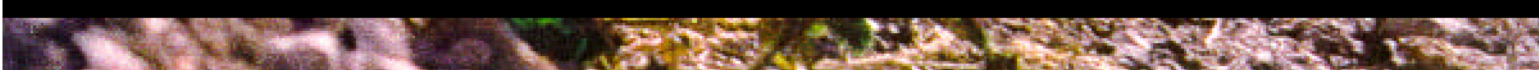

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DOE/NV/11718--361

NEVADA TEST SITE
ANNUAL SITE ENVIRONMENTAL REPORT
FOR CALENDAR YEAR 1998

Editors: Stuart C. Black and Yvonne E. Townsend

October 1999

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

Prepared for:

U.S. Department of Energy
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FOREWORD

Prior to 1989, annual reports of environmental monitoring and assessment results for the Nevada Test Site (NTS) were prepared in two separate parts. Onsite effluent monitoring and environmental monitoring results were reported in an onsite report prepared by the U.S. Department of Energy, Nevada Operations Office (DOE/NV). Results of the Offsite Radiological Surveillance and Long-Term Hydrological Monitoring programs conducted by the U.S. Environmental Protection Agency's (EPA's) Laboratory (various names) in Las Vegas, Nevada, were reported separately by that Agency.

Beginning with the 1989 Annual Site Environmental Report for the NTS, these two documents were combined into a single report to provide a more comprehensive annual documentation of the environmental protection activities conducted for the nuclear testing program and other nuclear and non-nuclear operations at the NTS. The two agencies have coordinated preparation of this tenth combined onsite and offsite report through sharing of information on environmental surveillance and releases as well as meteorological, hydrological, and other supporting data used in dose-estimation calculations.

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ACKNOWLEDGEMENTS

The skill, dedication, and perseverance of Angela L. McCurdy in text processing and graphics support were crucial to the production of this report. Also, very crucial to the production of this report was the graphics support provided by Larry R. Tinney and David W. Brickey of the Geographical Information System Group. The review and advice offered by the DOE/NV's Environment, Safety and Health Division (ESHD) and the EPA's Radiation & Indoor Environments National Laboratory, Las Vegas (R&IE-LV) reviewers were invaluable. The efforts of Robert Furlow in coordinating the review of the 1998 ASER by the ESHD are greatly appreciated. Compilation and verification of onsite data were provided by Robert F. Grossman and Orin L. Haworth. Compilation and verification of Bechtel Nevada's data from offsite locations were provided by Madelyn Hayes. Statistical analyses of data were provided by Robert R. Kinnison. The cooperative support of Anita A. Mullen and Terry L. Mouck of the R&IE-LV in production of this combined onsite and offsite environmental report is greatly appreciated.

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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 <u>r</u>oentgen <u>e</u>quivalent <u>m</u>an) 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

AEC	U.S. Atomic Energy Commission
AIP	Agreement in Principle
AIRFA	American Indian Religious Freedom Act
ANOVA	Analysis of Variance
APCD	Air Pollution Control Division
ARL/SORD	Air Resources Laboratory, Special Operations and Research Division
ASCII	American Standard Code for Information Interchange
ASL	Analytical Services Laboratory
ASN	Air Surveillance Network
BN	Bechtel Nevada
BOD	Biochemical Oxygen Demand
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)
CAU	Corrective Action Unit
CEDE	Committed Effective Dose Equivalent
CEI	Compliance Evaluation Inspection
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CP	Control Point
CRMP	Community Radiation Monitoring Program
CTLP	Community Technical Liaison Program
CWA	Clean Water Act
CX	Categorical Exclusion
CY	Calendar Year
DAF	Device Assembly Facility
DCG	Derived Concentration Guide
DDR	Data Discrepancy Report
DOE	U.S. Department of Energy
DOE/HQ	DOE Headquarters
DOELAP	DOE Laboratory Accreditation Program
DOE/NV	DOE Nevada Operations Office
DQO	Data Quality Objectives
DRI	Desert Research Institute, University and Community College System, Nevada
EA	Environmental Assessment
EDE	Effective Dose Equivalent
EGIS	Ecological Geographic Informational System
EHS	Extremely Hazardous Substances
EIS	Environmental Impact Statement
ELU	Ecological Landform Unit
EMAC	Ecological Monitoring and Compliance
EML	Environmental Measurements Laboratory (DOE)
EO	Executive Order
EOD	Explosive Ordnance Disposal (NTS)
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Reporting and Community Right-to-Know Act
ERP	Environmental Restoration Project
ESA	Endangered Species Act
ESHD	Environment, Safety and Health Division

ET	Evapotranspiration
FFACO	Federal Facilities Agreement and Consent Order
FFCA	Federal Facilities Compliance Act
FY	Fiscal Year
gpm	Gallons per Minute
GZ	Ground Zero
HRMP	Hydrologic Resources Management Program
HSC	Hazardous Materials Spill Center
HTO	Tritiated Water
HWSU	Hazardous Waste Storage Unit
ICRP	International Commission on Radiological Protection
ID	Identification
LANL	Los Alamos National Laboratory
LAO	Los Alamos Operations (BN)
LDR	Land Disposal Restrictions
LLNL	Lawrence Livermore National Laboratory
LLW	Low-Level (Radioactive) Waste
LO	Livermore Operations (BN)
LTHMP	Long-Term Hydrological Monitoring Program
MDC	Minimum Detectable Concentration
MEI	Maximally Exposed Individual
MOU	Memorandum of Understanding
MQO	Measurement Quality Objectives
MSL	Mean Sea Level
MSN	Milk Surveillance Network (R&IE-LV)
NAC	Nevada Administrative Code
NAFR	Nellis Air Force Range
NAGPRA	Native American Graves Protection and Repatriation Act
NDEP	Nevada Division of Environmental Protection
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
NLVF	North Las Vegas Facility (BN)
NPDES	National Pollution Discharge Elimination System
NRHP	National Register of Historic Places
NRS	Nevada Revised Statutes
NSPS	New Source Performance Standard
NTS	Nevada Test Site
NVLAP	National Voluntary Laboratory Accreditation Program (NIST)
ORIA	Office of Radiation and Indoor Air, EPA
ORNL	Oak Ridge National Laboratory
ORSP	Offsite Radiological Safety Program
P2	Pollution Prevention
PA	Performance Assessment
PCB	Polychlorinated Biphenyl
PE	Performance Evaluation
PES	Performance Evaluation Study
pH	Hydrogen ion concentration
PHS	U.S. Public Health Service
PIC	Pressurized Ion Chamber

PPOA	Pollution Prevention Opportunity Assessments
ppm	Parts per Million
QA	Quality Assurance
QAP	Quality Assessment Program
RCRA	Resource Conservation and Recovery Act
R&IE-LV	Radiation & Indoor Environments National Laboratory - Las Vegas (EPA)
RMP	Resource Management Plan
ROD	Record of Decision
RREMP	Routine Radiological Environmental Monitoring Plan
RSD	Relative Standard Deviation
RSL	Remote Sensing Laboratory (BN)
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
SDWA	Safe Drinking Water Act
SGZ	Surface ground zero
STEL	Short Term Exposure Level
STL	Special Technologies Laboratory (BN)
TaDD	Tactical Demilitarization Development
TLD	Thermoluminescent Dosimeter
TRU	Transuranic
TSCA	Toxic Substances Control Act
TTR	Tonopah Test Range
UGTA	Underground Test Area
UNLV	University of Nevada, Las Vegas
U.S.	United States of America
USFWS	U.S Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound
VZM	Vadose Zone Monitoring
WAMO	Washington Aerial Measurements Operations (BN)
WEF	Waste Examination Facility
WIPP	Waste Isolation Pilot Plant
WI	Work Instructions

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1.0 SUMMARY

Monitoring and surveillance, on and around the Nevada Test Site, (NTS) by United States Department of Energy (DOE) contractors and NTS user organizations during 1998, indicated that operations on the NTS were conducted in compliance with applicable DOE, state, and federal regulations and guidelines. All discharges of radioactive liquids remained onsite in containment ponds, and there was no indication of potential migration of radioactivity to the offsite area through groundwater. Surveillance around the NTS indicated that airborne radioactivity from diffusion, evaporation of liquid effluents, or resuspension of soil was not detectable offsite, and exposure above existing background to members of the offsite population was not measured by the offsite monitoring program. Using the U.S. Environmental Protection Agency's (EPA's) Clean Air Package 1988 model (CAP88-PC) and NTS radionuclide emissions and environmental monitoring data, the calculated effective dose equivalent (EDE) to the maximally exposed individual offsite would have been 0.092 mrem. This value is less than 1 percent of the federal dose limit prescribed for radionuclide air emissions. Any person receiving this dose would also have received 141 mrem from natural background radiation. There were no nonradiological releases to the offsite area. Hazardous wastes were shipped offsite to approved disposal facilities. Compliance with the various regulations stemming from the National Environmental Policy Act (NEPA) is being achieved and, where mandated, permits for air and water effluents and waste management have been obtained from the appropriate agencies. Cooperation with other agencies has resulted in 12 different agreements, memoranda, and consent orders.

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 DOE Nevada Operations Office (DOE/NV) 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 (ESHD) 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 DOE/NV, i.e., underground testing of nuclear explosive devices. DOE/NV 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 (EPA 1992) to calculate potential EDEs to people living beyond the boundaries of the NTS and the surrounding exclusion areas.

1.2 RADIOLOGICAL ENVIRONMENT

Radiological effluents in the form of air emissions and liquid discharges are 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 1998 consisted primarily of small amounts of tritium and plutonium that were 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 plutonium as measured with air sampling equipment or calculated by use of resuspension equations.

Diffuse emissions in 1998 included HTO, only slightly above detection limits, from the Radioactive Waste Management Site in Area 5 (RWMS-5), the SEDAN crater in Area 10, and the SCHOONER crater in Area 20 and resuspended $^{239+240}$Pu from areas on the NTS, where it was deposited by atmospheric nuclear tests or device safety tests in earlier years. Table 1.1 shows the quantities of radionuclides released from all sources, including postulated loss of standards during laboratory operations. The radioactive materials listed in this table were not detected in the offsite area above ambient radioactivity levels.

Onsite liquid discharges to containment ponds included approximately 300 Ci (11 TBq) of tritium. This was much more than the tritium discharge last year. Evaporation of this material could have contributed HTO to the atmosphere, but diffusion caused the concentration to be too small to be detected by the tritium monitors onsite. No liquid effluents were discharged to offsite areas.

ONSITE ENVIRONMENTAL SURVEILLANCE

Environmental surveillance on the 3,500-km^2 (1,350-mi^2) NTS is designed to cover the entire area with some emphasis on areas of past nuclear testing and present operational activities. In 1998, samplers were operated at 37 locations on and near the NTS to collect air particulate samples and at 13 locations to collect HTO in atmospheric moisture. Grab samples were collected frequently from water supply wells, water taps, containment ponds, and sewage lagoons. Thermoluminescent dosimeters (TLDs) were placed at 107 locations on the NTS to measure ambient gamma exposures.

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 2,400 air samples were analyzed by gamma spectroscopy. All isotopes detected by gamma spectroscopy were naturally occurring in the environment (^{40}K, ^{7}Be, and members of the uranium and thorium series), except for a few instances where very low levels of ^{137}Cs were detected.

Gross beta analysis of the air samples yielded an annual average for the network of 2.0 x 10^{-14} µCi/mL (0.74 mBq/m^3). Plutonium analyses of monthly or quarterly composited air filters indicated an annual arithmetic average below 10^{-16} µCi/mL (4 µBq/m^3) of $^{239+240}$Pu and about 10^{-18} µCi/mL (0.04 µBq/m^3) of ^{238}Pu for all locations during 1998, with the majority of results for both isotopes being on the order of 10^{-18} µCi/mL (0.04 µBq/m^3).

Slightly higher concentrations were found in samples from certain areas, but they were calculated to be only 0.01 percent of the Derived Concentration Guide (DCG) for exposure to the public. 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 tests in the 1950s and 1960s dispersed plutonium over a small portion of the NTS's surface.

Throughout the year atmospheric moisture was collected for two-week periods at 13 locations on the NTS and analyzed for HTO content. The annual arithmetic average of (17 ± 56) x 10^{-6} pCi/mL (0.63 ± 2.1 Bq/m^3) was slightly higher than last year. The highest annual average concentrations were at the SCHOONER crater, the Decon Pad, and the E Tunnel pond in that order. The primary radioactive liquid discharge to the onsite environment in 1998 was about 105 Ci (3.9 TBq) of tritium (as HTO) in seepage from E Tunnel and from water pumped from wells into containment 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 five containment ponds and an effluent and nine sewage lagoons. A grab sample was taken from each of these surface water sites for analysis of gross beta, tritium, gamma-emitters, and plutonium isotopes. Strontium-90 was analyzed once per year for each location. Water samples from the lagoons contained background levels of gross beta, tritium, plutonium, and strontium. Samples collected from the tunnel containment pond and containment ponds for Underground Test Area (UGTA) characterization wells contained detectable levels of radioactivity, as would be expected.

Water samples from onsite supply wells and drinking water distribution systems were also analyzed for radionuclides. The supply well average gross beta activity of 7.0 x 10^{-9} µCi/mL (0.26 Bq/L) was 3 percent of the DCG for ^{40}K (used for comparison purposes); gross alpha was 6.2 x 10^{-9} µCi/mL (0.23 Bq/L), which was about 40 percent of the drinking water standard; the maximum ^{90}Sr measured was 1.7 x 10^{-10} µCi/mL (6.3 mBq/L), about 2 percent of the DCG; ^{3}H averaged about 3.4 x 10^{-9} µCi/mL (0.12 Bq/L), less than 0.002 percent of the DCG; $^{239+240}$Pu and ^{238}Pu were both below their minimum detectable levels of about 2 x 10^{-11} µCi/mL (0.074 mBq/L).

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 floor of these sites. Also, Resource Conservation and Recovery Act (RCRA) monitoring wells, for sampling groundwater under RWMS-5, indicated that contamination from mixed waste buried therein is not detectable in the well samples.

Analysis of the TLD network showed that the 9 historic stations had an average annual exposure of 88 mR, while the 16 boundary stations (located at higher altitudes) had a higher average annual exposure of 120 mR. Both exposures were consistent with previous data.

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" was developed (DOE 1998a). As a result of the DQO process, some monitoring was eliminated. The number of air and TLD monitoring stations was reduced, and monitoring frequencies were changed. The Plan was implemented in the latter part of 1998.

OFFSITE ENVIRONMENTAL SURVEILLANCE

The offsite radiological monitoring program is conducted around the NTS by the EPA's Radiation and Indoor Environments National Laboratory-Las Vegas (R&IE-LV), under an Interagency Agreement with DOE. This program consists of several environmental sampling, radiation detection, and dosimetry networks as described below. These networks operated continuously during 1998.

The Air Surveillance Network (ASN) was made up of 19 continuously operating sampling locations surrounding the NTS, 6 of which also had high-volume air samplers. The ASN stations included 16 sampling locations, at Community Technical Liaison Program (CTLP) stations, described below. During 1998, no airborne radioactivity related to current activities at the NTS was detected on any sample from the ASN. Other than naturally occurring ^{7}Be, the only specific radionuclide detected by this network was ^{238}Pu or $^{239+240}$Pu on air-filter samples from high volume air samplers. The network average gross beta in air results were slightly less than the average for the NTS network.

The Milk Surveillance Network consisted of 10 sampling locations within 300 km (186 mi) of the NTS. Samples were analyzed for ^{90}Sr, which averaged 0.7 pCi/L. The data from this network are consistent with previous data and indicate little or no change.

In 1998, external exposure was monitored by a network of 39 TLDs and 25 pressurized ion chambers (PICs) located in towns and communities around the NTS. There was also a PIC located at the SALMON site near Baxterville, Mississippi. The PIC network in the communities surrounding the NTS indicated background exposures, ranging from 70 to 153 mR/yr, that were consistent with previous data and well within 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.

Sampling of Long-Term Hydrological Monitoring Program (LTHMP) wells and surface waters around the NTS showed only background radionuclide concentrations. The LTHMP also included groundwater and surface water monitoring at locations in Alaska, Colorado, Mississippi, New Mexico, and Nevada, where underground nuclear tests were conducted. The results obtained from analysis of samples collected at those locations were consistent with previous data, including a sample from a deep well at Project GASBUGGY, where ^{3}H and ^{137}Cs has been detected the last few years. No concentrations of radioactivity that were detected in air, water, or milk samples posed any significant health risk to nearby residents.

A network of 17 CTLP stations was operated by local residents, one without an air sampler. Each station was an integral part of the ASN and TLD networks. In addition, they were equipped with a PIC connected to a gamma-rate recorder. Samples and data from these CTLP stations were analyzed and reported by R&IE-LV and also interpreted and reported by the Desert Research Institute, University of Nevada System. All measurements for 1998 were consistent with previous years and were within the normal background range for the United States.

Although no radioactivity attributable to current NTS operations was detected by any of the offsite monitoring networks, based on the NTS releases reported in Table 1.1, an atmospheric dispersion model calculation (CAP88-PC) indicated that the maximum potential EDE to any offsite individual would have been 0.092 mrem (9.2×10^{-4} mSv), and the dose to the population within 80 km of the several emission sites on the NTS would have been 0.27 person-rem (2.7×10^{-3} person-Sv), both of which were similar to last year. The hypothetical person receiving this dose would also have been exposed to

141 mrem from natural background radiation. A summary of the potential EDEs due to operations at the NTS is presented in Table 1.2.

OVERALL ASSESSMENT

Gross beta measurements in air samples are, perhaps, a reasonable method for assessing the radioactive environment at a location. In order to indicate the present situation at the NTS, in comparison with that of previous years, the network annual average gross beta concentrations in NTS air for the last 34 years are plotted in Figure 1.0. The obvious peaks in this trend line are identified with associated tests, where possible. Also plotted are data from the NTS offsite network operated by EPA, where it exists.

Figure 1.1 indicates the decrease with time of gross beta concentration in air that occurs independently of the peaks. In the early years, the decrease occurred because atmospheric tests and Plowshare cratering tests were terminated. In the later years, improved containment methods to reduce accidental releases led to the extremely low levels of radioactivity in air. Only tests in the atmosphere and nuclear accidents at foreign locations interrupt the steady decrease of gross beta concentration in NTS air.

LOW-LEVEL WASTE DISPOSAL

Environmental monitoring at the RWMS, Area 3 (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. 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 tests conducted in the 1950s and 1960s. These tests spread plutonium on surface soil in the eastern and northeastern areas of the NTS (Figure 2.3, Chapter 2 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 migration of hazardous materials.

RADIOLOGICAL MONITORING AT OFFSITE SUPPORT FACILITIES

Fence line monitoring, using Panasonic UD-814 TLDs, was conducted at DOE/NV offsite support facilities in North Las Vegas, Nevada; Santa Barbara, California; and at the Washington Aerial Measurements Operation. The 1998 results indicated that only background radiation was detected at the fence line of these facilities.

In 1995, a small amount of tritium was accidently released from a calibration range building in North Las Vegas that was still detectable this year in the room where the release occurred. Monitoring of the release provided data for input into the CAP88-PC program for calculating offsite exposures. The maximum offsite exposure was estimated to be only 0.00025 mrem, which is far below the EPA permissible limit of 10 mrem.

1.3 NONRADIOLOGICAL MONITORING

Nonradiological environmental monitoring of NTS operations involved only onsite monitoring because there were no discharges of nonradiological hazardous

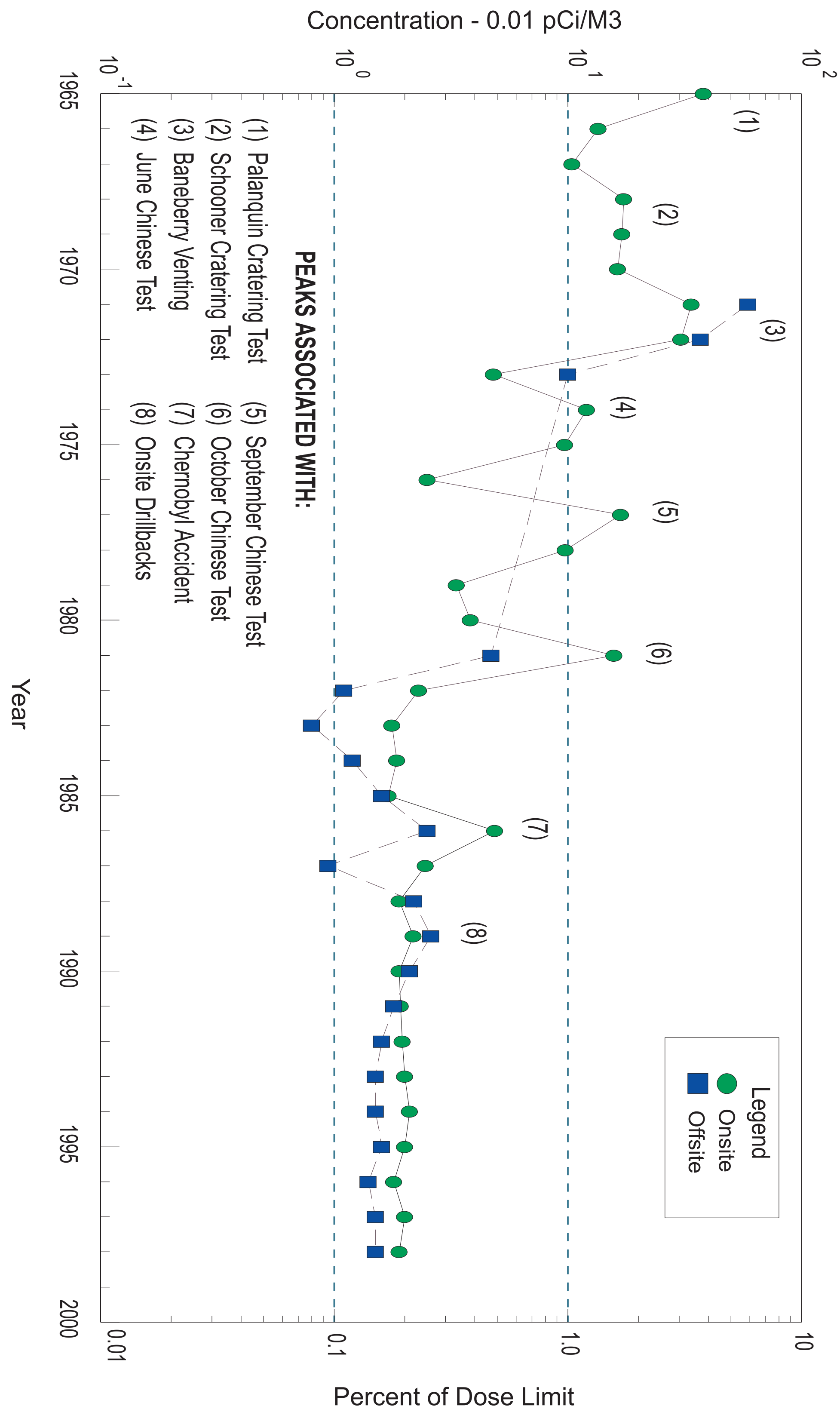


Figure 1.1 Trend of Gross Beta Concentration in Air at the NTS

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 1998, 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 open burning; four permits for surface disturbance (environmental restoration activities); seven permits for onsite drinking water distribution systems; one permit for sewage discharges to lagoon collection systems; six permits for septage 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, 1 sewage discharge permit, and 2 hazardous material storage permits. Two EPA Generator Identification numbers were issued to NTS operations, and three local RCRA-related permits were required at two of those operations.

The only nonradiological air emission of regulatory concern under the Clean Air Act (CAA) has been due to asbestos removal during building renovation projects and from insulated piping at various locations on the NTS. During 1998, there were no projects that required state of Nevada notifications. The annual estimate for non-scheduled asbestos demolition/renovation projects for fiscal year 1999 was sent to EPA Region 9 in December 1998.

RCRA requirements were met through an operating permit for hazardous waste storage, mixed waste storage, and explosive ordnance disposal operations. A Federal Facilities Agreement and Consent Order (FFACO) has been signed with the state that exempts the NTS from potential enforcement action related to mixed waste storage prohibition under RCRA.

The state's annual Compliance Evaluation Inspection during September 1998 found only minor deficiencies.

As there are no liquid discharges to navigable waters, offsite surface water drainage systems, or publicly owned treatment works, no Clean Water Act (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.

In January and June of 1998, the state inspected all NTS equipment regulated by the state air quality permit. There were no findings as a result of these inspections.

In compliance with the Safe Drinking Water Act (SDWA) and seven drinking water supply system permits from the state, the onsite distribution systems supplied by onsite wells are sampled monthly for analysis of residual chlorine, pH, bacteria, and, less frequently, for other water quality indicators. All results were within regulatory limits.

Monitoring for polychlorinated biphenyls, as required by the Toxic Substances Control Act (TSCA), was done and was reported to the EPA and the state in June 1998.

At the Hazardous Materials Spill Center (HSC), 6 series of spill tests involving 33 different chemicals were conducted during 1998. None of the tests generated enough airborne contaminants to be detected at the NTS boundary during or after the tests. Boundary monitoring would have been performed by R&IE-LV personnel if necessary.

1.4 COMPLIANCE ACTIVITIES

DOE/NV 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, TSCA, 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. NEPA activities included action on 3 Environmental Impact Statements (EISs), 6 Environmental Assessments (EAs), and 26 Categorical Exclusions (CXs). A total of 32 other projects were excluded because they had been considered in the Site-Wide EIS or the Record of Decision.

Wastewater discharges at the NTS are not regulated under NPDES permits, because all such discharges are to onsite sewage lagoons. Discharges to these lagoons are permitted under the Nevada Water Pollution Control Act. Wastewater discharges from the non-NTS support facilities were within the regulated levels established by city or county publicly owned treatment works.

There were 15 underground storage tanks (USTs) that were removed this year in accordance with state and federal regulations. There was also one regulated UST that was closed in place. Remedial activities continued at previous UST removal sites during 1998.

In 1998, 16 surveys were conducted for historical and archaeological sites that identified 19 prehistoric and historic archeological sites. One of these is considered a candidate for listing on the National Register of Historic Places.

The American Indian Religious Freedom Act (AIRFA) directs federal agencies to consult with Native Americans to protect their right to exercise their traditional religions. In 1998, work continued on a summary report, site records, and an artifact inventory of materials in the DOE/NV Curatorial Facility in preparation for an AIRFA consultation.

The Ecological Monitoring and Compliance Program monitoring tasks, which were selected for 1998, included habitat mapping on the northern portion of the NTS, characterizing the natural springs on the NTS, conducting a census of the horse population, and periodically monitoring man-made water sources to assess their effects on wildlife. Ecological monitoring of certain spill tests at the HSC (formerly Liquefied Gaseous Fuels Spill Test Facility) was also conducted.

Field surveys were conducted from June 1996 through February 1998 to identify those natural NTS springs, seeps, tanks, and playas, which could be designated by the United States (U.S.) Army Corps of Engineers as jurisdictional wetlands. A summary report of the survey findings entitled “NTS Wetlands Assessment” has been published.

The annual compliance report for calendar year 1998 NTS activities was prepared and submitted to the USFWS.

Waste minimization and pollution prevention activities conducted at the NTS and its offsite facilities involve an intensive recycling program and active product substitution projects. For the activities in Nevada, approximately 177 metric tons of materials were made useful (waste reduction) and about 1,743 metric tons of various materials were recycled.

1.5 GROUNDWATER PROTECTION

The LTHMP was instituted in 1972 to be operated by the EPA under an Interagency Agreement. In 1998, surface and groundwaters were monitored on and around the NTS at five sites in other states and at two off-NTS locations in Nevada to detect the presence of any radioactivity in potable water supplies that may be related to nuclear testing activities. 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, as has occurred previously. None exceeded 33 percent of the National Primary Drinking Water Regulation level.

HTO was detected in samples from wells at formerly utilized sites, such as the SALMON (Mississippi), GNOME (New Mexico), and GASBUGGY (New Mexico), at levels consistent with previous experience. The HTO concentration in water samples from Well EPNG 10-36 at GASBUGGY that began to increase in 1984, was still detectable in 1998. However, the concentration has been decreasing since 1992 from a peak of 480 pCi/L to 100 pCi/L this year.

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

Pit 3 in RWMS-5 has interim status for mixed waste generated on the NTS.

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 (NTS 1996) and that have received DOE/NV approval of the waste stream(s) for disposal at the NTS.

1.7 QUALITY ASSURANCE

The quality assurance (QA) program covering NTS activities has three components. There are QA programs for nonradiological analyses, onsite radiological analyses, and offsite radiological analyses conducted by EPA's R&IE-LV.

ONSITE NONRADIOLOGICAL QUALITY ASSURANCE

The onsite nonradiological QA program was not operative during 1998, because stable chemical analyses are done by offsite contract laboratories. These contract laboratories are monitored for their participation and performance in various performance evaluation programs.

ONSITE RADIOLOGICAL QUALITY ASSURANCE

The onsite radiological QA program includes conformance to best laboratory practice and implementation of the provisions of DOE Order 5700.6C (DOE 1991a). The external QA intercomparison program for radiological data QA consists of participation in the DOE Quality Assessment Program administered by the DOE Environmental Measurements Laboratory and the Performance Evaluation Study conducted by the EPA's National Exposure Research Laboratory, Las Vegas.

OFFSITE RADIOLOGICAL QUALITY ASSURANCE

The policy of the EPA requires participation in a centrally managed QA program by all EPA organizational units involved in environmental data collection. The QA program developed by the R&IE-LV for the NTS Offsite Radiological Safety Program meets all requirements of EPA policy and also includes applicable elements of the DOE QA requirements and regulations. The program defines DQOs, which are statements of the quality of data a decision maker needs to ensure that a decision based on those data is defensible. Achieved data quality may then be evaluated against these DQOs.

1.8 ISSUES AND ACCOMPLISHMENTS

PRINCIPAL COMPLIANCE PROBLEMS FOR 1998

- On June 28, 1994, the state of Nevada filed a Complaint for Declaratory Judgement and Injunction in the U.S. District Court against DOE. Nevada claimed that the DOE failed to comply with NEPA requirements at the NTS. All claims in that suit have now been met and a settlement agreement has been signed.

- Lead was found above acceptable levels in the Area 1 potable water system. Sample results were still high after replacing old brass fixtures. Other remedies are being sought.

ACCOMPLISHMENTS FOR 1998

- Two EAs were initiated during 1998, and CXs were documented for 26 projects.

- Throughout 1998, DOE/NV continued to maintain and update the "DOE/NV Compliance Guide" (Volume III), a handbook containing procedures, formats, and guidelines for personnel responsible for NEPA compliance activities.

- The Nevada Operations 1997 Site Pollution Prevention Program Plan was completed and submitted to DOE Headquarters. Operations under that plan in 1998 resulted in recycle or new uses of nearly 1,920 metric tons of materials.

- Continued use of a Just-in-Time supply system allowed NTS contractors to reduce product stock and control potentially hazardous products.

- Progress continued on the NTS groundwater characterization program by use of pumping programs on several wells to estimate yields and radionuclide content.

- Five new water sources were discovered on the NTS in 1998. All of these sources possess field indicators of a jurisdictional wetland.

- A RCRA Research, Development, and Demonstration Permit application was submitted to the state for construction and operation of a facility to develop treatment methods for deactivating waste missiles.

- Environmental Restoration Program activities were conducted at some 30 sites on and near the NTS during 1998.

- DOE/NV has entered in 12 agreements, memoranda, and consent orders with other entities, including an Interagency Agreement and Memorandum of Understanding (MOU) with EPA regarding environmental surveillance and NESHAP compliance; Agreements in Principle with Alaska, Mississippi, and Nevada on environment, safety, and health oversight activities; a MOU with Nevada covering radioactive releases; a MOU with Nellis Air Force Base regarding environmental restoration; a Settlement Agreement with Nevada on handling mixed TRU waste; a FFACO with Nevada on environmental restoration; and a Federal Facilities Compliance Act and Consent Order regarding restricted waste streams on the NTS.

- A redesign of environmental monitoring on the NTS was accomplished by use of the DQO process. The results of this process were published as “Routine Radiological Environmental Monitoring Plan” (DOE 1998a).

1.9 CONCLUSION

The environmental monitoring results presented in this report document that operational activities on the NTS in 1998 were conducted so that no measurable radiological exposure occurred to the public in offsite areas. Calculation of the highest individual dose that could have been received by an offsite resident (based on estimation of onsite worst-case radioactive releases obtained by measurement or engineering calculation and assuming the person remained outdoors all year) equated to 0.092 mrem to a person living in Springdale, Nevada. This may be compared to that individual's exposure to 141 mrem from natural background radiation as measured by the PIC instrument at Beatty, Nevada.

There were no major incidents of nonradiological contaminant releases to the environment in 1998. Many contaminated sites are on schedule for remediation, and intensive efforts to characterize and protect the NTS environment, implemented in 1990, were continued in 1998.

The Underground Test Area program and other activities devoted to characterization and protection of groundwater on and around the NTS continued on schedule.

Table 1.1 Radionuclide Emissions on the NTS - 1998[a]

Radionuclide	Half-life (years)	Quantity Released (Ci) [b]
Airborne Releases:		
^{3}H	12.35	[c]192
$^{239+240}Pu$	24065.	[c]0.24
Containment Ponds:		
^{3}H	12.35	[d]105
^{238}Pu	87.743	4.3×10^{-6}
$^{239+240}Pu$	24065.	3.8×10^{-5}
^{90}Sr	29.	2.4×10^{-5}
^{137}Cs	30.17	1.5×10^{-3}

(a) Assumes worst-case point and diffuse source releases.
(b) Multiply by 37 to obtain GBq.
(c) Includes calculated data from air sampling results, postulated loss of laboratory standards, and calculated resuspension of surface deposits.
(d) This amount is assumed to evaporate to become an airborne release.

Table 1.2 Summary of Effective Dose Equivalents from NTS Operations During 1998

	Maximum EDE at NTS Boundary[a]	Maximum EDE to an Individual[b]	Collective EDE to Population within 80 km of the NTS Sources
Dose	0.13 mrem (1.3×10^{-3} mSv)	0.092 mrem (9.2×10^{-4} mSv)	0.27 person-rem (2.7×10^{-3} person Sv)
Location	Site boundary 40 km WNW of NTS CP-1	Springdale, NV 58 km WNW of NTS CP-1	31,750 people within 80 km of NTS Sources
NESHAP Standard	10 mrem per yr (0.1 mSv per yr)	10 mrem per yr (0.1 mSv per yr)	-----
Percentage of NESHAP	1.3	0.92	-----
Background	141 mrem (1.41 mSv)	141 mrem (1.41 mSv)	3064 person-rem (30.6 person Sv)
Percentage of Background	0.09	0.06	0.009

(a) The maximum boundary dose is to a hypothetical individual who remains in the open continuously during the year at the NTS boundary located 40 km (25 mi) west northwest from the NTS Control Point 1.
(b) The maximum individual dose is to an individual outside the NTS boundary at a residence where the highest dose-rate occurs as calculated by CAP88-PC (Version 2.0) using NTS effluents listed in Table 5.1, assuming all HTO input to containment ponds was evaporated, assuming resuspended plutonium was carried offsite, and summing the contributions from each NTS source.

2.0 INTRODUCTION

The Nevada Test Site (NTS), located in southern Nevada, was the primary location for testing of nuclear explosives in the continental U.S. 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) eleven underground tests for various purposes at other locations in the United States. No nuclear tests were conducted in 1998. Nonnuclear testing included controlled spills of hazardous material at the Hazardous Materials Spill Center (HSC). Low-level radioactive and mixed waste disposal and transuranic (TRU) and hazardous waste storage facilities for defense waste are also operated on the NTS.

The 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. Restricted access and extended wind transport times are notable features of the remote location of the NTS and adjacent United States Air Force lands. Also, characteristic of this area are the great depths to slow-moving groundwater and little or no surface water. These features afford protection to the inhabitants of the adjacent areas from potential exposure to radioactivity or other contaminants resulting from operations on the NTS. Population density within 80 km of the NTS is only 0.2 persons/km^2 versus approximately 30 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.

In addition to the NTS operations, the U.S. Department of Energy, Nevada Operations Office (DOE/NV) is accountable for six non-NTS Bechtel Nevada (BN) facilities in five different cities. These BN operations support DOE/NV programs with activities ranging from aerial measurements and aircraft maintenance to electronics and heavy industrial fabrication. All of these latter operations are in metropolitan areas.

