, visual indication that one mean may be statistically similar to or different from another mean. If the error bars of two or more means overlap, as is the case with means 1 and 3 and means 2 and 3, the means may be statistically similar. If the error bars do not overlap (means 1 and 2), the means may be statistically different. Means that appear to be different visually (means 2 and 3) may actually be similar when compared statistically, and these means are said to be "not statistically (or significantly) different from one another".

When vertical lines are used with median values, the lower end of each bar represents the minimum concentration measured; the upper end of each bar represents the maximum concentration measured.

Figure C-1. Data plotted using a linear scale

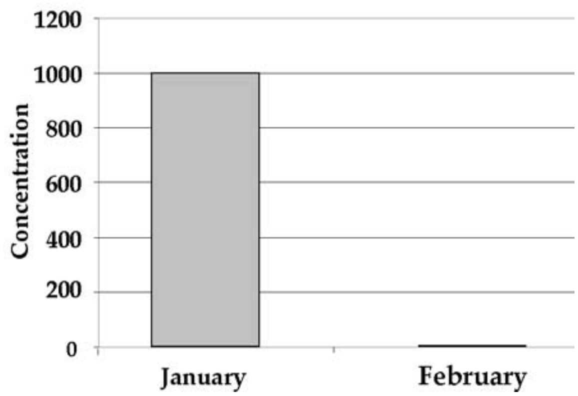


Figure C-2. Data plotted using a logarithmic scale

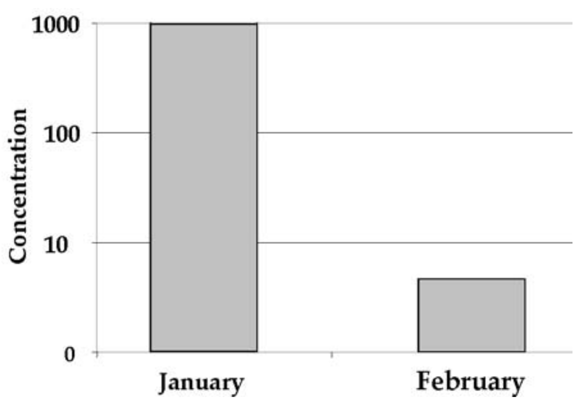
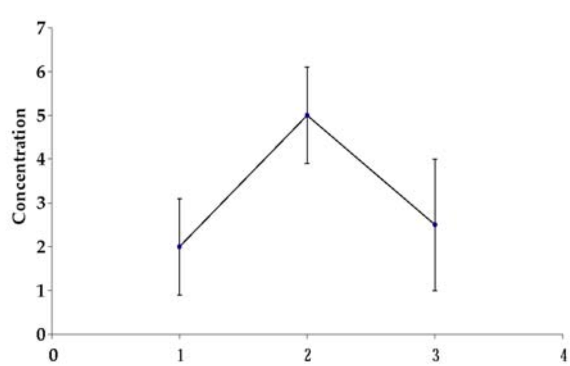


Figure C-3. Data with error bars plotted using a linear scale



Appendix D: Glossary

A **Absorbed dose:** the amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material, in which the absorbed dose is expressed in units of rad or gray (l rad = 0.01 gray)

Accuracy: the closeness of the result of a measurement to the true value of the quantity measured

Action level: defined by regulatory agencies, the level of pollutants which, if exceeded, requires regulatory action

Aerosol: a gaseous suspension of very small particles of liquid or solid

Alluvium: sediment deposited by flowing water

Alpha particle: a positively charged particle emitted from the nucleus of an atom, having mass and charge equal to those of a helium nucleus (two protons and two neutrons), usually emitted by transuranic elements

Ambient air: the surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures; not considered in monitoring purposes when immediately adjacent to emission sources

Analysis of variance (ANOVA): a test of whether two or more sample means are statistically different

Analyte: the specific component measured in a chemical analysis

Anion: a negatively charged ion, such as Cl^-

Aquifer: a saturated layer of rock or soil below the ground surface that can supply usable quantities of ground water to wells and springs, and be a source of water for domestic, agricultural, and industrial uses

Aquitard: low-permeability geologic formation that bounds an aquifer

Atom: the smallest particle of an element capable of entering into a chemical reaction

Atomic absorption (AA) spectroscopy: a method used to determine the elemental composition of a sample, where the sample is vaporized and its light absorbance measured

B **Background:** as used in this report, background is the term for the amounts of chemical constituents or radioactivity in the environment which are not caused by NTS operations

Barcad: device that samples water in a well in which water, collected in a discrete water-bearing zone, is forced to the surface by pressurized nitrogen

