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Prepared by Bechtel Nevada
Post Office Box 98521
Las Vegas, NV 89193-8521

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NEVADA TEST SITE ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 2002

Editors: Yvonne E. Townsend and Robert F. Grossman

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Prepared by:

Bechtel Nevada
Post Office Box 98521
Las Vegas, Nevada 89193-8521

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AUTHORS AND CONTRIBUTORS

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Robert F. Grossman, BN

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Robert F. Grossman, BN

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Elizabeth Calman, BN
Colleen M. Beck, DRI
Orin L. Haworth, BN
Alfred J. Karnes, BN
Patrick Matthews, BN
Mike O'keefe, BN
Phyllis M. Radack, BN
Carlton Soong, BN
Cathy A. Wills, BN

4.0 Environmental Program Information

Kevin Campbell, BN
Sigmund Drellack, BN
Dennis Gustafson, BN
Alfred J. Karnes, BN
Colleen Beck, DRI

5.0 Radiological Environmental Programs

Paul Greger, BN
Robert F. Grossman, BN
William T. Hartwell, DRI
Ronald Warren, BN

6.0 Nonradiological Environmental Programs

Colleen M. Beck, DRI
Elizabeth C. Calman, BN
Alfred J. Karnes, BN
Phyllis Radack, BN
Cathy A. Wills, BN

7.0 Site Hydrology

Sigmund Drellack, BN

8.0 Groundwater Monitoring

Frederick Nawrocki, BN
William T. Hartwell, DRI

9.0 Quality Assurance

Jerry Dugas, BN
Ted Redding, BN

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MEASUREMENT UNITS AND NOMENCLATURE

Radioactivity data in this report are expressed in both traditional units (e.g., pCi/L) and International System (abbreviated SI) units. These units are explained below.

background Ambient background radiation to which people are exposed. Naturally occurring radioactive elements contained in the body, in the ground, and in construction materials, cosmic radiation, and radioactivity in the air all contribute to an average radiation dose equivalent to humans of about 350 mrem per year. In laboratory measurements of radioactivity in samples, background is the activity determined when a sample of distilled water is processed through the system (Also called a blank).

becquerel Abbreviation Bq. The Bq is the SI unit for disintegration rate.
1 Bq = 1 disintegration per second.

concentration Activity per unit volume or weight. Usually expressed as µCi/mL, pCi/m^3 or pCi/g.

curie Abbreviation Ci. The historic unit for disintegration rate. 1 Ci = 3.7×10^{10} disintegrations per second = 3.7×10^{10} Bq. The usual submultiples of Ci are mCi (10^{-3} Ci or one thousandth Ci), µCi (10^{-6} Ci or one millionth Ci), and pCi (10^{-12} or one trillionth Ci).

EDE Effective dose equivalent - radiation dose corrected by various weighting factors that relate dose to the risk of serious effects.

rem Rem (for roentgen equivalent man) is the unit for expressing dose equivalent, or the energy imparted to a person when exposed to radiation. The commonly used subunit is the millirem (10^{-3} rem or one thousandth rem), abbreviated mrem.

roentgen Abbreviation R. A unit expressing the intensity of X or γ radiation at a point in air. The usual unit is mR or 10^{-3} R (one thousandth R).

volume The SI unit for volume is m^3 (cubic meter). Other units used are liter (L) and mL (10^{-3} L or one thousandth liter). One cubic meter = 1,000 L, 1 L = 1.06 quarts.

The elements and corresponding symbols used in this report are:

Element	Symbol	Element	Symbol
Actinium	Ac	Iron	Fe
Aluminum	Al	Krypton	Kr
Argon	Ar	Lead	Pb
Arsenic	As	Lithium	Li
Barium	Ba	Mercury	Hg
Beryllium	Be	Nitrogen	N
Bismuth	Bi	Oxygen	O
Boron	B	Plutonium	Pu
Cadmium	Cd	Potassium	K
Calcium	Ca	Radium	Ra
Cesium	Cs	Radon	Rn
Chlorine	Cl	Selenium	Se
Chromium	Cr	Silver	Ag
Cobalt	Co	Strontium	Sr
Copper	C	Thallium	Tl
Europium	Eu	Thorium	Th
Fluorine	F	Thulium	Tm
Hydrogen	H	Tritium	^3H
Iodine	I	Uranium	U

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LIST OF ACRONYMS AND ABBREVIATIONS

AA	Alluvial Aquifer
AIP	Agreement in Principle
ASA	Auditable Safety Analysis
ASER	Annual Site Environmental Report
ASN	Air Surveillance Network
B	Background
BCG	Biota Concentration Guide
BEEF	Big Explosives Experimental Facility
BEIDMS	Bechtel Environmental Integrated Data Management System
BN	Bechtel Nevada
CA	Composite Analysis
CAA	Clean Air Act
CADD	Corrective Action Decision Document
CAP	Corrective Action Plan
CAP88-PC	Clean Air Package 1988 (EPA software program for estimating doses)
CAS	Corrective Action Site
CAU	Corrective Action Unit
CCSD	Clark County Sanitation District
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
CGTO	Consolidated Group of Tribes and Organizations
CP	Control Point
CWA	Clean Water Act
CX	Categorical Exclusion
CY	Calendar Year
DAF	Device Assembly Facility
DAS	Disposal Authorization Statement
DCG	Derived Concentration Guide
DOE	U.S. Department of Energy
DOE/HQ	DOE Headquarters
DQA	Data Quality Assessment
DQO	Data Quality Objectives
DRI	Desert Research Institute, University and Community College System, Nevada
DWR	Division of Water Resources
E	Evaluate
E1	Environmental 1
E2	Environmental 2
EA	Environmental Assessment
EDE	Effective Dose Equivalent
EGIS	Ecological Geographic Information System
EHS	Extremely Hazardous Substances
EIS	Environmental Impact Statement
ELU	Ecological Landform Unit
EMAC	Ecological Monitoring and Compliance
EMCAD	Environmental Management Consolidated Audit Program
EML	Environmental Measurements Laboratory

EO	Executive Order
EODU	Explosive Ordnance Disposal Unit
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Reporting and Community Right-to-Know Act
ERA	Environmental Resource Associates
ESA	Endangered Species Act
ESHD	Environment, Safety and Health Division
FFACO	Federal Facilities Agreement and Consent Order
FFCA	Federal Facilities Compliance Act
FY	Fiscal Year
GCD	Greater Confinement Disposal
GIS	Geographic Information System
HGU	Hydrogeologic Unit
HRMP	Hydrologic Resources Management Program
HSC	Hazardous Materials Spill Center
HSU	Hydrostratigraphic Unit
HTO	Tritiated Water
IA	Inactive
IAEA	International Atomic Energy Agency
ICMP	Integrated Closure and Monitoring Plan
INEEL	Idaho National Engineering and Environmental Laboratory
ISMS	Integrated Safety Management System
IT	International Technology
JASPER	Joint Actinide Shock Physics Experimental Research
LANL	Los Alamos National Laboratory
LAO	Los Alamos Operations (BN)
LCA	Lower Carbonate Aquifer
LCA3	Lower Carbonate Aquifer, Upper Thrust Plate
LCCU	Lower Clastic Confining Unit
LDR	Land Disposal Restrictions
LLNL	Lawrence Livermore National Laboratory
LLW	Low Level (Radioactive) Waste
LLWMU	Low Level Waste Management Unit
LO	Livermore Operations (BN)
LQAP	Laboratory Quality Assurance Plan
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Level
MDC	Minimum Detectable Concentration
MEI	Maximally Exposed Individual
MGCU	Mesozoic Granite Confining Unit
MLLW	Mixed Low Level Waste
MOU	Memorandum of Understanding
MQO	Measurement Quality Objectives
MTRU	Mixed Transuranic
NAC	Nevada Administrative Code
NAFR	Nellis Air Force Range
NCRP	National Council on Radiation Protection
NDEP	Nevada Division of Environmental Protection
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
NPDES	National Pollution Discharge Elimination System
NRHP	National Register of Historic Places
NRS	Nevada Revised Statues
NSHPO	Nevada State Historic Preservation Office
NTS	Nevada Test Site
NTSWAC	Nevada Test Site Waste Acceptance Criteria
OI	Operating Instruction
P2	Pollution Prevention
PA	Performance Assessment
PCB	Polychlorinated Biphenyl
PEP	Performance Evaluation Program
PHS	Public Health Service
PIC	Pressurized Ion Chamber
PM-OV	Pahute Mesa-Oasis Valley
PNNL	Pacific Northwest National Laboratory
PPOA	Pollution Prevention Opportunity Assessments
PT	Proficiency Testing
QA	Quality Assurance
QAP	Quality Assessment Program
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RFP	Request for Proposal
ROD	Record of Decision
RREMP	Routine Radiological Environmental Monitoring Plan
RSD	Relative Standard Deviation
RSL	Remote Sensing Laboratory (BN)
RWID	Radioactive Waste Information Document
RWMS	Radioactive Waste Management Site
RWMS-3	Radioactive Waste Management Site, Area 3
RWMS-5	Radioactive Waste Management Site, Area 5
SAFER	Streamlined Approach for Environmental Restoration
SARA	Superfund Amendments and Reauthorization Act
SCCC	Silent Canyon Caldera Complex
SDWA	Safe Drinking Water Act
SOW	Statement of Work
STL	Special Technologies Laboratory
SWL	Static Water Level
SWNVF	Southwest Nevada Volcanic Field
TaDD	Tactical Demilitarization Development
TCU	Tuff Confining Unit
TDS	Total Dissolved Solids
TLD	Thermoluminescent Dosimeter
TMA	Timber Mountain Aquifer
TMCC	Timber Mountain Caldera Complex
TRI	Toxic Release Inventory
TRU	Transuranic
TSCA	Toxic Substances Control Act
TTR	Tonopah Test Range

UCCU	Upper Clastic Confining Unit
UGTA	Underground Testing Area
U.S.	United States
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VCU	Volcaniclastic Confining Unit
VZM	Vadose Zone Monitoring
WIPP	Waste Isolation Pilot Plant
WO	Waste Operations
WRCC	Western Regional Climate Center
WVCU	Wahmonie Volcanic Confining Unit
XRF	X-Ray Diffractometer
YF-LCU	Yucca Flat Lower Confining Unit
YMP	Yucca Mountain Project

1.0 SUMMARY

Monitoring and surveillance, on and around the Nevada Test Site, (NTS) by the United States Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office (NNSA/NSO) contractors and NTS user organizations during 2002, indicated that operations on the NTS were conducted in compliance with applicable NNSA/NSO, state, and federal regulations and guidelines. All discharges of radioactive liquids remained onsite in containment ponds, and there was no indication of migration of radioactivity to the offsite area through groundwater. During 2002, air samples were collected during efforts by fire fighters to extinguish a brush fire in Area 12; however the airborne concentrations of radioactivity from the potential re-suspension of soil did not result in a significant exposure to the fire fighters or offsite residents. Oversite surveillance by the Desert Research Institute (DRI) of the University and Community College System of Nevada around the NTS indicated that offsite airborne radioactivity from diffusion and evaporation of liquid effluents was not detectable. Using the U.S. Environmental Protection Agency's (EPA's) Clean Air Package 1988 model (CAP88-PC) and all estimated NTS radionuclide emissions calculated from the resuspension of soil and environmental monitoring data, Bechtel Nevada (BN), the Maintenance and Operations contractor for the NTS calculated the effective dose equivalent (EDE) to the maximally exposed individual (MEI) offsite to be 0.11 mrem/yr. This value is 1.1 percent of the dose limit prescribed for radionuclide air emissions by the National Emission Standards for Hazardous Air Pollutants. A maximized estimate of the EDE to the MEI, from the inhalation of NTS airborne emissions and the ingestion of wildlife, was calculated to be 1.35 mrem/yr (0.0135 mSv/yr), which is only 1.35 percent of the 100 mrem/yr dose limit to the general public. The MEI receiving this dose would also have received an external exposure of 336 mrem/yr from natural background radiation. There were no nonradiological releases to the offsite area. Hazardous wastes were shipped to approved offsite disposal facilities. The NNSA/NSO has a vigorous National Environmental Policy Act (NEPA) program. The NNSA/NSO maintains permits under the Clean Air Act (CAA), Clean Water Act (CWA), Safe Drinking Water Act (SDWA), and other state requirements. Cooperation with other agencies has resulted in 11 different agreements, memoranda, and consent orders.

Biota Concentration Guides derived by the DOE Biota Dose Assessment Committee were used to determine that the radiation dose to biota at the E Tunnel ponds were in compliance with the DOE standard dose limits for biota.

Support facilities at off-NTS locations have complied with the requirements of air quality permits and state or local wastewater discharge and hazardous waste permits as mandated for each location.

1.1 ENVIRONMENTAL MANAGEMENT

The NNSA/NSO is committed to increasing the quality of its management of NTS environmental resources. This has been promoted by the establishment of an Environment, Safety and Health Division under the purview of the Assistant Manager for Technical Services and by upgrading the Environmental Management activities to the Assistant Manager level to address those environmental issues that have arisen in the course of performing the original primary mission of the NNSA/NSO, i.e., underground testing of nuclear explosive devices. NNSA/NSO management has vigorously promoted the practice of pollution prevention, including waste minimization and material recycling.

Operational releases and seepage of radioactivity are reported soon after their occurrence. In compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP), as set forth in Title 40 Code of Federal Regulations Part 61, the accumulated annual emissions are used as part of the input to the EPA's CAP88-PC software program (DOE 1997b) to calculate potential EDEs to people living beyond the boundaries of the NTS and the surrounding exclusion areas.

RADIOLOGICAL ENVIRONMENT

Radiological effluents in the form of air emissions and liquid discharges are not normally released into the environment as a routine part of operations on the NTS. Radioactivity in liquid discharges released to onsite waste treatment or disposal systems (containment ponds) is monitored to assess the efficacy of treatment and control and to provide an annual summary of released radioactivity. Air emissions are monitored for source characterization and operational safety as well as for environmental surveillance purposes.

Air emissions in 2002 consisted primarily of small amounts of tritium, americium, and plutonium that were assumed to be released to the atmosphere and were attributed to:

- Diffusion of tritiated water (HTO) vapor from evaporation of HTO from tunnel and characterization well containment ponds.
- Diffuse emissions calculated from the results of environmental surveillance activities.
- Resuspension of americium and plutonium calculated by use of resuspension equations.

Diffuse emissions in 2002 included (1) HTO, with the most significant being from SCHOONER in Area 20, and others only slightly above detection limits, from the Area 5 Radioactive Waste Management Site (RWMS-5), the E Tunnel ponds, and the SEDAN crater in Area 10, and (2) resuspended $^{239+240}$Pu and ^{241}Am from areas on the NTS, where it was deposited by atmospheric nuclear tests or device safety experiment tests in earlier years. Table 1.1 shows the quantities of radionuclides estimated to be released from all sources. The radioactive materials listed in this table were not detected in the offsite area above ambient radioactivity levels. No liquid effluents were discharged to offsite areas.

ONSITE ENVIRONMENTAL SURVEILLANCE

Environmental surveillance on the NTS is designed to cover the entire area with some emphasis on areas of past nuclear testing and present operational activities. During calendar year (CY) 2002, air monitoring was conducted for radioactive particulates and HTO vapor at a total of 16 and 14 locations, respectively. Beginning in July 2001, the sampling locations were reduced to this number to accommodate a change in strategy for demonstrating compliance with NESHAPs as approved by the EPA. The changes maintained the monitoring of NTS areas with potential emissions of radioactivity and designated the sampler locations at SCHOONER, Gate 700 South, Mercury, Guard Station 510, Substation 3545, and Yucca as NESHAP compliance stations. These six stations, although located on the NTS, will conservatively represent offsite critical receptors. Grab samples were collected frequently from water supply wells, water taps, containment ponds, and sewage lagoons. Gamma exposures were measured using thermoluminescent dosimeters (TLDs), which were placed at 79 locations on the NTS.

Data from these networks are summarized as annual averages for each monitored location. Those locations with concentrations above the NTS average are assumed to reflect onsite emissions. These emissions arise from diffuse (areal) sources and from certain operational activities (e.g., radioactivity buried in the low-level radioactive waste [LLW] site).

Approximately 160 air samples were analyzed by gamma spectroscopy. All radionuclides detected by gamma spectroscopy were naturally occurring in the environment (^{40}K, ^{7}Be, and members of the uranium and thorium series), except for one sample in which ^{137}Cs was detected slightly above the MDC of the measurement.

Gross alpha and beta analysis of the air samples yielded an annual mean for the 16-station-network of 6.9 x 10^{-15} µCi/mL (0.26 mBq/m^3) and 2.0 x 10^{-14} µCi/mL (0.74 mBq/m^3) respectively. These network means were almost the same as the previous year.

Plutonium analyses for all 16 locations during 2002, of monthly NTS composited air filters, indicated an annual network mean of 55 x 10^{-18} µCi/mL (2.0 µBq/m^3) for $^{239+240}$Pu and 2.1 x 10^{-18} µCi/mL (0.078 µBq/m^3) for ^{238}Pu. These annual means were calculated to be less than 0.003 percent of the Derived Air Concentration for exposure to workers. Higher than background levels of plutonium are to be expected in some air samples because fallout from atmospheric tests in the 1950s, and nuclear safety experiment tests in the 1950s and 1960s dispersed plutonium over a small portion of the NTS's surface.

Atmospheric moisture was collected for two-week periods at 14 locations on the NTS and analyzed for HTO content. The annual network mean of 33 x 10^{-6} pCi/mL (1.2 Bq/m^3) was slightly lower than last year. The highest annual mean concentrations were at the SCHOONER crater, SEDAN crater, and the E Tunnel pond in that order. The primary radioactive liquid discharge to the onsite environment in 2002 was about 13 Ci (0.48 TBq) of tritium (as HTO) in seepage from the E Tunnel ponds. When calculating the dose for the offsite public, it was assumed that all of the HTO had evaporated.

Surface water sampling was conducted at two containment ponds and the effluent for the Area 12 E Tunnel. Sediment samples were also collected at these ponds and two others that were dry. A grab sample was taken from each of these surface water sites for analysis of tritium, gamma-emitters, americium, plutonium isotopes, and uranium isotopes. Strontium-90 was analyzed once per year for each location. Samples collected from the tunnel containment pond contained detectable levels of radioactivity, as would be expected. Water samples collected from the sewage lagoons were analyzed for tritium and gamma-emitting radionuclides. No tritium or other man-made radionuclides were detected.

Water samples from onsite supply wells and drinking water distribution systems were also analyzed for radioactivity and found to be in conformance with the standards in the National Primary Drinking Water Regulations (CFR 1976) and DOE Order 5400.5 (DOE 1990b). Additional analyses for ^{3}H, ^{90}Sr, $^{239+240}$Pu, and ^{238}Pu were all below their respective MDCs.

Monitoring of the vadose zone beneath the waste management sites in Areas 3 and 5 revealed that wetting fronts extended only a few feet below the surface of these sites. Also, Resource Conservation and Recovery Act (RCRA) monitoring well results, for sampling groundwater under RWMS-5, indicated that contamination from mixed waste buried therein is not detectable in the well samples.

Analysis of data from the TLD network showed statistically significant differences between both locations and quarters, though the quarter-to-quarter variation was much less than the location-to-location variation. The Highest exposure rates were measured at areas associated with historical surface tests. Eighty-three percent of the NTS locations had mean exposure rates within the range measured offsite by DRI, with 93 percent of the NTS locations within the range of background exposures measured across the United States (BIER III 1980). Overall mean exposure rates on the NTS were very similar to those measured in past years.

Monitoring System Design

During 1998, in an effort to make the environmental surveillance system on the NTS more efficient, it was redesigned. Using the Seven-Step Data Quality Objective (DQO) process, published by EPA and information on the distribution and amount of radioactive sources on the NTS, a "Routine Radiological Environmental Monitoring Plan" (RREMP) was developed and then revised in 2002 (DOE 2003b). As a result of the DQO process, some monitoring was eliminated or repositioned in 2002. In accordance to an agreement with the EPA (EPA 2001), six sampling stations near the NTS boundary were designated as NESHAPs compliance stations. During 2002, the monitoring was conducted in accordance with the Plan and the EPA agreement.

OFFSITE ENVIRONMENTAL SURVEILLANCE

Offsite radiological monitoring is conducted by public individuals in communities and at ranches around the NTS and is coordinated by the DRI of the University and Community College System of Nevada under contract with NNSA/NSO. These programs consist of several environmental sampling, radiation detection, and dosimetry networks as described below. A network of 24 Community Environmental Monitoring Program (CEMP) stations were operated continuously during 2002. During 2002 no airborne radioactivity related to current activities at the NTS was detected on any sample from low-volume samplers.

In 2002, external exposure was monitored by a network of 24 TLDs and pressurized ion chambers (PICs) located in towns and communities around the NTS. The PIC network in the communities surrounding the NTS indicated background exposures, ranging from 71 to 169 mR/yr, which were consistent with previous data and the range of background data in other areas of the United States. The exposures measured by the TLDs were slightly less, as has been true in the past.

Although no radioactivity attributable to current NTS operations was detected by any of the offsite monitoring networks, based on the NTS airborne releases, an atmospheric dispersion model calculation (CAP88-PC) indicated that the maximum potential EDE to any offsite individual would have been 0.11 mrem (1.1×10^{-3} mSv) at Cactus Springs, Nevada, and the dose to the population within 80 km of the several emission sites on the NTS would have been 0.42 person-rem (4.2×10^{-3} person-Sv), both of which were similar to last years. If one assumes that the MEI at Cactus Springs, Nevada, also ate the meat of wildlife which had migrated off the NTS after eating and drinking in radioactively contaminated areas, he could have received an additional EDE of 1.24 mrem/yr (0.0124 mSv/yr). These, added to the air pathway EDE, give a total of 1.35 mrem/yr (0.0135 mSv/yr). For comparison, the hypothetical person receiving this dose would also have been exposed to 336mrem/yr (3.36 mSv/yr) from all components of natural background radiation. A summary of the potential EDEs due to operations at the NTS is presented in Table1.2.

In compliance with the DOE standard the dose to assess dose to biota, the does was calculated for biota at the E Tunnel ponds. Based on radionuclide concentrations in water and sediment, no dose limits were exceeded.

LOW-LEVEL WASTE DISPOSAL

Environmental monitoring at the Area 3 RWMS (RWMS-3) has detected plutonium in air samples. However, the upwind/downwind sampler results were equivalent, and plutonium was detected in other air samples from Area 3, indicating that the source is resuspended plutonium from areas surrounding RWMS-3. Elevated levels of plutonium have been detected in air samples from several areas on the NTS where operational activities, vehicular traffic, and high winds resuspend plutonium for detection by air sampling. The presence of plutonium on the NTS is primarily due to atmospheric and safety experiment tests conducted in the 1950s and 1960s. These tests spread plutonium on surface soil in the eastern and northwestern areas of the NTS (Figure 5.1, Chapter 5.0 displays these locations).

Environmental monitoring at and around RWMS-5 indicated that HTO in air was detectable at, but not beyond, the waste site boundaries. This monitoring included air sampling, water sampling, and external gamma exposure measurement. Vadose zone monitoring for water seepage is conducted beneath RWMS-3 and RWMS-5, as a method of detecting any downward migration of waste. Also, three monitoring wells, installed to satisfy RCRA requirements for a mixed-waste disposal operation at RWMS-5, have not yet detected any migration of hazardous materials.

NONRADIOLOGICAL MONITORING

Nonradiological environmental monitoring of NTS operations involved only onsite monitoring because there were no discharges of nonradiological hazardous materials to offsite areas. The primary environmental permit areas for the NTS were monitored to verify compliance with ambient air quality and the RCRA requirements. Air emissions sources common to the NTS included particulates from construction, aggregate production, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities. NTS environmental permits active during 2002, which were issued by the state of Nevada or by federal agencies, included one comprehensive air quality permit covering emissions from construction of facilities, boilers, storage tanks, and surface disturbances; three onsite open-burn variances; one offsite permit for surface disturbance (environmental restoration activities); six permits for onsite drinking water distribution systems; one permit for sewage discharges to lagoon collection systems; four permits for septic waste hauling; one incidental take permit for the threatened desert tortoise; and one permit for the scientific collection and study of various species on the NTS. Further, a RCRA permit has been obtained for general NTS operations and for two specific facilities on the NTS.

Permits at non-NTS operations included 12 air pollution control permits, 3 sewage discharge permits, and 2 hazardous material storage permits.

The only nonradiological air emission of regulatory concern under the CAA has been due to asbestos removal during building renovation projects and from insulated piping at various locations on the NTS. During 2002, there were no projects that required state of Nevada notifications. The annual estimate for non-scheduled asbestos demolition/renovation projects for fiscal year 2002 was sent to EPA Region 9 in November 12, 2001.

RCRA requirements were met through an operating permit for hazardous waste storage and explosives ordnance disposal. NTS operations also include mixed waste storage through a Consent Agreement between NNSA and the state of Nevada.

As there are no liquid discharges to navigable waters, offsite surface water drainage systems, or publicly owned treatment works, no CWA 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 regularly tested for biochemical oxygen demand, pH, and total suspended solids. In addition to the state-required monitoring, these influents were also tested for RCRA related constituents as an internal initiative to further protect the NTS environment. The state inspected permitted sewage lagoons on July 2 and 3, 2002, with no findings noted.

There were no formal state inspections of NTS equipment regulated by the state air quality permit.

In compliance with the SDWA and five drinking water supply system permits from the state, the onsite distribution systems supplied by onsite wells are sampled either monthly or quarterly for coliform bacteria and water quality parameters, depending on the status as a community or non-community system.

1.2 COMPLIANCE ACTIVITIES

NNSA/NSO is required to comply with various environmental laws and regulations in the conduct of its operations. Monitoring activities required for compliance with the CAA, CWA, SDWA, Toxic Substance Control Act, and RCRA are summarized above. Endangered Species Act activities include compliance with the United States Fish and Wildlife Service (USFWS) Biological Opinion on NTS Activities and the Biological Opinion on Fortymile Canyon Activities. During CY 2002, NNSA/NSO processed 64 NEPA Checklists; 29 proposed actions met the requirements for categorical exclusion from further analysis, 33 proposed actions were determined to be adequately addressed in the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (NTS EIS) and 2 were addressed by other existing NEPA documents. In addition, in July 2002, NNSA/NSO completed a Supplement Analysis of the NTS EIS and determined that al ongoing and reasonably foreseeable actions were addressed by the NTS EIS and a supplemental EIS was not required. In September 2002, NNS/NSO completed an update of the November 1996 environmental assessment for the Hazardous Materials Spill Center (HSC) and found no significant impacts.

Wastewater discharges at the NTS are not regulated under NPDES permits, because all such discharges are to onsite sewage lagoons or septic tanks. Discharges to these lagoons are permitted under the Nevada Water Pollution Control Act, while discharges to septic tanks are permitted under NAC 444.750-444.8396. Wastewater discharges from the non-NTS support facilities (North Las Vegas Facility, Remote Sensing Laboratory [RSL]-Nellis, RSL-Andrews, and Special Technologies Laboratory) were within the regulated levels established by city or county publicly owned treatment works.

The Cultural Resources Management Program ensures compliance with all applicable federal laws, regulations, and executive orders. The primary directives come from the National Historic Preservation Act, Archeological Resources Protection Act, Native American graves Protection and Repatriation Act, and the American Indian religious Freedom Act. There is an active consultation program with the Nevada State Historic Preservation Officer and 17 trial groups and organizations.

The Ecological Monitoring and Compliance Program monitoring tasks, which were selected for 2002, included habitat mapping of the NTS, characterizing the natural wetlands on the NTS, conducting a census of the horse population, surveying bat species, surveying for raptors, and periodically monitoring man-made water sources to assess their effects on wildlife. Reviews of spill test plans for the HSC were also conducted.

The annual compliance report for CY 2002 NTS activities was prepared and submitted to the USFWS.

Pollution prevention activities conducted in CY 2002 at the NTS and its offsite facilities involve active programs for recycling, material exchange, and waste minimization.

1.3 GROUNDWATER PROTECTION

No radioactivity was detected above background levels in the groundwater sampling network surrounding the NTS. Low levels of tritium, in the form of HTO, were detected in onsite wells used only for monitoring purposes and not for drinking water.

Because wells that were drilled for water supply or exploratory purposes are used in the NTS monitoring program, rather than wells drilled specifically for groundwater monitoring, a program of well drilling for groundwater characterization at the NTS is underway. The design of the program is for installation or recompletion of groundwater characterization wells at strategic locations on and near the NTS.

Related activities included studies of groundwater transport of contaminants (radionuclide migration studies) and nonradiological monitoring for water quality assessment and RCRA requirements.

1.4 RADIOACTIVE AND MIXED WASTE STORAGE AND DISPOSAL

Two RWMSs are operated on the NTS: one each in Areas 3 and 5. During 2002, the RWMSs received LLW generated at the NTS and other NNSA/NSO facilities. Waste is disposed of in shallow pits and trenches in RWMS-5 and in subsidence craters in RWMS-3.

At RWMS-5, LLW is disposed of in standard packages. Transuranic (TRU) and TRU mixed wastes are stored on a curbed asphalt pad on pallets in over packed 55-gal drums and steel boxes. These will be characterized prior to shipment to the Waste Isolation Pilot Plant in New Mexico. The RWMS-3 is used for disposal of bulk LLW waste and LLW that is packaged, including packages that are larger than the specified standard size used at RWMS-5.

Environmental monitoring, at both sites, included air sampling for radioactive particulates and measurement of external exposure using TLDs. Water sampling and vadose zone monitoring for moisture and hazardous constituents are conducted at the RWMS-5, as is monitoring for tritium in atmospheric moisture. Environmental monitoring results for 2002 indicated that only measurable airborne tritium radioactivity from waste disposal operations was detectable in the immediate vicinity of the facilities. Mixed LLW is disposed of at the RWMS-5 in accordance with the NTS RCRA Part B permit.

Because the NTS is not a RCRA-permitted disposal facility, RCRA regulations require the shipment of nonradioactive hazardous waste to licensed disposal offsite facilities. Therefore hazardous waste is not disposed of onsite.

LLW is accepted for disposal only from generators (onsite and offsite) that have submitted a waste application that meets the requirements of the Waste Acceptance Criteria document (DOE 2002a) and that have received NNSA/NSO approval of the waste stream(s) for disposal at the NTS.

1.5 QUALITY ASSURANCE

It is the policy of the DOE NNSA/NSO that all data produced for its environmental surveillance and effluent monitoring programs be of known quality. Therefore, a quality assurance (QA) program is used for collection and analysis of samples for radiological parameters to ensure that data produced by the BN Subcontracted Radiochemistry Laboratory meets customer-and regulatory-defined requirements. Data quality is assured through process-based QA, procedure-specific QA, measurement quality objectives, and performance evaluation programs. The QA program for radiological data consists of participation in the Quality Assessment Program administered by the NNSA/NSO's Environmental Measurements Laboratory, the InterLaB RadCheM⊗ Proficiency Testing Program directed by Environmental Resource Associates, the Radiochemistry Intercomparison Program provided by the National Institute of Standards and Technology, and the Mixed Analyte Performance Evaluation Program conducted by the Idaho National Engineering and Environmental Laboratory. TLD radiation measurement QA for the program is assessed by the BN Dosimetry Group's participation in the NNSA/NSO's Laboratory Accreditation Program and intercomparisons provided by the Battelle Pacific Northwest National Laboratory during the course of the year.

1.6 ISSUES AND ACCOMPLISHMENTS

PRINCIPAL COMPLIANCE PROBLEMS FOR 2002

- Results in 2001 for lead were found above the SDWA action level in the Area 12, Building 12-43 drinking water systems. The water was restructured to non-potable use until the building was condemned and scheduled for demolishing in CY 2003.

- Engineering studies were initiated to protect the NTS public water systems from cross-connections with non-potable sources such as fire sprinkler systems.

ACCOMPLISHMENTS FOR 2002

- NEPA Environmental Evaluation Checklists were completed for 64 proposed projects.

- An updated EA for the HSC in Area 5 was completed.

- The EA for the Kistler Aerospace Corporation in Areas 18 and 19 was finalized and a Finding of No Significant Impact was issued by the Federal Aviation Administration.

- Conversions from sewage lagoons to septic tank/leach fields were completed for six systems in Areas 5, 6, 12, 22, and 25.

- FFACO actions included preparing 14 Post-Closure Monitoring Reports, 5 Closure Reports, 2 CAPs and 3 Safer Plans.

- A document revision to DOE Order 435.1-1 to incorporate lessons learned from the Maintenance and Operations Internal Assessment was completed.

- Thirteen tortoises were captured, measured, and weighed in the 21-acre circular enclosures in Rock Valley by a team of volunteer biologists led by the Southern Nevada Field Office of the USFWS.

- Throughout 2002, NNSA/NSO continued to maintain and update the "NNSA/NSO Compliance Guide" (Volume III), a handbook containing procedures, formats, and guidelines for personnel responsible for NEPA compliance activities.

1.7 CONCLUSION

The environmental monitoring results presented in this report document that operational activities on the NTS in 2002 were conducted so that no measurable radiological exposure occurred to the public in offsite areas. Calculation of the highest individual annual dose that could have been received by an offsite resident (based on estimation of onsite worst-case radioactive releases [totals listed in Table 1.1] obtained by measurement or engineering calculation and assuming the person remained outdoors all year) equated to 0.11 mrem to a person living in Cactus Springs, Nevada. If this same individual also was a hunter who ate a possession limit (20 each) of mourning doves from E Tunnel ponds and quail and jackrabbits from T2 site, he would also receive 1.24 mrem for a total of 1.35 mrem. This may be compared to that individual's exposure to 96 mrem/yr from natural background radiation (cosmic and terrestrial) as measured by the PIC instrument at Indian Springs, Nevada. When the doses (NCRP 1996) from the inhalation of naturally occurring radon in air (200 mrem/yr) and the internal radiation dose one receives from naturally occurring radionuclides in our body (40 mrem/yr) are included, the total natural background dose becomes 336 mrem/yr (96+200+40). The collective population dose to residents residing within 80 km of the NTS emissions was calculated as 0.42 person-rem/yr and compared to the population dose from the natural environmental background, 12,946 person-rem/yr. The results of the dose calculations are summarized in Table 1.2.

Table 1.1 Radionuclide Emissions on the NTS - 2002[(a)]

Radionuclide	Half-life (years)	Quantity Released (Ci)[(b)]
Airborne Releases:		
^{3}H	12.35	290[(c)]
$^{239+240}Pu$	24065.[(e)]	0.29[(d)]
^{241}Am	432.2	0.047[(d)]

(a) Assumes worst-case point and diffuse source releases; there were no unplanned releases.

(b) Multiply by 37 to obtain GBq.

(c) Estimated from air sampling results and evaporation of water from containment ponds.

(d) Calculated from the resuspension of surface deposits.

(e) This is the half-life of ^{239}Pu.

Table 1.2 NTS Radiological Dose Reporting - 2002

Pathway	Dose to Maximally Exposed Individual		Percent of DOE 100-mrem Limit	Estimated Population Dose		Population within 80 km	Estimated Natural Radiation Dose (person-rem)
	(mrem)	(mSv)		(person-rem)	(person-Sv)		
Air	0.11	0.0011	0.11	0.42	0.0042	35,566	12,946[(a)]
Air and Wildlife	1.35	0.0135	1.4	0.42	0.0042	35,566	12,946[(a)]

(a) Product of population within 80 km of NTS emissions and natural radiation dose (see Section 5.5 of Chapter 5.0).

2.0 INTRODUCTION

The Nevada Test Site (NTS) environment is characterized by desert valley and Great Basin mountain terrain and topography, with a climate, flora, and fauna typical of the southern Great Basin deserts. The key features that afford protection to the inhabitants of the adjacent areas from potential exposure to radioactivity or other contaminants resulting from operations on the NTS are restricted access, extended wind transport times, bounded on three sides by United States Air Force lands, and the general remote location of the NTS. Also, characteristic of this area are the great depths to slow-moving groundwater and little or no surface water. Population density within 80 km of the NTS is only 0.5 persons/km^2 versus approximately 29 persons/km^2 in the 48 contiguous states. The predominant use of land surrounding the NTS is open range for livestock grazing with scattered mining and recreational areas.

The NTS, located in southern Nevada was the primary location for the testing of devices containing nuclear materials in the continental United States from 1951 to 1992. Historically, nuclear testing has included, (1) atmospheric testing in the 1950s and early 1960s; (2) underground testing in drilled, vertical holes and horizontal tunnels; (3) earth-cratering experiments; (4) open-air nuclear reactor and engine testing; and (5) twelve underground tests for various purposes at other locations in the United States.

NTS activities in 2002 continue to be diverse, with the primary role being to help ensure that the existing United States stockpile remains safe and reliable. Facilities that support this mission include the U1a Facility, Big Explosives Experimental Facility (BEEF), 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), disposal of radioactive and mixed waste, and environmental research. In addition efforts continue to bring other business to the NTS, like aerospace and alternative energy technologies and support of Homeland Security National Center for Combating Terrorism work.

2.1 NTS SITE CHARACTERISTICS

The NTS, located in Nye County, Nevada, as shown in Figure 2.1, has been operated by the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office (NNSA/NSO), or its predecessors, as the on-continent test site for nuclear explosives testing since 1951. The southeast corner of the NTS is about 88 km (55 mi) northwest of the center of Las Vegas. By highway, it is about 105 km (65 mi) from the center of Las Vegas to Mercury. The NTS encompasses about 3,561 km^2 (1,375 mi^2), an area larger than the state of Rhode Island. The dimensions of the NTS vary from 46 to 56 km (28 to 35 mi) in width (eastern to western border) and from 64 to 88 km (40 to 55 mi) in length (northern to southern border). The NTS is surrounded on the east, north, and west sides by public exclusion areas, called the Nellis Air Force Range (NAFR) (see Figure 2.1). This area provides a buffer zone varying from 24 to 104 km (15 to 65 mi) between the NTS and public lands. The combination of the NAFR

Figure 2.1 Nevada Test Site Location in Nevada

and the NTS is one of the larger unpopulated land areas in the United States, comprising some 14,200 km^2 (5,470 mi^2). Figure 2.2 shows the general layout of the NTS, including the location of major facilities and the NTS Area numbers referred to in this report. The geographical areas previously used for nuclear testing are also indicated in Figure 2.2. Mercury, located at the southern end of the NTS, is the main base camp for worker housing and administrative operations for the NTS.

2.2 TOPOGRAPHY AND TERRAIN

The NTS terrain is typical of much of the Basin and Range physiographic province in Nevada, Arizona, and Utah. There are north to northeast trending mountain ranges separated by gentle sloping linear valleys and broad flat basins at the NTS. The principal valleys within the NTS are Frenchman Flat, Yucca Flat, and Jackass Flats, with the principal highlands consisting of Pahute Mesa, Rainier Mesa, Timber Mountain, and Shoshone Mountain. A large portion of the NTS ranges in elevation from about 914 to 1,219 m (3,000 to 4,000 ft) in the valleys to the south and east to 1,676 to 2,225 m (5,500 to 7,300 ft) in the high country toward the northern and western boundaries.

Surface drainage for Yucca and Frenchman Flats (east side of the NTS) are closed-basin systems that drain onto the dry lake beds (playas) in each valley. The remaining area on the western side of the NTS drains via arroyos and dry stream beds that carry water only during unusually intense or persistent storms. There are no continuously flowing streams on the NTS.

One notable feature of Yucca Flat is the formation of numerous dish-shaped surface subsidence craters as a direct result of nuclear testing (other areas on the NTS are affected on a much smaller scale). Most underground nuclear tests conducted in vertical shafts (also cratering experiments or following some tunnel tests) produced surface subsidence craters that occurred when the overburden above a nuclear cavity collapsed and formed a rubble "chimney" to the surface.

2.3 PRECIPITATION

The NTS is between the northern boundary of the Mojave Desert and the southern limits of the Great Basin Desert. This Transitional Desert is considered to be typical of either Dry Mid-latitude or Dry Subtropical climatic zones. The climate is characterized by low precipitation, a large diurnal temperature range, a large evaporation rate, and moderate to strong winds.

Most precipitation in the Transitional Desert occurs in winter and summer. Winter precipitation is generally associated with transitory low-pressure systems originating from the west and occurring as uniform storms over large areas (snowfall to elevations below 5,000 feet in the strongest of these storms). Summer precipitation is generally associated with convective storms originating from the south or southwest and occurring as intense local storms. The average annual precipitation ranges between three and ten inches, depending on elevation. Lower values of this range are typical in valleys, whereas higher values are typical in the surrounding mountains.

2.4 TEMPERATURE

Elevation influences temperatures on the NTS, with higher elevations having a higher sustained cooler temperature and the lower elevations having a higher sustained warmer temperature. At an elevation of 2,000 m (6,560 ft) Pahute Mesa recorded a maximum temperature of 39 °C (102 °F) and a minimum temperature of -11 °C (11 °F). The average maximum temperature was 16 °C (61 °F) and the average minimum was 5 °C (41 °F). In the Yucca Flat basin at an elevation

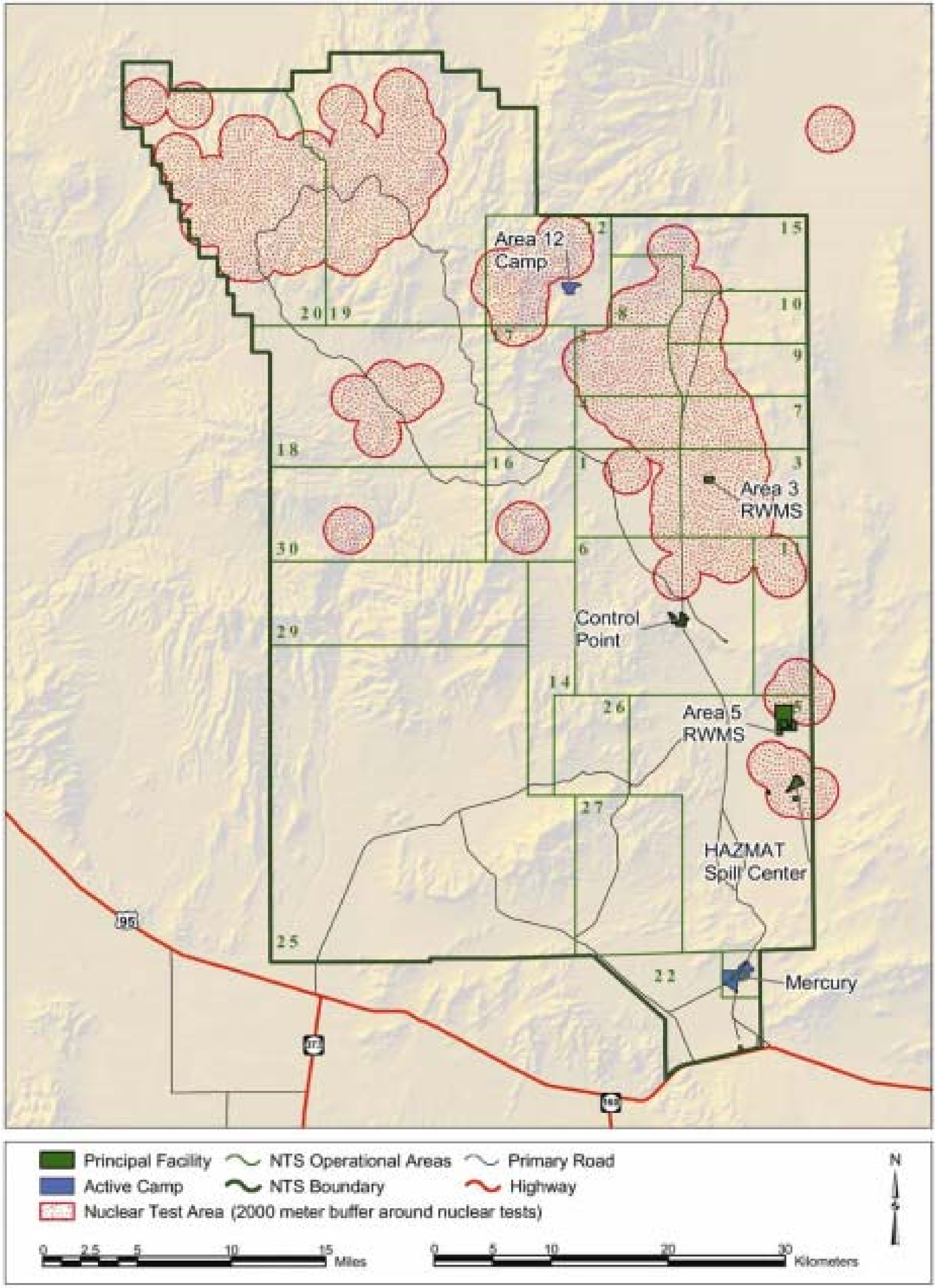


Figure 2.2 Nevada Test Site Operational Areas, Principal Facilities and Testing Areas

of 1,195 m (3,920 ft), the maximum temperature recorded was 48 °C (118 °F) and the minimum temperature was -13 °C (8 °F). The average maximum temperature was 23 °C (73 °F) and the average minimum was 3 °C (38 °F). The annual average temperature in the NTS area is 19 °C (66 °F). Monthly average temperatures range from 7 °C (44 °F) in January to 32 °C (90 °F) in July.

2.5 WIND

Winds are primarily southerly during summer months and northerly during winter months. Wind velocities tend to be greater in the spring than in the fall. At the Yucca Playa station, the average annual wind velocity was 11 kph (7 mph); the maximum wind velocity was nearby at the Meteorological Data Acquisition System Station 4 at 137 kph (85 mph). At Area 20 Camp on Pahute Mesa, the average annual wind velocity was 16 kph (10 mph) miles per hour; the maximum wind velocity was 83 kph (52 mph). The multi-year wind roses (1981-2001) for selected locations on the NTS are shown in Figure 2.3 as representative of the winds during 2002.

2.6 EVAPORATION

Evaporation at the NTS is high in the flats (Frenchman, Yucca, and Jackass) because of the large incident solar radiation and wind. Potential evaporation is evaporation at a potential, or energy-limiting rate; it is calculated using any of a number of available equations. The potential evaporation usually exceeds ten times the annual precipitation on the valleys of the NTS.

2.7 GEOLOGY

The NTS is located in the south central part of the Great Basin section of the Basin and Range physiographic province. The topography of this province is characterized by north- to northeast-tending mountain ranges, separated by broad, linear valleys and is evident on the eastern portion of the NTS. In the vicinity of the NTS, this series of ridges and valleys is locally disrupted by a large volcanic plateau and an associated complex of overlapping collapse calderas.

During the Paleozoic Era, the NTS region was part of the Cordilleran miogeosyncline, a subsiding trough on the submerged western edge of the North American continent. This miogeosyncline, extending from Mexico to Alaska, received thousands of feet of shallow water deposition, derived from erosion of the nearby continental land mass. As a result, in excess of 30,000 feet of Paleozoic clastic and carbonate rocks was deposited in the NTS region. During the Mesozoic Era, these rocks were complexly folded and thrust faulted in several periods of compressional deformation. The CP Thrust and the Mine Mountain Thrust are the major thrust faults formed during this time in the NTS region. These episodes of mountain building were accompanied by intrusions of granitic plutons, which are represented by the Climax, Twin Ridge, and Gold Meadows stocks on the NTS.

A major period of silicic volcanism began in the central portion of the Great Basin approximately 40 million years ago and spread outward through time. The dominant volcanic activity in the NTS region began about 16 million years ago and continued at least until 0.25 million years ago. A complex of six collapsed calderas, five of which overlap, was active along the western portion of the NTS between 6 and 16 million years ago. Ash flow tuffs that erupted from these centers exceed 15,000 ft thickness under Pahute Mesa, a volcanic plateau in the northwestern portion of the NTS. A transition to basalt eruptions occurred approximately 6 million years ago.

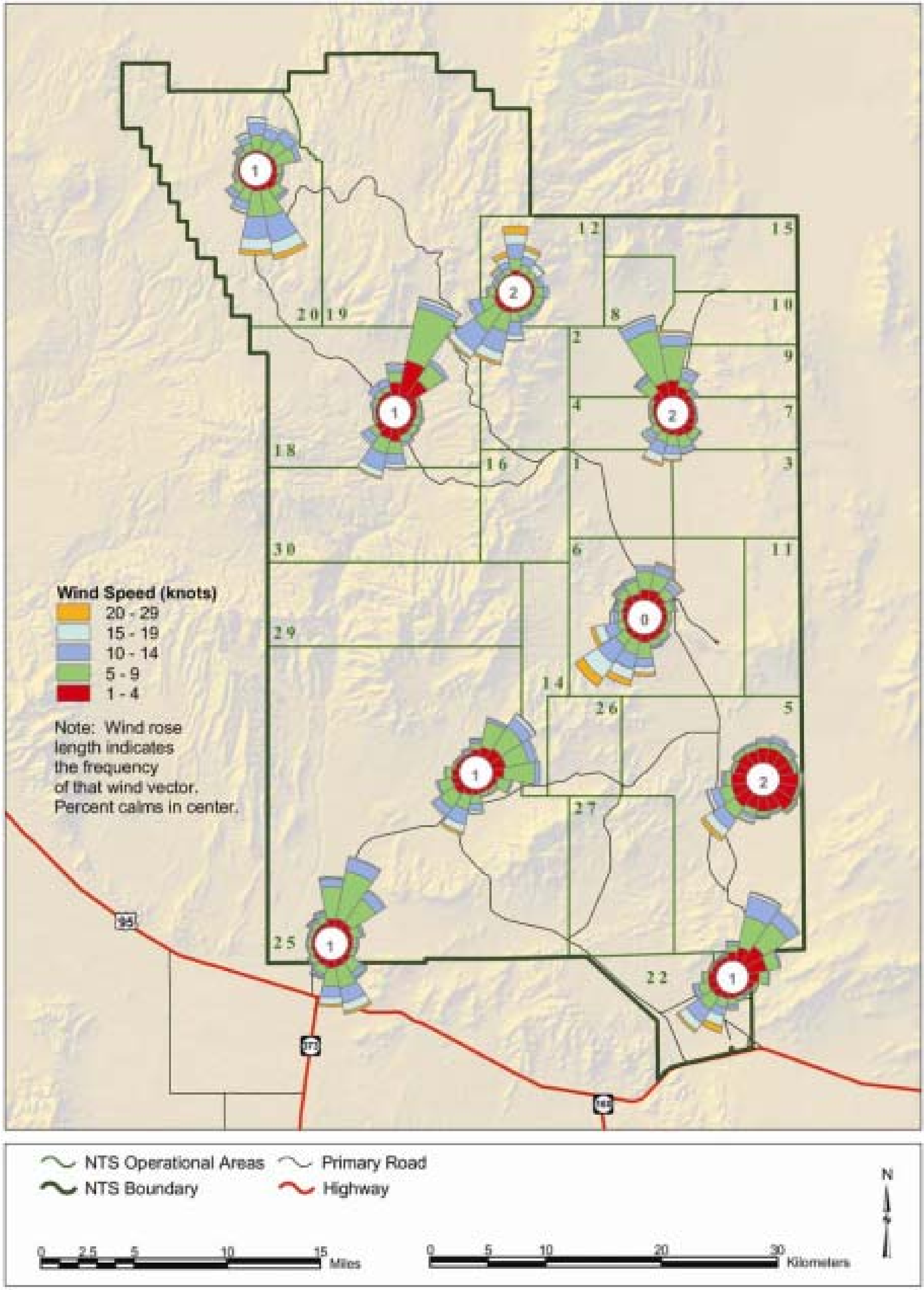


Figure 2.3 Annual Climatological Wind Rose Patterns for the NTS - 2002

The crustal extension which produced north- to northeast-tending normal faults began between 17 and 14 million years ago in southern Nevada. Uplift and subsidence along these faults resulted in the present-day system of mountain ranges and topographically closed basins. Alluvium and colluvium from the mountain ranges have filled the basins to depths of several hundred meters or more.

Refer to Chapter 7.0 of this report for a detailed overview of the geology of the NTS.

2.8 HYDROGEOLOGY

Depths to groundwater under the NTS vary from about 210 m (690 ft) beneath the Frenchman Flat playa (Winograd and Thordarson 1975) in the southern part of the NTS to more than 700 m (2,300 ft) beneath part of Pahute Mesa. In the eastern portions, the water table occurs generally in the alluvium and volcanic rocks above the regional carbonate aquifer and is characterized by regional flow from the upland recharge area in the north and east, towards discharge areas at Ash Meadows and Death Valley. In the western portion of the NTS, the water table occurs predominantly in volcanic rocks and moves in a southerly direction toward Oasis Valley, Crater Flat, and/or western Jackass Flats.

Groundwater is the only local source of drinking water in the NTS area. Drinking and industrial water supply wells for the NTS produce from the lower and upper carbonate aquifers and the volcanic and the valley-fill aquifers. Although a few springs emerge from perched groundwater lenses at the NTS, discharge rates are low, and spring water is not used for NNSA/NSO activities. North and south of the NTS, private and public supply wells are completed primarily in the valley-fill aquifers.

2.9 FLORA AND FAUNA

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. Vegetation associations characteristic of the Mojave Desert occur over the southern third of the NTS, on bajadas and mountain ranges at elevations below about 4,000 feet. 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 28.5° F or the extreme minimum is less than 1° F. It is also limited to zones with an average rainfall of 7.2 inches or less (Beatley, 1974). Between elevations of 4,000 to 5,000 feet, 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., 2001). Above 5,000 feet, 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 6,000 feet, 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.

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). Twenty of these have field indicators (hydrophytic vegetation, wetland hydrology, and hydric soils) that qualify them to be classified by the U.S. Army Corps of Engineers as jurisdictional wetlands which fall under the regulatory authority of the Clean Water Act of 1977.

There are 59 species of mammals on the NTS. Rodents account for about 40 percent of the known species, and in terms of distribution and relative abundance, are the most important group of mammals on the NTS (Wills and Ostler, 2001). Larger mammals include feral horses, mule deer, mountain lions, bobcats, coyote, kit foxes, and rabbits, among others. No native fish or amphibians 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. 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).

The desert tortoise (*Gopherus agassizii*) is listed as threatened under the Endangered Species Act. Habitat of the desert tortoise is in the southern third of the NTS. Most non-rodent mammals of the NTS are protected by the state of Nevada and managed as either game or furbearing mammals. Many bats of the NTS are considered species of concern by the U.S. Fish and Wildlife Service. Virtually all birds on the NTS are protected by federal legislation under the Migratory Bird Treaty Act and/or by the state of Nevada.

2.10 CULTURAL RESOURCES

Human habitation of the NTS area began at least as early as 10,000 years ago. Various indigenous cultures occupied the region in prehistoric times. The survey of less than 5 percent of the NTS area has located more than 2,000 archaeological sites. The site types identified include rock quarries, tool-manufacturing areas, plant-processing locations, hunting locales, rock art, temporary camps, and permanent villages. The prehistoric peoples' lifestyle was sustained by a hunting and gathering economy, which utilized all parts of the NTS.

While major springs provided perennial water, the prehistoric people developed strategies to take advantage of intermittent fresh water sources in this arid region. In the nineteenth century, at the time of initial contact, the area was occupied by Southern Paiute and Western Shoshone Indians. Prior to 1940, the historic occupation consisted of ranchers, miners, and Native Americans. Several natural springs were able to sustain livestock, ranchers, and miners. Stone cabins, corrals, and fencing stand today as testaments to these early settlers. The mining activities included two large mines: one at Wahmonie, the other at Climax Mine. Prospector claim markers are found in these and other parts of the NTS. Wahmonie was the last mining boom town on the NTS and existed for only a short time in the 1920's. Native Americans coexisted with the settlers and miners, utilizing the natural resources of the region and, in some cases, working for the new arrivals. They also maintained a connection with the land, especially areas important to them for religious and historical reasons. These locations, referred to as traditional cultural properties, continue to be significant to the Paiute and Shoshone Indians.

2.11 NTS NUCLEAR TESTING HISTORY

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 as the primary location for testing the Nation's nuclear explosive devices. 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, or dropped from an aircraft. Several tests were categorized as "safety experiments", and storage-transportation tests, involving the destruction of a nuclear device with nonnuclear 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, and four others, involving transport/storage safety, lie at the north end of the NAFR. All nuclear device tests are listed in United States Nuclear Test, July 1945 through September 1992 (DOE 2000a).

The first underground test, a cratering test was conducted in 1951. The first test totally contained underground 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. 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. There have been no United States nuclear explosive tests since September 1992.

Other nuclear testing history at the NTS has included the Bare Reactor Experiment - Nevada series in the 1960s. These tests were performed with a 14-MeV neutron generator mounted on a 465-m (1,530-ft) 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.

2.12 SURROUNDING AREAS

Figure 2.4 is a map of the offsite area showing a variety of lands uses and the various governmental agencies responsible for managing the land. The lands, with the exception of the Department of Defense and NNSA/NSO, are open to a wide variety of uses such as farming, mining, grazing, camping, fishing and hunting, within a 300-km (180-mi) radius of the Control Point-1 (CP-1).

2.13 DEMOGRAPHY

The population of the area surrounding the NTS has been estimated by the Nevada State Demographer Office (2002 Official Estimate) and is predominantly rural. Nevada annual populations estimate for Nevada counties, cities, and unincorporated towns is 2,206,022, with all but 656,365 residing in Clark County. Excluding Clark County, the major population center, the population density within a 150-km (90-mi) radius of the NTS is about 0.5 persons/km^2. In comparison, the 48 contiguous states (1990 census) had a population density near 29 persons/km^2. Several small communities are located in the areas of (populations in parenthesis), Alamo (442), Amargosa (1,171), Beatty (1,089), Goldfield (438), Indian Springs (1,557), Pahrump (27,527), and Tonopah (2,422). The largest of these communities is Pahrump Valley, which is approximately 50 mi (80 km) south of the NTS CP-1, which is near the center of the NTS.

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 swell the population more than 5,000 on any particular day during holiday periods during mild weather.

Figure 2.4 Land Use Around the Nevada Test Site

The extreme southwestern region of Utah is more developed than the adjacent portion of Nevada. The largest community is St. George, located 220 km (137 mi) east of the NTS, with a population of 49,600. The next largest town, Cedar City, with a population of 20,500, is located 280 km (174 mi) east-northeast of the NTS. 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 22,000, and Kingman, located 280 km (174 mi) southeast of the NTS, with a population of about 13,000.

2.14 MISSION AND NATURE OF OPERATIONS

The present mission of the NNSA/NSO is described by the following five statements:

- **National Security:** support the Stockpile Stewardship Program through subcritical and other weapons physics experiments, emergency management, test readiness, work for other national security organizations, and other experimental programs.
- **Environmental Management:** support environmental restoration, groundwater characterization, and low-level radioactive waste management.
- **Stewardship of the NTS:** manage the land and facilities at the NTS as a unique and valuable national resource.
- **Technology Diversification:** support nontraditional Departmental programs and commercial activities which are compatible with the Stockpile Stewardship Program.
- **Energy Efficiency and Renewable Energy:** support the development of solar energy, alternative fuel, and energy efficiency technologies.

2.15 STOCKPILE STEWARDSHIP

There were four subcritical experiments during CY 2002, which involved small amounts of special nuclear material that does not reach the fissioning stage during the experiment. In addition, construction was completed on JASPER and turned over to Lawrence Livermore National Laboratory in June 2002.

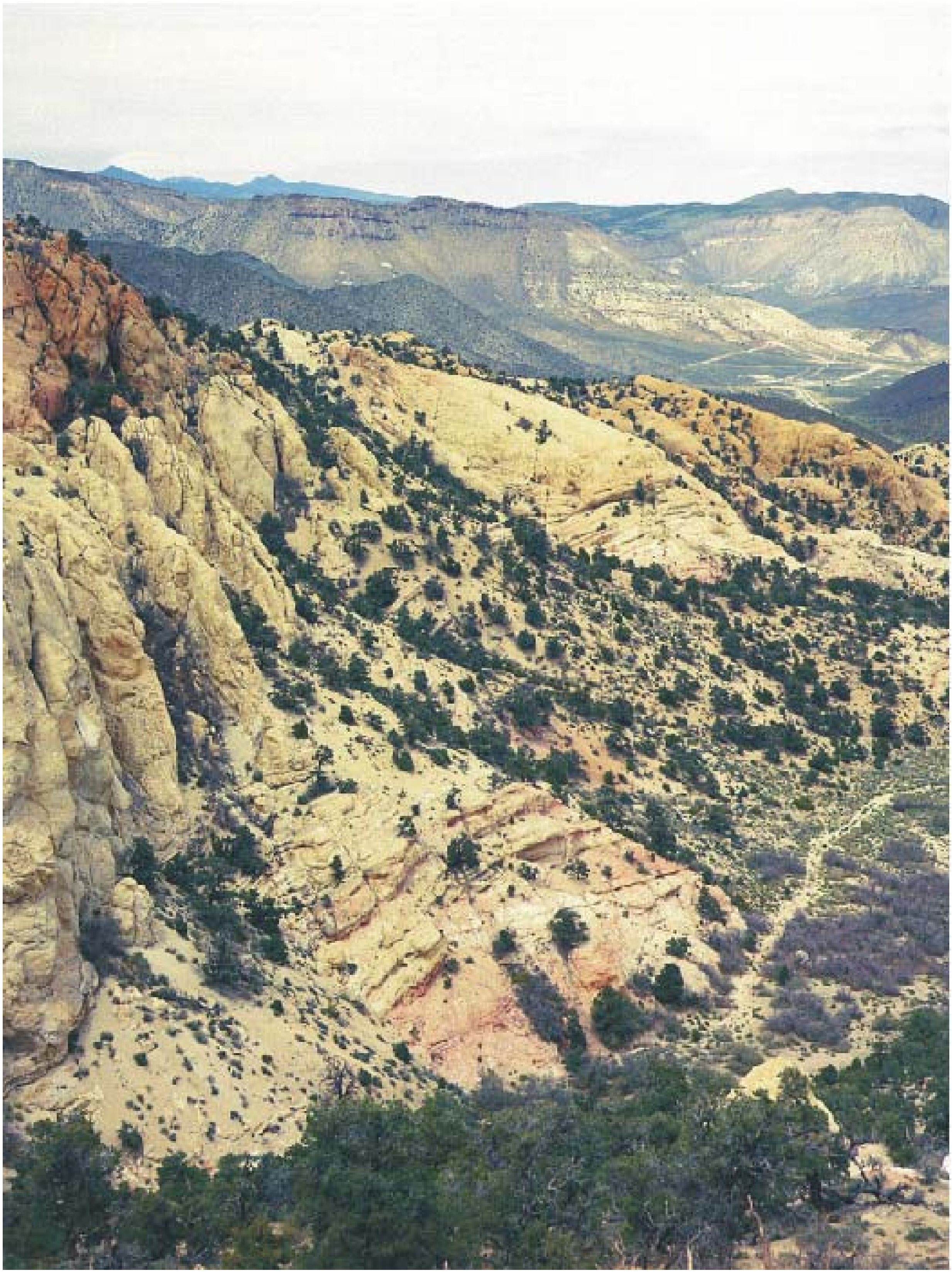
2.16 ENVIRONMENTAL MANAGEMENT

The Environmental Restoration efforts included remediating 21 industrial sites. The Underground Test Area program completed three holes and continued work on modeling efforts.

Approximately 1,769,824 cubic feet of low-level waste were disposed of at the Area 3 and Area 5 Radioactive Waste Management Sites (1,722 shipments) from offsite generators.

2.17 HAZARDOUS MATERIALS SPILL CENTER (HSC)

The NNSA/NSO's HSC is a research and demonstration facility available on a user-fee basis to private and public sector test and training sponsors concerned with the safety aspects of hazardous chemicals. The site is located in Area 5 of the NTS and is maintained by Bechtel Nevada. The HSC is the basic research tool for studying the dynamics of accidental releases of various hazardous materials.



Rainier Mesa (No Date Provided)

3.0 COMPLIANCE SUMMARY

Environmental compliance activities at the Nevada Test Site (NTS) during calendar year (CY) 2002 involved the permitting and monitoring requirements of numerous state of Nevada and federal regulations. Primary activities included the following: (1) National Environmental Policy Act (NEPA) documentation preparation; (2) Clean Air Act (CAA) compliance for asbestos renovation projects, radionuclide emissions, and state air quality permits; (3) Clean Water Act (CWA) compliance involving state wastewater permits; (4) Safe Drinking Water Act (SDWA) compliance involving monitoring of drinking water distribution systems; (5) Resource Conservation and Recovery Act (RCRA) and Federal Facility Compliance Act (FFCA) management of hazardous wastes; (6) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) reporting; (7)Toxic Substances Control Act (TSCA) management of polychlorinated biphenyls; (8) Endangered Species Act (ESA) compliance involving the conduct of pre-construction and site-wide surveys to document the status of state and federally listed endangered or threatened plant and animal species; and (9) National Historic Preservation Act (NHPA), Archaeological Resources Protection Act, and the Native American Graves Protection and Repatriation Act compliance for the protection of Cultural and Native American Resources. There were no activities requiring compliance with Executive Orders (EOs) on Flood Plain Management or Protection of Wetlands.

Throughout CY 2002 the NTS was subject to several formal compliance agreements with various regulatory agencies. Agreements with Nevada include a Memorandum of Understanding covering releases of radioactivity; a Federal Facilities Agreement and Consent Order (FFACO); an Agreement in Principle with the state of Nevada supporting environmental compliance, public health, and emergency management programs; a Settlement Agreement to manage mixed transuranic (TRU) waste; and a Mutual Consent Agreement on management of mixed land disposal restriction (LDR) wastes, among others. Emphasis on pollution prevention (P2) and waste minimization at the NTS continued in 2002.

Compliance activities at non-NTS facilities of the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office (NNSA/NSO) involved the permitting and monitoring requirements of (1) the CAA for airborne emissions, (2) the CWA for wastewater discharges, (3) SDWA regulations, (4) RCRA disposal of hazardous wastes, (5) hazardous substance reporting, and (6) solid waste disposal. P2 and waste minimization efforts continued at all locations.

3.1 COMPLIANCE STATUS

NATIONAL ENVIRONMENTAL POLICY ACT

Section 102 of NEPA requires Federal agencies to consider environmental effects of major federal actions that may impact the human environment. The Council on Environmental Quality's "Regulations for Implementing the Procedural Provisions of the National Environmental Policy

Act" (40 CFR 1500-1508) identifies two levels of NEPA documentation: (1) an environmental impact statement (EIS) is a full disclosure of the potential environmental effects of a proposed action and reasonable alternatives and includes strict procedural and public involvement provisions; and (2) an environmental assessment (EA) is a concise discussion of proposed actions and alternatives and the potential environmental effects to determine if an EIS is necessary. Agencies may develop categorical exclusions for classes of actions that have been found to have no adverse environmental impacts, based on similar previous activities. The goal of NEPA is to facilitate better decisions by federal managers by incorporating environmental considerations into the decision making process.

NNSA/NSO Order 451.1 requires that project managers complete a NEPA Environmental Evaluation Checklist for all proposed actions. The Checklist is reviewed by the NNSA/NSO NEPA compliance Officer to determine whether the proposed action is adequately addressed in the NTS EIS or other existing NEPA document or if it would fit within a class of actions that may be categorically excluded from further NEPA analysis. For proposed actions that neither are addressed by the NTS EIS nor fit within a categorically excluded class of actions, the NNSA/NSO NEPA Compliance Officer recommends to the Manager that either an EA or EIS be prepared. During CY 2002, 64 NEPA environmental Evaluation Checklists were processed by NNSA/NSO. In addition to processing these checklists, NNSA/NSO completed an EA and issued a Finding of No Significant Impact (FONSI) for the Hazardous Materials Spill Center (HSC) in Area 5 of the NTS in July 2002. NNSA/NSO was a Cooperating Agency and major contributor to an EA prepared by the Federal Aviation Administration (FAA) for a proposed apace vehicle launch and recovery facility by Kistler Aerospace Corporation, which would be located in Areas 18 and 19 of the NTS. FAA issued the final EA and FONSA in April 2002.

In July 2002, NNSA/NSO completed the Five-year Supplement Analysis (SA) for the NTS EIS. Based upon the SA, the NNSA/NSO determined that "there are no substantial changes to the NTS EIS or Record of Decision of significant new circumstances or information relevant to environmental concerns and that no supplemental EIS is needed."

CLEAN AIR ACT

The CAA and the state of Nevada air quality control compliance activities were limited to asbestos abatement, radionuclide monitoring, reporting under the National Emission Standards for Hazardous Air Pollutants (NESHAP), and air quality permit compliance requirements. There were no criteria pollutants or prevention of significant deterioration monitoring requirements for NTS operations. In 2002, the NNSA/NSO submitted a Title V, Class II air permit application to the state of Nevada.