2.1 NTS OPERATIONS

NTS DESCRIPTION

The NTS, located in Nye County, Nevada, as shown in Figure 2.1, has been operated by the DOE as the on-continent test site for nuclear explosives testing since 1951. The southeast corner of the NTS is about 88km (55mi) 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 3,500 km^2 (1,350 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 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

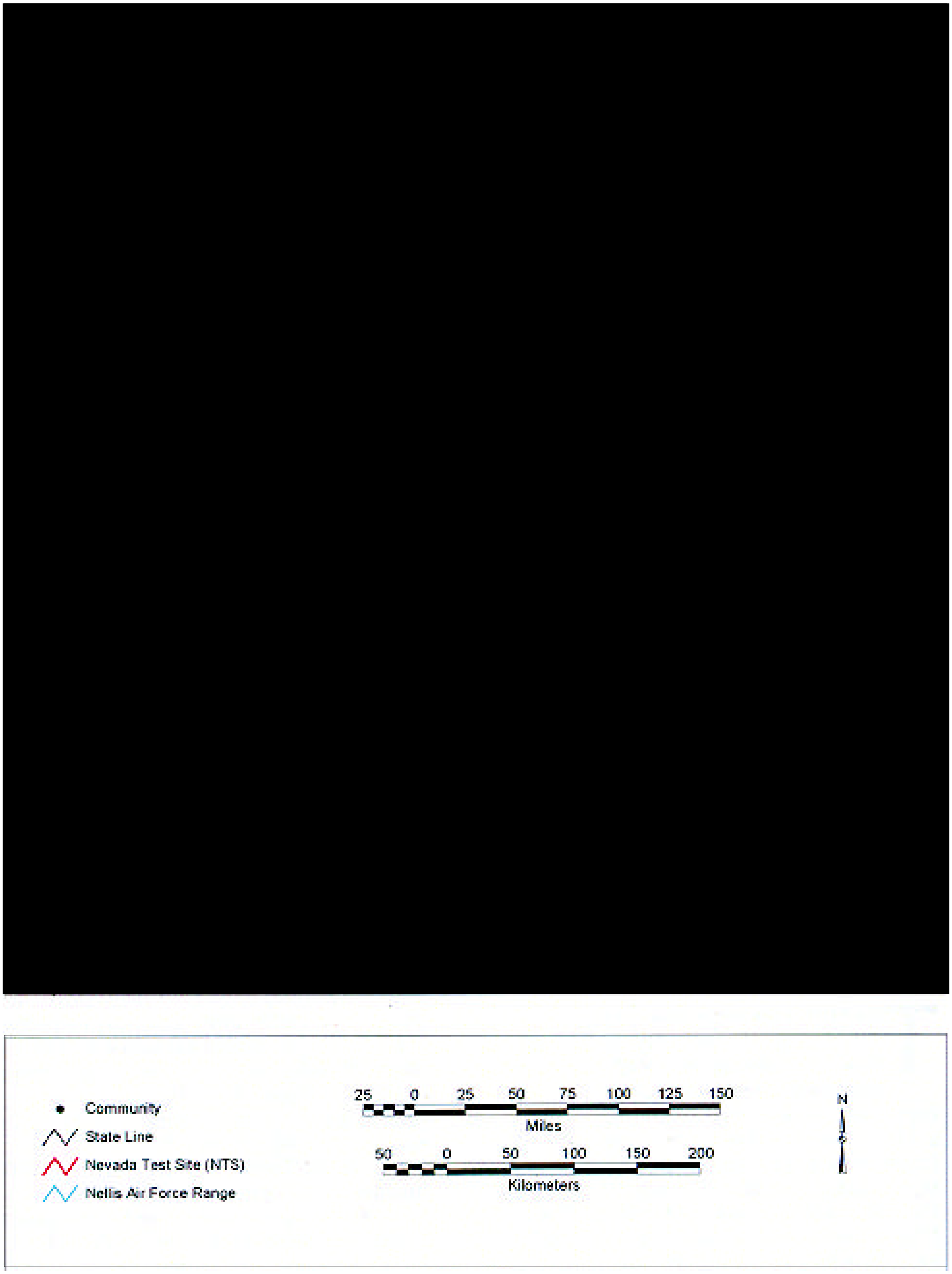


Figure 2.1 NTS Location in Nevada

[redacted]

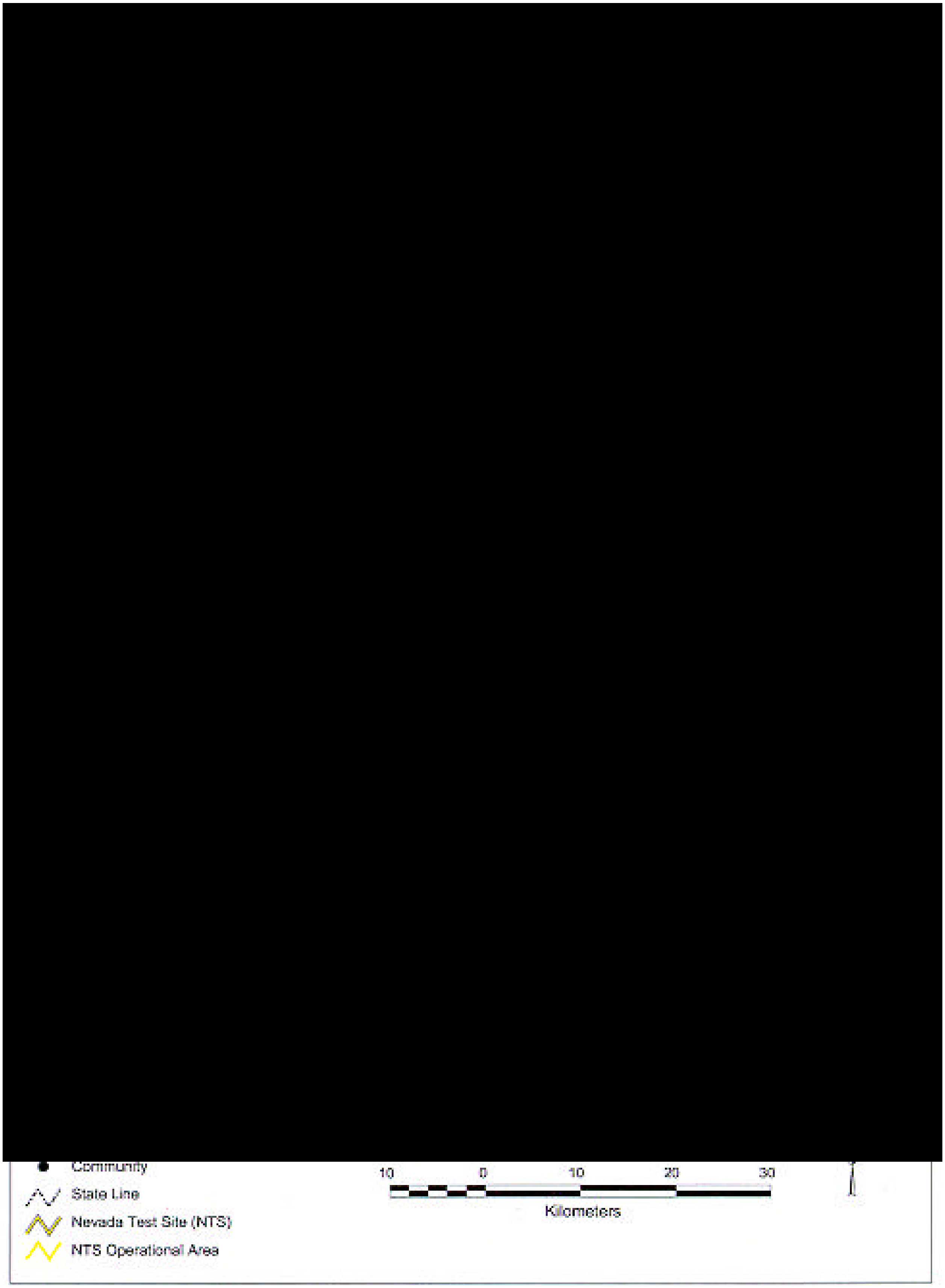


Figure 2.2 NTS Area Numbers, Principal Facilities, and Testing Areas

layout of the NTS, including the location of major facilities and the area numbers referred to in this report. The geographical areas previously used for nuclear testing are indicated in Figure 2.2. Mercury, located at the southern end of he NTS, is the main base camp for worker housing and administrative operations for the NTS.

MISSION AND NATURE OF OPERATIONS

The present mission of the DOE/NV 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.

Past and present operations on the NTS are described in the following paragraphs.

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, including transport and storage 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 (see Figure 2.3). All nuclear device tests are listed in DOE/NV Report NVO-209 (DOE 1994).

Underground nuclear tests were first conducted in 1951. Testing was discontinued during a moratorium that began in 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. There have been no United States nuclear explosive tests since September 1992.

Other nuclear testing over the history of 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 was conducted in Area 25, and a series of tests with a nuclear ramjet engine was conducted in Area 26.

Limited nonnuclear testing has also occurred at the NTS, including spills of hazardous materials at the HSC in Area 5. The tests conducted at the HSC, from the latter half of

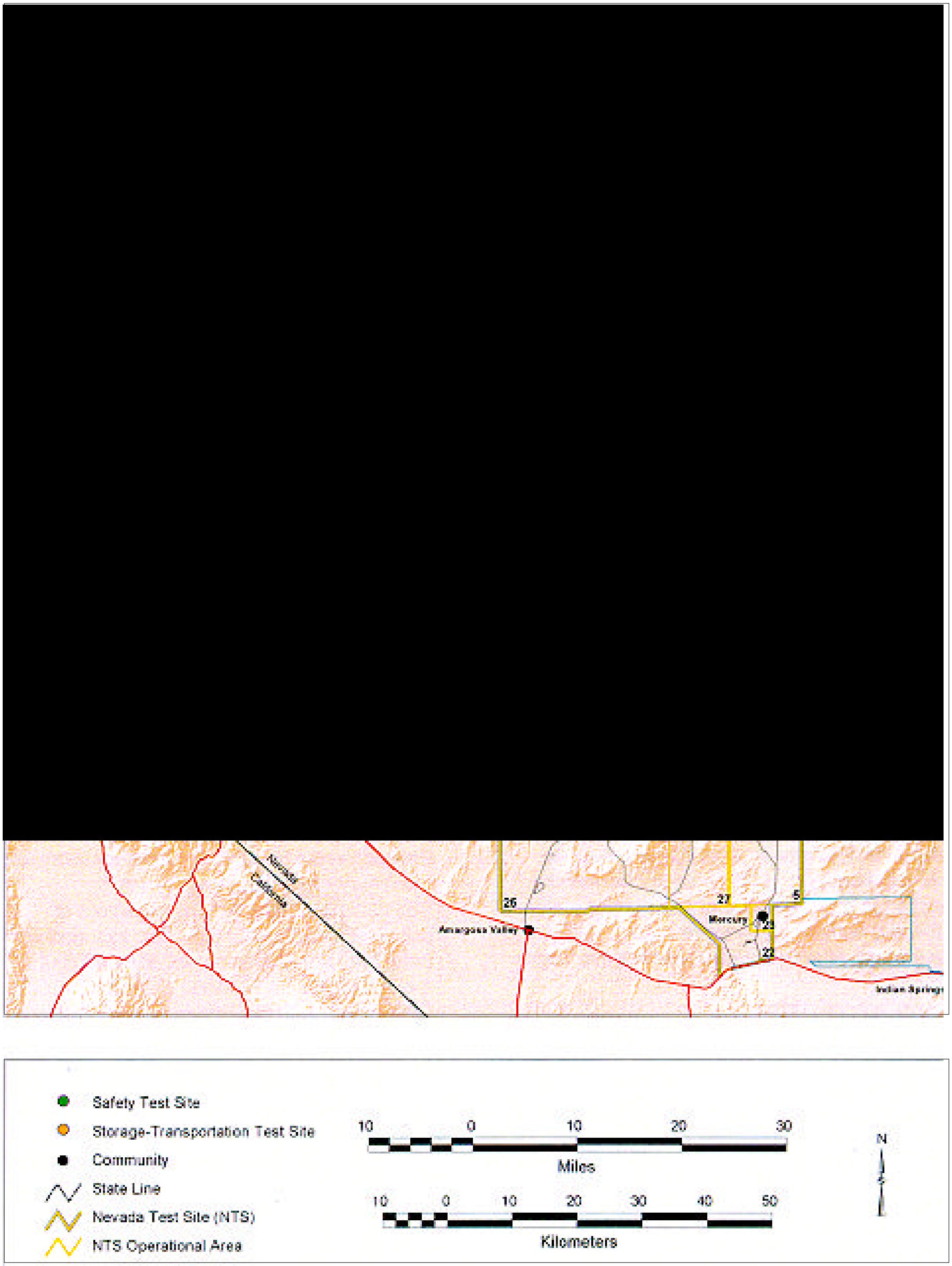


Figure 2.3 Location of Safety Tests on the NTS and the NAFR

the 1980s to date, involved controlled spilling of liquid materials to study both spill control and mitigation measures and the resultant dispersion and transport of airborne clouds. At the Explosive Ordnance Disposal in Area 11, explosive materials are destroyed, generally by detonation, with the amounts destroyed being limited in order to maintain downwind air concentrations within state limits. Tests are conducted involving depleted uranium and other materials at the Big Explosives Experimental Facility in Area 4.

Waste storage and disposal facilities for defense low-level radioactive waste (LLW) and mixed waste are located in Areas 3 and 5. At the Area 5 Radioactive Waste Management Site (RWMS-5), LLW from DOE-affiliated onsite and offsite generators is disposed of using standard shallow land disposal techniques.

TRU wastes are retrievably stored in surface containers at the RWMS-5 pending shipment to the Waste Isolation Pilot Plant (WIPP) facility in New Mexico. Nonradioactive hazardous wastes are accumulated at a special site before shipment to a licensed offsite disposal facility.

At the Area 3 RWMS (RWMS-3), bulk LLW (such as debris from atmospheric nuclear test locations) and LLW in large non-standard packages are emplaced and buried in selected surface subsidence craters (formed as a result of prior underground nuclear tests).

1998 ACTIVITIES

SUBCRITICAL EXPERIMENTS

No nuclear explosives tests were conducted during 1998, due to the moratorium announced in late 1992. There were three subcritical experiments which involved small amounts of fissionable materials that do not reach the fissioning stage during the experiment. However, continuous environmental surveillance for radioactivity and radiation was conducted both onsite and offsite, because of the large number of potential effluent sources that exist on the NTS as a result of the prior nuclear tests. The surveillance program and results are described in Chapters 4, 5, and 6.

NTS-RELATED ACTIVITIES

LLW and mixed waste handling and disposal, TRU waste storage and packaging prior to shipment to the WIPP in New Mexico, and remedial actions related to sites contaminated by tests of nuclear devices are some of the activities that occurred in 1998.

Compliance with state and federal environmental laws and regulations was another principal activity during 1998. Specifically included were actions related to (1) National Environmental Policy Act documentation preparation, such as Environmental Impact Statements, Environmental Assessments, etc.; (2) Clean Air Act compliance for asbestos renovation projects, radionuclide emissions, and state air quality permits; (3) Clean Water Act compliance involving state wastewater permits; (4) Safe Drinking Water Act compliance involving monitoring of drinking water distribution systems; (5) Resource Conservation and Recovery Act management of hazardous wastes; (6) Comprehensive Environmental Response, Compensation, and Liability Act reporting; and (7) Toxic Substances Control Act management of polychlorinated biphenyls. Also included were preactivity surveys to detect and document archaeological and historic sites on the NTS. Compliance with the Endangered Species Act involved conducting pre-operation surveys to document the status of state of Nevada and federally listed endangered or threatened plant and animal species.

HAZARDOUS MATERIALS SPILL CENTER (HSC)

DOE/NV’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 BN. The HSC is the basic research tool for studying the dynamics of accidental releases of various hazardous materials. This is described more completely in Chapter 6.

TOPOGRAPHY AND TERRAIN

The topography of the NTS is typical of the Great Basin Section of the Basin and Range physiographic province of Nevada, Arizona, and Utah. North-south-trending mountain ranges are separated by broad, flat-floored, and gently-sloped valleys. The topography is depicted in Figure 2.4. Elevations range from about 910 m (3,000 ft) above mean sea level (MSL) in the south and east, rising to 2,230 m (7,300 ft) in the mesa areas toward the northern and western boundaries. The slopes on the upland surfaces are steep and dissected, whereas the slopes on the lower surfaces are gentle and alluviated with rock debris from the adjacent highlands.

The principal effect upon the terrain from nuclear testing has been the creation of numerous dish-shaped surface subsidence craters, particularly in Yucca Flat. Most underground nuclear tests conducted in vertical shafts produced surface subsidence craters that occurred when the overburden above a nuclear cavity collapsed and formed a rubble "chimney" to the surface. A few craters have been formed as a result of tests conducted on or near the surface by shallow depth-of-burial cratering experiments, or following some tunnel events.

There are no continuously flowing streams on the NTS. Surface drainages for Yucca and Frenchman Flats closed-basin systems are onto the dry lake beds (playas) in each valley. The remaining areas of the NTS drain via arroyos and dry stream beds that carry water only during unusually intense or persistent storms. Rainfall or snow melt typically infiltrates quickly into the moisture-deficient soil or runs off in normally dry channels, where it evaporates and seeps into permeable sands and gravels. During extreme conditions, flash floods may occur.

GEOLOGY

The basic lithologic structure of the NTS is depicted in Figure 2.5. Investigations of the geology of the NTS, including detailed studies of numerous drill holes and tunnels, have been in progress by the U.S. Geological Survey (USGS) and other organizations since 1951. Because of the large number of drilled holes (see Figure 2.6), the NTS is probably one of the better geologically characterized large areas within the United States.

In general, the geology consists of three major rock units. These rock units are (1) complexly folded and faulted sedimentary rocks of Paleozoic age overlain at many places by; (2) volcanic tuffs and lavas of Tertiary age, which (in the valleys) are covered by; (3) alluvium of late Tertiary and Quaternary age. The sedimentary rocks of Paleozoic age are many thousands of feet thick and are comprised mainly of carbonate rocks (dolomite and limestone) with clastic rocks (shale and quartzite) near the top and at the bottom of the section. The volcanic rocks in the valleys are down-dropped and tilted along steeply dipping normal faults of late Tertiary age. The alluvium is rarely faulted and is derived from erosion of Tertiary and Paleozoic rocks. The volcanic rocks of the Tertiary age are predominantly rhyolitic tuffs and lavas, which erupted from various volcanic centers. The aggregate thickness of the volcanic rocks is many thousands of feet, but in most places the actual thickness of the section is far less because of erosion or nondeposition. These materials erupted before the collapse of large volcanic centers known as *calderas*. Alluvial materials fill the intermountain valleys and cover the adjacent slopes. These sediments attain thicknesses of 600 to 900 m (2,000 to 3,000 ft) in the central portions of the valleys.

HYDROGEOLOGY

The deep aquifers, slow groundwater movement, and exceedingly slow downward movement of water in the overlying

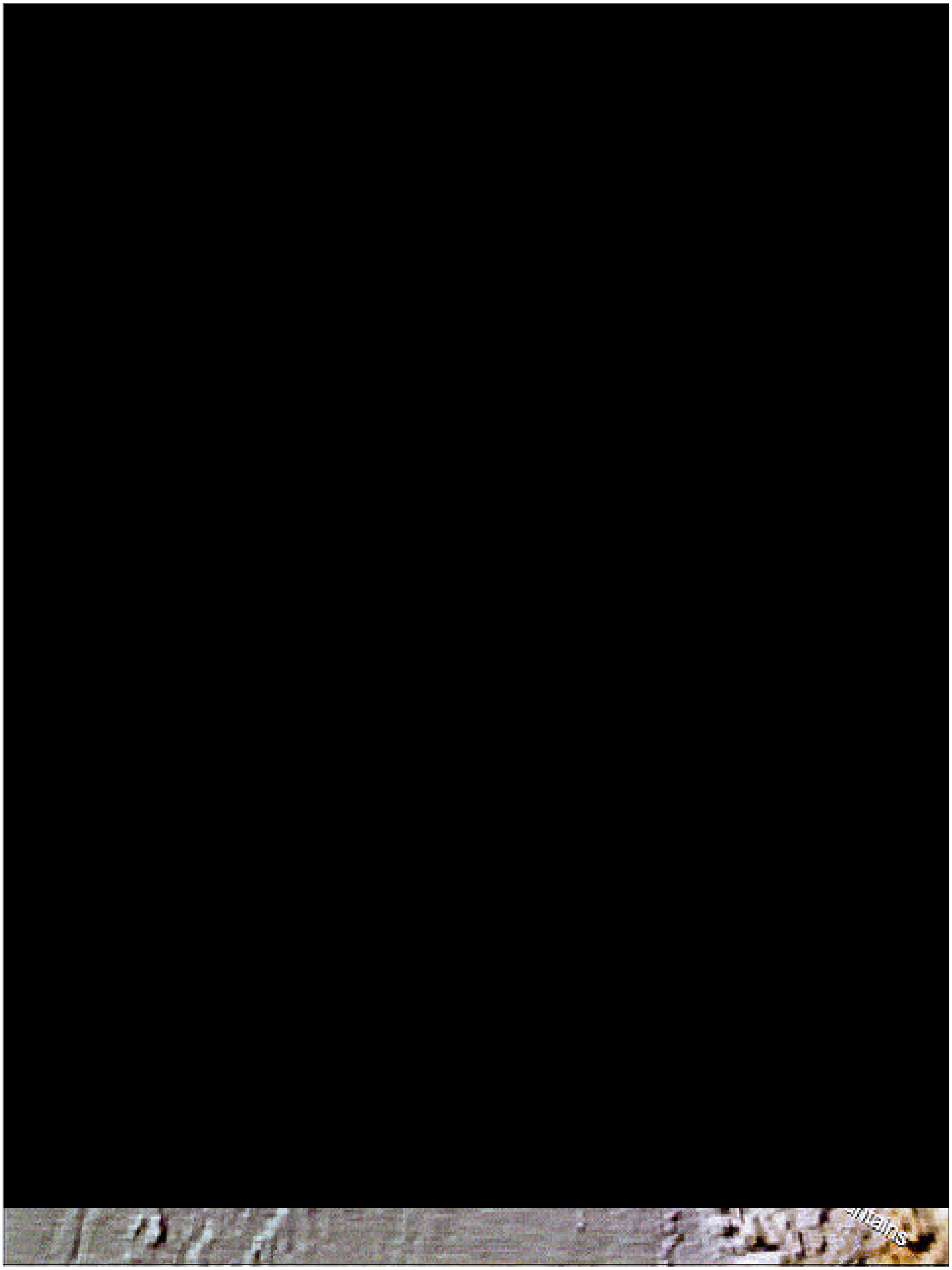
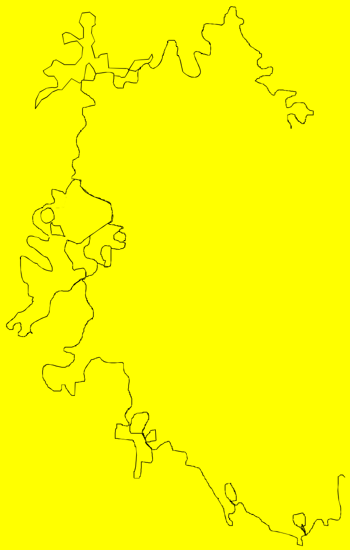


Figure 2.4 Topography of the NTS



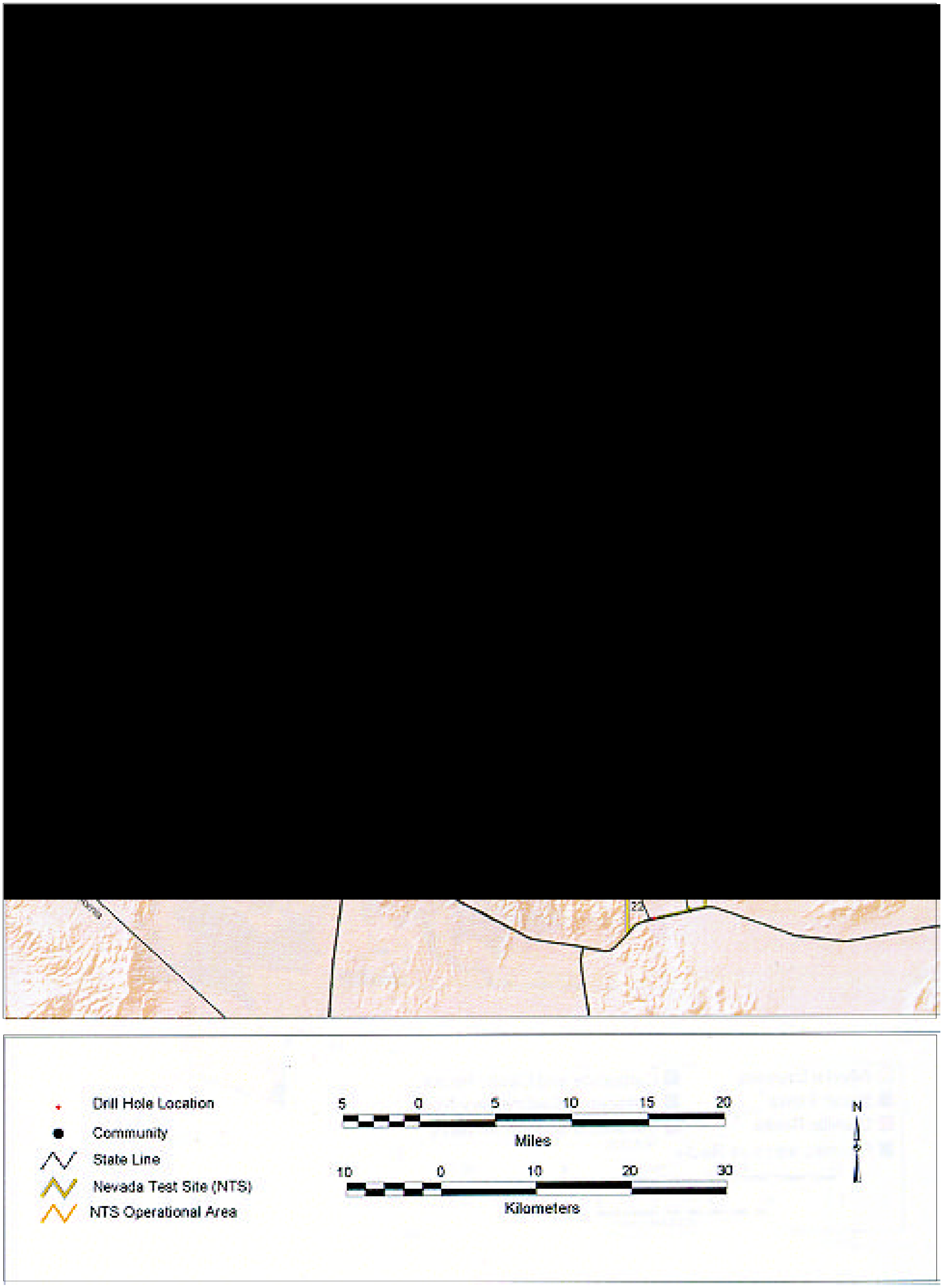


Figure 2.6 Drill Hole Locations on the NTS

unsaturated zone serve as significant barriers to transport of radioactivity from unsaturated zone sources via groundwater, greatly limiting the potential for transport of radioactivity to offsite areas. Some historic nuclear tests were conducted below the groundwater table; others were at varying depths above the groundwater table. Nuclear tests below the groundwater table have a greater potential for offsite migration. However, the great distance to offsite water supply wells or springs makes it unlikely that contaminants will be transported in significant quantities.

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, in the western portions, it occurs predominantly in volcanic rocks. The flow in the shallower parts of the groundwater is generally toward the major valleys (Yucca and Frenchman), where it may deflect downward to join the regional drainage to the southwest in the carbonate aquifer.

The hydrogeology of the underground nuclear testing areas on the NTS (Figure 2.7) has been summarized by the Desert Research Institute, University of Nevada System and the USGS (Russell 1990 and Laczniak et al., 1996). Yucca Flat is situated within the Ash Meadows groundwater subbasin. Groundwater occurs within the valley-fill, volcanic and carbonate aquifers, and in the volcanic and clastic aquitards. The depth to water generally ranges from 210 m (690 ft) to about 580 m (1,900 ft) below the ground surface. The tuff aquitard forms the principal Cenozoic hydrostratigraphic unit beneath the water table in the eastern two-thirds of the valley and is unconfined over most of its extent. The valley-fill aquifer is saturated in the central part of the valley and is unconfined (Winograd and Thordarson 1975).

Some underflow, past all of the subbasin discharge areas, probably reaches springs in Death Valley. Recharge for all of the subbasins most likely occurs by precipitation at higher elevations and infiltration along ephemeral stream courses and in playas. Regional groundwater flow is from the upland recharge areas in the north and east, towards discharge areas at Ash Meadows and Death Valley, southwest of the NTS. Due to the large topographic changes across the area and the importance of fractures to groundwater flow, local flow directions can be radically different from the regional trend.

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 currently used for DOE activities. South of the NTS, private and public supply wells are completed in a valley-fill aquifer.

Frenchman Flat is also within the Ash Meadows subbasin. Regional groundwater flow in this valley occurs within the major Cenozoic and Paleozoic hydrostratigraphic units at depths ranging from 210 to 350 m (690 to 1,150 ft) below the ground surface. Perched water is found as shallow as 20 m (66 ft) within the tuff and lava-flow aquitards in the western part and older Tertiary sedimentary rocks in the southwestern part of the valley. In general, the depth to water is at least 210 m (690 ft) beneath Frenchman playa and increases to nearly 360 m (1,180 ft) near the margins of the valley (Winograd and Thordarson 1975). The water table beneath Frenchman Flat is considerably shallower than beneath Yucca Flat. Consequently, the extent of saturation in the valley-fill and volcanic aquifers is correspondingly greater.

Winograd and Thordarson (1975) hypothesized that groundwater within the Cenozoic units of Yucca and Frenchman Flats probably cannot leave these basins without passing through the underlying and surrounding tuff confining unit. In addition,

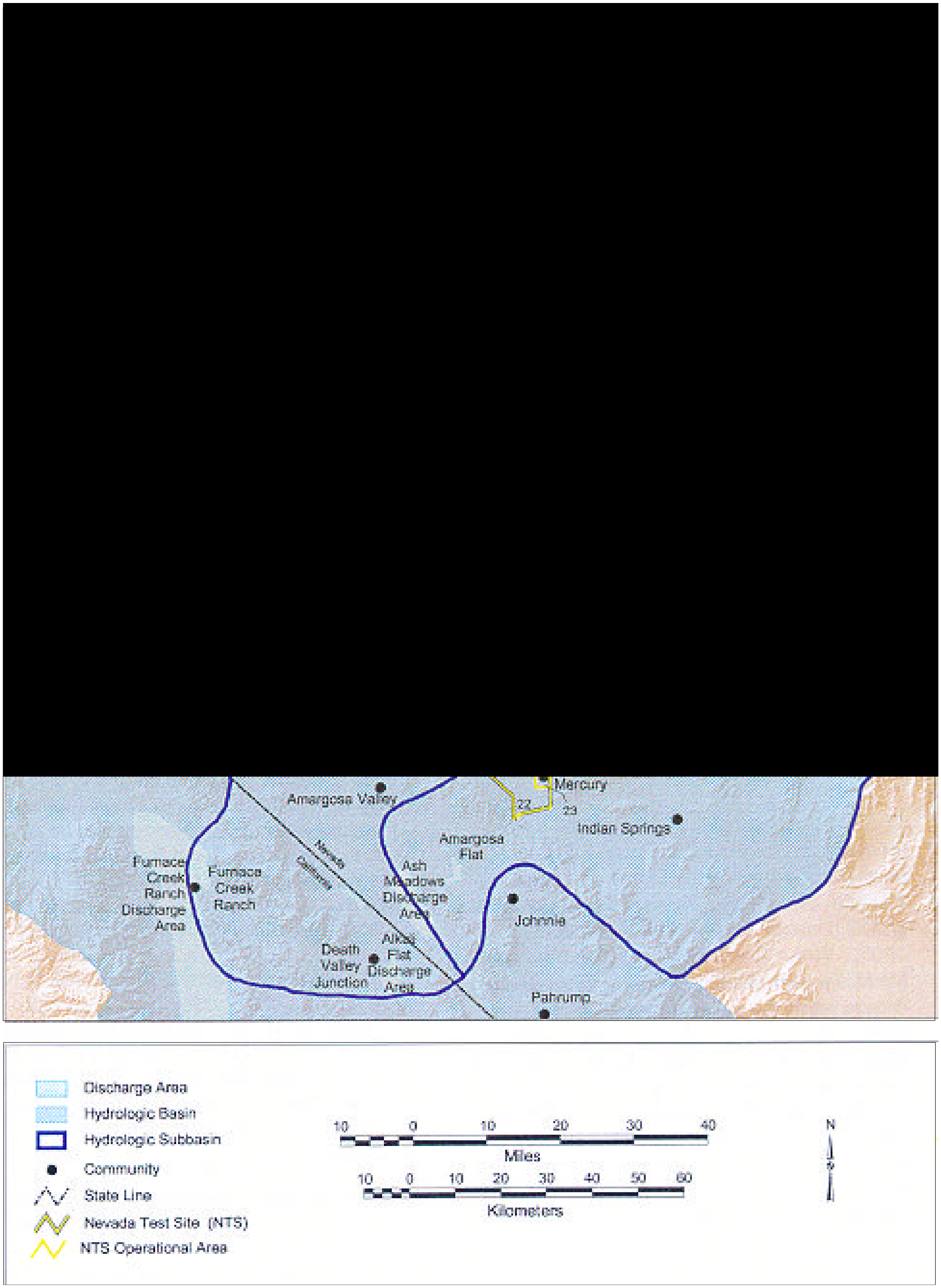


Figure 2.7 Groundwater Hydrologic Units of the NTS and Vicinity

lateral gradients within the saturated volcanic units exist and may indicate groundwater flow toward the central areas of Yucca and Frenchman Flats prior to vertical drainage.

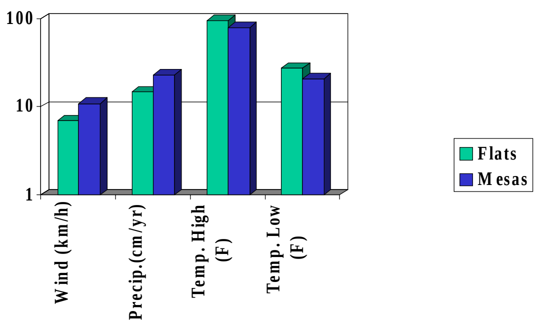
The only hydrostratigraphic units encountered at Pahute Mesa are the volcanic aquifers and aquitards. Pahute Mesa is thought to be a part of both the Oasis Valley and Alkali Flat/Furnace Creek Ranch subbasins (Figure 2.7). The location of the inter-basin boundary is uncertain. Groundwater is thought to move towards the south and southwest, through Oasis Valley, Crater Flat, and western Jackass Flats. Points of discharge are thought to include the springs in Oasis Valley, Alkali Flat, and Furnace Creek. The amount of recharge to Pahute Mesa and the amount of underflow, which moves to the various points of discharge, are not accurately known. Vertical gradients within Pahute Mesa suggest that flow may be downward in the eastern portion of the mesa but upward in the western part (Blankennagel and Weir 1973). The hydrostratigraphic units beneath Rainier Mesa consist of the welded and bedded tuff aquifer, tuff confining unit, the lower carbonate aquifer, and the lower clastic aquitard. The volcanic aquifer and aquitards support a semiperched groundwater lens. Nuclear testing at Rainier Mesa was conducted within the tuff aquitard. Work by Thordarson (1965) indicates that the perched groundwater is moving downward into the underlying regional aquifer. Depending on the location of the subbasin boundary, Rainier Mesa groundwater may be part of either the Ash Meadows or the Alkali Flat/Furnace Creek Ranch subbasin. The regional flow from the mesa may be directed either towards Yucca Flat or, because of the intervening upper clastic aquitard, towards the Alkali Flat discharge area in the south. The nature of the regional flow system beneath Rainier Mesa requires further investigation.

CLIMATE AND METEOROLOGY

Precipitation levels on the NTS are low, runoff is intermittent, and the majority of the active testing areas onsite drain into closed basins on the NTS. Topography contributes to temporal and spatial variability of precipitation (Quiring 1968).

Elevation also influences temperatures on the NTS, and wind direction and speed are important aspects of the environment at the NTS. The movements of large-scale pressure systems control the seasonal changes in the wind direction frequencies. Predominating winds are southerly from the south during summer and northerly during winter. The general downward slope in the terrain from north to south results in an intermediate scenario that is reflected in the characteristic diurnal wind reversal from southerly winds during the day to northerly winds at night. This north to south reversal is strongest in the summer. The average wind speed and precipitation along with the maximum and minimum temperatures on the mesas and flats of the NTS are shown in the graph below.

NTS METEOROLOGY



The 1992 10-m wind roses for the NTS are shown in Figure 2.8.

FLORA AND FAUNA

The vegetation on most of the NTS includes various associations of desert shrubs typical of the Mojave or Great Basin Deserts or the zone of transition between these two. Extensive floral collection has yielded 711 taxa of vascular plants within or near the boundaries of the NTS (O'Farrell and Emery 1976). Associations of creosote bush, *Larrea tridentata*, which are characteristic of the Mojave Desert, dominate the vegetation mosaic on the bajadas of the southern NTS. Between 1,220 and 1,520 m (4,000 and 5,000 ft)

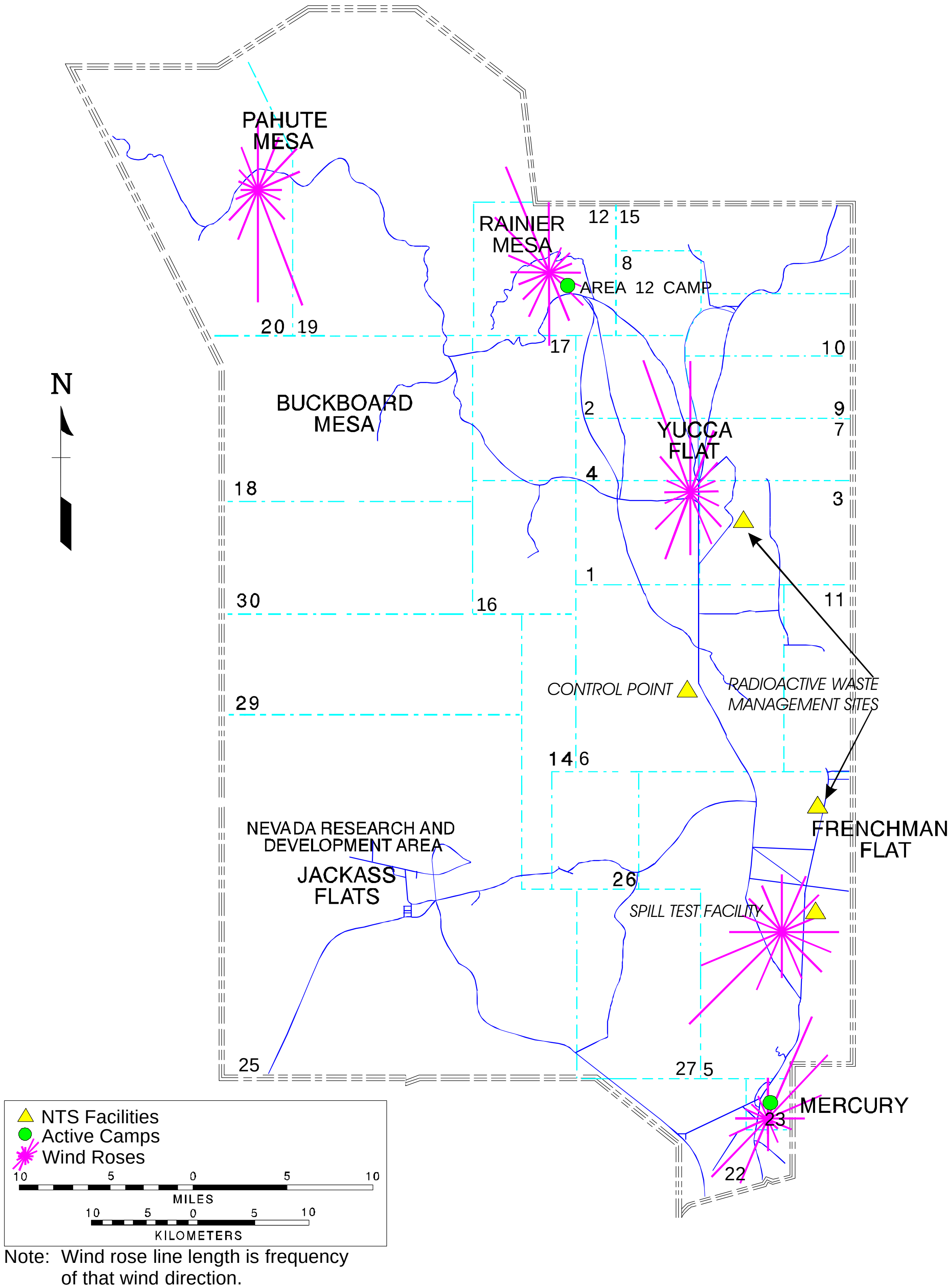


Figure 2.8 1992 Wind Rose Patterns for the NTS (Courtesy of Air Resources Laboratory, Special Operations and Research Division)

in elevation in Yucca Flat, transitional associations are dominated by *Grayia spinosa-Lycium andersonii* (hopsage/desert thorn) associations, while the upper alluvial fans support *Coleogyne* types. Above 1,520 m (5,000 ft), the vegetation mosaic is dominated by sagebrush associations of *Artemisia tridentata* and *Artemisia arbuscula* subspecies *nova*. Above 1,830 m (6,000 ft), piñon pine and juniper mix with the sagebrush associations, where there is suitable moisture for these trees. No plant species located on the NTS is currently on the federal endangered species list; however, the state of Nevada has placed *Astragalus beatleyae* on its critically endangered species list.

Most mammals on the NTS are small and secretive (often nocturnal in habitat), hence not often seen by casual observers. Rodents are the most important group of mammals on the NTS, based on distribution and relative abundance. Larger mammals include feral horses, mule deer, mountain lions, bobcats, coyote, kit foxes, and rabbits, among others. Among other taxa, the reptiles include the desert tortoise, over 12 lizards, and 17 snakes; 4 of which are venomous. Bird species are mostly migrants or seasonal residents. Most nonrodent mammals have been placed in the "protected" classification by the state of Nevada. The Mojave population of the desert tortoise, *Gopherus agassizii*, is listed as threatened by the U.S. Fish and Wildlife Service. The habitat of the desert tortoises on the NTS is found in its southern third, outside the recent areas of nuclear explosives test activities.

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, which contain the only information available concerning the prehistoric inhabitants. The site types identified include rock quarries, tool-manufacturing areas, plant-processing locations, hunting locales, rock art, temporary camps, and permanent villages. The prehistoric people's 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 Paiute and 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. 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.

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. Very few locations associated with this time period have been identified. In 1950, the NTS was selected as the continental nuclear testing ground. Surveys have located and recorded many structures associated with nuclear testing. These structures are significant because of the importance of the nuclear testing program in the history of the United States, as well as its effects on the rest of the world.

DEMOGRAPHY

The population of the area surrounding the NTS has been estimated based on the 1990 Bureau of Census estimates (Department of

Commerce 1990). Excluding Clark County, the major population center (over 1,000,000 in 1998), the population density within a 150-km (90-mi) radius of the NTS is about 0.2 persons/km^2. In comparison, the 48 contiguous states (1990 census) had a population density near 29 persons/km^2. The offsite area within 80 km (50 mi) of the NTS Control Point (CP) is predominantly rural. CP-1 (a building at the Control Point) historically has been the point from which distances from the NTS were determined. Several small communities are located in the area, the largest being in the Pahrump Valley. This growing rural community, with an estimated population of nearly 20,000, is about 50 mi (80 km) south of CP-1. The Amargosa Farm area, which has a population of about 1,200, is approximately 50 km (30 mi) southwest of CP-1. The largest town in the near offsite area is Beatty, which has a population of about 1,500 and is approximately 65 km (40 mi) to the west of CP-1.