Becquerel (Bq): the SI unit of activity of a radionuclide, equal to the activity of a radionuclide having one spontaneous nuclear transition per second

Beta particle: a negatively charged particle emitted from the nucleus of an atom, having charge, mass, and other properties of an electron, emitted from fission products such as Cs-137

Biochemical (biological) oxygen demand (BOD): a measure of the amount of dissolved oxygen that microorganisms need to break down organic matter in water, used as an indicator of water quality

Blowdown: water discharged from cooling towers in order to control total dissolved solids concentrations by allowing make-up water to replenish cooling apparatuses

C **CAP88-PC:** computer code required by the EPA for modeling air emissions of radionuclides

Categorical discharge: discharge from a process regulated by EPA rules for specific industrial categories

Chain-of-custody: a method for documenting the history and possession of a sample from the time of its collection, through its analysis and data reporting, to its final disposition

Chlorofluorocarbon (CFC): a compound that has fluorine and chlorine atoms on a carbon backbone, such as Freons

Chlorocarbon: a compound of carbon and chlorine, or carbon, hydrogen, and chlorine, such as carbon tetrachloride, chloroform, and tetrachloroethene

Code of Federal Regulations (CFR): a codification of all regulations promulgated by federal government agencies

Collective population dose: the sums of the dose equivalents or effective dose equivalents to all individuals in an exposed population within 80 km (50 mi) of the radiation source. These are evaluated by multiplying the dose received by an individual at each location by the number of individuals receiving that dose, and summing over all such products for locations within 80 km of the source. They are expressed in units of person-rem or person-sievert. The collective EDE is also referred to as the "population dose."

Committed dose equivalent: the dose equivalent to a tissue or organ over a 50-year period after an intake of a radionuclide into the body. Committed dose equivalent is expressed in units of rem (or sievert; 100 rem equals one sievert).

Committed effective dose equivalent: the sum of the committed dose equivalents to various tissues in the body, each multiplied by an appropriate weighting factor representing the relative vulnerability of different parts of the body to radiation. Committed effective dose equivalent is expressed in units of rem or sievert.

Compliance Level (CL): stands for the Clean Air Act National Emission Standards for Hazardous Air Pollutants Concentration Level for Environmental Compliance. The CL value represents the annual average concentration which would result in a dose of 10 mrem/yr which is the federal dose limit to the public from all radioactive air emissions.

Cosmic radiation: radiation with very high energies originating outside the earth's atmosphere; it is one source contributing to natural background radiation

Criteria pollutants: those air pollutants designated by the Environmental Protection Agency as potentially harmful and for which National Ambient Air Quality Standards (NAAQS) under the Clean Air Act have been established to protect the public health and welfare. These pollutants include sulfur dioxide, nitrogen oxides, carbon monoxide, volatile organic compounds, lead, and particulate matter.

Curie (Ci): a unit of measurement of radioactivity, defined as the amount of radioactive material in which the decay rate is 3.7×10^{10} disintegrations per second or 2.22×10^{12} disintegrations per minute; one Ci is approximately equal to the decay rate of one gram of pure radium

D **Daughter nuclide:** a nuclide formed by the radioactive decay of another nuclide, which is called the parent

Decision Level: the counts of radioactivity (or concentration level of a radionuclide) in a sample that must be exceeded before there is a 95 percent confidence that the sample contains radioactive material above the background.

Depleted uranium: uranium having a lower proportion of the isotope ^{235}U than is found in naturally occurring uranium. The masses of the three uranium isotopes with atomic weights 238, 235, and 234 occur in depleted uranium in the weight-percentages 99.8, 0.2, and 5×10^{-4}, respectively. Depleted uranium is sometimes referred to as D-38.

Derived Concentration Guide (DCG): concentrations of radionuclides in water and air that could be continuously consumed or inhaled for one year and not exceed the DOE primary radiation standard to the public (100 mrem/y EDE)

Dose: the energy imparted to matter by ionizing radiation; the unit of absorbed dose is the rad, equal to 0.01 joules per kilogram for irradiated material in any medium

Dose commitment: the dose that an organ or tissue would receive during a specified period of time (e.g., 50 or 70 years) as a result of one year's intake of one or more radionuclides

Dose equivalent: the product of absorbed dose in rad (or gray) in tissue and a quality factor representing the relative damage caused to living tissue by different kinds of radiation, and perhaps other modifying factors representing the distribution of radiation, etc. expressed in units of rem or sievert (l rem = 0.01 sievert)

Dosimeter: a portable detection device for measuring the total accumulated exposure to ionizing radiation

Dosimetry: the theory and application of the principles and techniques of measuring and recording radiation doses

Downgradient: in the direction of groundwater flow from a designated area; analogous to downstream

E **Effective dose equivalent (EDE):** an estimate of the total risk of potential effects from radiation exposure, it is the summation of the products of the dose equivalent and weighting factor for each tissue. The weighting factor is the decimal fraction of the risk arising from irradiation of a selected tissue to the total risk when the whole body is irradiated uniformly to the same dose equivalent. These factors permit dose equivalents from nonuniform exposure of the body to be expressed in terms of an effective dose equivalent that is numerically equal to the dose from a uniform exposure of the whole body that entails the same risk as the internal exposure (ICRP 1980). The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent caused by penetrating radiation from sources external to the body, and is expressed in units of rem (or sievert).