NTS NESHAP Asbestos Compliance

The state Division of Occupational Safety and Health regulations (Nevada Administrative Code [NAC] 618.850, 1989) require that all asbestos abatement projects in Nevada, involving friable asbestos in quantities greater than or equal to three linear feet or three square feet, submit a Notification Form. However, federal facilities are exempt from this requirement, and notification for asbestos abatement projects on the NTS is not necessary. Notification, however, is required to the U.S. Environmental Protection Agency (EPA) Region 9 for projects which disturb greater than 260 linear feet or 160 square feet of asbestos-containing material, in accordance with Title 40 CFR 61.145-146 (CFR 1989).

The annual estimate for non-scheduled asbestos demolition/renovation for fiscal year (FY) 2002 was sent to EPA Region 9 on November 21, 2001. There were no projects in FY 2002 that required notification to EPA Region 9 for removal of 260 linear feet or 160 square feet or more of asbestos-containing material.

Radioactive Emissions on the NTS

NTS operations were conducted in compliance with the NESHAP radioactive air emission standards of Title 40 CFR 61 Subpart H, which requires that the radiation dose to any member of the public from airborne radioactivity emissions is not to exceed 10 mrem/yr. In compliance with those requirements, a report on airborne radioactive effluents is provided to DOE/HQ and to EPA's Region 9.

During CY 2002, the sources of emissions were identified as: (1) tritium gas released from Area 6 CP-50 equipment calibrations; (2) evaporation of tritiated water (HTO) from containment ponds; (3) diffusion of HTO vapor from the Area 5 Radioactive Waste Management Site (RWMS-5), SEDAN crater in Area 10, SCHOONER crater in Area 20; and (4) resuspension of plutonium and americium from contaminated soil at nuclear device safety test and atmospheric test locations. As explained in the NESHAP report for 2002 (Grossman 2003), the airborne emissions of HTO vapor from the containment ponds were conservatively reported as if all the liquid discharges into the ponds had evaporated and become airborne. For HTO vapor diffusing from the RWMS-5, SEDAN, and SCHOONER, and plutonium/americium particulate resuspension from various areas on and near the NTS, the airborne effluents were conservatively estimated from air sampling measurements and CAP88-PC calculations.

From these conservative estimates of air emissions, the effective dose equivalent reported for CY 2002 was calculated to be only 0.11 mrem (1.1×10^{-3} mSv), much less than the 10-mrem limit that is specified in Title 40 CFR 61.

NTS Air Quality Permit Compliance

Compliance with air quality permits is accomplished by adhering to record keeping and reporting requirements and through renewal and ongoing verification of operational compliance with permit-specified limitations. A list of active NTS air quality permits appears in Table 3.1. Common air pollution sources at the NTS include aggregate production, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities and releases of various chemical at the HSC..

Quantities of emissions from operations at the NTS are calculated and submitted each year to the state of Nevada using forms provided by the state. The report also includes aggregate production amounts, operating hours of permitted equipment, and information for all ground surface disturbances of five acres or greater. During 2002, approximately 33 tons of pollutants were estimated to be emitted from permitted operations at the NTS. The CY 2002 Air Quality Permit Data Report was sent to the state of Nevada in February 2003.

One of the conditions of the permit is to allow the state of Nevada Bureau of Air Quality personnel access to the NTS to conduct inspections of facilities and operations regulated by state air permits. During 2002, there was one state inspection of NNSA/NSO facilities possessing air quality permits. There were no violations.

Monthly visible emission readings are a requirement of the NTS air quality operating permit, AP9711-0549. The permit limits particulate emissions to 20 percent opacity, except at the Area 1 Aggregate Plant, where portions of the Plant have a limit of 10 percent. Certification of personnel to perform valid visible emission opacity evaluations is required by the state, with recertification required every six months. During 2002, four employees from Bechtel Nevada (BN) were recertified, and several visible emission evaluations of permitted air quality point sources were conducted. The opacity limit was exceeded once in 2002 at the classified material incinerator. When the opacity limit was exceeded in 2001, the incinerator was placed out of service. Repairs were made to correct a leaking seal and other problems. Permission was received from the state to conduct a test burn in 2002. The opacity limit once again exceeded the three-minute 20 percent limit, and the state was notified. Subsequent repairs and another test burn in 2002 resulted in opacities that were within the 20 percent limit. No violations were issued by the state.

Non-NTS Air Quality Permit Compliance

Under normal conditions, the six non-NTS facilities operated by BN do not produce radioactive effluents. The six are, the North Las Vegas Facility (NLVF) and Remote Sensing Laboratory (RSL) at Nellis Air Force Base in North Las Vegas, Nevada; Special Technologies Laboratory (STL) in Santa Barbara, California; Livermore Operations (LO) in Livermore, California; Los Alamos Operations (LAO) in Los Alamos, New Mexico; and RSL Andrews Air Force Base in Washington, D.C. The NLVF and RSL-Nellis are regulated for the emission of criteria pollutants and maintain air quality operating permits for a variety of equipment that mainly includes boilers and generators (Table 3.2). Twelve air quality operating permits were required for operations at the NLVF and RSL-Nellis during 2002. There was no effluent monitoring requirements associated with these permits.

No air permits were held or required for the LO, LAO, or RSL-Andrews facilities in 2002.

CLEAN WATER ACT

The Federal Water Pollution Control Act, as amended by the CWA, establishes ambient water quality standards and effluent discharge limitations, which are generally applicable to facilities that discharge any materials into the waters of the United States (CFR 1977). Discharges from NNSA/NSO facilities are primarily regulated under the laws and regulations of the facility host states. Monitoring and reporting requirements are typically included under state or local permit requirements. A list of applicable permits appears in Tables 3.3, 3.4, and 3.5. There are no National Pollutant Discharge Elimination System permits for the NTS, as there are no wastewater discharges to onsite or offsite surface waters.

NTS Operations

Discharges of wastewater are regulated by the state under the Nevada Water Pollution Control Law (Nevada Revised Statutes 1977). The state of Nevada also regulates the design, construction, and operation of wastewater collection systems and treatment works. Wastewater monitoring at the NTS was limited to sampling wastewater influents to sewage lagoons and containment ponds.

State general permit GNEV93001 (Table 3.3), which regulates the ten usable sewage treatment facilities on the NTS, was issued by the Nevada Division of Environmental Protection (NDEP) and became effective on February 1, 1994. The general permit was renewed for five years on December 7, 1999. The permit was structured to allow the NNSA more flexibility in bringing new industrial processes on line.

Construction and permitting of several new septic tank/leachfield systems was completed in 2002. Each individual system can handle flows of 5,000 gallons per day.

Existing septic systems permitted in 2002 included the Area 22 Desert Rock Airport.

The Area 23 sewage lagoon system proceeded with design changes to eliminate the six primary lagoons. The conversion was completed in the first quarter of 2002. A new flow meter was also installed.

State inspections of the permitted sewage lagoons were conducted on July 2 and 3, 2002. No findings were noted. All lagoons were being operated in a safe and compliant manner. Permit requirements for quarterly, toxic, and groundwater monitoring were completed. Permit limits were met for all monitoring events, except the groundwater monitoring conducted during the first quarter of 2002. Monitoring well parameters for chromium, iron, and manganese were exceeded. Monitoring performed at the same time for the landfill permit (similar parameters) indicated an anomaly. Sampling notes indicated a discrepancy in purge volumes. In the second quarter (April 2002) the well was resampled (following an adequate purge) and all parameters were within permit limits.

Septic hauler permits for the NTS were renewed in 2002 (Table 3.5).

There are 20 wetlands on the NTS (vegetated wetlands) and two intermittently wet lakes or mudflats (Yucca Lake and Frenchman Lake) which are considered "waters of the United States" (specifically not vegetated), which fall under the jurisdiction of the United States Army Corps of Engineers. A Section 404 Permit (Clean Water Act) would be required for any physical alteration of these wetlands or lakebeds. The process of permitting is facilitated by nationwide permits that provide template documents for standard maintenance projects such as replacement of bridges, culverts, and pipelines or buried communication cables. More involved construction projects (e.g., construction of facilities and alteration of drainage patterns for roads) require a more detailed and involved permitting process with considerable lead time (e.g., 12 to 24 months) and may include notification and/or consultation with other U.S. Government agencies.

Non-NTS Operations

Three permits for wastewater discharges were held by non-NTS facilities. One permit is required for the NLVF, and the STL holds wastewater permits for the Botello Road and Ekwill Street locations (Table 3.3). Additionally, a new permit was issued to the RSL-Nellis. No wastewater permits were required for the LO, LAO, or RSL-Andrews facilities in 2002.

The Wastewater Contribution Permit for NLVF (VEH-112) was renewed in 2001. This permit expires in December 2006. In September 2002, self-monitoring was conducted. Outfall B permit limits were exceeded for cadmium, copper, lead, zinc, and total suspended solids.

Outfall B was resampled by NNSA/NSO in October 2002 and by the city of North Las Vegas in November 2002. All results were within permit limits. The Outfall B sewer lines were back washed and vacuumed in December 2002 and considerable sediment was removed. A final monitoring episode was completed in January 2003 and all results were within permit limits. It was concluded that sediment buildup in a relatively flat section of the line had trapped metals from the degradation of plumbing components, and these metals were released due to higher than normal flows. A preventative maintenance schedule will be initiated in 2003 to flush these lines on a regular basis.

The pretreatment permit (Clark County Sanitation District [CCSD]-080) was renewed by the CCSD pursuant to the Categorical Pretreatment regulations. The permit is good for one year, beginning in June 2002, and covers wastewater discharge from the RSL-Nellis. Six monitoring episodes were conducted in 2002. In one sampling episode conducted by the sanitation district, the permit limit for benzoic acid was exceeded. The sanitation district resampled and the subsequent results were within permit limits (benzoic acid is not used at RSL-Nellis).

SAFE DRINKING WATER ACT

NTS Operations

The SDWA and state of Nevada regulations (NAC 445A) constitute the basis for drinking water compliance at the NTS. The state of Nevada has enforcement authority for the SDWA and has promulgated regulations covering operation and maintenance, water haulage, operator certification, permitting, and SDWA monitoring requirements.

The NTS maintains three permitted public water systems. Permits are renewed annually in September. The water systems are monitored for coliform bacteria, volatile organic chemicals, inorganic chemicals, synthetic organic compounds, and other water quality parameters on a schedule established by the state of Nevada in accordance with federal requirements.

In 2002, the three systems were in compliance with SDWA monitoring requirements. All monitoring results for 2002 were within regulatory limits and are discussed in Chapter 6.0.

NTS Water Haulage

To accommodate the diverse and often transient field work locations at the NTS, a water haulage program is used. To ensure potability of hauled water, permitted water hauling trucks use a sanitary connection to obtain and deliver potable water from a permitted water system. In 2002, the NTS maintained two permitted water hauling trucks. Water hauling permits are renewed annually at the same time as the regular water system permits (Table 3.4).

Water hauling trucks are sampled monthly for coliform bacteria. None were detected.

Non-NTS Operations

All non-NTS operations receive municipal water and have no compliance activities under the SDWA and state/local regulations.

RESOURCE CONSERVATION AND RECOVERY ACT

RCRA (RCRA 1976) 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 FFCA of 1992 extends the full range of enforcement authorities in federal, state, and local laws for management of hazardous wastes to federal facilities, including the NTS.

NTS RCRA Compliance

In 2002, the NNSA/NSO operated the Hazardous Waste Storage Unit and Explosive Ordnance Disposal Unit in accordance with the RCRA Hazardous Waste Operating Permit issued in 2001. No violations were noted.

Hazardous Waste Reporting For Non-NTS Operations

The NLVF, LO, STL, and LAO locations generate hazardous waste and have EPA Identification numbers, but are operated as conditionally exempt small quantity generators of hazardous waste. The NLVF and LAO have state-mandated annual reporting requirements.

UNDERGROUND STORAGE TANKS

NTS Operations

The NTS UST program has met regulatory compliance schedules for the reporting, upgrading, or removal of documented USTs. During 2002, there were no regulated USTs removed or upgraded, as all requirements had been satisfied in 1998.

The NNSA/NSO operates one deferred UST and three excluded USTs at the Device Assembly Facility (DAF). The NNSA/NSO also maintains a fully-regulated UST that is not currently in service at the Area 6 heli-pad.

Non-NTS Operations

The RSL operates three fully-regulated USTs, one deferred UST, and two excluded USTs. Corrective actions stemming from a November 2001 Clark County Health District Inspection were completed in 2002. These two tanks are currently in compliance with UST regulations.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT /SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA)

In April 1996, the U. S. Department of Energy, U. S. Department of Defense, and the state of Nevada entered into a FFACO pursuant to Section 120(a)(4) of CERCLA (CERCLA 1980) and Sections 6001 and 3004(u) of RCRA (RCRA 1976) to address the environmental restoration of historic contaminated sites at the NTS, parts of Tonopah Test Range (TTR), parts of the Nellis Air Force Range (NAFR), the Central Nevada Test Area, and the Project SHOAL Area. Appendix VI of the FFACO describes the strategy that will be employed to plan, implement, and complete environmental corrective action at facilities where nuclear-related operations were conducted.

FEDERAL FACILITIES AGREEMENT AND CONSENT ORDER

Remedial Activities - Surface Areas

Environmental restoration activities continued at the NTS and TTR in calendar year 2002. These activities comply with the agreements specified in the FFACO signed between the U. S. Department of Energy and the state of Nevada and follow a formal work process beginning with a Data Quality Objectives (DQO) meeting between the NNSA, NDEP, Defense Threat Reduction Agency and contractors. The purpose of the DQO meeting is to define the scope of work, how the site characterization is to be done (sampling strategy), and to develop the conceptual model for the site. The conceptual model defines the nature and extent of waste in the subsurface and guides the investigation. A Corrective Action Investigation Plan is prepared, providing the information on how the site is to be characterized.

Site characterization is carried out and documented in the Corrective Action Decision Document (CADD). This report 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 (if appropriate), waste management, etc.

The NDEP is a participant throughout the remediation process. The Community Advisory Board is also kept informed by NNSA/NSO of the progress made.

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.

During CY 2002, all FFACO deadlines were met. The actions taken are summarized below:

- Annual Post-Closure Monitoring Reports were submitted to comply with the conditions of the RCRA Part B Permit for the Area 2 Bitcutter Shop and Lawrence Livermore National Laboratory (LLNL) Post Shot Containment Building Injection Wells (Corrective Action Unit [CAU] 90), U3fi Injection Well (CAU 91), Area 6 Decontamination Pond (CAU 92), and Area 23 Landfill Hazardous Waste Trenches (CAU 112) RCRA Closure Units.

- Several other CAUs also had Post-Closure Monitoring reports prepared. These were the Area 25 Test Cell A Leachfield System (CAU 261), U-3aus Disposal Site (CAU 333), Area 12 Fleet Operations Steam Cleaning Discharge Area (CAU 339), Roller Coaster Sewage Lagoons and North Disposal Trench, TTR (CAU 404), Roller Coaster RADSAFE Area, TTR (CAU 407), Area 3 Landfill Complex, TTR (CAU 424), Cactus Spring Waste Trenches, TTR (CAU 426), Area 3 Septic Waste Systems 2 and 6, TTR (CAU 427), and Area 9 UXO Landfill, TTR, (CAU 453). The closure report for CAU 143, Area 25 Contaminated Waste Dumps was prepared and approved by NDEP.

- The closure report for CAU 254, Area 25, R-MAD Decontamination Facility was prepared and approved by NDEP.

- A CAP for CAU 262, Area 25 Septic Systems and Underground Discharge Point was prepared and approved by NDEP.

- The closure report for CAU 326, Areas 6 and 27 Release Sites was prepared and approved by NDEP.

- The closure report for CAU 343, Areas 1,3, & 4 Housekeeping Sites was prepared and approved by NDEP.

- The SAFER Plan for CAU 355, Area 2 Cellars/Mud Pits was prepared.

- The SAFER Plan for CAU 358, Areas 18,19,20 Cellars/Mud Pits was prepared.

- The closure report for CAU 392, Spill Sites and Construction Materials was prepared and approved by NDEP.

- A SAFER plan for CAU 425, Area 9 Main Lake Construction Debris Disposal Area, TTR was prepared and approved by NDEP.

- A CAP for CAU 490, Station 44 Burn Area, TTR was prepared and approved by NDEP.

∉ A closure report for CAU 499, Hydrocarbon Spill Site, TTR was prepared and approved by NDEP.

EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT

Emergency Planning and Community Right-to-Know Act (EPCRA) compliance activities for 2002 included upgrading of the inventory system to accommodate intranet data submittal, improved reporting, and standardization of hazardous classifications for chemicals reported.

In March 2002, the Nevada Combined Agency Report was submitted to the state Fire Marshall's office by the NNSA/NSO. EPCRA compliance with Section 302 (Planning Notification) and Sections 311-312 (Material Safety Data Sheet/Chemical Inventory) for the NTS, HSC, NLVF, and the RSL was met. No planning thresholds were exceeded at these facilities. Chemical Catastrophe Prevention Program requirements were also met for these facilities. The latter program covers extremely hazardous substances (EHSs).

A Toxic Release Inventory (TRI) report required by Section 313 of the SARA Title III must be provided if the facility, any time in the prior CY, exceeds any Section 313 threshold for manufacture, process, or other use. In CY 2001, the reporting threshold for lead changed from 10,000 pounds to 100 pounds. As a result, a TRI report was developed and submitted by NNSA/NSO to the EPA in June 2002. The predominant release of lead at the NTS is at the security contractor's firing range.

Non-NTS Tier II Reporting Under SARA Title III

The reports for the off-NTS Nevada facilities, RSL, and NLVF, are described under EPCRA above.

Other non-Nevada operations either had no chemicals above reporting thresholds or submitted their chemical inventories to the cities/counties as part of their business plans.

DOE ORDER 435.1 RADIOACTIVE WASTE MANAGEMENT

In support of DOE Order 435.1-1, activities for CY 2002 plans include the development of process enhancements to expand organizational roles and responsibilities in support of Order compliance. This includes completion of a document revision to DOE Order 435.1-1 to incorporate lessons learned from the Maintenance and Operations Internal Assessment, creation of Radioactive Waste Information Document (RWID) process approval and revision flow diagrams, and discussions regarding optimal configuration management of RWIDs to ensure organizational reliability and access. Other activities include additional Radioactive Waste Management Basis Assistance and Review Team meetings, as necessary, to review new or revised RWIDs.

STATE OF NEVADA CHEMICAL CATASTROPHE PREVENTION ACT

The state of Nevada Chemical Catastrophe Prevention Act of 1992 contains regulations for facilities defined as Highly Hazardous Substance Regulated Facilities (NAC 1992). This law requires registration of facilities storing highly hazardous substances above listed thresholds. Reporting for this program is also covered by the Nevada Combined Agency Report discussed under EPCRA above.

There were no reportable EHS chemicals at any other NNSA/NSO facilities (NTS, RSL, NLVF) in 2002.

TOXIC SUBSTANCES CONTROL ACT

The regulations implementing TSCA, for the state of Nevada, require transmittal of an annual report describing polychlorinated biphenyl (PCB) control activities. There are no known pieces of PCB Electrical Equipment (transformers/capacitors/regulators) at the NTS. During 2002 hydraulic systems at the R-MAD Building in Area 25 were drained as part of a remediation project and found to contain PCB fluid. Twelve 55-gallon drums of PCB fluid were shipped offsite for disposal and will be reported in the 2003 report for CY 2002.

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT

Pesticide usage included insecticides, herbicides, and rodenticides. Insecticides were applied twice a month at the food service and storage areas. Herbicides were applied once or twice a year at NTS sewage lagoon berms. All other pesticide applications were on an as-requested basis. General-use pesticides are used exclusively at the NTS. Contract companies applied pesticides at all non-NTS facilities in 2002.

THREATENED AND ENDANGERED SPECIES PROTECTION

The ESA (CFR 1973) requires federal agencies to insure that their actions do not jeopardize the continued existence of federally listed endangered or threatened species or their critical habitat. The desert tortoise (*Gopherus agassizii*) is the only animal species commonly found on the NTS that is protected under the ESA. It is listed as a threatened species. The bald eagle (*Haliaeetus leucocephalus*) was down-listed in 1995 from an endangered to a threatened species. The peregrine falcon (*Falco peregrinus anatum*) was removed from endangered status in 1999. The mountain plover (*Charadrius montanus*) is proposed for listing as a threatened species. These three birds, though they have been observed on the NTS, are uncommon transients and are not expected to be impacted by NTS activities. The United States Fish and Wildlife Service (USFWS) has concurred with this assessment for these bird species. No threatened or endangered plant species are known to occur on the NTS.

Consultation with the USFWS resulted in receipt of a Biological Opinion for planned activities at the NTS for a ten-year period (USFWS 1996). The Biological Opinion concluded that proposed activities are not likely to jeopardize the continued existence of the Mojave population of the desert tortoise and that no critical habitat would be destroyed or adversely modified. The Biological Opinion also established limits on the allowable take of desert tortoises on the NTS and identified all terms and conditions which must be followed by projects conducted within the geographic range of the desert tortoise on the NTS (Figure 3.1).

The Desert Tortoise Compliance Program implements the terms and conditions listed in the Biological Opinion and documents compliance actions taken by NNSA/NSO. The terms and conditions which were implemented in 2002 included pre-construction tortoise clearance surveys at 56 sites (Figure 3.1), onsite monitoring of construction at 43 sites, and preparation of an annual compliance report issued to the USFWS for CY 2002. NTS activities conducted in CY 2002 resulted in the loss of 15.48 acres of tortoise habitat. Since issuance of the first non-jeopardy

Biological Opinion in 1992, no tortoises have been accidentally injured or killed at a project site; no tortoises have been captured and displaced from project sites; one tortoise has been killed along a paved road by a vehicle; and a total of 214.11 acres of desert tortoise habitat has been disturbed (Table 3.6).

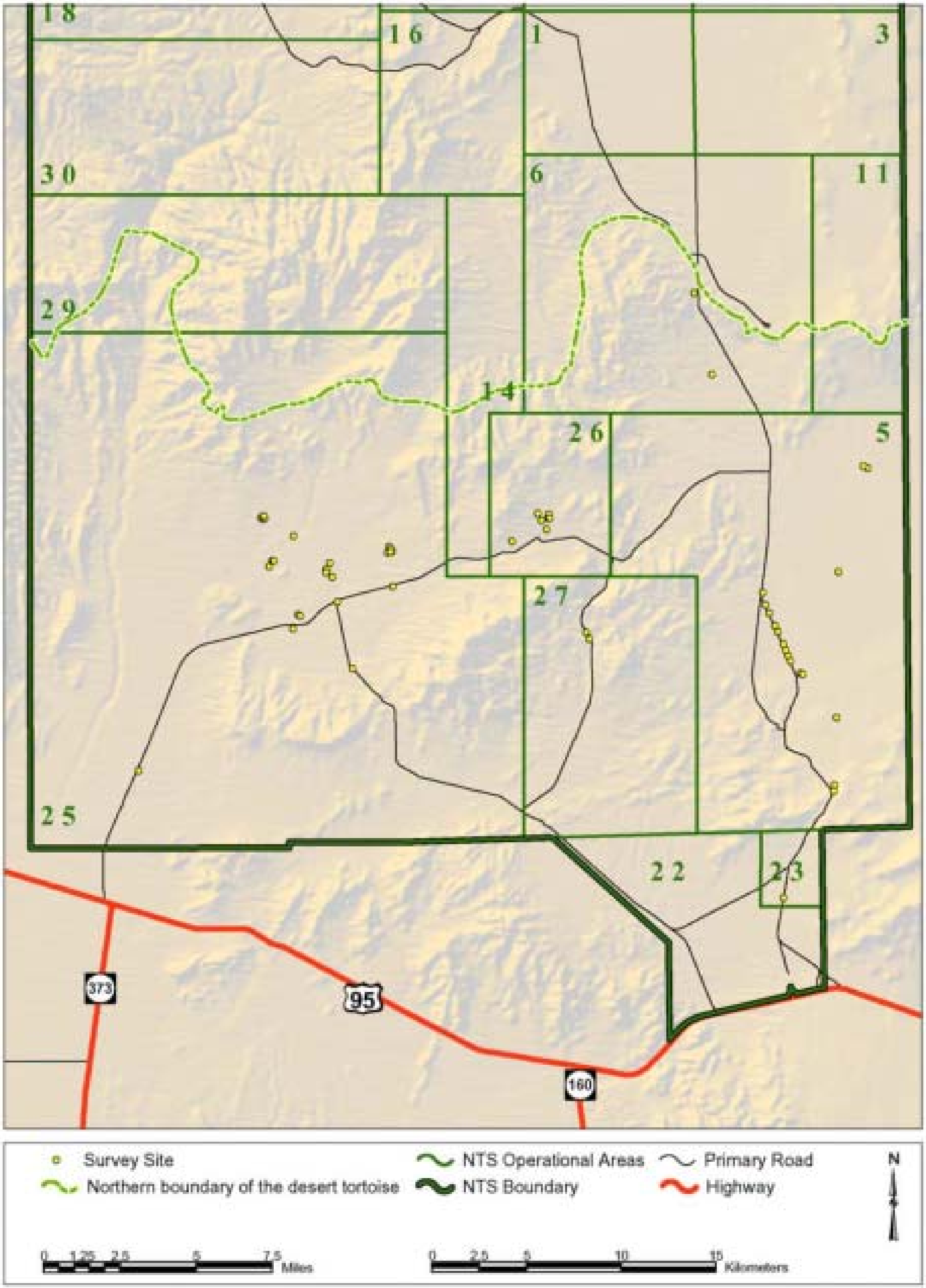


Figure 3.1 Desert Tortoise Clearance Surveys Conducted on the NTS – 2002

In September 2002, a team of volunteer biologists, led by the Southern Nevada Field Office of the USFWS, captured, measured, and weighed desert tortoises within three 21-acre circular enclosures in Rock Valley. The circular enclosures were constructed during 1962-1963 to study the effects of chronic, low-level ionizing radiation on the desert flora and fauna. Over the past decades, at least 24 tortoises have been found, individually marked, and periodically measured. There are approximately 18 adult tortoises remaining in the enclosures. In 2002, 13 tortoises were captured, measured, and weighed. They included two immature, seven adult male, and four adult female tortoises. They are considered captive by the USFWS and are not protected under the 1996 Biological Opinion.

Records of all bird sightings are documented in a wildlife observation database. These records include those of the threatened bald eagle and the proposed threatened mountain plover. Such sightings are made opportunistically and are maintained to provide some data on the occurrence and distribution of various birds on the NTS. There were no reported sightings of bald eagles or mountain plovers in 2002.

HISTORIC PRESERVATION

The NHPA, Archeological Resources Protection Act, Native American Graves Protection Repatriation Act, and the regulations related to these laws direct federal agencies to identify, inventory, and manage the cultural resources under their stewardship. The NHPA also requires consultation with interested parties, especially Native Americans, in regard to historic preservation activities and proposed decisions affecting cultural resources.

Section 106 Surveys

As required under Section 106 of the NHPA, the NNSA/NSO conducted cultural resources surveys and historical evaluations prior to undertakings in order to determine if proposed activities would adversely affect significant historic properties. Significant historic properties are those sites, locations, and structures that are determined to be eligible to the National Register of Historic Places (NRHP) through consultation between the NNSA/NSO and the state of Nevada Historic Preservation Office (NSHPO). Under the NHPA, all NNSA/NSO cultural resources reports and plans are reviewed by the NSHPO for compliance with the NHPA. All consultations with the NSHPO were completed successfully, with reports finalized and distributed to the Nevada State Cultural Resources Archives.

Mitigation of Adverse Effects to Significant Cultural Resources

In cases when project activities will adversely affect properties eligible to the NRHP, actions to mitigate the effects are required by law. No actions required mitigation activities in CY 2002.

Curation of Archaeological Collections

Under Title 36 CFR Part 79, a regulation for the NHPA, the NNSA/NSO is required to maintain the archaeological materials recovered from the lands under the control of the NNSA/NSO in a secure and environmentally-controlled facility. This curatorial facility houses more than a half million artifacts. Most were collected during data recovery (mitigation) activities at NRHP eligible sites. Site and survey records also are curated at this facility.

Consultation with Native Americans

In accordance with federal laws, executive orders, and departmental policy, the NNSA/NSO consults on a regular basis with American Indian tribes and conducts meetings with the

Consolidated Group of Tribes and Organizations (CGTO). The CGTO consists of 17 official tribal and organizational representatives. Consultation with the Western Shoshone, Southern Paiute, and Owens Valley Paiute-Shoshone tribes has been on-going for more than a decade.

MIGRATORY BIRD TREATY ACT

The Migratory Bird Treaty Act governs the taking, killing, or possession of migratory birds, as well as of their nests and eggs. All but a few of the 239 species of birds which are known to occur on the NTS are protected under this Act. Sixty-four buildings scheduled for demolition on the NTS were surveyed in 2002 to determine the presence of roosting or nesting birds. One active nest and five inactive nests were found (Table 3.7). Ecological Services biologists also received two separate reports of sightings of nesting American kestrels (*Falco sparverius*) (Table 3.7). The USFWS Southern Nevada Field Office provided verbal approval to remove all empty nests from buildings scheduled for demolition and to relocate unfledged young American kestrels.

During CY 2002, several birds were collected and sacrificed for radionuclide tissue analysis under the state of Nevada Division of Wildlife Scientific Collection Permit Number S21694. Birds sampled included five mourning doves (*Zenaida macroura*) and two Gambel's quail (*Callipepla gambelii*).

Sightings of dead birds are reported to biologists and are investigated to determine if NTS facilities/activities need to be modified to reduce the incidence of bird mortality. In 2002, five birds were found dead. A brown pelican (*Pelecanus occidentalis*), a very rare seasonal migrant, was found dead of unknown causes in July along the bank of Mercury Sewage Pond #3. A golden eagle (*Aquila chrysaetos*) was found in August at the base of a power pole at Camp 17 Pond in Area 18 and was most likely electrocuted. A burrowing owl (*Athene cunicularia*) was found along Lathrop Wells Road in October in Area 25 and appeared to have been hit by a vehicle. Two unidentified birds were found dead, presumably from entrapment, inside a building which was scheduled for demolition near Climax Mine in Area 15. The reported number of bird deaths on the NTS is low. Over the last 12 years, from 1990 to 2002, 31 incidents of dead raptors have been recorded on the NTS (Table 3.8). No mitigation actions were identified in 2002 that may reduce the incidence of bird mortality on the NTS.

EXECUTIVE ORDER 11988 FLOODPLAIN MANAGEMENT

NTS design criteria do not directly address floodplain management; however, all projects are reviewed for areas which would be affected by a 100-year flood pursuant to DOE Order 6430.1A (DOE 1989). There were no projects in 2002 that required consultation for floodplain management.

EXECUTIVE ORDER 11990 PROTECTION OF WETLANDS

There were no projects in 2002 which required consultation for protection of wetlands. NTS design criteria do not specifically address protection of wetlands; however, all projects are reviewed pursuant to the requirements of DOE Order 450.1 (DOE 2003a). There are 25 natural wetlands on the NTS which may be classified by the U.S. Army Corps of Engineers as jurisdictional wetlands regulated under the Clean Water Act and which are subject to protection under this EO. Limited monitoring of selected wetlands occurred during 2002 to characterize seasonal baselines and trends in physical and biological parameters (see section 6.3, Ecological Monitoring).

3.2 AGREEMENTS WITH STATES AND AGENCIES

During 2002, the NTS was subject to several agreements with regulatory agencies and states. These agreements are listed below:

- an Interagency Agreement with EPA covering environmental monitoring, emergency response, and related activities.
- a Memorandum of Understanding (MOU) with EPA regarding NESHAP compliance.
- a MOU with Nevada covering releases of radioactivity.
- a MOU with Nellis Air Force Base for environmental restoration on the TTR.
- a FFACO with the state of Nevada on environmental restoration activities.
- a Consent Order under the FFCA with the state of Nevada regarding the storage of restricted mixed waste streams on the NTS.
- an Agreement in Principle (AIP) with Nevada on environment, safety, and health oversight activities.
- an AIP with Mississippi on environment, safety, and health oversight activities.
- an AIP with Alaska on environment, safety, and health oversight activities.
- a Settlement Agreement with Nevada concerning the of existing inventory of mixed TRU waste.
- a Mutual Consent Agreement with Nevada on storage and management of newly generated mixed LDR wastes on NTS.

3.3 CURRENT ENVIRONMENTAL COMPLIANCE ISSUES AND ACTIONS

There were numerous activities and actions relating to environmental compliance issues in 2002. These activities and actions are discussed below, grouped by general area of applicability.

CLEAN AIR ACT

Under Title V, Part 70 of the CAA amendments, all owners or operators of Part 70 sources must pay annual fees to the state that are sufficient to cover the costs of operating permit programs.

Sources such as the NTS that have a potential to emit 50 tons or more of any regulated pollutant, except carbon monoxide, must pay an annual fee of $3,000. Sources that have a potential to emit less than 25 tons per year, such as the Tactical Demilitarization Development (TaDD) and Underground Testing Area (UGTA) projects, must pay an annual fee of $250. Maintenance and emissions fees of approximately $3,900 were paid to the NDEP in June 2002.

The NTS Class II Air Quality Operating Permit (AP9711-0549) expired in February, 2002. The state granted an extension of the expiration date so that the TaDD and UGTA air quality operating permits could be combined with the NTS air quality operating permit into a single permit. This requirement required additional computer modeling and completion of renewal application forms for TaDD and UGTA. In addition, the state required that the Big Experimental Explosives Facility

(BEEF) and the Explosives Ordnance Disposal Unit (EODU) be permitted. The 3-volume permit application was submitted in March, 2002. Following submittal of the application, the state determined that the HSC air quality operating permit should also be combined with the NTS air quality operating permit. Addendums to the renewal application were submitted to the state in 2002 in response to requests for revisions and further information, and for submittal of the HSC renewal forms. The renewed permit has not yet been issued. The NAC specifies that if the permit renewal application for a Class II source is submitted at least 30 days prior to the expiration date of the current operating permit, the source may continue to operate under the conditions of the existing permit until the renewed operating permit is issued.

During 2002, several open burn permits, known as Open Burn Variances, were issued by the state for NTS activities. These variances included 02-16 for training fires, and 02-61 for an emergency response exercise that was conducted in Area 5 of the NTS. The Open Burn Variance for the Area 27 burn box is now required to be renewed quarterly. Variances issued for the burn box during 2002 included 02-20, 02-62, 02-73 and 02-124.

Storage of hazardous wastes at the NTS is regulated by Nevada Hazardous Materials Storage Permit 13-00-0034-X, and at the HSC bys Permit 13-00-0037-X. These are issued by the state Fire Marshall and are renewed annually when a facility makes a report required by the state's Chemical Catastrophe Prevention Act (NAC 1992).

Table 3.7 contains a summary of the permits issued for NTS activities and for offsite activities that support the NTS.

Non-NTS Air Quality Permits

Five air quality operating permits were active for emission units at the NLVF, and seven permits were active for the RSL. These permits were issued through the Clark County Health District. Annual renewal is contingent upon payment of permit fees. Permits are amended and revised only if the situation under which the permit has been issued changes. For the other non-NTS operations, no air quality permits have been required, or the facilities have been exempted.

CLEAN WATER ACT

Low flows in several NTS sewage lagoons have reduced the efficiency of the lagoons to properly treat effluents. In response, the NNSA/NSO requested funding to install septic tank systems in these areas. Septic tank/leachfield system conversions from sewage lagoons in Areas 25, 23, 12, 6, and 5 were completed in 2002. Individual systems handle up to 5,000 gallons per day.

SAFE DRINKING WATER ACT

The Cross-Connection Control Program at the NTS continues. Engineering studies were initiated to protect the NTS public water systems from cross-connections with non-potable sources such as fire sprinkler systems.

SDWA Permits are listed in Table 3.4.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT

Other than the reporting covered in Section 3.1, there is no formal CERCLA program at the NTS. The FFACO, with the state, may preclude the NTS from being placed on the National Priority List. More of a RCRA approach in the remediation of environmental problems will be taken under the FFACO.

POLLUTION PREVENTION AND WASTE MINIMIZATION

The CY 2002 P2, waste minimization, and recycling efforts for waste generated at the NTS, NLVF, and offsite locations complied with DOE Order 5400.1 requirements for a P2 program. The NNSA/NSO P2 program establishes a process to reduce the volume and toxicity of waste generated at all locations and ensures that the proposed method of treatment and/or disposal minimizes the present and future threat to human health and the environment.

It is a priority of NNSA/NSO to minimize the generation, release, and/or disposal of pollutants to the environment by implementing cost-effective P2 technologies, practices, and policies in partnership with government and industry. A commitment to P2, waste minimization, and recycling manages operations in such a way as to minimize impact on the environment, improve the safety of operations, and promote energy efficiency and the sustainable use of natural resources. This commitment includes providing adequate administrative and financial materials on a continuing basis to ensure source reduction, recycling, and affirmative procurement goals are achieved.

Chapter 4.0 provides a summary of the P2 program, P2 accomplishments achieved during CY 2002, and activities that achieved reduction in volume and toxicity of waste.

SOLID/SANITARY WASTE

During CY 2002, landfills were operated in Areas 6, 9, and 23. The amount of waste disposed of in each is shown in Table 3.8, and their operating permits are in Table 3.7. State inspections of permitted landfills were conducted in March 2002. No compliance issues were noted.

Monitoring well sampling conducted in January 2002, indicated elevated levels of nickel and chromium in one well. Sampling notes indicated that purge volumes for the well were insufficient. Re-sampling (with adequate purge) was conducted for both the sewage lagoon and landfill parameters in April 2002. All parameters were consistent with previous monitoring episodes and there were no elevated concentration.

RADIATION PROTECTION

NTS Operations

Results of monitoring during 2002 indicated full compliance with the radiation exposure guidelines of DOE Order 5400.5, "Radiation Protection of the Public and the Environment", and the Title 40 CFR 141 “National Primary Drinking Water Regulations”. Onsite air monitoring results for the networks showed average annual concentrations ranging from 0.4 percent of the DOE Order 5400.5 guidelines for HTO in air to 1.4 percent of the guidelines for $^{239+240}Pu$ in air. Drinking water supplies on the NTS contained no man-made radioactivity above detection limits, and levels of naturally occurring radioactivity were in compliance with the National Primary Drinking Water Regulation.

Offsite monitoring in the vicinity of the NTS confirmed that emissions of radioactivity from the NTS were less than 2 percent of the guideline set forth in Title 40 CFR 61, Subpart H (CFR 1989).

Non-NTS BN Operations

Results of environmental monitoring at the off-NTS operations performing radiological work during 2002 indicate full compliance with the radiation exposure guidelines of DOE Order 5400.5. With one exception, no radioactive or nonradioactive surface water/liquid discharges, subsurface discharges through leaching, leaking, or seepage into the soil column, well disposal, or burial occurred at any of the BN operations. The exception was the NLVF Building A-1 radiation source well, in which water was found with concentrations of tritium that were above the drinking water standard of 20,000 pCi/L. From a review of geologic reports, historical aerial photos, Geoprobe borings, installation of temporary monitoring wells, and water analyses, the tritium was concluded to be from past local operations and was not found in ground water surrounding the facility.

Use of radioactive materials is primarily limited to sealed sources. Facilities, which use radioactive sources or radiation producing equipment, with the potential to expose the general population or non-project personnel to direct radiation, are the Atlas NLVF A-1 Source Range, Building C-3 (x-ray radiography operation), and the STL, during the operation of the sealed tube neutron generator or during operation of the Febetron. Sealed sources are tested every six months to ensure there is no leakage of radioactive material. Operation of any radiation generating devices is controlled by BN procedures. At least two thermoluminescent dosimeters (TLDs) are placed at the fence line of these facilities or where non-project personnel could be for limited periods and are exchanged quarterly. The TLD results were consistent with previous data indicating no exposures to the public from any of the monitored facilities.

ENVIRONMENTAL COMPLIANCE AUDITS

In 2002, regulatory agencies conducted compliance assessments at the NNSA/NSO facilities of hazardous waste treatment, storage, and accumulation areas, solid waste landfills, sewage discharge, and underground storage tanks. No notices of violation were issued.

OCCURRENCE REPORTING

Occurrences are environmental, health, and/or safety-related incidents, which are reported in several categories in accordance with the requirements of DOE Order O 232.1A, "Occurrence Reporting and Processing of Operations Information," (DOE 1997a). The 11 reportable environmental occurrences for 2002 on NTS facilities appear in Table 3.9.

LEGAL ACTIONS

No legal actions concerning environmental protection were filed against NNSA/NSO during 2002.

3.4 PERMITS FOR NTS OPERATIONS

Federal and state permits have been issued to NNSA/NSO and to BN (Table 3.7). These permits are required for the conduct of such NNSA/NSO activities as hazardous and solid waste storage and disposal for certain ecological studies, processes that emit air pollutants, tests at the HSC, and for operations involving endangered species. Annual reports associated with these permits are filed as stipulated in each permit.

The only RCRA permit in use at the NTS is the Hazardous Waste Management Permit NEV HW009. With this permit, hazardous waste generated at the NTS can be stored at the Area 5 Hazardous Waste Storage Unit for up to one year. It is then shipped offsite for treatment and/or disposal. The permit also allows for the thermal treatment (disposal) of explosives at the Area 11 Explosive Ordnance Disposal Unit.

The NLVF has a Waste Generator number of 03990265X that covers generation and a 90-day accumulation of hazardous waste. The waste is shipped offsite for final treatment and/or disposal.

NNSA/NSO activities on the NTS comply with all terms and conditions of a desert tortoise incidental take authorization issued in a Biological Opinion (File Number 1-5-96-F-33) from the USFWS.

The Nevada Division of Wildlife issued a scientific collection permit, S20571, to BN that allows collection of wildlife samples.

Table 3.1 Active Air Quality Permits - 2002

Permit	Description	Expiration Date	Annual Reporting
NTS Air Quality Permits			
AP9711-0549		02/07/2002	February 1
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		
Area 5 Facilities	Navy Thermal Treatment Unit		
Area 6 Facilities	Cementing Equipment (Silos) Decontamination Facility Boiler Diesel Fuel Tank Gasoline Fuel Tank Portable Field Bins Portable Stemming Systems 1 & 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)		
AP9711-0556	Area 5 HSC	10/20/2002	February 1
AP9711-0814	Area 11 TaDD Facility	07/21/2003	February 1
AP9711-0785	UGTA Surface Disturbance Permit	03/20/2003	February 1
02-16	Burn Variance, NTS (Training Fires)	03/10/2003	None
Non-BN Operated NTS Air Quality Permits			
01-146	Burn Variance Area 27 (LLNL)	02/21/2002	None
BN Operated Off-NTS Air Quality Permits (TTR and NAFR)			
AP9711-0785	UGTA Class II Air Quality Permit	04/16/04	February 1

Table 3.2 Active Air Quality Permits for Non-NTS Facilities – 2002

Permit	**Description**	**Expiration Date**	**Annual Reporting**
Remote Sensing Laboratory			
A0034811	Excimer Laser, Lumonics, EX-700	None	June 1
A34801	Boiler, Columbia, W1-180	None	March 1
A34802	Boiler, Columbia, WL-90	None	March 1
A34803	Heater, No. 2 National BD	None	March 1
A34804(a)	Emergency Fire Control Pump Engine	None	June 1
A34804(b)	Emergency Generator, Cummins	None	June 1
A34805	Spray Paint Booth	None	June 1
North Las Vegas Facility			
A38701	Spray Paint Booth (A-16)	None	June 1
A38703	Emergency Generators (C-1)	None	June 1
A06503	Emergency Generator (A-1/A-5/B-2)	None	June 1
A06505	Aluminum Sander (A-16)	None	June 1
A06507	Trinco Dry Blaster (A-1)	None	June 1

Table 3.3 Sewage Discharge Permits – 2002

Permit No./Location	**Areas**	**Expiration Date**	**Reporting Required**
NTS Permits			
GNEV93001	NTS General Permit	12/07/2004	Quarterly
NY-17-05704	X Tunnel Collection System	09/30/2003	None
NY-1090	Area 6 LANL Septic Tank	None	None
NY-1091	Area 23 Gate 100 Septic Tank	None	None
NY-1085	Area 25 CSA Septic Tank	None	None
NY-1086	Area 25 RCP Septic Tank	None	None
NY-1083	Area 5 RWMS Septic Tank	None	None
NY-1084	Area 6 DAF Septic Tank	None	None
NY-1089	Area 12 Camp Septic Tank	None	None
NY-1103	Area 22 Airport Septic Tank	None	None
Off-NTS Permits			
North Las Vegas Facility VEH-112	Class II Wastewater Contribution Permit	12/31/2006	Annually
Special Technologies Laboratory AII-204/Santa Barbara, California		12/31/2001	
III-331/Santa Barbara, California		12/31/2003	
Remote Sensing Laboratory CCSD #080	Pretreatment Permit	06/30/2003	Quarterly

Table 3.4 NTS Drinking Water System Permits - 2002

Permit No.	Area(s)	Expiration Date	Reporting Required
NY-4099-12NCNT	Area 12	09/30/2003	None
NY-360-12NCNT	Area 5, 6, 22, 23	09/30/2003	None
NY-4098-12NCNT	Area 25	09/30/2003	None
NY-835-12H	Sitewide Truck	09/30/2003	None
NY-836-12H	Sitewide Truck	09/30/2003	None

Table 3.5 Permits for NTS Septic Waste Hauling Trucks – 2002

Permit Number	Vehicle Identification Number	Expiration Date
NY-17-03313	Septic Tank Pumper E-106785	11/30/2003
NY-17-03315	Septic Tank Pumper E-107105	11/30/2003
NY-17-03317	Septic Tank Pumper E-105918	11/30/2003
NY-17-03318	Septic Tank Pumping Subcontractor	11/30/2003
NY-17-06838	Septic Tank Pumper E-105919	11/30/2003
NY-17-06839	Septic Tank Pumper E-105702	11/302003

Table 3.6 Allowable take of Desert Tortoises and their Habitat Permitted by the U.S. Fish and Wildlife Service for NTS Activities

Type of Take	Allowable Take Limit	2002 Status of Take Limit
Number of tortoises accidentally injured or killed as a result of NTS activities per year.	3	0
Number of tortoises captured and displaced from NTS project sites per year.	10	0
Number of tortoises taken in form of injury or mortality on paved roads on the NTS by vehicles other than those is use during a project.	Unlimited	5
Number of total acres of desert tortoise habitat disturbed during NTS project construction since 1992.	3,015	214.11

Table 3.7 Results of 2002 Building Surveys and Responses to Reported Bird Sightings Conducted to Ensure Protection of Migratory Birds, their Nests, and Eggs

Location	**Survey Finding**	**Mitigation Action Taken**
Area 3, Building 3C-55	Great horned owl (*Bubo virginianus*) nest with eggs/young	Demolition of building was delayed two months until young fledged
Area 1, Building 01-500	Inactive raven (*Corvus corax sinuatus*) nest	Removed empty nest before demolition
Area 2, Building 02-202566	Small nest of unknown species	Removed empty nest at time of survey before demolition
Area 25, Building 25-3140	New stick nest of unknown species	Closed doors and windows of building until time of demolition
Area 6, Building 06-CP-15A	Small nest of unknown species	Removed empty nest at time of survey before demolition
Area 6, Building 06-CP-99	Small nest of unknown species	Removed empty nest at time of survey before demolition
Area 1, outside at U1A complex	American kestrel nest with unfledged young found by workers on top of a crane	Delayed moving crane until young were moved to a man-made nest box placed near crane
Area 6, new Atlas Facility Building	Two young American kestrels reported trapped inside building	One young captured and released outside building

Table 3.8 Summary of NTS Raptor Mortality Records Since 1990

Species	**Road Kill**	**Electrocution**	**Drowning**	**Predation**	**Entrapment**	**Chick Mortality**	**Unknown**	**Total**
American kestrel (*Falco sparverius*)				1	1	3	2	**7**
Barn owl (*Tyto alba*)	1			1	1	3	1	**7**
Golden eagle (*Aquila chrysaetos*)	1	1					1	**3**
Great horned owl (*Bubo virginianus*)	3	1				1		**5**
Prairie falcon (*Falco mexicanus*)				1				**1**
Red-tailed hawk (*Buteo jamaicensis*)	2	1	1				1	**5**
Sharp-shinned hawk (*Accipiter striatus*)							1	**1**
Turkey vulture (*Cathartes aura*)							1	**1**
Western burrowing owl (*Athene cunicularia*)	1							**1**
Total	**8**	**3**	**1**	**3**	**2**	**7**	**7**	**31**

Table 3.9 Permits Required for NTS Operations - 2002

EPA Generator ID		
NV3890090001	NTS Activities	
NTS Permits		
Permit No.	**Areas**	**Expiration Date**
NEV HW009	NTS Hazardous Waste Management (RCRA)	11/01/2005
SW 13 097 02	Area 6 Hydrocarbon Disposal Site	Post Closure
SW 13 097 03	Area 9 U-10c Solid Waste Disposal Site	Post Closure
SW 13 097 04	Area 23 Solid Waste Disposal Site	Post Closure
13-00-0034-X	NTS Hazardous Materials	02/29/2003
13-00-0037-X	HSC Hazardous Materials	02/29/2003
S20571	Scientific Collection of Wildlife Samples	12/31/2002
1-5-96-F-33	USFWS -- Desert Tortoise Incidental Take Authorization	12/31/2006
Off-NTS Permits		
03-01-0265-X	North Las Vegas Facility Hazardous Materials	02/29/2003
03-01-0266-X	Remote Sensing Laboratory Hazardous Materials	02/29/2003
EPA Generator ID Numbers		
NVD097868731	North Las Vegas Facility Activities, NV	
CAL00177640	Santa Barbara Operations, CA	
CAL00177642	Santa Barbara Operations, CA	
CAL00197065	Livermore Operations, CA	
NMD986670370	Los Alamos Operations, NM	

Table 3.10 Quantity of Wastes Disposed of in Solid Landfills - 2002

	Quantity (in tons)		
Month	**Area 9**	**Area 23**	**Area 6**
January – March	2,513	354	110
April – June	6,164	275	454
July - September	3,189	302	286
October -December	2,858	199	2,378
Totals	**14,724**	**1,130**	**3,228**

Table 3.11 Off-Normal Occurrences at NTS Facilities – 2002

Date	Report Number	Description	Status
01/10/2002	NVOO-BN-NTS 2002-0001	Worker in radiological area had expired required Rad Worker training.	Closed
02/06/2002	NVOO-BN-NTS 2002-0005	Instrument used to determine the offsite release of low-level waste trucks was used past calibration date.	Closed
02/14/2002	NVOO-BN-NTS 2002-0006	Portable rad survey instrument became contaminated on jobsite, but was unknown and returned to storage.	Closed
07/23/2002	NVOO-BN-NTS 2002-0009	Historic heating oil spill at Area-6, CP-10 Compound, resulting in state notification.	Closed
07/29/2002	NVOO-BN-NTS 2002-0010	A 25 lb counter weight on drill rig at ER-5-4 #2 fell 20 ft when cable failed, barely missing worker.	Closed
08/21/2002	NVOO-BN-NTS 2002-0012	Waste drum was assayed and found to have higher Plutonium gram equivalent than previously reported, and assay should not have been allowed.	Open
09/19/2002	NVOO-BN-NTS 2002-0013	Laborer working in a Contamination Area left without being surveyed at the hot line.	Closed
09/19/2002	NVOO-BN-NTS 2002-0014	More waste drums than are authorized were being stored at the TRU Pad Cover Building.	Open
10/23/2002	NVOO-BN-NTS 2002-0015	A waste drum at the Area-5 TRU Pad was found to exceed the administrative limit for the “S” value.	Open
11/07/2002	NVOO-BN-NTS 2002-0016	HEPA filters required for doing work at the Waste Examination Facility may not have been properly tested.	Open
12/23/2002	NVOO-BN-NTS 2002-0017	Valve failure on tanker trailer caused spill of 1085 gallons of JP-8 fuel at Area-5 Hazardous Spill Center.	Open

4.0 ENVIRONMENTAL PROGRAM INFORMATION

Reported in this section are the environmental stewardship programs for the Nevada Test Site (NTS). These programs are under the purview of the Environment, Safety and Health Division (ESHD) of the U.S Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office (NNSA/NSO) for environmental management and compliance, field investigations for impact assessment, ecosystem management, pollution prevention (P2), waste minimization, science, and technology development.

4.1 ROUTINE RADIOLOGICAL ENVIRONMENTAL MONITORING PLAN

The NNSA/NSO manages the NTS in a manner that meets evolving NNSA missions and responds to the concerns of affected and interested individuals and agencies. The Routine Radiological Environmental Monitoring Plan (RREMP) addresses compliance with DOE Orders and other regulatory drivers requiring routine effluent monitoring and environmental surveillance on the NTS. The RREMP describes the objectives and design elements for all media: air, water, soil, biota, and direct radiation sources. Existing and historical site information and regulatory requirements were reviewed and site characteristics, transport and exposure pathways, regulatory requirements, and historical data evaluated to support the monitoring designs. Both onsite and offsite monitoring objectives are addressed under the RREMP.

The RREMP identifies the requirements for radiological monitoring on and off the NTS and focuses on the need to ensure that the public and the environment are protected, compliance with the letter and the spirit of the law is achieved, and good land stewardship is practiced. The monitoring plan uses a decision-based approach to identify the environmental data that are collected and provides Quality Assurance, Analysis, and Sampling Plans, which ensure that defensible data are generated.

Oversight of the monitoring plan is provided by the Community Environmental Monitoring Program (CEMP), managed by the Desert Research Institute (DRI). The CEMP uses offsite residents located around the NTS and in southwestern Utah to operate equipment that collects air particulate samples, records meteorological data, and measures external gamma radiation exposures in populated areas.

AIR MONITORING

Environmental monitoring includes the activities of environmental surveillance, effluent monitoring, and operational monitoring. For air monitoring, the principal difference among these three activities is the placement of the air sampling equipment. Environmental surveillance targets ambient air, but not specific facilities, while effluent and operational monitoring target facilities or activities. Effluent monitoring is directed at the measurement of a specific emission point, while operational monitoring is used to assess total emissions from an operating facility. The rationale, supporting the design of the air monitoring network for the NTS, addresses these types of monitoring and is discussed thoroughly in the RREMP.

The objective for the air monitoring network is to monitor all NTS radionuclide emissions 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 Clean Air Act. The regulatory driver for this network includes Title 40 Code of Federal Regulations (CFR) 61, "National Emission Standards for Hazardous Air Pollutants (NESHAPs): Radionuclides," Subpart H - "National Emission Standards for Emission of Radionuclides Other Than Radon From Department of Energy Facilities." Other drivers include DOE Order 5400.1 – "General Environmental Protection Program," DOE Order 5400.5 – "Radiation Protection of the Public and the Environment," and DOE/EH-0173T – "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance." These documents prescribe dose limits and air monitoring requirements.

To comply with the regulations listed above, a combination of approaches is used:

- Evaluating operational contributions through measurement of particulate-in-air and tritium-in-air emissions from such sources as the Radioactive Waste Management Sites (RWMSs) in Areas 3 and 5, and the Waste Examination Facility.

- Monitoring air at locations on the NTS known to be contaminated with radionuclides in order to evaluate the behavior of radionuclide emissions from those locations.

- Calculation of tritium in air based on the amounts of tritium in surface waters, confirmed through the observed behavior of tritium in air near tritium sources.

- Modeling particulate emissions in air using a soil resuspension model, based on the observed behavior of particulate emissions in air and confirmed by particulate air monitoring data from SCHOONER (Area 20), Gate 700 S (Area 10), Mercury (Area 23), Guard Station 510 (Area 25), 3545 Substation (Area 16) and Yucca (Area 6).

- Calculating an effective dose equivalent for each specific emission source at the NTS, using the CAP88-PC model as prescribed by NESHAPs, to provide dose calculations for all populated locations within 80 km (50 mi) (the location of the general public is assessed annually).

During the year 2002, no point sources qualified for offsite monitoring under NESHAPs requirements (capable of emitting ∅1 percent of the standard); however, point sources are continually evaluated for this potential. Accidental releases from facilities such as U-1a, Area 27, or the Device Assembly Facility will be monitored by the ambient monitoring network.

SURFACE WATER

The objectives of the routine radiological monitoring program for surface water are to determine (1) if concentrations of radionuclides in surface water bodies at the NTS and its vicinity are a threat to public health and the environment, and (2) if permitted facilities are in compliance with permit discharge limits.

The surface water sample locations on the NTS include the E Tunnel containment ponds and nine sewage lagoons. Offsite locations include seven natural springs. The criteria for selection were based on the monitoring objectives. Water sources have been selected based on potential for exposing the public, onsite biota, or the environment to significant levels of radionuclides, or requirements for monitoring under existing state discharge permits. The sources are as follows:

- Discharge from E Tunnel is collected in containment ponds and monitored under the current state permit.

- The nine sewage lagoons at the NTS receive effluents from sewage treatment plants permitted by the state (Bechtel Nevada [BN] 1997). Radionuclide monitoring of these lagoons is required under the current state permit.

Several offsite springs have historically been monitored and will continue to be monitored under this program. These springs are discharge sites for the local and regional aquifers, for which the upgradient direction may be the underground testing areas on the NTS. The offsite springs chosen for the monitoring network are therefore used as groundwater monitoring points in this hydrologic system. Continued monitoring will document and track trends in groundwater quality downgradient of the underground nuclear test sites on the NTS. Levels of radionuclides at all of the surface water sources mentioned above have consistently been below the Derived Concentration Guides listed in DOE Order 5400.5 over recent years (DOE 1990b).

GROUNDWATER

The characteristics of regional and local groundwater regimes at the NTS and the sources of radionuclides with potential impacts on groundwater are presented in Chapters 7.0 and 8.0 of this report. Groundwater is monitored onsite and offsite to comply with several regulatory drivers.

The objectives of the routine radiological monitoring program for groundwater include:

- **Water Supply Well Monitoring:** Determine if onsite water supply wells are impacted from radionuclides originating from NNSA operations on the NTS.

- **Permitted Facilities Monitoring:** Determine if there are groundwater impacts from surface and shallow vadose zone sources of radionuclides on the NTS.

- **Aquifer Monitoring:** Determine if groundwater at the NTS and its vicinity is further degraded as a result of the expansion of the radionuclide plumes associated with the underground test areas.

- **Water-level Information:** Determine the potential impact of demand for groundwater around the NTS on the long-term availability of water.

Water Supply Wells

Groundwater is the only local source of drinking water at the NTS and the surrounding area. The state permit for the NTS includes three drinking water supply systems that consist of nine potable water wells. These water systems are sampled to determine compliance with the Safe Drinking Water Act (SDWA) and Nevada Administrative Code (NAC), which include standards for radionuclides. In addition to the onsite water supply, the monitoring network includes offsite water supply and existing monitoring wells selected based on the following criteria:

- Select point-of-use water supply wells downgradient of the NTS (in the general direction of regional groundwater flow). Current site knowledge eliminates the possibility of transport of radionuclides from source areas to wells upgradient of the NTS, or opposite to the general direction of regional groundwater flow, which is generally to the southwest toward discharge areas at Ash Meadows, Oasis Valley, and Death Valley.

- Select wells close to the NTS boundary and in close proximity to the underground testing areas.

- Give preference to community wells.

- Give preference to high-yield, high-volume wells.

- Give preference to wells with appropriate construction/condition.
- Select wells where access is possible.
- Consult with Community Environmental Monitoring Programs to ensure that the concerns of local communities are addressed.

Permitted Facilities Wells

Five wells located at three facilities require routine groundwater monitoring under the terms of permits issued by the state of Nevada. These facilities are the Area 5 RWMS (RWMS-5), the Area 23 Infiltration Basin, and the Area 12 E Tunnel pond.

The Pit 3 Mixed Waste Disposal Unit located in the RWMS-5, currently under Resource Conservation and Recovery Act (RCRA) Interim Status, maintains compliance with Title 40 CFR 264/265 by monitoring three wells (UE-5PW1, UE5-PW2, and UE5PW3) around the RWMS.

To comply with the groundwater protection requirements of the state General Permit GNEV93001, a monitoring well (SM-23-1) was installed in 1996 for the Area 23 Infiltration Basin Sewage Lagoon.

Water Pollution Control Permit NEV96021, in compliance with the provisions of the Federal Water Pollution Control Act and NRS, allows NNSA/NSO and the Defense Threat Reduction Agency to manage and operate a system for the treatment and disposal of waste water discharging from the portal of E Tunnel in Area 12 of the NTS. The effluent from the portal is conveyed into six earthen impoundments for disposal by means of infiltration.

Groundwater from the five permitted wells is sampled for the necessary constituents and at the required frequency as stated in their respective permits.

Aquifer Monitoring

The RREMP includes an interim effort to identify existing wells and boreholes (called point-of-opportunity wells), which are located downgradient of the Corrective Action Units (CAUs) and/or are in the regional aquifer. Point-of-opportunity wells located within CAUs have been screened based on the following criteria for their inclusion in the proposed network:

- Select point-of-opportunity wells downgradient of source areas.
- Give preference to wells within 1,000 m (3,280 ft) of underground tests, which are located below or within two cavity radii of the water table.
- Select wells accessing relevant hydrostratigraphic units (HSU) within structural blocks having an upgradient source or sources.
- Give priority to wells in those transmissive units which also contain most of the underground test locations.

Wells screened have been further scrutinized to select those which would be most cost-effective to monitor, with the following construction criteria:

- Give priority to wells with immediate access to the aquifer.
- Give priority to wells with diameters appropriate for sampling.
- Give priority to wells that are completed (e.g., developed, casing exists, etc.).

Point-of-opportunity wells are existing wells which, according to the present level of understanding, appear to be at appropriate locations and completed in appropriate HSUs. It is important to note that the groundwater monitoring in the RREMP is an interim program until the final CAU post-closure monitoring network can be designed and implemented.

Source-term characterization wells, also referred to as “hot” or “near-field” wells are those used to sample groundwater from within or near the cavity produced by an underground nuclear test that was conducted near or below the water table. These groundwater samples are used to define the hydrologic source term (the type and concentration of radionuclides dissolved in groundwater or potentially available to groundwater). Source term information fulfills the requirement in DOE Order 5400.1 to monitor the effects of NNSA/NSO activities on the environment. This monitoring allows estimates to be made of the rate of radionuclide migration from an underground nuclear test.

In addition to wells monitored for potential releases, water-level measurements are performed for each sampling event at all wells if practical (e.g., no down-hole restrictions). There are wells onsite and offsite that are strictly monitored for water levels by the U.S. Geological Survey (USGS). Data from these wells are analyzed for trends, impacts of water usage, and used to calibrate and refine groundwater flow models.

VADOSE ZONE MONITORING

The vadose zone is being monitored at three general types of sites on the NTS: RWMSs (Area 3 and Area 5); RCRA closure sites (Area 23 Hazardous Waste Landfill and U-3fi); and permitted sanitary landfills (U-10c Landfill and the Area 6 Hydrocarbon Landfill) in addition to, or in lieu of, groundwater monitoring for the purpose of protecting groundwater resources. Vadose Zone Monitoring (VZM) at these sites generally consists of monitoring changes in soil moisture.

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.

VZM at the RWMSs is driven by DOE Orders and conducted to confirm Performance Assessment (PA) assumptions regarding the hydrologic conceptual models including soil water contents, and upward and downward flux rates. VZM at RCRA closure sites and sanitary landfills is driven entirely by agreements with the Nevada Division of Environmental Protection (NDEP). VZM at all NTS sites is also conducted to:

- Demonstrate negligible infiltration of precipitation into zones of buried waste.
- Detect changing trends in performance.
- Establish baseline levels for long term monitoring purposes.

Compliance at the RWMSs is achieved by demonstrating that PA assumptions are valid, and that there is negligible infiltration of precipitation into zones of buried waste. Compliance at the RCRA sites and sanitary landfills is achieved by demonstrating that soil moisture levels remain within limits agreed to with NDEP.

At the RWMSs, VZM is accomplished by measuring all the water balance components at several locations to account for some spatial variability and to apply measured water balance to an entire RWMS using the concept of surrogate sampling. This type of monitoring is not considered leak detection, it is performance monitoring.

Water balance measurements activities include:

∉ **Meteorological monitoring** to measure precipitation (the driving force for downward flow) and to calculate potential evapotranspiration (the driving force for upward flow).

∉ **Lysimeters** (weighing and drainage) to measure infiltration, soil water redistribution, bare-soil evaporation, evapotranspiration, and deep drainage.

∉ **Neutron logging** through access tubes 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) 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 to confirm PA assumptions and transport coefficients.

This strategy provides an accurate estimate of the RWMS water balance, including any drainage through the RWMS waste covers, and therefore, potential recharge. Based on these data, as well as other work (Tyler et al., 1996), there is essentially no recharge to the groundwater under current conditions in the valleys of the NTS (including the RWMSs), and all precipitation is effectively returned to the atmosphere by plant transpiration and soil evaporation.

The VZM strategy for the two RCRA closure sites and permitted sanitary landfills is similar to the RWMS strategy and is based on monitoring soil moisture at points of opportunity. At these sites, neutron logging is conducted in boreholes that were originally drilled for site characterization purposes. Neutron logging at these sites provides data to confirm that there is negligible infiltration of precipitation into zones of buried waste.

A summary of some selected NTS VZM data can be found in Chapter 8.0.

BIOTA MONITORING

Historical radionuclide studies on the NTS focused on man-made transuranics and showed declining concentrations in plants and animals over time (DOE 1992), although some plant and animal samples still contain measurable levels (EG&G/EM 1993; U. S. Environmental Protection Agency ([EPA] 1996). This, in itself makes the protection of natural resources an integral component of a successful Long Term Stewardship program and provides an immediate need for demonstrating protection of biota. Regulations set to protect biota include DOE Order 5400.5, "Radiation Protection of the Public and the Environment," which lists radiation dose limits set to protect aquatic animals. In addition, the National Council on Radiation Protection and Measurements (NCRP 1991), and the International Atomic Energy Agency (IAEA 1992) have recommended dose limits, protective of populations, for terrestrial plants and animals. The DOE has included these biota dose limits in proposed rule, 10 CFR 834, "Radiation Protection of the Public and Environment" (DOE 1990b). Because DOE is accountable to Congress and the public, for the safe conduct of its activities, there is a need to demonstrate compliance with these limits. DOE Standard, DOE-STD-1153-2002, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," (DOE 2002b) provides the guidance for demonstrating this compliance. Data on radionuclides in biota on the NTS directly supports this need.

Offsite plants and animals, namely crops and livestock in neighboring communities, have also been monitored for years to document possible radionuclide exposure to the public (EPA 1978; 1996). The only possible current pathway for radiation exposure through crops is their uptake of radionuclides from soil which was contaminated during past atmospheric tests. There are several communities to the north and east of the NTS (e.g., Rachel, Alamo, Hiko) that have received radioactive fallout in the past from these tests. Recent radioanalysis of selected fruits and vegetables from these communities has shown levels of ^{3}H, ^{90}Sr, and $^{239+240}Pu$ near or below detection limits (EPA 1996). Livestock or game animals within the same downwind fallout areas could ingest contaminated forage and then be consumed by humans. ^{90}Sr levels in the bones of deer, cattle, and bighorn sheep sampled in 1993 off the NTS were above detection limits, but have consistently decreased in samples since the early 1960s, since cessation of aboveground testing (EPA 1996). The edible portions of these offsite animals historically contain non-detectable levels of radionuclides. Because of these historically low levels and the consistently decreasing trends in radionuclide concentrations in offsite samples no offsite sampling is proposed.

Other objectives that biota monitoring data help meet are:

∉ **Validating the integrity of land buffers**: NNSA/NSO is planning to issue a land-use planning goal to provide a buffer around site operations to ensure public safety and prevent public exposure to radiation. Monitoring of selected onsite biota provides data on radionuclide transport beyond contaminated areas via mobile organisms.

∉ **Addressing current and future land-use issues**: Data on the levels of radiological contamination of both the natural and man-made resources on the NTS are needed for current land-use decisions such as project siting.

∉ **Supporting Nevada Division of Wildlife (NDOW) chukar relocation efforts**: In the past, the NDOW has requested and has been granted, permission to trap and remove chukar from the NTS. The chukars are then released in areas open to public hunting. Sampling at spring sites used by NDOW will provide a direct measure of the level of radionuclides in chukars from those sites.