The Mojave Desert of California, which includes Death Valley National Monument, lies along the southwestern border of Nevada. The National Park Service estimated that the population within the boundaries ranges from 200 permanent residents during the summer months to as many as 5,000 tourists and campers on any particular day during holiday periods in the winter months. The largest nearby population in this desert is in the Ridgecrest-China Lake area about 190 km (118 mi) southwest of the NTS, containing about 28,000 people. The next largest is in the Barstow area located 265 km (165 mi) south-southwest of the NTS with a population of 24,000. The Owens Valley, where many small towns are located, lies west of Death Valley. The largest town in Owens Valley is Bishop, 225 km (140 mi) west-northwest of the NTS, with a population of 3,500.

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 29,000. The next largest town, Cedar City, with a population of 14,000, 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.

SURROUNDING LAND USE

Figure 2.9 is a map of the offsite area showing a wide variety of land uses such as farming, mining, grazing, camping, fishing, and hunting within a 300-km (180-mi) radius of the CP-1. West of the NTS, elevations range from 85 m (280 ft) below MSL in Death Valley to 4,400 m (14,500 ft) above MSL in the Sierras, including parts of the Owens and San Joaquin agricultural valleys. The areas south of the NTS are more uniform, since the Mojave Desert ecosystem (mid-latitude desert) comprises most of this portion of Nevada, California, and Arizona.

The areas east of the NTS are primarily mid-latitude steppe with some of the older river valleys, such as the Virgin River and Moapa Valleys, supporting irrigation for small-scale but intensive farming of a variety of crops. Grazing is also common in this area, particularly towards the northeast. The area north of the NTS is also mid-latitude steppe where the major agricultural activity is grazing of cattle and sheep, and a minor agricultural activity is the growing of alfalfa hay. Many of the residents cultivate home gardens.

Recreational areas lie in all directions around the NTS and are used for such activities as hunting, fishing, and camping. In general, the camping and fishing sites to the north of the NTS are not utilized in the winter months. Camping and fishing locations to the south are utilized throughout the year. The peak hunting season is from September through January.

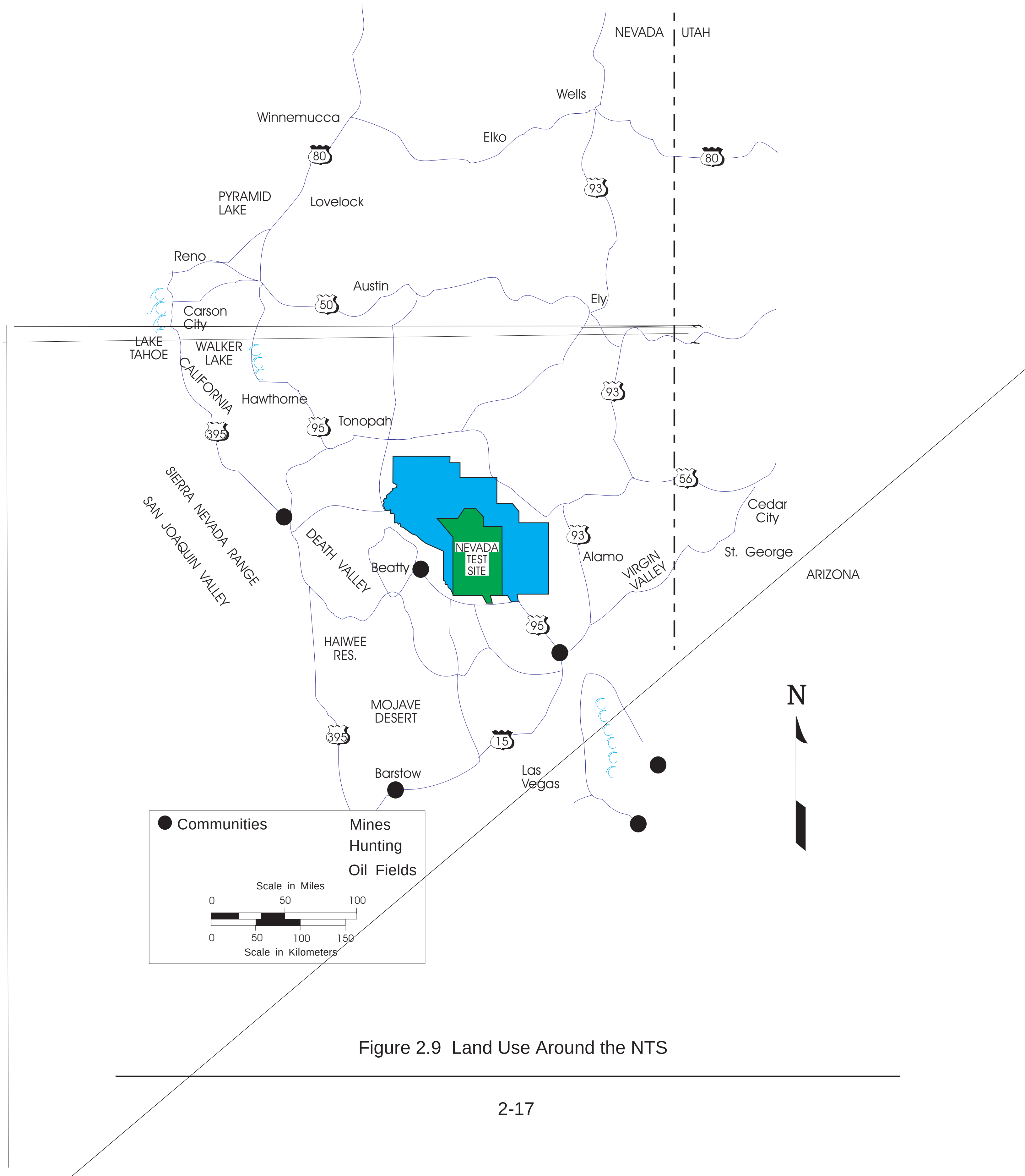


Figure 2.9 Land Use Around the NTS

2.2 NON-NTS FACILITIES

Under a contract with DOE/NV, BN has several offsite operations that support activities at the NTS. Each of these facilities is located in a metropolitan area.

City, county, and state regulations govern emissions, waste disposal, and sewage. No independent BN systems exist for sewage disposal or for supplying drinking water, and hazardous waste is moved off the facility sites for disposal. Radiation sources are sealed, and no radiological emissions above a small fraction of federal guidelines are expected during normal facility operations.

LIVERMORE OPERATIONS (LO)

The LO Facility occupies a 5,520-m^2 (59,445-ft^2) two-story combination office/laboratory building. LO is located near the Lawrence Livermore National Laboratory (LLNL) in Livermore, California, to simplify logistics and communications associated with BN support of LLNL programs. Although most of the work has been in support of NTS underground weapons testing, LO also supports LLNL with optical alignment systems and a variety of mechanical and electrical engineering activities associated with energy research and development programs. Areas of environmental interest include two small chemical cleaning operations.

SPECIAL TECHNOLOGIES LABORATORY (STL)

STL is located in Santa Barbara, California. The current facilities occupy approximately 4,608 m^2 (49,600 ft^2) and consist of combination office/laboratory areas, used primarily for engineering and electronic research. The research is conducted to develop a suite of sensor systems for testing and field deployment in support of DOE Headquarters and DOE/NV. Areas of environmental interest include a small printed circuit board operation, minor solvent cleaning operations, neutron activation, and pulsed X-ray system experiments.

NORTH LAS VEGAS FACILITY (NLVF)

The NLVF provides technical support for DOE/NV activities and includes multiple structures totaling about 53,820 m^2 (585,000 ft^2). There are numerous areas of environmental interest at the NLVF, including a machine shop using cutting fluids, a radiation source range, an X-ray laboratory, solvent and chemical cleaning operations, small amounts of pesticide and herbicide application, and hazardous waste generation and accumulation.

REMOTE SENSING LABORATORY (RSL)

The RSL is an 11,000-m^2 (118,000-ft^2) facility located on a 14-ha (35-acre) site within the confines of Nellis Air Force Base. The facility includes space for aircraft maintenance and operations, mechanical and electronics assembly, computer operations, photo processing, a light laboratory, warehousing, and emergency operations. Areas of environmental interest are photo processing, aircraft maintenance, and operations.

LOS ALAMOS OPERATIONS (LAO)

The LAO resides in an engineering and laboratory office complex of approximately 4,645 m^2 (50,000 ft^2). It is located near the Los Alamos National Laboratory (LANL) facility to provide local support for LANL's programs. The work performed includes direct support to the LANL Science-Based Stockpile Stewardship program, the DOE Research and Development Program, and miscellaneous DOE cash-order work. LAO's primary activities are twofold: the design, fabrication, and fielding of data acquisition systems used in underground and above ground testing diagnostics and the analysis of data from prior experiments. Areas of environmental interest include small solvent cleaning operations, metal machining, operations, and a small photo laboratory.

WASHINGTON AERIAL MEASUREMENTS OPERATIONS (WAMO)

The WAMO, located at Andrews Air Force Base, consists of five buildings: a 186-m^2 (2,000-ft^2) Butler Building used as office space; a 1,110-m^2 (12,000-ft^2) hangar, combination electronics laboratory, aircraft maintenance, and office complex; a 37-m^2 (400-ft^2) equipment service and storage building; and 186 m^2 (2,000 ft^2) in each of two other joint tenant buildings. A new 24,000 square foot building is 60 percent complete. Because of weather and other factors, the acceptance date will most likely be delayed until late spring or early summer 1999. This building will consolidate operations from Buildings 3802, 3812, 1792, and the deployment shed. WAMO provides an effective east coast emergency response capability and an eastern aerial survey capacity to the DOE/NV. Areas of environmental interest include minor solvent cleaning operations, used fuels, and oils.

2.3 NON-NTS UNDERGROUND TEST SITES

Nuclear explosive tests have been conducted underground for a variety of purposes at eight different non-NTS sites in the United States. The tests and their locations appear in Table 2.1 (Atomic Energy Commission (AEC) 1964, 1965, 1966, 1970, 1972, 1973a, 1973b; DOE 1978, 1984, 1986; PHS 1966). Activities at these locations generally are limited to annual sampling of surface and groundwater at over 200 wells, springs, etc., at locations near the sites where tests were conducted. A Remedial Investigation/Feasibility Study has begun at the Mississippi test location, which will include significant new characterization activities. Sampling near three test sites on Amchitka Island, Alaska, occurs only periodically. Sampling results for these sites appear in Chapter 5 of this report.

Table 2.1 Non-NTS Underground Nuclear Tests

Test Name	Location	Purpose	Date of Test
GNOME	Carlsbad, New Mexico	Plowshare	12/10/1961
SHOAL	Fallon, Nevada	Vela Uniform	10/26/1963
SALMON	Hattiesburg, Mississippi	Vela Uniform	10/22/1964
LONG SHOT	Amchitka Island, Alaska	Vela Uniform	10/29/1965
STERLING	Hattiesburg, Mississippi	Vela Uniform	12/03/1966
GASBUGGY	Farmington, New Mexico	Vela Uniform	12/10/1967
FAULTLESS	Central Nevada	Plowshare	01/19/1968
RULISON	Grand Valley, Colorado	Weapons Related	09/10/1969
MILROW	Amchitka Island, Alaska	Plowshare	10/02/1969
CANNIKIN	Amchitka Island, Alaska	Weapons Related	11/06/1971
RIO BLANCO	Rifle, Colorado	Plowshare	05/17/1973

3.0 COMPLIANCE SUMMARY

Environmental compliance activities at the Nevada Test Site (NTS) during calendar year (CY) 1998 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) 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) 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 1998 the NTS was subject to several formal compliance agreements with 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 covering environment, safety, and health activities; 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 and waste minimization at the NTS continued in 1998.

The state of Nevada filed a Complaint for Declaratory Judgement and Injunction against the U.S. Department of Energy (DOE) in June 1994. All of the claims in this Complaint have now been resolved.

Compliance activities at non-NTS facilities of DOE Nevada Operations Office (DOE/NV) 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, and (5) hazardous substance reporting. Pollution prevention and waste minimization efforts continued at all locations.

3.1 COMPLIANCE STATUS

NATIONAL ENVIRONMENTAL POLICY ACT

Paragraph 1500.2 of NEPA (Code of Federal Regulations [CFR] 1969) requires all federal agencies to consider environmental effects, values, and reasonable alternatives before making a decision to implement any major federal action that may have a significant impact on the human environment.

Since November 1994, DOE/NV has had full delegation of authority from DOE Headquarters (DOE/HQ) for Environmental Assessments (EAs), issuing Findings of No

Significant Impact and associated floodplain and wetland action documentation related to DOE/NV proposed actions.

DOE uses three levels of documentation to demonstrate compliance with NEPA: (1) an Environmental Impact Statement (EIS) is a full disclosure of the potential environmental effects of proposed actions and the reasonable alternatives to those actions; (2) an EA is a concise discussion of a proposed action and alternatives and the potential environmental effects to determine if an EIS is necessary; and (3) a Categorical Exclusion (CX) is used for classes of action which have been found to have no adverse environmental impacts, based on similar previous activities. DOE/NV activities involved only CXs and Eas during 1998.

During fiscal year (FY) 1996 and FY 1997, a draft NEPA Environmental Evaluation Checklist was circulated by DOE/NV's Environmental Protection Division, now the Environment, Safety and Health Division (ESHD). In October 1997, the Checklist was formally issued by DOE ESHD. Completion of the Checklist is required under the DOE/NV Work Acceptance Process Procedural Instructions (DOE 1997a) for all proposed projects or activities. The Checklist is reviewed by the DOE/NV NEPA Compliance Officer to determine whether the project or activity is included in the NTS/EIS and record of decision (ROD) or other previously completed NEPA analysis. During FY 1998, Checklists were completed for 60 proposed projects or activities. Twenty-six of these 60 were exempted from further NEPA analysis by being a CX; 32 were exempted due to previous analysis in the NTS/EIS and ROD; one needed further analysis as required for an EA; and one was withdrawn.

Still pending are the following documents developed by or with DOE/NV involvement:

- Nellis Air Force Range (NAFR) EIS.
- Kistler Aerospace Corporation in Areas 18 and 19 EA.
- Withdrawal of public lands for range safety and training purposes at the Naval Air Station in Fallon, Nevada EIS.
- Desert Rock Sky Park in Area 22, EA.
- B52 Bomb Bay Systems Level Fire Test in Area 5, EA.

Throughout CY 1998, the staff of the DOE ESHD continued to maintain and update the NEPA Compliance Guide (Volume III), a quick reference handbook containing procedures, formats, and guidelines for those personnel responsible for NEPA compliance activities. The staff of the DOE ESHD prepared Volume III to supplement the NEPA Compliance Guides, Volumes I and II, prepared and distributed by the Office of NEPA Policy and Assistance, DOE/HQ.

CLEAN AIR ACT (CAA)

The CAA and the state of Nevada air quality control compliance activities were limited to asbestos abatement, radionuclide monitoring, and reporting under the National Emission Standards for Hazardous Air Pollutants (NESHAP), and air quality permit compliance requirements. There were no criteria pollutant or prevention of significant deterioration monitoring requirements for NTS operations.

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. Notifications are also required to be made to the U.S. Environmental Protection Agency (EPA) Region 9 for projects which disturb greater than 260 linear ft or 160 ft^2 of asbestos-containing material, in accordance with Title 40 Code of Federal Regulations 61.145-146 (CFR 1989).

During 1998, there were no projects that required state of Nevada notifications be made. The annual estimate for non-scheduled asbestos demolition/renovation for FY 1999 was sent to EPA Region 9 in December 1998.

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. In compliance with those requirements, a report on airborne radioactive effluents is provided to DOE/HQ and to EPA's Region 9.

There are two locations on the NTS where airborne radioactive effluents may be emitted from permanent stacks: (1) the tunnels in Rainier Mesa, and (2) the analytical laboratory hoods in the community of Mercury. Based on the amount of radioactivity handled, the exhaust from the analytical laboratories is considered negligible compared to other sources on the NTS and the tunnels have been sealed (although water still seeps from one). Present sources are evaporation of tritiated water (HTO) from containment ponds, diffusion of HTO vapor from the Area 5 Radioactive Waste Management Site (RWMS-5), the SEDAN test in Area 10, the SCHOONER test in Area 20, and resuspension of plutonium contaminated soil from nuclear device safety test and atmospheric test locations.

In the 1998 NTS NESHAP report for airborne radioactive effluents (Black 1999), airborne emission of HTO vapor from the containment ponds was conservatively reported as if all the liquid discharge into the ponds had evaporated and become airborne. For HTO vapor diffusing from the RWMS-5, SEDAN, and SCHOONER, plutonium particulate resuspension from Areas 3 and 9, and various other areas on and near the NTS, the airborne effluents were conservatively estimated as follows.

The monitoring station with the maximum annual average concentration for the radionuclide in question was selected from among the surrounding sampling stations. An effective dose equivalent (EDE) was then calculated for that concentration. EPA's Clean Air Package 1988 (CAP88-PC [EPA 1992]) software program was used to determine what total emission from the geometric center of the region in question would be required in order to produce that EDE. Resuspended radioactivity was estimated by employing a published formula and confirming the estimate with offsite data.

Using these conservative estimates of air emissions in 1998 as input to the CAP88-PC computer model, the EDE would have been only 0.092 mrem (9.2×10^{-4} 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 through permit reporting and renewal and ongoing verification of operational compliance with permit-specified limitations. A summary of NTS permits is in Table 3.1. (See Chapter 4 for a listing of active permits.) Common air pollution sources at the NTS include aggregate production, stemming activities, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities. The 1997 Air Quality Permit Data Report was sent to the state of Nevada on January 28, 1998. This report includes aggregate production, operating hours of permitted equipment, and a report of all surface disturbances of five acres or greater. In order to provide consistency in responses, the state provided forms, which required calculation of actual emissions. During 1997, approximately 30 tons of pollutants were emitted from operations at the NTS.

NTS air quality permits limit particulate emissions to 20 percent opacity, except for the Area 1 Aggregate Plant, which is

10 percent. Certification of personnel to perform valid visible emission opacity evaluations is required by the state, with recertification required every six months. During 1998, one employee of Bechtel Nevada's (BN's) Environmental Compliance Department was recertified. In 1998, several visible emission evaluations of permitted air quality point sources were conducted. When visual evaluations determine that emissions are exceeding the opacity requirement, corrective action is initiated. In 1998, there was only one exceedance of the 10 percent limit at the Area 1 Aggregate Plant, which required no corrective actions.

On June 23, 1998, the state inspected all permitted facilities/equipment located in Areas 1, 6, 12, and 23 that are covered by the NTS Class II Air Quality Operating Permit No. AP9711-0549. There were no findings as a result of that inspection.

NON-NTS OPERATIONS

Under normal conditions, the six non-NTS facilities operated by the DOE/NV do not produce radioactive effluents. The six are the North Las Vegas Facility (NLVF) and Remote Sensing Laboratory (RSL) in North Las Vegas; Special Technologies Laboratory (STL) in Santa Barbara, California; Livermore Operations (LO) in Livermore, California; Los Alamos Operations (LAO) in Los Alamos, New Mexico; and Washington Aerial Measurements Operations (WAMO) in Washington, D.C.

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 DOE/NV 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 summary of NTS permits is displayed in Table 3.1, and a separate list of applicable permits appear in Chapters 4,5, and 6. 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 of Nevada 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, 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. Hydrogeological modeling, utilizing site-specific soil characteristics, vadose zone monitoring, groundwater monitoring, or lining an adequate portion of impoundments at a specific facility were all accepted by NDEP as methods to comply with the permit requirements for protection of groundwater. The following actions were taken to remain in compliance with sewage lagoon discharge permit requirements:

- A pump, cable, control box, level monitoring piping, and discharge piping were installed in the Area 23 Infiltration Basin Groundwater Monitoring Well in August 1998.

- NDEP concurred with studies conducted at the Area 6 LANL Camp system and the Area 6 Yucca Lake system, which demonstrated that liners installed in these systems met the groundwater protection standards required by the operating permit.

By January 31,1999, one method of groundwater protection must be installed or demonstrated at three remaining systems to maintain permit compliance and renewal. The following actions were taken in 1998:

- The primary lagoon at the Area 6 Device Assembly Facility (DAF) was installed during 1998 to attain permit compliance.
- Administrative Controls were accepted by NDEP for the Area 25 Central Support and the Area 25 Reactor Control Point systems.

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. No wastewater permits were required for the LO, LAO, or WAMO facilities in 1998.

SAFE DRINKING WATER ACT

NTS OPERATIONS

The SDWA primarily addresses quality of potable water supplies through sampling and monitoring requirements for drinking water systems. The state of Nevada has enacted and enforces SDWA regulations including system management such as operation and maintenance, water haulage, operator certification, permitting, and sampling requirements. A list of state potable water permits is shown in Chapter 5.

As required under state health regulations (NAC 1996), potable water distribution systems at the NTS are monitored for residual chlorine content and coliform bacteria. NTS potable water distribution systems are also monitored for volatile organic compounds, inorganic compounds, synthetic organic compounds, and other water quality parameters.

During 1998, lead was found above the acceptable level in the Area 1 system. Sample results were still high after replacing old brass fixtures. At the end of 1998 two 150 foot copper pipes were being excavated to look for lead solder or brass fittings as the source of lead. All other monitoring results for 1998 were within regulatory limits and are discussed in Chapter 5.

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, water is obtained from potable water fill stands and chlorinated to obtain a residual of at least one part per million (ppm) in the hauling tank. Water in the hauling tank is sampled periodically for coliform bacteria. The state of Nevada decided in 1994 that water hauling trucks should be permitted as water distribution systems. Permits were obtained again in 1998 for the three trucks used in the program. There were no positive coliform bacteria sample results in 1998.

NON-NTS OPERATIONS

All non-NTS operations are on municipal water systems and have no compliance activities under the SDWA.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

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 DOE/NV facilities. The Federal Facilities Compliance Act (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 1995, DOE/NV received a RCRA Hazardous Waste Operating Permit for the Area 5 Hazardous Waste Storage Unit

(HWSU) and the Area 11 Explosive Ordnance Disposal (EOD) Unit. In addition, the Part B Permit application was revised to include the Mixed Waste Storage Pad (now under interim status) and updated information concerning general facility conditions. During 1996, the permit was modified to include the change in contractor and operational changes concerning the EOD and HWSU. The permit application modification for the Pit 3 Mixed Waste Disposal Unit was completed and submitted to the state in 1997 (NAC 1982). Several other minor modifications were made to the permit during 1997 and 1998, mostly relating to updated personnel and training records.

During 1998, a RCRA Research Development and Demonstration Permit Application was submitted to NDEP for the construction and operation of the Tactical Demilitarization Development (TaDD) facility. This facility will develop treatment methods for deactivating waste missiles. The permit is expected to be issued in early 1999. A 1997 biennial state of Nevada Hazardous Waste Generator report was submitted on February 24, 1998.

On January 5, 1994, the state of Nevada and DOE/NV entered into a Mutual Consent Agreement, that allowed low-level radioactive mixed wastes generated on the NTS to be moved into storage at the RWMS-5 TRU pad. This was amended in June 1994 to include mixed waste generated in Nevada via environmental restoration work. Waste in storage at this facility will continue to be held in storage until a final determination of the proper treatment and disposal technology is established by the EPA. A FFACO (FFACO 1996) was signed, effective March 27, 1996, requiring compliance with a Site Treatment Plan (DOE 1996a), which was also finalized in March 1996. Compliance with the FFACO exempts the NTS from potential enforcement action resulting from the mixed waste storage prohibition under RCRA.

The NDEP conducted its annual Compliance Evaluation Inspection (CEI) on December 10, 1998. Only a few minor areas of concern were identified at the out briefing, and it is unlikely that NDEP will pursue any formal enforcement actions as a result of the CEI. A report is expected in early 1999.

HAZARDOUS WASTE REPORTING FOR NON-NTS OPERATIONS

In 1996, at contract transition, the existing EPA ID numbers for the LO, STL, and LAO locations were terminated. BN obtained new numbers for LO and STL and will operate the LAO facility as a conditionally exempt small quantity generator. In 1998, facilities were required to submit the state of Nevada Hazardous Waste Generator 1997 biennial report for hazardous wastes generated at the NLVF under EPA Identification Number NVD097868731. This report was sent on February 24, 1998.

UNDERGROUND STORAGE TANKS (USTs)

NTS OPERATIONS

The NTS UST program continues to meet regulatory compliance schedules for the reporting, upgrading, or removal of documented USTs. Efforts are continuing to identify undocumented USTs at the NTS. Once identified, undocumented USTs are reported to the NDEP to satisfy state regulatory reporting requirements.
During 1998, there were 15 USTs that were removed in accordance with state and federal regulations. There was also one regulated UST that was closed in place. Remedial activities continued at previous tank removal sites during 1998 as funding became available.

NON-NTS OPERATIONS

An assessment of UST compliance was completed at RSL during 1998. Some USTs had no overfill protection devices and were found to be out of compliance. These devices were installed and the USTs are now in compliance.

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

In April 1996, the DOE/NV, Department of Defense, and the NDEP entered into an 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 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.

EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT (EPCRA)

Compliance with this Act (EO 1986, CFR 1986) is discussed in the paragraphs below and summarized in the following checklist:
SARA Title III Reports

EPCRA Section	NTS Compliance Yes	No	Not Required
302-302: Planning Notification	x		
304: EHS Release Notification			x
311-312: Material Safety Data Sheet/Chemical Inventory	x		
313: TRI Reporting		x	

Additional compliance activities under CERCLA/SARA for 1998 included the Nevada Combined Agency Report, which combines reporting under SARA Section 312, Tier II and Nevada Chemical Catastrophe Prevention Program requirements. The latter program covers extremely hazardous substances (EHSs).

The 1998 Nevada Combined Agency Hazardous Substances Reports for the NTS, NLVF, and RSL were submitted to the state as required and included chemical categories and mixtures and single constituents. The report also included the EHSs present.

A separate Nevada Combined Agency Report was submitted for the Area 5 Hazardous Materials Spill Center (HSC) as required.

In compliance with EO 13101 (EO 1986), a Toxic Release Inventory Report required by Section 313 of the SARA Title III must be provided if the facility, any time in the prior calendar year, exceeds any section 313 threshold for manufacture, process, or other use. In CY 1997 no thresholds were exceeded, so no report was required in 1998.

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.

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 chemicals for 1997, and therefore no reports were submitted to the state in 1998.

TOXIC SUBSTANCES CONTROL ACT (TSCA)

State of Nevada regulations implementing the TSCA require submittal of an annual report describing polychlorinated biphenyl (PCB) control activities. The 1997 NTS PCB annual report was transmitted to DOE/NV on June 10, 1998. This report is no longer required to be sent to the state of Nevada, but must be available for their review. The report included the quantity and status of PCB and PCB-contaminated transformers and electrical equipment at the NTS. Also reported was the one shipment of PCB oils from the NTS to an EPA-approved disposal facility. Fifty-two large and four small low-volume PCB capacitors remain under the management of the LANL in Area 27 of the NTS.

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 were preferred, although restricted-use herbicides and rodenticides were used. Contract companies applied pesticides at all non-NTS facilities in 1998.

Records were maintained on all pesticides used, both general and restricted. These records will be held for at least three years. State-sponsored training materials are available for all applicators. No unusual environmental activities occurred in 1998 at the NTS relating to the Federal Insecticide, Fungicide, and Rodenticide Act.

HISTORIC PRESERVATION

The NHPA (CFR 1966, EO 1971), as amended, requires federal agencies to consider any impact of their actions on cultural resources (archaeological sites, historic sites, historic structures, and traditional cultural properties) eligible for listing in the National Register of Historic Places (NRHP). Accordingly, cultural resource surveys and other studies are conducted to assess any impacts NTS operations may have on such resources. When cultural resources eligible for the National Register are found in a project area and they cannot be avoided, plans are written for programs to recover data to mitigate the effects of the projects on these sites. The NHPA also requires that federal agencies inventory the cultural resources under their jurisdiction.

The American Indian Religious Freedom Act directs federal agencies to consult with Native Americans to protect their right to exercise their traditional religions. The Native American Graves Protection and Repatriation Act (NAGPRA) requires federal agencies to consult with Native Americans regarding items in their artifact collections, that may be associated funerary items, human remains, sacred objects, or objects of cultural patrimony. A collection of DOE/NV archaeological materials, that had been housed at the Harry Reid Center at University of Nevada, Las Vegas (UNLV), was transferred to the DOE/NV Curatorial Facility along with the data for the archaeological sites. A summary report, site records, and an artifact inventory were completed for this collection. NAGPRA consultation on these artifacts will be conducted in the near future.

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 American peregrine falcon is the only endangered species and the desert tortoise and bald eagle are the only threatened species which occur on the NTS. No threatened or endangered plants are known to occur on the NTS. Consultation with the United States Fish and Wildlife Service (USFWS) resulted in receipt of a non-jeopardy Biological Opinion in August 1996 for planned activities at the NTS for a ten-year period.

The Desert Tortoise Compliance Program implemented the terms and conditions of the USFWS Biological Opinion and documented compliance actions taken by DOE/NV (USFWS 1996). The terms and conditions which were implemented in 1998 included (1) tortoise clearance surveys for two projects (conducted within 24 hours from the start of project construction); (2) onsite monitoring of construction for one project when heavy equipment was being used; (3) periodic monitoring of tortoise-proof fencing around the ER-5-2 Well and at sewage treatment ponds in Areas 6 and 23; (4) Zone-of-Influence transect surveys around ER-OV-7 and ER-OV-8, two proposed UGTA well sites near Beatty, Nevada believed to be outside suitable tortoise habitat; and (5) preparation of an annual compliance report for the USFWS of NTS activities that were conducted in CY 1998. Project activities conducted in CY 1998 did not result in the loss of undisturbed tortoise habitat.

A report on The Abundance of Desert Tortoises on the NTS Within Ecological Landform Units was finalized and distributed in September 1998 (Woodward et al., 1998). This report summarizes the objectives, methods, and results of extensive field transect surveys conducted during 1997 and 1998.

There is one bird (mountain plover [*Charadrius montanus*]) and two plant species (Clokey's eggvetch [*Astragalus oophorus* var. *clokeyanus*] and Blue Diamond cholla [*Opuntia whipplei* var. *multigeniculata*]) which are known or are expected to exist on the NTS that are candidates for listing by the USFWS under the ESA. There are ten plant, one reptile, one bird, and six bat species that occur on the NTS, which the USFWS has removed from the list of candidate species for listing. These species are now considered by the USFWS to be "species of concern". In 1998, preconstruction biological surveys were conducted at 21 sites for 7 proposed projects to determine the presence of these species. No candidate species or species of concern were found. Results and mitigation recommendations were documented in survey reports.

Field surveys to determine the presence and distribution of Clokey's eggvetch were completed in 1998, and a report (Anderson 1998) was prepared. NTS populations of this plant appear vigorous and unthreatened and do not appear to warrant protection under the ESA. Flowers and fruits of a specific species of cholla found around Mercury were examined in 1998 to determine if the species is the candidate Blue Diamond cholla, but results showed it is not.

Inventories were conducted on the NTS for the western burrowing owl and six bat species. Surveys verified that burrowing owls, which are known to migrate, occur year-round on the NTS and that the small-footed myotis bat (*Myotis ciliolabrum*) occurs on the NTS. Several birds of prey (raptors) occur and breed on the NTS, which are not protected under the ESA and are not species of concern. Raptors, however, are protected by the federal government under the Migratory Bird Treaty Act and by the state of Nevada. Because these birds occupy high trophic levels of the food chain, they are regarded as sensitive indicators of ecosystem stability and health. Information on the number and distribution of raptor breeding sites on the NTS is lacking. Field studies were initiated in 1998 to identify such sites to better protect them from impacts of NTS activities. Twelve active nests of six raptor species were found, recorded, and mapped.

EXECUTIVE ORDER (EO) 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 1998 that required consultation for floodplain management.

- a MOU with Nevada covering releases of

CLEAN AIR ACT (CAA)

Under Title V, Part 70 of the CAA amendments, all owners or operators of Part 70 sources must pay annual fees that are sufficient to cover costs of state operating permit programs. The NAC determines annual fees based on tons of actual emissions.

In 1998, the NAC was revised to include an annual emissions fee of $5.60 per ton times the total tons of each regulated pollutant for sources that emit more than 25 tons per year. An annual maintenance fee is also required, which is based on the potential number of tons of emissions from a source. 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.

From the 1997 Annual Report, which was submitted in January 1998, it was determined that approximately 30 tons of emissions were produced. Fees of approximately $112 were paid to the NDEP.

The increase in emissions over the previous years was mainly due to the inclusion of diesel generators on the NTS Class II Air Quality Operating Permit.

The NTS Class II Air Quality Operating Permit AP9711-0549 was revised several times during 1998. Modifications included the addition of a portable screen plant and portable crushing plant; identification of three emission units as being subject to CAA New Source Performance Standards (NSPSs), including the Area 1 aggregate plant, the double deck screen, and portable screening plant; the removal of two boilers from the permit because according to the NAC they are exempt based on their output of British thermal units.

As a result of being identified as an NSPS source, the Area 1 aggregate plant is now required to adhere to a more stringent opacity limit of 10 percent, rather than the previous 20 percent. In December 1998, opacity readings at the aggregate plant indicated that one of the emission units was slightly in excess of the 10 percent limit. Informal notification (E-mail) was made to the state on the same day that the readings were taken, followed up by a formal notification.

The state issued a Class II Air Quality Operating Permit for the TaDD facility in July 1998. The facility, located in Area 11, would be to construct a prototype facility to static fire Shillelagh missiles.

One open burn permit was renewed by the state in 1998, which included Permit 98-40 for the Area 27 burn box. This permit was issued in February 1998. The NTS open burn permit expired in October 1998. Due to regional haze issues, DOE ESHD was informed that an annual “blanket” permit would no longer be issued, and that an individual Burn Variance would need to be obtained prior to each burn.

The NTS has a Nevada Hazardous Materials Storage Permit Number 13-98-0034-X, and the HSC has Permit Number 13-98-0037-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 3.1 contains a summary of the permits issued for NTS activities and for offsite activities that support the NTS.

NON-NTS AIR QUALITY PERMITS

The state issued a General Air Quality Permit for surface disturbances for the portions of the Underground Test Area (UGTA) Project located on NAFR, west of the NTS. The UGTA Project is a DOE/NV project for investigating and characterizing radiological contaminants in groundwater below areas that were previously used for nuclear testing. Pads and access roads to the future well sites were installed in 1998, subsequent to issuance of the Permit in March 1998. Well drilling is expected to commence in February 1999.

Six 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 permits have been required, or the facilities have been exempted.

During 1998 the Air Pollution Control Division (APCD) of the Clark County Health District began requiring an "Emissions Inventory" submittal for all permitted sources. The 1997 Emissions Inventory was submitted by BN to the APCD on June 30, 1998.

CLEAN WATER ACT (CWA)

Dewatering of septage and wintertime portable toilet waste was conducted in the Area 25 Engine Test Stand No. 1 sewage lagoon and two Area 12 sewage lagoon secondary infiltration basins during 1998 and will be used again in 1999.

A total of 12 active septic tank systems is in service on the NTS. Two of the active holding tanks, which require replacement with an approved system, are still in service. Nine additional septic tank systems serve unoccupied buildings, but will remain on active status until permanently closed. Facility Managers have been informed of deficiencies noted during inspections.

Construction of the Area 23 Infiltration Basin Groundwater Monitoring Well was completed on February 27, 1996. The monitoring well is now functional and in compliance with groundwater protection requirements contained in the state general permit Number GNEV93001.

A bypass sewer line for the Area 25 Central Support primary sewage lagoon was constructed in 1997 to provide for operational flexibility and in situ primary lagoon infiltration rate measurements. The effectiveness of biological clogging on the existing soils was determined to be inadequate for compliance with the groundwater protection program, so DOE requested the use of Administrative Controls for permit compliance. NDEP agreed, but during 1998 the Administrative Controls were exceeded for flow and organic loading. DOE is negotiating with NDEP to resolve this issue.

Administrative Controls were also agreed to by NDEP in 1998 for the Area 25 Reactor Control Point sewage lagoons. These limits were not exceeded during 1998.

Funding for design of an engineered liner in the Area 6 DAF primary sewage lagoon was obtained in FY 1997. The most feasible and cost effective method to comply with groundwater protection requirements at this site was to line the primary lagoon to attain full containment with existing flow rates. The liners were installed in 1998 to satisfy the permit deadline date.

SAFE DRINKING WATER ACT (SDWA)

Engineering design was completed on buildings or facilities at the NTS requiring installation of backflow prevention devices on water service lines. Through 1997, over 110 separate installations were required. Additional devices are installed as new locations are identified.

During 1998, the tank for Army Well No. 1 was replaced along with much of the piping and four other water tanks were recoated. Another six tanks were inspected externally, and a corrosion expert inspected the inside surfaces. All six of the tanks need some work in the near future, and funding has been requested to begin repairs on the four tanks that are currently in use.

The Operations and Maintenance Manual for the NTS water distribution systems is being updated to incorporate some recent revisions to state regulations.

There was no sanitary survey of the water distribution systems by the Nevada Bureau of Health Protection Services during 1998.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)

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 remediating environmental problems will be taken under the FFACO.

HISTORIC PRESERVATION

Historic preservation studies and surveys are conducted by the Desert Research Institute, University and Community College System of Nevada. In 1998, 16 surveys were conducted for historic properties on the NTS, and reports on the findings were prepared. These surveys identified 19 prehistoric and historic archaeological sites. Through consultation with the Nevada State Historical Preservation Office, one of these sites was determined to be eligible for the NRHP. Work continued on historic structures associated with early NTS activities. Removal of the EPA Farm in Area 15 required the preparation of Historic American Building Survey documentation for the facility. This documentation will reside in the Library of Congress.

NRHP archaeological sites located during the past year were monitored during construction activities and two reports were prepared. In addition, as part of the EA for the Intermodal Transportation Facility, cultural resources research and fieldwork resulted in the preparation of sections for the EA. Cultural Resources maps and text were prepared for the Resource Management Plan. Also written was a draft Cultural Resources Management Plan which will be finalized in 1999.

POLLUTION PREVENTION (P2) AND WASTE MINIMIZATION

The 1998 pollution prevention (P2), waste minimization, and recycling efforts for waste generated at the NTS, NLV, and offsite locations complied with the requirements of DOE Order 5400.1, Waste Minimization Program.

The DOE/NV P2 Program established a process to reduce the volume and toxicity of hazardous waste generated at all locations and to ensure that the proposed method of treatment or disposal minimizes the present and future threat to human health and the environment.

It is a priority 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 energy efficiency, and promote the sustainable use of natural resources. This commitment includes providing adequate personnel, budget, training, and materials on a continuing basis to ensure source reduction, recycling, and affirmative procurement goals are achieved.

Chapter 6 provides a summary of the P2 Program, P2 accomplishments achieved during CY 1998 including a summary of the notable activities that achieved reduction in volume and toxicity of waste, and recycling activities and quantities.

SOLID/SANITARY WASTE

During 1998, landfills were operated in Areas 6, 9, and 23. The amount of waste disposed of in each is shown in Chapter 6.0, and their operating permits are in Table 3.1.

The NTS Cleanup Project, initiated in 1994, is an activity devised to remove and dispose of or recycle, where applicable, nonhazardous debris and material and readily identify hazardous debris and material. In 1998, some cleanup activities were completed at inactive facilities throughout the NTS. During this cleanup, solid wastes were disposed of in the U10c Landfill, and reusable materials were delivered to the NTS Salvage Yard for recycling and reclamation.

FEDERAL FACILITIES AGREEMENT AND CONSENT ORDER (FFACO)

REMEDIAL ACTIVITIES - SURFACE AREAS

Environmental restoration activities continued at the NTS and TTR in 1998. These activities followed the agreements specified in the FFACO signed between the DOE/NV and the NDEP.

These activities follow a formal work process beginning with a Data Quality Objectives (DQO) meeting between DOE, NDEP, 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 identified for analysis that best provides site closure. In some instances, additional site characterization may be required before the CADD can be prepared. The CADD may also include a risk assessment to better define the risk to humans and the environment.

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 document 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 DOE/NV of the progress made.

Some small sites are closed under the Streamlined Approach for Environmental Restoration (SAFER) process. These sites typically have small amounts of contamination and can be remediated by simple excavation and sampling to verify that the Remediation Level has been reached. A SAFER plan is prepared providing the methods to be used to close the site. After closure a SAFER closure report is prepared documenting the work performed.