Effluent: used in this report to refer to a liquid discharged to the environment

Emission: used in this report to refer to a vapor, gas, air-borne particulate, or radiation discharged to the environment via the air

Environmental impact statement (EIS): a detailed report, required by the National Environmental Policy Act, on the environmental impacts from a federally approved or funded project. An EIS must be prepared by a federal agency when a "major" federal action that will have "significant" environmental impacts is planned.

F **Federal facility:** a facility that is owned or operated by the federal government, subject to the same requirements as other responsible parties when placed on the Superfund National Priorities List

Federal facility agreement (FFA): a negotiated agreement that specifies required actions at a federal facility as agreed upon by various agencies (e.g., EPA, DOE, DoD)

Federal Register: a document published daily by the federal government containing notification of government agency actions, including notification of EPA and DOE decisions concerning permit applications and rule-making

Fiscal year: NNSA/NSO's fiscal year is from October 1 through September 30

Freon 11: trichlorofluoromethane

Freon 113: 1,1,2-trichloro-1,2,2-trifluoroethane; also known as CFC 113

G **Gamma ray:** high-energy, short-wavelength, electromagnetic radiation emitted from the nucleus of an atom, frequently accompanying the emission of alpha or beta particles

Gray (Gy): the SI unit of measure for absorbed dose; the quantity of energy imparted by ionizing radiation to a unit mass of matter, such as tissue. One gray equals 100 rads, or 1 joule per kilogram.

Gross alpha: the measure of radioactivity caused by all radionuclides present in a sample which emit alpha particles. Gross alpha measurements reflect alpha activity from all sources, including those that occur naturally. Gross measurements are used as a method to screen samples for relative levels of radioactivity.

Gross beta: the measure of radioactivity caused by all radionuclides present in a sample which emit beta particles. Gross beta measurements reflect beta activity from all sources, including those that occur naturally. Gross measurements are used as a method to screen samples for relative levels of radioactivity.

Groundwater: all subsurface water

H **Half-life (radiological):** the time required for one-half the radioactive atoms in a given amount of material to decay; for example, after one half-life, half of the atoms will have decayed; after two halflives, three-fourths; after three half-lives, seven-eighths; and so on, exponentially

Hazardous waste: hazardous wastes exhibit any of the following characteristics: ignitability, corrosivity, reactivity, or EP-toxicity (yielding toxic constituents in a leaching test), but other wastes that do not necessarily exhibit these characteristics have been determined to be hazardous by EPA. Although the legal definition of hazardous waste is complex, according to EPA the term generally refers to any waste that, if managed improperly, could pose a threat to human health and the environment.

High-efficiency particulate air filter (HEPA): a throwaway, extended-media, dry type filter used to capture particulates in an air stream; HEPA collection efficiencies are at least 99.97% for 0.3 micrometer diameter particles

High explosives (HE): materials that release large amounts of chemical energy when detonated

Hydraulic gradient: in an aquifer, the rate of change of total head (water-level elevation) per unit distance of flow at a given point and in a given direction

Hydrology: the science dealing with the properties, distribution, and circulation of natural water systems

I **Inorganic compounds:** compounds that either do not contain carbon or do not contain hydrogen along with carbon, including metals, salts, and various carbon oxides (e.g., carbon monoxide and carbon dioxide)

In situ: in the natural or original position. Generally refers to measurements taken in the environment or to the treatment of contaminated areas in place without excavation or removal.