The study designs for radiological monitoring of NTS plants and animals focus on sampling those sites having the highest known concentrations of radionuclides in other media. The locations and boundaries of these sites will be determined from existing radiological surveys. The intent is to concentrate monitoring efforts at sites where there is a likelihood of maximum exposure of plants and animals to radionuclides. It is then expected that demonstrating protection of biotic populations at these sites will show protection of biota at lesser contaminated sites by default. It is also expected that consumption of game animals from these sites would create the highest potential dose to humans, as compared to game animals collected elsewhere on the NTS. One monitoring site was selected from each of the following types of contaminated areas on the NTS:

∉ **Runoff areas or containment ponds** associated with underground or tunnel test areas. These sites have the highest reported levels of radionuclides on the NTS, usually a result of contaminated surface water.

∉ **Plowshare sites in alluvial fill** at lower elevations with high surface contamination. Subsurface nuclear detonations at these sites have distributed contaminants over a wide area, usually in the lowest precipitation areas of the NTS.

∉ **Plowshare sites in bedrock or rocky fill** at higher elevations with high surface contamination. Subsurface nuclear detonations at these sites distributed contaminants over a wide area, usually in the highest precipitation areas of the NTS.

∉ **Atmospheric test areas** have highly disturbed soils due to past removal of topsoil from historical cleanup efforts and sterilization of soils from heat and radiation during testing. The same areas were often used for multiple nuclear tests.

∉ **Atmospheric safety experiment sites** are typified by remaining radioactive soil contamination, primarily in the form of plutonium and uranium.

A control site for each contaminated site will be selected and will have similar biological and physical features, but will not have radionuclide concentrations above worldwide levels of fallout. Measurements from the control sites will be used to document radionuclide levels in biota from areas believed to be uncontaminated by past and ongoing NNSA/NSO activities and representative of background levels.

DIRECT RADIATION MONITORING

Direct radiation monitoring is used to detect radiation exposures caused by sources that emit X rays, gamma rays, charged particles, and/or neutrons. Such monitoring can be done in real time by use of appropriate survey meters or by pressurized ion chambers (PICs) to obtain exposure rate and by various types of solid-state dosimeters to obtain total exposure. The objective of onsite Thermoluminescent Dosimeter (TLD) and PIC monitoring is to assess the state of the NTS's external radiation environment, detect changes in that environment, and measure gamma radiation levels near and in contaminated areas on the NTS. The onsite monitoring program will be used for trend analysis, in conjunction with fly-over data and demarcation studies, and to comply with DOE Orders. The data from environmental TLDs may also be used during future facility siting decisions.

4.2 POLLUTION PREVENTION AND WASTE MINIMIZATION PROGRAM

When economically feasible, source reduction is the preferred method of handling waste, followed by reuse and recycling, treatment, and, as a last resort, land disposal. NNSA/NSO's Integrated Safety Management System (ISMS) 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.

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 within NNSA/NSO, between NNSA/NSO, other DOE sites, and other government agencies (e.g., EPA). Created in 1998, the material exchange program has diverted over 184 metric 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 to be recycled or reused.

As required by Executive Order 13101, "Greening the Government through Waste Prevention, Recycling, and Federal Acquisition", NNSA/NSO maintains an affirmative procurement program where specific EPA-designated items, when purchased, must contain a minimum percentage of recycled materials. Purchasing items containing recycled materials stimulates a market for recycled content products and closes the loop on recycling.

P2 Assessments are conducted twice a year. These assessments look at facilities or processes throughout the complex and focus on what waste streams are generated, waste minimization activities are practiced, and are these activities tracked and reported in order to document that a waste minimization program is in place and operating as required.

EMPLOYEE AND PUBLIC AWARENESS

As stated in DOE Order 5400.1, chapter III-4c, NNSA/NSO's P2 program must include the implementation of an employee awareness program. Employee awareness of P2 issues throughout NNSA/NSO is accomplished by dissemination of articles through both electronic mail and NNSA/NSO newsletters, the maintenance of a P2 intranet website, employee training courses, and participation at employee and community events. These activities are intended to increase awareness of P2 and environmental issues and their role in improving environmental conditions in the workplace and community.

The following activities enhanced employee awareness of P2 practices:

- **Integrated Safety Management Day at the North Las Vegas Facility:** The event included an exhibit of various P2 success stories; an interactive P2 question and answer exhibit; literature about various P2 and waste minimization issues; and distribution of promotional items made from recycled materials as daily reminders regarding the benefits of recycling.

- **Earth Day:** The event, sponsored by the Nellis Air Force Base, included an exhibit on recycling; and distribution of promotional items made from recycled materials as daily reminders regarding the benefits of recycling.

- **Eco Jam:** The event, sponsored by the city of Las Vegas, included an interactive P2 question and answer exhibit; an exhibit of various P2 success stories; literature about various P2 and waste minimization issues; and distribution of promotional items made from recycled materials as daily reminders regarding the benefits of recycling.

- **Training:** Employees are instructed in P2 and waste minimization policies and practices during classroom training courses (e.g., Hazardous Waste Site General Worker Operator and Emergency Response, Waste Management for the Generator, Rad Worker II, and General Employee Orientation).

POLLUTION PREVENTION ACCOMPLISHMENTS

The activities listed below were major P2/Waste Minimization accomplishments for CY 2002:

- A new design for the management of investigation derived waste at the NNSA/NSO environmental restoration sites reduces the amount of waste entering potentially hazardous and potentially radioactive waste streams at the source of generation. This new process utilizes onsite inspection, survey, and testing to determine waste disposition. By instituting this new method, the NNSA/NSO will enhance work place safety, and reduce potentially hazardous and radioactive waste streams by an estimated 316 cubic meters over the life-cycle of the Environmental Restoration Project.

- Through the Homeland Defense Equipment Reuse Program, 30.5 packages of expired Gastec detector tubes left over from prior field projects were transferred to Oak Ridge for reuse in first response training exercises.

- Other agencies/schools purchased or were donated 67 metric tons of decommissioned buildings destined for deconstruction and disposal and dismantled the buildings and removed them from the NTS at no cost to NNSA/NSO.

- Through the NNSA/NSO excess program, a drill rig, no longer needed at the NTS, was reused by selling it to a private business in Houston, Texas. This activity diverted 245 metric tons of material from the landfill.

- An Area 25 spill site, CAU 398, contained an estimated 30.6 m^3 of soil contaminated with cadmium, lead, and PCBs. By using an X-Ray Diffractometer (XRD) to screen soil samples in the field, we were able to reduce the volume of soil removed to approximately 1.6 m^3, resulting in a 29 m^3 reduction of planned waste volume.

- During the fabrication of two whole body count chairs that will be used in the Pacific Islands, 5832 pounds of lead bricks destined for disposal were reused.

- As part of an effort to be a good corporate neighbor and to conserve water during an extended drought in the West, approximately 50,000 square feet of turf was converted to desert landscape. The Xericape project will save around 2,682,936 gallons of water each year. As a side benefit, 17.3 mega watt hours of electricity will be saved by not having to treat and deliver the water, enough electricity to meet the needs of 1.33 households for one year.

VOLUME AND TOXICITY REDUCTION

An overview of the estimated volume reductions accomplished during CY 2002, through implementation of P2/Waste Minimization activities, recycling, and material exchange, is shown in Tables 4.1 and 4.2.

4.3 HAZARDOUS MATERIALS SPILL CENTER

Biological monitoring at the Hazardous Materials Spill Center (HSC) is required for certain types of chemicals under the Center's Environmental Assessment. These chemicals have either not been tested before, have not been tested in large quantities, or have uncertain modeling predictions of downwind air concentrations. In addition, the NNSA's ESHD has requested that BN monitor (downwind) any test which may impact plants or animals outside the experimental area.

A document entitled "Biological Monitoring Plan for Hazardous Materials Testing at the Liquefied Gaseous Fuels Spill Test Facility on the Nevada Test Site" (BN 1996) describes the conduct of field surveys used to determine test impacts on plants and animals and verify that the spill program complies with pertinent state and federal environmental protection legislation. The monitoring plan calls for the establishment of three control transects and three treatment transects, which have similar environmental and vegetational characteristics at three distances from the chemical release point. BN biologists review spill test plans to determine if field monitoring along the treatment transects is required as per the monitoring plan criteria.

BN reviewed chemical spill test plans for three experiments during 2002. Biota monitoring was not needed for any of the three tests at the HSC during 2002 since they did not meet the criteria needed for monitoring in the 1996 monitoring plan. Baseline monitoring was conducted at established control-treatment transects near the HSC in August, 2002. No differences in biota were noted along downwind versus upwind transects.

4.4 RADIOACTIVE WASTE MANAGEMENT SITES

DISPOSAL ACTIVITIES

The Areas 3 and 5 RWMSs are designed and operated for disposal of LLW from onsite, NNSA offsite, and other offsite generators and mixed waste from onsite. All generators of waste streams must first request to dispose of waste, submit an application for specific waste streams, meet NTS Radioactive Waste Acceptance Criteria, and receive approval for disposal by NNSA/NSO. Waste acceptance criteria are based on how well the site is predicted to perform as described in Performance Assessment (PA) and Composite Analysis (CA) documents. The NNSA/NSO assesses the long-term performance of LLW disposal sites by conducting a PA, which is a systematic analysis of the potential risks posed by a waste disposal site to the public and to the environment. Disposal consists of placing waste in various sealed containers in the unlined cells and trenches. Soil backfill is applied over the containers 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. The Environmental Monitoring Program collects data to determine if performance is as expected and to meet regulatory compliance requirements.

Waste disposal at the RWMS-5 has occurred in a 37-hectare (92-acre) portion of the site, referred to as the LLW Management Unit (LLWMU), since the early 1960s. The LLWMU consists of 24 landfill cells (pits and trenches) and 13 Greater Confinement Disposal (GCD) boreholes. Four of the GCD boreholes were used to dispose of transuranic (TRU) waste, and five contain LLW. These nine boreholes were backfilled with soil after the waste was emplaced and are no longer active. The remaining four have not received waste, are inactive, and have not been backfilled with soil. Of the 24 landfill cells, 3 are open for disposal of LLW, 1 is an active mixed waste disposal unit, 1 is permitted for disposal of asbestos-form LLW, and 1 is reserved for long-term retrievable storage of non-specific classified materials. The remaining 18 landfill cells are covered and are no longer active. In CY 2002, the RWMS-5 received 639 shipments containing 828,562 cubic feet of LLW and no shipments containing mixed LLW (MLLW) for disposal.

Key documents in place that are necessary for disposal operations to occur at the RWMS-5 are as follows:

- A Disposal Authorization Statement (DAS) was issued in December 2000 for RWMS-5.
- PA for the RWMS-5 at the NTS, Nye County, Nevada, Revision 2.1, January 1998.
- CA for the RWMS-5 at the NTS, Nye County, Nevada, February 2000.
- NTS Waste Acceptance Criteria (NTSWAC) Revision 4, February 2002.
- Integrated Closure and Monitoring Plan (ICMP) for the Areas 3 and 5 RWMSs at the NTS, September 2001.
- Auditable Safety Analysis (ASA) for the Areas 3 and 5 RWMSs, August 2000.

Waste disposal cells within the RWMS-3 were developed from subsidence craters that resulted from underground nuclear testing. Disposal operations at the RWMS-3 began in the late 1960's. Of the seven craters within the RWMS-3, three are active, two are closed, and two are not in use. In CY 2002, the RWMS-3 received 1083 shipments containing 941,262 cubic feet of LLW for disposal.

Key documents in place that are necessary for disposal operations to occur are as follows:

∉ A DAS was issued in October 20, 1999, for the RWMS-3.

∉ PA/CA for the RWMS-3 at the NTS, Nye County, Nevada, Revision 2.1, October 2000.

The NTSWAC, ICMP, and ASA are the same as described for RWMS-5.

STORAGE ACTIVITIES

The RWMS-5 stores LLW, MLLW, TRU, and Mixed TRU (MTRU) waste for characterization to determine treatment and disposal options. TRU and MTRU wastes are being characterized for disposal at the Waste Isolation Pilot Plant in New Mexico.

4.5 HISTORIC PRESERVATION

The National Historic Preservation Act (NHPA) of 1966, the Archeological Resources Protection Act of 1979, and the regulations related to these laws directs federal agencies to identify, inventory and manage the cultural resources under their stewardship. The NHPA also requires consultation with interested parties, especially Native Americans, in regard to historic preservation activities and proposed decisions affecting cultural resources.

As required under Section 106 of the NHPA, in CY 2002, the NNSA/NSO conducted archival background research to identify known prehistoric and historic properties for 15 proposed projects. There were nine cultural resources field surveys conducted prior to undertakings. Five separate surveys were for Underground Test Area (UGTA) wells and associated features in NTS Areas 2, 6, 7, 8, and 12. One significant site was identified and protected by rerouting an access road. In Area 18, a proposed road way was surveyed with no sites found. The survey of a proposed extension of the Yucca Flat runway in Area 6 also did not locate sites. In Area 4, a survey for a Big Explosives Experimental Facility experiment did not locate new sites. There is one significant site near this facility but potential adverse effects were mitigated through documentation in the mid 1990s. During a survey in Area 19 for training areas, nine sites were identified within the area of potential effect, but none were significant and the project was able to proceed as planned. A total of 318 acres were surveyed for Section 106 projects in CY 2002.

Four historical evaluations were completed or initiated in CY 2002. A study of the T-3b FIZEAU Underground Bunker in Area 3 was completed with the recommendation that the bunker be considered eligible to the NRHP. There is no activity planned that would adversely impact this structure. Historical evaluations for four buildings in Area 6 (CP-2, CP-10, CP-43, and CP 400) were undertaken in CY 2002 with completion anticipated in early CY 2003. There are plans to excess or demolish these buildings at some time in the future.

Two inventory projects meeting the requirements of the NHPA Section 110 were conducted in 2002. A survey of the historic structures at Tippipah Spring was undertaken as part of an in-progress survey of the spring area. The fieldwork will be completed over the next couple years. Also, the fieldwork for a survey of the historic structures on Yucca Lakebed was done with a report to be prepared in CY 2003 that discusses the historic structure district there.

The Cultural Resources Management Plan for the NTS formalized a monitoring program that meets requirements of the NHPA and ARPA. This program focuses on monitoring the condition of archaeological sites and historic structures that have been determined eligible to the NRHP. Ten sites were monitored in 2002. A diversity of site types was examined, e.g., rock art sites, rock shelters, the Japanese Village, and prehistoric camps of various ages. Prior to fieldwork, background research for each site was conducted by reviewing all pertinent maps, site forms, short reports, and technical reports. Information regarding location, site type, site maps, site size, site eligibility statements, recommendations, and vegetation was compiled from records on file. Fieldwork consisted of relocating each site, photographing the site, examining the site to identify previously recorded information, and recording additional site data, when appropriate. A report documenting the results of the survey was prepared with site forms updated to include recent observations.

Since 1990, the NNSA/NSO has been involved in consultations with Native American tribal groups in Nevada, California, Arizona, and Utah, who have historical ties to NTS land. The three major groups are the Western Shoshone, the Southern Paiute, and the Owens Valley Paiute-Shoshone. NAGPRA consultations and repatriation activities for 95 percent of the NNSA/NSO collection were completed in 1996. Consultations also have been completed for the Worman, McKinnis, and Hot Creek collections. In 2002, objects from the Worman and McKinnis collections were repatriated to the tribes with ceremonies at the NTS.

4.6 ECOLOGICAL MONITORING AND COMPLIANCE PROGRAM

The Ecological Monitoring and Compliance (EMAC) Program provides ecological monitoring and compliance support for activities and programs conducted at the NTS. It is designed to ensure compliance with laws and regulations related to plants, animals, and ecosystems on the NTS, and to provide information that can be used to predict and evaluate the potential impacts of proposed projects and programs on species and ecosystems. There are four major components of the program: (1) compliance with federal and state acts and regulations, (2) sensitive species and sensitive habitat monitoring, (3) ecosystem mapping, and (4) biological monitoring for specific NTS programs.

Biological surveys are routinely conducted each year at proposed project sites on the NTS that will cause disturbance of native soils and vegetation. These surveys identify the presence of the threatened desert tortoise and breeding birds and identify any mitigation actions necessary to comply with the Endangered Species Act and the Migratory Bird Treaty Act. In CY 2002, biological surveys for 27 projects were conducted.

Long-term monitoring of several species considered sensitive by state or federal agencies is conducted annually or periodically. In CY 2002, such monitoring was conducted for two plant species, feral horses, and raptors. A three year effort of monitoring western burrowing owls was completed in CY 2001, and in CY 2002 efforts were focused on producing a draft topical report on the results of the monitoring study. Sensitive habitats monitored for wildlife use in CY 2002 included 11 natural seeps and springs, and 58 man-made sumps and ponds.

Digital mapping of vegetation associations and wildlife habitats and their linkage with animal historical sightings and distribution data are ongoing efforts of EMAC. In CY 2002, efforts were focused on compiling the metadata associated with the vegetation field data collected for preparation of the topical report "Classification of Vegetation on the Nevada Test Site" (Ostler et al., 2001). Also, work began on entering historical animal sighting and specimen collection sites into a geospatial database.

Specific biological monitoring is conducted each calendar year under EMAC at the HSC on Frenchman Flat for testing activities which may have an impact on downwind plants or animals. In CY 2002, no biological monitoring was recommended or conducted for tests conducted at the HSC.

4.7 UNDERGROUND TEST AREA PROJECT

The 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 NNSA/NSO on the NTS. From 1951 to 1992, 828 underground nuclear tests were conducted at the NTS. Most of these tests were conducted hundreds of feet above the groundwater table; however, over 200 of the tests were in proximity of, or within, 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 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 assure 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.

A regional three-dimensional computer groundwater model (International Technology Corporation [IT Corporation] 1996a) 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, one has been built: Frenchman Flat (IT Corporation 1998b). The Pahute Mesa-Oasis Valley model is 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 a monitoring network to ensure public health and safety.

In 2002, the UGTA Project drilled and completed a total of three wells and began drilling at a fourth site. All are located in the eastern portion of the NTS: one in Frenchman Flat (ER-5-4#2) and three in Yucca Flat (ER-6-1#2, ER-8-1, and ER-12-2). The UGTA Project initiated a hydrogeologic investigation well drilling program for the Frenchman Flat CAU in 2000 (IT Corporation 2000). The drilling initiative in Frenchman Flat included five new wells and was concluded with the completion of Well ER-5-4#2. In 2002, the UGTA Project initiated a similar hydrogeologic investigation well drilling program for the Yucca Flat CAU (IT Corporation 2002). The Yucca Flat drilling initiative includes five new wells. The goal of this program is to collect additional subsurface geologic and hydrologic data in the Frenchman Flat and Yucca Flat CAUs, where underground nuclear tests were conducted between 1957 and 1992 (DOE 2000a). Data from these wells will allow for more accurate modeling of groundwater flow and radionuclide migration in these two former test area. Some of the new wells may also function as long-term monitoring wells.

Well ER-5-4#2 is located in north central Frenchman Flat and was completed in the Wahmonie Volcanic Confining Unit in September 2002. It was drilled to a total depth of 2,133.6 m (7,000 ft). Well ER-6-1#2 is located in southeastern Yucca Flat and was completed in October 2002 at a total depth of 975.4 m (3,200 ft) in Paleozoic-age carbonate rocks. This well will be part of a multi-well tracer experiment designed to enhance understanding of the hydraulic properties of the lower carbonate aquifer.

Well ER-8-1 is located in northern Yucca Flat just south of the Climax granitic stock. The well was completed in November 2002 at a total depth of 872.6 m (2,863 ft). The primary purpose of this well will be to provide data that will be used to constrain groundwater flow into Yucca Flat from the north and to investigate the steep potentiometric gradient at the north end of Yucca flat.

Drilling activities at ER-12-2 began in December of 2002 and continued into CY 2003. The primary purposes of Well ER-12-2 will be 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.

Preliminary (predevelopment) groundwater characterization samples were collected from each of the above wells. No tritium or other man-made radionuclides were detected while drilling any of these wells.

Hydrological tests were conducted at Wells ER-5-4#2 and ER-6-1#2 in 2002. Well construction information and hydrologic and geologic data for these recent UGTA wells will be published in separate reports by BN for the NNSA/NSO in 2003.

Also completed in 2002 was the processing and subsequent interpretation of a 3D seismic reflection survey conducted in northern Frenchman Flat during the summer and fall of 2001. The survey area encompassed 13.8 square miles and included the two general areas within Frenchman Flat formerly used for underground nuclear testing. The primary goals of this seismic survey were to determine depth to the lower carbonate aquifer and identify geologic structures (e.g. faults) in the area. Secondary goals included mapping the alluvium/volcanic tuff contact and other horizons within the volcanic tuff sequence. Data from this study will be used to enhance the 3D hydrostratigraphic framework model of Frenchman Flat (IT Corporation 1998b).

4.8 HYDROLOGIC RESOURCES MANAGEMENT PROGRAM

The NNSA/NSO's Hydrologic Resources Management Program's (HRMP's) primary responsibility is to acquire hydrologic data and information of groundwater supplies to support ongoing activities and to assist in planning new uses for the 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.

MISSION

The mission 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 these objectives 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.

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.

Hydrology and Radionuclide Investigations for Operations

The HRMP assists the 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/bound water relationship in boreholes and cores.

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 itself, 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 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 SDWA 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.

4.9 NTS WELL AND BOREHOLE PLUGGING PLAN

Since the late 1950s, approximately 4,000 wells and boreholes have been constructed at the NTS to support uses ranging from water supply wells to large-diameter nuclear device emplacement holes. Most of the existing wells and boreholes were originally constructed to support the weapons testing program.

In 1997, the Nevada Division of Water Resources (DWR) issued revised regulations for water-wells and related drilling, which expanded its regulations to address a category of boreholes that are drilled for purposes other than evaluating or producing water. In March 1998, a letter from the Manager of the NNSA/NSO to the President and General Manager of BN stated that compliance with the revised DWR regulations will achieve the goal of protecting groundwater resources from contamination, as well as satisfy state of Nevada and SDWA objectives. The NNSA/NSO tasked BN to develop a plan for the management of all existing wells and boreholes and the construction of new wells and boreholes at the NTS in a manner that procedurally meets state regulations. The result of this effort was the NTS Well and Borehole Management Plan.

This plan discusses the objectives/intent of the DWR regulations and how these objectives will be applied to the management of the existing NTS well and borehole inventory and the construction and management of future wells and boreholes. The objectives include the prevention of contamination or waste of the groundwater resource during the drilling, construction, or plugging of wells and boreholes; drilling, construction, and plugging programs designed to isolate zones of poor-quality water from zones of good-quality water; isolation of artesian zones; and prevention of surface contamination and unauthorized entry. A detailed strategy and process for plugging of the existing unused wells and boreholes is provided within the plan because open wells and boreholes represent a significant potential risk for impacting the quality of the groundwater resource. The process produces a prioritized list of open NTS wells and boreholes that should be plugged, with corresponding cost estimates and tentative schedules.

During calendar year 2002, a total of 52 unused boreholes were plugged in Areas 1, 2, 3, 4, 9 and 10 under this plan. Additional unused or abandoned boreholes will be plugged each fiscal year under this multi-year initiative.

4.10 INDUSTRIAL SITES PROJECT

The Industrial Sites Project includes areas located on the NTS and the Tonopah Test Range that were used to support past testing operations. Over 1,500 of these historic areas, or industrial sites, have been identified, verified, and inventoried for characterization, closure, and/or restoration. Of these, nearly 750 sites have been formally closed. The remaining sites have been grouped according to source of contamination, location, and other technical characteristics. Industrial Sites Project activities focus on the characterization and applicable corrective actions for these sites. The Deactivation and Decommissioning process is also included under the Industrial Sites Project. This process supports the cleanup of the six remaining surplus facilities transferred from the NNSA/NSO Defense Programs to the Environmental Restoration Division. These facilities include the Pluto Facility; Super Kukla Facility; Reactor Maintenance Assembly and Disassembly Facility; Engine Maintenance Assembly and Disassembly Facility; Test Cell A; and Test Cell C.

Deactivation is the process used to remove radioactive, chemical, or other hazardous contamination from facilities, structures, soils, or equipment. Methods of deactivation include washing, scraping, or cleaning. Decommissioning involves stabilizing, reducing, or removing radioactive and/or other types of contamination and can consist of dismantling a facility, entombing or covering part or all of the facility, or converting a facility for other uses.

Table 4.1 Reduction in Volume of Hazardous Waste Generated at the NTS - 2002

Waste Minimization Category	Activity	Volume Reduction
Recycle/Reuse Project	Lead acid batteries were shipped to an offsite vendor for recycle.	27 mt
Recycle/Reuse Project	Lead scrap metal was sold for reuse/recycle instead of disposed of as hazardous waste.	0.3 mt
Recycle/Reuse Project	Spent fluorescent light bulbs, mercury lamps, metal hydride lamps, and sodium lamps were sent to an offsite vendor for recycle.	4.3 mt
Recycle/Reuse Project	Bulk used oil was sent to an offsite vendor for recycle.	111.7 mt
Recycle/Reuse Project	Lead tire weights were reused instead of being disposed of as hazardous waste.	0.9 mt
Recycle/Reuse Project	Rechargeable batteries were sent to an offsite vendor for recycle.	0.1 mt
Source Reduction	An Area 25 spill site contained an estimated 30.5 metric tons of soil contaminated with cadmium, lead, and PCBs. By using an XRD to screen soil samples in the field, we were able to reduce the volume of soil removed to approximately 1.6 metric tons.	29 mt
Recycle/Reuse Project	Lead bricks destined for disposal were reused during the fabrication of 2 whole body count chairs that will be used in the Marshall Islands.	2.6 mt
Recycle/Reuse Project	Pressurized containers containing Halon, destined for disposal at a Treatment, Storage, and Disposal Facility, were sent to the Defense Depot at Richman, Virginia for recycle/reuse.	1.2 mt
Recycle/Reuse Project	Through the Homeland Defense Equipment Reuse Program, expired Gastec detector tubes were transferred to Oak Ridge for reuse in first response training exercises.	0.1 mt
Total		**177.2 mt**

Table 4.2 Reduction in Volume of Solid Waste Generated at the NTS - 2002

Waste Minimization Category	Activity	Volume Reduction
Recycle/Reuse Project	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.	67 mt
Recycle/Reuse Project	Mixed paper/cardboard was sent offsite for recycle.	484 mt
Recycle/Reuse Project	Aluminum cans were sent offsite for recycle.	1.6 mt
Recycle/Reuse Project	#1 PET Plastic was sent offsite for recycle.	0.7 mt
Recycle/Reuse Project	Food waste from the cafeterias was sent offsite to be reused as pig feed for a local pig farmer.	52 mt
Recycle/Reuse Project	Spent toner cartridges were sent offsite for recycle.	6.5 mt
Recycle/Reuse Project	Obsolete software, video tapes, and audio tapes were sent offsite for recycle.	0.6 mt
Recycle/Reuse Project	Scrap ferrous metal was sold to a vendor for recycle.	2.8 mt
Recycle/Reuse Project	Scrap non-ferrous metal was sold to a vendor for recycle.	0.8 mt
Recycle/Reuse Project	Tires were sent to a vendor for recycle.	16 mt
Recycle/Reuse Project	Alkaline batteries were sent to a vendor for recycle.	0.3 mt
Recycle/Reuse Project	Glass was sent to a vendor for recycle.	0.1 mt
Recycle/Reuse Project	Shipping materials including pallets, Styrofoam, bubble wrap, and shipping containers, were reused.	25 mt
Recycle/Reuse Project	Non-hazardous chemicals, equipment, and supplies were relocated to new users through the material exchange program, diverting them from landfill disposal.	1.8 mt
Recycle/Reuse Project	Through the NNSA/NSO excess program, a drill rig, no longer needed at the site, was reused by selling it to a private business.	245 mt
Total		**904.2 mt**

5.0 RADIOLOGICAL ENVIRONMENTAL PROGRAMS

The radiological environmental surveillance at the Nevada Test Site (NTS) addresses compliance with U. S. Department of Energy (DOE) Orders, state and federal regulations, stakeholder issues, and other drivers as defined in the Routine Radiological Environmental Monitoring Plan (RREMP). The radiological compliance monitoring brings together sitewide environmental surveillance, site-specific effluent monitoring, and operational monitoring conducted by various missions, programs, and projects on the NTS. Monitoring used a decision-based approach to identify the environmental data that must be collected and provided Quality Assurance, Analysis, and Sampling Plans which ensure defensible data are generated. Sampling and analysis plans provide for monitoring water, soil (not collected in 2002), plant, air, and animal media in the onsite environment; and water media in the offsite environment. Oversite environmental surveillance is conducted for stakeholders by Desert Research Institute (DRI) of the University and Community College System of Nevada. This program consists of a network of monitoring stations operated by offsite residents. During 2002, no radioactivity related to current activities at the NTS was detected by environmental surveillance programs.

5.1 AIR SURVEILLANCE ACTIVITIES

The air surveillance network on the NTS monitors for radionulcides to demonstrate compliance with the Clean Air Act (for a complete description, see Chapter 3.0). During calendar Year (CY) 2002, air monitoring was conducted for radioactive particulates and tritiated water (HTO) vapor at a total of 16 and 14 locations, respectively. Beginning in July 2001, six of the sampling locations (SCHOONER, Gate 700 South, Mercury, Guard Station 510, Substation 3545, and Yucca) were selected as compliance stations for demonstrating compliance with National Emission Standards Hazardous Air Pollutants (NESHAP), as approved by the U. S. Environmental Protection agency (EPA) (EPA 2001). The air sampling locations and the ambient gamma radiation monitoring locations relative to the sites with potential for airborne radioactive emissions are shown in Figure 5.1.

In the following sections, each description of the sampling or monitoring method is followed by a summary of the analytical results and a discussion of the results. For convenience in reporting all values shown in the tables are formatted to a greater number of digits than can be justified by the accuracy of the measurements, which is only two significant figures at the most (25 or 0.025, as an example). The highest annual average concentration for each radionuclide is compared to its derived concentration guide (DCG) for the general public as specified in Federal regulations. The more conservative DCG used in the following sections is the concentration that will deliver a 10 mrem/yr committed effective dose equivalent (CEDE), assuming that the receptor resides at the sampling location throughout the year.

AIR PARTICULATE SAMPLING

A sample of airborne particulates from the air surveillance network is collected 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

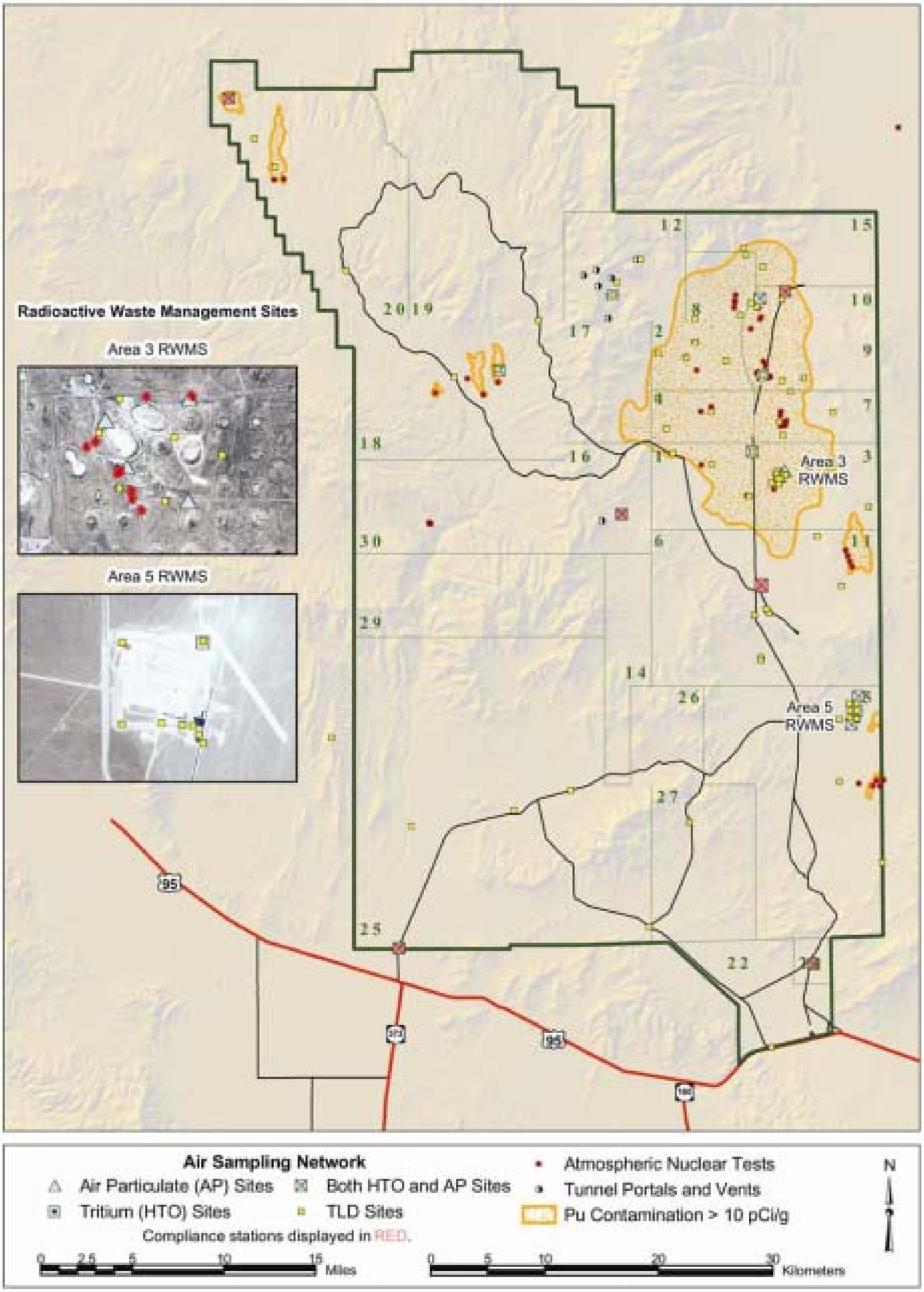


Figure 5.1 Air Sampling Network on the NTS - 2002

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 are measured with a mass-flow meter which corrects for variations in temperature and elevation on the NTS.

The 10-cm diameter filters are analyzed for gross alpha and gross beta radioactivity five days after collection to allow for the decay of naturally-occurring radon and its progeny. The filters from four weeks of sampling are composited, analyzed by gamma spectroscopy, and then analyzed for $^{239+240}Pu$ and ^{241}Am. To monitor for any potential emissions from tests using depleted uranium, BN also has the filter composites from Guard Station 510, Substation 3545, and Yucca analyzed for uranium isotopes.

In addition to the routine air surveillance network, high-volume air samplers were operated in Area 12 on August 17, 18, and 23, 2002, at five locations, to measure any airborne radionuclides that were re-suspended from surface soil by a 300 acre (121 hectares) wild brush fire ignited by an unknown source. The sampling was conducted to assess the exposure to fire fighters and to determine if the fire created a significant emission source to offsite residents. These air samplers, operating at a flow rate of 1.1 m^3/min or 40 cfm for 2-4 hour periods, also used 9-cm-diameter glass-fiber filters, resulting in air sample volumes of 136 to 271 m^3 (4800 to 9600 ft^3). The filters were analyzed for gross alpha and gross beta radioactivity immediately after collection and at five days after collection to allow decay of the radon progeny. The total filters from each location were then composited, dissolved, and prepared for analysis by gamma spectroscopy for gamma emitters and alpha spectroscopy for ^{241}Am and $^{239+240}Pu$.

The Community Environmental Monitoring Program (CEMP) continued to collect offsite data as oversite verification of the results of the onsite source term monitoring. A description of this program and summaries of its offsite monitoring results are given in section 5.6.

Area 12 Brush Fire Results

The sampling results are summarized in Table 5.1 and compared to a summary of the routine network. As shown in Table 5.1, the mean concentrations of ^{137}Cs, ^{241}Am, and $^{239+240}Pu$ determined from the brush fire air samples were all less than 4 percent of the DCGs (for an EDE of 10 mrem/yr or 0.10 mSv/yr), and therefore not considered to be a significant source of radiation exposure to onsite personnel or offsite residents. The concentration means of the gross alpha and gross beta radioactivity were about three times those for the routine network, and higher mean concentrations of ^{137}Cs and ^{241}Am, were observed; however no increase in the results of the routine network was observed for the month of August in the time-series plots for these analyses, except for a gross alpha concentration spike on August 22 at U-3ah/at south. The gross alpha concentration spike at U-3ah/at south was attributed to Area 3 effects and not the brush fire because a similar concentration spike was observed at this location for CY 2001 and there were other air sampling locations closer to Area 12 that did not show an increase of airborne radioactivity.

Gross Alpha and Beta Results

Gross alpha and gross beta radioactivity measurements in airborne particulates are used as a weekly screening of long-lived radionuclides in air. Descriptive statistics for both measurements, in units of µCi/mL of air, are given in Tables 5.2 and 5.3, respectively, for the routine network. Time-series plots of the weekly values are shown in Figures 5.2 and 5.3, respectively.

Although the locations included in the air particulate monitoring network changed somewhat from 2001 to 2002, the overall patterns and levels of gross alpha measurements are quite consistent between the years. Again the differences among locations are not great. There

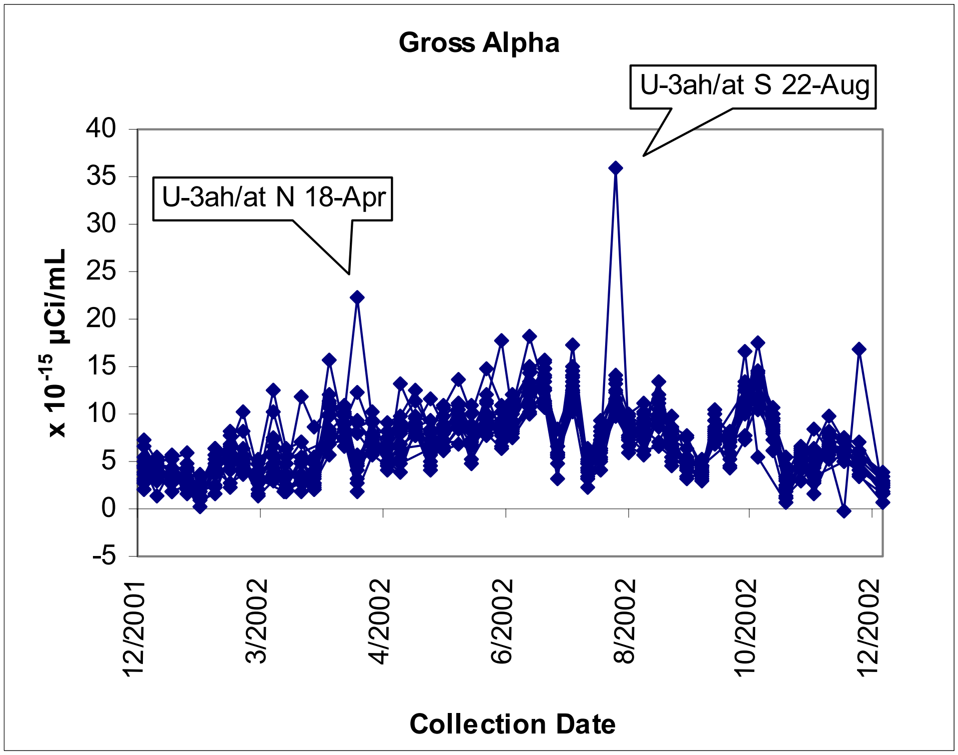


Figure 5.2 Times Series Plot of Alpha – 2002

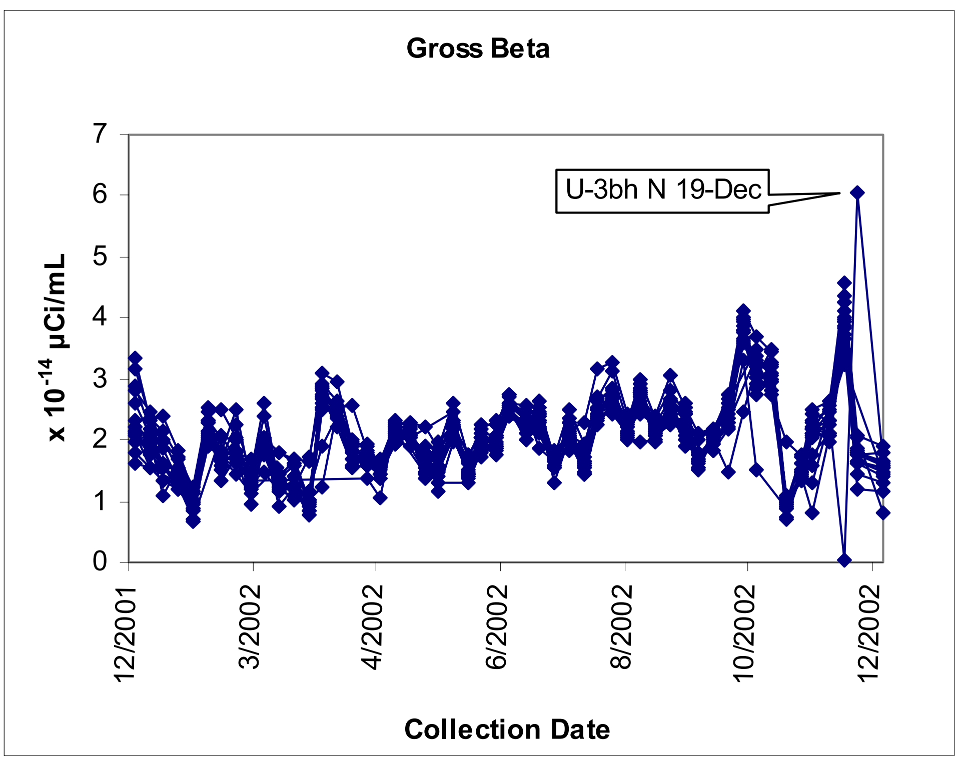


Figure 5.3 Times Series Plot of Beta – 2002

does appear to be an increase during the summer months. There also appears to be a significant systematic week-to-week variation in measurement levels, unrelated to season. The investigation as to the cause of the systematic variation continues. The proportion of gross alpha measurements above their minimum detectable concentrations (MDCs) remains around 90 percent. Considering only the 10 stations with measurements available during at least 40 weeks of each year, mean levels increased in six of these stations and decreased in three. The average of these means increased by 4.4 percent, from 6.8 to 7.1 x 10^{-15} µCi/mL (0.25 to 0.26 mBq/m^3).

As with gross alpha, gross beta measurements obtained during 2002, resembled the 2001 measurements, with a modest dip in late winter and rise in mid-summer. Again there is a systematic week-to-week variation, and again differences among locations are relatively minor. Nearly all measurements exceeded their MDCs for both years. The means for all of the 10 stations with data for at least 40 weeks each year increased mildly; the mean of means increased 11 percent from 1.8 to 2.0 x 10^{-14} µCi/mL (0.67 to 0.74 mBq/m^3).

Plutonium Results

Descriptive statistics for ^{238}Pu and $^{239+240}$Pu are given in Tables 5.4 and 5.5. As ^{238}Pu was detected above the MDC in only 12 percent of measurements overall, a time-series plot of only the $^{239+240}$Pu values are shown in Figure 5.4.

The proportion of ^{238}Pu measurements exceeding their MDCs was slightly higher in 2002 than 2001 over all locations. For 11 locations with data from all or nearly all of both years, the proportion exceeding the MDC increased from 11.0 percent to 15.7 percent, and the mean of means increased from 2.2 to 2.9 x 10^{-18} µCi/mL (82 to 107 nBq/m^3). The highest mean concentration (6.3 x 10^{-18} µCi/mL or 233 nBq/m^3) was observed at U-3ah/at north which was 0.21 percent of the DCG.

In a similar comparison for $^{239+240}$Pu for the 11 continuing locations, the average proportion of measurements exceeding their MDCs increased slightly from 58.7 percent to 59.8 percent, while the mean of the means decreased from 81 to 78 x 10^{-18} µCi/mL (3.0 to 2.9 µBq/m^3) . U-3ah/at south was the location with the highest mean, 288 x 10^{-18} µCi/mL (11 µBq/m^3) which is 14 percent of the DCG. As shown in Figure 5.4, other peak concentrations occurred at Bunker 9-300 and BJY areas that have shown peaks in the past due to radionuclides in the surface soil in the vicinity of the samplers.

Figure 5.5 shows the trend in the highest annual station averages of $^{239+240}$Pu for 1991 to 2002 and compares those values with the DCG. Figure 5.6 shows the long-term trends in $^{239+240}$Pu for 10 locations with at least 20-year histories. The overall picture is one of a steady, gradual decrease in concentrations through the late 1980s, with roughly steady-state variation since that time. The decrease is attributed to the termination of nuclear testing in 1992 and the general reduction of field activities that can cause a re-suspension of the plutonium in the surface soil.

Americium Results

Descriptive statistics for ^{241}Am are given in Table 5.6. As expected, the trend plot for ^{241}Am parallels that of $^{239+240}$Pu (see Figure 5.7). For the 11 continuing stations with data from all or nearly all months of both years, the proportion of measurements exceeding their MDCs decreased from 70 percent to 47 percent, and the mean of means decreased from 22 to 16 x 10^{-18} µCi/mL (0.82 to 0.59 µBq/m^3). The two highest annual means were 47 x 10^{-18} µCi/mL (1.7 µBq/m^3) at U-3ah/at north and 45 x 10^{-18} µCi/mL (1.7 µBq/m^3) at Bunker 9-300; the former is 2.4 percent of the DCG.

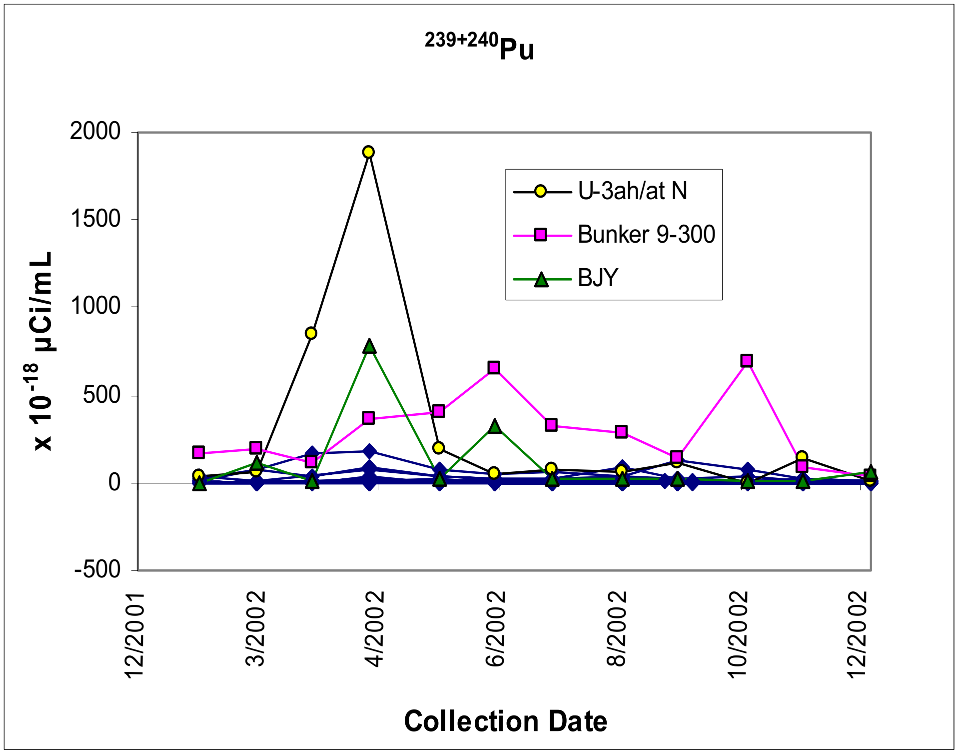


Figure 5.4 Time Series Plot of Plutonium in Air – 2002

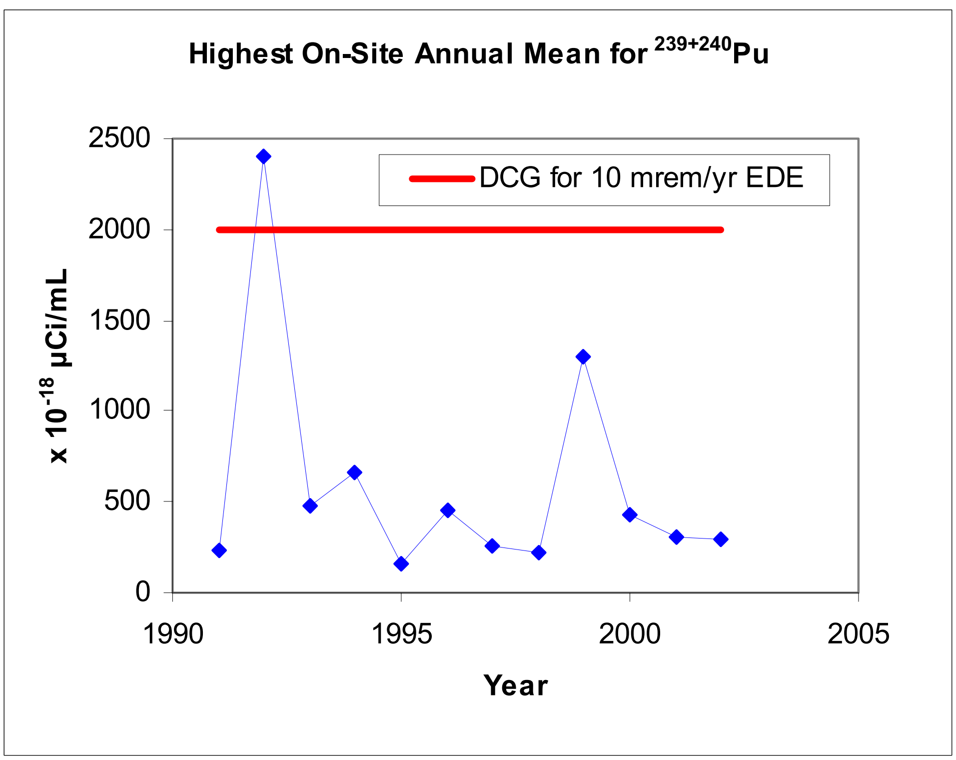


Figure 5.5 Trend in Highest Annual Averages for $^{239+240}Pu$ Concentrations

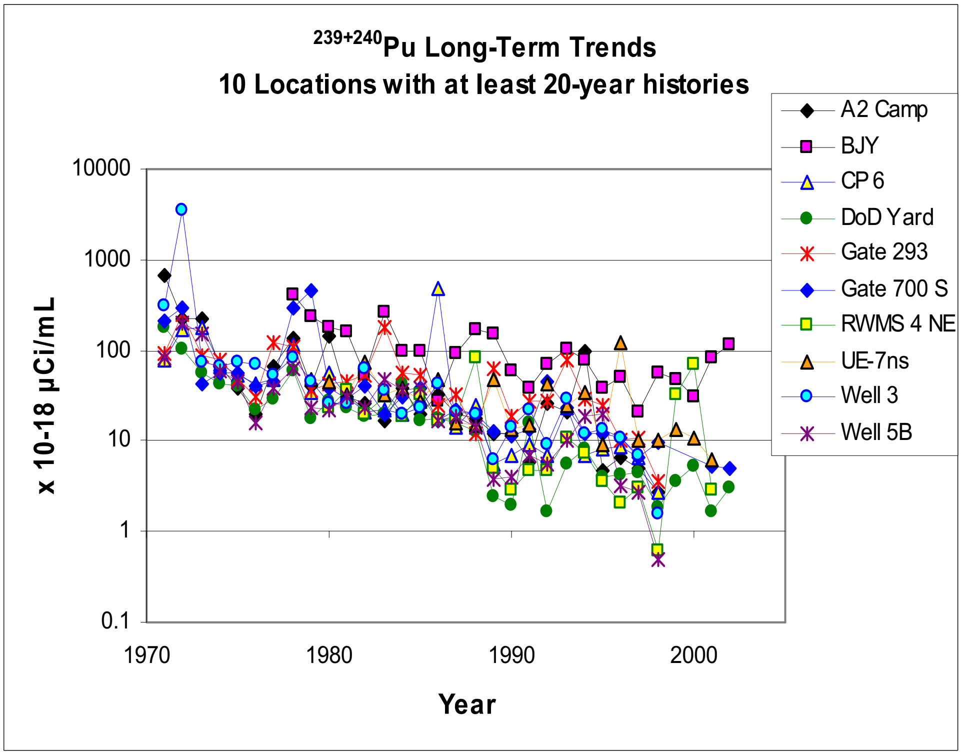


Figure 5.6 Time Series Plot for $^{239+240}$Pu Annual Averages

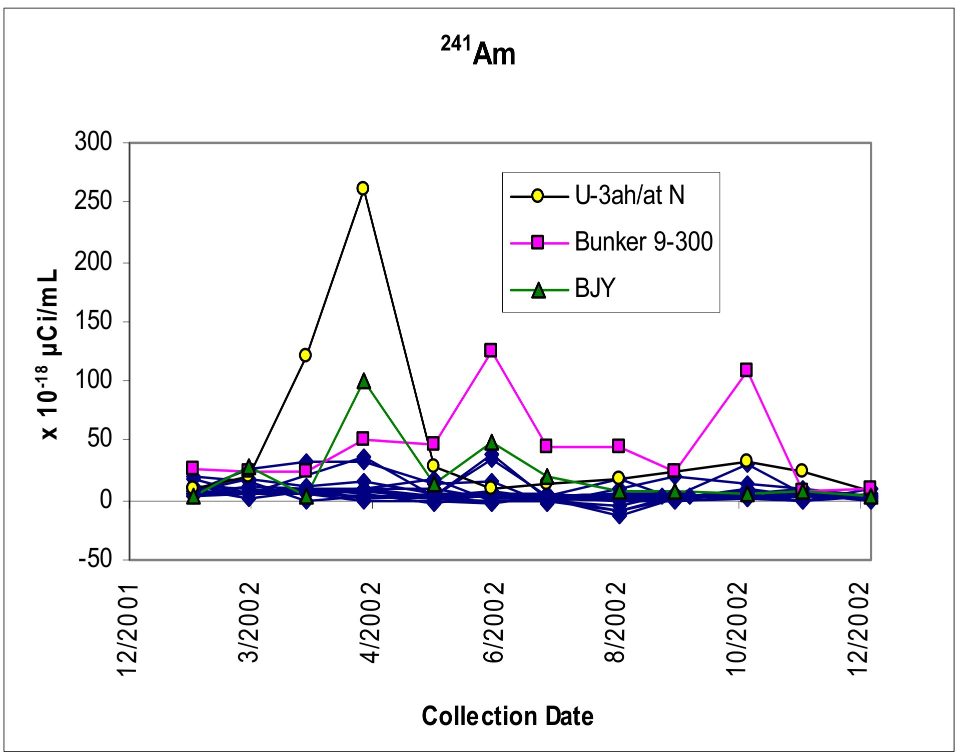


Figure 5.7 Time Series Plot of ^{241}Am in Air for all Locations – 2002

Uranium Results

Table 5.7 presents the descriptive statistics for the uranium analyses performed on the monthly filter composites from 3545 Substation, Yucca, and Guard Station 510. Nearly all $^{235+236}U$ measurements are less than their MDCs. Most (86 percent) $^{235+236}U$ and ^{238}U measurements were less than their MDCs, whereas most $^{233+234}U$ and ^{238}U exceeded their MDCs (85 and 79 percent, respectively). The rates exceeded are somewhat higher than 2001 for $^{235+236}U$, about the same as 2001 for $^{233+234}U$, and lower for ^{238}U. The average of the mean concentrations increased slightly for $^{233+234}U$, (from 82 to 91 x 10^{-18} µCi/mL or 3.0 to 3.4 µBq/m^3) and ^{238}U (from 72 to 82 x 10^{-18} µCi/mL or 2.7 to 3.0 µBq/m^3), but decreased for $^{235+236}U$ (from 11 to 9.1 x 10^{-18} µCi/mL or 0.41 to 0.34 µBq/m^3). The patterns of variation are quite similar among the three locations (see Figures 5.8, 5.9, and 5.10.

Gamma-Emitting Radionuclides

^{137}Cs was the only man-made radionuclide detected in air particulate samples by gamma spectroscopy. Its descriptive statistics are given in Table 5.8. Only 0.3 percent of the measurements (one of a pair of measurements at one location during one event) exceeded its MDC, which is lower than the 1 percent seen in 2001. For the 11 continuing locations with data from all months of both years, the mean of means decreased from 0.776 to 0.287 x 10^{-16}µCi/mL (3.0 to 1.1 µBq/m^3).

Naturally occurring ^7Be was also detected by gamma spectroscopy. 100 percent of the measurements were above their MDCs, as was the case in 2000. The "detect" rate for 2001 was somewhat lower (78 percent); however, this was due to anomalously high MDCs during the first part of 2001. The mean for all stations is 1.2 x 10^{-13} µCi/mL (4.7 mBq/m^3), the same as the mean for all stations in 2001, and slightly lower than the mean for all stations in 2000 (1.5 x 10^{-13} µCi/mL [5.9 mBq/m^3]).

TRITIUM IN AIR

Tritiated water vapor in the form of $^3H^3HO$ or ^3HHO (HTO) was monitored at 14 onsite locations. The samplers were operated at a constant flow rate of 0.6 L/min (1.25 ft^3/hr) by microprocessors, which summed the total volume sampled (about 11 m^3 over a two-week sampling period). At E Tunnel Pond 2, a sampler without constant flow capability that summed the air volume sampled with a dry-gas meter was operated until April 4, 2002, at which time the sampler was replaced with a constant flow unit and moved from Pond 2 to a location just south of Pond 6.

With either sampler, 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.

Tritium in Air Results

Overall 48 percent of HTO measurements exceeded their MDCs, down slightly from 52 percent in 2001. The network mean concentration was 32.6 x 10^{-6} pCi/mL (1.1 Bq/m^3), down slightly from 34.6 x 10^{-6} pCi/mL (1.2 Bq/m^3) in 2001. Concentrations vary dramatically by location, with SCHOONER having values two or three orders of magnitude higher than the other locations due to the sampler's proximity to the crater. SEDAN north also had concentrations distinctly above those of the other stations (see Table 5.9 and Figure 5.11). The SCHOONER measurements are plotted at one tenth of their actual value in Figures 5.11 - 5.13 to make the details more visible in the other stations. The higher measurements occur in the summer months, lagging slightly with the rise in average air temperature, but closely following the

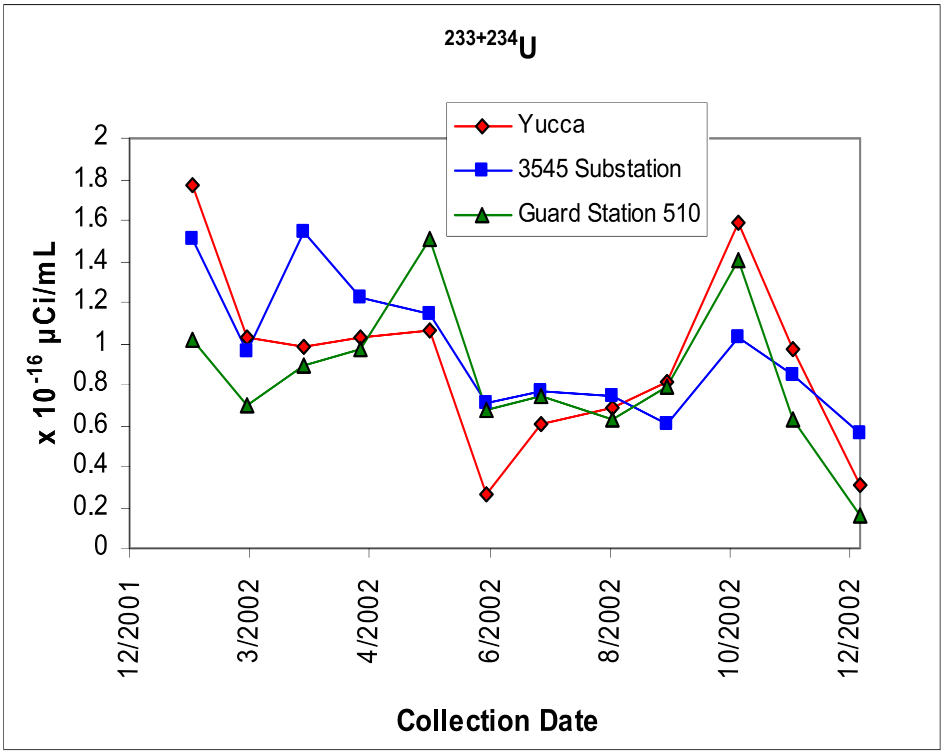


Figure 5.8 Time Series Plot of $^{233+234}U$

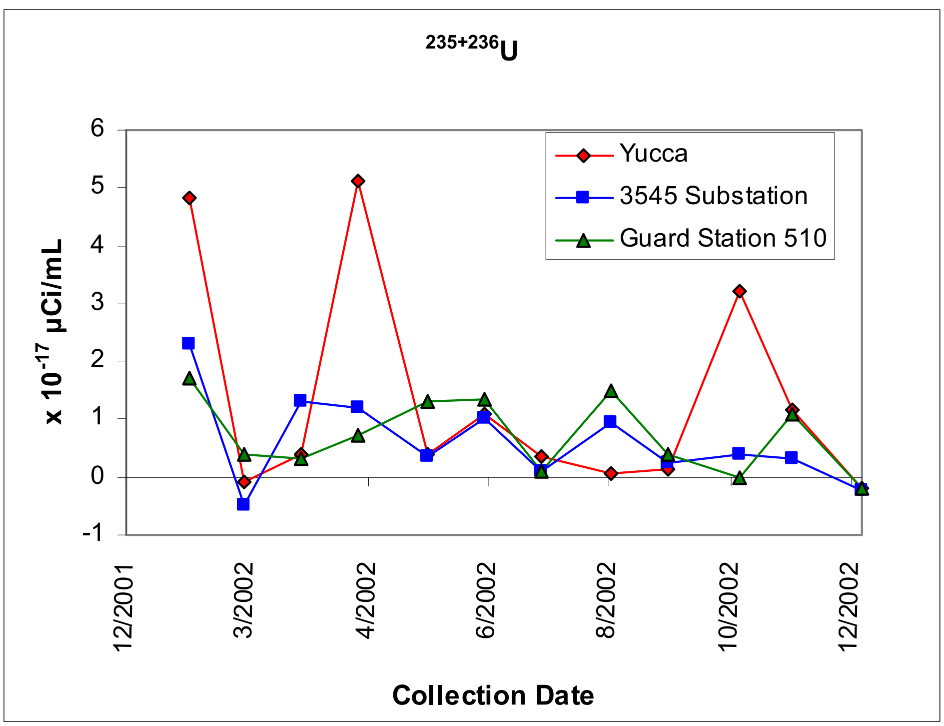


Figure 5.9 Time Series Plot of $^{235+236}U$

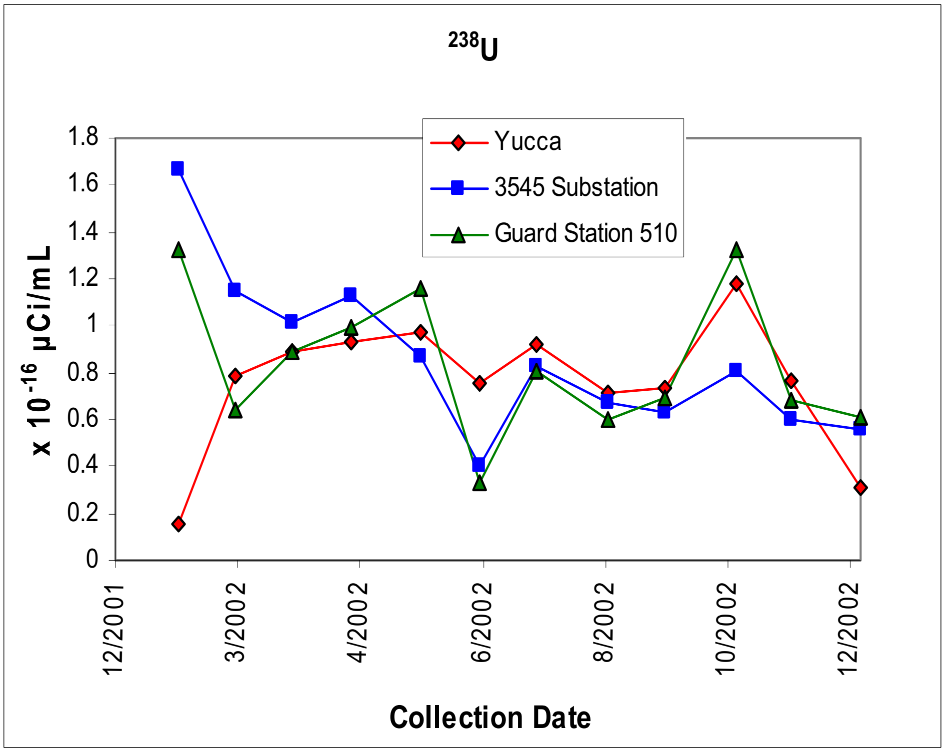


Figure 5.10 Times Series Plot of ^{238}U

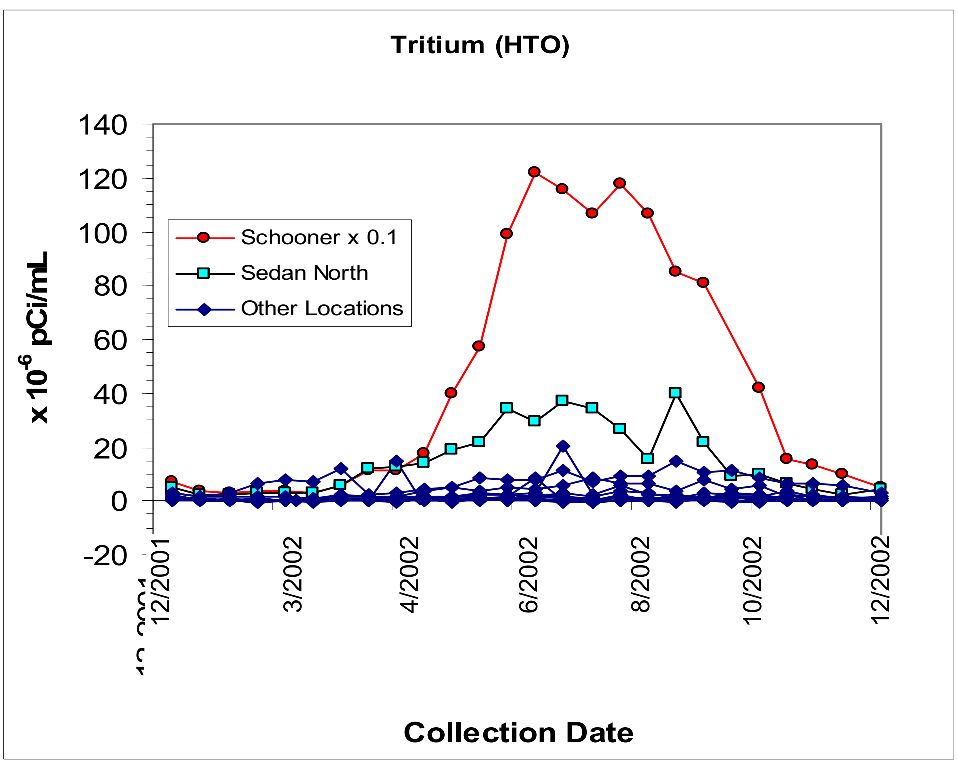


Figure 5.11 Time Series Plot of Tritium in Air - 2002

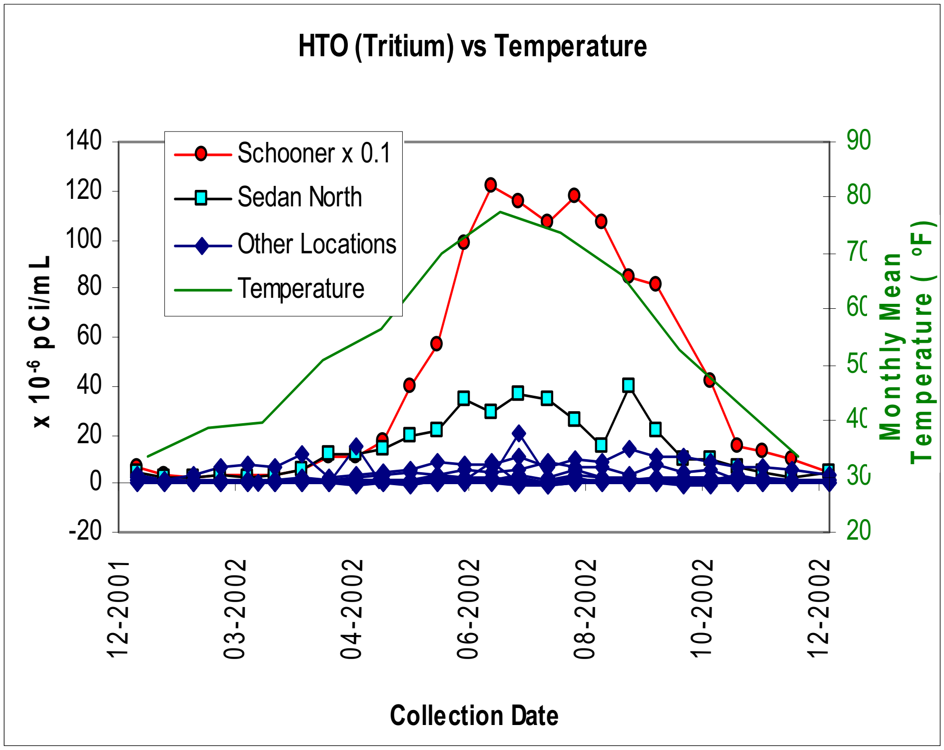


Figure 5.12 Time Series Plot of HTO in Air versus Temperature - 2002

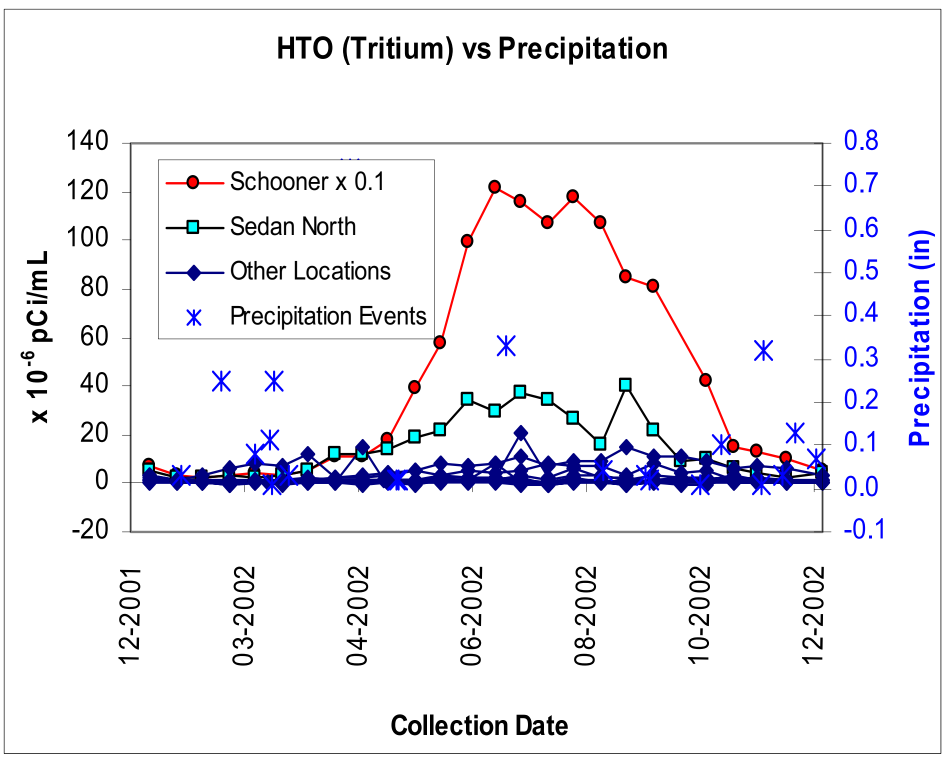


Figure 5.13 Time Series Plot of HTO versus Precipitation

decline in temperature later in the year (see Figure 5.12). There is an apparent negative correlation between high HTO measurements and bi-weekly precipitation averages (Figure 5.13). It has been suggested that precipitation suppresses HTO release from the soil.