Actions taken in 1998 are summarized below:

- The Area 6 Decontamination Pond RCRA Closure Unit design and field testing for the engineered cover was completed in 1998. Closure activities started in 1998 and will be completed in early 1999.

- An annual report was submitted to comply with the conditions of the RCRA Part B Permit for the Area 2 Bitcutter Shop and LLNL Post Shot Containment Building Injection Wells RCRA Closure Unit that were closed in 1996.

- The expedited closure of the Area 15 EPA Farm was completed in October 1997. The facility was decontaminated and dismantled. Waste disposal and closure documentation were completed in 1998.

- Closure of the Area 12 Fleet Operations Steam Cleaning Discharge Area was completed by excavation and removal of approximately 61 m^3 (80 yd^3) of petroleum hydrocarbon soil. A Closure Report was submitted in 1998. Biennial monitoring (every two years) for the next six years of undisturbed impacted areas will be required to evaluate whether or not sufficient degradation of the petroleum hydrocarbons has been demonstrated.

- Clean closure of the Area 6 Steam Cleaning Effluent Ponds RCRA Closure Unit was completed by excavation and disposal of approximately 413 m^3 (540 yd^3) of soil as a RCRA hazardous waste and 535 m^3 (700 yd^3) of nonhazardous petroleum hydrocarbon impacted soil. The Closure Report was prepared and transmitted to the NDEP for concurrence during 1998.

- The Area 23 Building 650 Leachfield RCRA Closure Unit characterization was completed. The Closure Plan and field work were completed in 1998.

- The contents of the aboveground tanks located at the Area 23 Fire Training Pit were characterized and disposed of as a RCRA hazardous waste (approximately 3,000 gal [11.4 m^3]). Site debris and materials were sampled for disposal or reuse. Some materials were removed from the site and disposed of as nonhazardous construction debris. The site characterization activities and additional site debris/material disposal or reuse were completed in 1998.

- The SAFER Closure Plan for the Area 5 and 6 aboveground tanks was prepared, completed, and approved by the NDEP. Closure activities were completed in 1998.

- Characterization activities were completed for the TTR Area 3 Landfill Complex and Area 9 UXO Landfill. The Corrective Action Decision Document and Corrective Action Plan were prepared and transmitted to the NDEP for concurrence during 1998. Remedial activities and the Closure Report are planned to be completed in 1999.

- Characterization of the TTR Second Gas Station was completed. Based upon the results, the NDEP has concurred with the recommended closure in-place of the petroleum impacted soils. The Closure Report was prepared and transmitted to the NDEP for concurrence during 1998.

- Characterization activities were started at the TTR Building 360 Underground Discharge Point and Areas 2 and 6 septic systems. The Corrective Action Decision Document and Corrective Action Plan were prepared and transmitted to the NDEP for concurrence during 1998.

- An expedited closure in-place of the TTR Roller Coaster Sewage Lagoons and North Disposal Trench was completed by constructing an engineered vegetative cover over the sites. The construction activities were designed to eliminate the generation of any waste during the closure activities since the site was impacted with pesticides above the EPA Preliminary Remediation Goals. The site is located approximately 56 km (35 mi) northwest of the NTS. The Closure Report was prepared and transmitted to the NDEP for concurrence during 1998.

- An expedited closure in-place of the TTR Cactus Spring Waste Trenches was completed by constructing an engineered vegetative cover over the site. The site is also located approximately 56 km (35 mi) northwest of the NTS. The Closure Report was prepared and transmitted to the NDEP for concurrence during 1998.

- An aerial radioactivity survey of the Project 57 site was completed. Completion of site characterization activities is planned for 1999.

- The Building A-1 (Atlas) tritium decontamination was completed. All decontaminated areas have been free-released with the condition that a weekly long-term monitoring program be conducted for a least one year. This monitoring was conducted during 1998.

- There were five Housekeeping Sites (Corrective Action Units [CAUs] 347, 348, 349, 353, and 354) in the FFACO, at the NTS, that were cleaned up and had Closure Reports submitted during 1998.

- There were four underground storage tank release sites (CAU 452, 454, 456, and 464) in the FFACO, at the NTS, that were remediated and had Closure Reports submitted in 1998.

RADIATION PROTECTION

NTS OPERATIONS

Redesign of the environmental surveillance networks on the NTS during 1997 will result in a reduction of monitoring costs while maintaining necessary and sufficient coverage. Results of monitoring during 1998 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 showed average annual concentrations ranging from 0.17 percent of the DOE Order 5400.5 guidelines for HTO in air to 1.2 percent of the guidelines for $^{239+240}$Pu in air. Drinking water supplies on the NTS contained less than 0.001 percent of the DOE Order 5400.5 guideline and less than 0.004 percent of the National Primary Drinking Water Regulation for tritium. All $^{239+240}$Pu concentrations in supply well water samples were less than the MDC.

Offsite monitoring in the vicinity of the NTS by EPA's Radiation & Indoor Environments National Laboratory-Las Vegas confirmed that emission of radioactivity from the NTS did not exceed 1 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 1998 indicate full compliance with the radiation exposure guidelines of DOE Order 5400.5 and Title 10 CFR 835. 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. Use of radioactive materials is primarily limited to sealed sources; however, unsealed tritium is used in some operations. Facilities, which use radioactive sources or radiation producing equipment, with the potential to expose the general population outside the property line to direct radiation, are the WAMO in Washington, D.C., the Atlas NLVF A-1 Source Range, 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 TLDs are at the fence line on each side of these facilities that are exchanged quarterly with additional control TLDs kept in a shielded safe. The TLD results were consistent with previous data indicating no exposures to the public from any of the monitored facilities.

ENVIRONMENTAL COMPLIANCE AUDITS

There were no such audits in 1998.

OCCURRENCE REPORTING

Occurrences are environmental, health, and/or safety-related tests, which are reported in several categories in accordance with the requirements of DOE Order O232.1A, "Occurrence Reporting and Processing of Operations Information," (DOE, 1997b). The fourteen reportable environmental occurrences for 1998 on NTS facilities appear in Table 3.2.

LEGAL ACTIONS

No legal actions were filed against DOE/NV during 1998.

3.4 PERMIT SUMMARY

For facilities used in the operation and maintenance of the NTS and non-NTS facilities, the contractors providing such operation and support activities for the DOE/NV have been granted numerous permits by the appropriate regulatory authorities. To facilitate management of environmental compliance and save costs, several operating permits have been combined into general permits. This reduced the number of permits, but all facilities remain regulated and permitted. In addition to the existing number of permits in 1998 (Table 3.1), the EOD Facility and the Area 5 Storage Facility of the RCRA Part B permit application were permitted, while the other units in the application are in various stages of the NDEP review for permission to construct or operate. The TaDD facility was also granted a RCRA Research and Development permit in 1988 under the same NTS generator number.

Table 3.1 Environmental Permit Summary - 1998

	Air Pollution	Wastewater	Drinking Water	Waste Disposal	Number of EPA Generator User IDs	Hazardous Materials Storage Permit	Endangered Species Act
NTS	6	8	7	4	1[(a)]	4	2
NAFR	3						
Las Vegas Area Operations Office	13[(b)]	1			1[(a)]	2	
Livermore Operations	1				1		
Los Alamos Operations					1		
Special Technologies Laboratory (Santa Barbara)		2			2	1	
TOTAL	23	11	7	4	6	7	2

(a) Biennial Report Required.
(b) Routine Monitoring of Emissions is Not Required.

Table 3.2 Off-Normal Occurrences at NTS Facilities - 1998

Date	Report Number	Description	Status
03/09/1998	NVOO-BNLV-NTS-1998-0004	Ten gallons of diesel fuel leaked out of a parked truck over the weekend at Sandia Warehouse in Area 23.	Open
04/09/1998	NVOO-BNLV-NTS-1998-0007	Technician violated Contaminated Area posting while collected soil sample In Area 3.	Open
04/09/1998	NVOO-BNLV-NTS-1998-0006	Worker violated Contaminated Area posting placing an air sampling unit in a contaminated area without having a Radiological Work Permit.	Open
06/15/1998	NVOO-BNLV-NTS-1998-0010	NTS Weather Service personnel service a portable weather station that had been incorrectly placed in a posted Contamination Area.	Complete
06/30/1998	NVOO-BNLV-MSRS-1998-0001	DOE/NV violated Contaminated Area posting by entering remediation area at Building 650 leachfield in Area 23.	Open
06/30/1998	NVOO-BNLV-NTS-1998-0014	BN electrician violated Contaminated Area posting by entering remediation area at Building 650 leachfield in Area 23.	Complete
07/09/1998	NVOO-BNLV-NTS-1998-0015	Window of a glove box at the Waste Examination Facility in Area 5 was broken while the lid from a drum of Transuranic waste was being removed.	Open
07/27/1998	NVOO-BNLV-MSRS-1998-0002	Worker at the Waste Examination Facility received a radiological puncture wound when a broken pair of forceps penetrated his glove while working in a glove box.	Open
07/29/1998	NVOO-BNLV-MSRS-1998-0003	BN teamster violated Contaminated Area posting by entering remediation area at Building 650 leachfield in Area 23.	Open
08/12/1998	NVOO-BNLV-NTS-1998-0019	Historical diesel fuel spill discovered in soil near fill port of underground storage tank at CP-9 in Area 6 during tank removal.	Open
08/17/1998	NVOO-BNLV-NTS-1998-0020	Historical diesel fuel leak discovered in soil under an aboveground storage tank being removed at the Area 25 Engine Test Stand.	Open
08/17/1998	NVOO-BNLV-NTS-1998-0021	About 100 gallons of sodium hydroxide was released when a storage tank being removed at the Area 25 Engine Test Stand fell over.	Open

Table 3.2 (Off-Normal Occurrences at NTS Facilities - 1998, cont.)

Date	Report Number	Description	Status
08/26/1998	NVOO-BNLV-NTS-1998-0023	Historical leak of sulfuric acid discovered under an aboveground storage tank being removed at the Area 25 Engine Test Stand.	Open
08/27/1998	NVOO-BNLV-NTS-1998-0024	A subcontractor violated Contaminated Area posting by entering remediation area at the Building 650 leachfield in Area 23.	Open

4.0 AIR SURVEILLANCE ACTIVITIES

The air surveillance activities consist of monitoring and compliance programs for the Nevada Test Site (NTS), near offsite areas, and support facilities. These activities include radiological and nonradiological monitoring and environmental permit and operations compliance. There are both onsite and offsite radiological monitoring programs associated with the NTS. The onsite program is conducted by Bechtel Nevada (BN), the operations and maintenance contractor for the NTS. BN is responsible for NTS air surveillance, effluent monitoring, and ambient gamma radiation monitoring. The offsite air and ambient gamma radiation monitoring program is conducted by the U. S. Environmental Protection Agency's (EPA's) Center for Environmental Restoration, Monitoring and Emergency Response of the Radiation and Indoor Environments National Laboratory in Las Vegas, Nevada (R&IE-LV). Non-radiological air monitoring is primarily for permit compliance.

4.1 ONSITE RADIOLOGICAL MONITORING

At the NTS, radiological effluents may originate from tunnels, underground test sites (at or near surface ground zeros), radiological waste disposal sites, resuspension of surface deposits, and facilities where radioactive materials are either used or processed. All of these sources have the potential to, or are known to, discharge radioactive effluents into the environment. Two types of monitoring operations are used for these sources: (1) effluent monitoring, which measures radioactive material collected at the point of discharge; and (2) environmental surveillance, which measures radioactivity in the general environment.

Table 4.1 is a summary of the routine air surveillance program, as of the end of 1998. Air sampling was conducted for radioactive particulates and tritiated water (HTO) vapor. The air sampling locations are shown in Figure 4.1, and Figure 4.2 shows the locations where ambient gamma radiation monitoring is conducted on the NTS using thermoluminescent dosimeters (TLDs). Due to the moratorium on nuclear testing and the lack of above background levels of radioactive noble gases, sampling for those gases was terminated at the beginning of this year.

CRITERIA

Title 40, Code of Federal Regulations (CFR) Part 50, "National Primary and Secondary Ambient Air Quality Standards" (CFR 1971) and Title 40 CFR 61,"National Emission Standards for Hazardous Air Pollutants," Subpart H, "Emission of Radionuclides Other Than Radon from Department of Energy Facilities" (CFR 1989) issued by the EPA are the primary drivers for air monitoring programs. In turn, the U.S. Department of Energy (DOE) published DOE Order 5400.1, "General Environmental Protection Program," (DOE 1990a), which establishes environmental protection program requirements, authorities, and responsibilities for DOE operations. These mandates require compliance with applicable federal, state, and local environmental protection regulations. Other DOE directives applicable to environmental monitoring include DOE Order 5480.11, "Radiation Protection for Occupational Workers" (DOE 1990d), DOE Order 5480.1B, "Environment, Safety, and Health Program for DOE Operations" (DOE 1990c); DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection

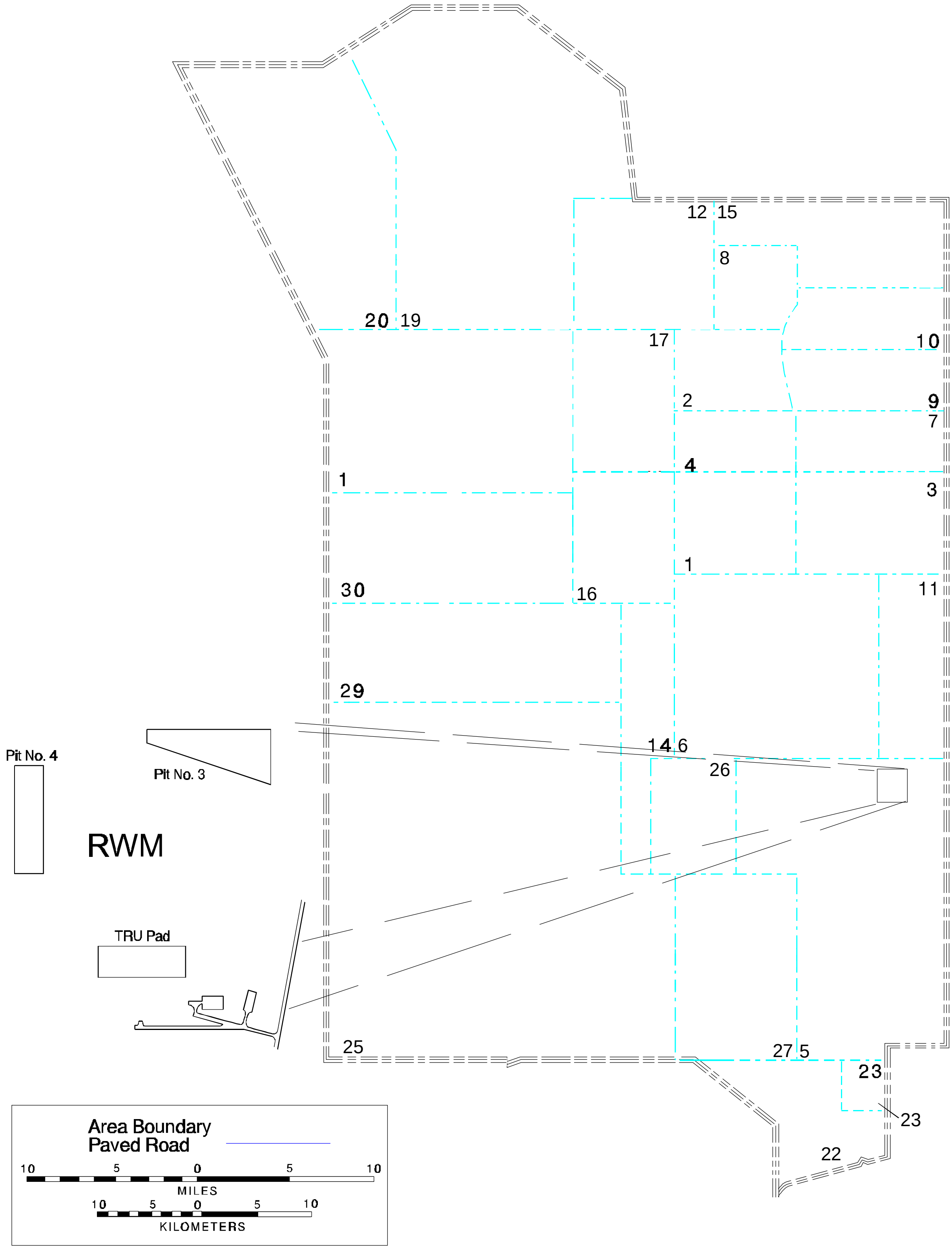


Figure 4.1 Air Sampling Stations on the NTS - 1998

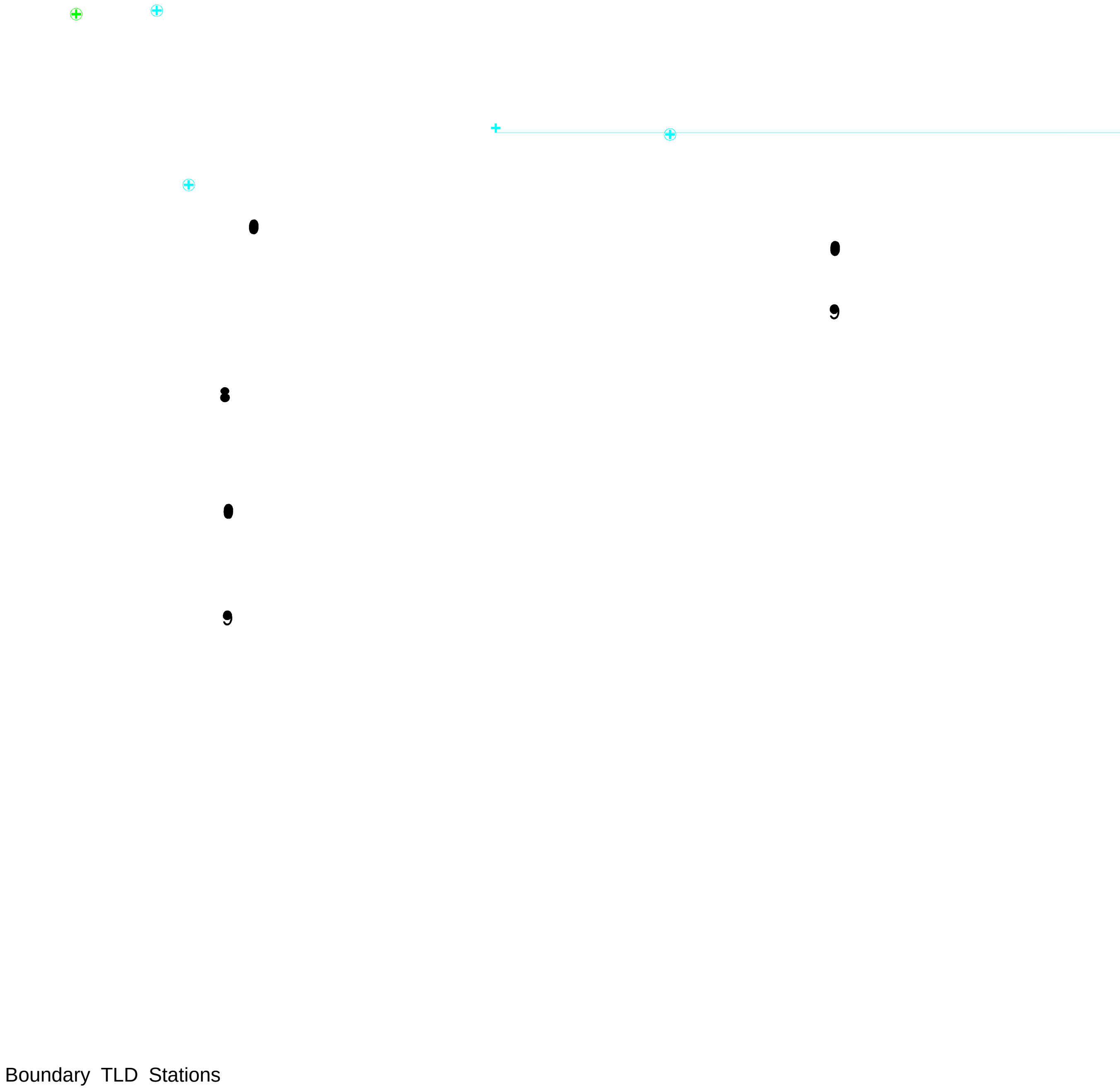


Figure 4.2 TLD Stations on the NTS - 1998

Information Reporting Requirements" (DOE 1990e); DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (DOE 1990b); and DOE/EH-0173T, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE 1991c).

AIRBORNE EFFLUENT MONITORING

Airborne radioactive effluents are the emissions on the NTS with the greatest potential for reaching members of the public. For all activities on the NTS, the estimated effective dose equivalent to any member of the public offsite from all airborne emissions continues to be much less than one mrem/yr (<10 percent of the guideline) (Black 1999). Compliance with the regulations listed above requires periodic measurements of effluents to confirm the low emission levels. The estimated effluents for 1998 are shown in Table 4.5 and include measured and calculated effluents, evaporated liquids, and resuspension of contaminated soils.

An increase in efforts to monitor radioactive air emissions at the NTS began in November 1988 as a result of requirements in DOE Order 5400.1. Known and potential effluent sources throughout the NTS were assessed for their potential to contribute to public dose and were considered in designing the “Site Effluent Monitoring Plan”, which forms part of the “Environmental Monitoring Plan, Nevada Test Site and Support Facilities” published in November 1991 (DOE 1991b). This plan was updated in 1992 and 1993, but has been superseded by a “Routine Radiological Environmental Monitoring Plan” (DOE 1998a).

ENVIRONMENTAL SURVEILLANCE

Air surveillance was conducted onsite throughout the NTS. Equipment at fixed locations continuously sampled the ambient air to monitor for radioactive material content. Ambient gamma exposures were measured with TLDs placed at fixed locations.

AIR MONITORING

The air surveillance program operated samplers that were designed to detect airborne radioactive particles, and ^{3}H, as water vapor in the form of $^{3}H^{3}HO$ or ^{3}HHO. The air sampling units used to measure radioactive particulates were operated at 32 stations on the NTS (Figure 4.1) and five on the Nellis Air Force Range (NAFR) during 1998. These stations included 10 at radioactive waste management facilities. Access, worker population, geographical coverage, presence of radioactivity, and availability of electrical power were considerations in site selection for air samplers. During 1996, air samplers powered by solar photovoltaic/ battery systems were acquired for operation in contaminated areas where commercial power was not available and were in use at many locations during 1998.

An air sampling unit consisted of a constant volume pump drawing approximately 85 L/min (3 cfm) of air through a 9-cm (3.5-in) diameter Whatman GF/A glass-fiber filter that trapped air particulates. Due to the moratorium on nuclear explosives testing, charcoal cartridges are no longer used in the air sampler. The particulate filter was mounted in a plastic, cone-shaped sample holder that faced downward at a height of 1.5 m (5 ft) above ground. A run-time clock measured the operating time. The time on the clock, multiplied by 85 L/min yields the volume of air sampled, which was about 860 m^3 (30,000 ft^3) during the typical seven-day sampling period.

The filters were analyzed for gross alpha, gross beta, and for gamma-emitting radionuclides until April when gamma spectroscopy of weekly air filters was discontinued. The filters from four weeks of sampling were composited and then analyzed for plutonium isotopes. Beginning in April, these filter composites were also analyzed by gamma spectroscopy.

Airborne HTO vapor was monitored at 13 locations throughout the NTS. For this monitoring, a pump continuously drew air into the sampler at approximately 0.4 L/min, the total volume being measured with a dry-gas meter. The HTO vapor was removed from the air stream by a silica-gel drying column followed by a Drierite column for detection of breakthrough. These columns were exchanged biweekly. Beginning in June of 1998, the silica gel desiccant was replaced with molecular sieve, which is more efficient for the collection of HTO in atmospheric moisture.

The analytical procedures used on all these air samples are summarized in Table 4.2.

AMBIENT GAMMA MONITORING

Ambient gamma monitoring was conducted at 106 stations on the NTS (Figure 4.2) by use of TLDs. The dosimeter used was the Panasonic UD-814AS environmental dosimeter, consisting of four elements housed in an air-tight, water-tight, ultraviolet-light-protected case. One element, made of lithium borate, was only slightly shielded in order to measure low-energy radiation. The other three elements, made of calcium sulfate, were shielded by 1,000 mg/cm^2 of plastic and lead and were used to monitor penetrating gamma radiation. TLDs were deployed in a holder placed about one meter above the ground and were exchanged quarterly. Locations were chosen at the site boundary, at locations where historical monitoring has occurred, or where operations or ground contamination have occurred.

The TLD network at the NTS in 1998 began with 102 TLDs at fixed locations. During the year, TLDs were used at a total of 106 locations. At the end of the year, after several adjustments to the network, the total number of stations was reduced to 85.

WASTE MANAGEMENT SITE MONITORING

Environmental surveillance on the NTS included monitoring of the radioactive waste management sites (RWMSs). These sites are used for the disposal of low-level radioactive waste from the NTS and other DOE facilities. Shallow-land disposal in trenches and pits was done at the Area 5 RWMS (RWMS-5) and in subsidence craters at the Area 3 RWMS (RWMS-3).

There were 6 air particulate sampling stations, 6 HTO vapor sampling stations, and 25 TLD stations placed inside and around RWMS-5 at the beginning of 1998. During the year, it was determined from site specific data that the number of HTO sampling stations and TLD stations could be reduced to four and ten, respectively.

At the beginning of 1998, monitoring at RWMS-3 included two air particulate sampling stations, one HTO vapor sampling station, and four TLD stations. During the year, the air particulate sampling stations were increased to four, with the addition of two stations at U-3bh. The number of TLD stations was increased to five, and the HTO station was removed.

4.2 OFFSITE RADIOLOGICAL MONITORING

Under the terms of an Interagency Agreement between DOE and EPA’s Office of Radiation and Indoor Air, the R&IE-LV conducts an Offsite Radiation Safety Program (ORSP) around the NTS. The primary activity of the ORSP is routine monitoring of potential human exposure pathways. Secondary activities include maintaining readiness to monitor during nuclear testing, emergency response, public information, and community assistance.

Maintaining readiness was exercised during three subcritical experiments conducted in 1998, STAGECOACH, BAGPIPE, and CIMARRON. For each of the experiments, R&IE-LV senior personnel served on the Test Controller's Scientific Advisory Panel and on the EPA offsite radiological safety staff.

Routine offsite environmental monitoring for compliance with National Emission Standards for Hazardous Air Pollutants (NESHAPs) and with DOE orders 5400.1 and 5400.5 continued throughout 1998.

Environmental monitoring networks, described in this and following Chapters, measure radioactivity in air (this chapter), groundwater (Chapter 5), and milk (Chapter 6). These networks monitor the major potential pathways for transfer of radionuclides to man. Ambient gamma radiation levels are monitored using Reuter-Stokes pressurized ion chambers (PICs) and Panasonic TLDs. Data from these networks are used to calculate an annual exposure to the offsite residents.

The Community Technical Liaison Program (CTLP) stations continued to operate in 17 communities around the NTS. The CTLP stations are managed by local residents and contain air samplers, PICs, and TLDs. The Desert Research Institute (DRI), University and Community College System of Nevada, is a cooperator with R&IE-LV in the CTLP.

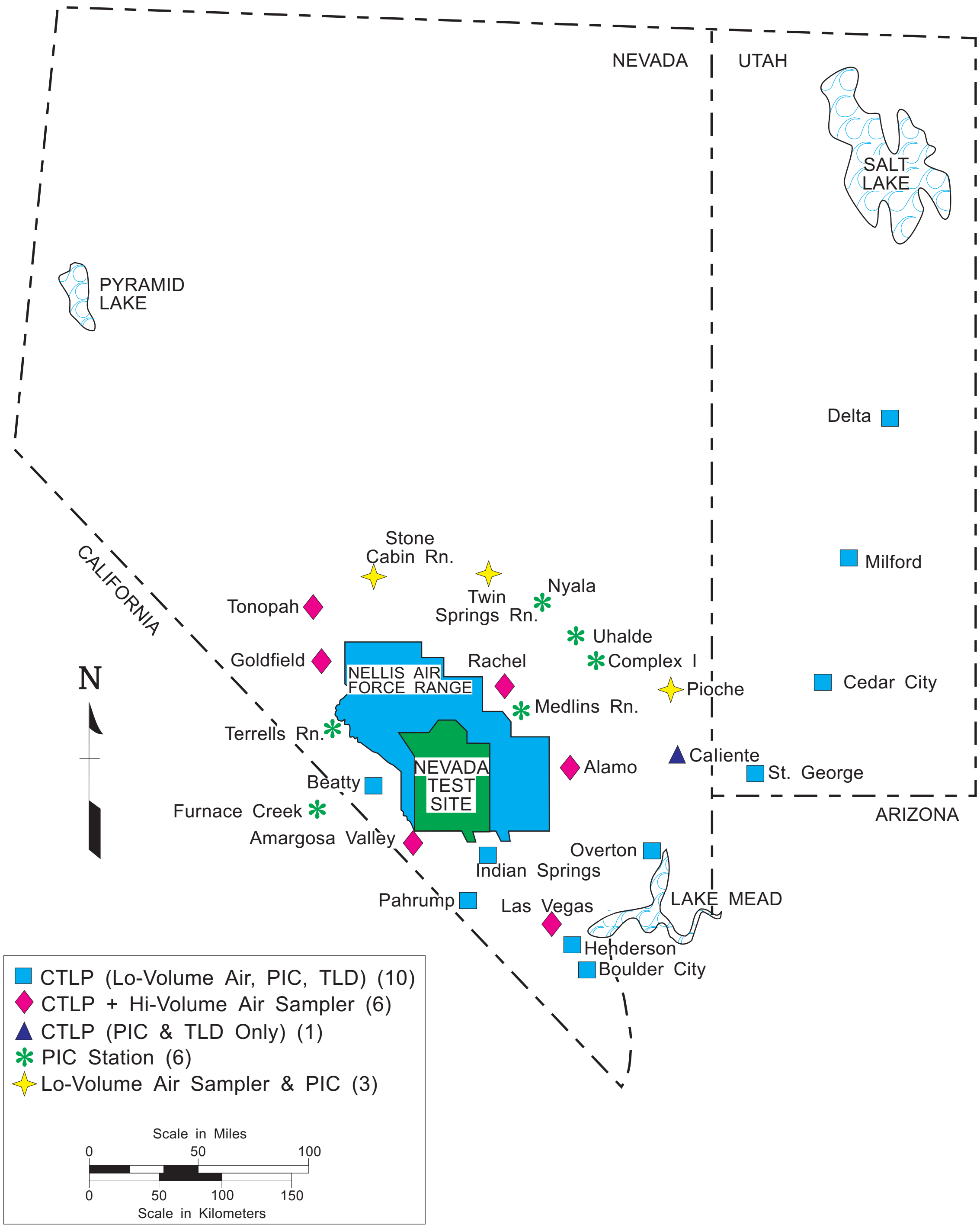
AIR SURVEILLANCE NETWORK (ASN)

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. 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 man.

The ASN is currently designed to monitor the areas within approximately 130 km (80 mi) of the NTS. During calendar year (CY) 1998 the ASN consisted of 18 continuously operating sampling stations (an additional station was activated in the third quarter). High-volume air samplers were operational at six of the stations. The current network is shown in Figure 4.3. Station location depends in part on the availability of electrical power and a resident willing to operate the equipment.

The low-volume air samplers at each station are equipped to collect particulate radionuclides on 5-cm (2.0-in) diameter glass-fiber filters at a flow rate of about 80 m^3 (2,800 ft^3) per day. Filters are changed weekly (approximately 560 m^3 or 20,000 ft^3 of air sampled). Activated charcoal cartridges placed directly behind the filters to collect gaseous radioiodine are changed at the same time as the glass-fiber filters. High-volume air samplers collect particulates on 20 x 25 cm (8 x 10 in) glass-fiber filters at a flow rate of approximately 1,600 m^3 (58,000 ft^3) per day. High-volume samples are collected monthly (approximately 48,000 m^3, or 1.7 million ft^3 of air sampled). 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. One duplicate high-volume sampler is operated in the same manner as the duplicate low-volume samplers.

At the R&IE-LV, both the glass-fiber filters and the charcoal cartridges from low-volume samplers are analyzed by high-resolution gamma spectrometry. Each of the glass-fiber filters is then analyzed for gross alpha and gross beta activity 7 to 14 days after sample collection to allow time for the decay of naturally occurring radon progeny. Filters from high-volume air samplers are analyzed using high-resolution gamma spectrometry and are then analyzed for plutonium isotopes using wet chemistry methods.



Note: Real time data transmittal.

Figure 4.3 CTLP, PIC, and Air Sampling Locations Around the NTS - 1998

THERMOLUMINESCENT DOSIMETRY (TLD) NETWORK

An essential component of environmental radiological assessments is external dosimetry, which is used to determine both individual and population exposure to ambient radiation, natural or otherwise.

The primary purpose of EPA's offsite environmental dosimetry program is to establish dose estimates to populations living in the areas surrounding the NTS. Panasonic Model UD-814 TLDs are used for environmental monitoring. The UD-814 consists of one element of $Li_2B_4O_7$:Cu and three elements of $CaSO_4$:Tm phosphors. The $CaSO_4$:Tm elements are behind a filter of approximately 1,000 mg/cm^2. An average of the corrected values for the latter three elements gives the total exposure for each TLD. For quality assurance purposes, two UD-814 TLDs are deployed at each fixed environmental station location. The TLDs are exchanged quarterly.

In addition to a fixed environmental TLD, EPA deploys personnel TLDs to individual volunteers, predominantly CTLP station managers and their alternates, living in areas surrounding the NTS.

Panasonic Model UD-802 TLDs are used for personnel monitoring. The UD-802 consists of two elements, each of $Li_2B_4O_7$:Cu and $CaSO_4$:Tm phosphors. The phosphors are behind filters of approximately 17,300,300 and 1,000 mg/cm^2 respectively. With the use of different phosphors and filtrations, a dose algorithm can be applied to ratios of the different element responses. This process defines the radiation type and energy and provides data for assessing an absorbed dose equivalent to the participating individuals. These TLDs are also exchanged quarterly.

An average daily exposure rate was calculated for each quarterly exposure period and the average of the four values was multiplied by 365.25 to obtain the total annual exposure for a station.

In 1998, the TLD program consisted of 39 fixed environmental monitoring stations and 18 offsite personnel. Figure 4.4 shows the fixed environmental TLD monitoring stations and the location of personnel monitoring participants.

PRESSURIZED ION CHAMBER (PIC) NETWORK

The PIC network uses Reuter-Stokes models 1011, 1012, and 1013 PICs. The PIC is a spherical shell filled with argon gas at 25 times atmospheric pressure. In the center of the shell is a spherical electrode with an electrical charge opposite to the shell. When gamma radiation penetrates the sphere, ionization of the gas occurs and the negative ions are collected by the center electrode. The current generated is proportional to the radiation exposure.

The PIC measures gamma radiation exposure rates and because of its sensitivity, may detect low-level exposures not detected by other monitoring methods. 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 altitudes (cosmic radiation), with radioactivity in the soil (terrestrial radiation), and may vary slightly within a location due to weather patterns.

Seventeen PICs are located at the CTLP stations in communities around the NTS, and ten PICs are located at ranches and other non-CTLP locations, including the SALMON test site in Mississippi. Meteorological data are collected from stations in Las Vegas, Boulder City, Henderson, and Mississippi. The locations of the PIC stations around the NTS are shown in Figure 4.3.

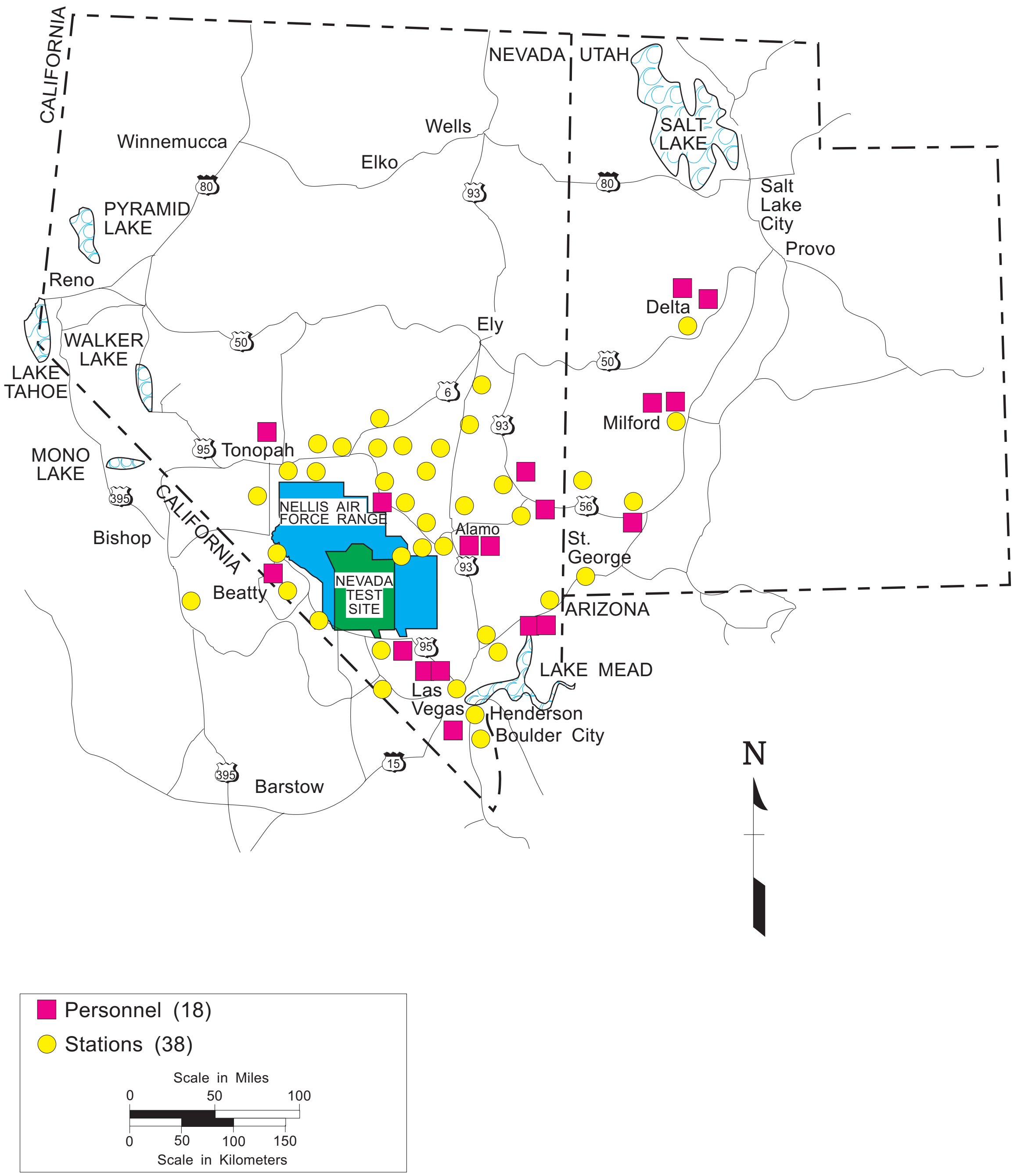


Figure 4.4 Locations of Offsite Station and Personnel TLDs - 1998

From October 1997 to August 1998, PIC data for all stations were recorded on magnetic tape, a memory data cartridge, or strip charts. The stations immediately adjacent to the NTS were visited weekly and other stations monthly to retrieve data. In August 1998, satellite telemetry data transfer was restored to the 17 CTLP stations in Nevada and the station in Mississippi. These data are displayed in near real-time on the Los Alamos National Laboratory NEWNET web page that is updated automatically. Data from the remaining stations continued to be gathered by non-telemetry means.

COMMUNITY TECHNICAL LIAISON PROGRAM (CTLP)

Because of the successful experience with the Citizen's Monitoring Program during the purging of the Three Mile Island containment in 1980, the Community Radiation Monitoring Program (CRMP) was begun. Due to reductions in the scope of monitoring, the CRMP was converted to the CTLP, which now consists of stations located in Nevada and Utah. In 1998, there were 17 stations located in these two states. The CTLP is a cooperative project of the DOE, EPA, and DRI. DOE/NV sponsors the program. The EPA provides technical and scientific direction, maintains the instrumentation and sampling equipment, analyzes the collected samples, interprets the data and sends reports to DRI. DRI administers the program by hiring the local station managers and alternates, securing rights-of-way, providing utilities, distributing data reports, and performing additional quality assurance checks of the data. The locations of the CTLP stations are shown in Figure 4.3.