Interim status: a legal classification allowing hazardous waste incinerators or other hazardous waste management facilities to operate while EPA considers their permit applications, provided that they were under construction or in operation by November 19, 1980 and can meet other interim status requirements

Interquartile range (IQR): the distance between the top of the lower quartile and the bottom of the upper quartile, which provides a measure of the spread of data

Isotopes: forms of an element having the same number of protons in their nuclei, but differing numbers of neutrons

L **Less than detection limits:** a phrase indicating that a chemical constituent or radionuclide was either not present in a sample, or is present in such a small concentration that it cannot be measured by a laboratory's analytical procedure, and therefore is not identified or not quantified at the lowest level of sensitivity

Low level radioactive waste (LLW): waste defined by DOE Order 5820.2A, which contains transuranic nuclide concentrations less than 100 nCi/g

Lower limit of detection: the smallest concentration or amount of analyte that can be detected in a sample at a 95% confidence level

Lysimeter: an instrument for measuring the water percolating through soils and determining the dissolved materials

M **Maximally exposed individual (MEI):** a hypothetical member of the public at a fixed location who, over an entire year, receives the maximum effective dose equivalent (summed over all pathways) from a given source of radionuclide releases to air. Generally, the MEI is different for each source at a site

Maximum Contaminant Level (MCL): the highest level of a contaminant in drinking water that is allowed by U.S. Environmental Protection Agency regulation

Minimum Detectable Concentration (MDC): also known as the lower limit of detection, the smallest amount of radioactive material in a sample that can be quantitatively distinguished from background radiation in the sample with 95 percent confidence

Multiple completion: a borehole with water surveillance monitoring devices (Barcads) placed at various levels and separated by impermeable layers of material such as grout. Usually referred to as a well, the uppermost "completion" is accessible from the surface, making physical sample-taking possible (as opposed to Barcads).

Metric units: Metric system and U.S. customary units and their respective equivalents are shown in Table C-6. Except for temperature for which specific equations apply, U.S. customary units can be determined from metric units by multiplying the metric units by the U.S. customary equivalent. Similarly, metric units can be determined from U.S. customary equivalent units by multiplying the U.S. customary units by the metric equivalent.

Mixed waste (MW): waste that has the properties of both hazardous and radioactive waste

N **National Emission Standards for Hazardous Air Pollutants (NESHAPs):** standards found in the Clean Air Act that set limits for hazardous air pollutants

National Pollutant Discharge Elimination System (NPDES): federal regulation under the Clean Water Act that requires permits for discharges into surface waterways

Nonpoint source: any nonconfined area from which pollutants are discharged into a body of water (e.g., agricultural runoff, construction runoff, and parking lot drainage), or into air (e.g., a pile of uranium tailings)

Nuclear Regulatory Commission (NRC): the federal agency charged with oversight of nuclear power and nuclear machinery and applications not regulated by DOE or the Department of Defense Nuclide: a species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons, number of neutrons, and energy content; or, alternatively, by the atomic number, mass number, and atomic mass. To be regarded as a distinct nuclide, the atom must be capable of existing for a measurable length of time.

O **Offsite:** for effluent releases or in the nuclear testing area, offsite is any place outside the NTS and adjacent NTTR

Onsite: for effluent releases or in the nuclear testing area, onsite is any place inside the NTS and adjacent NTTR

P **Part B permit:** the second, narrative section submitted by generators in the RCRA permitting process that covers in detail the procedures followed at a facility to protect human health and the environment

Parts per billion (ppb): a unit of measure for the concentration of a substance in its surrounding medium; for example, one billion grams of water containing one gram of salt has a salt concentration of one part per billion

Parts per million (ppm): a unit of measure for the concentration of a substance in its surrounding medium; for example, one million grams of water containing one gram of salt has a salt concentration of one part per million

Perched aquifer: aquifer that is separated from another water-bearing stratum by an impermeable layer

Performance standards (incinerators): specific regulatory requirements established by EPA limiting the concentrations of designated organic compounds, particulate matter, and hydrogen chloride in incinerator emissions

pH: a measure of hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0 to 6; basic solutions have a pH greater than 7; and neutral solutions have a pH of 7.

Piezometer: instrument for measuring fluid pressure used to measure the elevation of the water table in a small, nonpumping well

Pliocene: geological epoch of the Tertiary period, starting about 12 million years ago

PM-10: fine particulate matter with an aerodynamic diameter equal to or less than 10 microns

Point source: any confined and discrete conveyance (e.g., pipe, ditch, well, or stack)

Pretreatment: any process used to reduce a pollutant load before it enters the sewer system

Pretreatment regulations: national wastewater pretreatment regulations, adopted by EPA in compliance with the 1977 amendments to the Clean Water Act, which required that EPA establish pretreatment standards for existing and new industrial sources

Q **Quality assurance (QA):** a system of activities whose purpose is to provide the assurance that standards of quality are attained with a stated level of confidence

Quality control (QC): procedures used to verify that prescribed standards of performance are attained

Quality factor: the factor by which the absorbed dose (rad) is multiplied to obtain a quantity that expresses (on a common scale for all ionizing radiation) the biological damage to exposed persons, usually used because some types of radiation, such as alpha particles, are biologically more damaging than others. Quality factors for alpha, beta, and gamma radiation are in the ratio 20:1:1.