The highest annual mean occurred at SCHOONER (434×10^{-6} pCi/mL or 15 Bq/m^3) which is 4.3 percent of the DCG. The nearest member of the general public is at Tolicha Peak, which is 20 mi (32 km) west-southwest from the SCHOONER air sampler. The maximum bi-weekly measurement at SCHOONER was 1220 $\times 10^{-6}$ pCi/mL (45 Bq/m^3), slightly above the high for 2001 (1090 10^{-6} pCi/mL or 37 Bq/m^3).

Figure 5.14 illustrates the impact of the selection of sampling locations and equipment on the highest annual average and demonstrates how much lower the averages are in relation to the DCG. The historical trend in concentrations at five continuing NTS locations is shown in Figure 5.15 for the past five years. As shown by this figure, the concentrations are decreasing at a faster rate than can be explained by the physical decay of tritium (12.35 year half-life).

5.2 ENVIRONMENTAL DOSIMETRY

AMBIENT GAMMA MONITORING

Thermoluminescent dosimeters (TLDs) are used to measure ionizing radiation exposure. The TLDs measure ionizing radiation from all sources, including natural radioactivity from cosmic or terrestrial sources and from human-produced radioactive sources. At the end of 2002, there were a total of 79 active TLD locations (Figure 5.1). 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 is used to check low-energy radiation levels and three calcium sulfate elements are used to measure penetrating gamma radiation.

Two TLDs were deployed at each location, placed about one meter above the ground. All TLDs were exchanged quarterly.

TLD location categories were reclassified in 2002 to allow for location comparisons that are more meaningful based on current NTS operations. There are four current categories: background (B), environmental 1 (E1), environmental 2 (E2) and waste operations (WO) (see Table 5.10). The B category represents locations where effects from NTS operations are negligible. The E1 category represent those locations where there is no measurable added radioactivity from past operations but the locations are of interest due to personnel in the area or due to a potential for receiving radiation exposure from operations. The E1 category encompasses TLD locations previously described as “Historical” and some of the previously described “Environmental” locations. The E2 category represents those locations where there is measurable added radioactivity from past operations and the location is of interest due to potential for personnel to be in the area and to monitor trends of exposure rates. The WO category represents those locations that are in, and around, the Radioactive Waste Management Sites (RWMS) in Areas 3 and 5. In addition, control-TLDs are kept in an indoor location where long-term exposure rates have been made.

THERMOLUMINESCENT DOSIMETER MONITORING DATA

Descriptive statistics for TLD monitoring data are presented in Table 5.10. Statistical analyses were performed on these data with a log transformation used. A log transformation was used because the variability associated with the data was more constant across mean levels using the transformation compared with that associated with non-transformed data. Results showed

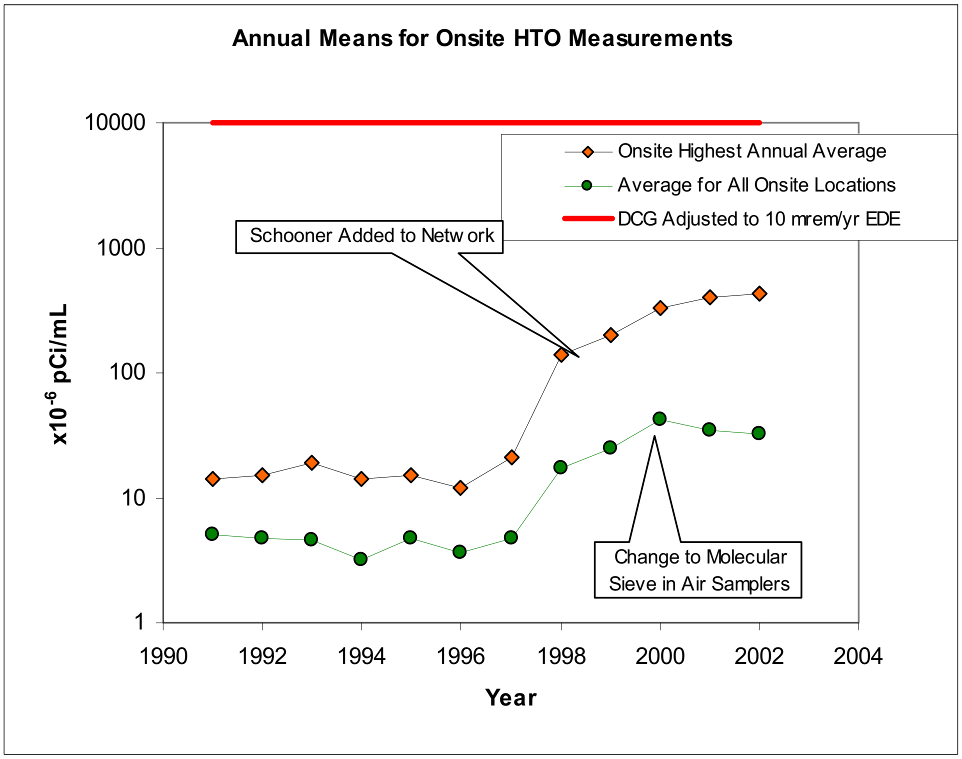


Figure 5.14 Trend in Annual Averages for HTO Concentrations Onsite

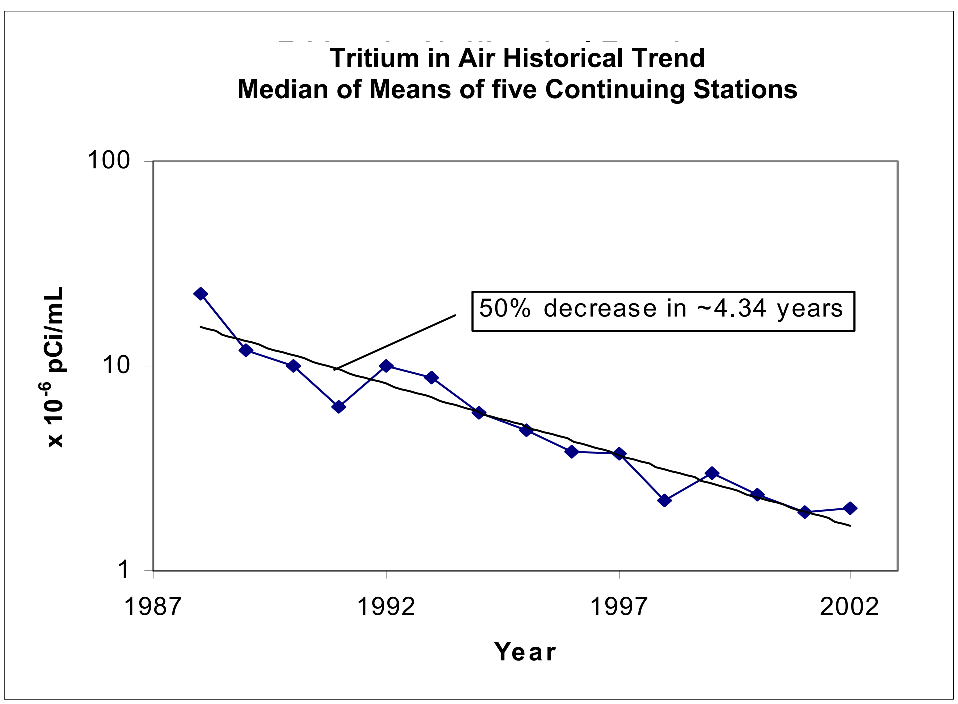


Figure 5.15 Time Series Plot for Tritium in Air on the NTS

highly statistically significant differences between locations. As in the last two years, three locations associated with atmospheric testing in Yucca Flat (Stake A-9 in Area 4, Stake N-8 in Area 2, and the Area 3 RWMS [RWMS-3] south) had gamma exposure rates higher than the remaining locations. Four additional locations (SEDAN West in Area 10, Bunker 7-300 in Area 7, T Tunnel #2 Pond in Area 12, and U-3co North in Area 3) had mean log gamma exposure rates that were barely distinct from the distribution of exposure rates across the remaining locations. These locations are also in Yucca Flat and are associated with surface tests, except for T Tunnel #2 Pond which is associated with an underground test on Rainier Mesa. Even with these seven locations removed, statistically significant differences remained among locations. This was due to both variability in gamma exposure rates between locations and highly consistent measurements at individual locations.

Figure 5.16 shows the 2002 annual average exposure rates measured at each location and grouped by the location categories described earlier: category B; category C - one location inside Building 650; E1 category - environmental with no history or expectation of increased exposure rates; E2 category - environmental with some history and/or expectation of possibly increased exposure rates; and locations associated with the WO category. The location representing category C had the lowest exposure rate of all locations. Two of the three highest locations were in category E2, the other being in category WO. When the three highest locations were separated out, the category means, in decreasing order, were E2 > WO > E1 > B. When the seven highest locations were removed, the order was E2 & WO > E1 > B. In these listings, "&" indicates that the differences between categories were not statistically significant. The E1 measurements average only 13 percent higher than the B measurements, and the E2 measurements, with the seven highest removed, were 35 percent higher than the B measurements.

There were seasonal differences again during 2002, with the highest quarter (third quarter) averaging around 14 percent higher than the lowest (second quarter). This difference was larger than the difference observed during 2001 (2.3 percent), but was similar to that observed during 2000 (11 percent). The third quarter has been highest during 2000 to 2002, but the quarter with the lowest exposure rates has varied.

Figure 5.17 shows the long-term trends in TLD measurements for 30 locations with data histories extending over the past 14 years. The two highest locations (Stake N-8 and Stake A-9) have consistently been among the highest, but have been decreasing with time. The third highest exposure rate measured in 2002 (RWMS-3 south) is a relatively new location and does not appear in this chart. The third and fourth highest locations on the chart are SEDAN West and T Tunnel #2 Pond.

Finally, the mean exposure rate decreased from 2001 to 2002 at every location. The amount of decrease ranged from 2.1 percent to 25.4 percent, with the average decrease being 6.7 percent.

5.3 WATER SURVEILLANCE ACTIVITIES

The surface waters that exist on the NTS are natural springs, containment ponds, and sewage lagoons. Water samples were collected only from the containment ponds and sewage lagoons. The onsite springs were not sampled because they are fed by locally derived groundwater that is not hydrologically connected to any of the aquifers that may be impacted by underground nuclear tests. Figure 5.18 shows the locations of all the containment ponds and sewage

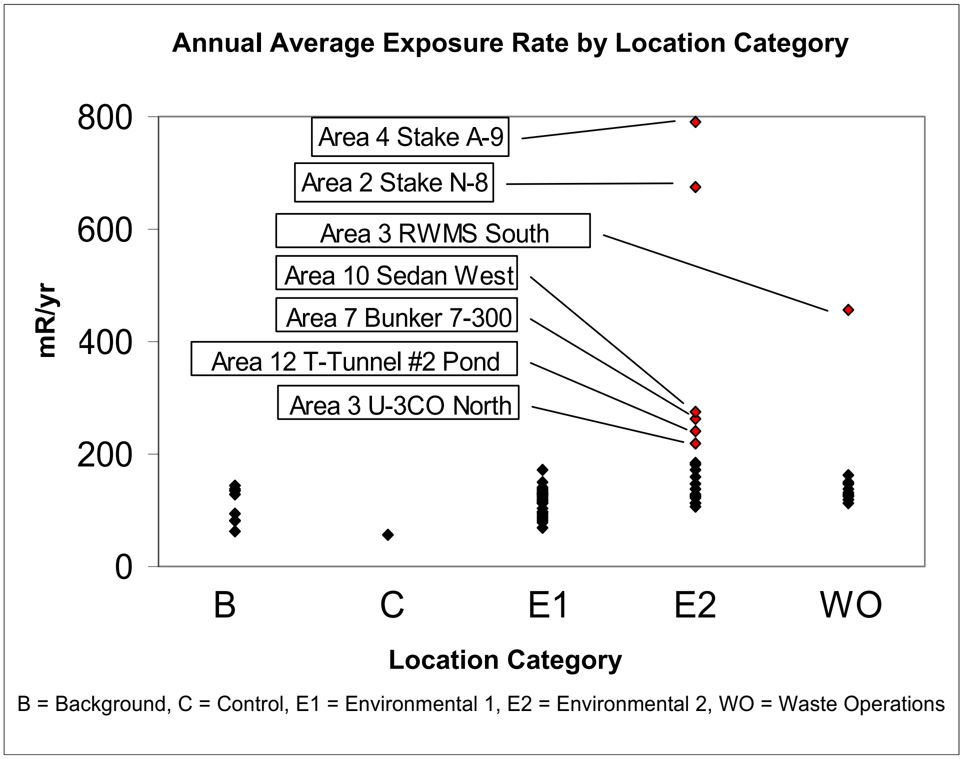


Figure 5.16 Average Annual Exposure Rate for Each Location by Location Category - 2002

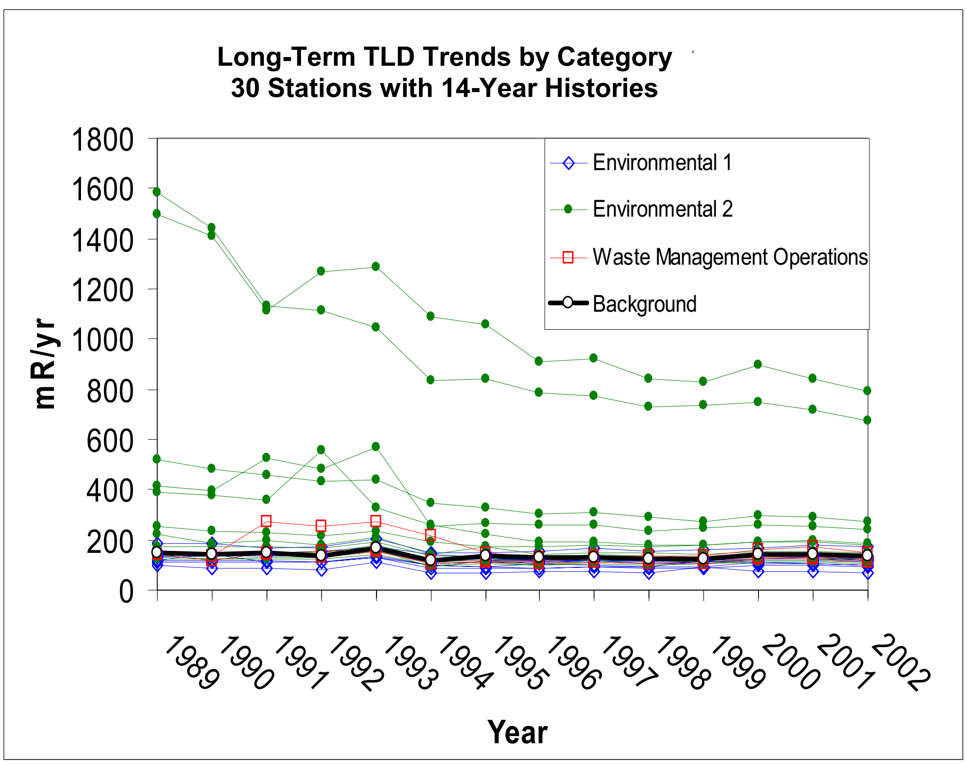


Figure 5.17 Historical Time Series of Annual Exposure Rates, by Category, for Locations with at Least 14 Years of Measurements

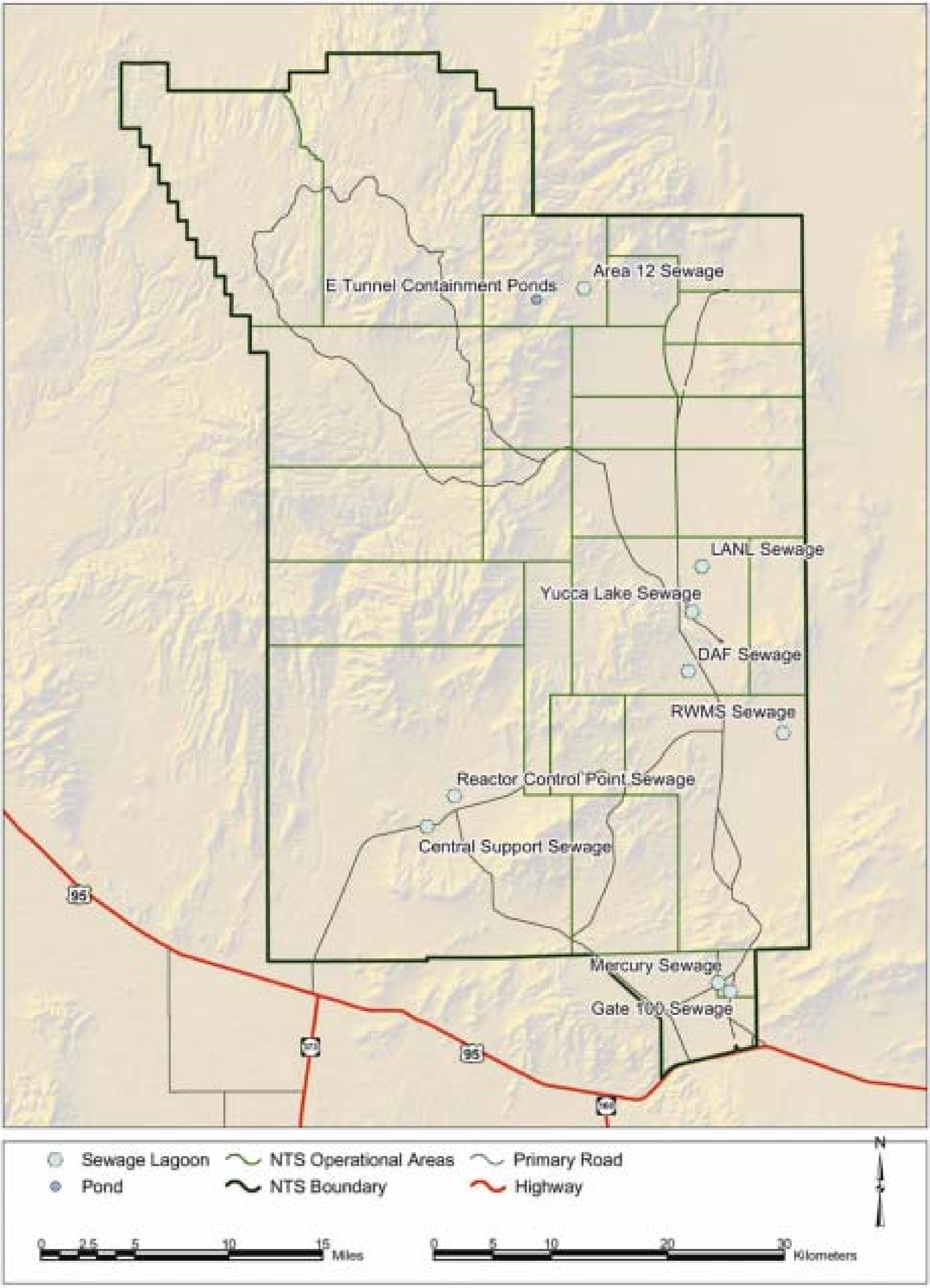


Figure 5.18 Surface Water Sampling Locations on the NTS - 2002

lagoons. No samples were collected from the Area 25 Reactor Control Point Sewage Lagoon or from the Area 25 Central Support Sewage Lagoon because the lagoons were closed and the liquid wastes directed into a septic tank at each location.

CONTAINMENT PONDS

On June 26, 2002, water and sediment samples were collected from the E Tunnel containment ponds to be analyzed for ^{3}H, ^{90}Sr, gamma-emitting radionuclides, uranium, plutonium, and americium. Water samples were filtered to 0.43 : m to collect particulate matter, which was also analyzed for radionuclides. Grab samples were collected from the sump in the outlet pipe near the tunnel and at the point where water flowed into Pond 4. Sediment samples were collected under the inlet pipes (grab samples) and around the basins (composite samples) of all ponds. Radionuclide concentrations in samples are listed in Table 5.11. Due to the levels of ^{3}H, ^{90}Sr, ^{137}Cs, uranium, plutonium, and ^{241}Am in the containment ponds, they are fenced and posted with radiological warning signs. Given that the ponds are available to wildlife, animals are sampled to better understand environmental impact. These results are discussed in Section 5.4 below.

SEWAGE LAGOONS

Each of the sewage lagoons is part of a closed system used for the evaporative treatment of sanitary sewage. Water samples collected quarterly from the lagoons were analyzed by liquid scintillation counting techniques for tritium and by gamma spectroscopy for other test-related radioactivity. No test-related radioactivity was detected in any of the samples.

5.4 BIOTA SURVEILLANCE ACTIVITIES

ROUTINE SAMPLING OF NTS BIOTA

Historical surface nuclear weapons testing, or outfalls from underground tests, provide a source of contamination and exposure to NTS plants and animals (biota). Current NTS land use precludes the harvest of plants or plant parts (e.g., pine nuts and wolf berries) for direct consumption by humans. Vegetation is still sampled, however, to measure radionuclide uptake rates and the potential for radionuclide transfer through the food chain. Because humans cannot directly consume plants from the NTS, the primary potential biotic pathway for radionuclides from the NTS to the public is through ingestion of game animals.

The study designed for radiological monitoring of NTS plants and animals focuses on sampling those sites having the highest known concentrations of radionuclides in other media and is fully described in the RREMP (DOE 2003b). Currently five sites are selected, which will be sampled at least once every five years. These sites are E Tunnel ponds, Palanquin, SEDAN, T2, and Plutonium Valley. During CY 2002, biota samples were collected at the E Tunnel Ponds, the T2 site, and a control site in Mid-Valley (Figure 5.19). Active sampling of biota took place, July through August, with opportunistic sampling of roadkill big game continuing, when available, throughout the year.

The E Tunnel ponds (Figure 5.20) are located in Area 12 in the northern part of the NTS at an elevation of 6,000 feet (1,829 meters). They were selected for continued biota monitoring because of the presence of radiologically contaminated water and soils (see Section 5.3) and a relatively high density of mourning doves which are a highly mobile game species. Only bird sampling was conducted at the E Tunnel ponds during CY 2002.

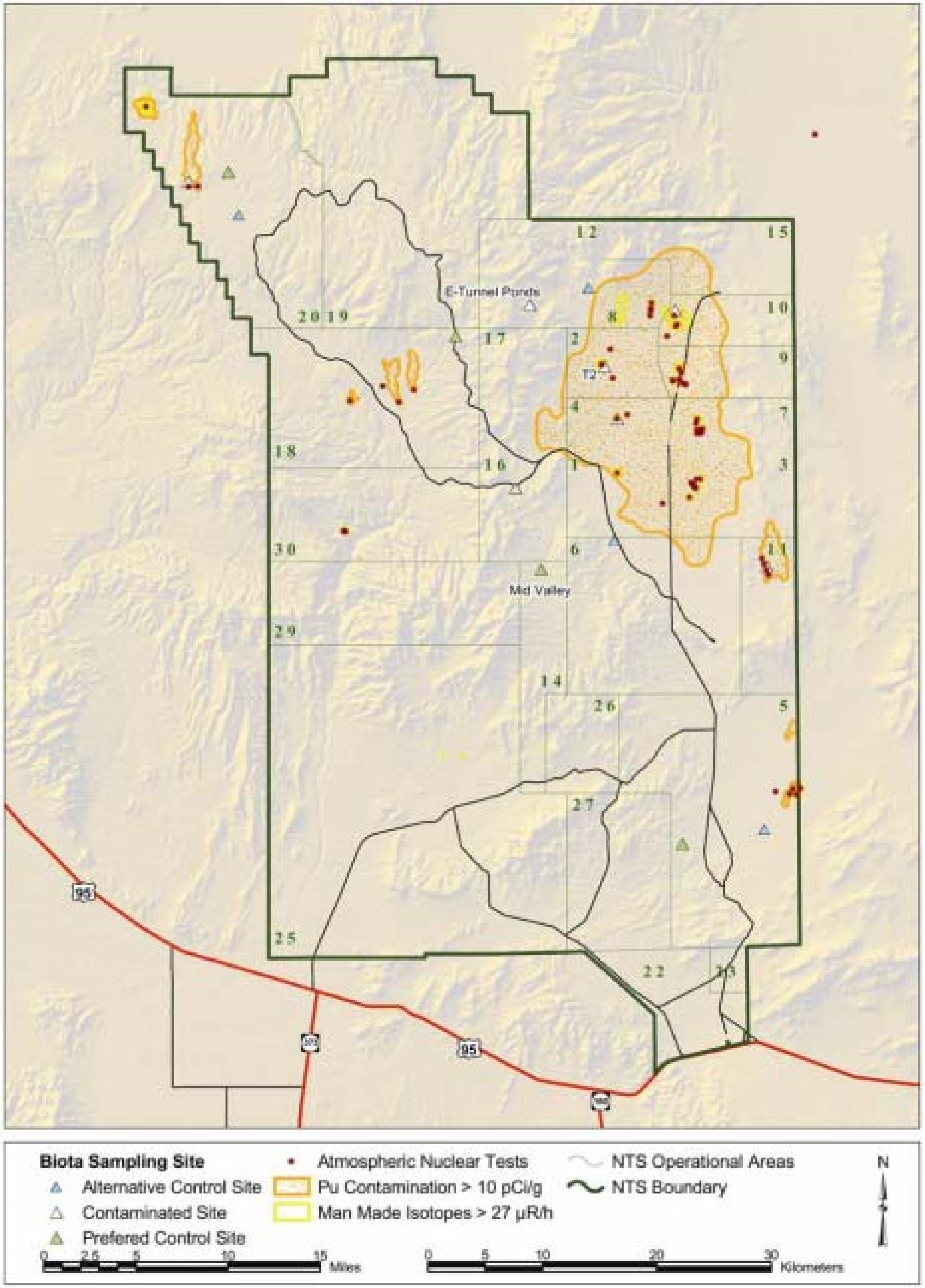


Figure 5.19 NTS Onsite Surface Biota Radiological Monitoring Sites - 2002

Figure 5.20 E Tunnel Pond Site where Doves were Collected - 2002

The T2 site (Figure 5.21) is located in Area 2 in the northern portion of the NTS at an elevation of about 4,300 feet (1,311 meters). Four nuclear weapons tests were conducted on the surface of the T2 site, 1952 - 1957. A control area for the T2 site was chosen in Mid-Valley, Area 14 (Figure 5.22). A historically bladed area within Mid-Valley (the light area shown in the center of Figure 5.22) was chosen for sampling because it represented a disturbed site analogous to the T2 site. Both plant and animal samples were collected at both the T2 and Mid-Valley locations.

VEGETATION SAMPLING

Woody vegetation was primarily selected for sampling because it has been reported to have deeper-penetrating roots with higher concentrations of tritium (Hunter and Kinnison, 1998). Additionally, this vegetation serves as a major source of browse for wildlife game animals that might eat such vegetation and potentially migrate offsite. Forbs were sampled where species of woody plants were limited.

About 300 to 500 grams (10.6 to 17.6 ounces) of fresh-weight, green-leaf plant material were collected from the current year's growth. All plant samples consisted of a composite of material from many plants in the area sampled. Rubber gloves were used by samplers and changed between each sample collected. Green-leaf plant materials from shrubs and forbs were hand-plucked and stored in air-tight plastic bags. Samples were labeled and stored in an ice chest. Within two 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, plutonium, and ^{241}Am.

Figure 5.21 T-2 Site Sampled for Biota

Figure 5.22 Mid-Valley Site Sampled for Biota

Plant sampling at the T2 site occurred on July 24, 2002. Samples were taken of the dominant shrubs species, brittlebush (*Encelia virginensis*), rubber rabbitbrush (*Ericameria nauseosus*), and white burrobrush (*Hymenoclea salsola*). The approximate location of plant samples at the T2 site was UTM Zone 11, 578440 easting, 4110350 northing. Plant sampling at the Mid-Valley site also occurred on July 24, 2002, and comprised samples of the dominant shrub species blackbrush (*Coleogyne ramosissima*), rubber rabbitbrush (*Ericameria nauseosus*), and Nevada jointfir (*Ephedra nevadensis*). Approximate location of plant samples at the Mid-Valley site was UTM Zone 11, 573059 easting, 4092423 northing.

ANIMAL SAMPLING

Game animals are sampled primarily to assess the potential dose to humans who may consume them. Three criteria were used to determine which animal species to sample. The first was that the species should have a relatively high probability of entering the human food chain. Second, they should have a small home range which overlaps a contaminated site and, as a result, should have relatively high radionuclide body burdens representative of 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*), and rabbits (cottontail rabbits [*Sylvilagus audubonii*], and jackrabbits [*Lepus californicus*]). Therefore, trapping efforts concentrated on collecting individuals of these species. Because large game animals are still of interest, opportunistic sampling (e.g., sampling roadkill) was additionally conducted on big game species killed on NTS roads.

State and federal permits were secured to take rabbits, Gambel's quail, chukar, and mourning doves during FY 2002. Animal trapping took place from July - August 2002, at all sites. Attempts were made to only collect game birds at the E Tunnel ponds while attempts to trap both game birds and rabbits occurred at the T2 and Mid-Valley sites.

Mourning doves were trapped at the E Tunnel ponds (location: UTM Zone 11, 572014 easting, 4115815 northing). Gambel's quail and a jackrabbit were trapped at the T2 site (locations: UTM Zone 11, 577740 easting, 4110830 northing, and 579340 easting, 4110487 northing, respectively) and a cottontail rabbit was trapped at the Mid-Valley site (location: UTM Zone 11, 573000 easting, 4091850 northing).

Animals were removed from the traps by hand and killed. Muscle tissue from two doves and the rabbits was sampled in the field by carefully skinning the animals and removing selected muscle tissue (breast meat of the doves and hind and front quarters for the rabbits). Efforts were made to prevent dust on the fur from getting onto the exposed meat during skinning of any animal. The remaining animal samples were brought into a laboratory whole. In the laboratory, each animal was carefully 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 an analytical laboratory to be analyzed for gamma-emitting radionuclides, ^{90}Sr, plutonium, and ^{241}Am.

Opportunistic sampling of one pronghorn antelope (*Antilocapra americana*) roadkill which occurred on December 10, 2002, on the Mercury Highway (UTM Zone 11, 589810 easting, 4058260 northing) on the north end of Mercury.

To document the general abundance of the target species present during the collection period, three 1 km wildlife transects were set up in the vicinity of the T2 fenced radiation site to count rabbits (jackrabbits and cottontails) and game birds (mourning dove, chukar and Gambel's

Quail). The transects were walked on three dates between June 25 and July 23, 2002. The observer recorded all target species observed and measured the perpendicular distances to the location where each animal flushed away from the transect. These data were entered into Program Distance (T1998) to calculate density.

Field observations indicate doves arrive on the NTS during the month of April, and numbers increase until about mid August, after which numbers begin to decline. It is reported that a majority of mourning doves in Nevada migrate to south central Arizona during the winter (Baskett 1993). Chukar and quail are considered permanent residents of the NTS region. It is not likely that chukar or quail migrate off the NTS in their lifetime because they are a short-lived species. Most quail that were radio-marked near Yucca Mountain did not live longer than 15 months (TRW 1999).

RESULTS

Plant Samples

Concentrations of radionuclides detected in 2002 NTS biota samples are listed in Table 5.12. As expected, increased numbers of radionuclides were detected at the T2 test site as compared with the control site. Tritium and ^{90}Sr were detected in 100 percent of the plant samples from the T2 site. Plutonium and americium were also detected in various plant samples from the T2 site. Uranium was detected in multiple samples from both the T2 and Mid-Valley locations. Though weapons testing may be an added source of uranium, it is also a naturally occurring radionuclide and therefore it's presence at the Mid-Valley location, especially in the absence of detected ^{235}U, does not necessarily indicate inputs from weapons tests to that location. A single, anomalous, tritium detection was found in a plant sample (blackbrush sample 2) from the Mid-Valley control location. The error associated with this result is relatively large, meaning there is a possibility that it is a false positive. Strontium-90 was also detected at the low concentration of 0.06 ± 0.05 pCi/g (2.2 ± 1.9 mBq/g) [MDC = 0.04 pCi/g (1.5 mBq/g)] in that same plant sample.

Animal Samples

All five morning doves (*Zenaida macroura*) collected near the E Tunnel ponds contained elevated tritium concentrations ranging from 345,000 to 608,000 pCi/L (12,765 to 22,496 Bq/L). The source of this tritium was E Tunnel pond water which had tritium concentrations, in 2002 samples, of about 930,000 pCi/L (34,410 Bq/L). Elevated tritium levels in game birds from the E Tunnel ponds have been reported in Annual Site Environmental Reports for the NTS for the past three years. Strontium-90 was detected in whole body samples (minus breast muscle tissue) of three doves (Table 5.12) Small sample size for muscle tissue of doves resulted in the laboratory not conducting analyses for gamma-emitting radionuclides on muscle tissue samples. However, the whole body sample (minus breast muscle tissue) of each bird was analyzed for gamma-emitting radionuclides. Only one of the samples had detectable levels of ^{137}Cs. Uranium and plutonium were also detected in two doves (Table 5.12).

No mourning doves, chukar, Gambel's quail, or cottontail rabbits were recorded on wildlife transects walked (N=9) from June 25 to July 23, 2003, in the vicinity of the T2 Site, indicating that these species were rare or not abundant in the area. Twenty-seven jackrabbits were recorded on transects walked during this period resulting in an estimated density of 0.79 rabbits per hectare. An opportunistic sighting of a quail covey of about 25 birds was made during a visit to an abandoned drill pad 1 km northwest of T2.

Two Gambel's quail (*Callipepla gambelii*) and one jackrabbit (*Lepus californicus*) were collected at the T2 site. Both quail had detectable levels of tritium, ^{90}Sr, ^{137}Cs, and $^{239+240}$Pu. The second quail sample also had detections of ^{238}Pu and ^{241}Am. The only radionuclides found in the jackrabbit were ^{90}Sr and a questionable ^{235}U detection. The ^{235}U detection in the jackrabbit is considered questionable due to the relatively large associated error and a lack of ^{238}U in the sample which should be seen if ^{235}U is present. One cottontail rabbit (*Sylvilagus audubonii*) was collected at the Mid-Valley site. Only naturally occurring radionuclides were detected in the muscle sampled from this rabbit.

The pronghorn antelope road-kill sampled from Mercury on December 10, 2002, had no detectable man-made isotopes in the meat (Table 5.12).

5.5 RADIOLOGICAL DOSE ASSESSMENT

To assure that the general public and the environment do not receive radiation doses above the limits specified in federal and state regulations or international recommendations, the following radiological dose assessment for offsite residents and onsite biota is provided. This assessment is based upon the pathways by which radionuclides on the NTS can reach and deliver a dose to offsite residents, an estimate of the airborne emissions, the concentrations of radioactivity measured in air and surface water samples (Section 5.1), and radiation dose conversion factors specified by federal and international authorities. The pathways by which radioactive emissions and effluents from the NTS can result in radiation doses to offsite residents are listed below:

- Inhalation of resuspended surface soil radioactively contaminated by past nuclear testing at NTS and transported offsite by the winds.
- Inhalation of tritiated atmospheric moisture transported offsite by the winds from the evaporation of the water discharged into containment ponds or ditches and the diffuse transpiration of soil or vegetation moisture at the SEDAN site, the SCHOONER site and the Area 5 Waste Management Facility.
- Ingestion of meat from migratory wild game animals which drink from surface waters and eat vegetation containing test-related radioactivity while residing on the NTS.
- Ingestion of water potentially contaminated by underground deposits of radioactivity created by past nuclear tests.

Since the migration of radioactivity in ground water has not been detected in the past nor in the year 2002 (see Chapter 8.0), the pathways by which offsite residents could receive a radiation dose from past or current activities on the NTS are limited to the first three pathways. The radiation doses assessed herein are estimates based upon measurements of radioactivity in surface water, air, and wildlife tissue and mathematical models that estimate emissions from the re-suspension of surface soils and relate the emissions to potential offsite radiation doses. The following sections identify the potential sources of onsite airborne emissions and liquid effluents containing radioactivity, the estimated quantities released, and the atmospheric diffusion model that is used for calculating the radiation effective dose equivalents (EDEs) received by hypothetical offsite receptors. Although Federal regulations are for the EDE received during the year, all dose factors used in the calculation of EDEs are for CEDEs; the calculated internal doses received up to 50 years depending upon the biological half-life of the particular radionuclide delivering the dose. Also included is an update of the assessment of radiation doses to terrestrial and aquatic biota that was begun in 2000.

RADIOACTIVE EMISSIONS

Known and potential sources of airborne emissions and liquid effluents containing radioactivity are identified and listed in Table 5.13. All sources are on the NTS, except for Building A-1, which is in North Las Vegas. A brief description of the methods used for estimating the emissions is given below. More details about the sources and methods used is reported separately (Grossman 2003).

Laboratory Sources

From a review of radiation sources used on the NTS, only one emission from laboratories was found. This was 40 µCi of tritium gas that was released during the calibration of analytical equipment at Area 6 CP-50.

The tritium emission for Building A-1 was assumed to be the same as that in 2001, 0.20 Ci. The tritium emission was estimated from tritiated atmospheric moisture samples collected during the months of February and December 2001 and the rate by which air was exhausted from the rooms. The assumed source of the tritium was the result of an accidental release of ^{3}H in July 1995 at a fixed radiation source range in the basement of Building A-1, where residual contamination has persisted despite considerable efforts to remove it. Due to the low concentrations of tritium resulting from clean-up, the frequency of air sampling was reduced to once a year; however, a sample was not collected in CY 2002 due to an error in scheduling.

Area Sources

The area sources in Table 5.13 are a summation of the estimated radionuclide emissions from the individual areas on the NTS. The major sources of tritium as HTO are attributed to the events SCHOONER (Area 20) and SEDAN (Area 10), the E Tunnel ponds (Area 12), and a low-level waste burial pit in RWMS-5.

The emissions of HTO from SCHOONER, SEDAN, and RWMS-5 were estimated from the annual average concentration of HTO at the nearest air sampling location and by back-calculating with Clean air Package 1988 (CAP88-PC) software (DOE 1997b) to determine what emission rate would be required to produce the concentration average from the air sampling measurement. The emission of HTO from the E Tunnel ponds was determined by multiplying the quarterly measurements of HTO concentrations in the E Tunnel effluent by the water volume discharged assuming that all the pond water evaporated.

The emissions of ^{241}Am and $^{239+240}Pu$ were estimated for each NTS area for which an inventory was assessed by past in situ gamma spectroscopy measurements and soil sampling (DOE 1991). The inventoried amount on the ground surface in curies was used as input to a re-suspension model (NRC 1983) to estimate the emission rate.

OFFSITE RADIOLOGICAL DOSE ESTIMATES

Dose from Airborne Emissions

The radiation doses to offsite residents from airborne emissions were estimated with CAP88-PC software (Version 2.0), in accordance with Title 40 CFR, Part 61. The estimates are described in detail in a report (Grossman 2003) to the Environmental Protection Agency. The software required the following input:

- The annual emission rates calculated for each point/grouped source (Table 5.13).

- 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). (for brevity, total emissions are summed for all areas in Table 5.13).
- Wind files that were constructed from wind rose and stability array data collected over the current one-year period.
- Location of populated areas within 80 km of the NTS sources of emissions.

The EDEs from each computer run for each emission source were summed for each populated offsite location. The location at which a hypothetical receptor received the highest offsite dose was Cactus Springs, Nevada, where the committed effective dose equivalent (CEDE) was 0.11 mrem/yr (1.1 nSv).

Dose from Consumption of Wild Game

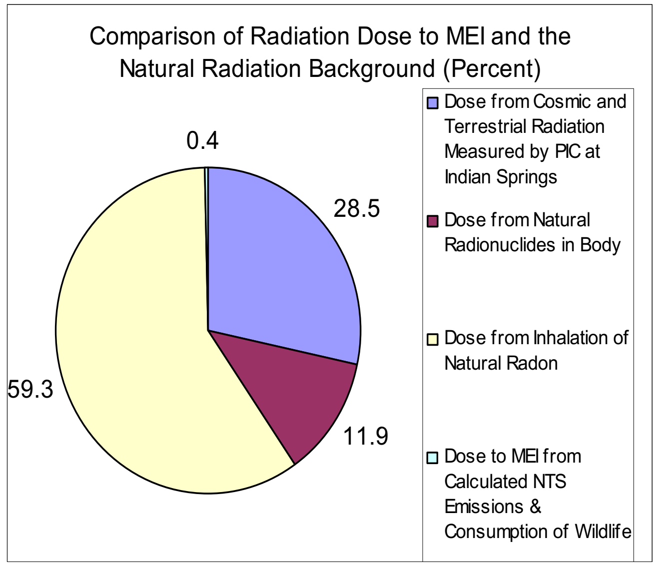
Although hunting is prohibited on the NTS, there is the remote possibility that animals on the NTS drinking water and feeding could migrate offsite where hunters could harvest them. No human-made radionuclides were detected in the one pronghorn sampled on the NTS during 2002 and therefore will not be used to estimate dose to humans. Muscle tissue from the five mourning doves sampled at the E Tunnel ponds during 2002 had detectable levels of tritium. Also, because dove muscle tissue was not analyzed for gamma-emitting radionuclides, the average concentration of ^{137}Cs, ^{235}U, and ^{238}U detected in the whole body of doves was used to represent that in muscle for all doves (see section 5.4). For the quail and jackrabbit sampled from the T2 site, observed concentrations of tritium, ^{90}Sr, ^{137}Cs, and ^{235}U detected in muscle tissue samples were used to estimate potential dose to a human consuming them. Though the uranium in biota samples was detected by gamma spectroscopy, which is less reliable than alpha spectroscopy due to interferences, and though it is also most likely natural uranium, the concentrations were used in order to estimate a conservative potential dose.

Hunting bag limits are set each year by the state of Nevada, Department of Wildlife. For 2002 the limit for mourning doves, quail, and rabbits was, for each species, 10 per day with no more than 20 in a hunter's possession at any one time. For this dose assessment it was assumed that one person consumed the possession limit of each species and that each animal contained the average concentration of radionuclides detected in muscle tissue for that species. It was also assumed that the average weight of muscle tissue on sampled animals was representative of that consumed and that the measured moisture content of the tissue was also representative (Table 5.14). 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. Results of this were that the total estimated potential CEDE from consuming 20 mourning doves from the E Tunnel ponds was 0.58 mrem (5.8×10^{-3}mSv); from consuming 20 quail from the T2 site was 0.08 mrem (8.0×10^{-4} mSv); and from consuming 20 jackrabbits from near the T2 site was 0.58 mrem (5.8×10^{-3} mSv) (Table 5.14). Approximately 97 percent of the potential CEDE from consuming mourning doves from the E Tunnel ponds was from ^{235}U and ^{238}U, 2 percent was from tritium, 0.9 percent from ^{137}Cs, and about 0.1 percent from ^{90}Sr. The potential CEDE from consuming quail from the T2 site was about 99 percent from ^{137}Cs and 1 percent from tritium. The potential CEDE from consuming jackrabbits from the T2 site was about 82 percent from ^{235}U and 18 percent from ^{90}Sr.

Total Offsite Dose to Maximally Exposed Individual (MEI)

A summary of the NTS radiological doses for CY 2002 can be found in Chapter 1.0, Table 1.2. Based upon the estimated airborne emissions of radioactivity from the NTS for all possible sources, the maximally exposed individual (MEI) was calculated to be at Cactus Springs, Nevada, 50 km (31 mi) southeast of CP-1 in Area 6. The CEDE to a hypothetical receptor at this location was calculated to be 0.11 mrem/yr (1.1 x 10^{-3} mSv/yr), which is 0.11 percent of the 10 mrem/yr limit required by NESHAPs (CFR 1989). If the receptor at Cactus Springs was the hunter harvesting and ingesting the mourning doves, quail, and jackrabbits mentioned in the previous section, the person would have received an additional 1.24 mrem/yr for a total EDE of 1.35 mrem/yr, which is 1.35 percent of the dose limit (DOE 1990b) to the general public.

The Cactus Springs dose is small compared to the gamma radiation background (96 mR/yr) measured with a pressurized ion chamber (PIC) at Indian Springs (see Table 5.15) by the offsite CEMP (section 5.6). This radiation exposure in air measured by the PIC is approximately equivalent to 96 mrem/yr (0.96 mSv/yr) in tissue, but includes only the cosmic and terrestrial components of the natural environmental background. The additional components of the background are the radiation doses from the natural radionuclides within the composition of our body, primarily from ^{40}K, and the radiation dose that we receive from the inhalation of naturally occurring radon gas (National Council on Radiation Protection [NCRP] 1996). When all components of the natural environmental background are included in the total radiation dose that a Cactus Springs resident could receive, the CEDE from the calculated NTS emissions and from the consumption of wildlife is insignificant as shown in the diagram.



Collective Population Dose

The collective population dose, the product of a radiation dose and the estimated population receiving it, was reported previously (Grossman 2003) for the estimated NTS emissions as 0.42 person-rem/yr (4.2 mSv/yr) within 80 km of the NTS points of emission. This dose is insignificant compared to the population dose (12,946 person-rem/yr or 129 person-Sv/yr) for the same area from the natural environmental background. The latter dose was estimated from the average of the annual gamma exposures from cosmic and terrestrial radiations (124 mR/yr) reported for the 24 offsite PIC stations (Table 5.15) and the dose equivalents estimated by the National Council on Radiation Protection and Measurements (NCRP 1996) for the remaining components of the natural environmental background; the dose (40 mrem/yr) from the radionuclides that are naturally part of the human body, primarily ^{40}K, and the dose (200 mrem/yr) from the inhalation of naturally occurring radon in the air we breathe. The gamma exposures in air measured by the PICs in mR/yr are approximately equivalent to dose rates in mrem/yr; therefore the total dose from environmental background was estimated as 364 mrem/yr (124 +40 + 200), which when multiplied by the population (35,566) within 80 km of the points of emission results in a collective population dose of 12,946 person-rem/yr. The population dose is less than the value reported for 2001 (13,940 person-rem/yr or 139 person-Sv/yr) due to the fact that Tonopah was not within 80 km of any NTS emission source this year.

Onsite Biota Doses

A new DOE Standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" was published in July, 2002 (DOE 2002b). This document outlines the process for evaluating compliance with requirements for protection of biota in DOE Order 5400.1, "General Environmental Protection Program," DOE Order DOE 5400.5, "Radiation

Protection of the Public and the Environment" and dose limits discussed by the NCRP (NCRP 1991) and the International Atomic Energy Agency (IAEA 1992). The dose limits listed below were set with the intention to protect populations of aquatic and terrestrial organisms:

∉ Dose limit to aquatic animals = 1 rad/day (10mGy/day).

∉ Dose limit to terrestrial plants = 1 rad/day (10mGy/day).

∉ Dose limit to terrestrial animals = 0.1 rad/day (1mGy/day).

The graded approach outlined in the technical standard is a three-step process consisting of data assembly, a general screening phase, and, if needed, a more detailed analysis phase. The screening phase consists of determining whether the sum of the ratios of radionuclide concentrations in soil and water to biota concentration guide (BCG) values is less than one. If it is, the absorbed dose to biota will be less than the limits listed above. To be conservative, maximum concentrations are compared first. If the sum of ratios exceeds one, average concentrations for each area are then compared. As an aid to the screening phase, a set of electronic spreadsheets (the RAD-BCG Calculator) was used with the technical standard documentation to calculate and sum the concentration ratios.

In 1999, a preliminary screening phase was completed for terrestrial biota on the NTS. This preliminary screening averaged over large operational areas and showed that the location with the highest radionuclide concentrations, Area 10, had a ratio of only 0.325, based primarily upon the soil concentrations of ^{90}Sr and ^{137}Cs. Since this ratio was less than one, the dose to terrestrial biota populations was considered to be less than 0.1 rad/day (1mGy/day). Soil concentration data for this evaluation was based upon past surveys of NTS surface contamination by in situ gamma spectroscopy measurements and soil sampling and analysis (DOE 1991). Because this preliminary screening did not identify assessment areas following new DOE technical standard methods, future efforts will be made to confirm compliance for specific areas contaminated with radionuclides on the NTS.

No natural rivers or streams exist on the NTS, and no natural spring-fed ponds are known to be contaminated but there is a set of tunnel drainage ponds at the Area 12 E Tunnel that have existed for many years and support some aquatic organisms. Water and sediment samples were collected from the E Tunnel ponds during 2002. Results from these (see section 5.3) were input to the RAD-BCG Calculator, developed by DOE's Biota Dose Assessment Committee, to determine whether radionuclide concentrations were below those which may result in a dose exceeding limits set to protect biota. Compliance is demonstrated by showing the ratio of measured concentrations to conservatively estimated BCG is less than one. Two runs were made with the RAD-BCG Calculator. Maximum radionuclide concentrations and a full time resident scenario were input for the first screening which gave a sum of fractions of 1.17 with ^{137}Cs in water accounting for approximately 85 percent of the total. Average radionuclide concentrations, which are more representative of levels in the ponds, were used on the second run and gave a sum of fractions of 0.94 (Table 5.16). Since 0.94 is less than 1.0, the average radionuclide concentrations in the E Tunnel ponds pass the screening level assessment which means dose rates to aquatic and riparian organisms are less than dose limits specified above. Using average radionuclide concentrations showed ^{137}Cs in water, again, to account for the majority of potential dose at about 92 percent.

5.6 COMMUNITY ENVIRONMENTAL MONITORING PROGRAM

The CEMP provides communities surrounding the NTS with radiological and weather data, and is operated by the DRI of the University and Community College System of Nevada. During CY 2002, there were 24 CEMP stations managed by DRI (Figure 5.23).

Figure 5.23 CEMP, MET, PIC and Air Sampling Sites – 2002

The CEMP stations include monitoring devices such as TLDs and PICs for direct measurement of gamma emitters and high-energy beta particles, and low-volume particulate air samplers for total suspended activity and radioactive particles. The PIC data are recorded in µR/hr, but no attempt is made to equate this to a dose. The air sampler draws two cubic feet of air per minute (at standard temperature and pressure) through a paper filter.

The stations (Figure 5.24) are also equipped with a full suite of meteorological equipment to measure air temperature, humidity, wind speed and direction, incident solar radiation, barometric pressure, precipitation, and soil temperature.

DATA COLLECTION AND DISSEMINATION

All data collected by electronic sensors at the CEMP stations are stored in a datalogger. Current data readings are displayed onsite and are updated every six seconds. Data are transmitted by telephone landline, cellular phone, or GOES satellite. Data storage is designed to allow for 20 days of storage on the datalogger in the event of communication loss. Collected data are transmitted once every three hours to the Western Regional Climate Center (WRCC). The data from the stations are posted on a publicly accessible WRCC web site at http://cemp.dri.edu.

COMMUNITY ENVIRONMENTAL MONITORS (CEMS)

The primary objective of the CEMP is to involve residents of the communities surrounding the NTS in offsite environmental monitoring. DRI employs local citizens, whose responsibilities include monitoring the equipment, assisting with maintenance, and posting information on the program and 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 and for routing them to DRI, where they are prepared for submission to an independent laboratory for analysis.

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.

CEMP AIR SURVEILLANCE NETWORK (ASN)

The inhalation of radioactive airborne particles can be a major pathway for human exposure to radiation. The atmospheric monitoring networks are designed to detect environmental radioactivity from both NTS and non-NTS activities, as well as natural sources. Data from atmospheric monitoring can be used to determine the concentration and source of airborne radioactivity and to project the fallout patterns and durations of exposure to the general public.

During CY 2002, the CEMP ASN consisted of 22 continuously operating low-volume air sampling locations. Duplicate air samples are collected from two routine ASN stations each week. The duplicate samplers are operated at randomly selected stations for three months and then moved to new locations.

The glass-fiber filters from the low-volume samplers are collected by the CEMs, sent to DRI, then prepared and sent to an independent laboratory to be analyzed for gross alpha and gross beta activity. Samples are analyzed 7 to 14 days after collection to allow time for the decay of naturally occurring radon progeny. Upon completion of the gross alpha/beta analyses, the air filter samples are returned to DRI to be recompiled on a quarterly basis for gamma spectroscopy analysis.

Figure 5.24 The CEMP Station at Betty, Nevada

CEMP THERMOLUMINESCENT DOSIMETRY (TLD) NETWORK

External dosimetry is another of the essential components of environmental radiological assessments. This is used to determine both individual and population exposure to ambient radiation from natural or artificial sources. In CY 2002, the TLD program consisted of 24 fixed environmental monitoring stations. The primary purpose of the CEMP offsite environmental dosimetry program is to establish dose estimates to populations living in the areas surrounding the NTS. For quality assurance purposes, duplicate TLDs are deployed at two randomly selected environmental stations. An average daily exposure rate was calculated for each quarterly environmental exposure period, and the average of the four values was multiplied by 365.25 to obtain the total annual exposure for each station.

CEMP PRESSURIZED ION CHAMBER (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 24 stations in the CEMP network. 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 differ among locations, as they may change with altitude (cosmic radiation), radioactivity in the soil (terrestrial radiation), and may vary slightly 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 changes in barometric pressure are more readily identified. These variations can be easily viewed by selecting the time series link from the CEMP home page, http://cemp.dri.edu, after selecting a desired station and then selecting the desired variables.

ANALYTICAL RESULTS

Procedures and Quality Assurance

Several methods are used by DRI to ensure that air filter sample radiological results conform to current quality assurance protocols. These methods include the use of standard operating procedures, field duplicate samples, and laboratory quality assurance procedures.

Standard Operating Procedures

DRI standard operating procedures describe the methods, materials, and equipment required for the collection and analysis of air filter samples. This includes equipment operation and calibration procedures, sample collection technique, and preparation of samples for analysis by an independent laboratory. Table 5.17 lists the types of analyses performed and methods used.

Field Quality Assurance Samples

The collection of duplicate samples in the field is an important part of quality assurance procedures. Two duplicate air samplers for the CEMP are kept in the field at all times and are rotated among 20 stations on a quarterly basis. This results in the collection of up to 13 duplicate air filter samples for each station over a two and one half year period. The results of these sample analyses are used to measure the repeatability of the collection and analytical technique. A summary of the results is shown in Table 5.18. The average %RSD (Relative Standard Deviation) is a measure of the precision of the analysis. This is calculated by dividing the standard deviation of the duplicate pair by the analytical mean then multiplying by 100 to obtain a percent.

Overall, the %RSD for all field duplicate analyses falls well within data quality objectives, only slightly higher than the %RSD for the laboratory duplicate results. Gross alpha results from the field duplicates individually show the most variation with about 3 percent of the duplicates exceeding or showing borderline results in terms of data quality objectives. Given the fact that equipment and field conditions are by far the most variable parameters in air sample collection, these results are acceptable. The %RSD for all gross beta and gamma spectroscopy analyses falls within data quality objectives.

Laboratory Quality Assurance Samples

Laboratory analyses were performed by Severn Trent Laboratories, St. Louis, Missouri. Quality assurance controls consisted of published laboratory techniques, method blanks, control samples, and duplicates. Method blanks consist of samples that are free of the analyte of interest, and are used to determine if the laboratory itself is contributing to the analysis. Control samples contain a known activity of the analyte and are used to assess the level of accuracy of the analysis. Duplicates in the case of air filter samples are a second analysis of an individual sample. These results indicate the repeatability of the analysis of interest. All gross alpha/beta and gamma spectroscopy quality assurance analyses fell within acceptable parameters.

AIR SAMPLING RESULTS

The CEMP ASN measures the major radionuclides that could potentially be emitted from activities on the NTS, as well as naturally occurring radionuclides. The ASN monitors the possible inhalation exposure pathway for the general public. All glass-filter samples are analyzed for gross alpha and gross beta activity. Upon completion, the samples are returned to DRI and compiled into quarterly composites. The quarterly composites are then analyzed by high resolution gamma spectroscopy.

Gross Alpha

Gross alpha analysis was performed on all low-volume network samples. The annual average gross alpha activity was $2.0 \pm 0.5 \times 10^{-15}$ µCi/mL (73 ± 20 µBq/m^3). A summary of the results is shown in Table 5.19. As in previous years, the results exceeded the analytical MDC and overall showed similar values to previous years' data.

Gross Beta

Gross beta analysis was also performed on all low-volume network samples. As in previous years, these results also exceeded the analytical MDC. The annual average gross beta activity was $2.5 \pm .02 \times 10^{-14}$ µCi/mL ($9.1 \pm 0.7 \times 10^{-4}$ µBq/m^3). A summary of the results is shown in Table 5.20. The results overall showed similar values to previous years' data.

Gamma Spectroscopy

Gamma spectroscopy analysis was performed on all samples from the low-volume network samples. The air filter samples were combined by station on a quarterly basis after gross alpha/beta analysis. This results in the analysis of up to 13 air filters simultaneously for gamma activity. All samples were gamma spectrum negligible, i.e., no man-made gamma-emitting radionuclides were detected.

TLD RESULTS

There were 24 offsite environmental stations monitored with TLDs in 2002. The total exposure for 2002 ranged from 87 mR (0.87 mSv) per year at Pahrump, Nevada, to 162 mR (1.62 mSv) at Twin Springs, Nevada, with a mean annual exposure of 126 mR (1.26 mSv) per year for all operating locations. All results shown in Table 5.21 are consistent with recent years' results. Overall, the 2002 results remain consistent with background levels observed in the United States.

PRESSURIZED ION CHAMBER (PIC) RESULTS

The PIC data presented in this section are based on daily averages of gamma exposure rates from each station. Table 5.15 contains the maximum, minimum, and standard deviation of daily averages for the periods during 2002 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 mean ranged from 71 to 169 mR/yr. Background levels of environmental gamma exposure rates in the United States (from the 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 5.22. The annual exposure levels observed at the CEMP stations in 2002 are well within these United States background levels.