Each station is operated by a local resident. In most cases, this resident is a high-school science teacher. All of the 17 CTLP stations had one of the samplers for the ASN and the Noble Gas and Tritium Surveillance Network, on either routine or standby status, and a TLD. In addition, a PIC and recorder for immediate readout of external gamma exposure and a recording barograph are located at all stations. All of the equipment is mounted on a stand at a prominent location in each community so the residents can become aware of the surveillance and, if interested, can check the data.

4.3 NONRADIOLOGICAL MONITORING

The 1998 nonradiological monitoring program for the NTS included onsite sampling of various environmental media and substances for compliance with federal and state regulations or permits and for ecological studies as discussed in Chapters 5 and 6. Air quality monitoring is not required for the NTS. The air permits issued by the state of Nevada do require opacity and material throughput measurements. Nonradiological monitoring was conducted for six series of tests conducted at the Hazardous Materials Spill Center (HSC) on the NTS.

MONITORING OF NTS OPERATIONS

ROUTINE MONITORING

As there were no industrial-type production facility operations on the NTS, there was no significant production of nonradiological air emissions or liquid discharges to the environment. Sources of potential contaminants were limited to construction support and NTS operational activities. These included motor pool facilities; large equipment and drill rig maintenance areas; cleaning, warehousing, and supply facilities; and general worker support facilities (including lodging and administrative offices) in the Mercury Base Camp, Area 12 Camp, and to a lesser extent in Area 20 and the NTS Control Point (CP) Complex in Area 6.

The HSC in Area 5 is a source of potential release of nonradiological contaminants to the environment, depending on the individual tests conducted. In 1998, the six test series conducted there, involved 23 different chemicals.

Routine nonradiological environmental monitoring on the NTS in 1998 was limited to Nevada operating permit requirements, and asbestos sampling in conjunction with asbestos removal and renovation projects and in accordance with occupational safety and NESHAP compliance.

NTS AIR QUALITY PERMIT COMPLIANCE

Compliance with air quality permits is accomplished through permit reporting and renewals, and ongoing verification of operational compliance with permit specified limitations. Common air pollution sources at the NTS include aggregate production, stemming activities, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities. The 1997 Air Quality Permit Data Report was sent to the state of Nevada on January 28, 1998. During 1997, approximately 30 tons of pollutants were emitted from operations at the NTS. This report includes aggregate production, operating hours of permitted equipment, and a report of all surface disturbances of five acres or greater.

NTS air quality permits limit particulate emissions to 20 percent opacity, except at the Area 1 Aggregate Plant, where the limit is 10 percent. Certification of personnel to perform valid visible emission opacity evaluations is required by the state, with recertification required every six months. During 1998, one employee of BN's Environmental Compliance Department was recertified. In 1998, several visible emission evaluations of permitted air quality point sources were conducted. When visual evaluations determine that an emission exceeds the opacity requirement, corrective

The inspection included an examination of

4.4 AIR SURVEILLANCE PROGRAM RESULTS

ONSITE RADIOLOGICAL MONITORING

AIRBORNE EFFLUENTS

During 1998, effluent monitoring at the NTS involved several operational facilities and some inactive locations. Due to the continuation of the moratorium on nuclear testing throughout 1998, effluent monitoring for nuclear tests was not required. The results of other effluent monitoring, calculated or measured, are set forth in Table 4.5. The total curies of radioactivity included in Table 4.5 are more than that reported in the 1997 Annual Site Environmental Report because of higher tritium effluents.

AIR SAMPLING RESULTS

GROSS ALPHA

The annual average gross alpha results for each air sampling station are shown in Table 4.6. The annual average for the network was 1.8×10^{-15} µCi/mL (67 µBq/m^3), which was the same as the median minimum detectable concentration (MDC). This average was slightly higher than the 1997 value. The samples from the NAFR were all higher than the NTS average at 2.2×10^{-15} µCi/mL (81 µBq/m^3).

The samples collected from the air samplers at the low-level radioactive waste disposal facility in RWMS-3 and in RWMS-5 had gross alpha levels slightly above the NTS average. Previous investigations have not discovered the source for gross alpha radioactivity in air.

GROSS BETA

The annual average gross beta results for each air sampling station are shown in Figure 4.5 and Figure 4.6 indicates the distribution of this radioactivity. The NTS average this year at 1.9×10^{-14} µCi/mL (0.70 mBq/m^3) was slightly lower than the 1997 value. The air samples from the NAFR had about the same average value. This is consistent with the results for the past few years. The basic data are in Table 4.6. Figure 4.7 depicts the trend in concentration for the past few years (a much longer trend is shown in Figure 1.1, Chapter 1), but expressed as percent DCG (Derived Concentration Guide), set by the EPA as 10 mrem per year for inhaled radioactivity. Note that the levels are only about 2 percent of the DCG. This guide is for public exposure and is based on ^{90}Sr, once a common beta-emitting isotope is in the environment.

Air samples from both RWMS-3 and RWMS-5 had average gross beta levels that were slightly higher than the NTS average.

PLUTONIUM

The annual average ^{238}Pu result of 8.6×10^{-19} µCi/mL (32 nBq/m^3) is less than the median MDC for this isotope and less than the 1997 average. The results from the NAFR were about half that. None of the 42 stations had results greater than the MDC. The annual averages for ^{238}Pu and for $^{239+240}$Pu are also included in Table 4.6.

The $^{239+240}$Pu network average of 2.5×10^{-17} µCi/mL (0.9 µBq/m^3) was about seven times the MDC but was less than the 1997 average value. To indicate the distribution of this nuclide over the NTS, the annual average concentration for each station is plotted in Figure 4.8 (see Figure 4.6 for RWMS-5). The highest annual average concentration was for Area 9 9-300, 2.2×10^{-16} µCi/mL. Of the NAFR samples, the set from CLEAN SLATE I had the highest concentration of any station offsite, perhaps because of cleanup activities at that location in the summer of 1998. The trend of the NTS site-wide $^{239+240}$Pu concentration

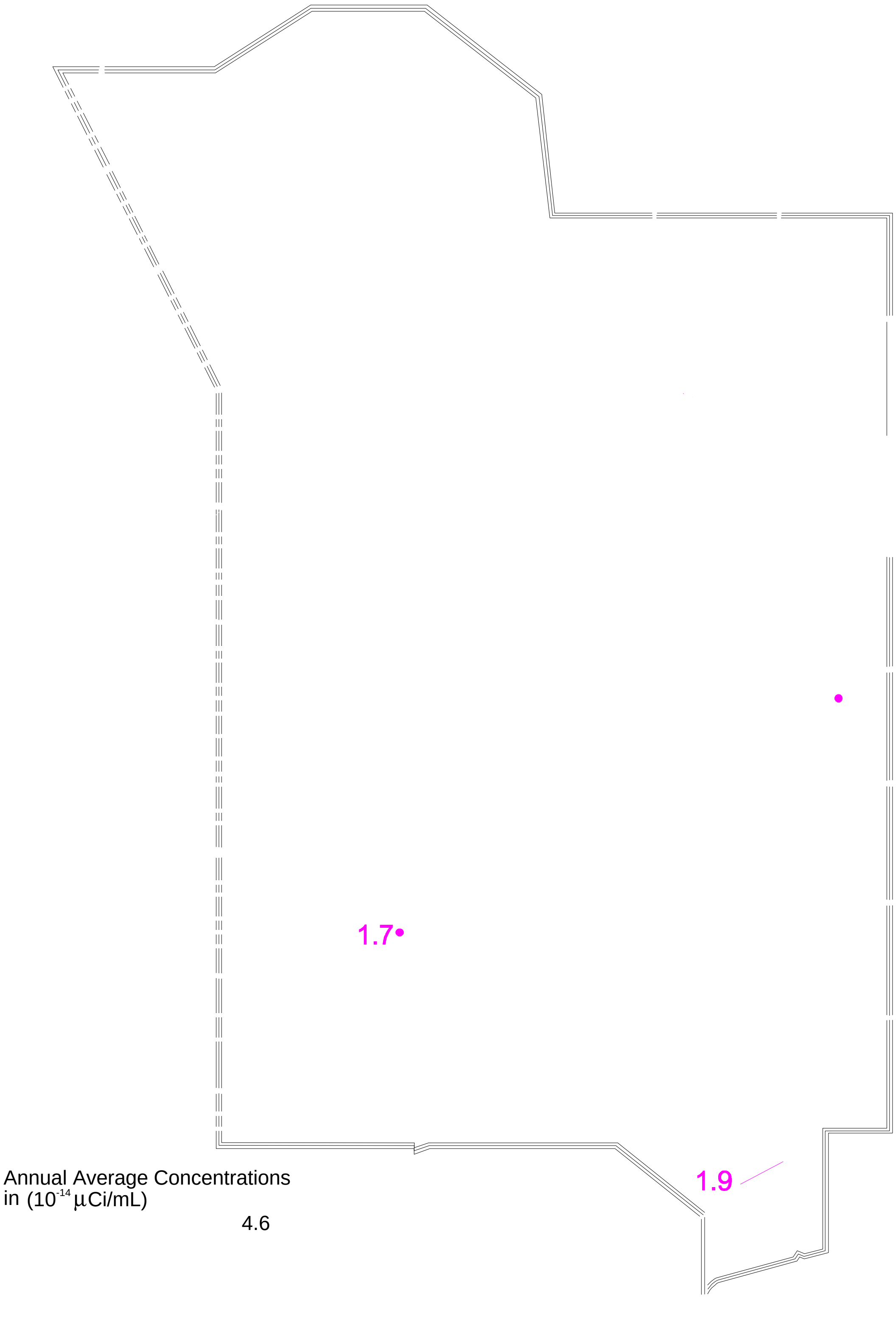


Figure 4.5 Annual Average Gross Beta from Air Sampling - 1998

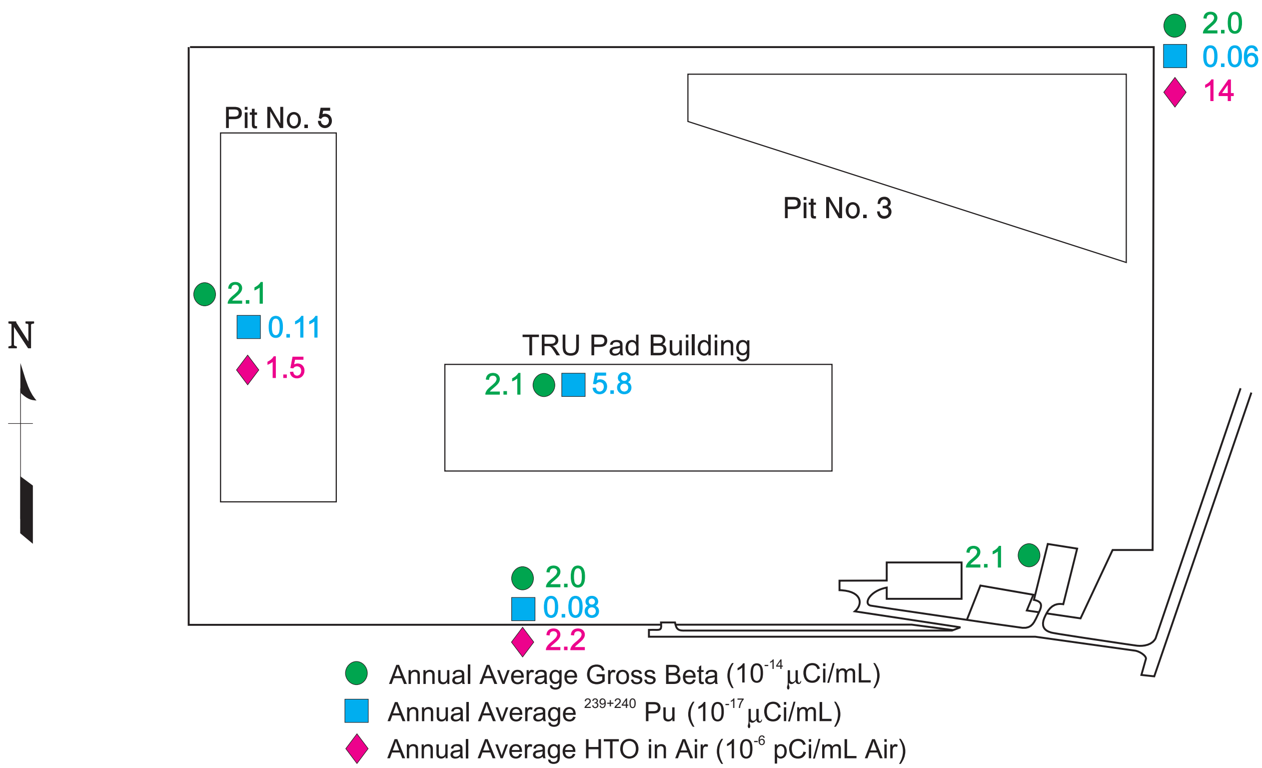


Figure 4.6 Air Monitoring Results for RWMS-5 - 1998

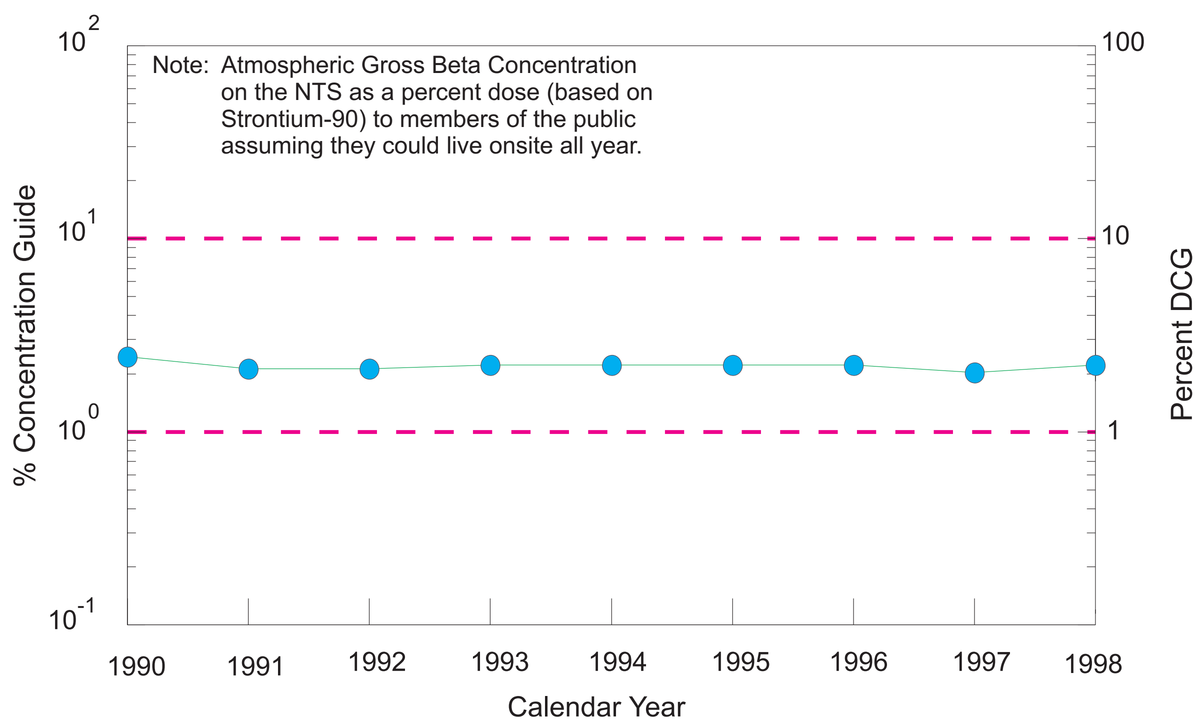


Figure 4.7 Trend in Annual Average Gross Beta Concentration in Air on the NTS

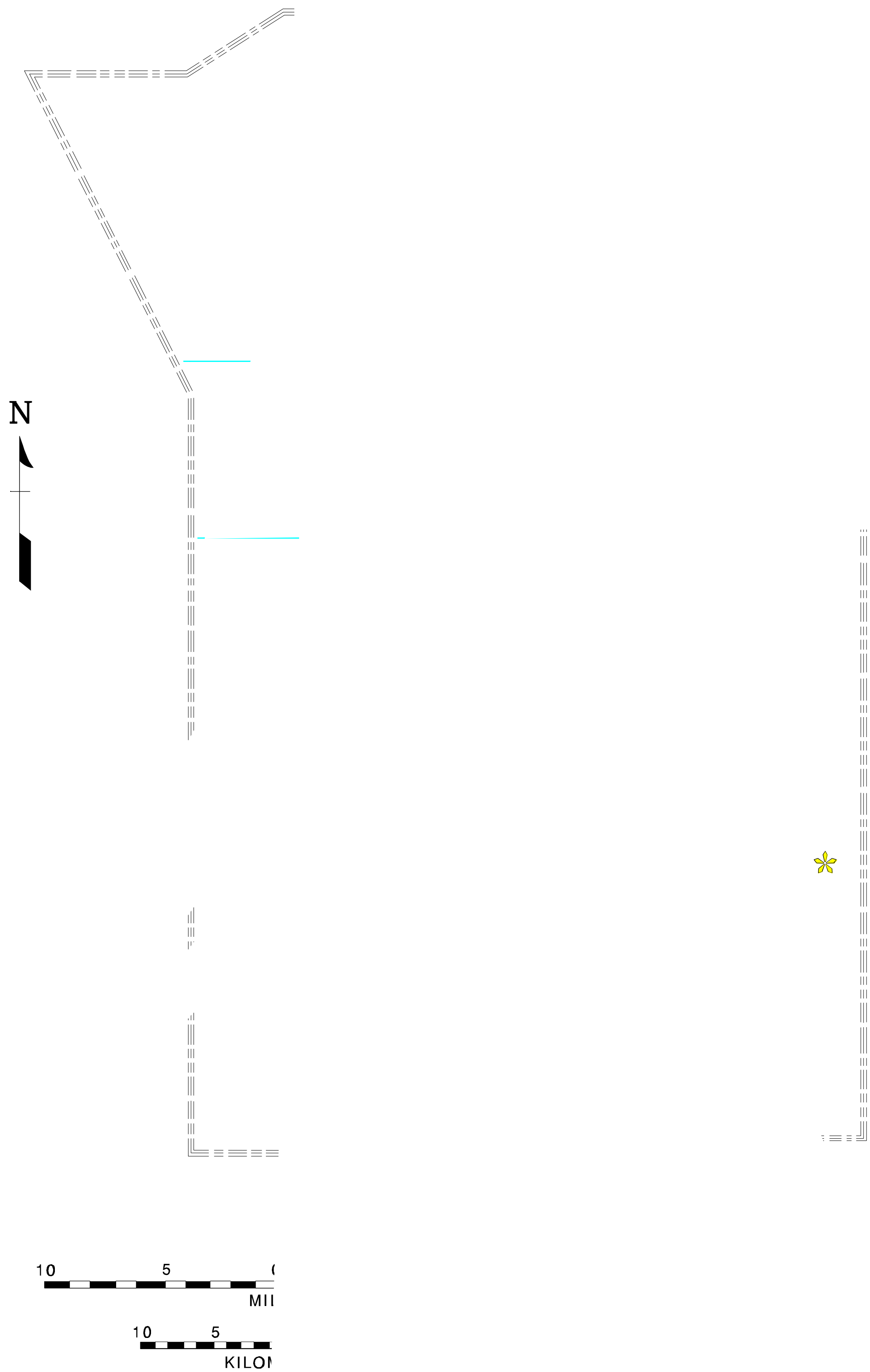


Figure 4.8 Ar

with time for the past few years is shown on Figure 4.9. There the data are plotted as a percent of the DCG for the general population as was done for the gross beta data above. The peak in the curve in 1992 was due to increased concentrations in Area 3 during the summer, probably related to increased vehicular travel and construction activities.

Air samples from RWMS-3 generally have concentrations of plutonium above the NTS average, while those from RWMS-5 are generally lower than the NTS average. However this year, one of the four RWMS-5 locations was above the NTS average.

GAMMA

Gamma spectral analyses of the glass-fiber filters indicated only naturally occurring radioactive materials. The predominant one was ^{7}Be formed by cosmic ray interaction with nitrogen in the atmosphere. The annual average values for this isotope are shown in Table 4.6 and the NTS average of 1.8×10^{-13} µCi/mL (6.7 mBq/m^3) is similar to the value for 1997. The concentrations in samples from the NAFR was slightly smaller at 1.7×10^{-13} µCi/mL (6.3 mBq/m^3).

Concentrations of ^{7}Be in air samples from both RWMS-3 and RWMS-5 were about 6 percent higher than the NTS average value. The reason for this increase is unknown.

TRITIATED WATER VAPOR (HTO)

The annual average value for the 13 stations in this network was 17×10^{-6} pCi/mL (0.6 Bq/m^3). This concentration is higher than it was in 1997 due to higher concentrations in 1998 at RWMS northeast, at the Decon Pad, and at SCHOONER (a new location added this year). The highest average was at SCHOONER and was 1.4×10^{-4} pCi/mL. The other locations which had annual averages above the median MDC were EPA Farm, SEDAN crater, and E Tunnel Pond 2. All of the data are displayed in Table 4.7 and are plotted as a trend over the last several years in Figure 4.10. The data plotted in Figure 4.10 are the network average concentration of HTO in each year expressed as a percent of the DCG for the general offsite population. There has been a slight downward trend over the period plotted, until this year (1998); however, all values are less than 2 percent of the DCG.

TREND AT THE WASTE MANAGEMENT SITES

The trends in air concentrations of HTO in atmospheric moisture and plutonium at RWMS-3 and RWMS-5 are set forth in Tables 4.8 and 4.9, respectively. There appears to be a trend of decreasing $^{239+240}$Pu and HTO concentration at RWMS-5 but not at RWMS-3. No average for HTO is shown for RWMS-3, because that sampling was terminated at the beginning of this year. The annual average HTO concentrations have been less than the median MDC for several years at RWMS-3.

ONSITE TLD RESULTS

The 1998 average exposure for the 14 boundary monitoring stations was 119 mR/year, essentially the same as the average value of 127 mR/yr for these stations in 1997 (see Table 4.10). Also, the 1998 average exposure for the nine historically monitored stations was 0.24 mR/day (88 mR/yr), as shown in Table 4.11. The results for these stations for the last five years have been almost identical.

Both sets of results indicate that external radiation measured by TLDs has not changed to any measurable extent, at least for the last few years.

OFFSITE RADIOLOGICAL RESULTS

AIR SAMPLING RESULTS

The ASN measures the major radionuclides which could potentially be emitted from activities on the NTS, as well as naturally occurring radionuclides. The ASN represents the possible inhalation exposure pathway for the general public.

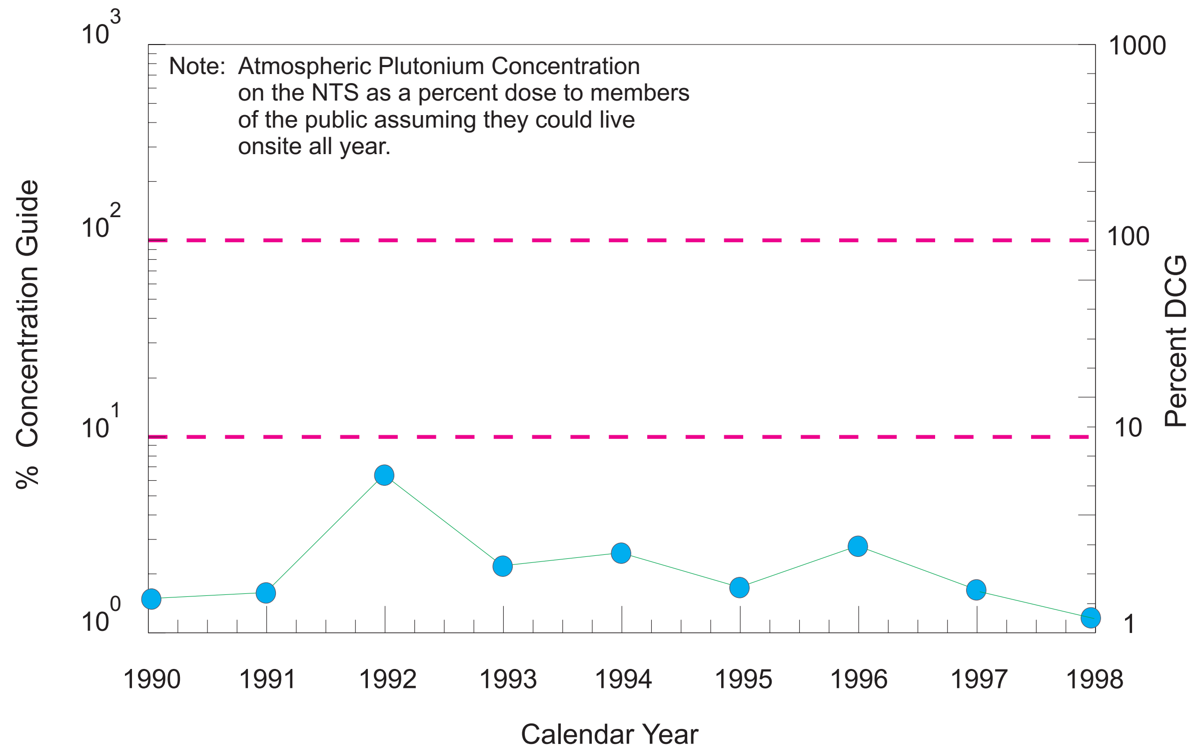


Figure 4.9 Trend in Annual Averages for Plutonium Concentration on the NTS

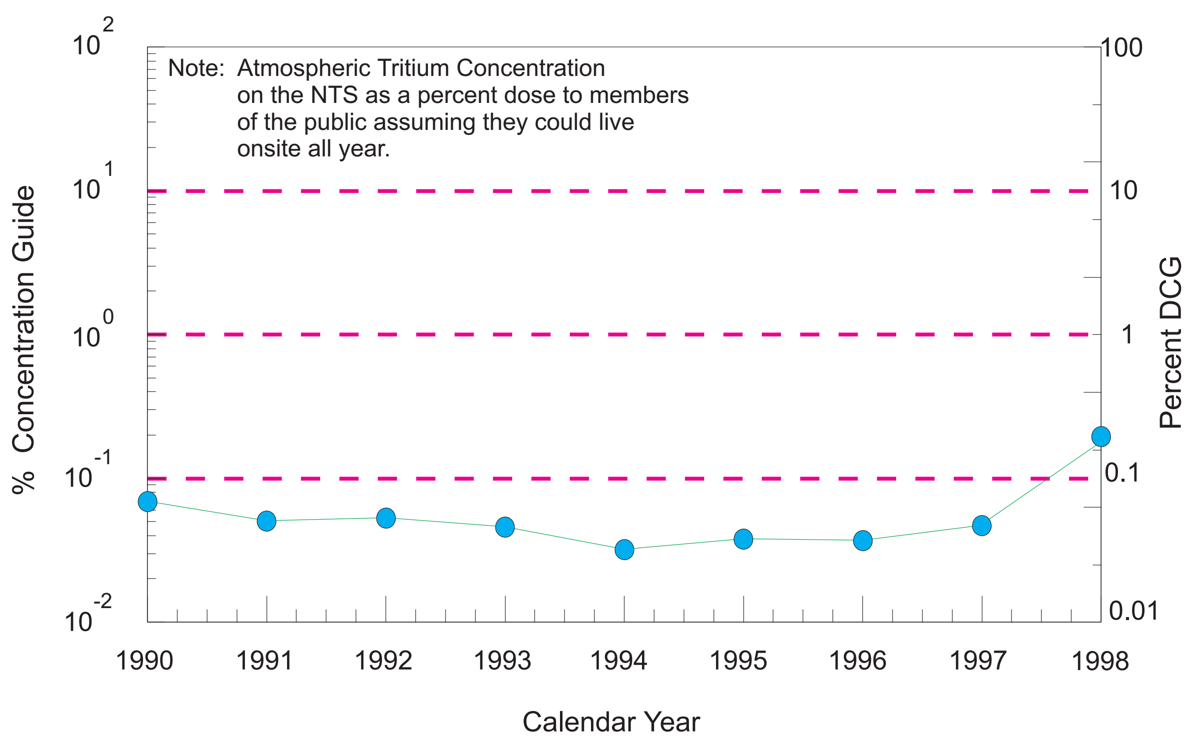


Figure 4.10 Trend in Annual Averages for HTO Concentration on the NTS

Gamma spectrometry was performed on all samples from the ASN high and low volume air samplers. The majority of the samples were gamma-spectrum negligible (i.e., no gamma-emitting radionuclides detected). Naturally occurring ^{7}Be was detected occasionally by the low-volume network of samplers. It was detected consistently by the high-volume sample method with an average annual activity of 1.4 x 10^{-13} µCi/mL, slightly less than the onsite average.

GROSS ALPHA

Gross alpha analysis was performed on all low-volume network samples. The average annual gross alpha activity was 1.8 x 10^{-15} µCi/mL (67 µBq/m^3), the same as the onsite results. Summary results for the ASN are shown in Table 4.12.

GROSS BETA

As in previous years, the gross beta results from the low-volume sampling network consistently exceeded the analytical MDC. The annual average gross beta activity was 1.5 ± 0.60 x 10^{-14} µCi/mL (5.5 ± 2.2 x 10^{-4} Bq/m^3), somewhat lower than the results for the onsite network. Summary gross beta results for the ASN are in Table 4.13.

PLUTONIUM

High-volume samples were collected monthly and analyzed for plutonium isotopes. Due to a low limit of detection for high-volume sampling and analysis methods, environmental levels of $^{239+240}Pu$ were consistently detected at all six of the sampling sites. Sixty-four samples were analyzed during CY 1998. The average annual activity was 0.1 x 10^{-18} µCi/mL (3.7 nBq/m^3) for ^{238}Pu and 1.4 x 10^{-18} µCi/mL (52 nBq/m^3) for $^{239+240}Pu$, about 6 percent of the activity detected in the onsite air network. Summary results of the high-volume data are shown in Table 4.14.

In November, 1998, special samples were collected at Beatty and at Indian Springs, Nevada. Plutonium-239 was detectable at Beatty, but all other results were below the MDC of the analyses.

TLD RESULTS FOR STATIONS

There were 38 offsite environmental stations monitored with TLDs in 1998. Figure 4.4 shows current fixed environmental monitoring locations. Total annual exposure for 1998 ranged from 54 mR (0.54 mSv) per year at Las Vegas, Nevada, to 170 mR (1.7 mSv) per year at Queen City Summit, Nevada, with a mean annual exposure of 100 mR (1 mSv) per year for all operating locations. All results are shown in Table 4.15. These results are consistent with those for 1997.

TLD RESULTS FOR PERSONNEL

Eighteen offsite residents were issued TLDs to monitor their annual dose equivalent. The locations of personnel monitoring participants are also shown in Figure 4.4. Annual whole body dose equivalents ranged from a low of 64 mrem (0.65 mSv) to a high of 120 mrem (1.2 mSv) with a mean of 88 mrem (0.88 mSv) for all monitored personnel during 1998. A summary of the results is shown in Table 4.16. These results are also similar to those for 1997.

PRESSURIZED ION CHAMBER (PIC) NETWORK

The PIC data presented in this section are based on daily averages of gamma exposure rates from each station. Table 4.17 contains the maximum, minimum, mean, standard deviation, and median of the daily averages. The table shows the total mR/yr and the average gamma exposure rate for each station. The mean ranged from 70 to 153 mR (18 to 39 µC/kg). 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 (13 to 64 µC/kg-yr) (BEIR III 1980). The annual exposure levels observed at each PIC station are well within these United

States background levels. The data from the Amargosa station shows the greatest range and the most variability. Most of these data, with the exception of Henderson and Las Vegas, are within a few tenths µR/hr from those of last year.

NON-NTS BN FACILITY MONITORING

BN facilities that use radioactive sources or radiation-producing equipment with the potential to expose the general population outside the property line to direct radiation are the STL, during operation of the Sealed Tube Neutron Generator and operation of the Febetron; WAMO, during storage of sealed sources; and Atlas NLVF A-1 Source Range. Sealed sources are tested every six months to ensure there is no leakage of radioactive material. The data from sealed source testing are kept in the BN Radiation Protection Records. Operation of radiation generating devices is controlled by BN procedures. Fence line radiation monitoring at STL, WAMO, and NLV was conducted during 1998 using Panasonic Type UD-814 TLDs. At least two TLDs were at the fence line on each side of any facility. TLDs were exchanged on a quarterly basis with additional control TLDs kept in a shielded safe. These TLD results are given in Table 4.18. The range of results, 38 to 86 mR/yr, is within the background range in the continental United States.

Table 4.1 Summary of the NTS Air and Direct Radiation Surveillance Program - 1998

Sample Type	Description	Collection Frequency	Number of Locations[(a)]	Type of Analysis
		Onsite Monitoring		
Air	Sampling through Whatman GF/A glass fiber filter, 85 L/min.	Weekly	37	Gamma spectroscopy, gross α & ß,($^{238,239+240}$Pu, monthly composite).
	Low-volume sampling through molecular Sieve	Biweekly	13	HTO (tritiated water)
External Gamma Radiation Levels	UD-814AS thermoluminescent dosimeters	Quarterly	107	Total quarterly exposure
		Offsite Monitoring		
Air	Sampling through 5-cm glass-fiber filter and a charcoal cartridge, 56 L/min	Weekly	20	Gamma spectroscopy, gross α & ß
	Sampling through 500-cm^2 glass-fiber filter at 1,100 L/min	Monthly	6	Gamma spectroscopy $^{238,239+240}$Pu
External Gamma Radiation Levels	UD-814AS thermoluminescent dosimeters	Quarterly	39	Quarterly exposure at deployed location
	UD-802 thermoluminescent dosimeters	Quarterly	18	Quarterly exposure of offsite personnel
External Gamma Radiation Rate	Reuter-Stokes Pressurized Ion Chambers	Continuous	26	Continuous rate recording summarized hourly

Table 4.2 Analytical Procedures, Air and TLD - 1998

Analysis	Sample Type Nominal Size	Analytical Procedure	Equipment	Count Time (min)	Estimated MDC
BN Analytical Procedures					
Gross α	Air, 860 m^3	After 5 - 7 days, place in planchet	Gas-flow proportional counter	20	74 µBq/m^3 (2 x 10^{-3} pCi/m^3)
Gross β	Air, 860 m^3	Continue count.	Gas-flow proportional counter	20	150 µBq/m^3 (4 x 10^{-3} pCi/m^3)
Gamma spectrometry composite	Air, 3,400 m^3	Filters placed on planched, that is placed on crystal	HpGe, calibrated 1 keV per channel,	20	370 µBq/m^3 (1 x 10^{-2} pCi/m^3) for ^{137}Cs
$^{238,239+240}$Pu Monthly Composite	Air, 3,400 m^3	Acid dissolution, ion-exchange, ppt with ^{242}Pu tracer, collect on filter	Alpha spectrometer with solid-state PIP detector	333	0.41 µBq/m^3 (11 x 10^{-6} pCi/m^3)
Tritium	Air, 8 m^3	Moisture trapped on molecular sieve, heat to remove	5 mL in cocktail counted in liquid scintillation counter	70	0.11 Bq/m^3 (3 pCi/m^3)
Ambient gamma	TLD, UD-814AS	Expose in field, 3 months	Automatic TL reader		10 mR per quarter
EPA Analytical Procedures					
Gross α	Air, 560 m^3	After 7-14 days place in planchet	Gas-flow proportional counter	30	30 µBq/m^3 (8 x 10^{-4} pCi/m^3)
Gross β	Air, 560 m^3	After 7-14 days place in planchet	Gas-flow proportional counter	30	90 µBq/m^3 (2.5 x 10^{-3} pCi/m^3)
Gamma spectrometry	Air, 560 m^3 Low-vol 10,000 m3 High-vol	Place on detector, has online analytical program	HpGe detector, calibrated 0.5 keV/channel from 40 to 2,000 keV	30	2 mBq (0.05 pCi)/m^3 20 µBq (5 x 10^{-4} pCi) per m^3 (Hi-vol), ^{137}Cs

Table 4.3 NTS Active Air Quality Permits - 1998

Permit	Description	Expiration Date	Annual Reporting
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 Equip. (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
AP9611-0683	DOUBLE TRACKS Surface Disturbance	06/12/2001	February 1
AP9711-0549	CLEAN SLATE I Env. Rest. Project	04/04/2002	February 1
AP9711-0549	CLEAN SLATE II Env. Rest. Project	06/30/2002	February 1
AP9711-0785	UGTA Surface Disturbance Permit	03/20/2003	February 1
99-14	Burn Variance, Areas 5 and 26	04/16/1999	None
99-25	Burn Variance, NTS	03/09/2000	None
	Non-BN Operated NTS Air Permits		
99-13	Open Burn Variance (LLNL)	02/05/2000	None

Table 4.4 Active Air Quality Permits for Non-NTS Facilities

	Expiration	Annual	
Permit	Description	Date	Reporting
	Remote Sensing Laboratory		
A0034811	Excimer Laser, Lumonics, EX-700	None	None
A34801	Boiler, Columbia, W1-180	None	March 1
A34802	Boiler, Columbia, WL-90	None	March 1
A34803	Water Heater, No. 2 Natl. BD	None	March 1
A34804(a)	Emergency Fire Control Pump Engine	None	None
A34804(b)	Emergency Generator, Cummins	None	None
A34805	Spray Paint Booth	None	None
	North Las Vegas Facility		
A38701	A-16 Spray Paint Booth	None	None
A38702	C-1 Hamada Offset Press	None	None
A38703	A-5/B-5 Emergency Generators	None	None
A06503	Emergency Generator	None	None
A06505	B-1 Aluminum Sander	None	None
A06507	Tinco Dry Blaster	None	None

Table 4.5 NTS Radionuclide Emissions - 1998

Onsite Liquid Discharges

Containment Ponds	Curies[a]				
	^{3}H	^{90}Sr	^{137}Cs	^{238}Pu	$^{239+240}Pu$
Area 12, E Tunnel	1.82×10^{1}	2.4×10^{-5}	1.5×10^{-3}	4.3×10^{-6}	3.8×10^{-5}
Area 19, Well U-19q PS No. 1	1.59×10^{0}				
Area 20, ER-20-5 No. 1	1.56×10^{1}				
Area 20, ER-20-6 No. 1, No. 3	2.9×10^{-3}				
Area 20, U-20n PS No.1	6.96×10^{1}				
TOTAL	1.05×10^{2}	2.4×10^{-5}	1.5×10^{-3}	4.3×10^{-6}	3.8×10^{-5}

Airborne Effluent Releases - Curies[a]

Facility Name	^{3}H[b]	$^{239+240}Pu$
Laboratories	6.2×10^{0}	
SCHOONER	4.5×10^{1}	
Area 5, RWMS[d]	9.2×10^{-1}	
SEDAN Crater [d]	1.4×10^{2}	
Areas 3 and 9[c]		0.04
Other Areas[c]		0.2
TOTAL	1.92×10^{2}	0.24

(a) Multiply by 3.7×10^{10} to obtain Bq. Calculated releases from laboratory spills and losses are included in Table 1.1.
(b) In the form of tritiated water vapor, primarily HTO.
(c) Resuspension from known surface deposits.
(d) Calculated from air sampler data.