Quaternary: the geologic era encompassing the last 2–3 million years

R **Rad:** the unit of absorbed dose and the quantity of energy imparted by ionizing radiation to a unit mass of matter such as tissue, and equal to 0.01 joule per kilogram, or 0.01 gray

Radioactive decay: the spontaneous transformation of one radionuclide into a different nuclide (which may or may not be radioactive), or de-excitation to a lower energy state of the nucleus by emission of nuclear radiation, primarily alpha or beta particles, or gamma rays (photons)

Radioactivity: the spontaneous emission of nuclear radiation, generally alpha or beta particles, or gamma rays, from the nucleus of an unstable isotope

Radionuclide: an unstable nuclide. See nuclide and radioactivity

Rem: a unit of radiation dose equivalent and effective dose equivalent describing the effectiveness of a type of radiation to produce biological effects; coined from the phrase "roentgen equivalent man," and the product of the absorbed dose (rad), a quality factor (Q), a distribution factor, and other necessary modifying factors. One rem equals 0.01 sievert.

Risk assessment: the use of established methods to measure the risks posed by an activity or exposure by evaluating the relationship between exposure to radioactive substances and the subsequent occurrence of health effects and the likelihood for that exposure to occur

Roentgen (R): a unit of measurement used to express radiation exposure in terms of the amount of ionization produced in a volume of air

S **Sanitary waste:** most simply, waste generated by routine operations that is not regulated as hazardous or radioactive by state or federal agencies

Saturated zone: a subsurface zone below which all rock pore-space is filled with water; also called the phreatic zone

Sensitivity: the capability of methodology or instrumentation to discriminate between samples having differing concentrations or containing varying amounts of analyte

Sievert (Sv): the SI unit of radiation dose equivalent and effective dose equivalent, that is the product of the absorbed dose (gray), quality factor (Q), distribution factor, and other necessary modifying factors. 1 Sv equals 100 rem

Source term: amount of a specific pollutant emitted or discharged to a particular medium, such as the air or water, from a particular source

Specific conductance: measure of the ability of a material to conduct electricity; also called conductivity

Subcritical experiment: an experiment using high explosives and nuclear weapon materials (including special nuclear materials like plutonium) to gain data used to maintain the nuclear stockpile without conducting nuclear explosions banned by the Comprehensive Test Ban Treaty.

Surface impoundment: a facility or part of a facility that is a natural topographic depression, manmade excavation, or diked area formed primarily of earthen materials, although it may be lined with man-made materials. The impoundment is designed to hold an accumulation of liquid wastes, or wastes containing free liquids, and is not an injection well. Examples of surface impoundments are holding, storage, settling and aeration pits, ponds, and lagoons.

Système International d'Unités (SI): an international system of physical units which include meter (length), kilogram (mass), kelvin (temperature), becquerel (radioactivity), gray (radioactive dose), and sievert (dose equivalent)

T **Thermoluminescent dosimeter (TLD):** a device used to measure external beta or gamma radiation levels, and which contains a material that, after exposure to beta or gamma radiation, emits light when processed and heated

Total dissolved solids (TDS): the portion of solid material in a waste stream that is dissolved and passed through a filter

Total organic carbon (TOC): the sum of the organic material present in a sample

Total organic halides (TOX): the sum of the organic halides present in a sample

Total suspended solids (TSS): the total mass of particulate matter per unit volume suspended in water and wastewater discharges that is large enough to be collected by a 0.45 micron filter

Transpiration: a process by which water is transferred from the soil to the air by plants that take the water up through their roots and release it through their leaves and other aboveground tissue

Tritium: the radioactive isotope of hydrogen, containing one proton and two neutrons in its nucleus, which decays at a half-life of 12.3 years by emitting a low-energy beta particle

Transuranic waste (TRU): material contaminated with alpha-emitting transuranium nuclides, which have an atomic number greater than 92 (e.g. ^{239}Pu), half-lives longer than 20 years, and are present in concentrations greater than 100 nCi/g of waste

U

Uncertainty: the parameter associated with a sample measurement that characterizes the range of the measurement that could reasonably be attributed to the sample. Used in this report, the uncertainty value is established at ± 2 standard deviations.

Unsaturated zone: that portion of the subsurface in which the pores are only partially filled with water and the direction of water flow is vertical; is also referred to as the vadose zone

U.S. Department of Energy (DOE): the federal agency responsible for conducting energy research and regulating nuclear materials used for weapons production

U.S. Environmental Protection Agency (EPA): the federal agency responsible for enforcing federal environmental laws. Although some of this responsibility may be delegated to state and local regulatory agencies, EPA retains oversight authority to ensure protection of human health and the environment.