Table 5.1 Comparison of Area 12 Brush Fire Air Sampling Results with NTS Network – 2002

Area 12 Wild Fire Concentrations, 10^{-15} µCi/mL						
Analysis	**Number of Samples**	**Mean**	**Max.**	**Min.**	**%>MDC**	**% DCG**
Gross Alpha	26	22.5	44.4	8.39	100	-
Gross Beta	26	62.8	121	3.8	100	-
^{137}Cs	9	3.11	18.7	-1.08	11	0.008
$^{239+240}Pu$	9	0.0345	0.366	-0.114	22	1.7
^{241}Am	9	0.0687	0.137	0.0258	67	3.4
NTS Concentrations, x 10^{-15} µCi/mL						
Analysis	**Number of Samples**	**Mean**	**Max.**	**Min.**	**%>MDC**	**% DCG**
Gross Alpha	26	6.95	35.9	-0.247	89	-
Gross Beta	26	20.4	60.6	0.49	99	-
^{137}Cs	9	0.0159	1.19	-1.93	0.3	<0.001
$^{239+240}Pu$	9	0.0549	1.88	0.0055	48	2.8
^{241}Am	9	0.012	0.26	-0.012	39	0.6

Table 5.2 Descriptive Statistics for Gross Alpha in Air (x 10^{-15} µCi/mL) – 2002

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Min.	Max.	% > MDC
1	BJY	51	6.942	6.568	3.373	1.120	15.718	84.3
3	U-3ah/at North	52	8.121	8.009	4.067	1.130	22.169	93.3
3	U-3ah/at South	52	7.779	6.984	5.059	1.863	35.923	94.2
3	U-3bh North	51	7.322	7.117	3.711	-0.247	16.923	88.2
3	U-3bh South	43	7.093	6.956	3.374	1.235	14.550	88.4
5	DoD	51	6.875	6.479	3.087	1.793	13.344	88.2
5	Sugar Bunker North	51	7.338	7.215	2.730	1.221	12.501	96.1
6	Yucca	50	8.209	7.470	3.828	1.921	17.346	94.0
9	Bunker 9-300	52	7.483	7.177	3.943	1.633	17.712	92.3
10	Gate 700 South	50	6.350	6.550	2.971	1.199	13.009	87.0
10	SEDAN North	51	6.391	6.582	3.214	0.795	15.567	84.3
16	3545 Substation	52	5.875	5.884	2.862	0.976	13.512	86.5
18	LITTLE FELLER 2 North	50	6.320	5.827	3.622	0.247	16.623	86.0
20	SCHOONER	44	6.311	5.749	3.188	1.620	14.005	90.9
23	Mercury Track	52	5.878	5.603	3.054	1.214	13.412	81.7
25	Guard Station 510	52	6.852	6.386	3.354	1.407	14.812	92.3
All Onsite Locations		**804**	**6.951**	**6.549**	**3.555**	**-0.247**	**35.923**	**89.2**

Table 5.3 Descriptive Statistics for Gross Beta in Air (x 10^{-14} µCi/mL) – 2002

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Min.	Max.	% > MDC
1	BJY	51	1.988	1.940	0.614	0.848	3.793	100.0
3	U-3ah/at North	52	2.039	2.041	0.573	1.008	3.955	100.0
3	U-3ah/at South	52	2.034	2.038	0.607	0.985	3.967	100.0
3	U-3bh North	51	2.110	2.042	0.850	0.049	6.056	98.0
3	U-3bh South	43	2.061	2.045	0.700	0.676	4.107	100.0
5	DoD	51	2.117	2.043	0.689	1.001	4.360	100.0
5	Sugar Bunker North	51	2.161	2.126	0.665	0.800	4.242	98.0
6	Yucca	50	2.207	2.174	0.587	0.983	3.995	100.0
9	Bunker 9-300	52	2.012	2.076	0.664	0.796	3.959	100.0
10	Gate 700 South	50	1.960	1.897	0.647	0.833	3.854	100.0
10	SEDAN North	51	1.986	2.075	0.648	0.717	3.821	100.0
16	3545 Substation	52	1.931	1.908	0.604	0.891	3.727	100.0
18	LITTLE FELLER 2 North	50	1.823	1.783	0.553	0.860	3.472	100.0
20	SCHOONER	44	1.904	1.950	0.559	0.914	3.370	100.0
23	Mercury Track	52	2.000	2.004	0.684	0.737	4.262	100.0
25	Guard Station 510	52	2.270	2.230	0.737	0.985	4.566	100.0
All Onsite Locations		**804**	**2.039**	**20.295**	**0.657**	**0.049**	**6.056**	**99.8**

Table 5.4 Descriptive Statistics for ^{238}Pu in Air (x 10^{-18} µCi/mL) – 2002

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Min.	Max.	% > MDC
1	BJY	12	1.350	0.000	3.625	-1.837	11.400	8.3
3	U-3ah/at North	12	6.257	2.837	11.271	-3.365	34.188	25.0
3	U-3ah/at South	12	1.827	1.483	2.614	-1.987	6.429	8.3
3	U-3bh North	12	4.044	2.081	8.549	-3.245	29.800	25.0
3	U-3bh South	11	2.191	1.406	2.967	-0.889	9.582	9.1
5	DoD	12	0.637	-0.105	2.699	-2.228	7.575	8.3
5	Sugar Bunker North	12	0.134	0.000	2.846	-6.570	5.337	8.3
6	Yucca	12	2.837	0.191	9.139	-1.269	31.655	4.2
9	Bunker 9-300	12	4.355	4.701	4.487	-2.666	13.134	33.3
10	Gate 700 South	13	0.035	0.139	1.563	-3.330	1.772	3.8
10	SEDAN North	12	3.162	0.608	8.707	-1.369	30.494	16.7
16	3545 Substation	12	0.493	0.000	1.930	-2.526	4.082	0.0
18	LITTLE FELLER 2 North	11	2.663	1.658	4.945	-2.913	16.488	9.1
20	SCHOONER	12	2.415	1.958	3.016	-1.472	10.434	25.0
23	Mercury Track	13	0.871	0.808	3.432	-5.255	9.991	7.7
25	Guard Station 510	12	0.507	0.220	1.289	-1.399	2.975	0.0
All Onsite Location		**192**	**2.091**	**0.869**	**5.502**	**-6.570**	**34.188**	**12.0**

Table 5.5 Descriptive Statistics for $^{239+240}$Pu in Air (x 10^{-18} μCi/mL) – 2002

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Min.	Max.	% > MDC
1	BJY	12	117.86	24.53	229.10	2.49	785.66	66.7
3	U-3ah/at North	12	288.76	66.27	551.93	0.96	1884.01	91.7
3	U-3ah/at South	12	76.54	67.32	57.22	9.90	182.36	100.0
3	U-3bh North	12	37.20	28.34	30.18	5.12	91.06	83.3
3	U-3bh South	11	25.50	28.47	21.06	1.54	75.66	72.7
5	DoD	12	3.01	1.54	5.28	-3.69	15.36	20.8
5	Sugar Bunker North	12	2.77	1.45	9.29	-5.45	30.75	16.7
6	Yucca	12	7.03	8.15	5.17	-0.77	16.35	29.2
9	Bunker 9-300	12	287.23	240.66	212.79	30.66	697.18	100.0
10	Gate 700 South	13	4.91	4.32	4.17	-1.06	14.18	38.5
10	SEDAN North	12	15.34	13.56	8.56	5.16	30.71	66.7
16	3545 Substation	12	4.04	3.11	3.76	0.22	12.50	20.8
18	LITTLE FELLER 2 North	11	2.80	1.42	3.18	-0.83	9.52	18.2
20	SCHOONER	12	0.81	1.07	3.18	-4.34	4.72	8.3
23	Mercury Track	13	2.21	2.33	3.56	-2.74	9.56	15.4
25	Guard Station 510	12	3.83	0.47	6.36	-1.42	18.44	25.0
All Onsite Locations		**192**	**54.88**	**6.84**	**179.55**	**-5.45**	**1884.01**	**48.2**

Table 5.6 Descriptive Statistics for ^{241}Am in Air (x 10^{-18} μCi/mL) – 2002

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Min.	Max.	% > MDC
1	BJY	12	20.73	7.83	28.54	2.78	101.06	50.0
3	U-3ah/at North	12	47.46	21.29	73.64	8.45	260.30	83.3
3	U-3ah/at South	12	14.75	13.15	11.10	-3.39	31.92	75.0
3	U-3bh North	12	8.63	6.50	6.20	2.26	18.71	50.0
3	U-3bh South	11	7.52	5.88	9.98	0.48	36.65	45.5
5	DoD	12	6.22	2.96	10.52	-0.94	38.28	29.2
5	Sugar Bunker North	12	3.91	4.93	3.19	-1.86	9.23	8.3
6	Yucca	12	6.71	3.02	10.30	-7.99	30.28	20.8
9	Bunker 9-300	12	45.01	35.52	36.62	8.55	125.13	91.7
10	Gate 700 South	13	4.63	3.65	3.45	0.00	11.20	26.9
10	SEDAN North	12	8.03	4.53	9.38	0.76	33.61	33.3
16	3545 Substation	12	4.47	5.30	6.55	-11.95	11.57	29.2
18	LITTLE FELLER 2 North	12	3.45	3.77	3.49	-1.76	8.92	33.3
20	SCHOONER	12	2.49	2.84	3.14	-3.70	6.40	8.3
23	Mercury Track	13	4.29	4.81	3.36	0.00	12.19	30.8
25	Guard Station 510	12	4.19	3.03	6.89	-8.67	18.43	16.7
All Onsite Locations		**193**	**11.98**	**5.55**	**25.74**	**-11.95**	**260.30**	**39.4**

Table 5.7 Descriptive Statistics for $^{233+234, 235+236, 238}U$ in Air

$^{233+234}U$ by chemistry (x 10^{-16} µCi/mL)								
Area	**Location**	**Number of Samples**	**Mean**	**Median**	**Standard Deviation**	**Min.**	**Max.**	**% > MDC**
6	Yucca	12	0.926	0.979	0.447	0.263	1.770	75.0
16	3545 Substation	12	0.968	0.899	0.329	0.557	1.541	91.7
25	Guard Station 510	12	0.843	0.766	0.362	0.157	1.505	87.5
All Onsite Locations		**36**	**0.912**	**0.867**	**0.375**	**0.157**	**1.770**	**84.7**
$^{235+236}U$ by chemistry (x 10^{-17} µCi/mL)								
Area	**Location**	**Number of Samples**	**Mean**	**Median**	**Standard Deviation**	**Min.**	**Max.**	**% > MDC**
6	Yucca	12	1.375	0.393	1.910	-0.177	5.104	16.7
16	3545 Substation	12	0.621	0.375	0.769	-0.499	2.299	16.7
25	Guard Station 510	12	0.718	0.554	0.648	-0.210	1.708	20.8
All Onsite Locations		**36**	**0.905**	**0.393**	**1.257**	**-0.499**	**5.104**	**18.1**
^{238}U by chemistry (x 10^{-16} µCi/mL)								
Area	**Location**	**Number of Samples**	**Mean**	**Median**	**Standard Deviation**	**Min.**	**Max.**	**% > MDC**
6	Yucca	12	0.761	0.780	0.281	0.153	1.180	66.7
16	3545 Substation	12	0.860	0.819	0.342	0.402	1.663	75.0
25	Guard Station 510	12	0.839	0.753	0.309	0.336	1.327	95.8
All Onsite Locations		**36**	**0.820**	**0.798**	**0.306**	**0.153**	**1.663**	**79.2**

Table 5.8 Descriptive Statistics for ^{137}Cs in Air (x 10^{-16} µCi/mL) – 2002

Area	**Location**	**Number of Samples**	**Mean**	**Median**	**Standard Deviation**	**Min.**	**Max.**	**% > MDC**
1	BJY	10	0.504	0.524	2.724	-2.820	6.607	0.0
3	U-3ah/at North	12	-0.466	-0.845	1.913	-3.259	3.572	0.0
3	U-3ah/at South	12	0.750	0.312	1.482	-0.949	3.836	0.0
3	U-3bh North	12	0.851	0.420	3.022	-2.991	8.749	0.0
3	U-3bh South	11	-1.045	0.877	6.220	-19.270	2.547	0.0
5	DoD	12	0.371	0.213	1.686	-2.412	4.559	0.0
5	Sugar Bunker North	12	0.773	0.404	2.850	-3.583	4.987	0.0
6	Yucca	12	0.828	0.481	4.030	-4.758	11.924	0.0
9	Bunker 9-300	12	0.954	1.484	2.708	-4.054	5.558	0.0
10	Gate 700 South	13	-0.899	-0.730	1.535	-3.831	1.404	0.0
10	Sedan North	12	0.664	0.448	1.894	-1.786	4.933	0.0
16	3545 Substation	12	-0.053	-0.297	1.222	-1.509	2.527	4.2
18	Little Feller 2 N	12	0.408	-0.015	2.067	-2.377	4.012	0.0
20	Schooner	11	-0.661	-0.160	1.437	-2.557	1.524	0.0
23	Mercury Track	13	-0.439	0.201	2.492	-4.627	3.781	0.0
25	Guard Station 510	12	0.037	0.072	1.867	-2.790	3.993	0.0
All Onsite Locations		**190**	**0.159**	**0.132**	**2.667**	**-19.270**	**11.924**	**0.3**

Table 5.9 Descriptive Statistics for HTO in Air (x 10^{-6} µCi/mL) – 2002

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Min.	Max.	% > MDC
1	BJY	24	1.41	1.25	1.10	-0.18	3.71	50.0
5	DoD	26	0.69	0.58	0.73	-0.50	2.45	28.8
5	RWMS 4 Northeast	26	2.62	1.64	3.75	0.80	20.25	88.5
5	Sugar Bunker North	26	0.91	0.53	1.67	-0.11	8.54	26.9
6	Yucca	26	1.42	0.81	2.86	-0.27	15.03	34.6
9	Bunker 9-300	26	3.33	2.74	2.45	0.39	8.58	86.5
10	Gate 700 South	25	0.84	0.72	0.63	-0.06	2.57	16.0
10	SEDAN North	26	14.46	10.83	12.28	2.09	39.81	100.0
12	E Tunnel Pond 2	26	7.12	6.99	3.27	1.59	14.45	100.0
16	3545 Substation	26	0.46	0.39	0.51	-0.21	1.92	3.8
18	LITTLE FELLER 2 North	26	0.31	0.24	0.46	-0.25	1.93	3.8
20	SCHOONER	25	434.20	151.86	452.85	26.79	1219.74	100.0
23	Mercury Track	26	0.37	0.18	0.55	-0.52	1.57	13.5
25	Guard Station 510	26	0.38	0.31	0.53	-0.66	1.56	13.5
All Onsite Locations		**360**	**32.62**	**0.94**	**160.64**	**-0.66**	**1219.74**	**47.5**

Table 5.10 Descriptive Statistics for TLD Annual Exposures, (mR/yr) – 2002

Area	Location	Loc. Type	Number of Samples	Mean	Median	Std. Dev.	Min.	Max.
1	BJY	E1	4	96	95	6	91	105
1	Bunker 1-300	E2	4	125	125	6	117	132
1	Sandbag Storage Hut	E1	4	114	113	8	106	125
1	Stake C-2	E1	4	118	117	7	110	128
2	Stake L-9	E2	4	182	181	9	173	193
2	Stake M-140	E1	4	136	133	9	129	149
2	Stake N-8	E2	4	674	676	25	648	696
2	Stake TH-58	E1	4	94	92	6	89	101
3	A3 RWMS Center	WO	4	162	160	8	154	173
3	LANL Trailers	E1	4	117	118	4	111	120
3	RWMS East	WO	4	151	150	9	143	162
3	RWMS North	WO	4	128	126	9	120	140
3	RWMS South	WO	4	456	452	20	437	483
3	RWMS West	WO	4	126	126	6	120	132
3	Stake A-6.5	E2	4	148	144	10	140	162
3	Stake OB-11.5	E1	4	129	128	9	120	141
3	Stake OB-20	E1	4	89	87	5	84	95
3	U-3co North	E2	4	218	217	7	211	228
3	U-3co South	E2	4	158	158	6	152	164
3	Well ER 3-1	E1	4	128	127	7	122	137
4	Stake A-9	E2	4	792	782	25	774	829
4	Stake TH-41	E1	4	113	110	11	105	128
4	Stake TH-48	E1	4	119	117	6	114	127
5	3.3 Mi SE of Aggregate Pit	B	4	62	61	5	57	69
5	Bldg 5-31	E1	4	114	113	6	107	122
5	RWMS East Gate	WO	4	146	149	16	125	160
5	RWMS Expansion NE	WO	4	139	138	5	135	146
5	RWMS Expansion NW	WO	4	146	145	9	137	157
5	RWMS Northeast Corner	WO	4	120	119	6	115	127
5	RWMS Northwest Corner	WO	4	125	125	6	117	132
5	RWMS South Gate	WO	3	113	112	5	109	118
5	RWMS Southwest Corner	WO	4	124	123	12	110	137
5	Water Well 5B	E1	4	113	114	5	106	117
5	WEF East	WO	4	124	123	7	116	133
5	WEF North	WO	4	120	118	7	115	129
5	WEF South	WO	4	124	122	7	118	134
5	WEF West	WO	4	131	130	8	122	140
6	CP-6	E1	4	70	69	5	66	76
6	DAF East	E1	4	92	90	5	87	98
6	DAF West	E1	4	83	81	7	77	94
6	Decon Facility Northeast	E1	4	121	119	7	114	131
6	Decon Facility Southeast	E1	4	125	123	6	120	133
6	Yucca Oil Storage	E1	4	98	98	5	93	105
7	Bunker 7-300	E2	4	261	260	13	247	277
7	Reitmann Seep	E1	4	129	128	8	123	139
7	Stake H-8	E1	4	131	130	6	125	138

B = Background Locations.
C = Control Locations.
E1 = Environmental Locations with no measurable radioactivity from past operations.
E2 = Environmental Locations with measurable radioactivity from past operations, excluding those designated “WO.”
WO = Locations in or near waste operations.

Table 5.10 (Descriptive Statistics for TLD Annual Exposures, [mR/yr] – 2002, cont.)

Area	Location	Loc. Type	No. of Samples	Mean	Median	Std. Dev.	Min.	Max.
8	Road 8-02	E2	4	129	129	7	121	137
8	Stake K-25	E2	4	105	102	9	97	117
8	Stake M-152	E2	4	171	168	13	159	187
9	Bunker 9-300	E2	4	125	123	8	118	137
9	Papoose Lake Road	E1	4	80	80	4	76	86
9	U-9cw South	E1	4	104	104	5	97	111
9	V & G Road Junction	E1	4	116	114	8	108	127
10	Circle & L Roads	E2	4	121	119	7	114	131
10	Gate 700 South	E1	4	134	133	10	123	146
10	Sedan East Visitor Box	E2	4	137	133	11	128	152
10	Sedan West	E2	4	274	269	14	264	295
11	Stake A-21	E1	4	131	130	8	123	140
12	T-Tunnel #2 Pond	E2	4	242	240	15	226	261
12	Upper Haines Lake	E2	4	112	111	9	102	123
12	Upper N Pond	E1	4	131	129	9	123	142
15	EPA Farm	E2	4	111	109	8	103	123
15	U-15e Substation	B	4	94	93	5	89	101
18	Stake A-83	E1	2	137	137	1	136	137
18	Stake F-11	E1	4	151	152	13	138	163
19	Stake P-41	E1	4	172	172	12	159	185
20	Stake A-118	B	2	145	145	0	145	145
20	Stake J-31	E2	4	185	187	15	167	198
20	Stake J-41	E1	4	142	143	14	129	155
22	Army #1 Water Well	B	4	81	80	5	76	87
23	Building 650 Dosimetry	C	4	57	56	4	53	63
23	Mercury Fitness Track	E1	4	78	77	5	74	86
25	Gate 25-4-P	B	4	133	131	7	127	143
25	Guard Station 510	B	4	128	125	8	121	139
25	Henre	E1	4	127	124	9	119	139
25	Jackass Flats & A-27 Roads	B	4	81	79	5	76	88
25	NRDS Warehouse	E1	4	125	123	8	117	136
25	Yucca Mountain	B	4	138	135	6	134	147
27	Cafeteria	E1	4	128	129	10	116	140
	Summary by Location Type							
Background		B	30	105	98	30	57	147
Control		C	4	57	56	4	53	63
Environmental 1		E1	138	116	120	23	66	185
Environmental 2		E2	76	225	160	184	97	829
Waste Operations		WO	63	153	131	81	109	483
All Locations			**311**	**148**	**125**	**109**	**53**	**829**

B = Background Locations.
C = Control Locations.
E1 = Environmental Locations with no measurable radioactivity from past operations.
E2 = Environmental Locations with measurable radioactivity from past operations, excluding those designated “WO.”
WO = Locations in or near waste operations.

Table 5.11 Radionuclide Concentrations in E Tunnel Ponds – 2002

			Radionuclide Concentrations[(a)]			
Sample	**Location**	**Units**	**^{3}H " Error (MDC)**	**^{90}Sr " Error (MDC)**	**^{137}Cs " Error (MDC)**	**$^{233/234}$U " Error (MDC)**
Filtered Water From Sump	**Sump**	pCi/L	937,000 " 119,000 (2,090)	0.28 " 0.17 (0.27)	21.60 " 6.60 (7.65)	3.27 " 0.68 (0.19)
Particulates In Water From Sump	**Sump**	pCi/L	NA[(b)]	0.02 " 0.05 (0.09)	17.09 " 3.23 (1.69)	0.34 " 0.10 (0.07)
Filtered Water From Influent	**Pond 4**	pCi/L	946,000 " 120,000 (2,310)	0.32 " 0.17 (0.26)	18.50 " 5.65 (6.20)	3.53 " 0.71 (0.15)
Particulates In Influent	**Pond 4**	pCi/L	[(b)]	0.07 " 0.07 (0.12)	18.54 " 3.45 (1.64)	0.39 " 0.12 (0.08)
Filtered Pond Water	**Pond 1**		No Water in Pond Basin ----------			
	Pond 2		No Water in Pond Basin ----------			
	Pond 3		No Water in Pond Basin ----------			
	Pond 4	pCi/L	932,000 " 118,000 (2,360)	-0.38 " 0.33 (0.27)	18.90 " 11.94 (7.40)	1.76 " 0.78 (0.15)
	Pond 4[(c)]	pCi/L	943,000 " 119,000 (2,260)	-0.64 " 0.31 (0.26)	22.80 " 8.53 (7.68)	3.01 " 0.78 (0.45)
	Pond 5	pCi/L	867,000 " 110,000 (2,330)	0.81 " 0.24 (0.28)	17.60 " 6.26 (7.78)	7.07 " 1.23 (0.29)
Particulates in Pond Water	**Pond 1**		No Water in Pond Basin ----------			
	Pond 2		No Water in Pond Basin ----------			
	Pond 3		No Water in Pond Basin ----------			
	Pond 4	pCi/L	[(b)]	0.84 " 2.33 (4.02)	11.00 " 9.21 (14.70)	2.01 " 0.77 (0.76)
	Pond 4[(c)]	pCi/L	[(b)]	1.31 " 2.21 (3.75)	12.50 " 8.64 (13.60)	0.82 " 0.46 (0.56)
	Pond 5	pCi/L	[(b)]	0.01 " 0.04 (0.06)	26.90 " 4.78 (1.59)	0.31 " 0.09 (0.07)
Sediment Under Inlet Pipe	**Pond 1**		Inlet to Pond 1 No Longer Exists ----------			
	Pond 2	pCi/g	[(b)]	0.28 " 0.27 (0.43)	32.20 " 5.44 (0.54)	0.94 " 0.19 (0.09)
	Pond 3	pCi/g	[(b)]	0.61 " 0.32 (0.45)	80.20 " 13.40 (0.43)	1.22 " 0.23 (0.06)
	Pond 4	pCi/g	[(b)]	0.36 " 0.27 (0.43)	97.70 " 16.20 (0.29)	1.05 " 0.17 (0.04)
	Pond 5	pCi/g	[(b)]	1.12 " 0.37 (0.42)	143.00 " 23.60 (0.36)	1.44 " 0.25 (0.03)
Sediment From Basin	**Pond 1**	pCi/g	[(b)]	0.19 " 0.25 (0.42)	0.93 " 0.22 (0.16)	1.11 " 0.21 (0.04)
	Pond 2	pCi/g	[(b)]	0.13 " 0.25 (0.42)	40.90 " 6.90 (0.38)	1.43 " 0.26 (0.05)
	Pond 2[(c)]	pCi/g	[(b)]	0.31 " 0.27 (0.44)	53.70 " 9.09 (0.43)	1.42 " 0.27 (0.16)
	Pond 3	pCi/g	[(b)]	2.51 " 0.64 (0.52)	36.30 " 6.13 (0.36)	1.01 " 0.18 (0.03)
	Pond 4	pCi/g	[(b)]	0.77 " 0.33 (0.44)	37.90 " 6.30 (0.24)	0.92 " 0.17 (0.05)
	Pond 5	pCi/g	[(b)]	2.77 " 0.64 (0.44)	47.20 " 7.95 (0.69)	1.46 " 0.25 (0.03)

(a) Measured concentrations of radionuclides detected in at least one sample. Background subtraction may result in negative values. Results less than the Minimum Detectable Concentration (MDC) or less than the Error (equal to twice the total uncertainty reported by the analytical laboratory) are not considered detected.
(b) NA = Not Applicable (tritium not measured in samples containing no water).
(c) Field Duplicate (duplicate sample collected in the field).

Table 5.11 (Radionuclide Concentrations in E Tunnel Ponds – 2002, cont.)

			Radionuclide Concentrations[(a)]				
Sample	**Location**	**Units**	**^{235}U " Error (MDC)**	**^{238}U " Error (MDC)**	**^{238}Pu " Error (MDC)**	**$^{239/240}$Pu " Error (MDC)**	**^{241}Am " Error (MDC)**
Filtered Water From Sump	**Sump**	pCi/L	0.43 " 0.19 (0.16)	1.00 " 0.31 (0.17)	0.21 " 0.08 (0.07)	2.02 " 0.34 (0.05)	0.10 " 0.05 (0.05)
Particulates In Water From Sump	**Sump**	pCi/L	0.08 " 0.05 (0.05)	0.20 " 0.07 (0.04)	0.22 " 0.07 (0.03)	1.36 " 0.24 (0.01)	0.15 " 0.10 (0.11)
Filtered Water From Influent	**Pond 4**	pCi/L	0.42 " 0.18 (0.10)	1.00 " 0.30 (0.13)	0.16 " 0.06 (0.05)	1.53 " 0.26 (0.05)	0.12 " 0.05 (0.04)
Particulates In Influent	**Pond 4**	pCi/L	0.05 " 0.05 (0.07)	0.19 " 0.07 (0.04)	0.23 " 0.08 (0.06)	1.56 " 0.28 (0.05)	0.17 " 0.09 (0.04)
Filtered Pond Water	**Pond 1**		No Water in Pond Basin ----------				
	Pond 2		No Water in Pond Basin ----------				
	Pond 3		No Water in Pond Basin ----------				
	Pond 4	pCi/L	-0.08 " 0.20 (0.17)	0.66 " 0.46 (0.18)	0.08 " 0.14 (0.11)	1.64 " 0.77 (0.04)	0.20 " 0.07 (0.02)
	Pond 4[(c)]	pCi/L	-0.16 " 0.22 (0.50)	1.31 " 0.42 (0.29)	0.15 " 0.10 (0.05)	1.47 " 0.48 (0.05)	0.19 " 0.07 (0.05)
	Pond 5	pCi/L	0.55 " 0.26 (0.37)	1.56 " 0.44 (0.48)	0.20 " 0.07 (0.04)	1.28 " 0.24 (0.06)	0.16 " 0.06 (0.04)
Particulates in Pond Water	**Pond 1**		No Water in Pond Basin ----------				
	Pond 2		No Water in Pond Basin ----------				
	Pond 3		No Water in Pond Basin ----------				
	Pond 4	pCi/L	0.52 " 0.36 (0.43)	0.81 " 0.44 (0.35)	0.35 " 0.20 (0.19)	1.26 " 0.38 (0.07)	0.13 " 0.78 (0.16)
	Pond 4[(c)]	pCi/L	0.19 " 0.28 (0.52)	0.28 " 0.23 (0.14)	0.24 " 0.23 (0.34)	1.67 " 0.58 (0.34)	0.26 " 0.62 (0.10)
	Pond 5	pCi/L	0.08 " 0.05 (0.05)	0.28 " 0.08 (0.03)	0.25 " 0.08 (0.04)	1.89 " 0.32 (0.03)	0.09 " 0.09 (0.13)
Sediment Under Inlet Pipe	**Pond 1**		Inlet to Pond 1 No Longer Exists ----------				
	Pond 2	pCi/g	0.08 " 0.06 (0.11)	0.68 " 0.16 (0.14)	0.04 " 0.03 (0.04)	0.43 " 0.10 (0.03)	0.07 " 0.03 (0.02)
	Pond 3	pCi/g	0.18 " 0.06 (0.03)	1.16 " 0.22 (0.02)	0.18 " 0.06 (0.04)	2.21 " 0.35 (0.02)	0.32 " 0.08 (0.04)
	Pond 4	pCi/g	0.08 " 0.03 (0.03)	0.94 " 0.16 (0.03)	0.20 " 0.06 (0.04)	1.39 " 0.24 (0.03)	0.16 " 0.05 (0.03)
	Pond 5	pCi/g	0.13 " 0.05 (0.03)	1.14 " 0.21 (0.03)	0.27 " 0.08 (0.05)	2.83 " 0.49 (0.04)	0.20 " 0.06 (0.01)
Sediment From Basin	**Pond 1**	pCi/g	0.16 " 0.06 (0.03)	1.00 " 0.19 (0.03)	0.25 " 0.07 (0.04)	2.11 " 0.33 (0.03)	0.30 " 0.08 (0.03)
	Pond 2	pCi/g	0.13 " 0.06 (0.06)	0.99 " 0.20 (0.06)	0.20 " 0.07 (0.05)	1.99 " 0.32 (0.03)	0.29 " 0.08 (0.03)
	Pond 2[(c)]	pCi/g	0.03 " 0.08 (0.17)	1.38 " 0.26 (0.10)	0.24 " 0.07 (0.02)	4.07 " 0.62 (0.03)	0.33 " 0.11 (0.02)
	Pond 3	pCi/g	0.11 " 0.05 (0.03)	1.02 " 0.18 (0.04)	0.38 " 0.10 (0.05)	3.04 " 0.50 (0.02)	0.36 " 0.10 (0.03)
	Pond 4	pCi/g	0.14 " 0.05 (0.04)	0.81 " 0.16 (0.04)	0.08 " 0.04 (0.04)	0.76 " 0.15 (0.04)	0.06 " 0.03 (0.01)
	Pond 5	pCi/g	0.20 " 0.06 (0.02)	1.30 " 0.23 (0.02)	0.10 " 0.04 (0.03)	1.19 " 0.21 (0.03)	0.16 " 0.06 (0.02)

(a) Measured concentrations of radionuclides detected in at least one sample. Background subtraction may result in negative values. Results less than the Minimum Detectable Concentration (MDC) or less than the 2s Error are not considered detected.
(b) Not Applicable (tritium not measured in samples containing no water).
(c) Field Duplicate (duplicate sample collected in the field).

Table 5.12 Radionuclide Activities in NTS Biota Samples – 2002

Location / Species	Tissue	H_2O[b]	Radionuclide Concentrations +/- Error[a] ^{3}H (pCi/L)[c]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	^{235}U (pCi/g)
T2 - Plants						
Brittlebush (*Encelia virginensis*) sample 1	New Growth, leaves/stems	47%	2,050 " 662	0.88 " 0.44	0.04 " 0.20[d]	0.01 " 1.04[d]
Brittlebush (*Encelia virginensis*) sample 2	New Growth, leaves/stems	48%	2,140 " 670	0.96 " 0.49	0.03 " 0.16[d]	0.36 " 0.62[d]
Rubber Rabbitbrush (*Ericameria nauseosus*) sample 1	New Growth, leaves/stems	51%	2,280 " 698	0.10 " 0.06	0.04 " 0.12[d]	0.21 " 1.29[d]
Rubber Rabbitbrush (*Ericameria nauseosus*) sample 2	New Growth, leaves/stems	56%	1,340 " 568	0.15 " 0.09	0.05 " 0.33[d]	0.23 " 0.60[d]
White Burrobrush (*Hymenoclea salsola*) sample 1	New Growth, leaves/stems	42%	2,120 " 656	0.34 " 0.18	0.30 " 0.18	0.44 " 0.55[e]
White Burrobrush (*Hymenoclea salsola*) sample 2	New Growth, leaves/stems	42%	1,880 " 636	1.58 " 0.68	1.27 " 0.54	1.08 " 0.86
T2 - Animals						
Black-tailed Jackrabbit (*Lepus californicus*)	Muscle (588 g)	74%	112 " 368[d]	0.27 " 0.14	0.02 " 0.14[d]	0.62 " 0.58
Gambel's Quail (*Callipepla gambelii*) sample 1 (181.1 g)[f]	Muscle from breast (57.6 g)	73%	6,170 " 1,012	0.00 " 0.03[d]	No Gamma or Uranium Analysis	
	Quail w/o breast muscle (123.6 g)	55%	5,620 " 972	0.07 " 0.06	0.24 " 0.28[e]	0.62 " 1.00[d]
Gambel's Quail (*Callipepla gambelii*) sample 2 (168.2 g)[f]	Muscle from breast (57.2 g)	73%	1,520 " 588	-0.01 " 0.05[d]	No Gamma or Uranium Analysis	
	Quail w/o breast muscle (111.0 g)	58%	950 " 528	0.44 " 0.23	3.16 " 0.92	0.13 " 0.62[d]
E Tunnel Pond – Animals						
Mourning Dove (*Zenaida macroura*) sample 1	Muscle from breast (34.1 g)	72%	608,000 " 23,800	0.05 " 0.07[d]	No Gamma or Uranium Analysis	
Mourning Dove (*Zenaida macroura*) sample 2	Muscle from breast (28.5 g)	68%	532,000 " 20,800	0.02 " 0.09[d]	No Gamma or Uranium Analysis	
Mourning Dove (*Zenaida macroura*) sample 3 (102.2 g)[f]	Muscle from breast (24.7 g)	75%	605,000 " 23,800	0.00 " 0.13[d]	No Gamma or Uranium Analysis	
	Dove w/o breast muscle (76.7 g)	61%	563,000 " 22,000	0.06 " 0.05	0.08 " 0.24[d]	0.73 " 0.95[e]
Mourning Dove (*Zenaida macroura*) sample 4 (88.2 g)[f]	Muscle from breast (20.4 g)	74%	353,000 " 14,200	0.03 " 0.09[d]	No Gamma or Uranium Analysis	
	Dove w/o breast muscle (66.7 g)	60%	345,000 " 13,880	0.25 " 0.15	0.36 " 0.65[d]	2.00 " 1.44
Mourning Dove (*Zenaida macroura*) sample 5 (122.3 g)[f]	Muscle from breast (32.5 g)	74%	574,000 " 22,600	0.01 " 0.04[d]	No Gamma or Uranium Analysis	
	Dove w/o breast muscle (89.8 g)	54%	547,000 " 21,600	0.35 " 0.18	1.69 " 0.83	0.59 " 2.46[d]
Mid-Valley Bladed Area – Plants						
Blackbrush (*Coleogyne ramosissima*) sample 1	New Growth, leaves/stems	24%	0 " 412[d]	0.04 " 0.05[d]	0.03 " 0.13[d]	0.11 " 0.57[d]
Blackbrush (*Coleogyne ramosissima*) sample 2	New Growth, leaves/stems	25%	1,540 " 1,340	0.06 " 0.05	-0.02 " 0.11[d]	0.33 " 0.91[d]
Nevada Jointfir (*Ephedra nevadensis*) sample 1	New Growth, leaves/stems	39%	66.8 " 502[d]	0.03 " 0.04[d]	0.00 " 0.14[d]	0.06 " 0.62[d]
Nevada Jointfir (*Ephedra nevadensis*) sample 2	New Growth, leaves/stems	17%	-82.6 " 458[d]	0.01 " 0.03[d]	0.10 " 0.20[d]	0.31 " 0.96[d]
Rubber Rabbitbrush (*Ericameria nauseosus*) sample 1	New Growth, leaves/stems	52%	120 " 616[d]	0.01 " 0.03[d]	0.01 " 0.04[d]	0.06 " 0.21[d]
Rubber Rabbitbrush (*Ericameria nauseosus*) sample 2	New Growth, leaves/stems		-55.2 " 394[d]	0.02 " 0.05[d]	0.01 " 0.02[d]	0.01 " 0.22[d]
Mid-Valley Bladed Area – Animals						
Desert Cottontail (*Sylvilagus audubonii*)	Whole body Muscle (166.3 g)	75%	-102 " 358[d]	0.01 " 0.03[d]	0.01 " 0.09[d]	0.10 " 0.76[d]
Area 23, Mercury – Roadkill						
Pronghorn (*Antelocapra americana*)	Muscle from hind quarter	49%	-129 " 356[d]	0.00 " 0.03[d]	0.00 " 0.10[d]	0.06 " 0.69[d]
AVERAGE MDC			359	0.05	0.11	0.47

(a) Concentrations per gram are dry weight. Error = 2 times the total error reported by lab. Concentrations may be negative values occasionally due to subtraction of background.
(b) Percent of water in the sample on a weight basis.
(c) Concentration of ^{3}H in water distilled from the sample.
(d) Result is less than the minimum detectable activity (MDA) and is therefore considered not detected.
(e) Potential false positive due to relatively large uncertainty.
(f) Whole body weight.

Table 5.12. (Radionuclide Activities in NTS Biota Samples – 2002, cont.)

Location / Species	Tissue	Radionuclide Concentrations +/- Error(a)			
		^{238}U (pCi/g)	^{238}Pu (pCi/g)	$^{239/240}$Pu (pCi/g)	^{241}Am (pCi/g)
T2 - Plants					
Brittlebush (*Encelia virginensis*) sample 1	New Growth, leaves/stems	1.35 " 5.00(d)	0.01 " 0.02(d)	0.03 " 0.03	0.02 " 0.02
Brittlebush (*Encelia virginensis*) sample 2	New Growth, leaves/stems	8.61 " 6.30	0.03 " 0.02	0.05 " 0.03	0.03 " 0.03
Rubber Rabbitbrush (*Ericameria nauseosus*) sample 1	New Growth, leaves/stems	3.43 " 6.46(d)	0.00 " 0.02(d)	0.01 " 0.02(d)	0.01 " 0.02(d)
Rubber Rabbitbrush (*Ericameria nauseosus*) sample 2	New Growth, leaves/stems	0.04 " 10.10(d)	0.01 " 0.01(e)	0.05 " 0.03	0.01 " 0.02(d)
White Burrobrush (*Hymenoclea salsola*) sample 1	New Growth, leaves/stems	10.00 " 4.54	0.02 " 0.02(e)	0.07 " 0.03	0.03 " 0.02
White Burrobrush (*Hymenoclea salsola*) sample 2	New Growth, leaves/stems	0.31 " 4.10(d)	0.93 " 0.19	2.01 " 0.39	0.41 " 0.11
T2 - Animals					
Black-tailed Jackrabbit (*Lepus californicus*)	Muscle (588 g)	1.30 " 3.10(d)	0.00 " 0.00(d)	0.00 " 0.00(d)	0.00 " 0.01(d)
Gambel's Quail (*Callipepla gambelii*) sample 1 (181.1 g)(f)	Muscle from breast (57.6 g)	No ^{238}U analysis	0.00 " 0.00(d)	0.00 " 0.00(d)	0.00 " 0.00(d)
	Quail w/o breast muscle (123.6 g)	2.90 " 12.20(d)	0.01 " 0.01(d)	0.04 " 0.03	0.01 " 0.02(d)
Gambel's Quail (Callipepla gambelii) sample 2 (168.2 g)(f)	Muscle from breast (57.2 g)	No ^{238}U analysis	0.00 " 0.00(d)	0.02 " 0.01(d)	0.00 " 0.01(d)
	Quail w/o breast muscle (111.0 g)	1.16 " 5.70(d)	0.02 " 0.03(e)	0.67 " 0.18	0.05 " 0.04
E Tunnel Pond – Animals					
Mourning Dove (*Zenaida macroura*) sample 1	Muscle from breast (34.1 g)	No ^{238}U analysis	0.00 " 0.01(d)	0.00 " 0.01(d)	0.00 " 0.01(d)
Mourning Dove (*Zenaida macroura*) sample 2	Muscle from breast (28.5 g)	No ^{238}U analysis	0.00 " 0.00(d)	0.00 " 0.01(d)	0.00 " 0.01(d)
Mourning Dove (*Zenaida macroura*) sample 3 (102.2 g)(f)	Muscle from breast (24.7 g)	No ^{238}U analysis	0.00 " 0.01(d)	0.01 " 0.02(d)	0.00 " 0.01(d)
	Dove w/o breast muscle (76.7 g)	1.24 " 9.80(d)	0.00 " 0.01(d)	0.00 " 0.01(d)	0.00 " 0.01(d)
Mourning Dove (*Zenaida macroura*) sample 4 (88.2 g)(f)	Muscle from breast (20.4 g)	No ^{238}U analysis	0.00 " 0.01(d)	0.00 " 0.01(d)	0.00 " 0.01(d)
	Dove w/o breast muscle (66.7 g)	41.30 " 16.88	0.00 " 0.00(d)	0.01 " 0.01(e)	0.00 " 0.01(d)
Mourning Dove (Zenaida macroura) sample 5 (122.3 g)(f)	Muscle from breast (32.5 g)	No ^{238}U analysis	0.00 " 0.00(d)	0.00 " 0.01(d)	0.00 " 0.01(d)
	Dove w/o breast muscle (89.8 g)	1.09 " 13.32(d)	0.01 " 0.01(e)	0.04 " 0.02	0.00 " 0.01(d)
Mid-Valley Bladed Area – Plants					
Blackbrush (*Coleogyne ramosissima*) sample 1	New Growth, leaves/stems	6.90 " 4.26	0.01 " 0.01(d)	0.01 " 0.02(e)	0.01 " 0.02(d)
Blackbrush (*Coleogyne ramosissima*) sample 2	New Growth, leaves/stems	0.57 " 5.08(d)	0.00 " 0.01(d)	0.00 " 0.01(d)	0.01 " 0.02(d)
Nevada Jointfir (*Ephedra nevadensis*) sample 1	New Growth, leaves/stems	6.19 " 4.20	0.00 " 0.01(d)	0.00 " 0.01(d)	0.00 " 0.02(d)
Nevada Jointfir (*Ephedra nevadensis*) sample 2	New Growth, leaves/stems	7.68 " 5.56	0.00 " 0.01(d)	0.00 " 0.01(d)	0.00 " 0.01(d)
Rubber Rabbitbrush (*Ericameria nauseosus*) sample 1	New Growth, leaves/stems	1.47 " 1.34	0.00 " 0.01(d)	0.00 " 0.01(d)	0.00 " 0.01(d)
Rubber Rabbitbrush (*Ericameria nauseosus*) sample 2	New Growth, leaves/stems	1.83 " 1.24	0.00 " 0.01(d)	0.00 " 0.01(d)	0.00 " 0.01(d)
Mid-Valley Bladed Area - Animals					
Desert Cottontail (*Sylvilagus audubonii*)	Muscle from whole body (166.3 g)	2.91 " 2.42	0.00 " 0.00(d)	0.00 " 0.01(d)	0.00 " 0.01(d)
Area 23, Mercury - Roadkill					
Pronghorn (*Antelocapra americana*)	Muscle from hind quarter	6.24 " 3.64	0.00 " 0.00(d)	0.00 " 0.00(d)	0.00 " 0.01(d)
AVERAGE MDC		2.46	0.01	0.01	0.01

(a) Concentrations per gram are dry weight. Error = 2 times the total error reported by lab. Concentrations may be negative values occasionally due to subtraction of background.
(b) Percent of water in the sample on a weight basis.
(c) Concentration of ^{3}H in water distilled from the sample.
(d) Result is less than the minimum detectable concentration (MDC) and is therefore considered not detected.
(e) Potential false positive due to relatively large uncertainty.
(f) Whole body weight.

Table 5.13 Summary of Annual Air Emissions Data by Source[(a)] (Multiply Ci by 37 to obtain GBq)

Source Type	Type of Control	Distance to Nearest Receptor	Nuclide	Quantity (Ci)
Point Sources				
CP-50, Area 6	None	42 km	^{3}H	0.000040
Building A-1[(a)]	None	0.1 km	^{3}H	0.20
Area Sources				
E Tunnel ponds	None	50 km	^{3}H[(b)]	13
RWMS-5	None	36 km	^{3}H[(c)]	5.3
SCHOONER	None	20 km	^{3}H[(c)]	230
SEDAN	None	50 km	^{3}H[(c)]	40
Grouped Area Sources				
All NTS Areas	None	20-60 km	^{241}Am[(d)]	0.047
	None	20-60 km	$^{239+240}Pu$[(d)]	0.29

(a) All locations at or near the NTS except Building A-1, which is in North Las Vegas.
(b) Emission based on tritiated water discharged into containment pond(s).
(c) Emission based on environmental surveillance results and CAP88-PC software.
(d) Sum of emissions estimated from re-suspension model (DOE 1991) and CAP88-PC software

Table 5.14 Hypothetical Dose to a Human Consuming Doves from the E Tunnel Ponds or Quail and Jackrabbits from the T2 Site, 2002

	Detected Radionuclides	Average Concentration	CEDE Factors (mrem/pCi Consumed)[(a)]	CEDE (mrem)
<u>**E Tunnel Ponds**</u>				
Dove Breast Muscle	^{3}H	534,400 pCi/L (water)	6.30E-08	0.01
Average Wt: 28.0 g (wet)	^{137}Cs	0.71 pCi/g (dry)	5.00E-05	0.01
72.6% H_2O	^{235}U	1.11 pCi/g (dry)	2.50E-04	0.04
7.7 g (dry)	^{238}U	14.54 pCi/g (dry)	2.30E-04	0.51
				TOTAL:0.58
<u>**T2 Site**</u>				
Gambel's Quail Muscle	^{3}H	3,845 pCi/L (water)	6.30E-08	0.00
Average Wt: 174.7 g (wet)	^{137}Cs	1.70 pCi/g (dry)	5.00E-05	0.08
73.0% H_2O				**TOTAL:0.08**
47.2 g (dry)				
Jackrabbit Muscle	^{90}Sr	0.27 pCi/g (dry)	1.30E-04	0.11
Average Wt: 588.0 g (wet)	^{235}U	0.62 pCi/g (dry)	2.50E-04	0.47
74.0% H_2O				**TOTAL:0.58**
152.9 g (dry)				

(a) Dose Factors for -human ingestion from DOE/EH-0071. It was assumed that a person ate the listed average wet weight of muscle from each of 20 doves, 20 quail, and 20 jackrabbits.

Table 5.15 Summary of Gamma Exposure Rates (μR/hr) as measured by PIC – 2002

Sampling Location	Maximum	Minimum	Standard Deviation	Average	mR/Year
Alamo	18.8	11.6	0.18	12.5	110
Amargosa Center	15.6	11.5	0.13	12.4	108
Beatty	21.8	16.8	0.27	18.3	160
Boulder City	17.1	11.1	0.16	14.3	125
Caliente	17.9	13.8	0.43	14.9	131
Cedar City	16.6	9.5	0.16	10.5	92
Delta	18.3	11	0.42	16.2	142
Garden Valley	18.8	14.6	0.21	11.8	104
Goldfield	19.1	13.8	0.12	15.0	132
Henderson	18.0	14.1	0.35	15.1	132
Indian Springs	15.0	8.2	0.85	11.0	96
Las Vegas	12.4	8.4	0.94	10.1	89
Medlin's Ranch	20.2	13.9	0.46	16.0	141
Milford	22.5	15.8	0.36	17.5	154
Nyala	17.7	11.5	0.40	13.0	114
Overton	13.2	6.7	0.18	9.6	84
Pahrump	10.8	7.3	0.13	8.1	71
Pioche	16.9	10.6	0.55	13.9	122
Rachel	20.5	13.1	0.26	15.0	132
St. George	12.5	8.3	0.19	9.2	80
Sarcobatus Flats	22.7	12.7	0.37	17.3	152
Stone Cabin	20.4	15.9	0.19	17.7	155
Tonopah	22.1	13.7	0.40	16.9	148
Twin Springs	23.0	17.9	0.52	19.3	169

Table 5.16 Screening Level Comparisons of Radionuclide Concentrations in the E Tunnel Ponds with Biota Concentration Guides (BCG) To Assess Potential Dose to Biota

E Tunnel Pond Aquatic System Screening Level Biota Dose Assessment							
Nuclide	**Water Limit pCi/L (BCG[a])**	**E Tunnel Pond Water Average[b] (pCi/L)**	**Water Partial Fraction**	**Sediment Limit pCi/g (BCG[a])**	**E Tunnel Pond Sediment Average[b] (pCi/g)**	**Sediment Partial Fraction**	**Water & Sediment Sum of Fractions**
^{241}Am	438	0.312	7.12E-4	5150	0.224	4.35E-5	7.56E-4
^{137}Cs	42.6	37.1	8.70E-1	3120	57.0	1.82E-2	8.88E-1
^{3}H	265,000,000	925,000	3.49E-3	374,000	--[c]	--	3.49E-3
^{239}Pu	187	3.14	1.68E-2	5860	2.00	3.41E-4	1.71E-2
^{90}Sr	279	0.528	1.90E-3	582	0.906	1.56E-3	3.45E-3
^{233}U	200	4.50	2.26E-2	5280	1.20	2.27E-4	2.28E-2
^{235}U	218	0.413	1.90E-3	3730	0.123	3.30E-5	1.93E-3
^{238}U	223	1.46	6.53E-3	2490	1.04	4.19E-4	6.95E-3
Sum of Fractions:			**9.24E-1**			**2.09E-2**	**9.44E-1**

(a) BCG = Biota Concentration Guides (levels of radionuclides, under certain conservative circumstances, that may result in an organism receiving a dose equal to the biota dose limit).

(b) Average of samples collected during 2002 (see section 5.3).

(c) ^{3}H not measured in sediment as sediment was dry.

Table 5.17 Air Filter Analyses and Techniques

Analyte	**Collection Time**	**Minimum Holding Time**	**Method**
Gross Alpha	168 hours	168 hours	DOE RP-710 mod
Gross Beta	168 hours	168 hours	DOE RP-710 mod
Gamma Spectroscopy	Quarterly Composite	None	EPA 901.1 mod

Table 5.18 Results of Field and Laboratory Quality Assurance Samples – 2002

Analyte	Number of Field Duplicates	Average %RSD	Number of Laboratory Duplicates	Average %RSD
Gross Alpha	104	13.7	146	10.9
Gross Beta	104	3.5	146	2.15
Gamma 7Be	8	17.2	8	12.8
Gamma 210Pb	8	7.4	8	15.6

Table 5.19 Gross Alpha Results for the Offsite Air Surveillance Network – 2002

Concentration (10^{-15} µCi/mL [37 µBq/m^3])					
Sampling Location	**Number**	**Maximum**	**Minimum**	**Mean**	**Standard Deviation**
Alamo	52	5.8	0.4	2.4	1.3
Amargosa Center	52	7.2	0.5	2.9	1.6
Beatty	50	3.8	0.7	2.0	0.9
Boulder City	52	6.1	0.9	2.9	1.3
Caliente	51	5.0	0.8	2.1	1.0
Cedar City	52	6.9	0.7	2.5	1.3
Delta	51	4.3	0.6	1.5	0.7
Garden Valley	52	2.4	0.4	1.5	0.4
Goldfield	52	2.9	0.7	1.6	0.5
Henderson	51	3.9	0.6	2.3	0.9
Indian Springs	47	3.2	0.8	1.5	0.6
Las Vegas	52	4.6	0.5	2.3	0.9
Milford	52	5.3	0.4	1.7	0.8
Nyala	52	2.4	0.5	1.2	0.4
Overton	52	7.9	0.8	2.4	1.3
Pahrump	52	5.2	0.4	1.8	0.8
Pioche	52	2.6	0.4	1.4	0.5
Rachel	52	4.0	0.9	1.7	0.7
St. George	52	2.8	0.7	1.6	0.5
Stone Cabin	52	6.7	1.6	3.1	1.1
Tonopah	48	3.2	0.6	1.5	0.6
Twin Springs	52	3.3	0.3	1.5	0.6
Mean MDC = 5.7 x 10^{-16} µCi/mL Standard Deviation of Mean MDC = 1.3 x 10^{-16}µCi/mL					

Table 5.20 Gross Beta Results for the Offsite Air Surveillance Network – 2002

Concentration (10^{-14} µCi/mL [0.37 µBq/m^3])					
Sampling Location	**Number**	**Maximum**	**Minimum**	**Mean**	**Standard Deviation**
Alamo	52	4.5	1.4	2.5	0.7
Amargosa Center	52	5.4	1.4	2.7	0.9
Beatty	50	4.5	1.2	2.5	0.7
Boulder City	52	5.4	1.4	2.8	0.9
Caliente	51	5.0	1.5	2.6	0.7
Cedar City	52	4.8	1.2	2.3	0.7
Delta	51	7.2	1.2	2.6	1.0
Garden Valley	52	4.4	1.4	2.2	0.6
Goldfield	52	4.1	1.1	2.3	0.7
Henderson	51	5.0	1.5	2.6	0.8
Indian Springs	47	4.5	1.3	2.4	0.7
Las Vegas	52	4.5	1.5	2.5	0.7
Milford	52	7.2	1.4	2.6	0.9
Nyala	52	4.7	1.1	2.0	0.6
Overton	52	7.2	1.5	2.8	1.0
Pahrump	52	5.3	1.2	2.4	0.8
Pioche	52	4.3	1.1	2.2	0.6
Rachel	52	5.0	1.2	2.5	0.7
St. George	52	6.0	1.7	2.7	0.9
Stone Cabin	52	5.1	1.6	2.4	0.6
Tonopah	48	4.8	1.3	2.3	0.7
Twin Springs	52	5.1	1.2	2.5	0.7
Mean MDC = 1.1 x 10^{-15} µCi/mL		**Standard Deviation of Mean MDC = 1.8 x 10^{-16} µCi/mL**			

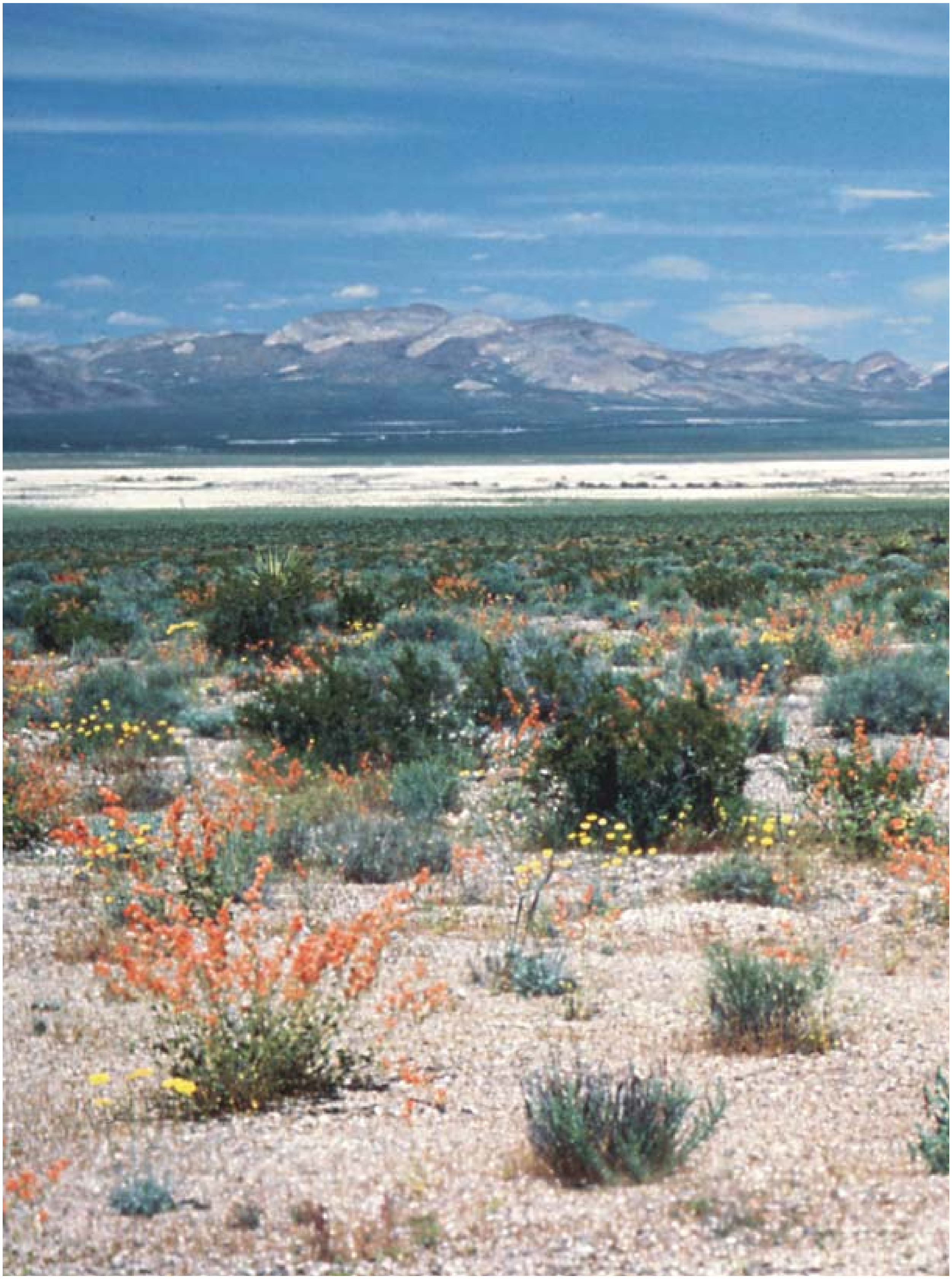
Table 5.21 TLD Monitoring Results for Offsite Stations – 2002

Daily Exposure (mR)					
Sampling Location	**Days**	**Minimum**	**Maximum**	**Mean**	**Total (mR) Exposure**
Alamo	364	0.31	0.34	0.32	116
Amargosa Center	366	0.29	0.33	0.31	112
Beatty	364	0.41	0.47	0.44	160
Boulder City	368	0.28	0.33	0.30	108
Caliente	366	0.36	0.40	0.37	136
Cedar City	363	0.29	0.32	0.30	110
Delta	366	0.30	0.33	0.32	115
Goldfield	364	0.35	0.43	0.38	139
Garden Valley	363	0.34	0.42	0.37	136
Henderson	368	0.30	0.36	0.33	119
Indian Springs	366	0.26	0.31	0.29	107
Las Vegas	368	0.24	0.28	0.26	95
Medlins Ranch	366	0.37	0.44	0.40	147
Milford	366	0.36	0.44	0.40	147
Nyala	364	0.29	0.35	0.32	118
Overton	278	0.23	0.29	0.26	95
Pahrump	366	0.23	0.27	0.24	87
Pioche	366	0.31	0.35	0.33	120
Rachel	364	0.39	0.45	0.41	150
Sarcobatus Flats	364	0.41	0.46	0.44	162
St. George	363	0.24	0.26	0.26	94
Stone Cabin	364	0.40	0.42	0.41	151
Tonopah	363	0.35	0.43	0.41	149
Twin Springs	364	0.39	0.49	0.44	162

Table 5.22 Average Natural Background Radiation for Selected U.S. Cities (Excluding Radon)

City	Radiation (mrem/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

Note: From http://www.wrcc.dri.edu/cemp/Radiation.html ("Radiation in Perspective," August 1990).



Frenchman Flat in the Spring (No Data Provided)

6.0 NONRADIOLOGICAL ENVIRONMENTAL PROGRAMS

The 2002 nonradiological monitoring program for the Nevada Test Site (NTS) included onsite sampling of various environmental media and substances for compliance with federal and state regulations or permits and for ecological studies. The Ecological Monitoring and Compliance (EMAC) program performed biological surveys at proposed construction sites, ecosystem mapping/data management, monitoring of sensitive species and unique habitats, and reviews of Hazardous Materials Spill center (HSC) test plans. In 2002, nonradiological monitoring was performed for four series of test involving 24 chemicals that were at the HSC.

6.1 WATER SURVEILLANCE

SAFE DRINKING WATER ACT

The NTS operates three permitted public water systems and two permitted water hauling trucks. All other water systems on the NTS are considered private water systems and are operated outside of the scope of state and federal regulations.

In 2002, water sampling was conducted for analysis of coliform bacteria, inorganic chemicals, lead, copper, nitrates, and fluoride as required by the Safe Drinking Water Act (SDWA), state of Nevada regulations, and the NTS Contaminant Monitoring Waivers. Samples were collected from entry points for nitrates, fluoride, and inorganic chemicals. Samples were also collected from taps within the drinking water distribution systems for coliform bacteria, lead, and copper. All samples were collected in accordance with accepted practices, and the analyses were performed by state-approved laboratories. Approved analytical methods listed in Nevada Administrative Code (NAC) 445A (NAC 1996) and Title 40 Code of Federal Regulations (CFR) 141 were used.

Bacteriological Sampling

All water distribution systems were tested either monthly or quarterly for coliform bacteria, with the number of people being served determining the number of samples collected and the frequency (see Table 6.1). No coliform bacteria were detected in any of the permitted water systems.

Samples from permitted water hauling trucks were analyzed monthly for coliform bacteria. None were detected.

Metal Analysis

Samples were collected from taps in the three public water systems in the third quarter and analyzed for lead and copper. All results were below the action level of 1.3 mg/L for copper and 0.015 mg/L for lead. Taps in the Area 12 public water system (NV0004099) had previously exceeded the action level for lead (0.015 mg/L). Several buildings were closed and others reactivated. In the current configuration, this system is in compliance with the Lead and Copper Rule.

Samples were collected from the three public water systems for arsenic analysis. All results were below the maximum contaminant level (MCL) of 0.05 mg/L.

Other Inorganic Chemical Analysis

To comply with a 1991 variance to the Area 25 water system permit, fluoride samples are collected annually from the two wells in Area 25 (NV0004098) before July 31 to confirm that the fluoride concentration is less than four parts per million. Samples taken from Area 25 Wells J-12 and J-13 in the second quarter of 2002 confirmed that the fluoride concentrations were acceptable.

During the first quarter of 2002, samples were collected from each entry point and analyzed for nitrates and Phase V Inorganic Chemicals. All results were within acceptable limits.

The results of inorganic analyses are shown in Tables 6.2 and 6.3 respectively.

Inspections

The Nevada Bureau of Health Protection Services performed a formal inspection of the permitted water hauling trucks and reported no findings or discrepancies.

6.2 AIR SURVEILLANCE

Air quality monitoring for the criteria pollutants is not required for the NTS. With the exception of the air permit for the HSC, the permits issued by the state of Nevada require opacity and material throughput measurements. Nonradiological monitoring is required by the HSC's air permit, and was conducted for four series of tests conducted at the HSC in 2002.

MONITORING OF NTS OPERATIONS

Routine nonradiological environmental monitoring on the NTS in 2002 was limited to the HSC air permit requirements and sampling in conjunction with asbestos removal and renovation projects, in accordance with occupational safety and National Emission Standards for Hazardous Air Pollutants compliance.

The HSC was established in Frenchman Flat in Area 5 as a basic research tool for studying the dynamics of accidental releases of various hazardous materials and the effectiveness of mitigation procedures. In addition to the state of Nevada air permit monitoring requirements, offsite monitoring of HSC tests may be required by the U.S. Environmental Protection Agency (EPA). Prior to each HSC test series, and, at other tests in the series depending on projected need, the documentation describing the tests are reviewed by the EPA to determine whether appropriate air sampling equipment should be deployed downwind of the test at the NTS boundary to measure chemical concentrations that may have reached the offsite area. During 2002, no monitoring was required.

6.3 ECOLOGICAL MONITORING

The EMAC program is designed to ensure compliance with applicable laws and regulations, delineate and define NTS ecosystems, and provide ecological information that can be used to predict and evaluate the potential impacts of proposed projects and programs on those ecosystems. EMAC tasks conducted in 2002 included biological surveys for sensitive species at proposed project locations, ecosystem mapping/data management, sensitive species and habitat monitoring, and reviews of HSC test plans.

BIOLOGICAL SURVEYS

Biological surveys are performed at proposed project sites where land disturbance will occur. The goal is to minimize adverse effects of land disturbance on sensitive plant and animal species, their associated habitat, and important biological resources. Sensitive species include those protected under state or federal regulations which are known or suspected to occur on the NTS (Table 6.4). Important biological resources include such things as cover sites, nest or burrow sites, roost sites, or water sources important to sensitive species. Survey reports are written to document species and resources found and to provide mitigation recommendations.

Biological surveys for 26 projects were conducted at 46 sites in 2002 on or near the NTS (Figure 6.1, Table 6.5). For some of the projects, multiple sites were surveyed. A total of 631.28 acres was surveyed for the projects (Table 6.5).

Thirteen of the projects had sites within the range of the threatened desert tortoise (*Gopherus agassizii*) (Figure 6.1). Sensitive species (or their sign) and important biological resources found within proposed project boundaries included an active great horned owl (*Bubo virginianus*) nest, active and inactive predator burrows, and mature yucca and cacti (Table 6.5). A pair of breeding great horned owls was found in a building scheduled for demolition. Demolition of this building was delayed until the owl chicks fledged. BN provided a written summary report of all survey findings and mitigation recommendations, where appropriate (Table 6.5).

HABITAT MAPPING

In fiscal year (FY) 1996, efforts began to map wildlife and plant habitats of the NTS. Field data were collected, analyzed, and preliminary maps created to show basic habitat features. Databases were developed and linked to geographic information system (GIS) maps to facilitate creation of habitat-physical feature maps. The topical report "Classification of Vegetation on the Nevada Test Site" (Ostler et al., 2001) was published and distributed in 2001. Ten vegetation alliances and twenty associations were recognized as occurring on the NTS.

This year, work started on entering location coordinates into the Ecological GIS (EGIS) fauna database for historical animal sighting and specimen collection sites on the NTS. The data will be used to link animal distribution data to the habitat-physical feature data gathered during the 1996-1998 NTS habitat mapping efforts (Ostler et.al., 2001). A review of all published vertebrate and invertebrate inventories and research performed on the NTS was conducted to identify geographical information. Other sources searched included field notes from past and present researchers on the NTS and collection records for vertebrate specimens maintained at the Brigham Young University museum in Provo, Utah. Wildlife observations made by Bechtel Nevada (BN) biologists or reported to Ecological Services by NTS workers are maintained in the EGIS animal database. Work on the EGIS fauna database will continue next fiscal year and faunal distribution maps will begin to be produced.

Metadata associated with the topical report Classification of Vegetation on the Nevada Test Site (Ostler et.al., 2000) were prepared to help document the extent of field information collected for Ecological Landform Units (ELUs) on the NTS. The location and extent of field photographs were reviewed for completeness and, where necessary, digitally scanned from old films and prints. Rectified images of 1:24000 scale aerial digital images of the NTS were secured to provide basemaps for correction of the ELU polygons and registration with the georectified base-map images.

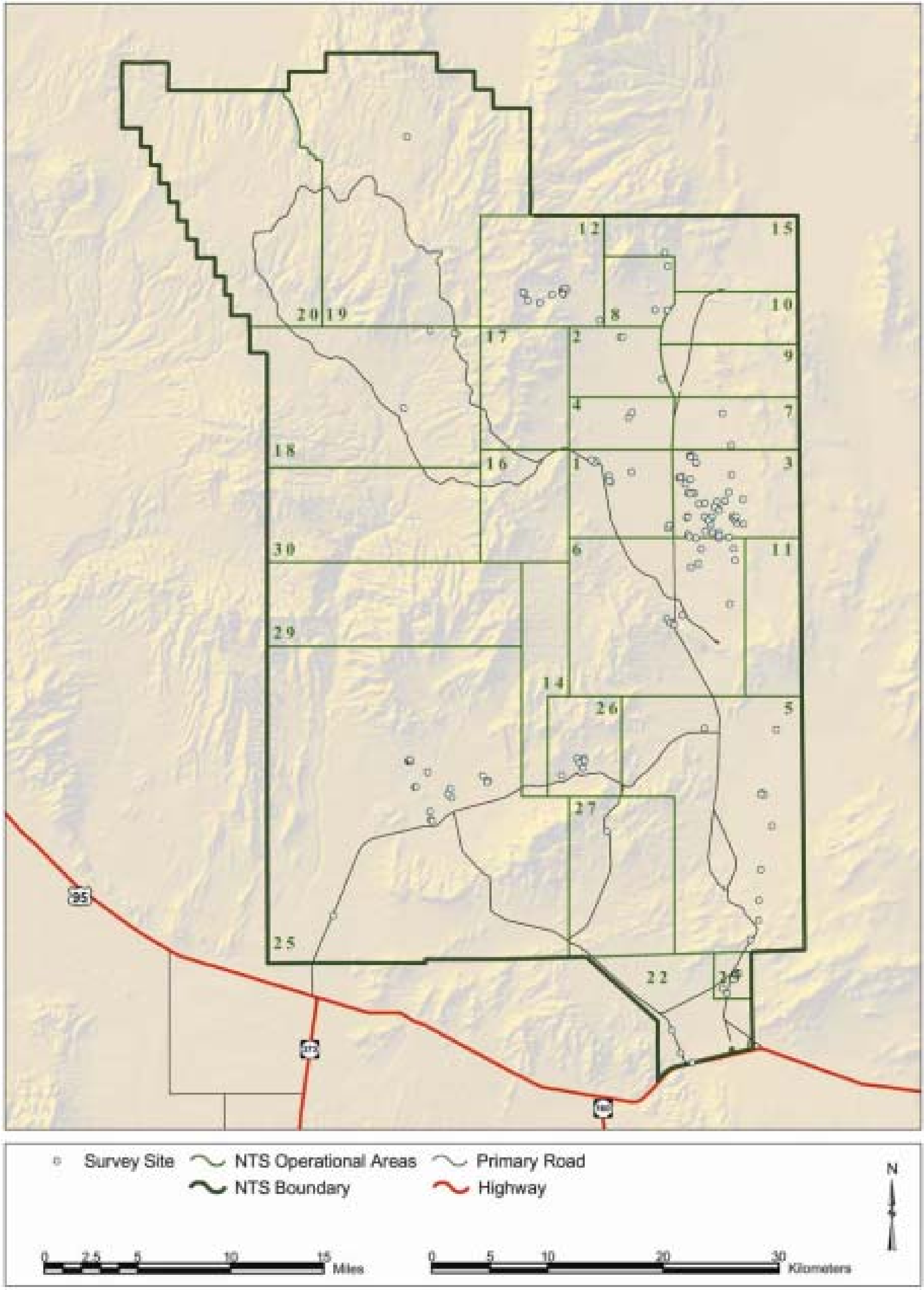


Figure 6.1 Biological Surveys Conducted on the NTS - 2002

SENSITIVE SPECIES MONITORING

There are 22 plants and 34 animals which occur on the NTS that are considered sensitive because they are either: (1) listed as threatened or endangered under the ESA, (2) current candidates for listing, (3) species of concern to FWS or state agencies, or (4) state-managed species of public interest (Table 6.4). The desert tortoise is the only threatened or endangered species which could be significantly impacted by National Nuclear Security Administration Nevada Site Office (NNSA/NSO) activities. EMAC tasks related to the desert tortoise are addressed in Section 3.0, "Threatened and Endangered Species Protection" of this report. As with the desert tortoise, the goal of species and habitat monitoring is to ensure the continued presence of all sensitive plants and animals on the NTS by protecting them from significant impacts due to NNSA/NSO actions. A secondary goal is to gather sufficient information on these species' distribution and abundance on the NTS to determine if further protection/management under state or federal law is necessary.

SENSITIVE PLANTS

The Department of Conservation and Natural Resources of the Nevada Natural Heritage Program (NNHP) maintains a detailed list of rare plants and lichens. The list includes plants protected by all federal agencies, the Division of Forestry of the state of Nevada, and the Nevada Native Plant Society. Any species included in their list and known or suspected to occur on the NTS are considered as sensitive plant species for the NTS (BN 2001b). The list of sensitive plant species being monitored on the NTS was reviewed and revised in 2002. The revised list is shown in Table 6.4. All sensitive plant species were categorized as a species (1) to be monitored, (2) not to be monitored, or (3) to be evaluated. Species that will be monitored are classified as "active" (A) in Table 6.4 and include those known to occur on the NTS, are on the FWS or NNHP list of sensitive plant species, and have limited distribution either on the NTS or its entire range. Those species in Table 6.4 classified as "inactive" (IA) will not be monitored under the long-term monitoring plan for NTS plant species (although their presence at proposed project sites during biological surveys are still documented). They include species that are known to occur on the NTS, but for which sufficient data have been gathered to suggest that they have widespread distribution on the NTS, in Nevada, or over the western United States. Species classified as "evaluate" (E) in Table 6.4 include those for which there is insufficient information to determine if they occur on the NTS and whether their distribution or abundance warrants their protection and monitoring.

Two species were monitored in 2002: *Astragalus beatleyae* (Beatley's milkvetch), a perennial forb, and *Eriogonum concinnum* (Darwin's buckwheat), an annual forb. No sensitive plant evaluations were conducted in 2002. Several mosses were collected during field surveys for *A. beatleyae* and *E. concinnum* but identifications have not been made. Ten of 18 known populations of *A. beatleyae* in Areas 19 and 20 were monitored (Figure 6.2) to collect plant density estimates and to note any conditions that may be impacting the plants (e.g., herbivory, disease, etc.). Plant density was higher in 2002 than it had been in 1989 at two of the populations. However, at all other populations, *A. beatleyae* density was lowest in 2002. This was not unexpected given the poor growing conditions in 2002 and considering there was no evidence of growth of other perennial forbs in 2002. There was no evidence of any of the populations being impacted by DOE activities.