Table 4.6 Summary Data (µCi/mL) for Gross Alpha/Beta, ^{7}Be and Plutonium in Air - 1998

Location	Gross α	Gross β	Beryllium-7	^{238}Pu	$^{239+240}$Pu
Area 1, BJY	1.9 x 10^{-15}	2.0 x 10^{-14}	1.8 x 10^{-13}	1.7 x 10^{-18}	5.7 x 10^{-17}
Area 2, Complex	1.5 x 10^{-15}	1.6 x 10^{-14}	1.6 x 10^{-13}	7.9 x 10^{-19}	2.8 x 10^{-18}
Area 2, 2-1 Substation	1.7 x 10^{-15}	1.8 x 10^{-141}	1.7 x 10^{-13}	-2.2 x 10^{-19}	3.1 x 10^{-17}
Area 3, Bunker 3-300	1.7 x 10^{-15}	1.8 x 10^{-14}	1.8 x 10^{-13}	6.5 x 10^{-19}	4.8 x 10^{-17}
Area 3, U-3ah/at N	1.8 x 10^{-15}	1.9 x 10^{-14}	1.8 x 10^{-13}	1.2 x 10^{-18}	5.6 x 10^{-17}
Area 3, U-3ah/at S	1.8 x 10^{-15}	1.9 x 10^{-14}	1.9 x 10^{-13}	5.5 x 10^{-19}	4.6 x 10^{-17}
Area 3, U-3bh S	2.1 x 10^{-15}	2.2 x 10^{-14}	1.9 x 10^{-13}	-3.2 x 10^{-19}	2.3 x 10^{-17}
Area 3, U-3bg N	2.1 x 10^{-15}	2.2 x 10^{-14}	2.0 x 10^{-13}	1.4 x 10^{-18}	2.2 x 10^{-17}
Area 3, Well ER-3-1	1.5 x 10^{-15}	1.8 x 10^{-14}	1.7 x 10^{-13}	2.1 x 10^{-19}	1.0 x 10^{-18}
Area 4, Bunker T-4	1.5 x 10^{-15}	1.8 x 10^{-14}	1.7 x 10^{-13}	5.5 x 10^{-18}	2.4 x 10^{-17}
Area 5, RWMS NE	1.9 x 10^{-15}	2.0 x 10^{-14}	1.9 x 10^{-13}	-2.9 x 10^{-19}	6.5 x 10^{-19}
Area 5, RWMS S	2.0 x 10^{-15}	2.0 x 10^{-14}	1.9 x 10^{-13}	5.6 x 10^{-20}	8.3 x 10^{-19}
Area 5, RWMS W	2.3 x 10^{-15}	2.1 x 10^{-14}	2.0 x 10^{-13}	-6.0 x 10^{-19}	1.1 x 10^{-18}
Area 5, TP Building N	2.4 x 10^{-15}	2.1 x 10^{-14}	1.7 x 10^{-13}	1.8 x 10^{-18}	5.8 x 10^{-17}
Area 5, WEF NE	1.6 x 10^{-15}	1.9 x 10^{-14}	1.8 x 10^{-13}	-5.0 x 10^{-22}	3.2 x 10^{-18}
Area 5, WEF SW	1.9 x 10^{-15}	2.1 x 10^{-14}	1.9 x 10^{-13}	6.2 x 10^{-19}	1.3 x 10^{-17}
Area 5, DOD	1.7 x 10^{-15}	2.0 x 10^{-14}	1.8 x 10^{-13}	1.1 x 10^{-19}	1.9 x 10^{-18}
Area 5, Well 5B	1.6 x 10^{-15}	1.8 x 10^{-14}	1.8 x 10^{-13}	-8.1 x 10^{-20}	4.6 x 10^{-19}
Area 6, YUCCA	2.0 x 10^{-15}	2.0 x 10^{-14}	1.8 x 10^{-13}	3.0 x 10^{-19}	8.0 x 10^{-18}
Area 6, CP-6	1.6 x 10^{-15}	1.8 x 10^{-14}	1.9 x 10^{-13}	-2.5 x 10^{-19}	2.8 x 10^{-18}
Area 6, Well 3	1.7 x 10^{-15}	1.7 x 10^{-14}	1.7 x 10^{-13}	3.7 x 10^{-19}	1.6 x 10^{-18}
Area 7, UE-7ns	1.6 x 10^{-15}	1.9 x 10^{-14}	1.8 x 10^{-13}	-2.2 x 10^{-19}	1.0 x 10^{-17}
Area 9, 9-300	1.9 x 10^{-15}	1.6 x 10^{-14}	1.7 x 10^{-13}	3.3 x 10^{-18}	2.2 x 10^{-16}
Area 10, Gate 700 S	1.7 x 10^{-15}	1.7 x 10^{-14}	1.9 x 10^{-13}	2.0 x 10^{-18}	9.8 x 10^{-18}
Area 10, SEDAN Crater	1.6 x 10^{-15}	1.9 x 10^{-14}	1.8 x 10^{-13}	4.4 x 10^{-18}	7.1 x 10^{-17}
Area 11, Gate 293	1.5 x 10^{-15}	1.8 x 10^{-14}	1.7 x 10^{-13}	2.9 x 10^{-19}	3.6 x 10^{-18}
Area 15, EPA Farm	1.6 x 10^{-15}	1.8 x 10^{-14}	1.8 x 10^{-13}	2.5 x 10^{-19}	2.5 x 10^{-17}
Area 18, Little Feller II N	1.8 x 10^{-15}	1.9 x 10^{-14}	2.0 x 10^{-13}	-7.5 x 10^{-19}	4.9 x 10^{-18}
Area 20, CABRIOLET	1.7 x 10^{-15}	1.8 x 10^{-14}	1.8 x 10^{-13}	3.6 x 10^{-18}	1.4 x 10^{-19}
Area 20, SCHOONER	1.7 x 10^{-15}	1.9 x 10^{-14}	1.8 x 10^{-13}	2.7 x 10^{-18}	9.9 x 10^{-18}
Area 23, Bldg 790 No. 2	1.8 x 10^{-15}	1.9 x 10^{-14}	1.9 x 10^{-13}	-6.6 x 10^{-20}	1.3 x 10^{-18}
Area 25, E-MAD N	1.6 x 10^{-15}	1.7 x 10^{-14}	1.7 x 10^{-13}	1.9 x 10^{-19}	5.6 x 10^{-19}
Average	1.8 x 10^{-15}	1.9 x 10^{-14}	1.8 x 10^{-13}	8.6 x 10^{-19}	2.5 x 10^{-17}
Near Offsite Air Sampling					
Area 13, Project 57	1.6 x 10^{-15}	1.4 x 10^{-14}	1.4 x 10^{-13}	4.1 x 10^{-19}	1.5 x 10^{-17}
Area 52, CLEAN SLATE I	2.2 x 10^{-15}	1.5 x 10^{-14}	1.5 x 10^{-13}	9.4 x 10^{-19}	1.9 x 10^{-16}
Area 52, CLEAN SLATE II	2.5 x 10^{-15}	2.0 x 10^{-14}	1.8 x 10^{-13}	9.1 x 10^{-19}	1.4 x 10^{-16}
Area 52, CLEAN SLATE III	2.4 x 10^{-15}	2.0 x 10^{-14}	1.8 x 10^{-13}	4.5 x 10^{-19}	1.9 x 10^{-18}
Area 52, DOUBLE TRACKS	2.3 x 10^{-15}	1.8 x 10^{-14}	1.7 x 10^{-13}	1.6 x 10^{-19}	1.4 x 10^{-17}
Average	2.2 x 10^{-15}	1.8 x 10^{-14}	1.7 x 10^{-13}	4.7 x 10^{-19}	4.7 x 10^{-17}
Median MDC	1.8 x 10^{-15}	4.1 x 10^{-15}	2.1 x 10^{-14}	9.9 x 10^{-18}	3.3 x 10^{-18}

Table 4.7 Airborne Tritium Concentrations on the NTS - 1998

Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
		^{3}H Concentration (10^{-6} pCi/mL)				
Area 1, BJY	26	3.4	-0.81	1.0	0.96	0.010
Area 5, RWMS NE (4)	25	84	-0.12	14	22	0.14
Area 5, RWMS S (9)	27	4.6	0.11	2.2	1.1	0.022
Area 5, RWMS W (7)	26	2.8	-0.29	1.5	0.63	0.015
Area 5, WEF NE	35	3.7	-0.66	1.4	1.1	0.014
Area 5, WEF SW	26	5.6	0.0038	1.8	1.3	0.018
Area 5, Well 5B	32	2.5	-1.7	0.24	0.96	<0.01
Area 6, Decon Pad	26	180	1.8	37	41	0.37
Area 10, SEDAN Crater	35	29	1.3	8.5	7.7	0.085
Area 12, E Tunnel Pond No. 2	31	110	0.91	15	21	0.15
Area 12, Stake T-18	4	0.69	-0.32	0.11	0.42	<0.01
Area 15, EPA Farm	33	14	1.2	8.8	3.4	0.088
Area 20, Schooner	24	460	9.4	140	160	1.4
All Stations	35	460	-1.7	17	56	0.17

Median MDC was 2.9 x 10^{-6} pCi/mL

Table 4.8 Mean Air Monitoring Results for Various Radionuclides at the RWMS-3, 1994 - 1998

Year	$^{239+240}$Pu (x 10^{-17} µCi/mL)	^{238}Pu (x 10^{-17} µCi/mL)	Tritium (x 10^{-12} µCi/mL)
Arithmetic Mean 1998	4.2	0.08	(a)
Arithmetic Mean 1997	3.8	0.06	1.2
Arithmetic Mean 1996	16	0.25	0.5
Arithmetic Mean 1995	8.8	0.16	(a)
Arithmetic Mean 1994	13	0.25	(a)
Mean MDC	1.1	0.99	2.8
Derived Concentration Guide	2,000	3,000	100,000

(a) Sampling for tritium was stopped at the end of 1997 due to concentrations less than the MDC

Table 4.9 Mean Air Monitoring Results for Various Radionuclides at the RWMS-5, 1995 - 1998

Year	$^{239+240}$Pu (x 10^{-17} µCi/mL)	^{238}Pu (x 10^{-17} µCi/mL)	Tritium (x 10^{-12} µCi/mL)
Arithmetic Mean 1998	1.3	0.03	4.0
Arithmetic Mean 1997	0.23	0.03	3.7
Arithmetic Mean 1996	0.51	0.02	3.2
Arithmetic Mean 1995	0.6	0.01	5.7
Arithmetic Mean 1994	1.1	0.04	4.9
Mean MDC	1.1	0.99	2.9
Derived Concentration Guide	2,000	3,000	100,000

Table 4.10 NTS Boundary Gamma Monitoring Results - 1998

Location	First Quarter (mR/day)	Second Quarter (mR/day)	Third Quarter (mR/day)	Fourth Quarter (mR/day)	Annual Average (mR/d)	Annual Average (mR/yr)
U-15E Substation	0.26	0.24	0.25	0.26	0.25	92
Stake J-41	0.34	0.39	0.35	0.37	0.36	130
Stake LC-4	0.51	0.45	0.43	0.45	0.46	170
Stake A-118	0.37	0.39	0.39	0.41	0.39	140
Papoose Lake Road	0.22	0.20	0.21	0.21	0.21	77
Gate 19-3P	0.41	0.40	0.41	0.41	0.41	150
East of U-11B	0.31	0.32	0.31	[a]	0.31	120
Army Well No. 1	0.20	0.19	0.22	0.21	0.21	76
3.3 Miles SE of Aggregate Pit	0.16	0.16	0.16	0.17	0.16	60
Guard Station 510	0.31	0.32	0.34	0.34	0.33	120
Yucca Mountain	0.33	0.35	0.36	0.36	0.35	130

Table 4.11 NTS Historical TLD Station Comparisons, 1992-1998

Table 4.12 (Gross Alpha Results for the Offsite Air Surveillance Network - 1998, cont.)

Sampling Location	Concentration (10^{-15} µCi/mL [37 µBq/m^3]) Number	Maximum	Minimum	Mean	Standard Deviation
Delta	51	7.1	0.0	1.8	0.13
Goldfield	49	4.3	0.1	1.4	0.09
Henderson	52	5.3	0.3	1.9	0.10
Indian Springs	49	4.5	0.2	1.4	0.09
Las Vegas	49	5.5	0.1	2.3	0.14
Milford	52	3.7	-0.3	1.6	0.09
Overton	50	4.3	0.2	1.7	0.10
Pahrump	52	5.0	-0.3	1.3	0.10
Pioche	47	4.4	0.1	1.3	0.08
Rachel	48	7.1	0.1	2.4	0.13
St. George	51	3.0	-0.4	1.5	0.09
Stone Cabin	48	5.4	-0.3	2.6	0.12
Tonopah	53	4.3	-0.2	2.1	0.09
Twin Springs	48	7.2	-0.2	2.1	0.18

Mean MDC = 7.9 x 10^{-16} µCi/mL Standard Deviation of Mean MDC = 3.6 x 10^{-16} µCi/mL

Table 4.13 Gross Beta Results for the Offsite Air Surveillance Network - 1998

Sampling Location	Concentration (10^{-14} µCi/mL [0.37 mBq/m^3]) Number	Maximum	Minimum	Mean	Standard Deviation
Alamo	52	3.1	0.46	1.5	0.55
Amargosa Center	51	6.0	0.54	1.6	0.80
Beatty	51	2.7	0.27	1.6	0.57
Boulder City	50	3.5	0.33	1.7	0.65
Caliente	6	2.6	0.82	2.1	0.68
Cedar City	52	2.2	0.47	1.4	0.48
Delta	51	5.9	0.47	1.5	0.83
Goldfield	49	2.9	0.11	1.2	0.58
Henderson	52	3.0	0.62	1.7	0.58
Indian Springs	49	2.8	0.16	1.5	0.59
Las Vegas	49	3.3	0.49	1.6	0.55
Milford	52	4.6	0.03	1.5	0.73
Overton	50	4.0	0.17	1.6	0.69
Pahrump	52	2.5	0.43	1.5	0.54
Pioche	47	2.3	0.12	1.4	0.51
Rachel	48	2.6	0.04	1.4	0.63
St. George	51	3.7	0.39	1.6	0.67
Stone Cabin	48	2.2	0.33	1.5	0.52
Tonopah	53	2.2	0.14	1.5	0.45
Twin Springs	48	3.5	0.03	1.5	0.81

Mean MDC = 2.44 x 10^{-15} µCi/mL Standard Deviation of Mean MDC = 1.05 x 10^{-15} µCi/mL

Table 4.14 Plutonium Results for the Offsite Hi-Volume Air Surveillance Network - 1998

Sampling Location	Number	^{238}Pu Concentration (10^{-18} µCi/mL) Maximum	Minimum	Mean	Standard Deviation	%DCG[(a)]
Alamo	13	0.43	-0.26	0.07	0.16	(b)
Amargosa Center	12	0.28	-0.10	0.06	0.10	(b)
Goldfield	11	0.31	0.00	0.09	0.09	(b)
Las Vegas	10	0.21	-0.52	-0.01	0.22	(b)
Rachel	8	0.84	0.00	0.26	0.29	(b)
Tonopah	10	0.67	-0.18	0.12	0.24	(b)

Mean MDC = 0.53 x 10^{-18} µCi/mL   Standard Deviation of Mean MDC = 0.39 x 10^{-18} µCi/mL

(a) Derived Concentration Guide; Established by DOE Order as 2 x 10^{-15} µCi/mL.
(b) Not applicable, result less than MDC.
Note: To convert µCi/mL to Bq/m^3 multiply by 3.7 x 10^{10} (e.g., [0.43 x 10^{-18}] x [3.7 x 10^{10}] = 52 nBq/m^3).

Alamo	13	1.4	0.17	0.81	0.42	0.03
Amargosa Center	12	12	0.26	1.9	3.4	0.11
Goldfield	11	1.6	0.11	0.73	0.47	0.02
Las Vegas	10	0.48	-0.08	0.23	0.19	(b)
Rachel	8	12	0.94	4.9	4.6	0.15
Tonopah	10	2.0	0.00	0.68	0.66	0.02

Mean MDC = 0.41 x 10^{-18} µCi/mL   Standard Deviation of Mean MDC = 0.29 x 10^{-18} µCi/mL

(a) Derived Concentration Guide; Established by DOE Order as 3 x 10^{-15} µCi/mL.
(b) Not applicable, result less than MDC.
Note: To convert µCi/mL to Bq/m^3 multiply by 3.7 x 10^{10} (e.g., [1.4 x 10^{-18}] x [3.7 x 10^{10}] = 52 nBq/m^3).

Table 4.15 TLD Monitoring Results for Offsite Stations - 1998

Station Name	Daily Exposure (mR) Min	Max	Mean	Total (mR) Exposure
Alamo, NV	0.05	0.28	0.25	91
Amargosa Center, NV	0.19	0.23	0.21	78
Beatty, NV	0.28	0.49	0.37	130
Blue Jay, NV	0.31	0.51	0.40	150
Boulder City, NV	0.21	0.24	0.22	82
Caliente, NV	0.23	0.29	0.26	96
Cedar City, UT	0.18	0.21	0.19	73
Complex I, NV	0.23	0.34	0.30	110
Coyote Summit, NV	0.28	0.39	0.35	130
Delta, UT	0.20	0.24	0.22	81
Furnace Creek, CA	0.18	0.23	0.20	76
Goldfield, NV	0.27	0.42	0.33	120
Groom Lake, NV	0.21	0.43	0.30	110
Henderson (CCSN), NV	0.23	0.27	0.24	91
Hiko, NV	0.18	0.22	0.20	74
Indian Springs, NV	0.18	0.23	0.20	93

Table 4.15 (TLD Monitoring Results for Offsite Stations - 1998, cont.)

Station Name	Daily Exposure (mR) Min	Max	Mean	Total (mR) Exposure
Las Vegas UNLV, NV	0.02	0.20	0.13	54
Lund, NV	0.26	0.32	0.30	110
Lund, UT	0.26	0.33	0.29	110
Medlins Ranch, NV	0.25	0.36	0.32	120
Mesquite, NV	0.18	0.20	0.19	70
Milford, UT	0.29	0.34	0.31	120
Moapa, NV	0.21	0.25	0.23	86
Nyala, NV	0.21	0.40	0.29	110
Overton, NV	0.16	0.19	0.18	66
Pahrump, NV	0.16	0.25	0.21	70
Pioche, NV	0.20	0.27	0.24	89
Queen City Summit, NV	0.35	0.60	0.46	170
Rachel, NV	0.29	0.50	0.38	140
Sacorbatus Flats, NV	0.30	0.52	0.40	150
St. George, UT	0.14	0.18	0.16	60
Stone Cabin, NV	0.29	0.52	0.39	140
Sunnyside, NV	0.20	0.24	0.22	80
Tonopah Test Range, NV	0.32	0.54	0.42	150
Tonopah, NV	0.31	0.51	0.40	140
Twin Springs, NV	0.30	0.50	0.36	140
Uhaldes Ranch, NV	0.10	0.29	0.17	85
Warm Springs No. 1, NV	0.23	0.36	0.31	120

Table 4.16 TLD Monitoring Results for Offsite Personnel - 1998

Personnel ID No.	Associated Station Name	Number of Days	Daily Deep Dose Exposure (mrem) Min	Max	Mean	Total Annual Exposure
022	Alamo, NV	351	0.20	0.24	0.22	81
038	Beatty, NV	365	0.31	0.36	0.34	120
293	Pioche, NV	365	0.20	0.26	0.23	82
344	Delta, UT	365	0.19	0.24	0.21	78
345	Delta, UT	351	0.20	0.26	0.23	82
346	Milford, UT	175	0.26	0.31	0.28	100
347	Milford, UT	351	0.27	0.32	0.29	110
348	Overton, NV	350	0.17	0.21	0.19	68
427	Alamo, NV	365	0.27	0.28	0.27	100
592	Rachel, NV	107	0.25	0.25	0.25	92
593	Cedar City, UT	351	0.24	0.33	0.29	100
595	Las Vegas, NV	365	0.17	0.20	0.18	65
596	Las Vegas, NV	349	0.14	0.24	0.20	68
607	Tonopah, NV	365	0.32	0.35	0.33	120
608	Logandale, NV	350	0.15	0.22	0.18	64
610	Caliente, NV	350	0.26	0.34	0.29	100
621	Indian Springs, NV	352	0.16	0.22	0.19	67
656	Henderson, NV	350	0.20	0.35	0.26	90

Table 4.17 Summary of Gamma Exposure Rates as Measured by PIC - 1998

	Gamma Exposure Rate (µR/hr)				
Station	Max	Min	Standard Deviation	Average	mR/yr
Alamo	16.2	9.6	0.38	12.4	109
Amargosa	18.4	8.2	1.65	11.8	103
Beatty	20.0	11.	0.43	16.1	141
Boulder City	15.5	9.9	0.51	11.4	99
Caliente	17.9	11.4	0.47	14.4	126
Cedar City	14.1	8.6	0.45	9.8	86
Complex I	18.7	13.6	0.66	15.3	134
Delta	16.9	10.0	0.54	11.9	104
Furnace Creek	13.9	7.6	0.38	9.9	87
Henderson	15.7	10.9	0.36	12.0	105
Goldfield	10.8	13.1	0.55	14.9	131
Indian Springs	14.7	8.3	0.75	11.2	98
Las Vegas	13.6	8.3	0.33	9.1	80
Medlin's	21.2	12.8	0.45	16.6	146
Milford	23.0	13.5	0.63	17.4	153
Nyala	NO DATA 1998				
Overton	16.8	7.0	0.43	9.1	80
Pahrump	11.2	6.8	0.26	8.0	70
Pioche	17.2	8.6	0.49	11.9	105
Rachel	21.6	14.2	0.57	16.2	142
St. George	13.5	7.6	0.38	8.6	75
Stone Cabin	21.7	13.2	0.71	17.4	153
Terrel's	18.6	15.1	0.31	16.1	141
Tonopah	22.0	13.4	0.58	17.4	152
Twin Springs	19.9	9.1	0.60	15.8	139
Uhalde's	NO DATA 1998				

Note: Multiply µR/hr by 2.6×10^{-4} to obtain $\mu C \cdot kg^{-1} \cdot hr^{-1}$.

Table 4.18 BN Offsite Boundary Monitoring Data - 1998

Station ID No.	Description	1st Qtr (mR)	2nd Qtr (mR)	3rd Qtr (mR)	4th Qtr (mR)	1998 (mR)
	Washington Aerial Measurements Operation					
WA-006	NEST Calib. Lab Door, Bldg 1794	16.5	12.8	15.4	--	44.6
WA-007	Work Area Wall, Bldg 1794	15.6	15.6	15.0	--	42.3
WA-020	Work Area Corridor Corn. Bldg 1792	14.4	11.0	12.3	--	37.8
WA-021	Deployment Bldg. Desk Area	17.7	37.8	25.4	--	80.9
WA-022	Background Avn Machine Shop	18.6	15.1	17.4	--	51.1
WA-023	Background Avn Machine Shop	18.9	14.8	17.7	--	51.5
WA-012	Control -1, RSO Office, Bldg. 1792	11.4	8.7	10.0	11.4	41.6
WA-012	Control -2, RSO Office, Bldg. 1792	11.7	9.3	10.0	11.7	42.7

-- Station terminated

Table 4.18 (BN Offsite Boundary Monitoring Data - 1998, cont.)

Station ID No.	Description	1st Qtr (mR)	2nd Qtr (mR)	3rd Qtr (mR)	4th Qtr (mR)	1998 (mR)
	North Las Vegas Facility					
LV-055	NW Corner Fence/Gate C6	22.6	18.4	20.9	--	61.9
LV-056	NW Corner Fence/Gate C6	22.2	18.9	20.9	--	62.4
LV-057	N Fence--West End A-12	18.5	15.2	15.3	--	49.0
LV-058	N Fence--West End A-12	18.8	14.9	15.6	--	49.2
LV-059	N Fence--West End A-4	19.1	15.2	16.5	--	50.7
LV-060	N Fence--West End A-4	19.4	14.3	15.9	--	49.6
LV-061	NE Corner Fence/A-12	17.0	14.3	14.1	--	45.4
LV-062	NE Corner Fence/A-12	17.6	14.3	14.1	--	46.0
LV-063	E Fence/Center A-Complex	17.6	14.3	15.0	--	46.9
LV-064	E Fence/Center A-Complex	17.6	14.3	15.6	--	47.5
LV-065	NLV Badge Off (A-7)/A-2	17.0	13.8	14.1	--	44.8
LV-066	NLV Badge Off (A-7)/A-2	16.4	13.2	13.5	--	43.1
LV-067	E Fence/North End B-Complex	17.9	14.3	15.3	--	47.5
LV-068	E Fence/North End B-Complex	19.0	14.6	15.0	--	48.6
LV-069	E Fence/South End B-Complex	18.8	14.6	15.6	--	49.0
LV-070	E Fence/South End B-Complex	18.5	15.5	15.6	--	49.5
LV-071	S Fence/Center	19.6	15.8	17.1	--	52.5
LV-072	S Fence/Center	19.4	15.2	16.5	--	51.0
LV-075	C-1 W End Guard Gate	22.3	18.0	19.1	--	59.5
LV-076	C-1 W End Guard Gate	21.8	18.9	19.1	--	59.8
LV-077	W Fence/Gate C-3	19.0	15.5	17.1	--	51.6
LV-078	W Fence/Gate C-3	19.6	17.5	16.5	--	53.6
LV-079	NW End A-13/Double G	Not Coll.	26.4	16.5	15.4	58.2
LV-080	NW End A-13/Double G	Not Coll.	26.6	17.1	15.7	59.4
LV-098	Control - 1	Lost	11.5	10.3	9.4	31.2
LV-099	Control - 2	Lost	11.2	10.9	9.7	31.7
	Special Technologies Laboratory					
ST141	Bldg. 227, Rear on Fence	23.2	Missing	21.9	21.0	66.0
ST199	Bldg. 229-C, Left Side	22.0	19.7	22.5	21.0	85.2
ST200	Bldg. 229-C, Left Side	21.7	19.7	23.0	21.0	85.5
ST209	Bldg. 227, Behind CF Shed	23.2	20.3	21.9	19.5	84.9
ST210	Bldg. 227, Behind CF Shed	21.4	19.7	21.0	18.6	80.8
ST-C1	Control 1	17.3	15.6	16.6	13.8	63.2
ST-C2	Control 2	18.2	15.2	15.4	13.8	62.6

-- Station terminated

5.0 WATER SURVEILLANCE ACTIVITIES

The Nevada Test Site (NTS) has a history of underground nuclear testing and continues to operate radioactive waste storage sites, environmental restoration sites, and a hazardous material testing facility. Groundwater surveillance is particularly important because of the potential for groundwater contamination from some of these activities and the scarcity of water supplies in this desert region. The water program includes a combination of effluent controls, groundwater protection, monitoring, restoration, and permit compliance. Groundwater quality monitoring is conducted both onsite and offsite by Bechtel Nevada (BN) and Environmental Protection Agency's (EPA's) Radiation & Indoor Environments National Laboratory-Las Vegas (R&IE-LV). In 1998, significant new results from in and near underground nuclear tests indicated the migration of plutonium up to 1.3 km. Groundwater quantity monitoring is conducted by the U.S. Geological Survey (USGS) and BN. No significant water level changes were detected associated with groundwater pumping, and water usage on the NTS continued to decline. The NTS water supply system continues to be free of any detectable man-made radionuclides.

The Nevada Environmental Restoration Project (ERP) goals are to safeguard the public's health and safety and to protect the environment. This involves the assessment and cleanup of contaminated sites and facilities to meet standards required by federal and state environmental laws. In 1996, DOE formalized an agreement with the state for implementing corrective actions based on public health and environmental considerations in a cost-effective and cooperative manner. Investigation and cleanup activities continued on the NTS and Nellis Air Force Range and at offsite locations in the state of Nevada and other states. Particular emphasis was directed at the Pahute Mesa, Frenchman Flat, and Oasis Valley areas.

DOE/NV instituted a Long-Term Hydrological Monitoring Program (LTHMP) in 1972 to be operated by the U.S. Environmental Protection Agency (EPA) under an Interagency Agreement. In 1998, groundwater was monitored on and around the NTS, at five sites in other states, and at two off-NTS locations in Nevada to detect any radioactivity that may be related to previous nuclear testing activities. Although tritium initially seeped from two of the offsite tests, the tritium levels in wells at both sites have been decreasing and were well below the National Primary Drinking Water Regulation levels.

5.1 WATER MONITORING PROGRAM INFORMATION

Water monitoring activities conducted in the past on the NTS and related facilities involve surveillance of surface and groundwaters, drinking water systems, sewage treatment ponds, and actions protective of groundwater resources. During 1998, the sampling of onsite surface waters (reservoirs and natural springs) was terminated in accordance with the "Routine Radiological Environmental Monitoring Plan", published in December 1998 (DOE 1998a). The past concentrations of radionuclides in the reservoirs have consistently been below the Derived Concentration Guides (DCGs), and the supply wells, the source of water for the reservoirs, are routinely sampled. Likewise, the radionuclide concentrations in past spring samples have also been consistently below the DCGs, and all of the onsite springs are not hydrologically connected to the aquifers that may have been radioactively contaminated by underground nuclear tests.

ONSITE ENVIRONMENTAL MONITORING CRITERIA

DOE Order 5400.1, "General Environmental Protection Program," establishes environmental protection program requirements, responsibilities, and authorities for DOE operations. These mandates require compliance with applicable federal, state, and local environmental protection regulations. Other DOE directives applicable to environmental monitoring include DOE Order 5480.11, "Radiation Protection for Occupational Workers"; DOE Order 5480.1B, "Environment, Safety, and Health Program for DOE Operations"; DOE Order 5484.1, "Environmental Protection, Safety and Health Protection Information Reporting Requirements"; 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."

WATER EFFLUENT MONITORING

Radiologically contaminated water continued to be discharged from E Tunnel in Rainier Mesa (Area 12) despite efforts to seal that tunnel. A grab sample was collected quarterly from the tunnel's effluent discharge point and from the tunnel's containment pond. These samples were analyzed for tritium (^{3}H), gross alpha, gross beta, ^{238}Pu, $^{239+240}Pu$, and gamma emitters. In addition, one of the quarterly samples was analyzed for ^{90}Sr and two quarterly samples were analyzed for ^{234}U, ^{235}U, and ^{238}U. Tritium was the radionuclide most consistently detected at the tunnel sites. Other radionuclides were detected at lower concentrations. Flow data obtained from the Defense Threat Reduction Agency (formerly the Defense Special Weapons Agency) were used to calculate the total volume discharged. Annual average radioactivity concentrations were calculated from the quarterly measurements. From these, the total amount of radioactivity in the effluent was obtained.

Water pumped from wells to obtain data for characterization of the NTS groundwater was discharged into containment ponds. In 1998, six wells were sampled. These wells were purged and the purge water placed in lined containment ponds. The total volume and tritium concentration of water in each pond were measured. No new wells were drilled or recompleted at the NTS during 1998.

WATER ENVIRONMENTAL MONITORING

Environmental monitoring was conducted onsite throughout the NTS and the near offsite area. Groundwater samples were routinely collected at preestablished locations and analyzed for radioactivity.

Water samples were collected from selected potable tap water points, water supply wells, sewage lagoons, and containment ponds. The frequency of collection and types of analyses done for these types of samples are shown in Table 5.2. Sampling locations are shown on Figures 5.1 and 5.2.

A 500-mL aliquot was taken from the water sample, placed in a plastic bottle, and counted for gamma activity with a germanium detector. A 2.5-mL aliquot was used for ^{3}H analysis by liquid scintillation counting. An 800-mL aliquot was evaporated to 15 mL, transferred to a stainless steel counting planchet, and evaporated to dryness after the addition of a wetting agent. Alpha and/or beta analyses were accomplished by counting the planchet samples for 100 minutes in a gas-flow proportional counter.

Tritium enrichment analyses were done on samples from the water supply wells by concentrating the volume and tritium content of a 250-mL sample aliquot to 10 mL by

Figure 5.1 Supply Well and Potable Water Sampling Stations on the NTS - 1998

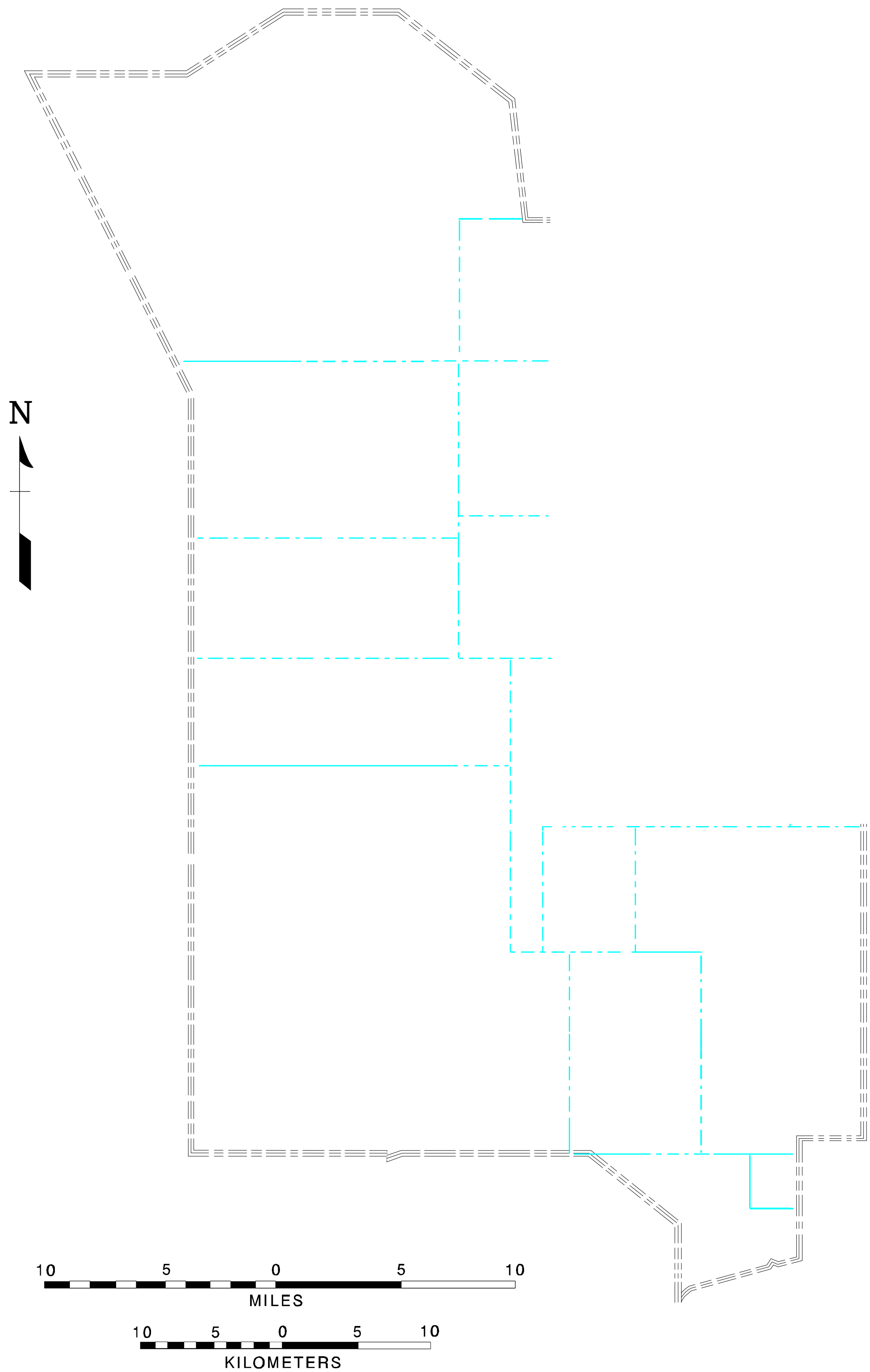


Figure 5.2 Surface Water Sampling Locations on the NTS - 1998

electrolysis of a basic solution and analyzing a 5-mL portion of the concentrate by liquid scintillation counting.

The ^{226,228}Ra concentrations were determined from low-background gamma spectrometric analyses of radium sulfate precipitates. The samples were prepared by adding a barium carrier and ^{225}Ra tracer to 800 mL of a sample, precipitating the barium and radium as a sulfate, separating the precipitate, and analyzing it by counting for 500 minutes in a low-level gamma spectroscopy facility.

The radiochemical procedure for plutonium was similar to that described in Section 4.1. Alpha spectroscopy was used to measure any ^{238}Pu, $^{239+240}$Pu, and the ^{242}Pu tracer present in the samples.

The present R&IE-LV sampling locations on the NTS, or immediately outside its borders on federally owned land are shown in Figure 5.3. All sampling locations are selected by DOE and primarily represent potable water supplies. R&IE-LV samples onsite wells without pumps and, for quality assurance purposes, collects samples from some potable wells sampled by Bechtel Nevada (BN). A total of 22 wells was sampled. All samples were analyzed by gamma spectrometry and for tritium.

5.2 LONG-TERM HYDROLOGICAL MONITORING PROGRAM (LTHMP)

The EPA's R&IE-LV is responsible for operation of the LTHMP, including sample collection, analysis, and data reporting. Until implementation of the LTHMP in 1972, monitoring of ground and surface waters was done by the U.S. Public Health Service (PHS), the USGS, and the U.S. Atomic Energy Commission (AEC) contractor organizations. The LTHMP consists of routine radiological monitoring, analysis, and reporting of samples collected from specific wells on the NTS and of wells, springs, and surface waters in the offsite area around the NTS. Samples are also collected from sites in Nevada, Colorado, New Mexico, Mississippi, and Alaska where nuclear tests have been conducted. In 1965, tritium escaped from the LONG SHOT test on Amchitka Island and contaminated the shallow groundwater, and during cleanup and disposal operations, shallow groundwater at the SALMON test site in Mississippi was contaminated with tritium. The tritium level in wells at both sites have been decreasing and were well below the National Primary Drinking Water limit.

Summaries of the 1998 sampling results for the onsite sampling program and for each of the offsite LTHMP locations are provided in Section 5.5.

SAMPLING AND ANALYSIS PROCEDURES

The procedures for the analysis of water samples, used herein, are described by Johns et al., 1979 and are summarized in Table 5.1. These include gamma spectral analysis and radiochemical analysis for tritium. The procedures are based on a standard methodology for the stated analytical procedures. Two methods for tritium analysis were performed; these were conventional and electrolytic enrichment. The samples were initially analyzed for tritium by the conventional method followed by enrichment analysis if the results were less than 800 pCi/L (30 Bq/L). In late 1995, it was decided that only 25 percent of the samples would be analyzed by the electrolytic enrichment method. The samples selected have a tritium result of less than 800 pCi/L by the conventional method and are from locations that are in position to show possible migration. Two 250-mL glass bottles and a 1-gal plastic container are filled at each sampling location. At the sample collection sites, the pH, conductivity, water temperature, and sampling depth are measured and recorded when the sample is collected. For wells with

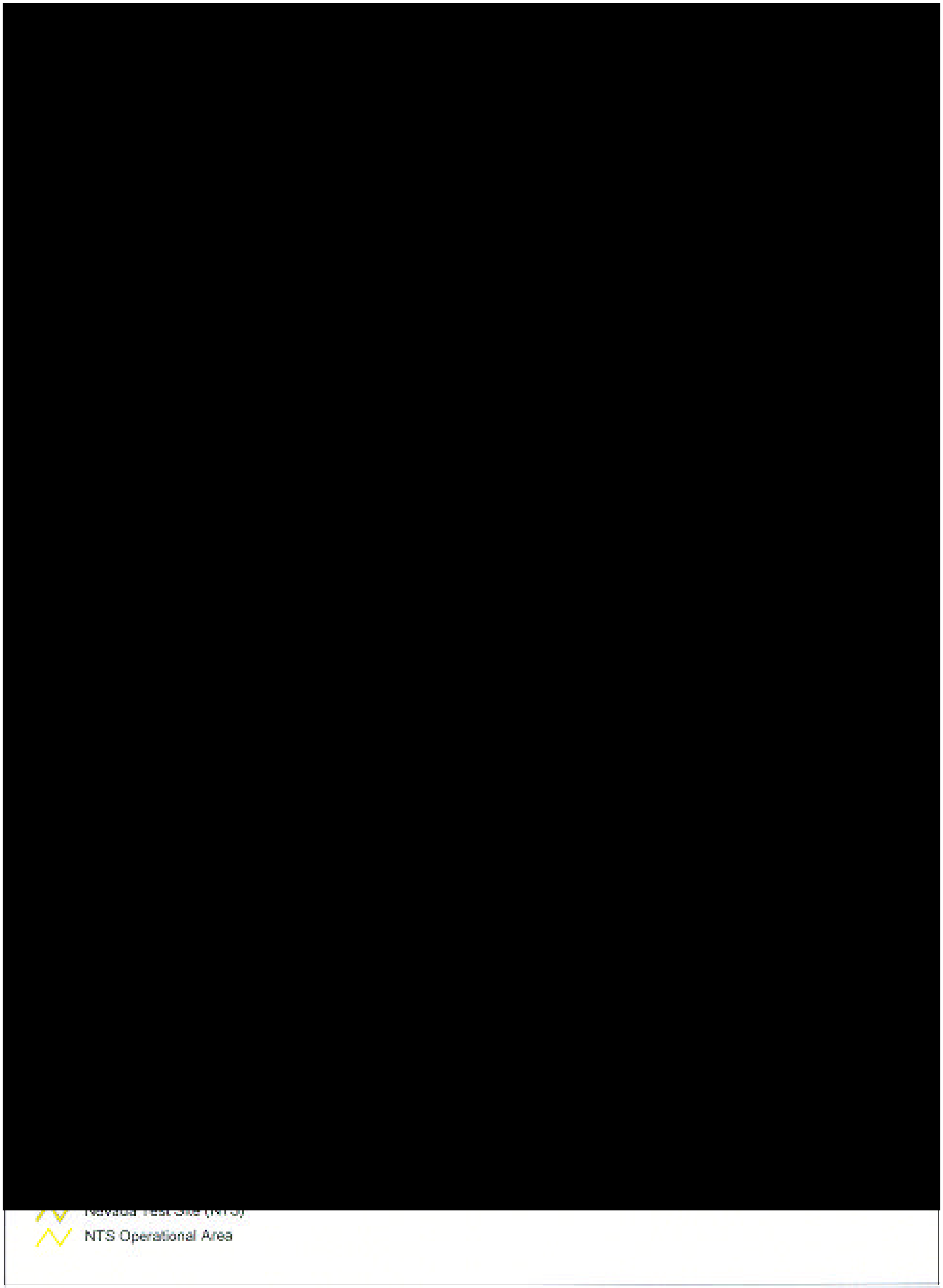


Figure 5.3 Wells on the NTS Sampled by R&IE-LV - 1998

operating pumps, the samples were collected at the nearest convenient outlet. If the well has no pump, a truck-mounted sampling unit is used. With this unit, it is possible to collect 3-L samples from wells as deep as 1,800 m (5,900 ft).