V

Vadose zone: the partially saturated or unsaturated region above the water table that does not yield water to wells

Volatile organic compound (VOC): liquid or solid organic compounds that have a high vapor pressure at normal pressures and temperatures and thus tend to spontaneously pass into the vapor state

W

Waste accumulation area (WAA): an officially designated area that meets current environmental standards and guidelines for temporary (less than 90 days) storage of hazardous waste before off-site disposal

Wastewater treatment system: a collection of treatment processes and facilities designed and built to reduce the amount of suspended solids, bacteria, oxygen-demanding materials, and chemical constituents in wastewater

Water table: the water-level surface below the ground at which the unsaturated zone ends and the saturated zone begins, and the level to which a well that is screened in the unconfined aquifer would fill with water

Weighting factor: a tissue-specific value used to calculate dose equivalents which represents the fraction of the total health risk resulting from uniform, whole-body irradiation that could be contributed to that particular tissue. The weighting factors used in this report are recommended by the International Commission on Radiological Protection (ICRP 1980).

Wind rose: a diagram that shows the frequency and intensity of wind from different directions at a specific location

Appendix E: Acronyms and Abbreviations

a.k.a	also known as
AA	alluvial aquifer
AIP	agreement in principle
ALARA	as low as reasonably achievable
ARL	Air Resources Laboratory
ASER	Annual Site Environmental Report
ARPA	Archeological Resources Protection Act
ASA	Auditable Safety Analysis
ASN	Air Surveillance Network
ATM	Atomic Testing Museum
B	background
BCG	Biota Concentration Guide
BEEF	Big Explosives Experimental Facility
BEIDMS	Bechtel Environmental Integrated Data Management System
BGS	below ground surface
BHPS	Bureau of Health Protection Services
BLM	Bureau of Land Management
BN	Bechtel Nevada
BOD	biological oxygen demand
BP	before present
BPW	bulk product waste
Bq	Becquerel
^{0}C	degree Celsius
ca.	*circa,* meaning “approximately”
CA	Composite Analysis
CAA	Clean Air Act
CADD	Corrective Action Decision Document

CAIP	Corrective Action Investigation Plan
CAP	Corrective Action Plan
CAPP	Chemical Accident Prevention Program
CAP88-PC	Clean Air Package 1988 (EPA software program for estimating doses)
CAS	Corrective Action Site
CAU	Corrective Action Unit
CCHD	Clark County Health District
CCSD	Clark County Sanitation District
CCWRD	Clark County Reclamation District
CD-ROM	Compact Disk-Read Only Memory
CEDE	committed effective dose equivalent
CEM	Community Environmental Monitor
CEMP	Community Environmental Monitoring Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CG	cloud-to-ground
CGTO	Consolidated Group of Tribes and Organizations
Ci	curie
cm	centimeter(s)
CL	Compliance Level (used in text for the Clean Air Act National Emission Standards for Hazardous Pollutants Concentration Level for Environmental Compliance)
CLVF	Cheyenne Las Vegas Facility (BN)
CNLV	City of North Las Vegas
CNTA	Central Nevada Test Area
CP	Control Point
CRM	Cultural Resources Management
CTLP	Community Technical Liaison Program
CTOS	Counter Terrorism Operations Support
CWA	Clean Water Act
CX	categorical exclusion

CY	calendar year
DAF	Device Assembly Facility
DAS	Disposal Authorization Statement
DCG	Derived Concentration Guide
DEA	Dose Evaluation Area
DNFSB	Defense Nuclear Facility Safety Board
DNWR	Desert National Wildlife Refuge
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/HQ	DOE Headquarters
DOE LAP	U.S. Department of Energy, Laboratory Accreditation Program
DOE/ORO	DOE Oak Ridge Office
DQA	Data Quality Assessment
DQO	Data Quality Objectives
DRI	Desert Research Institute, University and Community College System, Nevada
DTRA	Defense Threat Reduction Agency
DWR	Division of Water Resources
EA	Environmental Assessment
ECD	Environmental Compliance Department (BN)
EDE	effective dose equivalent
EFMR	EFMR Monitoring Network
EGIS	Ecological Geographic Information System
EHS	extremely hazardous substances
EIS	Environmental Impact Statement
ELU	ecological landform unit
EM	environmental monitor
EMAC	Ecological Monitoring and Compliance Program
EMCAD	Environmental Management Consolidated Audit Program
EML	Environmental Measurements Laboratory
EMS	Environmental Management System