Eight known E. concinnum populations in Areas 7, 17, 18, and 30 were identified from herbarium records and from historic plant location maps of the NTS (Rhoads et al. 1977). Characterization of E. concinnum populations had not been done previously. Only brief habitat descriptions are

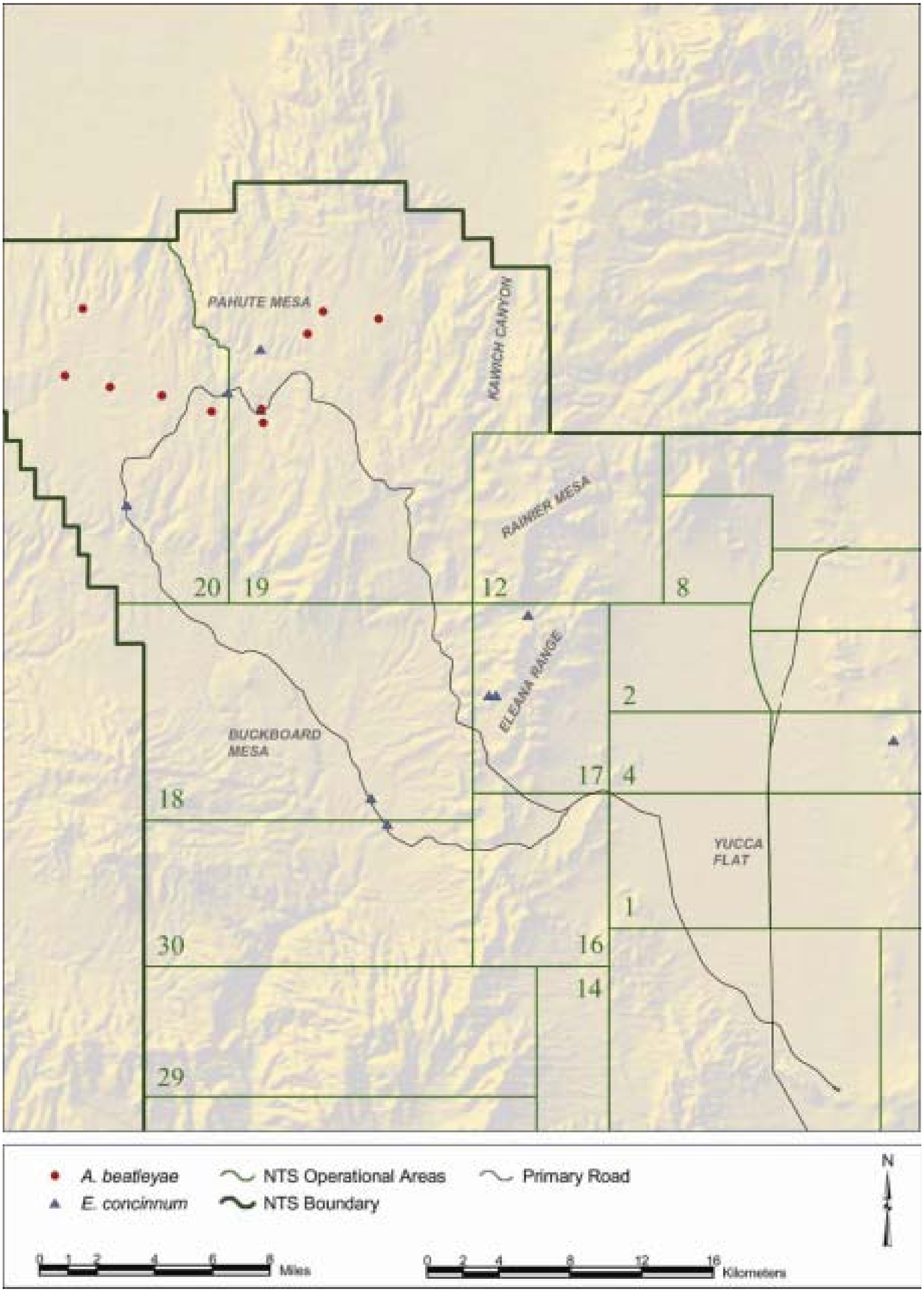


Figure 6.2 Populations of Sensitive Plant Species Monitored on the NTS - 2002

available from NTS herbarium collections made in the 1960s and 1970s. Efforts in 2002 were focused on relocating the eight historic populations and gathering information to characterize the habitat of *E. concinnum*. Ten sites which comprised the eight historic populations were visited (Figure 6.2). The habitat for *E. concinnum* is characterized by sandy soils associated with white volcanic tuff. Slopes vary from >35 percent to sandy flat bottoms and borrow areas along roads.

Plotting population boundaries of *E. concinnum* in the field was not done this year due to the poor growing conditions and almost complete absence of *E. concinnum*. This phase of long-term monitoring will be completed in future years under more favorable growing conditions. Monitoring of population status will continue at a future time when conditions are more favorable for germination and growth. From the preliminary observations this year, it appears that only a fraction of the potential habitat *for E. concinnum* has been identified on the NTS. Future studies may show this species to be much more widespread than is currently indicated from herbarium records.

WESTERN BURROWING OWL

The western burrowing owl (*Athene cunicularia hypugea*) is a species of concern which breeds on the NTS. This owl occurs in all three ecoregions of the NTS: the Great Basin Desert, transition, and Mojave Desert ecoregions. It occupies the burrows of predators (e.g., coyote, kit fox, badger) and desert tortoises, as well as man-made structures such as buried culverts and pipes. Three new burrowing owl burrow sites were found opportunistically while conducting other resource surveys. Monthly monitoring of burrows was completed in December 2001, yielding three full years of continuous burrow use data. The major focus of effort in 2002 was the completion of a draft document which summarizes the data results from more than four years of owl monitoring efforts on the NTS. Major sections of the report include: distribution, burrow use, reproduction, activity patterns, food habits, disturbance effects, winter burrow temperatures, and management implications. This report is important because it represents the first comprehensive study of burrowing owls in Nevada.

BAT SPECIES OF CONCERN

Bats or bat sign were documented at seven buildings this year during biological surveys of 64 buildings scheduled for demolition. Five live bats (two California myotis [*Myotis californicus*], one Brazilian free-tailed bat [*Tadarida brasiliensis*], and two unknown myotis species [*Myotis* spp.]) and eight dead bats (four Brazilian free-tailed, one California myotis, one pallid bat [*Antrozous pallidus*], and two unknown species) were observed during these surveys. None of the identified species are species of concern. Bats in buildings were found on three other occasions by NTS workers who then contacted Ecological Services biologists. None of these were bat species of concern. All bats were taken out of the buildings and released a substantial distance away.

Results from biological surveys of buildings and reports by others of bats in buildings, enables BN biologists to increase their knowledge about bat roosting sites on the NTS. These data are valuable because little information on specific bat roost sites exists for the NTS. Figure 6.3 shows the 28 known bat roost locations on the NTS to date.

A BN biologist attended a meeting of the Nevada Bat Working Group in March 2002. The Nevada Bat Working Group discussed the final format and content of the Nevada Bat Conservation Plan that was written to address the status and conservation strategies for all bat species occurring in Nevada. The BN biologist provided input as one of the contributing authors to the Nevada Bat Conservation Plan, which was published and distributed in July 2002 (Altenbach et al., 2002). Information from bat monitoring on the NTS was included in the plan.

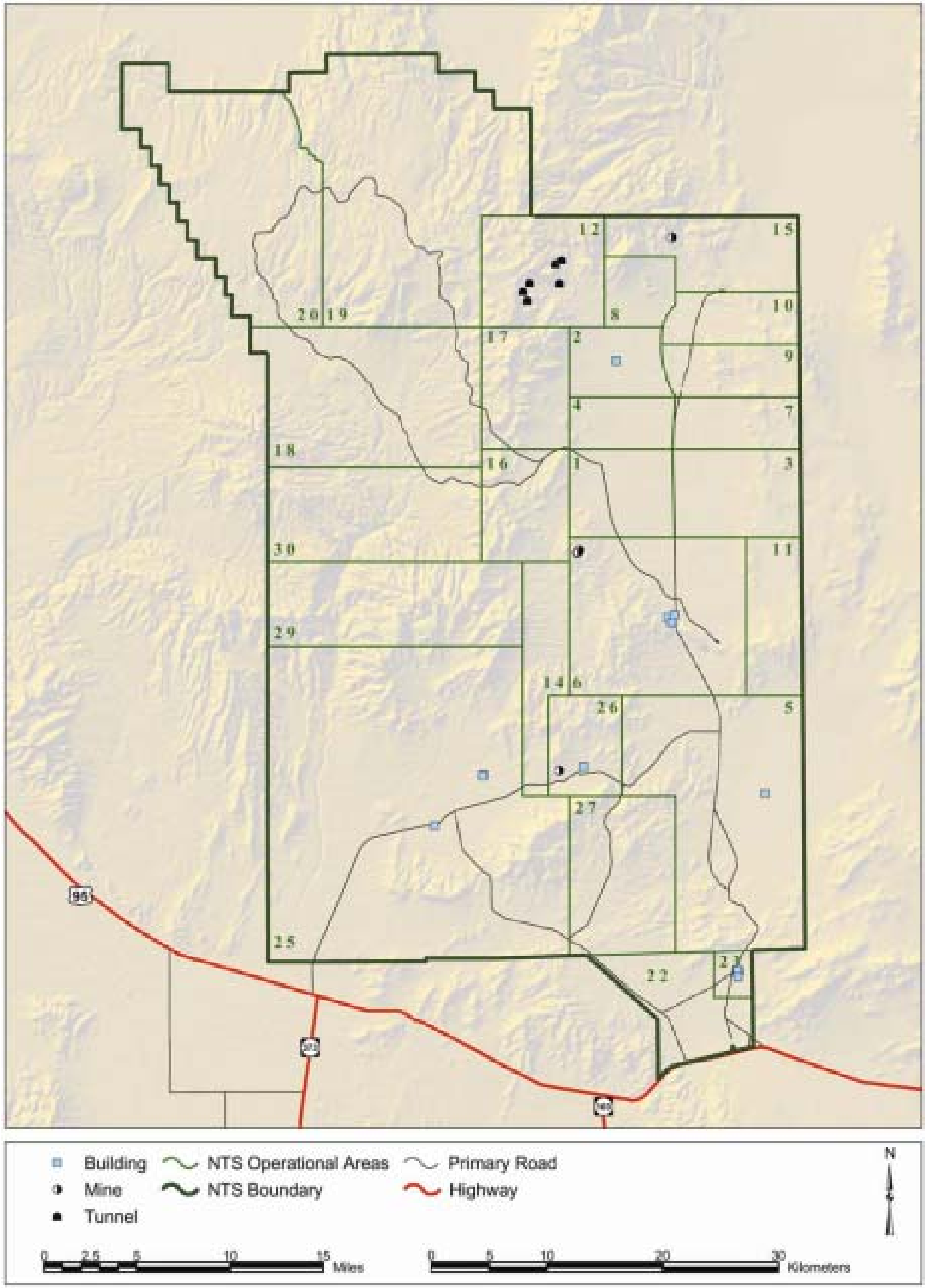


Figure 6.3 Known Bat Roost Sites on the NTS

WILD HORSES

Cattle and other livestock were removed from the NTS prior to testing of nuclear weapons in 1951, but a small herd of horses (Equus caballus) was not removed (Greger and Romney, 1994a). There were no efforts to monitor the size of that herd from 1951 through the 1970s, although O'Farrell and Emery (1976) reported that "A band of about 20 mustangs is located in the vicinity of Rainier Mesa… . . Their numbers have not increased markedly over the last few years." Wild horses are protected on public lands under the Wild Free-Roaming Horse and Burro Act of 1971. This act calls for the management and protection of wild horses and burros in a manner that is designed to achieve and maintain a thriving natural ecological balance. Although the NTS is on land withdrawn from public use, the NNSA/NSO is committed to this same management goal on the NTS. In 1997, the DOE/NV signed a Five-Party Cooperative Agreement with Nellis Air Force Range (NAFR), USFWS, U.S. Bureau of Land Management, and the State of Nevada Clearinghouse. The goal of the agreement is to enhance management of the natural resources within ecosystems on the NAFR, the NTS, and the Desert National Wildlife Range. This agreement facilitates an ecosystem-based approach in the management of free-roaming animals with large home ranges, such as wild horse.

In 1989, a program was initiated to estimate the abundance of horses on the NTS annually by identifying and photographing all horses seen during systematic surveys. Information on the NTS horse population from 1990-1998 is summarized in Greger and Romney (1999). In 2002, biologists determined horse abundance and recorded horse sign along roads. Also, selected natural and man-made water sources were visited in the summer to determine their influence on horse distribution and movements and to determine the impact horses are having on NTS wetlands.

The direct horse population count in 2002 was 33 (Table 6.6). This count does not include foals. None of the 11 foals observed last year survived to yearlings. Only five foals were observed with their mares in 2002. All were missing by the end of the summer. Three adult males and one adult female (> 3 years old) that were observed on the NTS last year were not observed this year. From 1995 to 1998, the feral horse population declined 31 percent, from 54 to 37 adult horses (Table 6.6). The population decline appeared to be the result of low recruitment due to low foaling rates, poor foal survival, none to very low immigration of new adults, and moderate adult mortality. Also, older male horses have tended to disappear from the population over time, with only eight males presently known in the NTS population (Table 6.6). It is not known how much of this decline is due to mortality versus emigration. Over the past five years, the population appears to have stabilized. Six of the 16 foals observed in 1999 and 2000 survived to reach two years of age. Over the past ten years, observed causes of mortality among adults have included predation (four), collisions with vehicles (two), and drowning (one). An additional four adult horses have been found dead from unknown causes.

Horse sign data collected during the road surveys and horse use at natural and man-made water sources indicate that the 2002 NTS horse range includes Kawich Canyon, Gold Meadows, Yucca Flat, southwest foothills of the Eleana Range, and southeast Pahute Mesa (Figure 6.4). Overall, the annual horse range appears not to have changed greatly from previous years.

The NTS horse population is dependent on several natural and man-made water sources in Areas 18, 12, and 30 (Figure 6.4) during different seasons. Wildhorse and Little Wildhorse seeps, both located in Area 30, are important winter-spring water sources. Two other natural water sources (Captain Jack Spring in Area 12, Gold Meadows Spring in Area 12) and one man-made pond

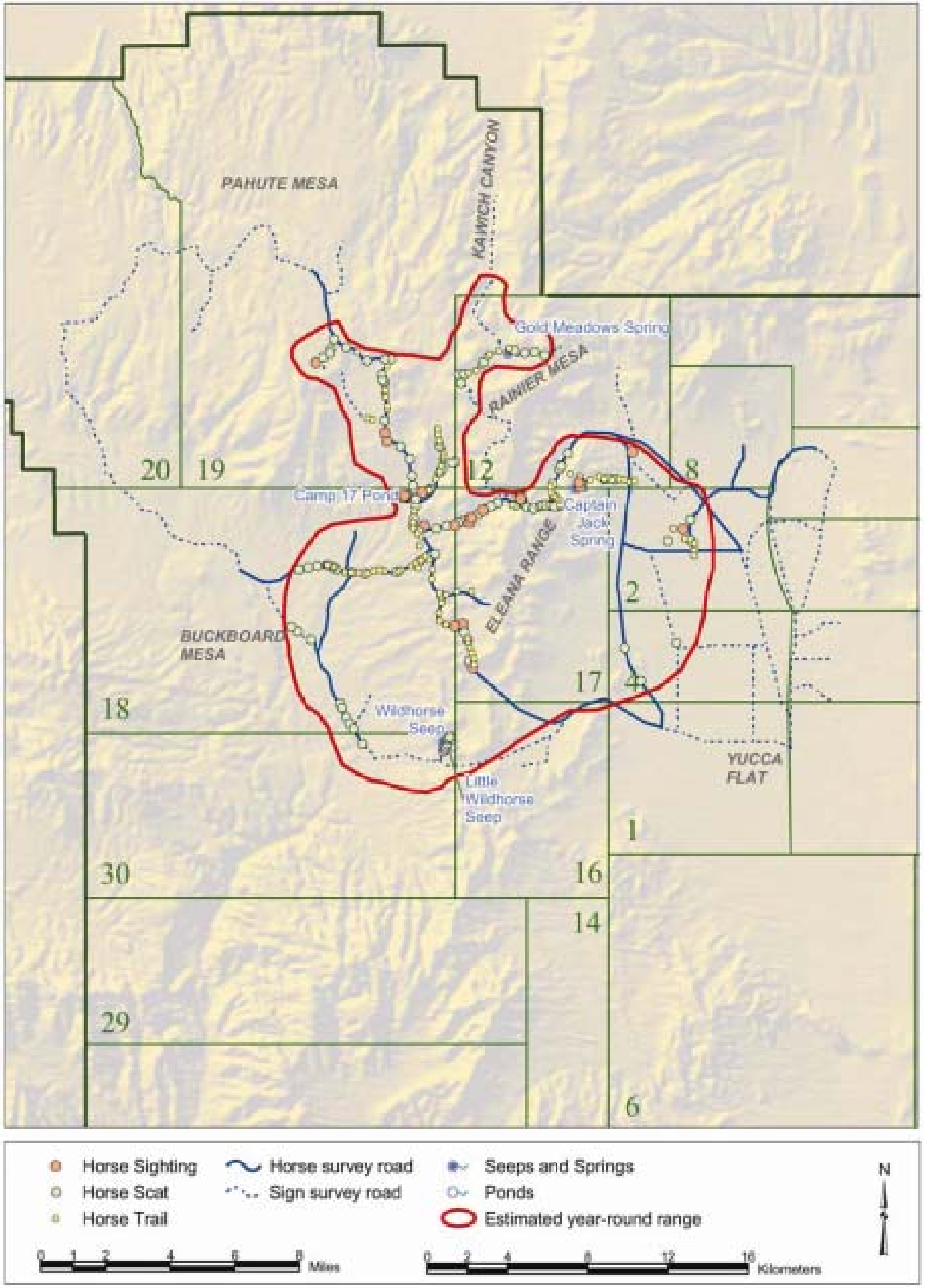


Figure 6.4 Feral Horse Sightings and Horse Sign Observed on the NTS - 2002

(Camp 17 Pond in Area 18) were used by horses this summer, as in past years. There are presently six other man-made water sources within or on the edge of the annual horse range, however none of them were used by horses in 2002.

RAPTORS

Several raptors occur and breed on the NTS which are not protected under the ESA and are not species of concern. They are, however, protected by the federal government under the Migratory Bird Treaty Act and by the state of Nevada. Raptors include all vultures, hawks, kites, eagles, ospreys, falcons, and owls. Because these birds occupy high trophic levels of the food chain, they are regarded as sensitive indicators of ecosystem stability and health. There are nine raptors which are known to breed on the NTS (Greger and Romney, 1994b). They include the American kestrel (*Falco sparverius*), prairie falcon (*Falco mexicanus*), red-tailed hawk (*Buteo jamaicensis*), swainson's hawk (*Buteo swainsoni*), golden eagle (*Aguila chrysaetos*), long-eared owl (*Asio otus*), great horned owl (*Bubo virginianus*), western burrowing owl (*Athene cunicularia hypugaea*), and the barn owl (*Tyto alba*). Work in 2002 was focused on monitoring nests found during previous years and those found this year by BN biologists or other NTS workers in buildings or at sites close to ongoing disturbances.

Fourteen previously located nests and four new nests were visited from April through July to check for reproduction. A total of six nests were active this year (Table 6.7) and 11 young raptors were observed in nests.

MONITORING MAN-MADE WATER SOURCES

Natural wetlands and man-made water sources on the NTS provide unique habitats for mesic and aquatic plants and animals and attract a variety of other wildlife. Natural NTS wetlands may qualify as jurisdictional wetlands under the Clean Water Act (CWA). Characterization of these mesic habitats to determine their status under the CWA, and periodic monitoring of their hydrologic and biotic parameters were started in 1997 as components of the EMAC program. Periodic wetland monitoring may help identify annual fluctuations in measured parameters that are natural and unrelated to NNSA/NSO activities. Also, if a spring classified as a jurisdictional wetland were to be unavoidably impacted by an NNSA/NSO project, mitigation for the loss of wetland habitat would be required under the CWA. Under these circumstances, wetland hydrology, habitat quality, and wildlife usage data collected at the impacted spring over several previous years can help to develop a viable mitigation plan and demonstrate successful wetland mitigation.

Monitoring of selected NTS wetlands continued this fiscal year to characterize seasonal baselines and trends in physical and biological parameters. Eleven wetlands (Figure 6.5) were visited at least once during the year to record the presence/absence of land disturbance, water flow rates, and surface area of standing water (Table 6.8). No jurisdictional wetlands on the NTS were disturbed during 2002.

Mule deer sign and coyote sign were observed at all 11 wetlands visited (wetlands are listed in Table 6.8). Gambel's quail (*Callipepla gambelii*) were observed at three of the wetlands. Only nine other bird species were observed, and those species were seen at only one or two different wetlands visited. Pinion jays (*Gymnorhinus cyanocephalus*) were seen in the highest numbers during any visit (25). Unlike 2001, mourning doves (*Zenaida macroura*) were rarely observed.

Due to low rainfall in 2001, declines in wetland surface area, flow rates, and wildlife use were noted at most wetlands on the NTS during 2002 compared to 2001.

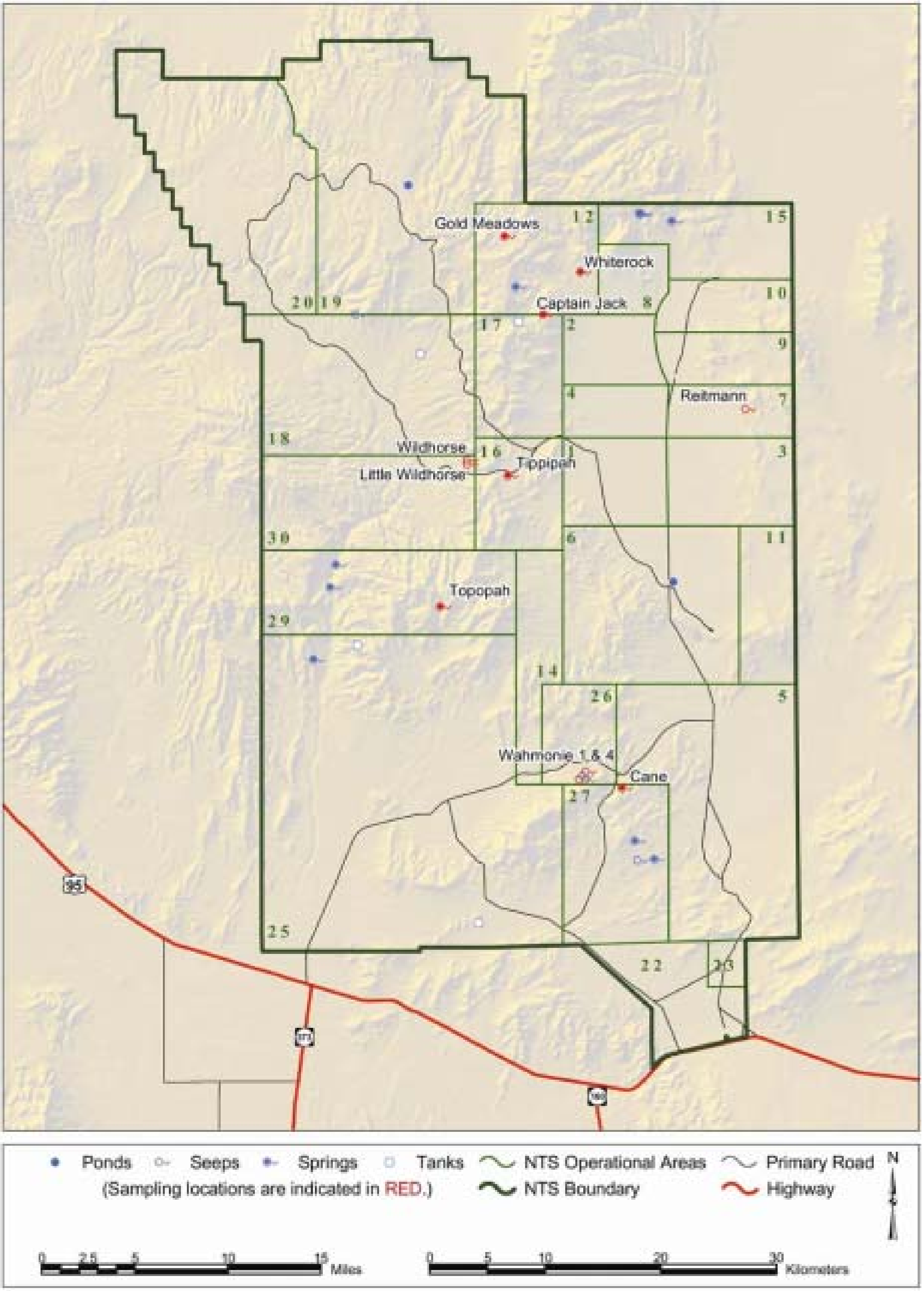


Figure 6.5 Natural Water Sources Sampled on the NTS - 2002

MONITORING MAN-MADE WATER SOURCES

Man-made water sources are located throughout the NTS (Figure 6.6) and include 35 plastic-lined sumps, 9 sewage treatment ponds, 8 unlined well ponds, and 2 radioactive containment ponds. Several ponds or sumps are located next to each other at the same project site. Many NTS animals rely on these man-made structures as sources of free water. Wildlife and migratory birds may drown in steep-sided or plastic-lined sumps as a result of entrapment, or ingest contaminants in drill-fluid sumps or evaporative ponds. Ponds are monitored to assess their use by wildlife and to develop and implement mitigation measures to prevent them from causing significant harm to wildlife.

During 2002, use of unlined sumps and ponds by waterfowl (ducks, shorebirds), passerine birds (ravens, horned larks, house finches), and mammals, such as coyotes and deer, was common, although numbers observed were low. Only one man-made pond (Camp 17 Pond in Area 18) was used this year by wild horses. Birds were observed much less at the plastic-lined sumps compared to the unlined ponds.

No dead animals were recorded in any plastic-lined sumps during 2002. A sediment mound was constructed in Sump No. 3 at ER-20-6 during FY 2001 and has been monitored since that time to assess its effectiveness in preventing animal entrapment or drowning. This sediment ramp appears to be working well as deer sign have been recorded at this site, yet no deer or other wildlife entrapment or mortality has occurred.

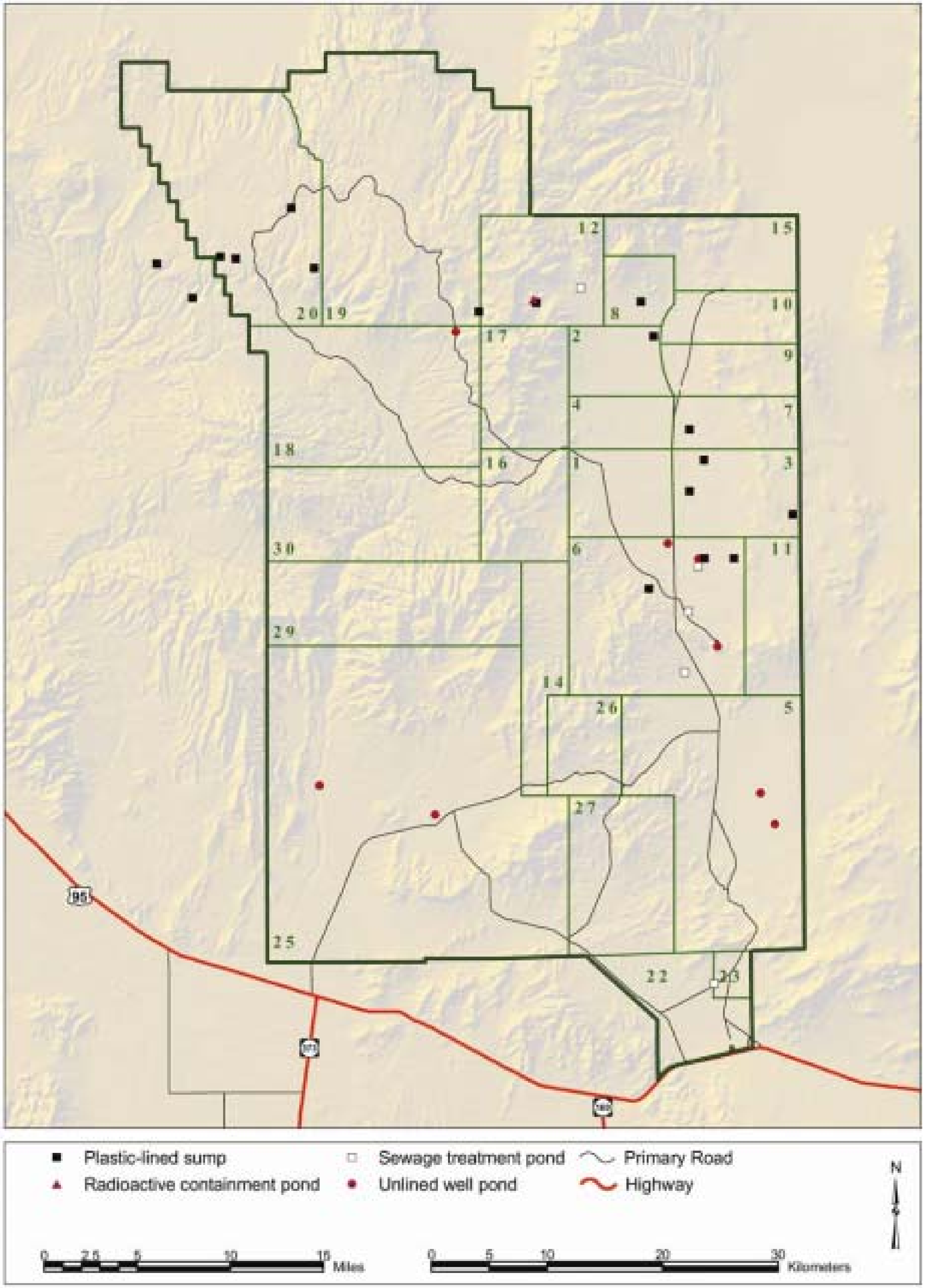


Figure 6.6 Man-made Water Sources Monitored for Wildlife use and Mortality on the NTS - 2002

Table 6.1 Frequency of Coliform Bacteria Monitoring for NTS Public Water Systems

Public Water System/Permit Number	Monitoring Frequency
NV0000360/NY-0360-12C	Monthly - 3 Samples
NV0004098/NY-4098-12NTNC	Quarterly - 1 Sample
NV0004099/NY-4099-12C	Quarterly - 1 Sample
NY-0835-12H	Monthly - 1 Sample
NY-0836-12H	Monthly - 1 Sample

Table 6.2 Analyses of Well Water Samples - 2002

Water System/Well	Nitrates (MCL[c] 10 ppm[a])	Nitrate+Nitrite (MCL 10 ppm)	Arsenic (MCL 0.05 ppm)	Fluoride (MCL 4 ppm)	Lead (action level 0.015 ppm)
NV0000360					0.005
Army Well Tank	(b)	(b)	11.5		
Mercury Tank (N)	2.3	2.3	19.5		
Well 4/4a Tank (S)	3.9	3.9	8.4		
Well C-1	(b)	(b)	12.6		
NV0004098					0.0035
J-11 Tank	1.9	1.9	12.8		
J-12				2.3	
J-13				2.3	
NV0004099					0.0135
Area 12 Tank (S)	1.1	1.1	(b)		

(a) Parts per million.
(b) Not detected.
(c) Maximum contaminant level.

Table 6.3 Phase V Inorganic Chemicals (all results in mg/L)

Public Water System/Entry Point	Antimony	Beryllium	Cyanide	Nickel	Thallium
NV0000360					
Army Well Tank	(a)	0.00033	(a)	0.0014	(a)
Mercury Tank (N)	(a)	0.00028	(a)	(a)	(a)
Well 4/4a Tank (S)	(a)	0.00033	(a)	0.0019	(a)
Well C-1 (S)	(a)	(a)	(a)	(a)	(a)
NV0004098					
J-11 Tank	(a)	0.00023	(a)	0.0018	(a)
NV0004099					
Area 12 Tank (S)	(a)	0.00029	(a)	(a)	(a)

(a) Not detected.

Table 6.4 Sensitive Species that are Protected Under State or Federal Regulations 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 woollypod	SOC, W, A
Astragalus oopherus var. clokeyanus	Clokey's egg milkvetch	SOC, W, A
Camissonia megalantha	Cane Spring suncup	SOC, W, IA
Cymopterus ripleyi var. saniculoides	Ripley's springparsley	SOC, W, IA
Eriogonum concinnum	Darin's buckwheat	W, A
Eriogonum heermannii var. *clokeyi*	Clokey's buckwheat	W, A
Frasera pahutensis or *F. albicaulis* var. *modocensis*	Pahute green gentian or 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 sweetii	Sweet trichostomum	W, E

(a) Status Codes:

Endangered Species Act, U.S. Fish and Wildlife Service
LT - Listed Threatened
PT - Proposed for listing as Threatened
PD - Proposed for delisting
RA - Former Candidate or Proposed species; current information does not support proposal to list because species has proven more abundant or widespread, or to lack identifiable threats; a species of concern
<LE - Former listed endangered species
SOC - Species of concern

Long-term Plant Monitoring Status for Nevada Test Site (NTS)
A - Active
IA - Inactive
E - Evaluate
W - On Nevada Natural Heritage Program's watch list

(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 6.4 (Sensitive Species that are Protected Under State or Federal Regulations which are Known to Occur on or Adjacent to the NTS, cont.)

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	EA, 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, EA, 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 (ESA), U.S. Fish and Wildlife Service (FWS)

LT - Listed Threatened

PT - Proposed for listing as Threatened

<LE - Former listed endangered species

SOC - Species of concern

U.S. Department of Interior

H&B - Protected under Wild Free Roaming Horses and Burros Act

EA - Protected under Bald and Golden Eagle Act

State of Nevada

NPT - Protected Threatened

G - Regulated as game

F - Regulated as fur-bearer

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 6.4 (Sensitive Species that are Protected Under State or Federal Regulations which are Known to Occur on or Adjacent to the NTS, cont.)

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 (ESA), U.S. Fish and Wildlife Service (FWS)

LT - Listed Threatened
PT Proposed for listing as Threatened
PD - Proposed for delisting
RA - Former Candidate or Proposed species; current information does not support proposal to list because species has proven more abundant or widespread, or to lack identifiable threats; a species of concern
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State of Nevada

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F - Regulated as fur-bearer

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 6.5 Summary of Biological Surveys Conducted on the NTS - 2002

Project Number	Project	Important Species/ Resources Found	Area Surveyed (acres)	Project Area in Undisturbed Habitat (acres)	Mitigation Recommendations
02-01	Corrective Action Unit (CAU) 271 (8 sites)	None	9.85	2.04	None
02-02	Borehole Plugging (35 sites)	Predator burrow	32	0	Avoid flagged burrow
02-03	Engine Maintenance, Assembly, and Disassembly (E-MAD) Remediation (CAU 143) (6 sites)	Inactive predator burrows	21.72	6.94	None
02-04	Mercury Highway Culvert Repairs (14 sites)	Inactive predator burrow	10.48	0.71	None
02-05	New Septic Tanks (7 sites)	Mature yucca, cacti	29.31	12.56	Avoid yucca, cacti if possible
02-06	Mud Pit Disposal Sites (CAU 356) (6 sites)	Inactive predator burrow, collapsed kit fox burrow, stick nest	6.13	0	Do not disturb nest
02-07	Surface Laid Cable	None	2.08	0.52	None
02-08	18-01 Road Renovation	Mature yucca, cacti	1.48	0.49	Avoid yucca, cacti if possible
02-09	Underground Test Area (UGTA) Drill Holes in Yucca Flat (5 sites)	Mature yucca, cacti, relic creosote shrub population	59.53	39.71	Avoid yucca, cacti, and relic creosote shrubs if possible
02-10	Phoenix Facility	None	0.1	0.07	None
02-11	Closure of Release Sites (CAU 326) (2 sites)	None	2.77	0	None
02-12	Explosive Magazine Move (CANCELLED)	None	0.2	0.1	None
02-13	Fiscal Year 2002 Building Demolition (64 buildings)	Active great horned owl nest, inactive raven nest, 5 live bats	N/A	0	Delay demolition of building until owl chicks fledge, have biologist remove roosting bats prior to demolition

Table 6.5 (Summary of Biological Surveys Conducted on the NTS - 2002, cont.)

Project Number	Project	Important Species/Resources Found	Area Surveyed (acres)	Project Area in Undisturbed Habitat (acres)	Mitigation Recommendations
02-14	Areas 25 and 26 Contaminated Materials and Waste Dumps (CAU 168) (7 sites)	Collapsed tortoise burrow, mature yucca, cacti	24.47	1.07	Avoid yucca, cacti if possible
02-15	WATUSI Project	None	29.63	5.56	None
02-16	Radioactive Waste Maintenance Site Expansion	None	1.95	1.95	None
02-17	Fill Pipeline, A06 Construction Sump	None	1.04	0	None
02-18	Area 25 Spill Sites (CAU 398)	None	0.32	0	None
02-19	Yucca Lake Runway Repair and Extension	Inactive predator burrows	14.63	13.77	None
02-20	HSC Sensors and Communications System	Collapsed burrows	11.44	11.44	None
02-21	CAU 165 (8 sites)	None	26.59	0.07	None
02-22	Radiological Demarcation (2 sites)	Predator burrows, mature cacti	57.08	44.2	Avoid burrows and cacti if possible
02-23	Munitions Test Range	Pronghorn antelope	241.42	231.6	None
02-24	CAU 394 (3 sites)	None	0.49	0.14	None
02-25	U1a 100 Pair Phone Cable Installation	Inactive predator burrows	1.81	1.81	None
02-26	Tweezer Road to U1g Powerline	Inactive predator burrows, mule deer, antelope	43.44	15.19	None
Total			**629.96**	**379.75**	

Table 6.6 Number of Horse Observed on the NTS by Age Class, Gender, and Year Since 1995

Age/Class	Number of Horses Observed															
	1995		1996		1997		1998		1999		2000		2001		2002	
Foals	1		1		3		8		5		11		11		5	
Yearlings	3		0		0		0		0		4		2		0	
Adults	**M***	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
2 Years Old	0	0	0	1	0	0	0	0	0	0	2(**)	0	0	4	0	2
3 Years Old	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4
>3 Years Old	22	29	21	24	19	20	16	21	11	20	13	21	11	20	8	19
Total (excluding foals)	**54**		**46**		**40**		**37**		**31**		**38**		**37**		**33**	

Note: M=male; F=female; **=dead

Table 6.7 Known Active Raptor Nests on the NTS - 2002

Nest ID	Species	Nest Location	Nest Site Type	Number of Young Observed
A6-B2	American kestrel	Area 6, South Yucca Flat	Cavity Nest in Building	3
A1-CR1	American kestrel	Area 1, Southwest Yucca Flat	Cavity Nest in Crane	3
A6-B1	Great-horned owl	Area 6, Southwest Yucca Flat	Stick Nest in Building	3
A3-B2	Great-horned owl	Area 3, Central Yucca Flat	Stick Nest in Building	2
A27-PP1	Red-tailed hawk	Area 27, Northeast Skull Mountain	Stick Nest on Powerline Pole	Unknown
A3-Y2	Red-tailed hawk	Area 3, Eastern Yucca Flat	Stick Nest in Joshua Tree	Unknown
Known Total				**11**

Table 6.8 Seasonal Data from Selected Natural Water Sources on the NTS Collected – 2002

Water Source	Date	Surface Area of Water (m^2)[(a)]	Surface Flow Rate (L/min)[(b)]	Disturbance at Spring
Cane Spring	08/07/2003	6	0.3	None
Captain Jack Spring	08/20/2003	23	1	Horse grazing and trampling of vegetation
Gold Meadows Spring	07/03/2003	0	0	Horse grazing and trampling
Little Wildhorse Seep	09/05/2003	0	0	Horse grazing and trampling
Reitmann Seep	09/04/2003	0.4	0	None
Tippipah Spring	08/01/2003	130	[(c)]	None
Topopah Spring	09/05/2003	1.5	0.015	None
Wahmonie Seep No. 1	08/07/2003	0	0	None
Wahmonie Seep No. 4	08/07/2003	0	0	None
Whiterock Spring	08/27/2003	2	1.7	None
Wildhorse Seep	09/05/2003	0	0	Horse grazing and trampling

(a) Square meters.
(b) Liters per minute.
(c) Not measurable due to diffused flow.

7.0 SITE HYDROLOGY

The hydrologic character of the Nevada Test Site (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 more than 40 years (U.S. Department of Energy [DOE] 1996), and numerous scientific reports and large databases are available. The following sections present an overview of the hydrologic setting of the NTS and vicinity, including summary descriptions of surface water and groundwater, hydrogeologic framework, and finally brief descriptions of the hydrogeology for each of the idle underground test areas on the NTS. For additional information regarding hydrogeology of the individual testing areas on the NTS, refer to Chapter 7.0 of the NTS Annual Site Environmental Report for calendar year 2000 (BN 2001c).

7.1 SURFACE WATER

The NTS is located within the Great Basin, a closed hydrographic province which comprises several closed hydrographic basins (Figure 7.1). 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 locally perched groundwater systems are the only natural sources of perennial surface water in the region. There are 20 known springs or seeps on the NTS (Hansen et al., 1997) (Figure 7.2). Spring discharge rates are low, ranging from 0.014 to 2.2 liters/sec (0.22 to 35 gal/min) (International Technology [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 2003b). Surface water is not a source of drinking water on the NTS.

7.2 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 7.3).

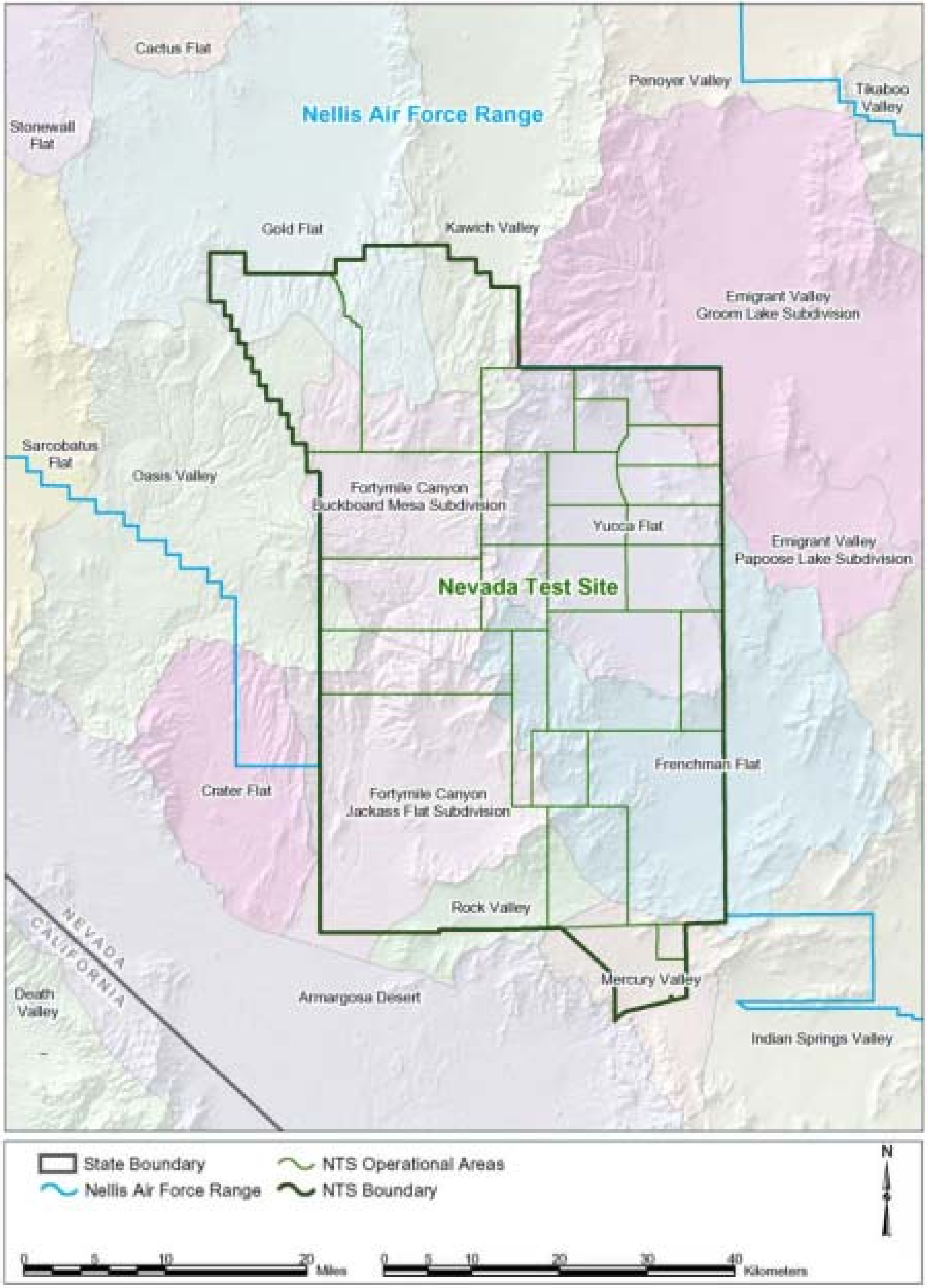


Figure 7.1 Closed Hydrographic Subbasins on the NTS

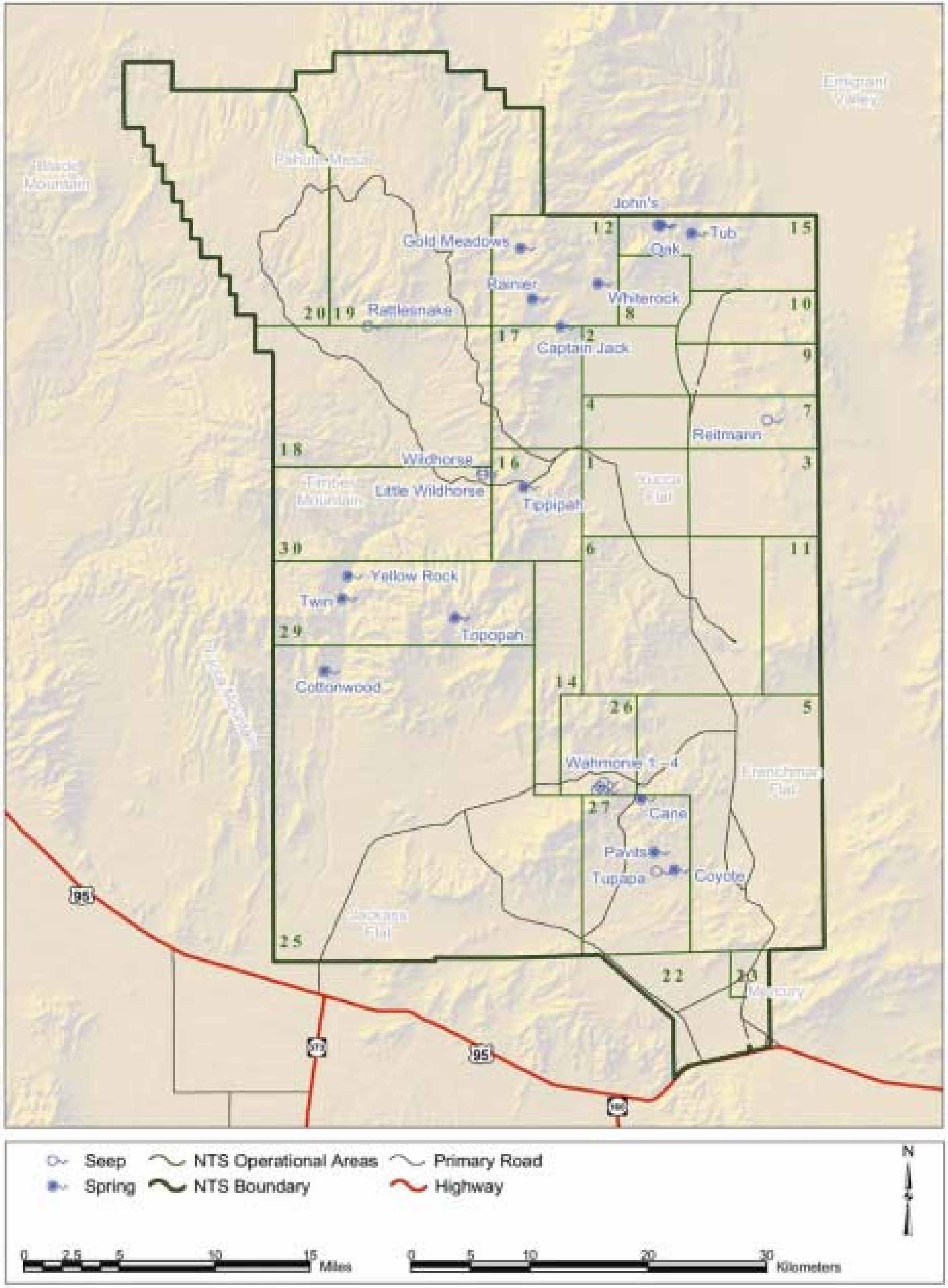


Figure 7.2 Natural Springs and Seeps on the Nevada Test Site

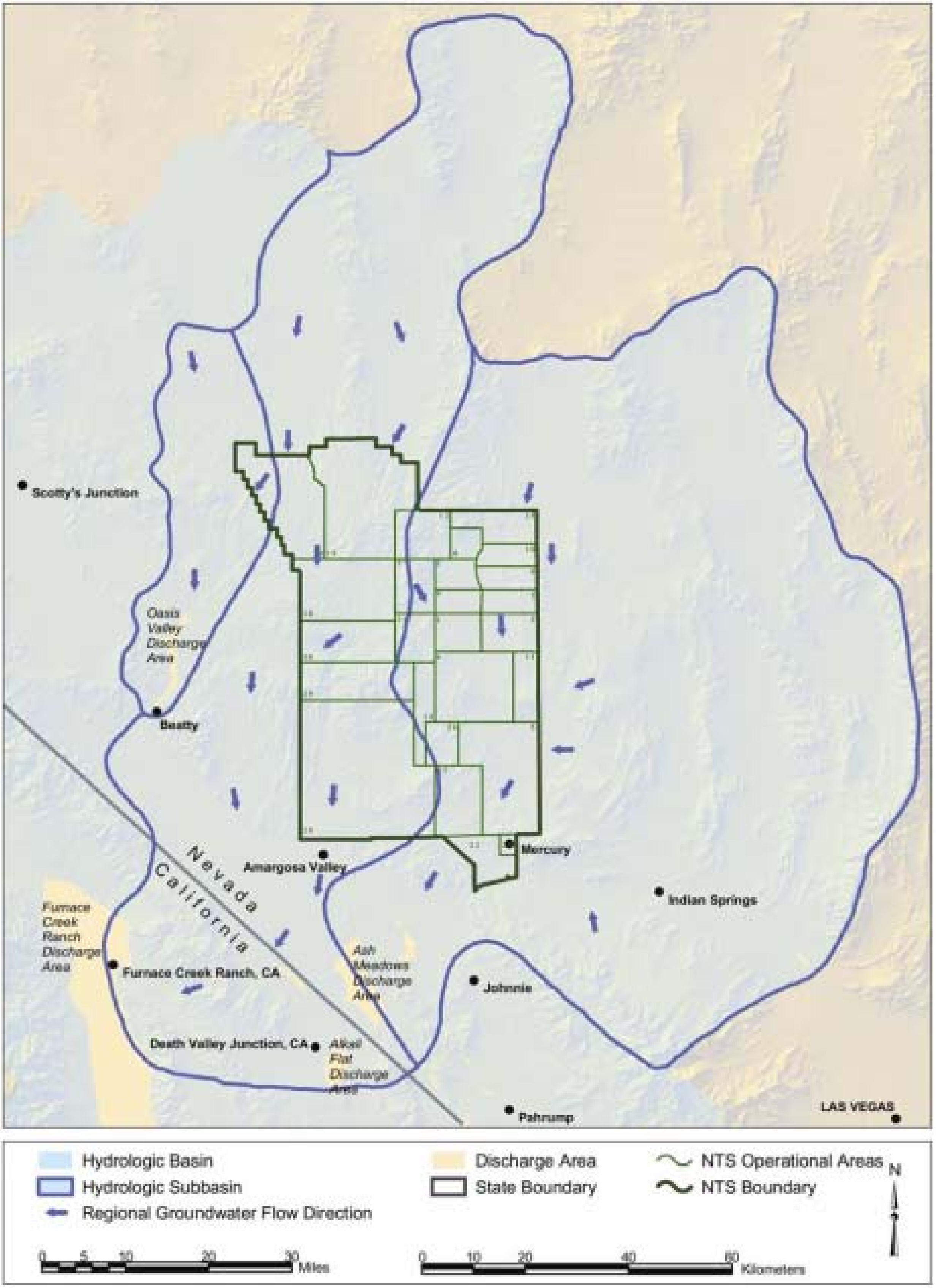


Figure 7.3 Groundwater Subbasins of the Nevada Test Site and Vicinity

The groundwater-bearing rocks at the NTS have been classified into several hydrogeologic units, of which the most important is the lower carbonate aquifer, a thick sequence of Paleozoic-age 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 (IT 1996b; Reiner 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.

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; IT 1996b; DOE 2003b) 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 (Figure 7.3).

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 ten potable water wells that make up the NTS water system and 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 the U.S. Environmental Protection Agency (EPA) drinking Water Standards (Chapman and Lyles 1993; Rose et al., 1997; Bechtel Nevada [BN] 2001c).

7.3 HYDROLOGIC MODELING

The information in this section was compiled from various sources, as referenced throughout the discussion. However, the basic approach to these discussions is based on that taken to produce groundwater models for the various idle test areas at the NTS for the Underground Test Area (UGTA) Program.

The Environmental Restoration Division of the National Nuclear Security Administration, Nevada Site Office initiated the UGTA project to study the effects of past underground nuclear testing in shafts and tunnels on groundwater at the NTS and surrounding areas. The multi-disciplinary UGTA investigation focuses on the geology and hydrology of the NTS to determine how contaminants are transported by groundwater flow. A regional three-dimensional computer groundwater model (IT 1996a; 1997) 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 Corrective Action Units [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 models have been built: Frenchman Flat (IT 1998b) and Pahute Mesa (BN, 2002; IT 1998a). The Yucca Flat model is in progress. The results of the UGTA modeling efforts will be used to refine a monitoring network to ensure public health and safety.

Other hydrogeologic models for the area include those developed for the Yucca Mountain Program (YMP) (YMP 1998) and the Death Valley regional groundwater flow system (D'Agnese et al., 1997). There are also site-specific models for the Radioactive Waste Management Sites (RWMSs) in Frenchman Flat, Area 5 (Shott et al., 1998) and Yucca Flat, Area 3 (BN 1997).

7.4 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 in 1963) was designed in part to study explosion effects on groundwater and the movement in groundwater of radioactive byproducts from the explosion. 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 been developed further by the UGTA hydrogeologic modeling team (IT 1996c, 1998b; BN 2002a).

Winograd and Thordarson (1975) established a hydrogeologic framework, incorporating the work of Blankennagel and Weir (1973) who defined the first hydrogeologic units to address the complex hydraulic properties of volcanic rocks. Hydrogeologic units (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) (see Seaber [1988] for a discussion of hydrostratigraphy). 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). The following paragraphs summarize the current understanding of the hydrogeologic framework of the NTS, first addressing HGUs, then describing the main HSUs.

HYDROGEOLOGIC UNITS OF THE NTS AREA

All the rocks of the NTS and vicinity can be classified as one of nine hydrogeologic units, which include the alluvial aquifer, four volcanic hydrogeologic units, two intrusive units, and two hydrogeologic units that represent the pre-Tertiary sedimentary rocks (Table 7.1).

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-age sedimentary rocks (Slate et al., 1999). The volcanic rocks of the NTS and vicinity can be categorized into four hydrogeologic units based on primary lithologic properties, degree of fracturing, and secondary mineral alteration. In general, the altered (typically zeolitized or 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; BN 2002a).

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 (quartzites, siltstones, shales) 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 Tertiary-age intracaldera intrusives and Mesozoic-age granite intrusives are both considered to behave as a confining unit due to low primary porosity, low permeability, and because most fractures are probably filled with secondary minerals.

HYDROSTRATIGRAPHIC UNITS OF THE NTS AREA

The rocks at the NTS and vicinity are grouped into roughly sixty HSUs. The more important and widespread HSUs in the area are discussed separately, from oldest to youngest, in this section. Additional information regarding other HSUs is summarized in tables introduced in Section 7.5.

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 (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 area, 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 7.4). 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 7.4, the volcanic rocks are divided into aquifer or confining unit 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, 1998b; 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 alluvial aquifer HSU is restricted primarily to the basins of the NTS (Figure 7.4). 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.

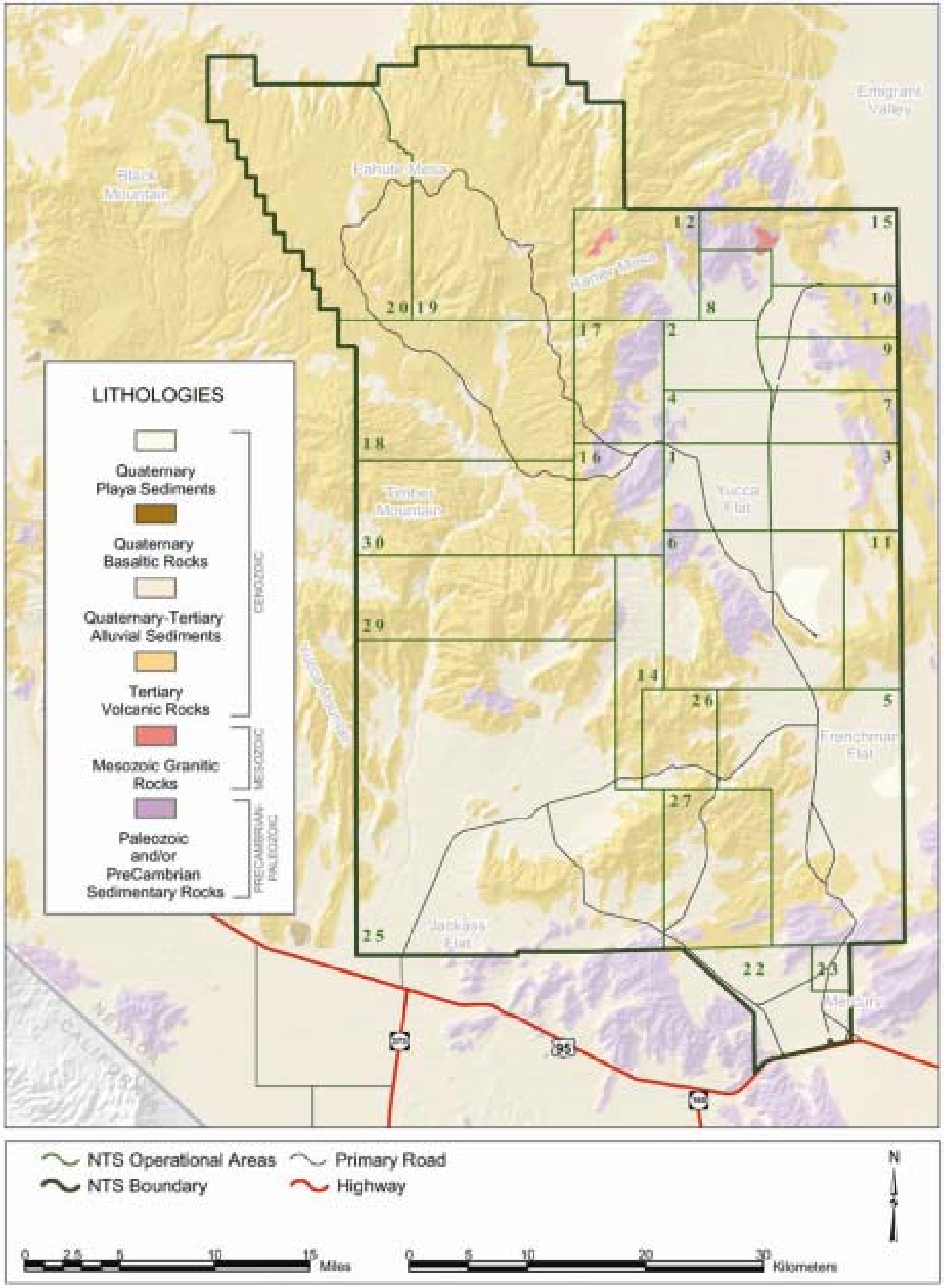


Figure 7.4 Generalized Geologic Map of the Nevada Test Site and Vicinity

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. Juxtapositioning 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. 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 Southwest Nevada Volcanic Field (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. At least six major calderas have been identified in the SWNVF, a multi-caldera silicic volcanic field that formed by the voluminous eruption of zoned ignimbrites between 16 and 7.5 million years ago (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).

HYDRAULIC PROPERTIES

It is difficult to give precise hydraulic conductivity values for NTS HSUs because of their spatial variability (aquifer heterogeneity). Volcanic rocks typically are extremely variable in lithologic character both laterally and vertically, which accounts for some of the observed heterogeneity. In some areas, units of different character are so finely interbedded that they are assigned to a composite unit (e.g., lava flows embedded within zeolitized bedded tuffs) whose overall hydrologic properties are variable. Another cause of heterogeneity is the irregular distribution of the effects of hydrothermal alteration. Hydraulic properties have rarely been measured for specific HSUs, as borehole hydraulic test intervals tended to span HSU contacts. However, laboratory and field measurements of hydraulic conductivity, flow rates, and temperature profiles indicate that almost all of the groundwater at the NTS is moving through fractures (Geo Trans 1995).

General Hydraulic Characteristics of NTS Rocks

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., 1997a; IT 1996c). Fracture density typically increases with proximity to faults, potentially increasing the hydraulic conductivity of the formation; however, the hydrologic properties of faults 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). Prediction of the influence of any fault on the hydrologic system thus is made very difficult by the uncertainties associated with estimating the hydraulic properties of that fault, complicated by the potential for the fault to juxtapose permeable and less permeable water-bearing units.

Table 7.2 presents a 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 7.4, 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).

Effect of Underground Nuclear Explosions on Hydraulic Characteristics

Underground nuclear explosions may affect hydraulic properties of the geologic medium (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), and usually are addressed in the UGTA program on a case-by-case basis or in sub-CAU-scale models, rather than in regional or CAU-level models.

7.5 HYDROGEOLOGY OF THE NTS TEST AREAS

Most NTS underground nuclear detonations were conducted in three main test areas: (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 utilized test area, hosting 659 underground tests (747 detonations), four of which were high-yield detonations (Allen et al., 1997).

In addition to the three main test areas, 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 7.3 is a synopsis of information about each underground test area at the NTS, and Figure 7.5 is a map showing the areal distribution of underground nuclear tests conducted at 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 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 geographical testing areas on the NTS (Figure 7.5). The hydrogeology of the NTS idle test areas is summarized in the following sections.

FRENCHMAN FLAT

The Frenchman Flat CAU consists of ten CASs located in the northern part of NTS Area 5 and southern part of Area 11 (Figure 7.5). The detonations were conducted in vertical emplacement holes and two mined shafts. Nearly all the tests were conducted in alluvium above the water table.

Geologic Overview of Frenchman Flat

The stratigraphic section for the Frenchman Flat area 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 (Drellack and Prothro 1997b). 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.

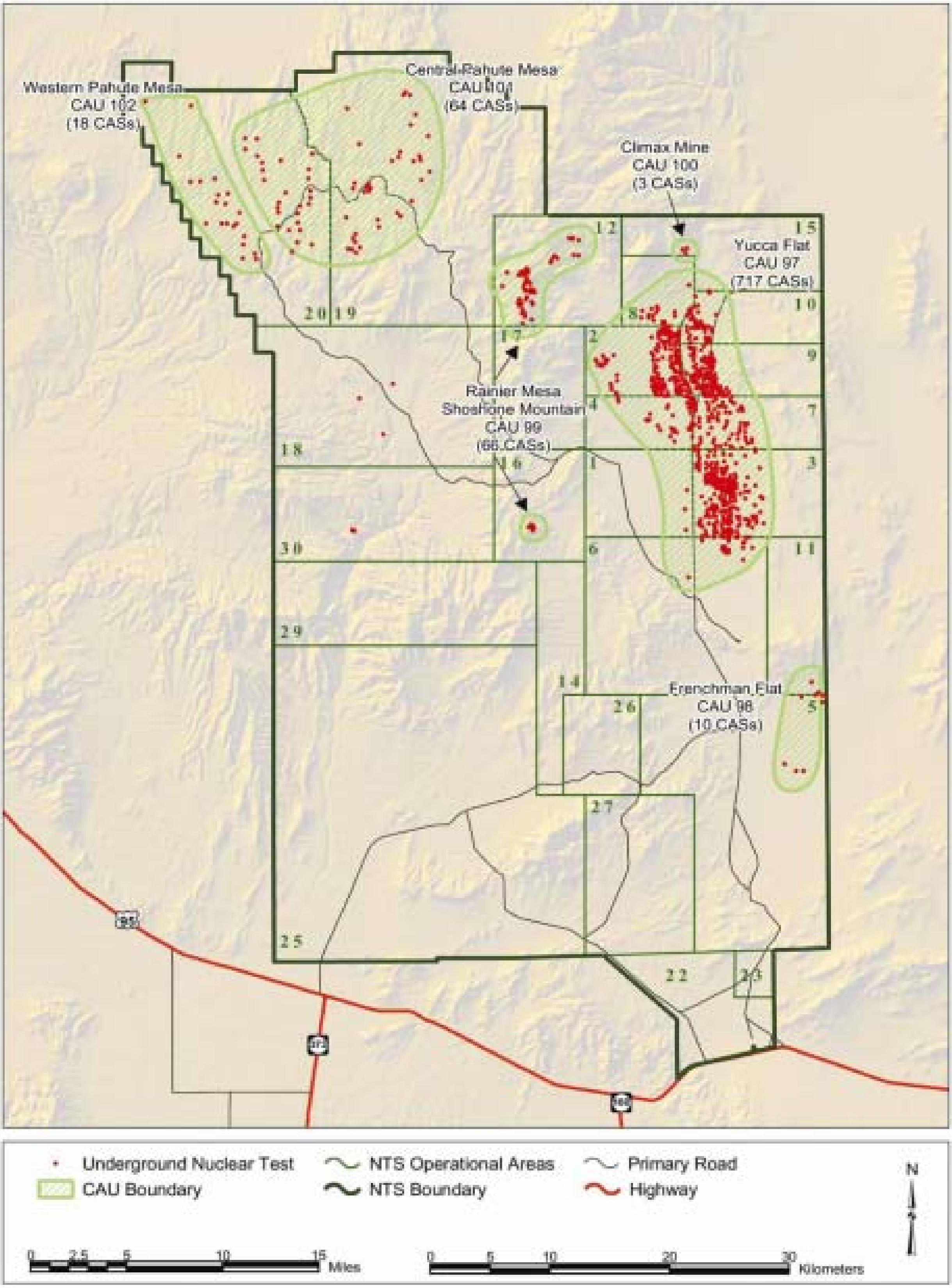


Figure 7.5 Location of Corrective Action Units and Corrective Action Sites on the Nevada Test Site

The structural geology of the Frenchman Flat area 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 million years ago, the region has undergone 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 east-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 series of relatively narrow, east-dipping, half-graben subbasins elongated in a northern direction (Figure 7.6).

Hydrogeology Overview of Frenchman Flat

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 volcanic confining unit (WVCU), the tuff confining unit (TCU), the volcaniclastic confining unit (VCU), the LCA, and the LCCU (Table 7.4).

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).

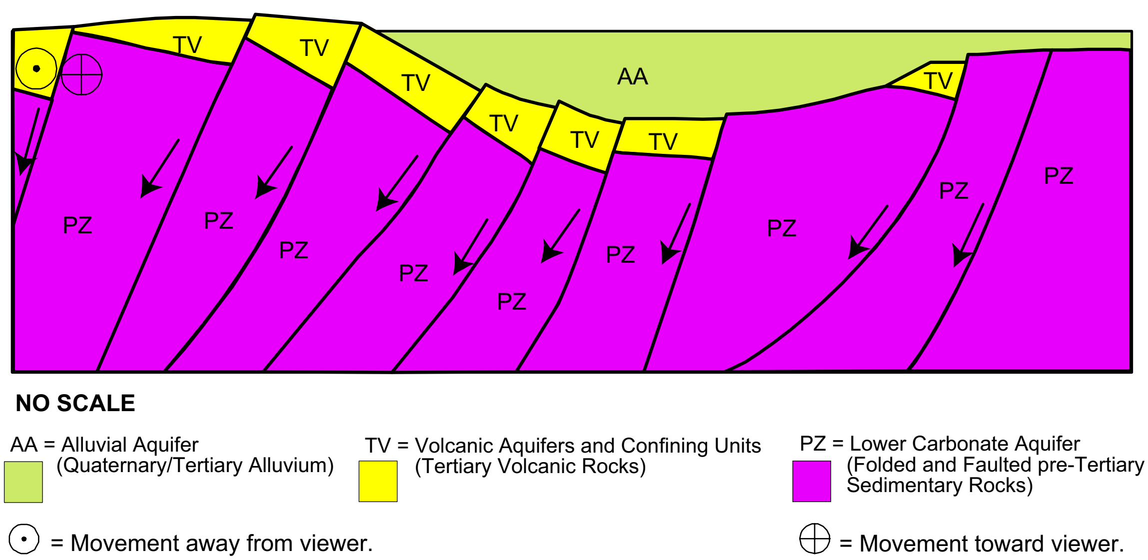


Figure 7.6 Conceptual East-West Cross Section Through Frenchman Flat Showing Subbasins Formed by Fault Blocks

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 area. 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 (Figure 7.3). An increasing westward flow vector in southern NTS may be due to preferential flow paths subparallel to the east-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.

YUCCA FLAT

The Yucca Flat/Climax Mine CAU consists of 717 CASs located in NTS Areas 1, 2, 3, 4, 6, 7, 8, 9, 10, and three CASs located in Area 15 (Figure 7.5). These tests were typically conducted in vertical emplacement holes and a few related tunnels (Table 7.3).

The Yucca Flat and Climax Mine testing areas 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 testing area on the NTS (Figure 7.5). 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 (503 m [1,650 ft]) provides additional operational and environmental benefits.