The first time samples are collected from a well, $^{89,90}Sr$, ^{238}Pu, $^{239+240}Pu$, and uranium isotopes are determined by radiochemical analysis, in addition to analyses mentioned above. The 250-mL samples are analyzed for tritium and the 1-gal sample from each site is analyzed by gamma spectrometry.

GROUNDWATER NEAR THE NEVADA TEST SITE

Water sampling around the NTS is conducted by R&IE-LV under an interagency agreement with DOE to ensure the radiological safety of public drinking water supplies, and representative water sources of rural residents and, where suitable, to monitor any migration of radionuclides from the NTS. This water monitoring is conducted within the LTHMP. R&IE-LV personnel routinely collect and analyze water samples from locations in the offsite areas surrounding the NTS. Due to the scarcity of surface waters in the region, most of the samples are groundwater, collected from existing wells. Samples from specific locations are collected monthly, biannually, annually, or biennially in accordance with a preset schedule. Many drinking water supplies used by the offsite population are represented in the LTHMP samples. Figure 5.4 is a map of the locations sampled.

GROUNDWATER AT OTHER TEST AREAS

Sampling for the LTHMP is also conducted at sites of past nuclear device testing in other parts of the United States to ensure the radiological safety of public drinking water supplies and, where suitable sampling points are available, to monitor any migration of radionuclides from the test cavity. Annual sampling of surface waters and groundwaters is conducted at the Projects SHOAL and FAULTLESS sites in Nevada, the Projects GASBUGGY and GNOME sites in New Mexico, the Projects RULISON and RIO BLANCO sites in Colorado, and the SALMON site in Mississippi. Sampling is normally conducted in odd numbered years on Amchitka Island, Alaska, at the site of Projects CANNIKIN, LONG SHOT, and MILROW.

5.3 GROUNDWATER PROTECTION PROGRAM

HYDROGEOLOGY OF THE NTS

The NTS has three general water-bearing units: the lower carbonate aquifer, volcanic aquifers, and valley-fill aquifers. The water table occurs variably in the latter two units, while groundwater in the lower carbonate aquifer occurs under confined conditions. The depth to the saturated zone is highly variable, but is generally at least 210 m (approximately 690 ft) below the land surface and is often more than 300 m (approximately 1,000 ft). The hydrogeologic units at the NTS occur in three groundwater subbasins in the Death Valley Groundwater Basin (see Chapter 2, Figure 2.7, for a diagram of these systems). The actual subbasin boundaries are poorly defined, but what is known about the basin hydrology is summarized below.

Groundwater beneath the eastern part of the NTS is in the Ash Meadows Subbasin and discharges along a spring line in Ash Meadows, south of the NTS. Most of the western NTS is in the Alkali Flat-Furnace Creek Subbasin, with discharges occurring by evapotranspiration at Alkali Flat and by spring flow near Furnace Creek Ranch.

Groundwater beneath the far northwestern corner of the NTS may be in the Oasis Valley Subbasin, which discharges by evapotranspiration in Oasis Valley. Some underflow from the subbasin discharge areas probably travels to springs in Death Valley. Regional groundwater flow is from the upland recharge areas in the north and

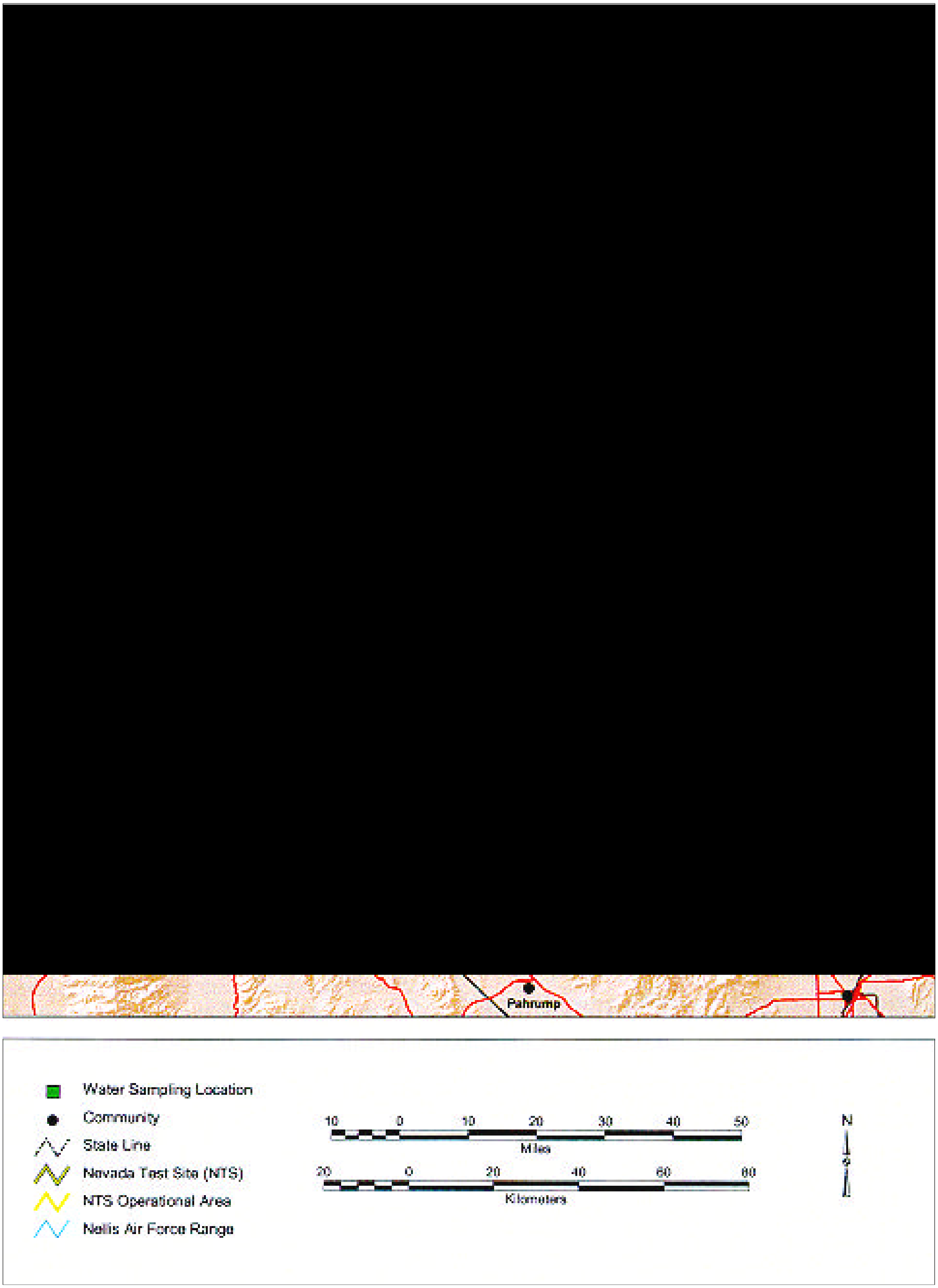


Figure 5.4 Wells and Springs Outside the NTS Included in the LTHMP - 1998

east toward discharge areas in Ash Meadows and Death Valley, southwest of the NTS. Because of large topographic changes across the area and the importance of fractures to groundwater flow, local flow directions may be radically different from the regional trend (Laczniak et al., 1996).

HYDROGEOLOGY OF NON-NTS UNDERGROUND TEST SITES

The following descriptions of the hydrogeology of non-NTS underground test sites are summarized from Chapman and Hokett, 1991.

FALLON, NEVADA

The Project SHOAL site is located in the granitic uplift of the Sand Spring Range. The highland area around the site is a regional groundwater recharge area, with regional discharge occurring to the west in Fourmile Flat and Eightmile Flat and to the northeast in Dixie Valley. Evidence suggests that a groundwater divide exists northwest of the site and that the main component of lateral movement of groundwater near the site is southeast toward Fairview Valley. Groundwater in Fairview Valley moves north to the discharge areas in Dixie Valley. Groundwater in Fairview Valley occurs in three separate alluvial aquifers separated by clay aquitards. Ground-water flow velocities through the granite to the alluvial aquifers of Fairview Valley are calculated to be very low (Chapman and Hokett 1991).

CENTRAL NEVADA TEST AREA

The Project FAULTLESS site is located in a thick sequence of alluvial material underlain by volcanic rocks in the northern portion of Hot Creek Valley. Recharge to the alluvial aquifer and volcanic aquifer occurs in the higher mountain ranges to the west, with groundwater flowing toward the east-central portion of the valley, and discharging by evapotranspiration and underflow to Railroad Valley.

AMCHITKA ISLAND, ALASKA

The groundwater system of Amchitka Island is typical of an island-arc chain with a freshwater lens floating on seawater in fractured volcanic rocks. Active freshwater circulation occurs by precipitation, recharging the water table with a curving flow path downward in the interior of the island and upward flow near the coast. Generally, the hydraulic gradient is from the axis of the island toward the coast. Groundwater travel times have been estimated to be between 23 and 103 years from the test cavities to the Bering Sea.

RIFLE, COLORADO

Project RIO BLANCO is located in the Fort Union and Mesa Verde sandstones in the Piceance Creek Basin. Three aquifers comprise most of the groundwater resources: a shallow alluvial aquifer, the upper "A" potable aquifer, and the lower "B" saline aquifer. The "A" and "B" aquifers are separated by the Mahogany Oil Shale aquitard. These aquifers lie well above the test depth. The alluvial aquifer is the primary source of groundwater in the area with flow to the northeast toward the Piceance Creek. Recharge to the alluvial aquifer occurs by downward infiltration of precipitation and surface water and by upward leakage from underlying aquifers.

The "A" aquifer is larger in areal extent than the overlying alluvial aquifer with the permeability in the "A" aquifer controlled by a vertical fracture system. The "B" aquifer exhibits minimal communication with the "A" aquifer.

GRAND VALLEY, COLORADO

Project RULISON is located in the Mesa Verde Sandstone, which is overlain by alluvium, the Green River Formation (shale and marlstone), the Wasatch Formation (clay and shale), and the Ohio Creek Formation (conglomerate). The direction of groundwater flow is thought to be northward.

The principal groundwater resources of the area are in the alluvial aquifer, which is separated from the test horizon by great thicknesses of low-permeability formations. Pressure tests of deep water-bearing zones indicated very little mobile water.

HATTIESBURG, MISSISSIPPI

Project DRIBBLE and the Miracle Play Program were conducted in a salt dome (known as the SALMON Site) near this town. The salt dome interrupts and deforms the lower units of coastal marine deposits in the area, has low permeability, and allows little water movement. Seven hydrologic units are recognized in the area, exclusive of the salt dome and its anhydrite caprock. These are, from the surface downward, the Surficial Aquifer, the Local Aquifer, and Aquifers 1, 2, 3, 4, and 5. These aquifers consist of sands and gravels, sandstones, shales, and limestones with low-permeability clay beds acting as aquitards. The natural flow has been disrupted by pumping from the upper aquifers and by injection of oil-field brines into Aquifer 5. The transient conditions and lack of data results in uncertainties in groundwater flow directions.

FARMINGTON, NEW MEXICO

Project GASBUGGY is located on the eastern side of the San Juan Basin. The direction of groundwater movement is not well known, but is thought to be to the northwest in the Ojo Alamo sandstone toward the San Juan River. The test was conducted in the underlying Pictured Cliffs sandstone and Lewis Shale, which are not known to yield substantial amounts of water. The rate of groundwater movement in the Ojo Alamo sandstone is estimated to be approximately 0.01 m/yr.

CARLSBAD, NEW MEXICO

The Project GNOME site is located in the northern part of the Delaware Basin, which contains sedimentary rocks and a thick sequence of evaporites. The test was conducted in the halites of the Salado Formation, which is overlain by the Rustler Formation, the Dewey Lake Redbeds, and alluvial deposits. The Rustler Formation contains three water-bearing zones: a dissolution residue at its base, the Culebra Dolomite, and the Magenta Dolomite. The Culebra Dolomite is the most regionally extensive aquifer in the area. The groundwater in the Culebra is saline, but is suitable for domestic and stock uses. Groundwater in the Culebra flows to the west and southwest toward the Pecos River.

NTS AREAS OF POSSIBLE GROUNDWATER CONTAMINATION

In 1996, DOE/NV confirmed the location of 828 underground tests at the NTS that are included in areas of possible groundwater contamination as indicated on Figure 5.5. Approximately one third (259) of these tests were at or below the water table (DOE 1996b). The principal by-products from these tests were heavy metals and a wide variety of radionuclides with differing half-lives and decay products. Detonations within, or near, the regional water table have contaminated the local groundwater with over 60 radionuclides being present in significant quantities. Tritium is the most abundant radionuclide, with an estimated 300 million curies present in or near the water table (DOE 1996c).

Surface activities associated with underground testing and other NTS activities such as disposal of low-level radioactive waste (LLW) and mixed wastes, spill testing of hazardous liquefied gaseous fuels, and transport of radioactive materials, also pose potential soil and groundwater contamination risks. The types of possible contaminants found on the surface of the NTS include radionuclides, organic compounds, metals, and residues from plastics, epoxy, and drilling muds. A wide variety of surface facilities, such as former injection wells, leach fields, sumps, waste storage facilities, tunnel containment ponds and muck piles, and storage tanks, may have contaminated

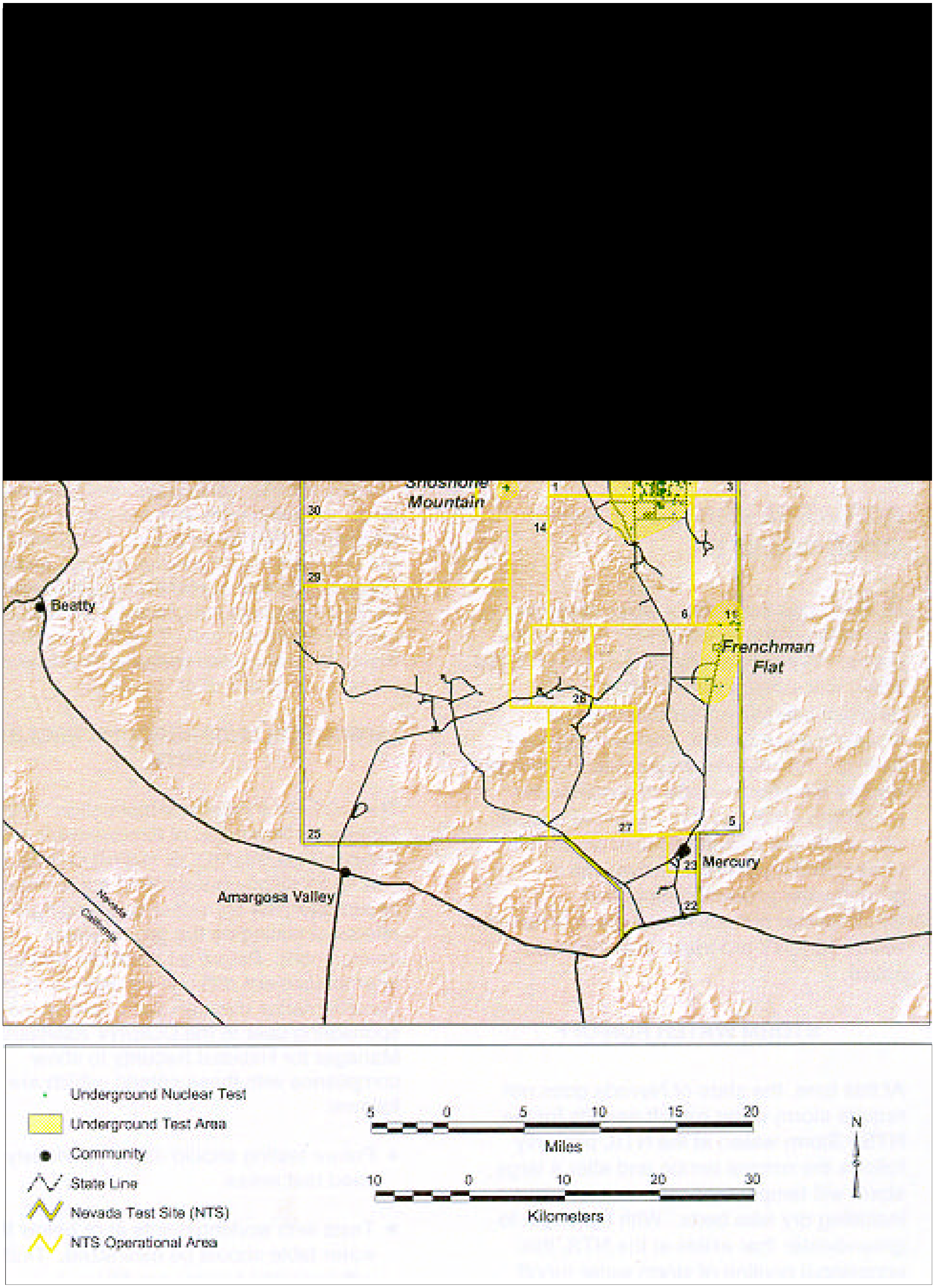


Figure 5.5 Areas of Potential Groundwater Contamination on the NTS

the soil and shallow unsaturated zone of the NTS. The known sites are categorized by type and listed in Appendices II, III, and IV of the Federal Facility Agreement and Consent Order (FFACO 1996), agreed to by DOE, U. S. Department of Defense, and Nevada Division of Environmental Protection (NDEP). The great depths to groundwater and the arid climate mitigate the potential for mobilization of surface and shallow subsurface contamination. However, contaminants entering the carbonate bedrock from Rainier Mesa tunnel ponds, contaminated wastes injected into deep wells, underground tests near the water table, and wastes disposed of into subsidence craters have the potential to reach groundwater.

ACTIVITIES PROTECTIVE OF GROUNDWATER

DOE/NV has instituted a policy regarding protection of the environment. This policy states: "A principal objective of the DOE/NV policy is to assure the minimization of potential impacts on the environment, including groundwater, from underground testing." An ongoing program to monitor and assess the effectiveness of groundwater protection efforts will be enhanced so that resources are allocated based on current understanding of the effectiveness of groundwater protection programs. Groundwater protection activities contained within DOE/NV programs are described below.

STORM WATER RUN-OFF

At this time, the state of Nevada does not require storm water run-off permits for the NTS. Storm water, at the NTS, primarily follows the natural terrain and after a large storm will temporarily collect on low spots, including dry lake beds. With the depth to groundwater that exists at the NTS, this occasional pooling of storm water runoff presents no hazard to groundwater.

WASTE MINIMIZATION AND POLLUTION PREVENTION AWARENESS PROGRAM

The Waste Minimization and Pollution Prevention Awareness Program is designed to reduce waste generation and possible pollutant releases to the environment, thus increasing the protection of employees and the public. All DOE/NV contractors and NTS users who exceed the EPA criteria for small-quantity generators have established implementation plans in accordance with DOE/NV requirements. Contractor programs ensure that waste minimization activities are in accordance with federal, state, and local environmental laws and regulations and DOE Orders. A discussion of 1998 activities is given in Chapter 6.

There are three closed-loop recirculating steam cleaning units that are used to clean equipment prior to servicing. These units not only minimize the water that is needed to operate, but also prevent the wastewater from running onto the ground and potentially contaminating the soil. These hydrocarbon materials are instead captured in a filter and properly disposed of or recycled.

SITING FOR UNDERGROUND NUCLEAR TESTS

The DOE/NV Procedural Instruction “Siting Criteria for Protection of Groundwater at the Nevada Test Site” (DOE 1997d) defines five criteria for siting underground nuclear tests, based upon the current understanding of the effects of testing on the groundwater environment. Before an emplacement hole or emplacement drift can be used for a test, documentation must be submitted by the sponsoring user to the DOE/NV Assistant Manager for National Security to show compliance with these criteria, which are as follows:

- Future testing should utilize previously used test areas.

- Tests with working points at or below the water table should be minimized. Testing within perched water conditions is excluded from this criterion.

- Working points should be placed no closer than two cavity radii from any regional carbonate aquifer.

- Emplacement holes should not be sited within 1,500 m of the NTS boundary where groundwater leaves the NTS.

- Emplacement holes, which extend more than two cavity radii or 30 m, whichever is greater, beneath the working point, should be plugged to prevent the open borehole from becoming a preferential pathway for groundwater contamination.

WASTE TREATMENT, STORAGE, AND DISPOSAL

DOE/NV currently operates disposal facilities in Areas 3 and 5 at the NTS for LLW generated by DOE and the DOD facilities. All hazardous wastes generated at the NTS are stored at a Hazardous Waste Accumulation Site in Area 5 until shipped offsite to EPA-approved commercial disposal facilities.

Since both the RWMS-3 and RWMS-5 disposal sites contain mixed as well as LLW waste, they are subject to Hazardous Waste regulations dictated by RCRA. In accordance with Title 40 Code of Federal Regulations (CFR) 265 - Subpart F (CFR 1984), operators of interim status treatment, storage, and disposal facilities for hazardous waste are required to collect quarterly samples for one year from one upgradient and three downgradient wells for characterization of groundwater quality. However, the lack of a hydraulic gradient in the uppermost aquifer makes it difficult to define upgradient and downgradient directions around RWMS-5. There are three groundwater monitoring wells surrounding the RWMS-5. In a letter from NDEP to DOE/NV, dated February 24, 1994, NDEP stated that there was no need to install additional wells pending future data on the groundwater gradient, thereby effectively substituting the three pilot wells for the standard four RCRA wells. At the RWMS-3, there are currently no groundwater monitoring wells, and it is likely none will be required pending approval of a groundwater monitoring waiver. At RWMS-5, sampling protocols for characterization and detection data collection were based on the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (EPA 1986). Groundwater elevation was measured prior to each sampling event. The first collections of these characterization data were performed in 1993. Subsequent semi-annual sampling was continued through 1998, and results were statistically compared with the initial characterization data. No chemical or radiological constituents attributable to the DOE's weapons testing or waste disposal activities have been detected. The uppermost aquifer meets current water quality standards for drinking water sources. The analyses performed are shown in Table 5.3. Groundwater monitoring results for 1998 can be found in the "1998 Annual Groundwater Monitoring Data Report" (BN 1999).

At the NTS there are three nonhazardous waste landfills that have state of Nevada Operating Permits. The permitting process considers groundwater protection at these locations. At the Area 23 Class II Municipal and Industrial Solid Waste Disposal Site, there is no groundwater monitoring well. However, Well SM-23-1 described below is considered (informally) by the state as a supplement to vadose monitoring at the landfill.

VADOSE ZONE MONITORING

A vadose zone monitoring strategy is being implemented at the RWMSs in conjunction with groundwater monitoring at RWMS-5, in support of the RWMS-5 and RWMS-3 Performance Assessments (PAs), and as proof of concept. Vadose zone monitoring (VZM) offers many advantages over groundwater monitoring including:

- providing critical assessment of facility performance.

- detecting potential problems long before the groundwater resource would be impacted.

- allowing corrective actions to be made early.
- differentiating the source of contamination (UGTA versus RWMS).
- eliminating the need to retrofit monitoring on existing waste cells using near by sites.
- considerably less expensive than groundwater monitoring.

The primary objective of RWMS VZM is to support the assumptions made in the PAs and to measure water movement through the vadose zone. In addition, DOE Orders 5820.2A (DOE 1988) and 435.1 (435.1 will replace 5820.2A) require that monitoring provide data to evaluate the performance of a waste management operation.

The RWMS VZM strategy is to directly measure the water balance for an entire facility. This is accomplished by use of meteorological data to measure precipitation and to calculate potential evapotranspiration (ET); weighing lysimeters to measure actual ET; neutron logging through access tubes; and automated soil water sensors to measure actual soil water content and water potential changes with time and over a large spatial coverage. This strategy provides an accurate estimate of downward drainage through the facilities and therefore, potential recharge. Based on the initial results of this strategy, as well as other work (Tyler et al., 1996), there is essentially zero recharge to the groundwater under current conditions at the RWMS-3 and RWMS-5, and all precipitation is effectively returned to the atmosphere by plant transpiration and soil evaporation.

Soil water content is monitored at Pits 1 through 4 at RWMS-5 and is monitored under the U-3ah/at, U-3ax/bl, and U-3bh disposal units at RWMS-3. Water content is monitored every other month at these locations to detect the downward movement of wetting fronts from precipitation. At the RWMS-5, monitoring is conducted using neutron moisture meters in access tubes penetrating the operational cover (approximately 8 ft), the waste zone (20 - 30 ft), and the vadose zone below the pit floor. No wetting fronts were observed to pass through the operational covers at the RWMS-5 in 1998. At the RWMS-3, soil water content monitoring is conducted in cased boreholes angled under the U-3ah/at and U-3ax/bl disposal units, and in cased boreholes drilled directly into the floor of the U-3bh disposal unit. Soil water content below the RWMS-3 remained unchanged in 1998.

Installation of automated vadose zone monitoring systems was initiated in 1998 with water content sensors (Total Domain Reflectometry Probes) buried beneath the floors of Pit 3 and 5 at the RWMS-5. Sensors for measurement of water content and water potential will be installed in the operational cover of Pit 3 in 1999 to provide data on waste cell cover performance.

WELLHEAD RECONSTRUCTION AND WELL REHABILITATION

The Hydrologic Resources Management Program (HRMP) began an active borehole surface rehabilitation program in 1997. The rehabilitation of 11 boreholes was completed in 1998. Rehabilitation activities include either the extension or shortening of the well's casing to approximately one-half meter aboveground level. Locking caps are installed on each well along with the hole designation inscribed on the outside of the casing extension using a weld bead and the painting of casings for easy identification. Many of the holes identified for rehabilitation are either included in monitoring programs such as the Routine Radiological Environmental Monitoring Plan (RREMP) or are suitably located for potential utilization in the monitoring networks. Video logging will be used to determine the integrity of the hole and accessability to the water table.

All of the wells associated with the state permitted drinking water distribution systems at the NTS have been inspected by the state and meet current wellhead protection regulations.

SEWAGE LAGOON COMPLIANCE

State Water Pollution Control Permit GNEV93001 requires that one of four methods of groundwater protection be established at active sewage lagoons on the NTS by January 31, 1999. The four acceptable groundwater protection methods identified in the permit include groundwater monitoring, VZM, engineered liner installation, and hydrogeological site characterization.

Over the past four years, groundwater protection permit compliance has been attained at all but three of the NTS facilities. During 1998, groundwater protection permit compliance was attained at these three remaining facilities: (1) the Area 6 Device Assembly Facility, (2) the Area 25 Reactor Control Pond, and (3) the Area 25 Central Support Facility.

Initial groundwater sampling at the Area 23 Infiltration Basin Groundwater Monitoring Well SM-23-1 was performed in August 1997, and compliance monitoring began in 1998. Results indicate that the groundwater adjacent to and beneath the infiltration basin meets drinking water standards. Information on improvements to the monitoring well is contained in Chapter 3.

5.4 ENVIRONMENTAL RESTORATION PROGRAM (ERP)

The Nevada ERP was begun in the late 1980s to address contamination resulting primarily from nuclear weapons testing and related support operations. The goals of the project are to safeguard the public's health and safety and to protect the environment. This involves the assessment and cleanup of contaminated sites and facilities to meet standards required by federal and state environmental laws. Approximately 878 sites used for historic underground nuclear tests will be investigated, along with areas where more than 100 aboveground tests were conducted. Additionally, 1,500 other sites that were used for support operations will potentially require environmental remediation.

The DOE/NV is working closely with representatives of the state of Nevada to ensure compliance with applicable environmental regulations. The 1996 FFACO provides a mechanism for implementing corrective actions based on public health and environmental considerations in a cost-effective and cooperative manner. It also establishes a framework for identifying, prioritizing, investigating, remediating, and monitoring contaminated DOE sites in Nevada. The FFACO's corrective action requirements supersede some portions of the NTS RCRA Permit issued in May 1995. Investigations and remediations follow a strategy for investigation and remediation outlined in Appendix VI, Corrective Action Strategy, of the FFACO. The strategy is based on four steps: (1) identifying corrective action sites, (2) grouping the sites into corrective action units, (3) prioritizing the units for funding and work, and (4) implementing investigations or actions as applicable. The sites are broadly organized into underground test area sites, industrial sites, soil sites, and off sites. Information related to investigation and cleanup activities as it relates to groundwater protection follows.

UNDERGROUND TEST AREA (UGTA) SITES

The 1998 UGTA subproject field activities focused on well development, testing, and sampling wells near underground nuclear tests. Some of this work was also supported by the HRMP. These activities were conducted in order to determine radiochemical and hydrogeologic conditions near tests in support of modeling at the scale of Corrective Action Units. Contaminated fluid produced during sampling was managed in accordance with the UGTA Waste Management Plan (DOE 1996d) to prevent degradation of groundwater. Evaporation of tritiated water from the sampling operations is included in the calculations for compliance with the National Emissions Standard for Hazardous Air Pollutants.

Accomplishments of the UGTA project in 1998 include the sampling of four near-event wells and two post-shot/cavity wells on Pahute Mesa. The near-event wells were at the TYBO (ER-20-5 #1 and #3) and the

BULLION (ER-20-6 #1 and #3) underground nuclear tests. The two cavity wells were at the CHESHIRE (U-20n PS1ddh) and CAMEMBERT (U-19q PS1A) tests. In general, results show expected levels of contamination in the post shot and near-event wells on Pahute Mesa. Other activities included support/contributions, along with other agencies and projects, to various studies. These activities are summarized below. Results are scheduled for publication in 1999.

POST-SHOT WELLS ("HOT WELLS")

A multi-agency team consisting of personnel from the United States Geological Survey (USGS), Los Alamos National Laboratory (LANL) and Lawrence Livermore National Laboratory (LLNL) collected fluid samples via bailing techniques from two wells completed in and near expended test cavities. Fluid samples were successfully collected from wells associated with the ALMENDRO (U-19v PS1ds) and ALEMAN (UE-3e#4 piezometer cluster) tests. Samples were collected at slant depths of 1091.2 m, 658.4 m, and 573.0 m (3580', 2160', and 1880') from U-19v PS1ds, UE-3e#4 P1, and UE-3e#4 P2, respectively. During sample collection, field parameters including temperature, pH, and conductivity were measured. Samples were then analyzed for major cations and anions, trace metals, ^{3}H, ^{13}C, ^{14}C, ^{90}Sr, γ-emitting radionuclides, Pu, and colloids. For results describing the discovery of colloidal transport of plutonium over 1.3 km from the working point of a device, see Kersting et al., 1999. For other analytical results associated with ALMENDRO and ALEMAN sampling, see Smith et al., 1999.

Samples collected from the lower zone of U20-n PS#1ddh present a unique opportunity to analyze cavity fluids and represent the first cavity fluid samples collected in 14 years. U-20n PS#1ddh was drilled to support studies of radionuclide migration from the cavity/chimney region of the CHESHIRE underground test that was conducted on Pahute Mesa in February of 1976. Radionuclide migration studies at this site have been intermittent since 1976.

Samples were analyzed at LLNL for major cations and anions, hydrogen and oxygen isotopes, ^{13}C, ^{14}C, ^{36}Cl, $^{87/86}Sr$, $^{234/238}U$, noble gases, and Pu. For each of these wells, analytical letters of accomplishment were prepared.

Personnel of BN successfully pumped and sampled cavity fluids from well U-4uPS#2A (DALHART post-shot well drilled into the cavity in 1990) using tandem in-line Bennett pumps. This new method of sample collection may facilitate the collection of representative cavity fluid samples. The DALHART test was fired on October 13, 1988, in central Yucca Flat.

Samples collected at U-4uPS#2A in 1998 were analyzed at LLNL and LANL for major cation and anions, trace metals, γ-emitting radionuclides, and plutonium. For results, see Smith et al., 1999.

NEAR-TEST STUDIES

Near-test wells that were sampled in 1998 include ER-20-5 #1 and #3, ER-20-6 #1 and #3. Samples were analyzed at LLNL and LANL for major cations and anions, hydrogen and oxygen isotopes, ^{13}C, ^{14}C, ^{36}Cl, $^{87/86}Sr$, $^{234/238}U$, noble gases, and Pu. Analytical letters of accomplishment were prepared for each of these wells.

From 1995 to early 1996, the UGTA subproject drilled two holes, ER-20-5 #1 and #3, adjacent to the site of the underground nuclear test, code named TYBO (DOE 1997c). Water samples from these wells were analyzed at LANL and LLNL and were found to contain radionuclides not often measured in similar sites (LANL 1998).

The purpose of drilling at Well Cluster ER-20-5 was to characterize the nature and extent of radionuclide migration adjacent to a relatively large yield test conducted below the water table. The TYBO test was conducted on Pahute Mesa on May 14, 1975, at a depth of 765 m (2,509 ft), which is below the static water level of 630 m (2,066 ft). Well ER-20-5 #1 was completed and screened in a transmissive aquifer at a depth comparable to the working point of the TYBO test.

Well ER-20-5 #3 was completed and screened in a deeper transmissive aquifer at a depth comparable to the working point of the 1968 BENHAM test, located 1,300 m (4,265 ft) to the north (DOE 1997c). The BENHAM test was fired on December 19, 1968, at a depth of 1,402 m (4,599 ft), which is below the static water table of 641 m (2,102 ft). Both ER-20-5 #1 and #3 were believed to be sited hydrologically downgradient of the TYBO test.

Radionuclides detected include ^{137}Cs, ^{60}Co, ^{152,154,155}Eu, and $^{239+240}$Pu. Except for tritium, the activity levels measured in the ER-20-5 groundwater are below the drinking water limits calculated by EPA standards. Groundwater samples collected in April 1997 at ER-20-5 #1 had a tritium activity of 6.89×10^7 pCi/L (2.55 MBq/L) and 1.42×10^5 pCi/L (5.3 kBq/L) at ER-20-5 #3. Prefiltering of the water samples indicates that, except for tritium, the radionuclides are associated with particulates and colloids. Furthermore, isotopic ratios for $^{239+240}$Pu are relative to the BENHAM test 1,300 m (4,265 ft) to the north, and not to the closer TYBO test, as expected (Thompson et al., 1997).

The BULLION Forced-Gradient Experiment was conducted from June 2 to August 28, 1997, at Well Cluster ER-20-6 on Pahute Mesa in the northwestern corner of the NTS. This well cluster consists of three wells: a production well (ER-20-6 #3) and two injection/sampling wells located 88.7 m (ER-20-6 #2) and 130.1 m (ER-20-6 #1) from the production well. The wells are aligned approximately with the local groundwater gradient and the major fracture system, a short distance downgradient from the BULLION test. In 1998, Well #3 was pumped to sustain a groundwater gradient towards this well.

Radionuclides in water samples were variously analyzed by International Technology, LLNL, Desert Research Institute (DRI), and LANL. Additional information and analytical results for 1998 studies will be reported by the respective organizations during 1999.

DOE continued efforts to create a long-term monitoring program for wells in or near underground nuclear test cavities. The program objectives are to characterize the hydrologic source term and evaluate the decay and potential migration of radionuclides through monitoring at or near the source. LANL and LLNL monitored water at the TYBO (ER-20-5), BULLION (ER-20-6), and ALMENDRO (U-19v PS1ds) tests on Pahute Mesa and the DALHART (U-4u PS2A) and ALEMAN (UE-3e#4) tests in Yucca Flat (Smith et al., 1999). A LANL summary will also be released in 1999.

In addition to radionuclides more commonly found in cavity fluids, the presence of low-levels of plutonium (0.22 pCi/L at collection time) were confirmed in well ER-20-5#3. Results from this sampling event will be included in the LLNL Hot Well Database, which compiles new and historical radiochemical data from cavity and near cavity wells on the NTS. LLNL continues to investigate the occurrence, distribution, and potential mobility of radionuclides in the sub-surface through investigation of archival post-shot debris. Static leaching experiments of glass and crystalline samples were continued to elucidate controls on the solubility of radionuclides.

INDUSTRIAL SITES AND DECONTAMINATION AND DECOMMISSIONING

The Area 6 Decontamination Pond RCRA Closure Unit characterization was completed in 1998. Additional geotechnical sampling and testing were completed for the Corrective Measures Study. Design and field testing for the engineered cover were completed in 1998. Closure activities were also completed in 1998.

An annual report was submitted to comply with the conditions of the RCRA Part B Permit for the Area 2 Bitcutter Shop and LLNL Post-Shot Containment Building Injection Wells RCRA Closure Unit that were closed in 1996. These facilities and other NTS facilities with RCRA closure plans are listed in Table 5.4.

ABANDONED UNDERGROUND STORAGE TANKS

The NTS underground storage tank (UST) program continues to meet regulatory compliance schedules. Details of this program are discussed in Chapter 3.

OFFSITE LOCATIONS

The offsite areas are described in Section 5.2 of this chapter. Activities related to groundwater protection at these sites are conducted as part of the ERP. Investigation and cleanup at these sites are being conducted in accordance with the FFACO, with the state of Nevada, for the two sites in Nevada, SHOAL and FAULTLESS. In the remainder of the states, agreements will be developed as the restoration activities proceed. Following is a summary of activities at sites where activities were conducted during 1998.

Routine sampling and analysis of groundwater was conducted at the following offsite project locations: FAULTLESS, SHOAL, RULISON, RIO BLANCO, GNOME, GASBUGGY, and DRIBBLE. Additional work at the Project DRIBBLE site included the addition of 14 shallow wells to the annual sampling program; increasing the total wells sampled onsite to 55. Results of the 1998 sampling and analysis efforts are discussed in Section 5.5.

5.5 WATER SURVEILLANCE PROGRAM RESULTS

The analytical results obtained for water samples collected onsite and offsite are described in this Section. Only a few samples contained detectable concentrations of radionuclides. Table 5.5 lists the routine sampling locations, onsite and offsite, where well water samples contained concentrations greater than 0.2 percent of the National Primary Drinking Water Standards.

ONSITE WATER MONITORING RESULTS

RADIOACTIVITY IN SURFACE WATER

Surface water sampling at the NTS was conducted at six containment ponds, one tunnel effluent, and nine sewage lagoons. The locations of these sources are shown in Figure 5.2. When water was available and the weather permitted, a grab sample was taken and analyzed in accordance with Table 5.2.

The annual average for each radionuclide analyzed in surface waters is presented in Table 5.6, along with the results from analysis of tunnel effluents. The results from gamma spectrometry were non-detectable for all sample locations, except for samples from the E Tunnel effluent and pond.

With the exception of containment ponds, no annual average concentration in surface waters was found to be statistically different from any other at the 5 percent significance level.

RESERVOIRS AND SPRINGS

These surface waters (water well reservoirs and natural springs) were eliminated from the environmental monitoring program in accordance with the RREMP that was developed in 1998.