EMSL-LV	Environmental Monitoring Systems Laboratory
EO	Executive Order
EODU	Explosive Ordnance Disposal Unit
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Reporting and Community Right-to-Know Act
ER	Environmental Restoration
ERA	Environmental Resource Associates
ESA	Endangered Species Act
ESHD	Environment, Safety and Health Division
ET	evapotranspiration
ETS	Environmental Technical Services (BN)
^{0}F	degree Fahrenheit
FEMA	Federal Emergency Management Agency
FFACO	Federal Facilities Agreement and Consent Order
FFCA	Federal Facilities Compliance Act
FIFRA	Federal Insecticide, Fungicide, Rodenticide Act
ft	foot or feet
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
g	gram(s)
gal	gallon(s)
GCD	Greater Confinement Disposal
GIS	Geographic Information System
gpm	gallons per minute
GPS	global positioning satellite
ha	hectare
HAP	hazardous air pollutants
HDP	heat dissipation probe
HEPA	high efficiency particulate air
HGU	hydrogeologic unit

HPD	Health Physics Department (BN)
HQ	Headquarters
hr	hour
HRMP	Hydrologic Resources Management Program
HSC	Hazardous Materials Spill Center
HSU	hydrostratigraphic unit
HTO	tritiated water
HW	hazardous waste
HWSU	hazardous waste storage unit
IA	inactive
IAEA	International Atomic Energy Agency
ICMP	Integrated Closure and Monitoring Plan
in	inch(es)
INEEL	Idaho National Engineering and Environmental Laboratory
ISMS	Integrated Safety Management System
IT	International Technology
JASPER	Joint Actinide Shock Physics Experimental Research
kg	kilogram(s)
km	kilometer(s)
LANL	Los Alamos National Laboratory
LAO	Los Alamos Operations (BN)
lb	pound
lbs	pounds
LCA	lower carbonate aquifer
LCA3	lower carbonate aquifer, upper thrust plate
LCCU	lower clastic confining unit
LDR	Land Disposal Restrictions
LEED	U.S. Green Building Council Leadership in Energy and Environmental Design
LFA	lava-flow aquifer
LLNL	Lawrence Livermore National Laboratory

LLW	low level radioactive waste
LLWMU	Low Level Waste Management Unit
LO	Livermore Operations (BN)
lpm	liters per minute
LQAP	Laboratory Quality Assurance Plan
m	meter(s)
M&O	Management and Operations
Ma	million years ago
MAPEP	Mixed Analyte Performance Evaluation Program
MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MDC	minimum detectable concentration
MEDA	meteorological data acquisition
MEI	maximally exposed individual
MGCU	Mesozoic granite confining unit
mi	miles
MLU	Mobile Loading Unit
mm	millimeter(s)
MOU	Memorandum of Understanding
MQO	Measurement Quality Objectives
MSA	Management Self-Assessments
MSDS	Material Safety Data Sheet
mt	metric ton
MT	magnetotelluric
MTRU	mixed transuranic
MW	mixed low level radioactive waste
MWDU	Mixed Waste Disposal Unit
NA	not applicable
NAAQS	National Ambient Air Quality Standards
NAC	Nevada Administrative Code

NAFR	Nellis Air Force Range
NAGPRA	Native American Graves Protection and Repatriation Act of 1990
NCA	Nevada Combined Agency
NCRP	National Council on Radiation Protection
NDEP	Nevada Division of Environmental Protection
NDOA	Nevada Department of Agriculture
NDOW	Nevada Division of Wildlife
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NLV	North Las Vegas
NLVF	North Las Vegas Facility (BN)
NNHP	Nevada Natural Heritage Program
NNSA/NSO	U. S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NNSA/NV	U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office
NPDES	National Pollution Discharge Elimination System
NRD	Nuclear Radiation Assessment Division
NRHP	National Register of Historic Places
NRS	Nevada Revised Statues
NSDO	Nevada State Demographer Office
NSHPO	Nevada State Historic Preservation Office
NSPS	New Source Performance Standards
NTS	Nevada Test Site
NTSER	Nevada Test Site Environmental Report
NTSWAC	Nevada Test Site Waste Acceptance Criteria
NTTR	Nevada Test and Training Range
NVLAP	National Voluntary Laboratory Accreditation Program
ODS	ozone-depleting substances
OI	Operating Instruction

ORSP	Offsite Radiological Safety Program
oz	ounce(s)
P2	pollution prevention
P2/WM	pollution prevention/waste minimization
PA	Performance Assessment
PAAA	Price-Anderson Amendments Act
PCB	polychlorinated biphenyl
PCC	Post Closure Plan
PEP	Performance Evaluation Program
PHS	Public Health Service
PIC	pressurized ion chamber
PM-OV	Pahute Mesa-Oasis Valley
PNNL	Pacific Northwest National Laboratory
POTW	publically owned treatment works
PPOA	Pollution Prevention Opportunity Assessments
PT	proficiency testing
PTE	potential to emit
PWS	public water systems
QA	quality assurance
QAP	Quality Assurance Program
QAPP	Quality Assurance Program Plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFP	request for proposal
RIDP	Radionuclide Inventory and Distribution Program
ROD	Record of Decision
R-MAD	Reactor Maintenance, Assembly, and Disassembly
RREMP	Routine Radiological Environmental Monitoring Plan
RSD	relative standard deviation
RSL	Remote Sensing Laboratory