This section provides brief descriptions of the geologic and hydrogeologic setting of the Yucca Flat/Climax Mine area, as well as a discussion of the hydrostratigraphic framework. This summary was compiled from various sources, including 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.

Geology Overview of Yucca Flat

Yucca Flat is a topographically closed basin with a playa at its southern end (Figure 7.4). 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 (Figure 7.4). These rocks also compose the "basement" of the basin, which is now covered by alluvium.

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). During Cenozoic time, the sedimentary and intrusive rocks were buried by thick sections of volcanic material deposited in several eruptive cycles from source areas (calderas) to the north and west. The volcanic rocks include primarily ash-flow tuffs, ash-fall tuffs, and reworked tuffs.

Large-scale normal faulting began in the Yucca Flat area 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 configuration of the Yucca Flat basin is illustrated on the generalized west-east cross section shown in Figure 7.7. The cross section is simplified to show the positions of only the primary hydrostratigraphic units in the region. This cross section provides a conceptual illustration of the irregular Precambrian and Paleozoic rocks overlain by the Tertiary-age volcanic units and the basin-filling alluvium at the surface. The main Tertiary-age, basin-forming large-scale normal faults are also shown.

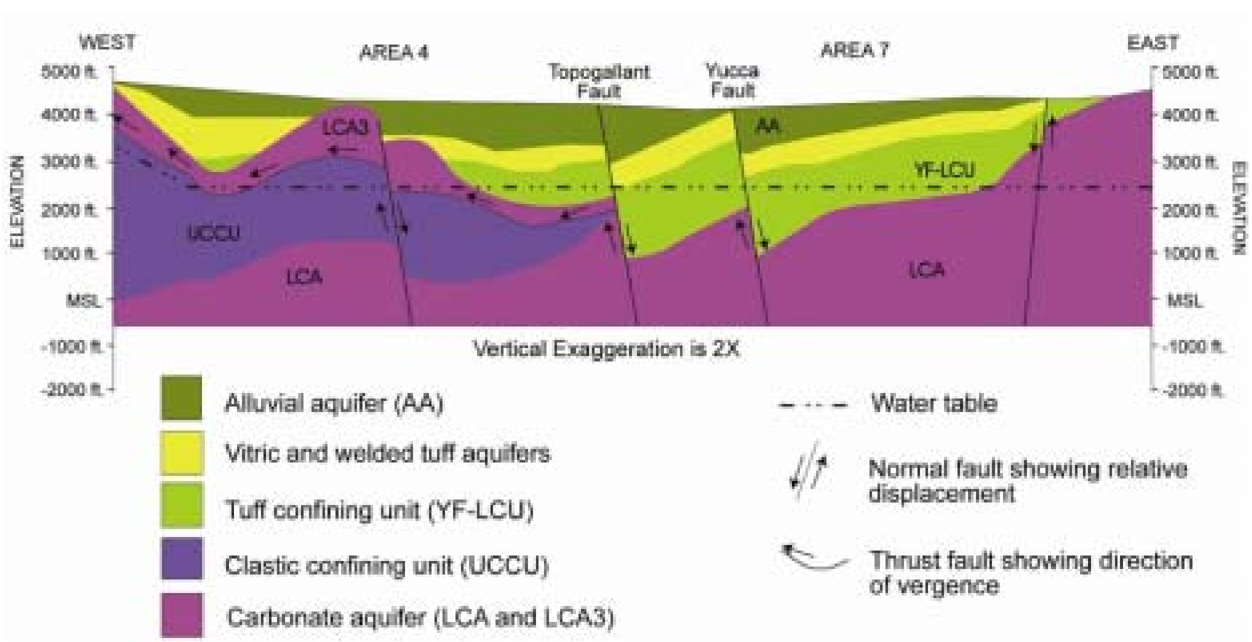


Figure 7.7 Generalized West-East Hydrogeologic Cross Section Through Central Yucca Flat

Hydrogeology Overview of Yucca Flat

All the rocks of the Yucca Flat study area can be classified as one of eight hydrogeologic units, which include the alluvial aquifer, four volcanic hydrogeologic units, an intrusive unit, and two hydrogeologic units that represent the pre-Tertiary rocks (Table 7.1).

The strata in the Yucca Flat area 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 7.5, 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 7.4.

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.

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 the Yucca Flat area 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 Section 7.4). In Yucca Flat these units are generally present in the central portions of the basin. They can be saturated in the deepest structural subbasins.

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 regional 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). 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.

Based on the existing data and as interpreted from the regional groundwater flow model (DOE 1997c), the overall groundwater flow direction in the Yucca Flat area is to the south and southwest (Figure 7.3). Groundwater ultimately discharges at Franklin Lake Playa to the south and Death Valley to the southwest.

PAHUTE MESA

The Western and Central Pahute Mesa CAUs, encompassing Areas 19 and 20 of the NTS, were the site of 85 underground nuclear tests (DOE 2000a) (Figure 7.5). These detonations were all conducted in vertical emplacement holes (Table 7.3). 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 testing areas of Frenchman Flat and Yucca Flat, a CAU-level hydrostratigraphic framework model is also being developed for the PM-OV area to support modeling of groundwater flow and contaminant transport for the UGTA program (BN 2002a).

Geology Overview of Pahute Mesa

Pahute Mesa is a structurally high-volcanic plateau in the northwest portion of the NTS (Figure 7.4). This physiographic feature covers most of NTS Areas 19 and 20, which are the second most utilized testing areas 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,b). Borehole and geophysical data 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.

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.

The SCCC consists of at least two nested calderas, the Grouse Canyon caldera and younger Area 20 caldera (13.7 and 13.25 million years old, respectively; Sawyer et al., 1994).

Like the Silent Canyon caldera complex, 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 million years old, 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 million years old; Sawyer et al., 1994) in the southern portion of the model area.

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 million years ago, of tuffs assigned to the Thirsty Canyon Group (Sawyer et al., 1994).

Underlying the Tertiary 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 9,600 m (31,500 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 this 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 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 7.4), 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 7.8. For a more detailed geologic summary, see Ferguson et al., (1994); Sawyer et al., (1994); and BN (2002).

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 7.4, their work has provided the foundation for most subsequent hydrogeologic studies at the NTS (IT 1996a; BN 2002a).

The hydrogeology of PM-OV area 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.

All the rocks in the PM-OV area can be classified as one of nine hydrogeologic units, which include the alluvial aquifer, four volcanic hydrogeologic units, two intrusive units, and two hydrogeologic units that represent the pre-Tertiary rocks (Table 7.1).

The rocks within the PM-OV area are grouped into 46 HSUs for the UGTA framework model (Table 7.6). The volcanic units are organized into 40 HSUs that include 16 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 7.4.

Water-level Elevation and Groundwater Flow Direction

Water-level data are relatively abundant for the underground test area on Pahute Mesa in the northwestern portion of the NTS, 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 regional model (IT 1996b) and the Pahute Mesa water table map (O'Hagan and Laczniak 1996).

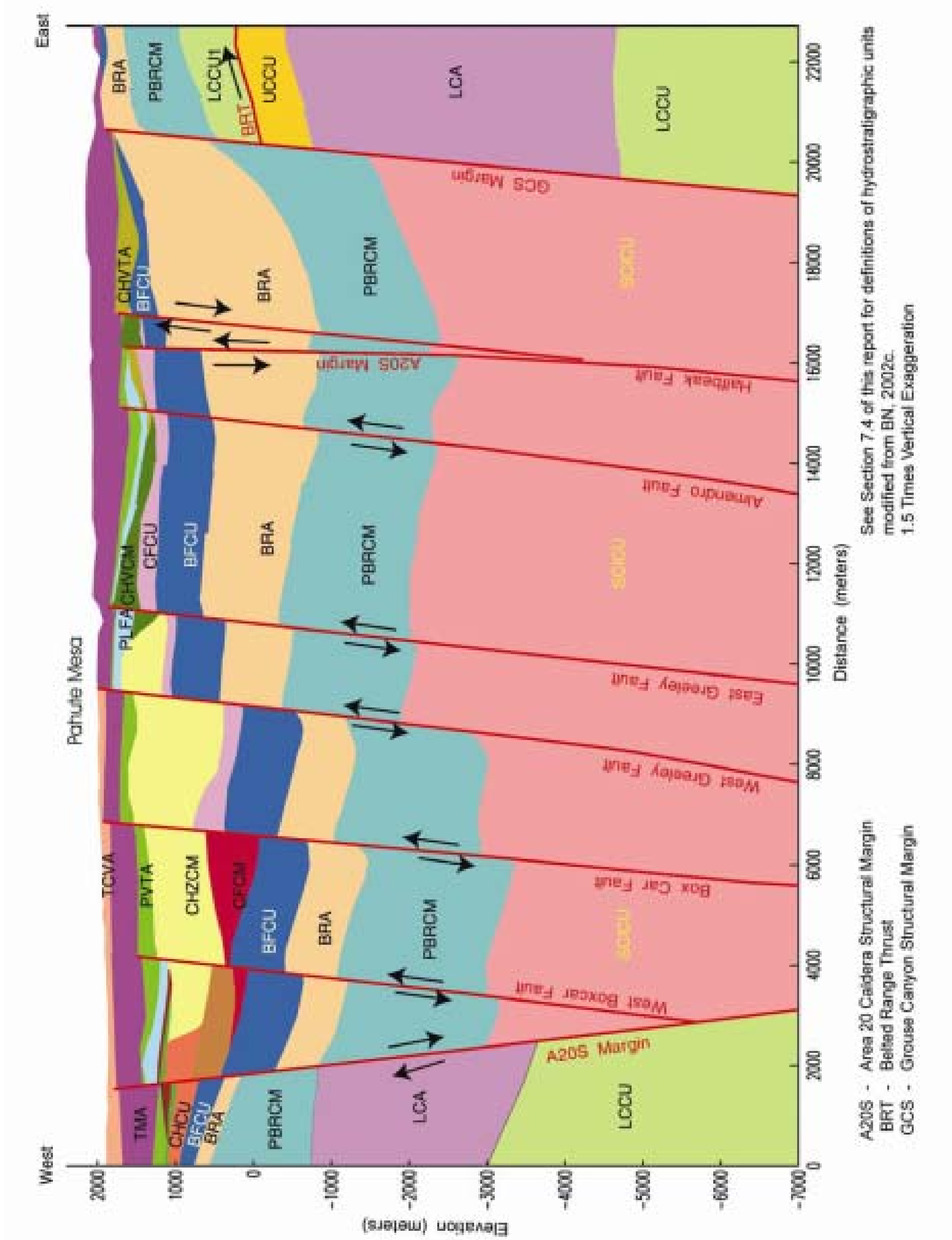


Figure 7.8 Generalized Hydrostratigraphic Cross Section through the Silent Canyon Complex, Pahute Mesa

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.

RAINIER MESA

Rainier Mesa/Shoshone Mountain CAU consists of 60 CASs on Rainier Mesa and six on Shoshone Mountain, which are located in NTS Areas 12 and 16 respectively (Figure 7.5). Rainier Mesa and Aqueduct Mesa form the southern extension of the northeast trending Belted Range (Figure 7.4). Together, these two mesas constitute the third major area utilized for underground testing of nuclear weapons at the NTS between 1957 and 1992. Weapons effects 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 test area.

Geology Overview of Rainier Mesa and Shoshone Mountain

Both mesas are composed of Miocene age air-fall and ash-flow tuffs, which were 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). The stratigraphic units and lithologies are similar to those present in the subsurface of Yucca Flat (Section 7.5). 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 trace of the CP thrust fault extends through the pre-Tertiary rocks of Rainier Mesa, and several high-angle, normal faults have been mapped in the volcanic rocks at both test areas. 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.

Hydrogeology Overview of Rainier Mesa and Shoshone Mountain

Construction of UGTA CAU-level models for the Rainier Mesa and Shoshone Mountain test areas 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 7.5).

Water-level Elevation and Groundwater Flow Direction

The SWL at Rainier Mesa is at a depth of about 258 m (846 ft), or about 1,847 m (6,061 ft) elevation above Mean Sea Level and typically within the TCU. This anomalously high water level relative to the regional water level reflects the presence of water perched above the underlying tuff confining units (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; 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.

Regional groundwater flow from Rainier Mesa may be directed either toward Yucca Flat or, because of the intervening UCCU, to the south toward Alkali Flat discharge area (Figure 7.3). The groundwater flow direction beneath Shoshone Mountain is probably southward as indicated in Figure 7.3.

7.6 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 formations (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, sorbtion, and natural decay, to operate.

It is imperative that those responsible for developing viable monitoring programs understand this unique hydrogeologic setting. As described in this chapter, a vast amount of hydrogeologic data has been acquired in support of NTS programs over the last 40 years, and data continue to be acquired. Now scientists are using these data to develop and improve models for predicting groundwater flow and contaminant transport at the NTS. All of these resources, including databases, groundwater flow models, and subject matter experts, were utilized during the development of the Routine Radiological Environmental Monitoring Program (RREMP) (DOE 2003b).

Another beneficial consequence of previous and current NTS activities is the availability of an array of boreholes that penetrate the saturated zone. A significant number of these “holes of opportunity” are in optimal locations, with appropriate well completions that provide access to aquifers of interest. Selected monitoring wells and water supply wells, both on and off the NTS, have been incorporated into a monitoring network for the RREMP. Additional wells will become available as the UGTA characterization wells are phased into the RREMP. Analytical results from routine sampling of these wells are reported in Chapter 8.0, “Groundwater Monitoring.”

Table 7.1 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).

Table 7.2 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 7.1 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 Drellack et al., 1997a.

(e) Fractures tend to be sealed by the presence of secondary minerals.

Note: Adapted from BN (2002a).

Table 7.3 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.
Pahute Mesa	19, 20	85	85	1965 - 1992	31 - 1452 m (100 - 4765 ft)	Alluvium (thin)Volcanic tuffs & lavas	Almost all were large-diameter vertical emplacements above and below static water level; includes 19 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 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 tunnel-based tests above static water level. (HARD HAT, TINY TOT, and PILE DRIVER).
Buckboard Mesa	18	3	3	1962 - 1964	$\leq$ 27 m (90 ft)	Basaltic Lavas	Shallow, low-yield experiments (SULKY, JOHNNIE BOY[b] 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) 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.

Table 7.4 Hydrostratigraphic Units of the Frenchman Flat 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 7.1 for descriptions of hydrogeologic units.

Note: Adapted from IT, 1998b.

Table 7.5 Hydrostratigraphic Units of the Yucca Flat 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 7.1 for description of hydrogeologic units.

Note: Adapted from Gonzales and Drellack, 1999.

Table 7.6 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.

(a) See Table 7.1 for definitions of hydrogeologic units.

Note: Adapted from BN, 2002a.

Table 7.6 (Hydrostratigraphic Units of the Pahute Mesa-Oasis Valley Area, cont.)

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.

(a) See Table 7.1 for definitions of hydrogeologic units.

Table 7.6 (Hydrostratigraphic Units of the Pahute Mesa-Oasis Valley Area, cont.)

Hydrostratigraphic Unit (Symbol)	Dominant HydrogeologicUnit(s)[a]	Typical Lithologies
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.
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 7.1 for definitions of hydrogeologic units.

8.0 GROUNDWATER MONITORING

Groundwater monitoring on and near the Nevada Test Site (NTS) is of particular importance due to existing and potential groundwater contamination resulting from historical underground nuclear testing activities. Fifty-four groundwater monitoring locations, including onsite wells and offsite wells and springs, were sampled for radioactivity by Bechtel Nevada (BN) in Calendar Year 2002. Analytical results from the 2002 sampling continue to indicate that radionuclide contamination has not migrated significant distances from the underground test areas.

8.1 INTRODUCTION

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 (U.S. Department of Energy [DOE] DOE 2000a). The legacy of nuclear testing has resulted in the contamination of groundwater in some areas. Figure 8.1 provides the underground nuclear testing areas which correlate to areas of potential groundwater contamination.

Groundwater on and near the NTS is monitored for radioactivity to safeguard the health and safety of workers, the public, and the environment; to comply with applicable federal, state, and local environmental protection regulations; and to fulfill DOE directives and orders. Monitoring in the past has been conducted by the U.S. Public Health Service, U.S. Geological Survey (USGS), U.S. Environmental Protection Agency (EPA), and others. In 1998, BN was tasked by the DOE, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) to establish and maintain a single integrated and comprehensive monitoring program. This monitoring program is conducted in accordance with the NTS Routine Radiological Environmental Monitoring Plan (RREMP) (DOE 2003b). The RREMP details groundwater monitoring objectives, regulatory drivers, and quality assurance protocols, which are summarized in Chapter 4.0 of this document.

The NTS groundwater monitoring network consists of a variety of monitoring locations to determine if and to what extent, aquifers have been impacted by radionuclides originating from NTS activities. The NTS groundwater monitoring locations are located in a complex hydrogeologic setting as described in Chapter 7.0. These locations include onsite supply wells, wells specifically designed to monitor groundwater, natural springs, domestic offsite wells, and point-of-opportunity locations.

8.2 GROUNDWATER SAMPLING ACTIVITIES

Groundwater samples for the RREMP program are collected based, in part, on the characteristics and configurations of the sample location. Wells with dedicated pumps may simply be sampled from the associated plumbing (e.g., spigots) at the wellhead. Wells without pumps may be sampled via wireline bailer or a portable pumping system. Grab samples are typically obtained from the springs via dipping cups.

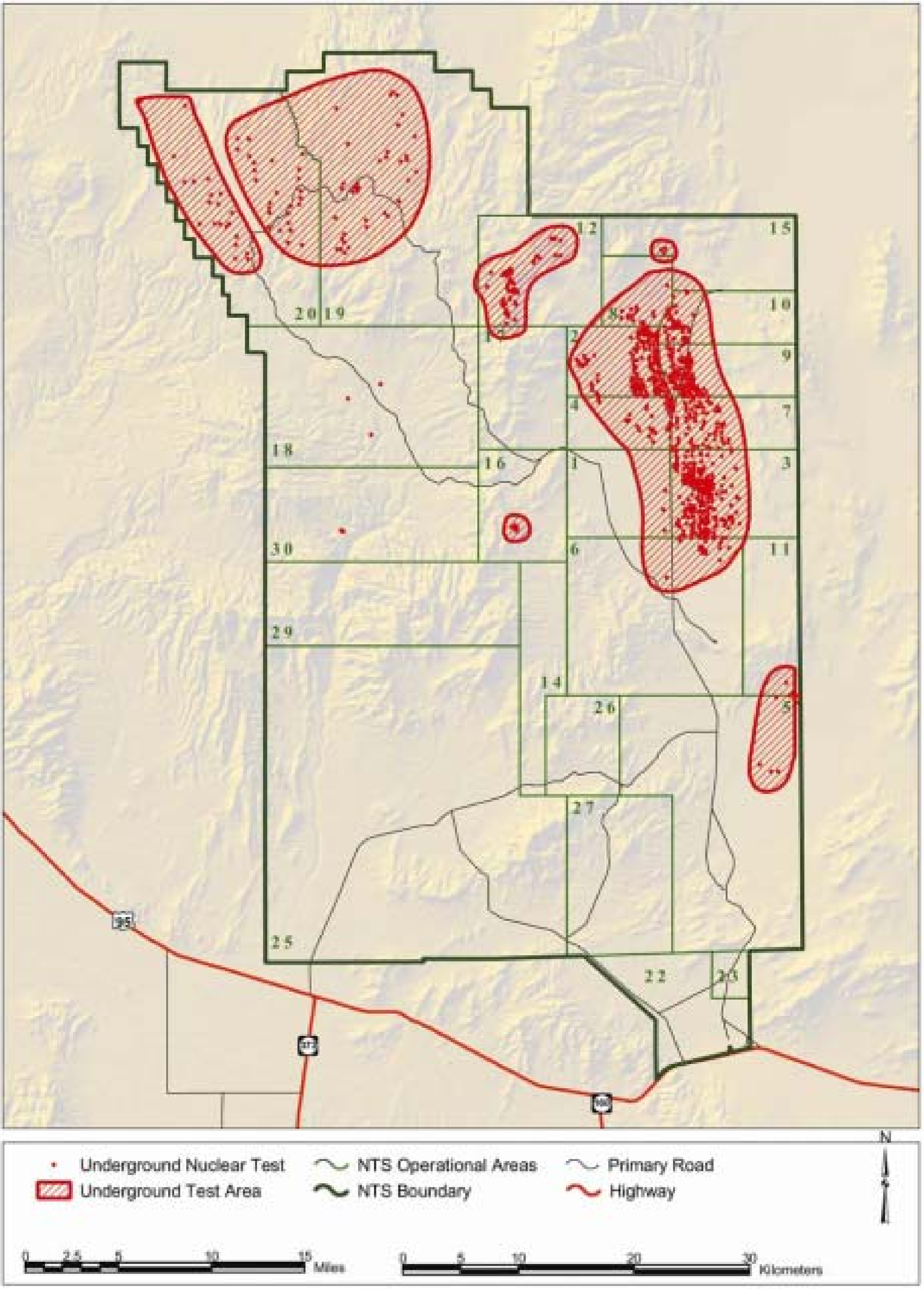


Figure 8.1 Areas of Potential Groundwater Contamination on the NTS

SAMPLING LOCATIONS

In 2002, fifty-four groundwater monitoring locations were sampled for radionuclides and other constituents. The onsite and offsite locations sampled in 2002 are presented along with predicted groundwater flowpaths for the NTS area, in Figures 8.2 and 8.3, respectively. The locations included:

- Ten onsite water-supply wells.
- Nineteen onsite monitoring wells, three of which serve as points of compliance for the Area 5 Radioactive Waste Management Site (RWMS-5) and one which is a compliance well for the Area 23 sewage lagoon.
- Twenty-five offsite locations, including eighteen wells and seven springs.

Some of the 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 (HSUs). Based on these configurations, multiple samples were collected from the following locations in these wells:

- 2,017 and 2,228 feet (ft) below ground surface in Well ER-6-1.
- 1,935, 2,040, 2,130, and 2,300 ft below ground surface in Well USGS HTH #1.
- 1,700 and 2,130 ft below ground surface in Well UE-18r.
- 2,710 and 3,280 ft below ground surface in Well ER-19-1.
- 1,560 and 1,994 ft below ground surface in Well PM-3.

QUALITY ASSURANCE

Quality Assurance (QA) protocols, including Data Quality Objectives (DQOs), were developed as a component of the RREMP. The various QA requirements established for the monitoring program include the use of sample packages, database support tasks, and the completion of essential training. The program also provides for the oversight of external analytical laboratories, along with stringent internal data review and assessment requirements.

8.3 GROUNDWATER MONITORING ANALYSES

The analytes of interest for the RREMP groundwater monitoring program are based on the radiological source term from historical nuclear testing, and regulatory and characterization requirements. Results from radiological and chemical analyses are evaluated to assess potential impacts to aquifers from past nuclear testing and to facilitate the characterization of the NTS groundwater system. Sampling frequencies and requisite analyses for the program are based on well type and location (Table 8.1). The isotopic inventory remaining from nuclear testing is presented in the NTS Environmental Impact Statement (DOE 1996c) and a recent Lawrence Livermore National Laboratory document (Smith 2001). Many of the radioactive species generated from subsurface testing are not considered available for groundwater transport in the near term due to short half-lives, strong sorption onto the solid phase, and/or binding within “puddle glass” via vitrification processes (Smith 1993; Smith et al., 1995).

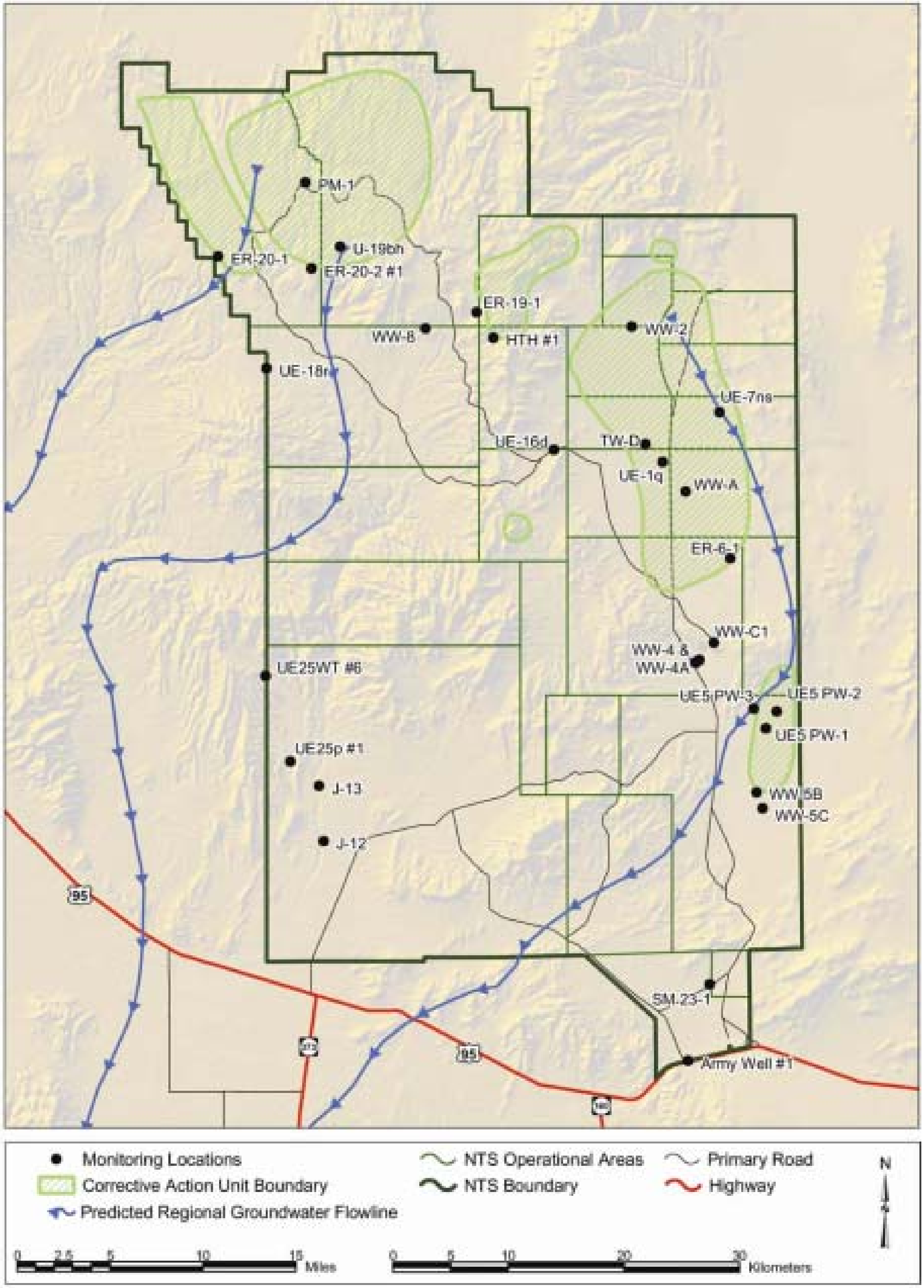


Figure 8.2 NTS Onsite Groundwater Monitoring Locations - 2002

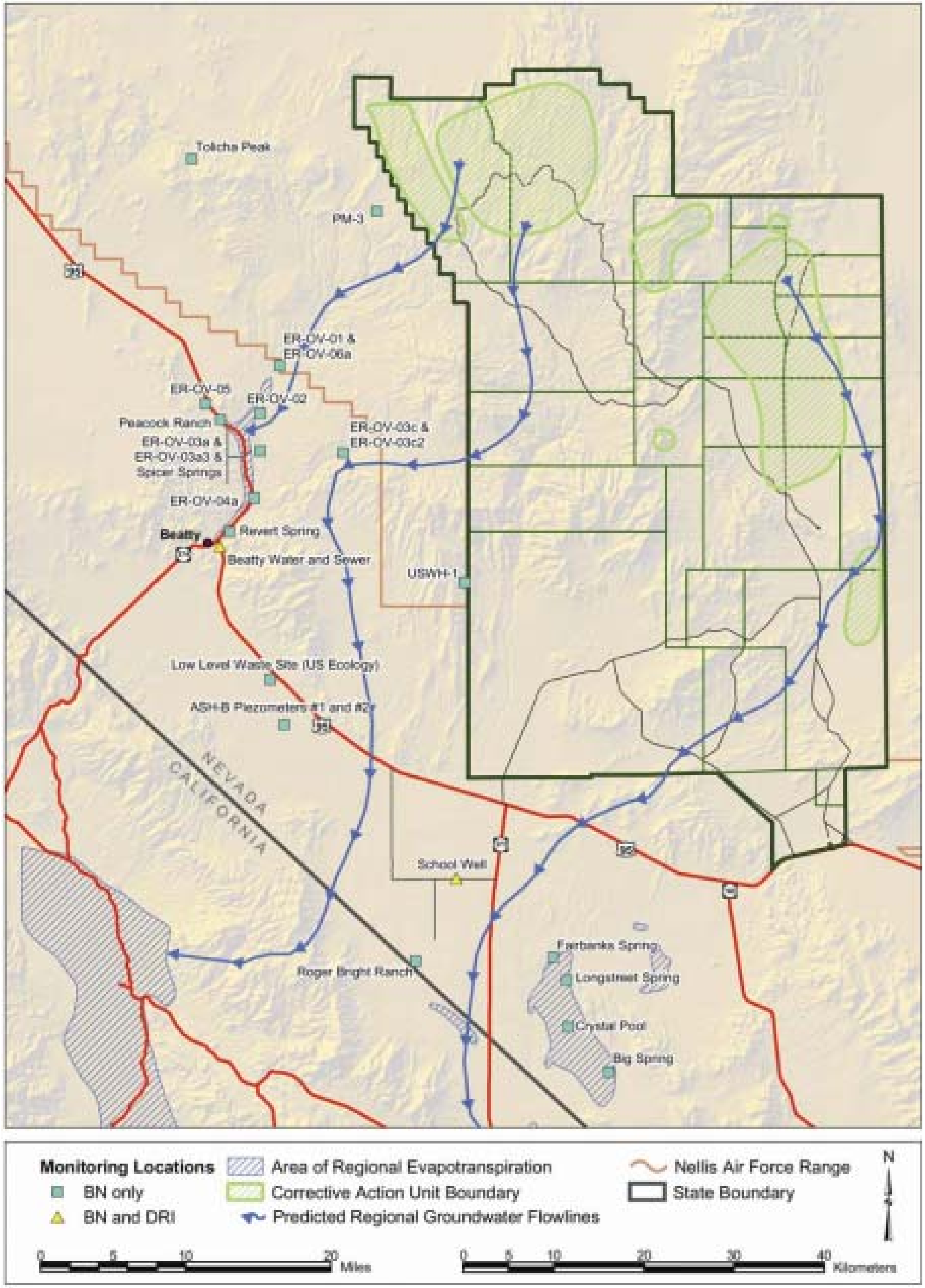


Figure 8.3 NTS Offsite Groundwater Monitoring Locations - 2002

To achieve a sufficiently low detection limit, the analyses for select tritium samples were conducted after the samples underwent an enrichment process. Enrichment concentrates tritium in a sample to provide an effective minimum detectable concentration (MDC) of approximately 20 pCi/L. The MDC for standard (non-enriched) tritium analyses ranges from 200-400 pCi/L. It should be noted that the uncertainty/error values presented in the summary tables at the end of this chapter represent the counting uncertainty/error of the analytical method. The enrichment uncertainty associated with sample enrichment is not encompassed by these counting uncertainty/error values. Therefore, the total (system) error associated with the enrichment and analysis process for tritium samples is somewhat higher than the values presented in the summary tables. Although the uncertainty associated with the enrichment process has not been quantified, it is estimated to be in upwards of twenty percent.

8.4 GROUNDWATER MONITORING RESULTS

The analytical data obtained in 2002 continue to be of high quality, in good agreement with historical data, and indicate that radionuclides have not migrated significant distances from the underground testing areas. Of the fifty-four locations sampled, only one result exceeded its respective regulatory limits (e.g., Safe Drinking Water Act [SDWA] Maximum Contaminant Levels [MCLs]).

TRITIUM

Tritium is one of the most abundant radionuclides generated by an underground nuclear test. Since tritium is incorporated into the water molecule itself, it is believed to be one of the most mobile. As a result, tritium represents the greatest long-term concern to users of groundwater near the NTS (DOE 1996c; International Technology Corp. [IT] 1997). Based on its mobility and ubiquitous presence near the underground testing areas, tritium has been established as the principal target analyte for the RREMP program.

All analytical results for the 2002 tritium samples were below the federal regulatory standard MCL of 20,000 pCi/L. The vast majority of tritium results were below their respective MDCs. A summary of the tritium results from the 2002 monitoring is presented in Table 8.2. A time-series plot of tritium concentrations in wells which have a history of detectable tritium and sampled in 2002 is presented in Figure 8.4. The data provided, in Figure 8.4 for Wells PM-1, UE-7nS, and Water Well A, prior to 1999 are annual averages obtained from the EPA.

Onsite Supply Wells

Samples for tritium analyses were collected quarterly in 2002 from the onsite water-supply wells. All data collected to date indicate that the current onsite water-supply network has not been impacted by subsurface nuclear testing. All of the 2002 tritium results for the samples obtained from the onsite supply wells were well below the SDWA standard (Table 8.2).

The only water-supply well with a history of validated tritium detections is Water Well C-1. 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). Annually-averaged tritium concentrations in Water Well C-1 continue to occur below the effective analytical MDC as indicated in Figure 8.4.

Onsite Monitoring Wells

Data from sampling of the onsite monitoring wells indicate that migration from the test areas is not significant. All of the 2002 tritium results for the samples obtained from the wells were well below the SDWA standard (Table 8.2). Only four onsite monitoring wells had results above

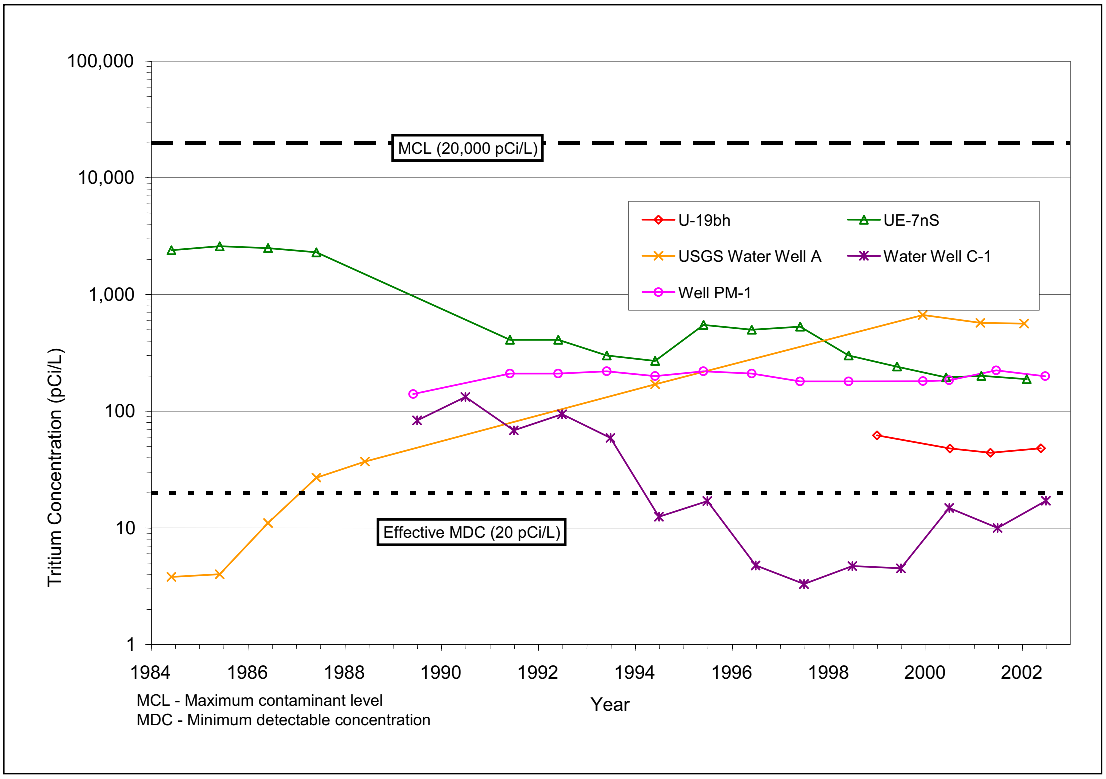


Figure 8.4 Concentrations in Wells with a History of Detectable Tritium - 2002

their respective MDCs for tritium in 2002. These wells were PM-1, UE-7nS, U-19bh, and Water Well A (see Figure 8.4). Each of these wells is located within one kilometer (km) of historical underground nuclear tests.

Well PM-1, located in Area 20 in the Central Pahute Mesa Corrective Action Unit (CAU), has a history of tritium concentrations near 200 pCi/L over the last ten years. The well is constructed with unslotted (blank) casing from the ground surface to a depth of 2,300 meters (m) below ground surface with an open-hole completion from 2,300 - 2,356 m below ground surface. The static water level (SWL) in the well occurs at a depth of approximately 640 m below ground surface. Sampling via discrete wireline bailer has historically been completed at depths ranging from 3 to 100 m below the SWL. In 2001, it was determined via discrete profile sampling that tritium is entering the borehole near the water table. Potential sources of the tritium detected in Well PM-1 include the FARM (U-20ab), GREELEY (U-20g), and KASSERI (U-20z) underground nuclear tests. The closest test to Well PM-1 that was detonated near/below the water table is the FARM test. However, the location of the FARM test is believed to be hydrologically downgradient from Well PM-1. The GREELEY and KASSERI tests, located further from Well PM-1, were of relatively large magnitude and were detonated at depths of 2,429 and 1,196 m below ground surface, respectively. These two tests are believed to be upgradient of PM-1.

Well UE-7nS, located in the Yucca Flat CAU, was drilled 137 m 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 2002, a tritium concentration of approximately 189 pCi/L was detected in water samples from Well UE-7nS.

This result is consistent with the trend of decreasing concentrations observed in recent years. 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 than 200 m from the NASH test, which was conducted in Yucca Flat in 1967. Well UE-2ce is not currently configured for routine sampling.

Well U-19bh is located in the Central Pahute Mesa CAU. The well is an inventory emplacement borehole which is currently being used for monitoring purposes. In 2002, the tritium concentration from water samples was approximately 48 pCi/L, slightly above the analytical MDC. There were several nuclear detonations conducted near Well 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. Regardless, the data are provided as a point of interest due to the detection of tritium.

Water Well A is completed in alluvium in the Yucca Flat CAU. It is located within 1 km 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 1980's. Measured concentrations in 2002 are lower than those reported in previous years, which may indicate a sustained downward trend at this location.

It should be noted that radionuclide contamination has not been detected in Well U-3cn #5. This well is completed in the LCA in the Yucca Flat CAU and is located 60 m from the BILBY (U-3cn) test. BILBY was conducted in 1963 in a zeolitic volcanic tuff confining unit (TCU) less than 120 m above the carbonate aquifer. This well is not sampled as part of the RREMP program, but it is sampled intermittently as part of the UGTA Project.

Offsite Locations

Twenty-five offsite locations were sampled for tritium analyses in 2002 (Figure 8.3). All results were below their respective MDCs (Table 8.2).

GROSS ALPHA

Gross alpha may be considered a standard indicator of radionuclide contamination. However, in addition to man-made radionuclides, many naturally-occurring isotopes/minerals (e.g., isotopes of Uranium and ^{226}Ra) can contribute to alpha radiation in the groundwater at the NTS and in the southern Nevada region. Such minerals can be abundant in volcanic rocks. Wells producing groundwater from aquifers derived from volcanic formations typically have greater gross alpha concentrations. Of all the samples analyzed for gross alpha for the 2002 monitoring period, a single result was validated to be above the established MCL of 15 pCi/L. A summary of the gross alpha results from the 2002 monitoring is presented in Table 8.3. A time-series plot of annually-averaged gross alpha concentrations in the onsite water-supply wells since 1990 is provided in Figure 8.5.

Quarterly samples were collected from the onsite supply wells for gross alpha analyses. All results were below the established MCL of 15 pCi/L, with the exception of the first quarter result from Water Well C-1. The result for this sample had a measured value of 19 pCi/L. However,

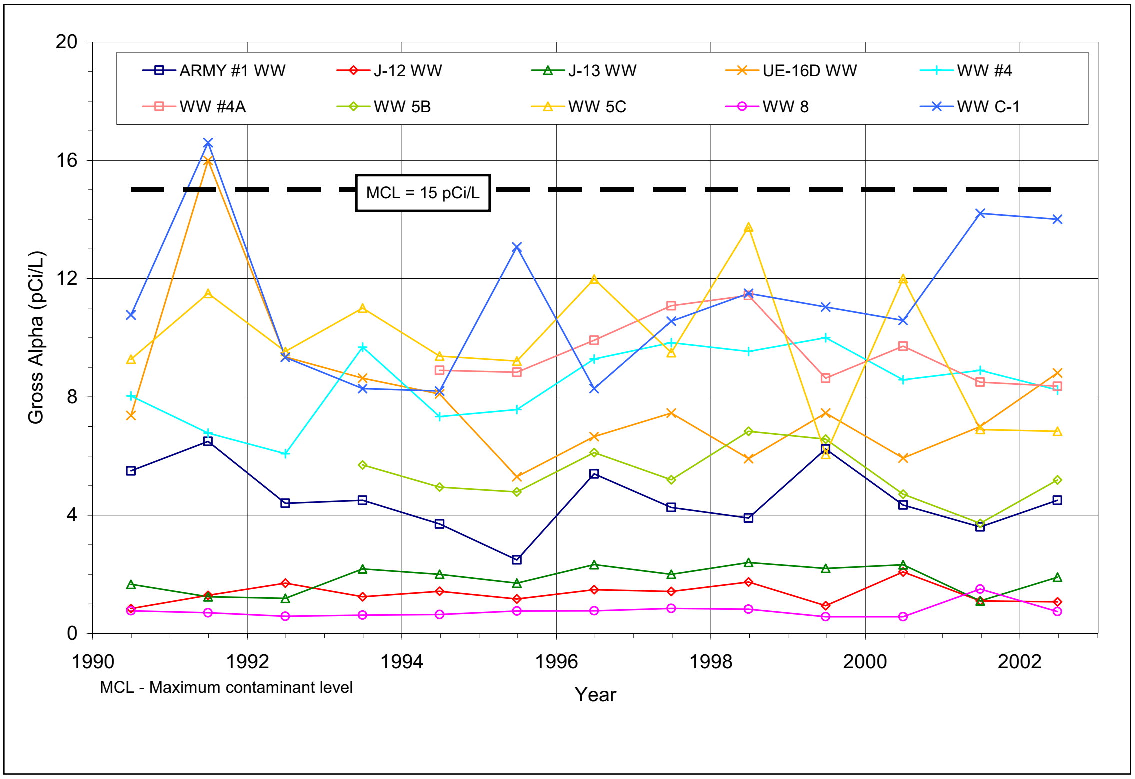


Figure 8.5 Annual Averages of Gross Alpha in Onsite Supply Wells - 2002

subsequent samples collected from the well in 2002 were all below the MCL. The well remained in compliance as a water-supply well for 2002 since the annual average from the quarterly sampling events was below the requirements of the SDWA regulations. During 2002, the validated gross alpha results for all of the onsite monitoring wells and offsite locations indicate concentrations less than the MCL (Table 8.3).

GROSS BETA

Gross beta may be considered a standard indicator of radionuclide contamination. Beta and photon emitters typically result from human activities. However, in addition to anthropogenic sources, many naturally-occurring minerals and isotopes (e.g., ^{228}Ra and ^{40}K) can contribute to beta radiation in the groundwater at the NTS and in the southern Nevada region. These minerals can be abundant in volcanic rocks. Wells producing groundwater from aquifers derived from volcanic formations typically have greater gross beta concentrations. The current MCL established for beta/photon particles is 4 mRem/year based on a water intake of 2 L/day. However, the EPA has established a “Level-of-Concern” of 50 pCi/L. Using the established Level-of-Concern, only one validated result exceeded the regulatory limit for gross beta. A summary of the gross beta results from the 2002 monitoring is presented in Table 8.4. A time-series plot of gross beta concentrations (annual averages) in the onsite water-supply wells since 1989 is provided in Figure 8.6.

The 2002 results for all of the quarterly gross beta analyses for the onsite supply wells were below the EPA Level-of-Concern. Gross beta concentrations within the supply wells have remained fairly stable with no indication of significant increasing trends (Figure 8.6). The

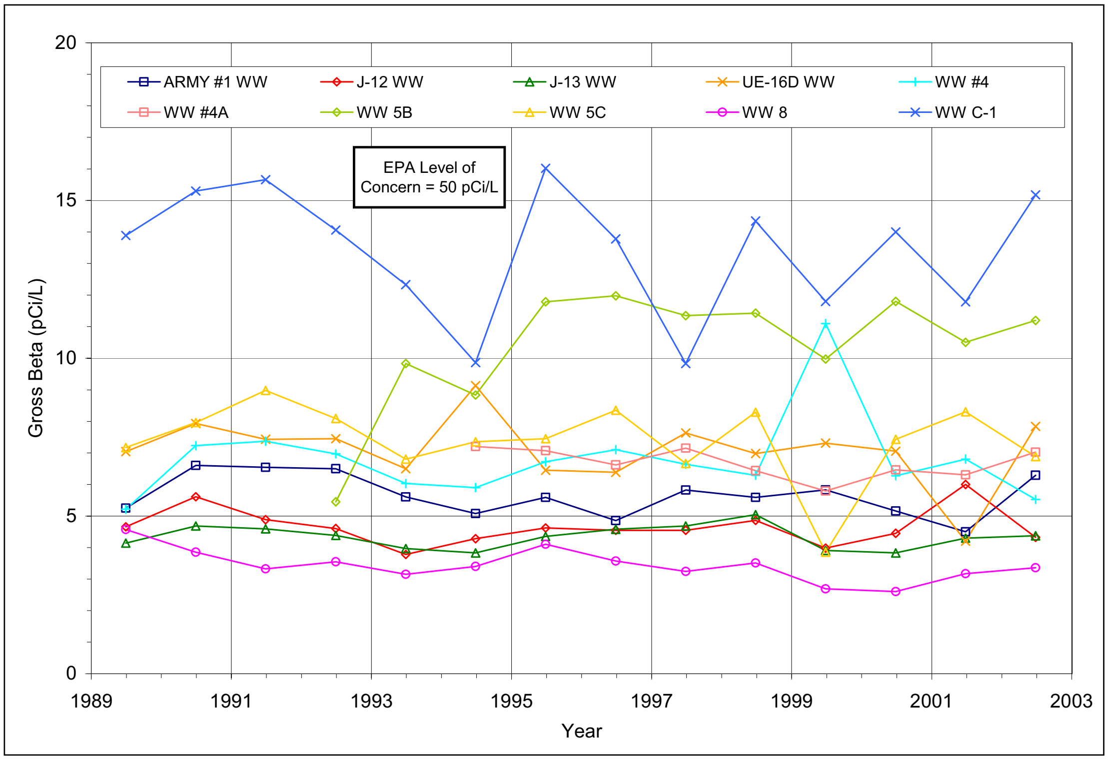


Figure 8.6 Annual Averages of Gross Beta in Onsite Supply Wells

analytical data from the onsite monitoring wells and all offsite locations indicate that only one sample had a validated result that exceeded the EPA level. Although flagged as being below the MDC ("non-detect") by data reviewers, a sample collected from Well ER-19-1 on May 29, 2002, had a measured concentration of 115 pCi/L (Table 8.4). This sample was collected at a depth of 2,710 ft below ground surface. However, a second sample from the well, collected on the same day from a depth of 3,280 ft below ground surface, had a analyzed concentration of 44.8 pCi/L (Table 8.4). Continued sampling of the well will determine if these concentrations are anomalous.

GAMMA SPECTROSCOPY

Gamma spectroscopy analyses for the monitored wells produced results for over 1,100 individual radiological results. Only one result from this dataset exceeded its respective MDC and 2 Sigma (2ω) error values, although internal BN data reviewers flagged the result as estimated ("J" flag). This sample was collected from Well PM-1 collected on June 25, 2002. The result for ^{99}Tc was 16 pCi/L. The corresponding MDC and 2ω for the sample were 12 pCi/L and 15.8, respectively. The result is considered anomalous as previous monitoring data provide no indication of radiological constituents in the well. Future analytical results from this well will be monitored.

RADIUM, PLUTONIUM, AND STRONTIUM

Two suites of samples for radium analysis (^{226}Ra and ^{228}Ra) were collected from each onsite water-supply well during the 2002 monitoring activities. All results from the wells were below the MCL of 5 pCi/L, for combined ^{226}Ra and ^{228}Ra concentrations. Five ^{226}Ra results were validated to have exceeded their respective MDC and 2ω error values, although one result was flagged by the analytical laboratory (Table 8.5). Only one ^{228}Ra result exceeded its respective MDC and 2ω error value (Table 8.6).

All 2002 analytical results for plutonium constituents (^{238}Pu and $^{239+240}$Pu) were near or below their respective MDCs. Two to three suites of samples were collected for ^{238}Pu analyses for the ten onsite water-supply wells. Additionally, 12 onsite monitoring wells, and 21 offsite locations were also sampled for ^{238}Pu analyses (Table 8.7). Analyses for $^{239+240}$Pu included the same samples as the analyses for ^{238}Pu, with the exception of water samples from wells in Area 20 of the NTS and the offsite springs (Table 8.8).

During the 2002 monitoring, all ten onsite supply wells and one offsite well were sampled for ^{90}Sr analysis. All of the results were below the MDC (Table 8.9).

8.5 GROUNDWATER MONITORING OVERSIGHT ACTIVITIES

COMMUNITY ENVIRONMENTAL MONITORING PROGRAM - WATER MONITORING PROJECT

The Desert Research Institute (DRI) was tasked by the DOE, during fiscal year 2002, to provide independent verification of the tritium activity within some of the offsite groundwater wells and water supply systems in areas surrounding the NTS. Samples collected by DRI personnel provide not only an independent measure of the levels of radioactivity within these wells, but, in some cases, a direct comparison to the results obtained by the RREMP.

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

Sample Locations

Fifteen wells, five water supply systems, and four springs were sampled during the period of April 30 to July 10, 2002. Sample locations were selected based upon input from the Community Environmental Monitors (DRI employees living within each community and acting as a liaison between DOE sponsored environmental monitoring programs and the local populace) and local ranch owners participating in the CEMP. All wells were sampled utilizing down hole 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 10 to 15 minutes prior to sampling to purge water from the well. This process ensured that the resultant sample was representative of local groundwater. Table 8.10 lists all of the sample points, the dates they were sampled, and the sampling methods. The locations of the wells, springs, and municipal water supply sample points are also presented in Figure 8.3.

Procedures and Quality Assurance

Several methods are used to ensure that radiological results reported herein conform to current quality assurance protocols. This was achieved through the use of standard operating procedures, field quality assurance samples, and laboratory quality assurance procedures.

DRI's standard operating procedures are detailed step-by-step instructions that describe the methods and materials that are required to decontaminate and operate the sample equipment, 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. In addition, duplicate samples were collected to establish a measure of the repeatability of the analysis. Field quality assurance samples were collected solely to support the interpretation of the tritium samples. Ten samples (41 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 limit of detection of the reported results. Analysis of field and laboratory quality assurance samples indicate a high degree of confidence can be associated with all of DRI's FY 2002 results.

Tritium Results

The results of tritium analyses from the DRI Tritium Laboratory are presented in Table 8.11. Tritium activities averaged 3.83 pCi/L and ranged from <1 to 27 pCi/L. All sample analyses were well below the safe drinking water limit of 20,000 pCi/L. The highest activities were associated with samples collected from Henderson and Boulder City. The water in these samples originated from Lake Mead, and the measured tritium levels are consistent with those reported in previous investigations. Tritium activities in Lake Mead are due to residual tritium persisting in the environment that originated from atmospheric nuclear testing.

8.6 VADOSE ZONE MONITORING (VZM)

As explained in Chapter 4.0 of this report, the vadose zone is monitored at three types of sites on the NTS: the Area 3 RWMS (RWMS-3) and RWMS-5, Resource Conservation and Recovery Act (RCRA) closure sites, and permitted sanitary landfills. VZM is conducted at these locations as a component of characterization efforts and to ensure the assumptions made in regulatory and planning documents, including the RWMS-3 and RWMS-5 Performance Assessments (PAs). Additionally, the VZM is conducted to complement, or in lieu of, groundwater monitoring for the purpose of protecting groundwater resources. Due to the extensive nature of the VZM program, not all elements of the program are provided in this report. However, several aspects of the ongoing work are discussed. For further details on the VZM program refer to the "NTS 2002 Waste Management Monitoring Report Area 3 and Area 5 Radioactive Waste Management Sites," (BN 2003).

Area 5 Weighing Lysimeter Facility

A vadose zone dataset has been acquired since March 1994 at the Area 5 weighing lysimeter facility. This facility consists of two weighing lysimeters located about 400 m (1,312 ft) southwest of the RWMS-5. Each lysimeter consists of a steel box that is 2 m (6.6 ft) deep, filled with soil and having a surface area of 2 m x 4 m (6.6 ft x 13 ft). Each lysimeter is mounted on a sensitive scale, with the weights of the lysimeters being continuously monitored using an electronic loadcell. One lysimeter is vegetated with native plant species at the approximate density of the surrounding desert, and one lysimeter is kept bare to simulate the bare operational waste covers at the RWMS-5. The facility has been in continuous operation since its inception in 1994 and has provided data to support the assumptions made in the RWMS-3 and RWMS-5 Performance Assessments (PAs) of no downward movement of water beyond the rooting depths of local plants. This facility has also provided data to justify other NTS closure covers (DOE 2000b; c).

The data recorded for total soil water storage and daily precipitation totals since March 1994 is illustrated in Figure 8.7. Increases in soil water storage in the vegetated lysimeter (early-time data) resulted from irrigation that was applied to ensure that the transplanted vegetation survived. Rapid decreases in soil water storage in the vegetated lysimeter following periods of high rainfall, indicating efficient removal of water, may be observed in Figure 8.7. Figure 8.7 also shows how the vegetated lysimeter is considerably drier than the bare-soil lysimeter, despite the paucity of plants in the vegetated lysimeter (about 15 percent vegetative cover). To date, no water drainage has been measured from the bottom of either lysimeter. However, volumetric water content at a depth of 170 cm (5.6 ft) in the bare-soil lysimeter has increased from about 9 to 14 percent since it was installed in 1994.

Area 3 Drainage Lysimeter Facility

In addition to the weighing lysimeter facility in Area 5, a drainage lysimeter facility was installed next to the U-3ax/bl disposal unit at the RWMS-3. This facility is instrumented for the measurement of soil water content using Time Domain Reflectometry sensors and matric potential using heat dissipation probe sensors. The lysimeters were employed to evaluate the effectiveness of different surface treatments in support of waste cover, mono-layer evapotranspiration design.

RWMS-5 Automated Monitoring

In addition to the lysimeter facilities, VZM of waste cell covers and floors using automated systems has been conducted at the RWMS-5 since late 1998. Temporal and spatial changes in soil water content for the Pit 3 waste cover at the RWMS-5 is provided in Figure 8.8. The figure clearly shows that depth of infiltration has not exceeded a depth of 90 cm (3 ft) before the water is returned to the atmosphere by evaporation (this operational cover is not currently vegetated).

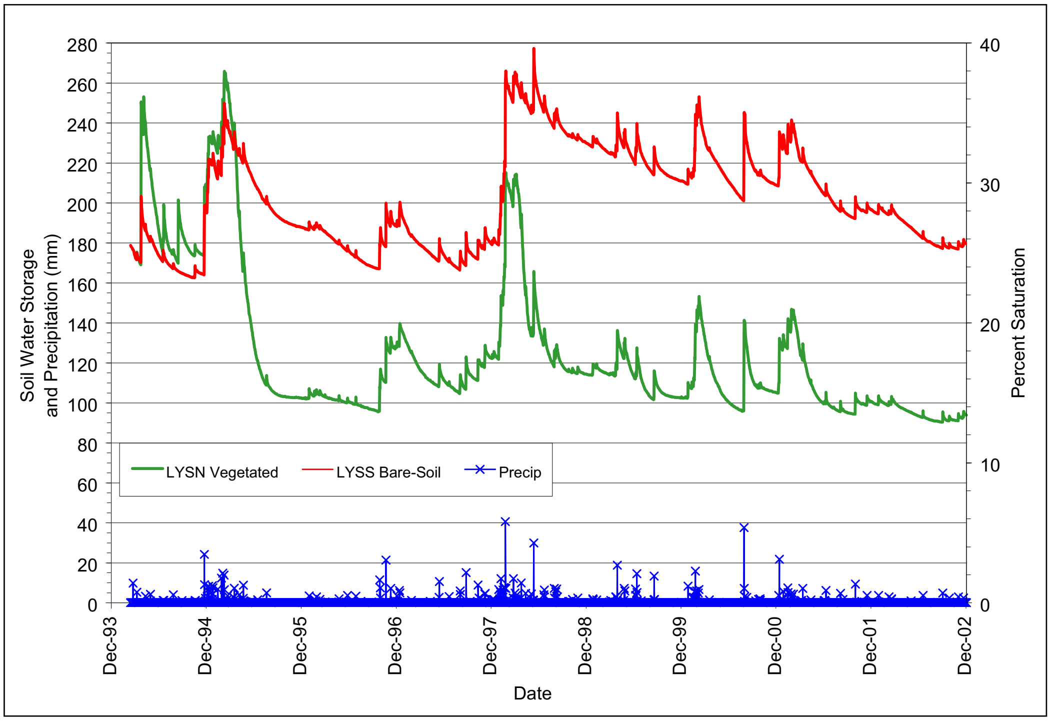


Figure 8.7 Weighing Lysimeter and Precipitation Data from March 1994 - December 2002

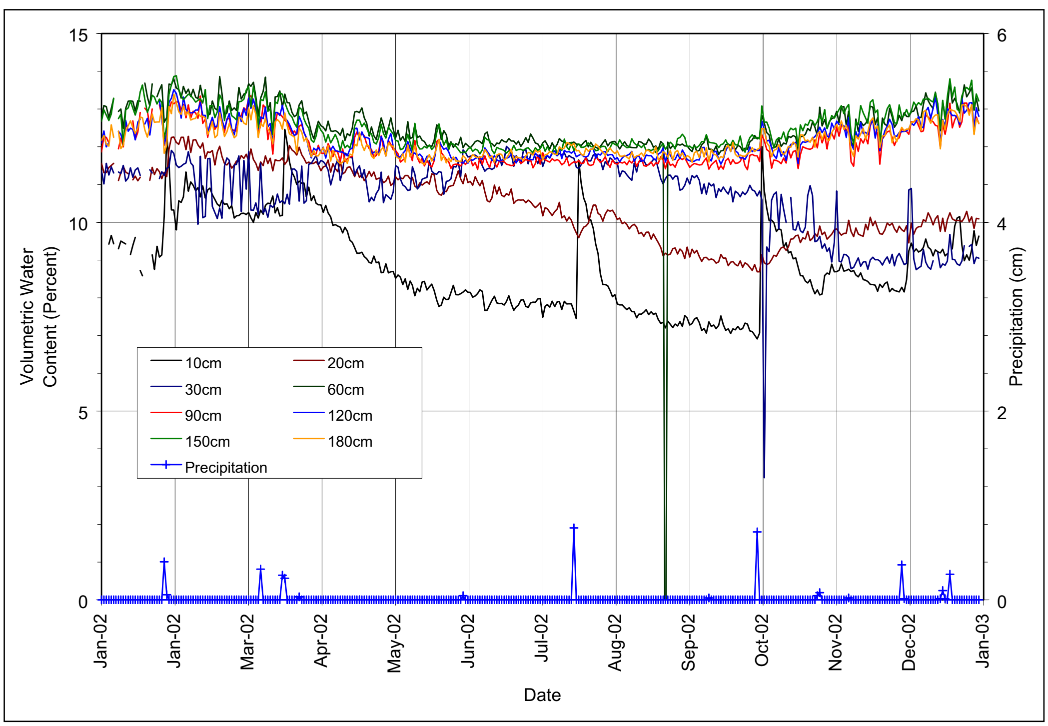


Figure 8.8 Soil Water Content in Pit 3 Waste Cover (North Side)

Table 8.1 Typical Sampling and Analysis Schedule for RREMP Groundwater Monitoring

Location/Type		Analysis [(a)]	Sample Frequency	Regulatory Driver
Onsite	Potable water supply well within CAU [(b)]	^{3}H(e); Gross ζ/η #$^{226/228}$Ra	Quarter	40CFR 61; DOE Order 5400
		ν emitters; Pu; WQ	Annual	
	Other potable water supply well	^{3}H; Gross ζ/η_#$^{226/228}$Ra	Quarter	DOE Order 5400 Series
		ν emitters; Pu; WQ	Annual	
	Non-potable water supply well within CAU	^{3}H(e)	Quarter	DOE Order 5400 Series
		Gross ζ/η; ν emitters; Pu; WQ	Annual	
	Other non-potable water supply well	^{3}H	Semiannual	DOE Order 5400 Series
		Gross ζ/η; ν emitters; Pu; WQ	Biennial	
	Monitoring Well (Non-water supply)	^{3}H	Annual	DOE Order 5400 Series
		Gross ζ/η; ν emitters; Pu; WQ	Biennial	
	Source Characterization Well [(c)]	^{3}H; Gross ζ/η; ν emitters; Pu; WQ	Biennial	DOE Order 5400 Series
	New Wells	^{3}H(e); Gross ζ/η; ν emitters; Pu; WQ	Quarter	DOE Order 5400 Series
Offsite [(d)]	Group A locations (proximal)	^{3}H(e); ν emitters; Pu	Quarter	40CFR 61; DOE Order 5400
		Gross ζ/η; ν emitters; Pu; ^{90}Sr	Annual	
	Group B locations (distal)	^{3}H; ν emitters	Semiannual	DOE Order 5400 Series
	Group C locations (most distant)	^{3}H; ν emitters	Annual	DOE Order 5400 Series
	New locations	^{3}H(e); Gross ζ/η; ν emitters; Pu; ^{90}Sr; WQ	Initial	40CFR 61; DOE Order 5400

(a) Select samples (e.g., wells with low tritium concentrations) may require enrichment, ^{3}H(e), prior to analysis.

(b) Corrective Action Unit (CAU) as defined by Underground Test Area Project (IT, 1996).

(c) Source Characterization Wells may also be termed "Hot" or "Near-Field" wells, additional analytes may be specified for these wells.

(d) Offsite locations include both drilled wells and natural springs.

WQ - Water Quality analyses; including pH, specific conductance, temperature, TDS, principal cations/anions, and alkalinity/bicarbonate.

Note: Sampling frequencies and analytes are subject to revision as data are acquired and reviewed, if justified. After four quarterly samples are acquired, frequency and analytes will be based on the well type. Biennial frequency may be modified for well-specific sampling program.

Table 8.2 Summary of Tritium Results - 2002

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier	Sample Type
Onsite Supply Wells							
05	Water Well 5B	19-Feb-2002	-3.59	13.33	11.77	U	Grab
05	Water Well 5B	23-Apr-2002	-14.21	42.76	36.32	U	Grab
05	Water Well 5B	16-Jul-2002	11.88	35.05	29.11	U	Grab
05	Water Well 5B	15-Oct-2002	-4.05	20.71	18.16	U	Grab
05	Water Well 5C	19-Feb-2002	4.09	14.74	12.26	U	Grab
05	Water Well 5C	23-Apr-2002	-13.77	32.46	27.61	U	Grab
05	Water Well 5C	16-Jul-2002	-1.02	29.73	26.49	U	Grab
05	Water Well 5C	15-Oct-2002	-13.18	21.21	19.39	U	Grab
06	Water Well #4	25-Feb-2002	-3.05	14.51	12.80	U	Grab
06	Water Well #4	23-Apr-2002	-10.00	22.40	18.87	U	Grab
06	Water Well #4	16-Jul-2002	5.92	30.99	26.49	U	Grab
06	Water Well #4	15-Oct-2002	-2.94	23.71	20.65	U	Grab
06	Water Well #4A	19-Feb-2002	8.89	14.65	11.77	U	Grab
06	Water Well #4A	23-Apr-2002	2.53	23.45	19.52	U	Grab
06	Water Well #4A	16-Jul-2002	-6.52	29.73	27.39	U	Grab
06	Water Well #4A	15-Oct-2002	-9.03	23.06	20.65	U	Grab
06	Water Well C-1	19-Feb-2002	73.89	21.67	12.94		Grab
06	Water Well C-1	23-Apr-2002	2.93	27.11	22.55	U	FD
06	Water Well C-1	23-Apr-2002	-3.03	24.55	20.55	U	Grab
06	Water Well C-1	16-Jul-2002	5.72	30.99	26.49	U	Grab
06	Water Well C-1	15-Oct-2002	-4.60	23.55	20.65	U	FD
06	Water Well C-1	15-Oct-2002	-8.06	23.23	20.65	U	Grab
16	UE-16D ELEANA Water Well	19-Feb-2002	-0.68	13.71	11.83	U	Grab
16	UE-16D ELEANA Water Well	23-Apr-2002	-4.87	23.58	19.80	U	Grab
16	UE-16D ELEANA Water Well	16-Jul-2002	-1.24	36.40	32.34	U	Grab
16	UE-16D ELEANA Water Well	15-Oct-2002	-9.76	23.06	20.65	U	Grab
18	Water Well 8 (USGS HTH-8)	19-Feb-2002	-3.61	13.82	12.20	U	FD
18	Water Well 8 (USGS HTH-8)	19-Feb-2002	2.18	14.23	12.01	U	Grab
18	Water Well 8 (USGS HTH-8)	23-Apr-2002	-5.91	23.17	19.52	U	Grab
18	Water Well 8 (USGS HTH-8)	16-Jul-2002	4.85	29.40	25.13	U	Grab
18	Water Well 8 (USGS HTH-8)	15-Oct-2002	-10.48	22.90	20.65	U	Grab
22	ARMY #1 Water Well	20-Feb-2002	1.52	15.57	13.24	U	Grab
22	ARMY #1 Water Well	24-Apr-2002	-9.16	21.82	18.38	U	Grab
22	ARMY #1 Water Well	17-Jul-2002	9.19	31.71	26.49	U	Grab
22	ARMY #1 Water Well	16-Oct-2002	-11.61	22.90	20.65	U	FD

Table 8.2 (Summary of Tritium Results - 2002, cont.)

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier	Sample Type
Onsite Supply Wells, cont.							
22	ARMY #1 Water Well	16-Oct-2002	-9.76	27.74	25.89	U	Grab
25	J-12 Water Well	20-Feb-2002	0.84	14.70	12.59	U	FD
25	J-12 Water Well	20-Feb-2002	4.06	15.89	13.31	U	Grab
25	J-12 Water Well	24-Apr-2002	-15.76	33.64	28.34	U	FD
25	J-12 Water Well	24-Apr-2002	-5.53	21.68	18.26	U	Grab
25	J-12 Water Well	17-Jul-2002	12.43	25.77	21.08	U	Grab
25	J-12 Water Well	16-Oct-2002	-17.66	22.26	20.65	U	Grab
25	J-13 Water Well	20-Feb-2002	6.05	15.93	13.16	U	Grab
25	J-13 Water Well	24-Apr-2002	-9.33	22.55	18.99	U	Grab
25	J-13 Water Well	17-Jul-2002	-10.00	23.60	21.35	U	Grab
25	J-13 Water Well	16-Oct-2002	-9.03	23.06	20.65	U	Grab
Onsite Monitoring Wells							
01	UE-1Q	15-Jan-2002	-2.03	22.03	19.07	U	Grab
01	UE-1Q	16-Oct-2002	-31.80	280.00	243.00	U	FD
01	UE-1Q	16-Oct-2002	66.40	312.00	260.00	U	Grab
02	Water Well 2 (USGS HTH #2)	16-Jan-2002	9.57	23.62	19.40	U	Grab
03	USGS Water Well A	16-Jan-2002	564.10	57.44	19.23		Grab
04	USGS TEST WELL D	15-Jan-2002	13.71	23.97	19.40	U	Grab
05	UE5PW-1	15-May-2002	-3.85	17.70	15.52	U	FD
05	UE5PW-1	15-May-2002	-1.78	19.27	16.67	U	Grab
05	UE5PW-1	22-Oct-2002	-10.88	37.58	33.87	U	FD
05	UE5PW-1	22-Oct-2002	2.30	23.87	20.24	U	Grab
05	UE5PW-2	15-May-2002	-2.39	19.47	16.84	U	FD
05	UE5PW-2	15-May-2002	2.69	19.87	16.84	U	Grab
05	UE5PW-2	22-Oct-2002	-0.38	23.55	20.24	U	FD
05	UE5PW-2	22-Oct-2002	-11.12	40.00	35.90	U	Grab
05	UE5PW-3	15-May-2002	-4.13	17.70	15.52	U	FD
05	UE5PW-3	15-May-2002	-2.39	19.47	16.84	U	Grab
05	UE5PW-3	22-Oct-2002	-18.72	34.24	31.82	U	FD
05	UE5PW-3	22-Oct-2002	-8.41	35.61	31.82	U	Grab
06	ER-6-1	29-Jan-2002	1.24	16.07	13.64	U	FD
06	ER-6-1 (2,017 ft)	29-Jan-2002	1.37	17.80	15.12	U	Grab
06	ER-6-1 (2,228 ft)	29-Jan-2002	-2.14	16.90	14.76	U	Grab
07	UE-7nS	05-Feb-2002	192.81	31.38	14.79		FD
07	UE-7nS	05-Feb-2002	184.83	29.66	13.88		Grab
17	USGS HTH #1	27-Feb-2002	4.31	16.82	13.98	U	FD
17	USGS HTH #1 (1,935 ft)	27-Feb-2002	5.80	16.46	13.59	U	Grab

Table 8.2 (Summary of Tritium Results - 2002, cont.)

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier	Sample Type
Onsite Monitoring Wells, cont.							
17	USGS HTH #1 (2,040 ft)	27-Feb-2002	0.62	16.00	13.67	U	Grab
17	USGS HTH #1 (2,130 ft)	27-Feb-2002	1.75	16.29	13.82	U	Grab
17	USGS HTH #1 (2,300 ft)	27-Feb-2002	17.73	22.13	17.45		Grab
18	UE-18R	22-May-2002	-6.83	22.42	19.77	U	FD
18	UE-18R (1,700 ft)	22-May-2002	3.92	25.00	21.05	U	Grab
18	UE-18R (2,130 ft)	22-May-2002	-3.51	22.73	19.77	U	Grab
19	ER-19-1	29-May-2002	-4.85	24.03	21.05	U	FD
19	ER-19-1 (2,710 ft)	29-May-2002	0.18	23.03	19.77	U	Grab
19	ER-19-1 (3,280 ft)	29-May-2002	5.60	23.64	19.77	U	Grab
19	U-19BH	23-May-2002	45.46	25.82	18.51		FD
19	U-19BH	23-May-2002	50.71	26.24	18.51		Grab
20	ER-20-1	18-Jun-2002	0.39	24.79	21.28	U	FD
20	ER-20-1	18-Jun-2002	5.77	24.03	20.08	U	Grab
20	ER-20-2 #1	19-Jun-2002	5.95	24.03	20.08	U	Grab
20	WELL PM-1	25-Jun-2002	200.00	39.19	20.08		FD
20	WELL PM-1	25-Jun-2002	198.29	40.68	21.28		Grab
25	UE-25 WT #6	02-Oct-2002	-5.85	23.23	20.40	U	FD
25	UE-25 WT #6	02-Oct-2002	-13.71	22.26	20.40	U	Grab
25	UE-25P #1	25-Sep-2002	4.03	24.19	20.40	U	FD
25	UE-25P #1	25-Sep-2002	10.97	24.84	20.40	U	Grab
Offsite Wells and Springs							
95	ASH-B PIEZOM #1	10-Sep-2002	-9.92	22.74	20.40	U	FD
95	ASH-B PIEZOM #1	10-Sep-2002	-4.04	23.39	20.40	U	Grab
95	ASH-B PIEZOM #2	10-Sep-2002	-8.79	21.52	19.17	U	Grab
95	BEATTY WATER AND SEWER	11-Dec-2002	8.97	250.00	215.00	U	Grab
95	BIG SPRINGS	18-Apr-2002	-7.48	38.32	32.10	U	FD
95	BIG SPRINGS	18-Apr-2002	-11.63	22.13	18.58	U	Grab
95	CRYSTAL POOL	18-Apr-2002	-7.01	22.77	19.12	U	FD
95	CRYSTAL POOL	18-Apr-2002	-18.60	22.94	19.26	U	Grab
95	ER-OV-01	11-Jun-2002	0.79	26.15	22.31	U	FD
95	ER-OV-01	11-Jun-2002	-2.17	25.81	22.31	U	Grab
95	ER-OV-01	05-Nov-2002	-86.10	272.00	242.00	U	Grab
95	ER-OV-2002	11-Jun-2002	-6.69	23.87	21.05	U	Grab
95	ER-OV-2002	06-Nov-2002	40.80	286.00	242.00	U	Grab
95	ER-OV-03A	10-Jun-2002	-3.33	21.67	18.86	U	FD
95	ER-OV-03A	10-Jun-2002	-5.40	22.90	20.08	U	Grab
95	ER-OV-03A3	10-Jun-2002	0.00	23.39	20.08	U	Grab

Table 8.2 (Summary of Tritium Results - 2002, cont.)

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier	Sample Type
Offsite Wells and Springs, cont.							
95	ER-OV-03C	11-Jun-2002	0.53	21.97	18.86	U	Grab
95	ER-OV-03C	06-Nov-2002	-29.50	280.00	242.00	U	Grab
95	ER-OV-03C2	11-Jun-2002	3.24	33.18	28.18	U	Grab
95	ER-OV-03C2	06-Nov-2002	90.60	324.00	269.00	U	FD
95	ER-OV-03C2	06-Nov-2002	-47.60	278.00	242.00	U	Grab
95	ER-OV-04A	10-Jun-2002	0.20	24.79	21.28	U	Grab
95	ER-OV-05	10-Jun-2002	4.34	25.30	21.28	U	FD
95	ER-OV-05	10-Jun-2002	4.15	25.30	21.28	U	Grab
95	ER-OV-06A	11-Jun-2002	3.36	25.13	21.28	U	Grab
95	ER-OV-06A	05-Nov-2002	-43.10	278.00	242.00	U	FD
95	ER-OV-06A	05-Nov-2002	158.00	268.00	216.00	U	Grab
95	FAIRBANKS SPRING	18-Apr-2002	-11.02	49.05	41.09	U	FD
95	FAIRBANKS SPRING	18-Apr-2002	-5.16	22.94	19.26	U	Grab
95	LONGSTREET SPRING	18-Apr-2002	-12.52	20.13	16.90	U	FD
95	LONGSTREET SPRING	18-Apr-2002	-17.94	49.71	41.76	U	Grab
95	PEACOCK RANCH	18-Apr-2002	-7.86	23.72	19.93	U	Grab
95	PM-3	07-Aug-2002	-2.95	28.87	25.73	U	FD
95	PM-3 (1,560 ft)	07-Aug-2002	3.41	21.42	18.09	U	Grab
95	PM-3 (1,994 ft)	07-Aug-2002	0.92	24.03	20.56	U	Grab
95	REVERT SPRING	18-Apr-2002	-9.52	21.52	18.07	U	Grab
95	ROGER BRIGHT RANCH	11-Dec-2002	195.00	272.00	215.00	U	Grab
95	SCHOOL WELL	11-Dec-2002	126.00	264.00	215.00	U	FD
95	SCHOOL WELL	11-Dec-2002	76.20	258.00	215.00	U	Grab
95	SPICER RANCH	18-Apr-2002	-26.67	45.39	38.16	U	Grab
95	TOLICHA PEAK	27-Aug-2002	-10.34	24.27	21.71	U	Grab
95	U.S. ECOLOGY	11-Dec-2002	45.70	306.00	257.00	U	Grab
95	U.S. ECOLOGY	11-Dec-2002	-189.00	584.00	511.00	U	Grab
95	USW H-1	20-Nov-2002	149.00	298.00	242.00	U	FD
95	USW H-1	20-Nov-2002	-13.60	280.00	242.00	U	Grab
95	USW H-1	21-Nov-2002	45.20	286.00	242.00	U	FD

MDC - Minimum detectable concentration.
U - Below detectable limit.
FD - Field duplicate

Table 8.3 Summary of Gross Alpha Results - 2002

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier
Onsite Supply Wells						
05	Water Well 5B	19-Feb-2002	4.80	2.40	1.20	
05	Water Well 5B	23-Apr-2002	5.91	2.42	1.04	
05	Water Well 5B	16-Jul-2002	3.64	2.92	1.90	
05	Water Well 5B	15-Oct-2002	6.42	3.26	1.19	
05	Water Well 5C	19-Feb-2002	12.00	4.00	1.30	
05	Water Well 5C	23-Apr-2002	6.11	2.52	1.01	
05	Water Well 5C	16-Jul-2002	4.98	2.76	1.68	
05	Water Well 5C	15-Oct-2002	4.26	3.70	2.90	
06	Water Well #4	25-Feb-2002	6.40	2.60	0.98	
06	Water Well #4	23-Apr-2002	9.55	3.30	0.96	
06	Water Well #4	16-Jul-2002	6.45	3.06	1.29	
06	Water Well #4	15-Oct-2002	10.50	4.36	2.09	
06	Water Well #4A	19-Feb-2002	8.70	3.60	1.40	
06	Water Well #4A	23-Apr-2002	8.31	2.94	0.92	
06	Water Well #4A	16-Jul-2002	6.98	3.50	1.67	
06	Water Well #4A	15-Oct-2002	9.45	4.04	1.58	
06	Water Well C-1	19-Feb-2002	19.00	6.60	2.40	
06	Water Well C-1	23-Apr-2002	14.10	5.14	1.92	
06	Water Well C-1	16-Jul-2002	11.60	4.72	1.98	
06	Water Well C-1	15-Oct-2002	11.30	4.46	2.08	
16	UE-16D ELEANA Water Well	19-Feb-2002	6.40	2.80	1.10	
16	UE-16D ELEANA Water Well	23-Apr-2002	12.80	4.20	1.04	
16	UE-16D ELEANA Water Well	16-Jul-2002	7.67	3.54	1.45	
16	UE-16D ELEANA Water Well	15-Oct-2002	8.35	3.86	1.98	
18	Water Well 8 (USGS HTH-8)	19-Feb-2002	0.41	1.18	1.00	U
18	Water Well 8 (USGS HTH-8)	23-Apr-2002	0.71	1.11	0.89	U
18	Water Well 8 (USGS HTH-8)	16-Jul-2002	0.89	1.67	1.35	U
18	Water Well 8 (USGS HTH-8)	15-Oct-2002	0.93	1.68	1.55	U
22	ARMY #1 Water Well	20-Feb-2002	5.30	2.40	1.10	
22	ARMY #1 Water Well	24-Apr-2002	5.13	2.22	1.07	
22	ARMY #1 Water Well	17-Jul-2002	4.14	2.44	1.52	
22	ARMY #1 Water Well	16-Oct-2002	3.44	3.60	2.90	
25	J-12 Water Well	20-Feb-2002	1.80	1.58	1.00	B
25	J-12 Water Well	24-Apr-2002	1.53	1.08	0.71	B
25	J-12 Water Well	17-Jul-2002	0.11	1.12	1.02	U
25	J-12 Water Well	16-Oct-2002	0.85	1.56	1.34	U

Table 8.3 (Summary of Gross Alpha Results - 2002, cont.)

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier
Onsite Supply Wells, cont.						
25	J-13 Water Well	20-Feb-2002	2.00	1.82	1.30	B
25	J-13 Water Well	24-Apr-2002	2.58	1.45	0.85	
25	J-13 Water Well	16-Oct-2002	2.01	1.73	0.99	
25	J-13 Water Well	17-Jul-2002	1.02	1.80	1.45	U
Onsite Monitoring Wells						
01	UE-1Q	16-Oct-2002	4.02	3.54	2.39	
06	ER-6-1 (2,017 ft)	29-Jan-2002	3.80	2.20	1.30	
06	ER-6-1 (2,228 ft)	29-Jan-2002	2.90	1.98	1.20	
07	UE-7NS	05-Feb-2002	0.26	1.46	1.30	U
17	USGS HTH #1 (1,935 ft)	27-Feb-2002	1.31	1.66	1.25	B
17	USGS HTH #1 (2,040 ft)	27-Feb-2002	0.41	2.10	1.82	U
17	USGS HTH #1 (2,130 ft)	27-Feb-2002	1.07	1.84	1.48	U
17	USGS HTH #1 (2,300 ft)	27-Feb-2002	1.81	2.14	1.62	B
18	UE-18R (1,700 ft)	22-May-2002	4.93	2.96	1.69	
19	ER-19-1 (2,710 ft)	29-May-2002	12.50	11.92	6.82	
19	ER-19-1 (3,280 ft)	29-May-2002	-3.24	3.54	3.18	U
20	ER-20-1	18-Jun-2002	3.00	2.00	1.30	
20	ER-20-2 #1	19-Jun-2002	2.20	2.60	2.00	
20	WELL PM-1	25-Jun-2002	1.22	1.93	1.54	U
25	UE-25 WT #6	02-Oct-2002	5.80	3.40	2.17	
25	UE-25P #1	25-Sep-2002	11.30	4.04	1.17	
Offsite Wells and Springs						
95	Ash-B Piezom #1	10-Sep-2002	0.26	1.18	1.02	U
95	Ash-B Piezom #2	10-Sep-2002	2.20	2.72	2.05	
95	Beatty Water And Sewer	11-Dec-2002	14.30	5.16	2.13	
95	Big Springs	18-Apr-2002	4.05	2.24	1.30	
95	Crystal Pool	18-Apr-2002	4.75	2.22	1.01	
95	ER-OV-03C	06-Nov-2002	11.50	4.10	1.65	
95	ER-OV-03C2	06-Nov-2002	10.90	3.72	1.72	
95	ER-OV-06A	05-Nov-2002	9.23	3.68	1.58	
95	Fairbanks Spring	18-Apr-2002	2.74	2.04	1.43	
95	Longstreet Spring	18-Apr-2002	4.65	2.08	1.00	
95	Peacock Ranch	18-Apr-2002	1.86	2.34	1.84	B
95	PM-3	07-Aug-2002	8.86	3.64	1.61	
95	Revert Spring	18-Apr-2002	5.63	2.34	0.99	
95	Roger Bright Ranch	11-Dec-2002	5.54	3.88	2.26	
95	School Well	11-Dec-2002	3.51	3.10	2.13	
95	Spicer Ranch	18-Apr-2002	12.30	4.26	1.27	
95	Tolicha Peak	27-Aug-2002	3.02	1.96	1.20	
95	U.S. Ecology	11-Dec-2002	5.68	3.90	2.37	
95	USW H-1	20-Nov-2002	8.25	3.24	1.64	

MDC - Minimum detectable concentration.
U - Below detectable limit.
B - Result less than requested MDC, but greater than sample-specific MDC.
Note: All sample types are “grab”.

Table 8.4 Summary of Gross Beta Results - 2002

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier
Onsite Supply Wells						
05	Water Well 5B	19-Feb-2002	10.00	3.40	1.30	
05	Water Well 5B	23-Apr-2002	10.50	3.24	1.01	
05	Water Well 5B	16-Jul-2002	11.80	4.42	2.09	
05	Water Well 5B	15-Oct-2002	12.50	1.65	1.84	
05	Water Well 5C	19-Feb-2002	7.30	2.60	1.30	
05	Water Well 5C	23-Apr-2002	5.95	2.26	1.18	
05	Water Well 5C	16-Jul-2002	7.06	3.00	1.77	
05	Water Well 5C	15-Oct-2002	7.21	1.61	2.04	
06	Water Well #4	25-Feb-2002	4.50	2.00	1.30	
06	Water Well #4	23-Apr-2002	5.86	2.14	1.07	
06	Water Well #4	16-Jul-2002	6.12	2.78	1.62	
06	Water Well #4	15-Oct-2002	5.60	1.85	2.02	
06	Water Well #4A	19-Feb-2002	5.90	2.40	1.40	
06	Water Well #4A	23-Apr-2002	6.31	2.22	1.03	
06	Water Well #4A	16-Jul-2002	7.14	3.36	2.05	
06	Water Well #4A	15-Oct-2002	8.72	1.78	1.85	
06	Water Well C-1	19-Feb-2002	14.00	4.60	2.00	
06	Water Well C-1	23-Apr-2002	16.10	5.20	1.99	
06	Water Well C-1	16-Jul-2002	14.70	5.24	2.49	
06	Water Well C-1	15-Oct-2002	15.90	2.34	2.25	
16	UE-16D ELEANA Water Well	19-Feb-2002	8.00	2.80	1.30	
16	UE-16D ELEANA Water Well	23-Apr-2002	7.63	2.56	1.09	
16	UE-16D ELEANA Water Well	16-Jul-2002	7.77	3.44	1.98	
16	UE-16D ELEANA Water Well	15-Oct-2002	7.94	1.73	2.21	
18	Water Well 8 (USGS HTH-8)	19-Feb-2002	3.00	1.82	1.30	B
18	Water Well 8 (USGS HTH-8)	23-Apr-2002	3.32	1.57	1.00	B
18	Water Well 8 (USGS HTH-8)	16-Jul-2002	3.30	2.36	1.72	B
18	Water Well 8 (USGS HTH-8)	15-Oct-2002	3.83	1.38	2.18	
22	ARMY #1 Water Well	20-Feb-2002	6.20	2.40	1.30	
22	ARMY #1 Water Well	24-Apr-2002	6.11	2.30	1.21	
22	ARMY #1 Water Well	17-Jul-2002	5.70	3.18	2.21	
22	ARMY #1 Water Well	16-Oct-2002	7.15	1.53	2.04	
25	J-12 Water Well	20-Feb-2002	4.60	2.20	1.30	
25	J-12 Water Well	24-Apr-2002	3.62	1.62	0.99	B
25	J-12 Water Well	17-Jul-2002	4.48	2.40	1.55	
25	J-12 Water Well	16-Oct-2002	4.58	1.13	1.74	

Table 8.4 (Summary of Gross Beta Results - 2002, cont.)

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier
Onsite Supply Wells, cont.						
25	J-13 Water Well	20-Feb-2002	4.30	2.00	1.30	
25	J-13 Water Well	24-Apr-2002	4.76	1.86	1.00	
25	J-13 Water Well	17-Jul-2002	3.25	2.20	1.57	B
25	J-13 Water Well	16-Oct-2002	5.18	1.17	1.68	
Onsite Monitoring Wells						
01	UE-1Q	16-Oct-2002	9.31	3.94	2.09	
06	ER-6-1 (2,017 ft)	29-Jan-2002	13.00	4.20	1.30	
06	ER-6-1 (2,228 ft)	29-Jan-2002	14.00	4.40	1.30	
07	UE-7NS	05-Feb-2002	4.80	2.20	1.30	
17	USGS HTH #1 (1,935 ft)	27-Feb-2002	1.23	1.71	1.39	U
17	USGS HTH #1 (2,040 ft)	27-Feb-2002	1.02	1.75	1.44	U
17	USGS HTH #1 (2,130 ft)	27-Feb-2002	0.90	1.80	1.49	U
17	USGS HTH #1 (2,300 ft)	27-Feb-2002	0.63	1.81	1.52	U
18	UE-18R (1,700 ft)	22-May-2002	1.32	1.36	1.30	
18	UE-18R (2,130 ft)	22-May-2002	3.99	1.05	0.61	
19	ER-19-1 (2,710 ft)	29-May-2002	115.00	4.90	3.56	
19	ER-19-1 (3,280 ft)	29-May-2002	44.80	1.52	1.23	
20	ER-20-1	18-Jun-2002	4.30	2.60	1.80	
20	ER-20-2 #1	19-Jun-2002	5.30	2.80	2.00	
20	WELL PM-1	25-Jun-2002	4.61	2.32	1.53	
25	UE-25 WT #6	02-Oct-2002	10.10	4.74	3.04	
25	UE-25P #1	25-Sep-2002	8.76	3.08	1.38	
Offsite Wells and Springs						
95	Ash-B Piezom #1	10-Sep-2002	4.67	2.14	1.29	
95	Ash-B Piezom #2	10-Sep-2002	9.97	4.52	2.71	
95	Beatty Water And Sewer	11-Dec-2002	4.94	1.61	1.28	
95	ER-OV-01	05-Nov-2002	23.40	3.46	2.35	
95	ER-OV-2002	06-Nov-2002	25.70	3.96	2.69	
95	ER-OV-03C	06-Nov-2002	6.70	2.54	2.44	
95	ER-OV-03C2	06-Nov-2002	5.24	2.70	2.72	
95	ER-OV-06A	05-Nov-2002	12.20	2.44	2.32	
95	PM-3	07-Aug-2002	21.30	6.78	2.48	
95	Roger Bright Ranch	11-Dec-2002	9.23	1.35	1.31	
95	School Well	11-Dec-2002	8.59	1.40	1.33	
95	Tolicha Peak	27-Aug-2002	4.13	2.42	1.68	
95	U.S. Ecology	11-Dec-2002	5.80	1.44	1.46	

Table 8.4 (Summary of Gross Beta Results - 2002, cont.)

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier
Offsite Wells and Springs, cont.						
95	USW H-1	20-Nov-2002	5.73	2.56	2.54	
95	Big Springs	18-Apr-2002	8.34	3.08	1.53	
95	Crystal Pool	18-Apr-2002	8.67	3.12	1.50	
95	Fairbanks Spring	18-Apr-2002	7.80	2.76	1.31	
95	Longstreet Spring	18-Apr-2002	6.74	2.56	1.32	
95	Peacock Ranch	18-Apr-2002	9.76	3.46	1.62	
95	Revert Spring	18-Apr-2002	4.39	2.02	1.26	
95	Spicer Ranch	18-Apr-2002	5.82	2.74	1.74	

MDC - Minimum detectable concentration.
U - Below detectable limit.
B - Result less than requested MDC, but greater than sample-specific MDC.
Note: All sample types are “grab”.

Table 8.5 Summary of ^{226}Ra Results - 2002

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier
Onsite Supply Wells						
05	Water Well 5B	16-Jul-2002	0.0926	0.1788	0.139	U
05	Water Well 5B	15-Oct-2002	0.147	0.498	0.441	U
05	Water Well 5C	15-Oct-2002	0.296	0.616	0.486	U
05	Water Well 5C	16-Jul-2002	0.0753	0.31	0.269	U, X
06	Water Well #4	16-Jul-2002	0.179	0.326	0.263	U
06	Water Well #4	15-Oct-2002	0.213	0.522	0.427	U
06	Water Well #4A	16-Jul-2002	0.0363	0.1334	0.119	U
06	Water Well #4A	15-Oct-2002	0.178	0.576	0.503	U
06	Water Well C-1	16-Jul-2002	1.37	0.576	0.239	
06	Water Well C-1	15-Oct-2002	2	1.07	0.254	
16	UE-16D ELEANA Water Well	16-Jul-2002	1.07	0.54	0.246	
16	UE-16D ELEANA Water Well	15-Oct-2002	0.961	0.922	0.542	
18	Water Well 8 (USGS HTH-8)	16-Jul-2002	-0.09	0.1406	0.187	U
18	Water Well 8 (USGS HTH-8)	15-Oct-2002	0.255	0.622	0.514	U
22	ARMY #1 Water Well	17-Jul-2002	0.651	0.47	0.287	B
22	ARMY #1 Water Well	16-Oct-2002	0.562	0.588	0.259	
25	J-12 Water Well	17-Jul-2002	-0.106	0.232	0.246	U
25	J-12 Water Well	16-Oct-2002	-0.0394	0.408	0.473	U
25	J-13 Water Well	17-Jul-2002	-0.0689	0.1398	0.171	U
25	J-13 Water Well	16-Oct-2002	0.104	0.408	0.374	U

MDC - Minimum detectable concentration.
U - Below detectable limit.
B - Result less than requested MDC, but greater than sample-specific MDC.
X - Problem with result is specified in the analytical laboratory case narrative.
Note: Only onsite water-supply wells were sampled for ^{226}Ra. All sample types are “grab”..

Table 8.6 Summary of ^{228}Ra Results - 2002

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier
Onsite Supply Wells						
05	Water Well 5B	16-Jul-2002	0.16	0.82	0.68	U
05	Water Well 5B	15-Oct-2002	0.166	0.844	0.772	U
05	Water Well 5C	16-Jul-2002	0.42	0.96	0.78	U
05	Water Well 5C	15-Oct-2002	0.443	1.012	0.897	U
06	Water Well #4	16-Jul-2002	0.52	0.86	0.68	U
06	Water Well #4	15-Oct-2002	0.889	1.232	1.04	U
06	Water Well #4A	16-Jul-2002	0.38	0.8	0.64	U
06	Water Well #4A	15-Oct-2002	0.59	1.218	1.07	U
06	Water Well C-1	16-Jul-2002	0.89	0.92	0.71	B
06	Water Well C-1	15-Oct-2002	0.803	1.19	1.02	U
16	UE-16D ELEANA Water Well	16-Jul-2002	0.27	0.9	0.74	U
16	UE-16D ELEANA Water Well	15-Oct-2002	0.526	0.892	0.773	U
18	Water Well 8 (USGS HTH-8)	16-Jul-2002	0.28	0.78	0.64	U
18	Water Well 8 (USGS HTH-8)	15-Oct-2002	-0.133	0.804	0.757	U
22	ARMY #1 Water Well	17-Jul-2002	1.2	1.04	0.77	
22	ARMY #1 Water Well	16-Oct-2002	0.836	0.944	0.774	
25	J-12 Water Well	17-Jul-2002	0.72	0.92	0.72	B
25	J-12 Water Well	16-Oct-2002	0.674	1	0.841	U
25	J-13 Water Well	17-Jul-2002	0.84	1	0.77	B
25	J-13 Water Well	16-Oct-2002	0.405	0.918	0.811	U

MDC - Minimum detectable concentration.
U - Below detectable limit.
B - Result less than requested MDC, but greater than sample-specific MDC.
Note: Only onsite water-supply wells were sampled for ^{228}Ra. All sample types are “grab”.

Table 8.7 Summary of ^{238}Pu Results - 2002

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier	Sample Type
Onsite Supply Wells							
05	Water Well 5B	19-Feb-2002	-0.00376	0.01806	0.0208	U	Grab
05	Water Well 5B	16-Jul-2002	-0.00175	0.01684	0.0194	U	Grab
05	Water Well 5C	19-Feb-2002	0.00383	0.01842	0.0147	U	Grab
05	Water Well 5C	16-Jul-2002	0	0.01672	0.00522	U	Grab
06	Water Well #4	25-Feb-2002	0.00181	0.01736	0.0173	U	Grab
06	Water Well #4	01-Jul-2002	0.00793	0.0242	0.0229	U	Grab
06	Water Well #4	16-Jul-2002	0.00181	0.01736	0.0138	U	Grab
06	Water Well #4A	19-Feb-2002	-0.00234	0.042	0.0432	U	Grab
06	Water Well #4A	01-Jul-2002	-0.0044	0.025	0.0321	U	Grab
06	Water Well #4A	16-Jul-2002	0.00375	0.01802	0.00562	U	Grab
06	Water Well C-1	19-Feb-2002	0.00377	0.0234	0.0232	U	Grab
06	Water Well C-1	19-Feb-2002	0.00626	0.02	0.00626	B	FD
06	Water Well C-1	16-Jul-2002	-0.00367	0.01764	0.0176	U	Grab
16	UE-16D ELEANA Water Well	19-Feb-2002	-0.00235	0.0226	0.026	U	Grab
16	UE-16D ELEANA Water Well	16-Jul-2002	0.00661	0.023	0.0211	U	Grab
18	Water Well 8 (USGS HTH-8)	19-Feb-2002	0	0.01802	0.018	U	Grab
18	Water Well 8 (USGS HTH-8)	16-Jul-2002	-0.00515	0.0202	0.0247	U	Grab
22	ARMY #1 Water Well	20-Feb-2002	0.00239	0.0364	0.0366	U	Grab
22	ARMY #1 Water Well	17-Jul-2002	0	0.0258	0.0285	U	Grab
25	J-12 Water Well	20-Feb-2002	0.00264	0.045	0.0447	U	Grab
25	J-12 Water Well	17-Jul-2002	-0.00352	0.01692	0.0195	U	Grab
25	J-13 Water Well	20-Feb-2002	-0.0155	0.04	0.0452	U	Grab
25	J-13 Water Well	17-Jul-2002	0.00701	0.01694	0.0134	U	Grab
Onsite Monitoring Wells							
01	UE-1Q	16-Oct-2002	0.000953	0.0378	0.044	U	Grab
06	ER-6-1 (2,017 ft)	29-Jan-2002	-0.0037	0.0244	0.0249	U	Grab
06	ER-6-1 (2,228 ft)	29-Jan-2002	0.00437	0.0288	0.0336	U	Grab
07	UE-7NS	05-Feb-2002	0.0127	0.0316	0.0272	U	Grab
17	USGS HTH #1 (1,935 ft)	27-Feb-2002	0.00442	0.025	0.0208	U	Grab
17	USGS HTH #1 (2,040 ft)	27-Feb-2002	0.0248	0.0532	0.0458	U	Grab
17	USGS HTH #1 (2,130 ft)	27-Feb-2002	-0.00162	0.0456	0.0559	U	Grab
17	USGS HTH #1 (2,300 ft)	27-Feb-2002	0.00314	0.0422	0.0491	U	Grab
18	UE-18R (1,700 ft)	22-May-2002	0.0057	0.01296	0.0057		Grab
18	UE-18R (2,130 ft)	22-May-2002	0	0.00792	0.00606	U	Grab
19	ER-19-1 (2,710 ft)	29-May-2002	0.0161	0.0366	0.0161		Grab

Table 8.7 (Summary of ^{238}Pu Results - 2002, cont.)

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier	Sample Type
Onsite Monitoring Wells, cont.							
19	ER-19-1 (3,280 ft)	29-May-2002	0.00462	0.0258	0.0289	U	Grab
19	U-19BH	23-May-2002	-0.00613	0.01702	0.0365	U	Grab
20	ER-20-1	18-Jun-2002	-0.00199	0.0234	0.0266	U	Grab
20	ER-20-2 #1	19-Jun-2002	-0.012	0.0368	0.0407	U	Grab
20	WELL PM-1	25-Jun-2002	-0.000706	0.028	0.0286	U	Grab
25	UE-25 WT #6	02-Oct-2002	-0.00249	0.0328	0.0273	U	Grab
25	UE-25P #1	25-Sep-2002	0.004	0.0264	0.0308	U	Grab
Offsite Wells and Springs							
95	Ash-B Piezom #1	10-Sep-2002	0.00563	0.0318	0.0266	U	Grab
95	Ash-B Piezom #2	10-Sep-2002	0.00655	0.0372	0.0309	U	Grab
95	Beatty Water And Sewer	11-Dec-2002	-0.00195	0.01708	0.0215	U	Grab
95	Big Springs	18-Apr-2002	0.00827	0.0274	0.0227	U	Grab
95	Crystal Pool	18-Apr-2002	-0.0114	0.0252	0.0373	U	Grab
95	ER-OV-01	05-Nov-2002	0.00327	0.01284	0.00981	U	Grab
95	ER-OV-2002	06-Nov-2002	0.00387	0.0258	0.0283	U	Grab
95	ER-OV-03C	06-Nov-2002	0.00288	0.0167	0.0188	U	Grab
95	ER-OV-03C2	06-Nov-2002	0	0.0095	0.00727	U	Grab
95	ER-OV-06A	05-Nov-2002	-0.0177	0.0322	0.0494	U	Grab
95	Fairbanks Spring	18-Apr-2002	-0.0105	0.026	0.0411	U	Grab
95	Longstreet Spring	18-Apr-2002	-0.00203	0.0268	0.0223	U	Grab
95	Peacock Ranch	18-Apr-2002	0	0.0366	0.0139	U	FD
95	Peacock Ranch	18-Apr-2002	-0.00156	0.0308	0.0398	U	Grab
95	PM-3	07-Aug-2002	0.00671	0.0344	0.0371	U	Grab
95	Revert Spring	18-Apr-2002	0.00262	0.026	0.0265	U	FD
95	Revert Spring	18-Apr-2002	-0.00124	0.0246	0.0316	U	Grab
95	Roger Bright Ranch	11-Dec-2002	-0.00192	0.00754	0.0147	U	Grab
95	School Well	11-Dec-2002	0.00173	0.0068	0.0052	U	Grab
95	Spicer Ranch	18-Apr-2002	-0.00129	0.0254	0.0328	U	FD
95	Spicer Ranch	18-Apr-2002	-0.00608	0.0304	0.045	U	Grab
95	Tolicha Peak	27-Aug-2002	0.00112	0.0222	0.0185	U	Grab
95	U.S. Ecology	11-Dec-2002	0.0018	0.00706	0.00539	U	Grab
95	USW H-1	20-Nov-2002	0.00301	0.0264	0.0288	U	Grab

MDC - Minimum detectable concentration.
U - Below detectable limit.
B - Result less than requested MDC, but greater than sample-specific MDC.
FD - Field duplicate.

Table 8.8 Summary of $^{239+240}Pu$ Results - 2002

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier	Sample Type
Onsite Supply Wells							
05	Water Well 5B	19-Feb-2002	0.00188	0.01804	0.00563	U	Grab
05	Water Well 5B	16-Jul-2002	0	0.01684	0.00526	U	Grab
05	Water Well 5C	19-Feb-2002	0.00192	0.0184	0.0147	U	Grab
05	Water Well 5C	16-Jul-2002	0.00348	0.01674	0.00522	U	Grab
06	Water Well #4	25-Feb-2002	0	0.01734	0.00542	U	Grab
06	Water Well #4	01-Jul-2002	0.00283	0.0224	0.00849	U	Grab
06	Water Well #4	16-Jul-2002	0	0.01734	0.0173	U	Grab
06	Water Well #4A	19-Feb-2002	-0.00468	0.026	0.0314	U	Grab
06	Water Well #4A	01-Jul-2002	0.00315	0.025	0.00944	U	Grab
06	Water Well #4A	16-Jul-2002	0	0.018	0.00562	U	Grab
06	Water Well C-1	19-Feb-2002	0.00189	0.01812	0.0144	U	Grab
06	Water Well C-1	19-Feb-2002	0	0.02	0.016	U	FD
06	Water Well C-1	16-Jul-2002	0.00183	0.01762	0.0176	U	Grab
16	UE-16D ELEANA Water Well	19-Feb-2002	0	0.0226	0.018	U	Grab
16	UE-16D ELEANA Water Well	16-Jul-2002	-0.0022	0.0212	0.0244	U	Grab
18	Water Well 8 (USGS HTH-8)	19-Feb-2002	0	0.01802	0.00563	U	Grab
18	Water Well 8 (USGS HTH-8)	16-Jul-2002	-0.00172	0.01648	0.0164	U	Grab
22	ARMY #1 Water Well	20-Feb-2002	0.00718	0.0282	0.0265	U	Grab
22	ARMY #1 Water Well	17-Jul-2002	-0.00463	0.0222	0.0256	U	Grab
25	J-12 Water Well	20-Feb-2002	0.0105	0.0294	0.0253	U	Grab
25	J-12 Water Well	17-Jul-2002	-0.00176	0.0169	0.0135	U	Grab
25	J-13 Water Well	20-Feb-2002	0.00443	0.0212	0.0169	U	Grab
25	J-13 Water Well	17-Jul-2002	-0.00351	0.01686	0.0168	U	Grab
Onsite Monitoring Wells							
01	UE-1Q	16-Oct-2002	-0.00286	0.0378	0.0314	U	Grab
06	ER-6-1 (2,017 ft)	29-Jan-2002	0	0.0244	0.00924	U	Grab
06	ER-6-1 (2,228 ft)	29-Jan-2002	0.00146	0.0288	0.024	U	Grab
07	UE-7NS	05-Feb-2002	-0.00402	0.0266	0.0271	U	Grab
17	USGS HTH #1 (1,935 ft)	27-Feb-2002	0.000631	0.025	0.0292	U	Grab
17	USGS HTH #1 (2,040 ft)	27-Feb-2002	-0.0031	0.0306	0.0357	U	Grab
17	USGS HTH #1 (2,130 ft)	27-Feb-2002	0.0138	0.0334	0.0267	U	Grab
17	USGS HTH #1 (2,300 ft)	27-Feb-2002	0.00784	0.0312	0.0118	U	Grab
18	UE-18R (1,700 ft)	22-May-2002	0.0057	0.0224	0.021	U	Grab
18	UE-18R (2,130 ft)	22-May-2002	-0.00605	0.0286	0.0326	U	Grab
19	ER-19-1 (2,710 ft)	29-May-2002	0.00171	0.0388	0.0483	U	Grab

Table 8.8 (Summary of $^{239/240}$Pu Results - 2002, cont.)

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier	Sample Type
Onsite Monitoring Wells, cont.							
19	ER-19-1 (3,280 ft)	29-May-2002	0.00924	0.0364	0.0359	U	Grab
19	U-19BH	23-May-2002	-0.00187	0.0238	0.0365	U	Grab
25	UE-25 WT #6	02-Oct-2002	-0.00248	0.0328	0.0273	U	Grab
25	UE-25P #1	25-Sep-2002	0.0127	0.0314	0.0269	U	Grab
Offsite Wells And Springs							
95	Ash-B Piezom #1	10-Sep-2002	0.00402	0.0318	0.0121	U	Grab
95	Ash-B Piezom #2	10-Sep-2002	-0.000935	0.037	0.0379	U	Grab
95	Beatty Water And Sewer	11-Dec-2002	-0.00779	0.0286	0.033	U	Grab
95	ER-OV-01	05-Nov-2002	0.000409	0.01702	0.024	U	Grab
95	ER-OV-2002	06-Nov-2002	-0.000387	0.0408	0.0449	U	Grab
95	ER-OV-03C	06-Nov-2002	-0.00224	0.01332	0.0188	U	Grab
95	ER-OV-03C2	06-Nov-2002	0.00242	0.0095	0.00727	U	Grab
95	ER-OV-06A	05-Nov-2002	-0.00153	0.0318	0.0399	U	Grab
95	PM-3	07-Aug-2002	-0.00536	0.0268	0.0396	U	Grab
95	Roger Bright Ranch	11-Dec-2002	-0.00384	0.01846	0.0236	U	Grab
95	School Well	11-Dec-2002	-0.0052	0.0264	0.0294	U	Grab
95	Tolicha Peak	27-Aug-2002	-0.000562	0.0222	0.0227	U	Grab
95	U.S. Ecology	11-Dec-2002	0	0.01726	0.0199	U	Grab
95	USW H-1	20-Nov-2002	-7.17E-10	0.0236	0.0288	U	Grab

MDC - Minimum detectable concentration.
U - Below detectable limit.
FD - Field duplicate.

Table 8.9 Summary of ^{90}Sr Results - 2002

Area	Location	Date Sampled	Result (pCi/L)	Error (2ω)	MDC (pCi/L)	Lab Qualifier	Sample Type
Onsite Supply Wells							
05	Water Well 5B	16-Jul-2002	0.212	1.054	0.911	U	Grab
05	Water Well 5C	16-Jul-2002	0.259	0.886	0.753	U	Grab
06	Water Well #4	16-Jul-2002	0.278	1.054	0.896	U	Grab
06	Water Well #4A	16-Jul-2002	-0.383	0.768	0.723	U	Grab
06	Water Well C-1	16-Jul-2002	-0.0617	0.826	0.74	U	FD
06	Water Well C-1	16-Jul-2002	-0.11	0.79	0.716	U	Grab
16	UE-16D ELEANA Water Well	16-Jul-2002	-0.0107	0.828	0.736	U	Grab
18	Water Well 8 (USGS HTH-8)	16-Jul-2002	0.0517	0.642	0.558	U	Grab
22	ARMY #1 Water Well	17-Jul-2002	0.015	0.822	0.728	U	Grab
25	J-12 Water Well	17-Jul-2002	0.184	1.056	0.914	U	Grab
25	J-13 Water Well	17-Jul-2002	0.368	1.022	0.856	U	Grab
Offsite Wells And Springs							
95	USW H-1	20-Nov-2002	0.54	0.92	0.857	U	Grab

MDC - Minimum detectable concentration.
U - Estimated.
FD - Field duplicate.

Table 8.10 Summary of the DRI Groundwater Monitoring Program - 2002

Monitoring Location	Date	Sampling Method
Alamo city water supply system - source of water is municipal well field	07-May-2002	By hand from distribution system
Amargosa school well	30-May-2002	By hand from well head
Beatty Water and Sanitation - municipal well	08-May-2002	By hand from well head
Boulder City- at Hemingway Park from municipal water distribution system	05-May-2002	By hand from distribution system
Caliente municipal water supply well	11-May-2002	By hand from well head
Cedar City municipal water supply well located 8 miles west of town	13-May-2002	By hand from well head
Delta municipal well	12-May-2002	By hand from well head
Goldfield Municipal Water System	08-May-2002	By hand from Water Utilities headquarters
Henderson CCSN, source of water is municipal water system originating at Lake Mead	05-May-2002	By hand from distribution system
Indian Springs municipal well	30-May-2002	By hand from well head
Las Vegas Valley Water District #103	10-May-2002	By hand from well head
Medlin's Ranch spring located 11 miles west of ranch house	01-May-2002	By hand from faucet at ranch house
Overton municipal water supply well located 18 miles northwest of town	06-May-2002	By hand from well head
Pahrump municipal well	30-May-2002	By hand from well head
Pioche municipal well located ½ mile east of town	11-May-2002	By hand from well head
Rachel - Little Ale Inn well	07-May-2002	By hand from well head
St. George Gunlock Well Field Storage System	12-May-2002	By hand from inlet pipe to storage tank
Tonopah Public Utilities well field located 12 miles from town	08-May-2002	By hand from well head
Milford Municipal Well	12-Jun-2002	By hand from well head
Adaven Springs	30-Apr-2002	By hand from stream draining spring discharge
Nyala Ranch Water Well	25-Jun-2002	By hand from faucet outside house
Stone Cabin Ranch Spring	01-May-2002	By hand from faucet inside house
Twin Springs Ranch Spring	01-May-2002	By hand from faucet at house
Sarcobatus Flat wellhead	08-May-2002	By hand from well head

Table 8.11 Summary of DRI Groundwater Tritium Results - 2002

Sample Point	Results (pCi/L)	Uncertainty (2 Std Deviation pCi/L)	Minimum Detection Limit (pCi/L)
Alamo city water supply system - source of water is municipal well field	2	8	0.82
Amargosa school well	<1	8	0.85
Beatty Water and Sanitation - municipal well	2	7	0.75
Boulder City water treatment plant - source of water is Lake Mead	27	8	0.85
Caliente municipal water supply well	8	9	0.88
Cedar City municipal water supply well located 8 mi west of town	<1	12	0.85
Delta municipal well	<1	7	0.88
Goldfield Utilities Klondike #2 located 12 miles north of town	<1	6	0.75
Henderson CCSN, source of water is municipal water system originating at Lake Mead	26	6	0.85
Indian Springs municipal well	5	7	0.85
Las Vegas Valley Water District #103	1	7	0.85
Medlin Ranch spring located 11 miles west of ranch house	4	8	0.82
Milford municipal water supply well located 1 mi south of town	<1	9	0.88
Overton municipal water supply well located 18 miles NW of town	<1	8	0.88
Pahrump municipal well	<1	8	0.85
Pioche municipal well located ½ mile east of town	4	8	0.88
Rachel - Little Ale Inn well	1	8	0.82
St. George municipal water supply well located 15 mi. north of town	8	9	0.85
Tonopah Public Utilities well field located 12 miles from town	<1	7	0.75
Nyala Ranch	<1	6	0.85
Adaven Springs	15	10	0.82
Stone Cabin Ranch	2	6	0.75
Twin Springs Ranch	<1	8	0.82
Sarcobatus Flat	<1	9	0.75

U12 Overview of all Ponds from the Top of Muck Pile (March 13, 1989)

9.0 QUALITY ASSURANCE PROGRAM

The Routine Radiological Environmental Monitoring Plan (RREMP) quality assurance program (QAP) ensures compliance with U.S. Department of Energy (DOE) Order 414.1A Change 1 and implements a quality management system which ensures the generation and use of quality data. Accordingly, this QAP addresses the following:

- **Data Quality Objectives (DQO) (see Appendix E, DOE 2003b) development appropriate to execute scope in accordance with DOE and other requirements.**
- **Sampling Plan development (see Appendices A through E, DOE 2003b) appropriate to satisfy the DQOs.**
- **Environment, Safety, and Health - ensuring scope is executed in a manner that achieves, maintains and improves quality while minimizing environment, safety, and health risks to the public and the environment.**
- **Sampling Plan execution - conducted in accordance with plans, procedures, and instructions.**
- **Sample Analyses - ensuring analysis of samples for required parameters meet BN, customer, and regulatory-defined requirements.**
- **Data Review (see Appendix F, DOE 2003b) - instructions for analytical data deliverable reviews to ensure quality data.**
- **Continuous Improvement - establishing a process for assessing the process, identifying nonconforming items, determining casual factors, implementing corrective actions, monitoring for corrective action effectiveness, and providing feedback and lessons learned.**

9.1 DATA QUALITY OBJECTIVES (DQOS)

The DQO 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. Since DQOs are unique to the specific data collection/monitoring activity, they are further explained in Appendices A through E of DOE 2003b.

9.2 MEASUREMENT QUALITY OBJECTIVES (MQOS)

The 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 precision, accuracy, representativeness, completeness, and comparability from the overall monitoring effort to provide correlation with laboratory efforts. See Appendices A through E of DOE 2003b for additional discussions on the monitoring of precision, accuracy, representativeness, completeness, and comparability.

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. See Appendices A through E of DOE 2003b for additional discussion.

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 and/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.

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. See the specific appendix for additional discussion.

Accuracy related to laboratory operations is monitored by performing measurements and evaluating results of control samples of known composition which contain the analyte(s) 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.

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 related to the overall monitoring effort is discussed in Appendices A through E of DOE 2003b. 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 that samples, if a heterogeneous matrix (soil, sludge, solids, etc.), should be homogenized prior to aliquoting for preparation and/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/replicate analyses are additional controls allowing determination of representativeness.

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 managed through ensuring that sampling design, sample collection and handling, laboratory analyses, and data review are performed in accordance with established Operating Instructions and Organizational Procedures and standardized methodologies.

Comparability regarding laboratory operations is managed through direction to the laboratory that standard methods 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.

9.3 SAMPLING QA PROGRAM

QA in field operations includes sampling assessments, surveillances, and oversight of the following supporting elements:

- The statement of work (SOW) or sampling plan, data quality objectives, organizational instructions, and field logs maintained in the Sample Package.
- Database support including the Bechtel Environmental Integrated Data Management System (BEIDMS) for field data and laboratory results and the Optix system used for scanning and long term storage and retrieval of the Sample Package as a graphic image.
- A training program to ensure qualified personnel are available to perform the required tasks.

Sample Packages must be prepared prior to conducting any sampling and may include the following items:

- Checklist to include:

  Routing list showing all personnel which must review and approve the sample package.
  - Pre-job and post-job checklist which cover PPE, safety, etc.
  - Sample package task lead summary.

- Requested analyses.
- Performance evaluation or certification for all labs that do the requested analyses.
- Signature page (which includes signatures of all personnel).

∉ Field Logs for all samples required to be taken.

∉ Work Package which includes the traveler sheet, if required.

∉ Specific, detailed Work Instructions.

∉ Material Safety Data Sheets for all chemicals that are being used for the job.

∉ Support Execution Plan.

∉ 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 operating instructions and sampling protocol and that the operating instructions represent what is actually being done.

DATABASE SUPPORT

Data obtained in the course of executing field operations are entered in the Sample Package during field work and in the BEIDMS (see Appendix F, DOE 2003b) after completion of the field activities.

Completed Sample Packages, analysis results, data review checklists, etc., are optically scanned and entered into the Optix Data Base (see Appendix F, DOE 2003b) to enhance accessibility to these documents.

TRAINING

BN ensures that all personnel are properly trained and qualified prior to doing work under the RREMP. Training must be current for personnel involved in work performed under the RREMP. Records are maintained to identify training required for each individual and current status, and are checked prior to each sampling episode to ensure proper qualification of personnel. Job-specific training requirements are checked by the field sampling supervisor prior to assignment of personnel to sampling jobs. Personnel not properly trained will not be allowed to perform the associated sampling tasks.

9.4 LABORATORY QA OVERSIGHT

BN ensures DOE Order 414.1A, “Quality Assurance” requirements are met with respect to laboratory services through flow-down to vendor laboratories via subcontracts. The laboratory policies and approach to the implementation of DOE Order 414.1A must be formalized in 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. BN is assured of obtaining quality data through a multifaceted approach.

PROCUREMENT

Laboratory services are procured through subcontract. The subcontract provides the requirements flow-down mechanism which 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 competed via the request for proposal (RFP) process and is awarded on a "best value" basis. The RFP generally requires a prospective vendor to submit in a proposal:

- All procedures pertinent to subcontract scope.
- ES&H plan.
- LQAP.
- Example deliverables (hardcopy and electronic).
- Proficiency Testing (PT) results from previous years from participation in recognized PT programs (9.3.2).
- Resumes.
- Facility design/description.
- Accreditations and certifications.
- Licenses.
- Audits performed within the last year by the DOE Environmental Management Consolidated Audit Program (EMCAP), other DOE sites, or other audits (DOD, etc.) covering comparable scope and acceptable to the BN.
- Past performance surveys.
- 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 the technical evaluation is not biased by pricing.

INITIAL AND CONTINUING ASSESSMENT

Initial assessment is managed through 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 EMCAP audit) of those laboratories awarded the contract. However, in no instance shall BN initiate work with a laboratory without approval of BN personnel authorized for ensuring acceptable vendors.

Continuing assessment involves 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, DOE 2003b).
- Monitoring of the lab's adherence to the LQAP.
- Conducting regular audits or participation in and/or evaluation of EMCAP audit products.
- Monitoring for continued successful participation in PT programs. The subcontract established with the laboratory requires or suggests participation in the following proficiency testing (PT) programs:
  - DOE Environmental Measurements LQAP.
  - DOE Mixed Analyte Performance Evaluation Program administered by the Radiological and Environmental Sciences Laboratory located at the Idaho Operations Office.
  - 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.

LABORATORY QA PROGRAM

The laboratory policies and approach to the implementation of DOE Order 414.1A must be formalized in a 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.

Program

A written QAP shall be developed, implemented, and maintained. Such program shall be documented by a LQAP that contains or references written policies, procedures, or instructions representing compliance to DOE 414.1A. The LQAP shall:

- Describe the organizational structure, functional responsibilities, levels of authority, and interfaces for those managing, performing, and assessing the work.
- Define the organization's policies regarding, and its commitment to, ethical standards, client confidentiality, and the implementation of safety and quality standards.
- Establish that senior management shall be responsible for establishing the scope of the LQAP and implementing, assessing, and continually improving an effective quality system.
- Establish that line management shall be responsible for achieving quality in specific activities.
- Designate an individual responsible for developing, implementing, and routinely monitoring the LQAP program.
- Establish 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.

- Establish 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.

- Establish 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.

QA and/or Quality Control (QC) positions shall report to the highest level of management (e.g., manager or director). The QA program shall identify positions 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.

Following are excerpts of additional requirements placed on the laboratory through the subcontract. Compliance with requirements are verified through Initial and Continuing Assessment.

- **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 EPA, NIST, 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 Statement of Work 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.

9.5 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 operations data collection prior to and upon data entry into the BEIDMS.

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.

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. 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:

- Evaluate the quality of the data to ensure that all project requirements are met.
- Determine 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.
- Document 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). Operating Instructions/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.

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 review requires a systematic review against pre-established criteria to verify that the data are valid for their intended use. Data review is conducted by the technical lead and is the final review performed.

9.6 ASSESSMENTS

The overall effectiveness of the QA program is determined through systematic assessments and/or surveillances of 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 the program requirements (6.3.3.1 as pertains to the organization). Deficiencies are addressed on assessment/surveillance checklist, and if warranted will be entered on the CaWeb Issues Tracking System for corrective action and disposition.

9.7 RESULTS FOR FIELD DUPLICATES, LABORATORY CONTROL SAMPLES, BLANK ANALYSIS, AND INTERLABORATORY COMPARISON STUDIES

A brief discussion of the year 2002 results for duplicates, laboratory control samples, blank analysis, and interlaboratory comparison studies are provided within this section. Summary tables are also included.

FIELD DUPLICATES (PRECISION)

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 9.1.

LABORATORY CONTROL SAMPLES (ACCURACY)

The LCS results obtained for 2002 are summarized in Table 9.2. The LCS results were satisfactory with no more than two results being out of control for any given analysis/matrix category for the year.

BLANK ANALYSIS

The laboratory blank sample results obtained for 2002 are summarized in Table 9.3. 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.

INTERLABORATORY COMPARISON STUDIES

The interlaboratory comparison sample results obtained for 2002 are summarized in Tables 9.4 and 9.5.

Table 9.4 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 102 out of 108 parameters analyzed.

Table 9.5 shows the summary of interlaboratory comparison sample results for the BN in-house Dosimetry Group. They 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 17 out of 18 TLDs analyzed. The only outlier was a S60/Cf-252 UN. Mixture (1:3), which was within the test range of 0.03 to 5 rem.

Table 9.1 Summary of Field Duplicate Samples - 2002

Analysis	Matrix	Number[a] Samples Reported	Number[b] Reported above DL	Average Absolute[c] RPD of those above DL (%)
Gross Alpha	Air	101	85	20.0
Gross Beta	Air	101	100	9.6
Americium-241	Air	24	5	48.0
Plutonium-239/240	Air	25	5	59.2
Gamma - Beryllium-7	Air	28	28	11.8
Tritium	Air	49	20	20.4
Uranium-234	Air	10	6	34.3
Uranium-238	Air	9	3	23.9
Plutonium-239/240	Water	5	1	7.9
Gamma – Cesium-137	Water	3	1	16.6
Tritium	Water	31	4	5.2
Strontium-90	Water	2	1	37.2
TLDs	Ambient Radiation	441	441	0.72

(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 here.

(b) Represents the number of field duplicate - field sample result sets reported above the detection limit (detection limit is not applicable for TLD). 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 detection limit. The Absolute RPD calculation is as follows:

$$Absolute\ \ RPD\ \mid\ \frac{IFD\,4\,FSI}{(FD\,2\,FS)/2}\,X\,100$$

Where:
FD = Field Duplicate result
FS = Field Sample result

Table 9.2 Summary of Laboratory Control Samples (LCS) - 2002

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits[a]
$^{239+240}Pu$	Air	15	15
Gross Alpha	Water	21	21
Gross Beta	Water	21	21
$^{239+240}Pu$	Water	20	20
Tritium	Water	40	40
^{90}Sr	Water	2	2
^{226}Ra	Water	2	1
^{228}Ra	Water	2	2
^{90}Sr	Soil	1	1
$^{239+240}Pu$	Soil	5	5

(a) Control limits are as follows: 80 to 120 percent for all analyses and matrices except for gross alpha and beta which are 50 to 120 percent.

Table 9.3 Summary of Laboratory Blank Samples - 2002

Analysis	Matrix	Number of Blank Results Reported	Number Within Control Limits[a]
Gross Alpha	Air	156	156
Gross Beta	Air	156	156
$^{239+240}Pu$	Air	32	28
Gamma	Air	267	258
Tritium	Air	1	1
Gross Alpha	Water	42	42
Gross Beta	Water	42	42
$^{239+240}Pu$	Water	20	20
Gamma	Water	464	464
Tritium	Water	52	52
^{90}Sr	Water	9	9
^{226}Ra	Water	2	2
^{228}Ra	Water	4	4
^{90}Sr	Soil	2	2
$^{239+240}Pu$	Soil	35	35
Gamma	Soil	220	213

(a) Control limit is less than detection level.

Table 9.4 Summary of Interlaboratory Comparison Samples for the Subcontract Radiochemistry Laboratory - 2002

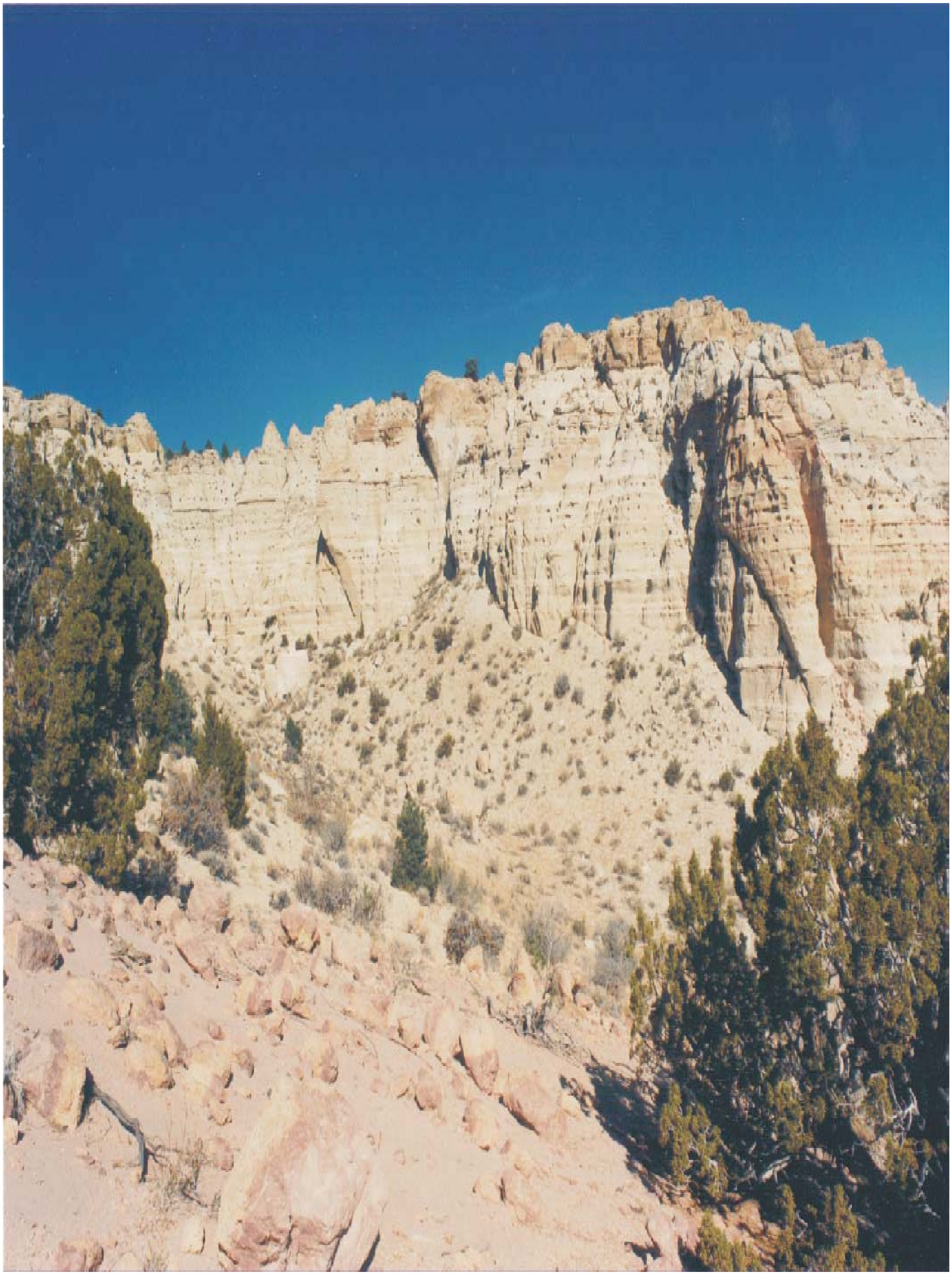
Analysis	Matrix	Number of Results Reported	Number Within Control Limits(a)
ERA Results			
Gross Alpha	Water	9	9
Gross Beta	Water	9	7
Gamma	Water	7	7
Tritium	Water	3	3
^{90}Sr	Water	7	5
^{226}Ra	Water	10	8
^{228}Ra	Water	10	8
EML Results			
Gross Alpha	Air	2	2
Gross Beta	Air	3	3
$^{239+240}Pu$	Air	6	6
Gamma	Air	3	3
Gross Alpha	Water	7	6
Gross Beta	Water	7	6
$^{239+240}Pu$	Water	7	7
Gamma	Water	7	7
Gamma	Soil	8	8
$^{239+240}Pu$	Soil	8	8
^{90}Sr	Soil	8	7
Gamma	Vegetation	5	5
$^{239+240}Pu$	Vegetation	6	6
^{90}Sr	Vegetation	5	5
MAPEP Results			
Gamma	Water	4	4
$^{239+240}Pu$	Water	4	4
^{90}Sr	Water	3	0
Gamma	Soil	4	4
$^{239+240}Pu$	Soil	5	5
^{90}Sr	Soil	4	3

(a) Control limits are determined by the individual interlaboratory comparison study.

Table 9.5 Summary of Interlaboratory Comparison TLD Samples for the BN in-house Dosimetry Group - 2002

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[a]
TLDs	Ambient Radiation	60	60

(a) Based upon DOELAP criteria; absolute value of the bias plus one standard deviation < 0.3.



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Assistant Manager for Technical Services, Nevada Site Office, U.S. Department of Energy, National Nuclear Security Administration, P. O. Box 98518, Las Vegas, NV 89193-8518, M/S 505

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S. E. Lacy, Sandia National Laboratories, P. O. Box 5800, Albuquerque, NM 87185-0184

DTRA

L. J. Ashbaugh, Defense Threat Reduction Agency, P. O. Box 98539, Las Vegas, NV 89193-8518, M/S 573

DRI

Colleen M. Beck, Desert Research Institute, 755 E. Flamingo Road, Las Vegas, NV 89120, M/S 505

David Shafer, Desert Research Institute, 755 E. Flamingo Road, Las Vegas, NV 89120, M/S 505 (3)

William Hartwell, Desert Research Institute, 755 E. Flamingo Road, Las Vegas, NV 89120, DRI M/S 505

Shaw Environmental and Infrastructure, Inc.

Paul Gretsky, Shaw Environmental and Infrastructure, Inc., P. O. Box 93838, Las Vegas, NV 89193-3838, M/S NLV439

June Simms, Shaw Environmental and Infrastructure, Inc., P. O. Box 93838, Las Vegas, NV 89193-3838, M/S NLV439 (2)

BN

Manager, Bechtel Nevada, P. O. Box 98521, Las Vegas, NV 89193-8521, M/S NLV001

Manager, Environmental Management, Bechtel Nevada, P. O. Box 98521, Las Vegas, NV 89193-8521, M/S NLV102 (2)

Manager, Waste Management Program, Bechtel Nevada, P. O. Box 98521, Las Vegas, NV 89193-8521, M/S NLV080

B. Calman, Environmental Management, Bechtel Nevada, P. O. Box 98521, Las Vegas, NV 89193-8521, M/S NLV080

O. L. Haworth, Environmental Management, Bechtel Nevada, P. O. Box 98521, Las Vegas, NV 89193-8521, M/S NTS110

D. A. Nichols, Defense and Civil Projects, Bechtel Nevada, P. O. Box 98521, Las Vegas, NV 89193-8521, M/S NLV103

W. K. Ostler, Environmental Management, Bechtel Nevada, P. O. Box 98521, Las Vegas, NV 89193-8521, M/S NLV081

LIBRARIES

Office of Scientific and Technical Information, Technical Center, U.S. Department of Energy, P. O. Box 62, Oak Ridge, TN 37831 (electronic copy)

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

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Pahrump Library District, 2101 E. Calvada Boulevard, Pahrump, NV 89048

Tonopah Library District, P. O. Box 449, Tonopah, NV 89049

White Pine County Library, 950 Campton Street, Ely, NV 89301

Cedar City Public Library, 136 W. Center Street, Cedar City, UT 84720-2597

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Milford Public Library, P. O. Box 579, Milford, UT 84751-0579

Washington County Library, 50 S. Main Street, St George, UT 84770-3490

CEMP

Clark M. Hardy, P. O. Box 394, Alamo, NV 89001

Dell Sullivan, P. O. Box 182, Alamo, NV 89001

Michael DeLee, P. O. Box 9 6, Amargosa Valley, NV 89020

Kenneth G. Gary, Bar B Q Ranch, Box 1, Amargosa Valley, NV 89020

Linda L. Hafen, 1009 Providence Lane, Boulder City, NV 89005

Ann P. Smith, P. O. Box 101 Caliente, NV 89008

Ruston Taylor, 917 Three Fountains, Cedar City, UT 84720

John C. Lisle, P. O. Box 357, Beatty, NV 89003

Richard A. Johnson, P. O. Box 626, Beatty, NV 89003

Bradford M. Benson, 606 Lake Superior Lane, Boulder City, NV 89005

Brent H. Perkins, P. O. Box 495, Caliente, NV 890087

Donald Newman, 141 Sunbow, Cedar City, UT 84720

Thomas S. Judd, 850 North 500 West, Delta, UT 84624

Beverly Jean DeWyze, P. O. Box 295, Delta, UT 84624

Rita Gillum, P. O. Box 3, Goldfield, NV 89013

Jon Skullestad, P. O. Box 593 Goldfield, NV 89013

Michael Herndon, 5867 Alcott Avenue, Henderson, NV 89142

Kenneth F. McFate, P. O. Box 373, Indian Springs, NV 89018

Don M. Curry, 8207 Burnt Sienna, Las Vegas, NV 89123

David J. Peltz, 10194 Eden Falls Lane, Las Vegas, NV 89014

Dale E. Jenson, 402 West 500 S, Box 25, Milford, UT 84751

Morden Leon Guy, P. O. Box 369, Milford, UT 84751

Nicklas J. Bowler, P. O. Box 368, Logandale, NV 89021

Jack W. Nelson, P. O. Box 232, Logandale, NV 89021

Larry B. Goins, 2440 South River Plate Drive, Pahrump, NV 89048

Jason L. Odegard, 630 Tomahawk Court, Pahrump, NV 89060

Melanie Darby, 1111 Avenue M, Ely, NV 89301

Larry Martin, 1200 Avenue H, Ely, NV 89301

Gerald F. Hein, 612 Largo Azul Avenue, Henderson, NV 89105

Scott Mortenson, 143 S. Main, St. George, UT 84770

Curt Walker, 903 Coyote Way, Dammeron Valley, UT 84738

Mark E. Howard, P. O. Box 935, Tonopah, NV 89049

Ted Charles Sauvageau, P. O. Box 1674, Tonopah, NV 89049

J Randall Allen, P. O. Box 93, Panaca, NV 89042

Paul Donohue, P. O. Box 291, Pioche, NV 89043

Gayle Williams, HCR 61, Box 24, Alamo, NV 89001

Kaye Allisen-Medlin, HCR 61, Box 30, Alamo, NV 89001-9706

Miscellaneous

Michael Dwyer, Las Vegas District Manager BLM, 4765 Vegas Dr., Las Vegas, NV 89108

J. R. Dryer, Yucca Mountain Site Characterization Office, 1551 Hillshire Dr., Suite A, Las Vegas, NV 89134

Richard Martin, Superintendent, Death Valley National Monument, P. O. Box 579, Death Valley, CA 92328

Richard Birger, Project Leader, Desert National Wildlife Refuge Complex, 1500 N. Decatur, Las Vegas, NV 89108

E. W. Chew, U.S. Department of Energy, 785 Doe Place, Idaho Falls, ID 83402, M/S 4149

Mason and Hanger, Environmental Protection Department, Silas-Mason Co., Inc., Pantex Plant, P. O. Box 30020, Amarillo, TX 79177

E. A. Hopper USAF/EV, 4551 Devlin Drive, Nellis AFB, Las Vegas, NV 89191-6828

Ann-Marie Choephel, Nuclear Waste Repository Project Office, P. O. Box 1767, Tonopah, NV 89049

Steve Deandi, Western Governmental Association, 223 Old P. O. Road, Boulder, CO 80302

Diane Watson, Waste Policy Institute, Savannah River Research Campus, 227 Gateway Drive, Aiken, SC 29803

Roy Clifford, Stone Cabin Ranch, P. O. Box 48, Tonopah, NV 89040

Joe and Sue Fallini, Twin Springs Ranch, HC 76, Box 1100, Tonopah, NV 89040

Mike Heizer, Garden Valley, P. O. Box 33, Hiko, NV 89017

Steve Medlin, Medlin Ranch, HCR 61, Box 30, Alamo, NV 89001

Norman Sharp, Nyala Ranch, HC 76, Box 900, Tonopah, NV 89040

Joan Terrell, Sarcobatus Flat Ranch, P. O. Box 454, Goldfield, NV 89013

Helen Uhalde, Uhalde Ranch, P. O. Box 88, Ely, NV 89301

N. W. Golchert, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439

David and Natalie Spicer, P. O. Box 897, Beatty, NV 89003

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