RWID	Radioactive Waste Information Document
RWMC	Radioactive Waste Management Complex
RWMS	Radioactive Waste Management Site
RWMS-3	Radioactive Waste Management Site, Area 3
RWMS-5	Radioactive Waste Management Site, Area 5
SA	Supplement Analysis
SAFER	Streamlined Approach for Environmental Restoration
SARA	Superfund Amendments and Reauthorization Act
SCCC	Silent Canyon caldera complex
SDWA	Safe Drinking Water Act
SHPO	Nevada State Historic Preservation Office
SOC	species of concern
SOP	Standard Operating Procedures
SORD	Special Operations and Research Division
SOW	Statement of Work
SSCS	Structures, Systems, and Components
STL	Special Technologies Laboratory
STP	standard temperature and pressure
SWL	static water level
SWNVF	Southwest Nevada Volcanic Field
SWRHL	Southwestern Radiological Health Laboratory
t	short ton or 2,000 lbs
TaDD	Tactical Demilitarization Development Project
TCP	thermocouple psychrometer
TCU	tuff confining unit
TDR	time domain reflectometry
TDS	total dissolved solids
TLD	thermoluminescent dosimeter
TMA	Timber Mountain aquifer
TMCC	Timber Mountain caldera complex
TMI	Three-Mile Island
TMI-CMN	Three Mile Island Citizen's Monitoring Network

TPCB	Transuranic Pad Cover Building
TRB	to be determined
TRI	Toxic Release Inventory
TRU	transuranic
TSCA	Toxic Substances Control Act
TSS	total suspended solids
TTR	Tonopah Test Range
UCCU	upper clastic confining unit
UGTA	Underground Test Area
U.S.	United States
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
VCU	volcaniclastic confining unit
VTA	vitric-tuff aquifer
VZM	vadose zone monitoring
WEF	Waste Examination Facility
WGS	Waste Generation Services
WIPP	Waste Isolation Pilot Plant
WMO	World Meteorological Organization
WO	Waste Operations (BN)
WRCC	Western Regional Climate Center
WSI	Wackenhut Services, Inc.
WTA	welded-tuff aquifer
WTP	Weapons Testing Program
WVCU	Wahmonie volcanic confining unit
XRF	x-ray diffractometer
yd	yard
YF-LCU	Yucca Flat lower confining unit
YMP	Yucca Mountain Project

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Yucca Flat,
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Caliente Branch Library, P.O. Box 306, Caliente, NV 89009

Cedar City Public Library, 136 W. Center Street, Cedar City, UT 84720-2597

Delta City Library, 76 N. 200 W. Delta, UT 84624-9440

Goldfield Public Library, P.O. Box 430, Goldfield, NV 89013

Henderson District Public Library, 280 Water Street, Henderson, NV 89015

Indian Springs Library, P.O. Box 629, Indian Springs, NV 89018

Lincoln County Library, P.O. Box 330, Pioche, NV 89043

Milford Public Library, P.O. Box 579, Milford, UT 84751-0579

Moapa Valley Library, P.O. Box 397, Overton, NV 89040

Office of Scientific and Technical Information, Technical Center, U.S. Department of Energy, P.O. Box 62, Oak Ridge, TN 37831 (electronic copy)

Pahrump Library District, 2101 E. Calvada Boulevard, Pahrump, NV 89048

Public Reading Facility, Nuclear Testing Archive, Nevada Site Office, U.S. Department of Energy, National Nuclear Security Administration P.O. Box 98521 Las Vegas, NV 89193-8521M/S 400

Technical Library, Nevada Site Office, U.S. Department of Energy, National Nuclear Security Administration, P.O. Box 98518, Las Vegas, NV 89193-8518, M/S 505

Tonopah Library District, P.O. Box 449, Tonopah, NV 89049

UNLV Library Government Documents, University of Nevada-Las Vegas, P.O. Box 457013, Las Vegas, NV 89154-7013

UNR Getchell Library, University of Nevada-Reno, Reno, NV 89557-0044

Washington County Library, 50 S. Main Street, St George, UT 84770-3490

White Pine County Library, 950 Campton Street, Ely, NV 89301

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