CONTAINMENT PONDS

Due to the sealing of the tunnels at the close of 1993, liquid effluents ceased at all except E Tunnel. The E Tunnel containment ponds were fenced and posted with radiological warning signs. During each sampling, a grab sample was taken from the E Tunnel containment pond and at the effluent discharge point. The samples were analyzed for ^{3}H, ^{90}Sr, ^{238}Pu, $^{239+240}$Pu, gross alpha, gross beta, and gamma activity in accordance with the schedule in Table 5.2. The annual averages of these analyses from the two sampling locations are listed in Table 5.6. Also detectable were $^{234, 235, 238}$U.

The effluent from characterization wells in Areas 4, 19, and 20 was discharged into containment ponds. The total liquid discharged was measured. By multiplying that volume by the average concentration of ^{3}H in collected samples, shown in Table 5.6, the total amount of tritium discharged (87 Ci or 3.2 TBq) was calculated.

SEWAGE LAGOONS

Samples were collected quarterly during 1998 from the nine sewage lagoons on the network. Each of the lagoons is part of a closed system used for evaporative treatment of sanitary waste. The lagoons are located in Areas 5, 6, 12, 22, 23, and 25. The annual gross beta concentration averages for all lagoons ranged between 4.0 to 76 x 10^{-9} µCi/mL (0.14 to 2.8 Bq/L). No radioactivity was detected above the MDCs for ^{3}H, ^{90}Sr, ^{238}Pu, or $^{239+240}$Pu. No test-related radioactivity was detected by gamma spectrometric analyses.

RADIOACTIVITY IN SUPPLY WELLS AND DRINKING WATER

The principal water distribution system on the NTS is potentially the critical pathway for ingestion of waterborne radionuclides. Consequently, the water distribution system is sampled and evaluated frequently. The NTS water system consisted of 13 supply wells, 10 of which supplied potable water to onsite distribution systems. The drinking water is pumped from the wells to the points of consumption. The supply wells were sampled on a quarterly basis. Drinking water is sampled at taps on the end-points of the distribution systems to provide a constant check of the radioactivity and to allow end-use activity comparisons to the radioactivity of the water in the supply wells. In this section, analytical results are presented from samples taken at the 13 supply wells. Each well was sampled and analyzed as noted in the schedule in Table 5.2. As a cross check on the comparability of analyses by BN and EPA's R&IE-LV on water well samples, several wells were concurrently sampled by both organizations. The results of these analyses, listed in Table 5.7, showed reasonably good agreement.

The locations of the supply wells are shown in Figure 5.1. Water from these wells (11 potable and 2 nonpotable) was used for a variety of purposes during 1998. Samples were collected from those wells which could potentially provide water for human consumption. These data were used to help document the radiological characteristics of the NTS groundwater system. The sample results are maintained in a database so that long-term trends and changes can be studied. Table 5.8 lists the drinking water sources, and Table 5.9 lists the potable and nonpotable supply wells and their respective radioactivity averages. No test-related radionuclides were detected by gamma spectrometry. Included in the table are the median MDCs for each of the measurements for comparison to the concentration averages for each location. For various operational reasons, samples could not be collected from all locations every sampling period.

As a check on any effect the water distribution system might have on water quality, samples were taken from seven water distribution system end-points (tap water samples). To ensure that all of the water available for consumption was being considered, each drinking water system was identified. The drinking water network at the NTS consists of four drinking water systems. The components of the four are shown in Table 5.8. These systems, fed by ten potable supply wells, are the source of the water for the seven end-points. Table 5.10 lists the annual concentration averages for all of the analyses performed on tap water samples. No test-related radionuclides were detected by gamma spectrometry.

GROSS BETA

As shown in Table 5.9, the gross beta concentration averages for all the supply wells were above the median MDC of the measurement. The highest average gross beta activity occurred at Well C-1 and was 1.4×10^{-8} µCi/mL (0.51 Bq/L), which was 4.7 percent of the DCG for ^{40}K and 35 percent of the DCG for ^{90}Sr based upon 4 mrem effective dose equivalent (EDE) per year. In earlier reports (Scoggins 1983, 1984), it was noted that the majority of gross beta activity was attributable to naturally occurring ^{40}K. All concentration averages were comparable to those reported in 1997.

As in previous years, the gross beta concentration averages for all tap water samples were above the median MDC of the measurements. The highest annual average of 7.3×10^{-9} µCi/mL (0.27 Bq/L) occurred in the Area 23 Cafeteria, similar to the supply well water. The annual EDE is also equivalent to that from the supply well water.

TRITIUM

As shown in Table 5.9, the average tritium concentrations at all supply wells was below the average MDC of the measurement (note that the MDC was 14×10^{-9} µCi/mL, based on tritium enrichment analysis).

The annual average tritium concentrations in tap water samples, as shown in Table 5.10, were all less than the median MDC of 7.3×10^{-7} µCi/mL. The tritium concentrations for all end-point water samples, which were determined by a conventional liquid scintillation counting method, are expected to be lower than the MDC, since the levels of tritium in the potable supply wells were below the median tritium enrichment MDC of 1.4×10^{-8} µCi/mL (0.52 Bq/L). These MDC values are 0.9 percent and 0.018 percent, respectively, of the drinking water DCG adjusted to a 4 mrem (0.04 mSv) EDE.

PLUTONIUM

All supply-well water samples analyzed for ^{238}Pu and $^{239+240}Pu$ had concentrations below the MDCs of about 2.0×10^{-11} µCi/mL, which are about 2.0 percent of their respective DCGs adjusted to a 4 mrem EDE per year. Table 5.9 lists the concentration averages of these nuclides for each location.

The annual averages of $^{239+240}Pu$ and ^{238}Pu for each tap water sample were below the median MDC of the measurements, which were both less than 2 percent of the 4 mrem DCG. These isotopes are not normally detected in drinking water.

GROSS ALPHA

In accordance with the National Primary Drinking Water Regulations (CFR 1976), gross alpha measurements were made on quarterly samples from the drinking water systems, namely the potable supply wells.

As shown in Table 5.9, the average gross alpha concentration for all of the supply wells, except Well 8, was above the median MDC of 1.7×10^{-9} µCi/mL. The highest concentration occurred in samples from Well 5C in Area 5 and was 14×10^{-9} µCi/mL (0.51 Bq/L). This is acceptable according to the EPA drinking water standard (CFR 1976) as long as the combined concentration of ^{226}Ra and ^{228}Ra is less than 5×10^{-9} µCi/mL (0.18 Bq/L). The combined radium concentration, for this well, was less than the combined MDC of 4.5×10^{-9} µCi/mL (0.17 Bq/L), as shown in Table 5.11.

As added assurance that no radioactivity gets into the systems between the supply wells and end-point users, measurements of gross alpha are also made on quarterly tap water samples. As shown in Table 5.10, the annual concentration averages for gross alpha radioactivity in tap water samples, collected at three locations, exceeded the screening level of 5 pCi/L (0.19 Bq/L), at which ^{226}Ra analysis is required. Samples from the supply wells were collected and analyzed for both ^{226}Ra and ^{228}Ra. As shown by the radium results in Table 5.11, the sum of the average concentrations for ^{226}Ra and ^{228}Ra were all less than 5 pCi/L, which showed the onsite systems were in compliance with drinking water regulations.

STRONTIUM

Beginning in 1994, ^{90}Sr analyses were changed from annually to quarterly on samples collected from the potable supply wells, and analyses on non-potable supply wells were on an annual basis. This year both types of well received quarterly ^{90}Sr analysis. The concentration averages of ^{90}Sr for each location, as shown in Table 5.9, were below the median MDC.

As indicated by Table 5.10, the ^{90}Sr results for samples collected from all the selected tap water samples had concentrations that were less than the median MDC of the measurements.

LTHMP MONITORING ON AND AROUND THE NEVADA TEST SITE

NEVADA TEST SITE MONITORING

The present R&IE-LV sampling locations on the NTS, or immediately outside its borders on federally owned land are shown in Figure 5.3. All sampling locations are selected by DOE and primarily represent locations included in the RREMP. Since 1995, R&IE-LV has sampled only wells without pumps and, for quality assurance purposes, collected samples from some of the potable water supply wells sampled by BN. A total of 22 wells was included in this project.

All samples were analyzed by gamma spectrometry and for tritium. No gamma-emitting radionuclides were detected in any of the NTS samples collected in 1998.

Summary results of tritium analyses are given in Table 5.12. The highest average tritium activity was 7.8 x 10^4 pCi/L (2.9 kBq/L) in a sample from Well UE-5n. This activity is less than the DCG for tritium as established in DOE Order 5400.5 for comparison with the dose limit (4 mrem) in the National Primary Drinking Water Regulations. Seven of the wells yielded tritium results greater than the MDC. The trend in tritium concentration in samples from Test Well B is shown in Figure 5.6 and is typical of a well with decreasing tritium concentrations. The source of the tritium is unknown. Well UE-7ns was routinely sampled between 1978 and 1987 and such sampling began again in 1992.

OFFSITE MONITORING IN THE VICINITY OF THE NEVADA TEST SITE

Water sampling around the NTS is conducted by the EPA's R&IE-LV, under an interagency agreement with DOE, to ensure the radiological safety of public drinking water supplies and representative water sources of rural residents and, where suitable, to monitor any migration of radionuclides from the NTS. The sampling locations are shown on Figure 5.4 and the analytical results are in Table 5.13. No man-made gamma-emitting radionuclides were detected in any sample.

LTHMP MONITORING AT OTHER TEST SITES

Annual sampling of surface and groundwaters is conducted at the Projects SHOAL and FAULTLESS sites in Nevada, Projects GASBUGGY and GNOME sites in New Mexico, Projects RULISON and RIO BLANCO sites in Colorado, and Project DRIBBLE site in Mississippi. Sampling is normally conducted in odd numbered years on Amchitka Island, Alaska, at the site of Projects CANNIKIN, LONG SHOT, and MILROW. These were last sampled in 1997 (Faller 1997).

The sampling procedure is the same as that used for sites on the NTS and offsite areas (described above), with the exception that

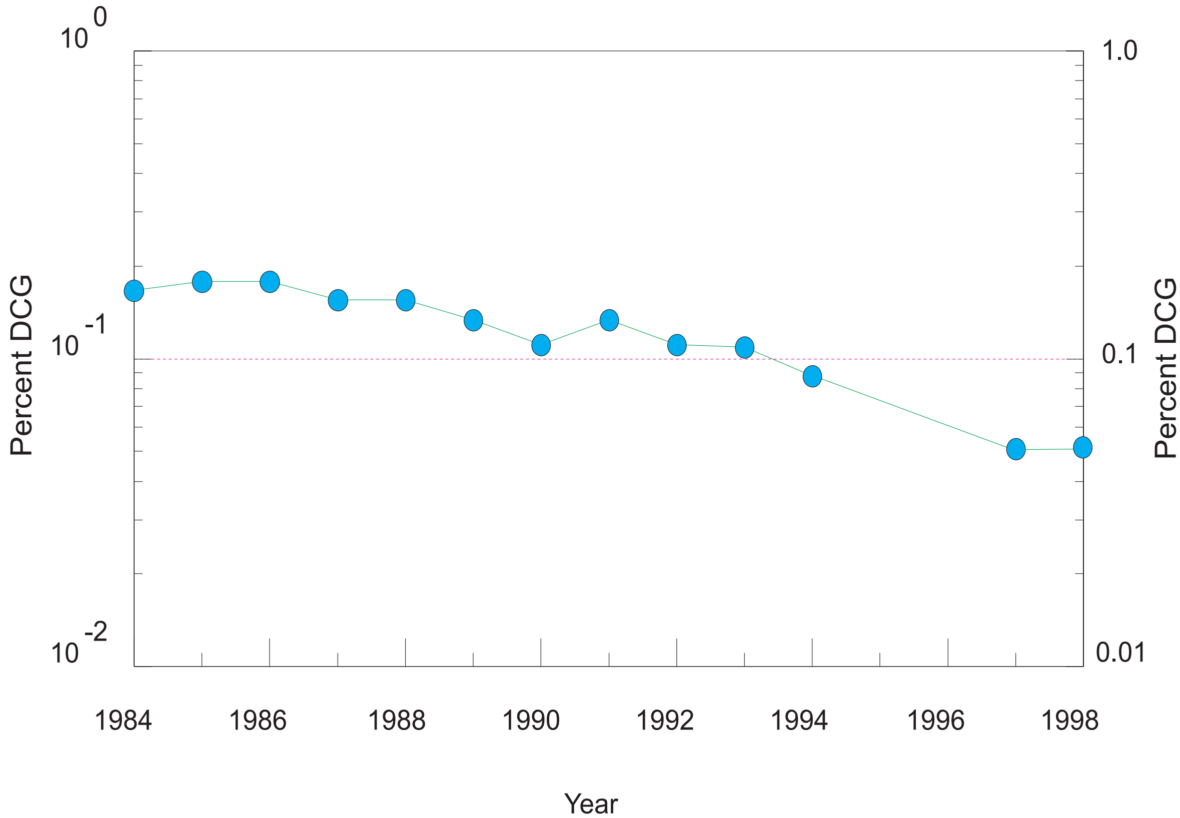


Figure 5.6 Trend in Tritium Concentration Test ell on the NTS

t o 3.8- samples are collected in Cubitainers. The second sample serves as a bac up or as a duplicate sample.

P O CT FA T SS

Pro ect FA T SS as a eapons related test conducted on anuary 19 1968 in Central Nevada in a sparsely populated area near lue ay aintenance Station Nevada. The test had a yield bet een 200 and 1000 t and as designed to test the behavior of seismic aves and to determine the site s usefulness for high-yield tests. The emplacement depth as 975 m 3199 ft . A surface depression as created but as an irregular bloc along local faults rather than as a saucer-shaped crater. The area is characteri ed by basin and range topography ith alluvium overlying tuffaceous sediments. The or ing point of the test as in tuff.

Sampling as conducted on February 26 and arch 17 1998 at locations sho n in Figure 5.7. outine sampling locations include one spring and five ells of varying depths. All routine samples ere collected. At least t o ells HTH-1 and HTH-2 are positioned to intercept migration from the test cavity should it occur Chapman and Ho ett 1991 .

Gamma-ray spectral analysis results indicated that no man-made gamma-emitting radionuclides ere present in any sample above the DC. Tritium concentrations ere less then the DC see Table 5.14 . These results are consistent ith those obtained in previous years. The results for tritium indicate that no migration into the sampled ells has ta en place and no test-related radioactivity has entered area drin ing ater supplies.

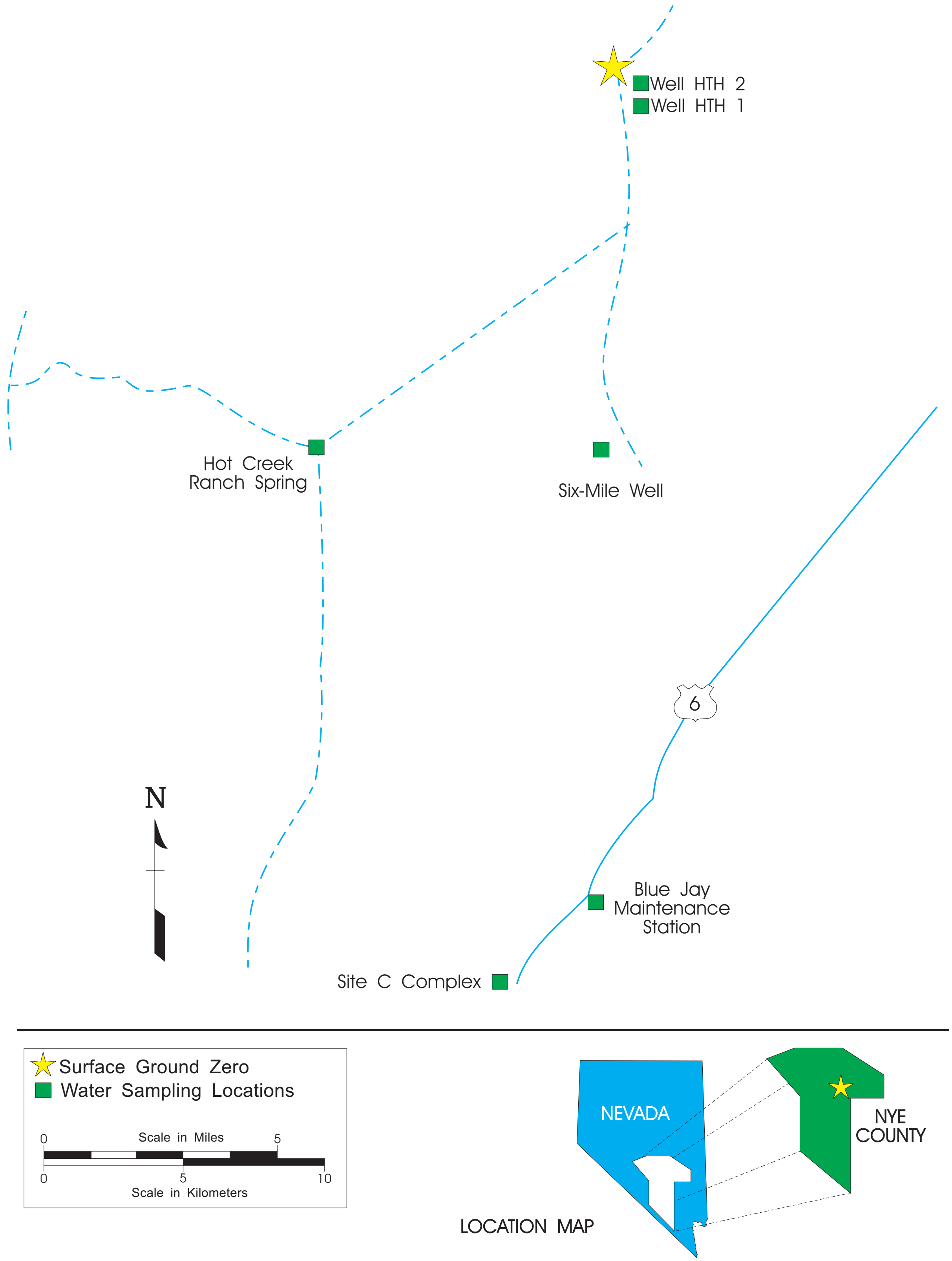


Figure 5.7 Sampling Locations at the FAULTLESS Site - 1998

PROJECT SHOAL

Project SHOAL, a 12-kt test emplaced at 365 m (1,198 ft), was conducted on October 26, 1963, in Fallon Nevada, in a sparsely populated area near Frenchman Station, Nevada. The test, part of the Vela Uniform Program, was designed to improve the capability to detect, identify, and locate nuclear explosions. The working point was in granite and no surface crater was created.

Samples were collected on February 24 and 25, 1998. The sampling locations are shown in Figure 5.8. Only eight of the nine routine wells were sampled. In 1997, four new wells were added to the LTHMP, which are near surface ground zero (SGZ). Sampling of these wells was done in February and March 1998. Well HC-3 was dry and will have to be reworked; it will be sampled in 1999. The routine locations include one spring, one windmill, and seven wells of varying depths. At least one location, Well HS-1, should intercept radioactivity migrating from the test cavity, should it occur (Chapman and Hokett 1991).

Gamma-ray spectral analysis results indicated that no man-made gamma-emitting radionuclides were present in any samples above the MDC. One of the new wells, HC-4 drilled in 1996, had a tritium concentration of 680 ± 140 pCi/L (25 ± 5 Bq/L). Tritium concentrations at all the other locations were below the MDC (see Table 5.15).

PROJECT RULISON

Cosponsored by the AEC and Austral Oil Company under the Plowshare Program, Project RULISON was designed to stimulate natural gas recovery in the Mesa Verde formation. The test, conducted near Grand Valley, Colorado, on September 10, 1969, consisted of a 40-kt nuclear explosive emplaced at a depth of 2,568 m (8,425 ft). Production testing began in 1970 and was completed in April 1971. Cleanup was initiated in 1972 and the wells were plugged in 1976. Some surface contamination resulted from decontamination of drilling equipment and fallout from gas flaring. Contaminated soil was removed during the cleanup operations.

Sampling was conducted May 12, 1998, with collection of samples from all sampling locations in the area of Grand Valley and Rulison, Colorado. Routine sampling locations are shown in Figure 5.9 and include the Grand Valley municipal drinking water supply springs, water supply wells for five local ranches, and five sites in the vicinity of SGZ, including one test well, a surface-discharge spring and a surface sampling location on Battlement Creek. Seven new monitoring wells were completed at the RULISON site in 1995 as part of the Remedial Investigation and Feasibility Study. Two of these wells were added to the LTHMP in 1997, RU-1 and RU-2.

Tritium has never been observed in measurable concentrations in the Grand Valley City Springs. All of the remaining sampling sites show detectable levels of tritium, which have generally exhibited a stable or decreasing trend over the last two decades. The range of tritium activity in 1998 was from 33 ± 5 pCi/L (1.2 ± 0.2 Bq/L) at Well RU-2, to 80 ± 4.7 pCi/L (3 ± 0.2 Bq/L) at Lee Hayward Ranch. All values were less than 1 percent of the DCG (see Table 5.16). The detectable tritium activities were probably a result of the high natural background in the area. This was supported by the DRI analysis, which indicated that most of the sampling locations were shallow, drawing water from the surficial aquifer which was unlikely to become contaminated by any radionuclides arising from the Project RULISON cavity (Chapman and Hokett 1991). Gamma-ray spectral analysis results indicated that man-made gamma-emitting radionuclides were not present in any samples above the MDC.

Shallow wells at three local ranches (Koch, Goad, and Arnold Machley) were sampled during the routine visit to the RULISON site

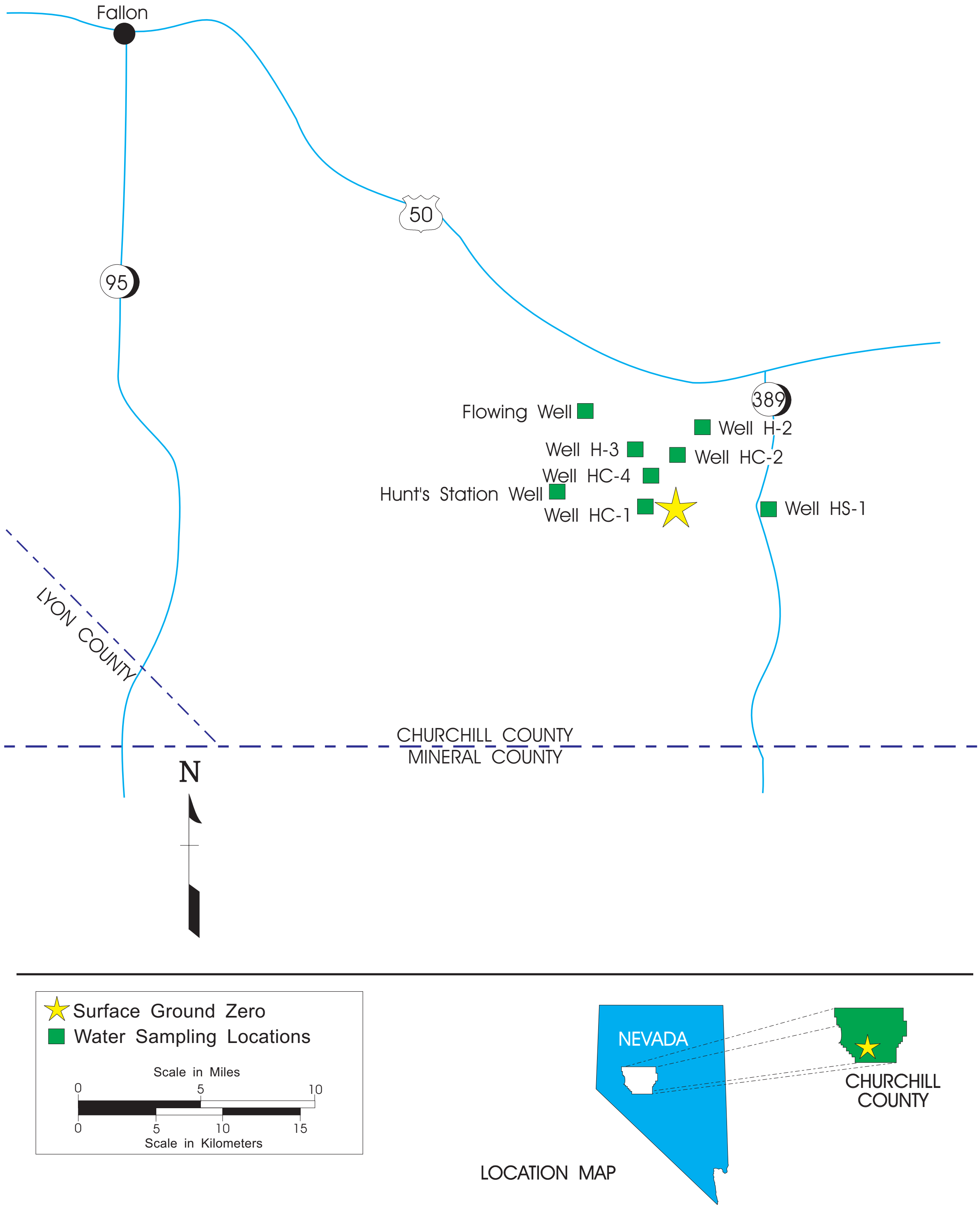


Figure 5.8 Sampling Locations at the SHOAL Site - 1998

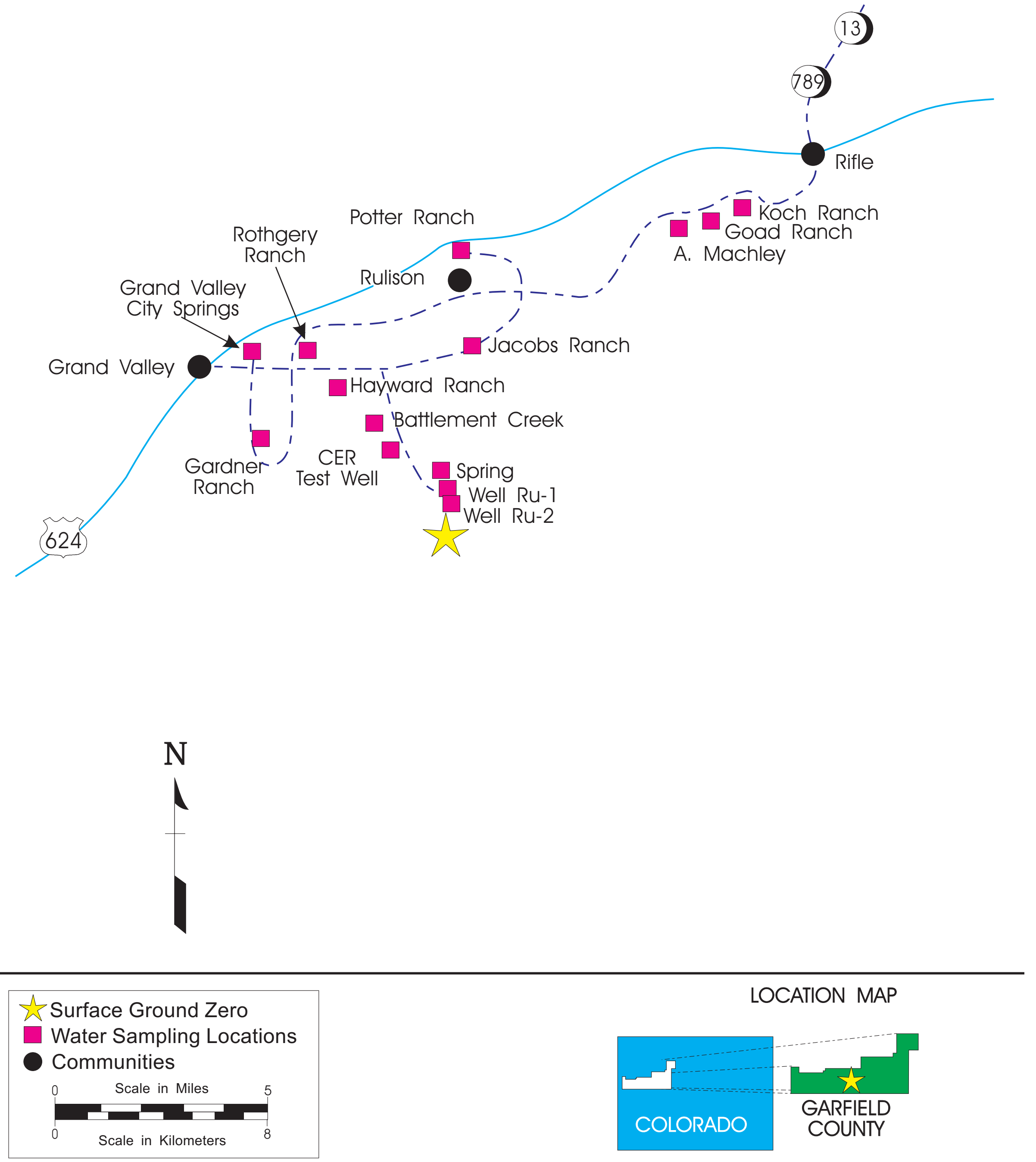


Figure 5.9 Sampling Locations at the RULISON Site - 1998

in May of 1998. A second sample was collected later in the month from Goad Ranch by Maxim Environmental of Golden, Colorado with the in-line filter removed from the well outlet. All samples were analyzed for tritium, uranium, and plutonium, and surveyed for gamma-emitting radionuclides at the EPA laboratory. In all three wells, tritium concentrations were very similar (~30-40 pCi/L) and consistent with the levels of tritium typically found in surface waters and shallow wells at this latitude. Uranium was also detectable in all the samples, including the second sample from the Goad Ranch well (unfiltered). Total uranium concentrations (^{238}U + ^{235}U + ^{234}U) in the Rulison special samples ranged from a high of 11 pCi/L in the Koch Ranch well to a low of 4.2 pCi/L at the Goad Ranch with the wellhead filter in place. The corresponding uranium concentration in the unfiltered sample collected from Goad Ranch later in the month by Maxim Environmental was 6.0 pCi/L, or slightly higher than the filtered sample. The sample from the Arnold Machley well contained 7.9 pCi/L of uranium.

PROJECT RIO BLANCO

Project RIO BLANCO, a joint government-industry test designed to stimulate natural gas flow, was conducted under the Plowshare Program. The test was conducted on May 17, 1973, at a location between Rifle and Meeker Colorado. Three nuclear explosives, with a total yield of 99 kt, were emplaced at 1780-, 1920-, and 2040-m (5840-, 6299-, and 6693-ft) depths in the Fort Union and Mesa Verde formations. Production testing continued to 1976 when cleanup and restoration activities were completed. Tritiated water produced during testing was injected to 1710 m (5610 ft) in a nearby gas well.

Samples were collected May 13 and 14, 1998, from the sampling sites shown in Figure 5.10. The routine sampling locations included four springs, four surface sites, and five wells. Three of the wells are located near the cavity and at least two of the wells (RB-D-01 and RB-D-03) are suitable for monitoring possible migration of radioactivity from the cavity.

No radioactive materials attributable to the RIO BLANCO test were detected in samples collected in the offsite areas during May 1998. The range of tritium activity in 1998, using the enrichment method, was from 1.3 ± 2.8 pCi/L (0.05 ± 0.10 Bq/L) at the RB-D-03, to 2.7 ± 32 pCi/L (0.10 ± 1.2 Bq/L) at RB-D-01 (see Table 5.17). In samples analyzed conventionally, all results were well below the MDC. All tritium concentrations are much less than the 20,000 pCi/L level defined in the EPA National Primary Drinking Water Regulations (CFR 1976). All samples were analyzed for presence of gamma-emitting radionuclides, and none were detected.

PROJECT GNOME

Project GNOME, conducted on December 10, 1961, near Carlsbad, New Mexico, was a multipurpose test performed in a salt formation under the Plowshare Program. A 3-kt nuclear explosive was emplaced at a depth of 371 m (1,217 ft) in the Salado salt formation. Radioactive gases were unexpectedly vented during the test. The USGS conducted a tracer study in 1963, involving injection of 20 Ci ^{3}H, 10 Ci ^{137}Cs, 10 Ci ^{90}Sr, and 4 Ci ^{131}I (740, 370, 370, and 150 GBq, respectively) into Well USGS-8 and pumping water from Well USGS-4. During cleanup activities in 1968-1969, contaminated material was placed in the test cavity access well. More material was slurried into the cavity and drifts in 1979.

Sampling at Project GNOME was conducted May 19 through 21, 1998. The routine sampling sites, depicted in Figure 5.11, include nine monitoring wells in the vicinity of GZ and the municipal water supplies at Loving and Carlsbad, New Mexico.

Tritium results greater than the MDC were detected in water samples from 4 of the 12 sampling locations in the immediate vicinity of GZ. Tritium activities in Wells DD-1, LRL-7, USGS-4, and USGS-8 ranged from

Figure 5.10 Sampling   ocations at the   O   ANCO Site - 1998

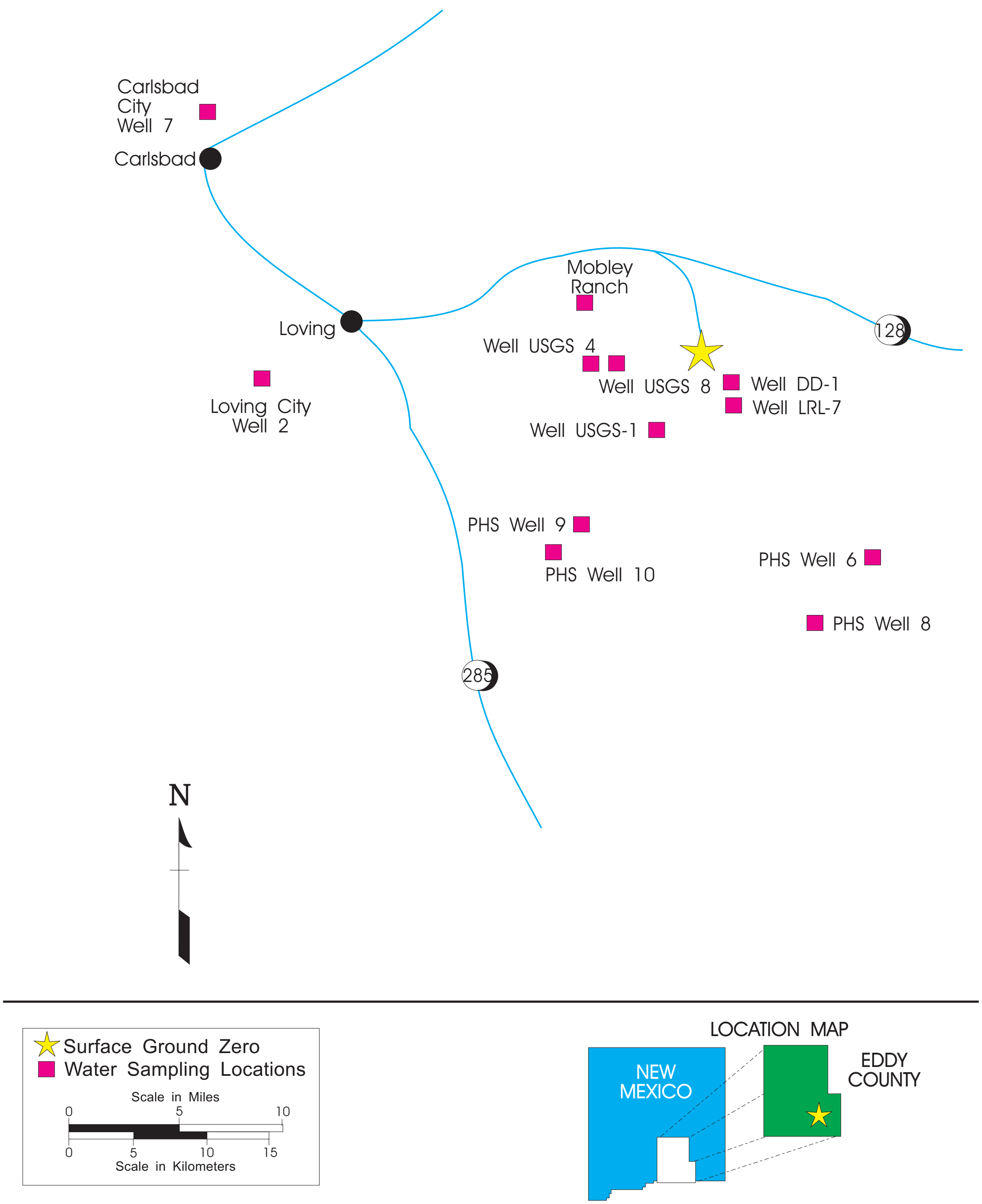


Figure 5.11 Sampling Locations at the GNOME Site - 1998

5.8×10^7 to 1.8×10^3 pCi/L (2.1×10^6 to 67 Bq/L). Well DD-1 collects water from the test cavity; Well LRL-7 collects water from a side drift; and Wells USGS-4 and -8 were used in the radionuclide tracer study conducted by the USGS. None of these wells are sources of potable water.

In addition to ^{3}H, ^{137}Cs and ^{90}Sr concentrations were observed in samples from Wells DD-1, LRL-7, and USGS-8 and ^{90}Sr activity was detected in Well USGS-4 as in previous years (see Table 5.18). No ^{3}H was detected in the remaining sampling locations, including Well USGS-1, which the DRI analysis (Chapman and Hokett 1991) indicated is positioned to detect any migration of radioactivity from the cavity. All other tritium results were below the MDC.

PROJECT GASBUGGY

Project GASBUGGY was a Plowshare Program test co-sponsored by the U.S. Government and El Paso Natural Gas. Conducted near Farmington, New Mexico, on December 10, 1967, the test was designed to stimulate a low productivity natural gas reservoir. A nuclear explosive with a 29-kt yield was emplaced at a depth of 1290 m (4240 ft). Production testing was completed in 1976, and restoration activities were completed in July 1978.

Sampling at GASBUGGY was conducted during May 16 through 17, 1998. Only twelve samples were collected at the designated sampling locations shown in Figure 5.12. The Bixler Ranch well has been sealed and the Well 28.3.32.343 north had the pumps removed and no samples could be obtained.

The Cedar Springs sampling site yielded enriched tritium activity of 36 ± 4.1 pCi/L (1.3 ± 0.15 Bq/L) and for Cave Spring it was 36 ± 3.5 pCi/L (1.3 ± 0.13 Bq/L), which was less than 0.5 percent of the DCG and similar to the range seen in previous years. Tritium samples from the other locations were all below the average MDC.

Well EPNG 10-36, a gas well located 132 m (435 ft) northwest of the test cavity, with a sampling depth of approximately 1,100 m (3,600 ft), has yielded detectable tritium activities since 1984. The sample collected in May 1998 contained ^{3}H at a concentration of 100 ± 4.5 pCi/L (3.7 ± 0.17 Bq/L) as shown in Table 5.19. The migration mechanism and route are not currently known, although an analysis by DRI indicated two feasible routes, one through the Printed Cliffs sandstones and the other one through the Ojo Alamo sandstone, one of the principal aquifers in the region (Chapman et al., 1996). In either case, fractures extending from the cavity may be the primary or a contributing mechanism.

All gamma-ray spectral analysis results indicated that no man-made gamma-emitting radionuclides were present in any offsite samples. Tritium concentrations of water samples collected onsite and offsite are consistent with those of past studies at the GASBUGGY site.

PROJECT DRIBBLE

Project DRIBBLE was comprised of two nuclear and two gas explosive tests, conducted in the SALMON site area near Hattiesburg, Mississippi, under the Vela Uniform Program. The purpose of Project DRIBBLE was to study the effects of decoupling on seismic signals produced by nuclear explosives tests. The first test, SALMON, was a nuclear device with a yield of 5.3 kt, detonated on October 22, 1964, at a depth of 826 m (2710 ft). This created the cavity used for the subsequent tests, including STERLING, a nuclear test conducted on December 3, 1966, with a yield of 380 tons, and the two gas explosions, DIODE TUBE (on February 2, 1969) and HUMID WATER (on April 19, 1970). The ground surface and shallow groundwater aquifers were contaminated by disposal of drilling muds and fluids in surface pits. The radioactive contamination was primarily limited to the unsaturated zone and upper, nonpotable aquifers near SGZ. Shallow wells, labeled HMH wells on

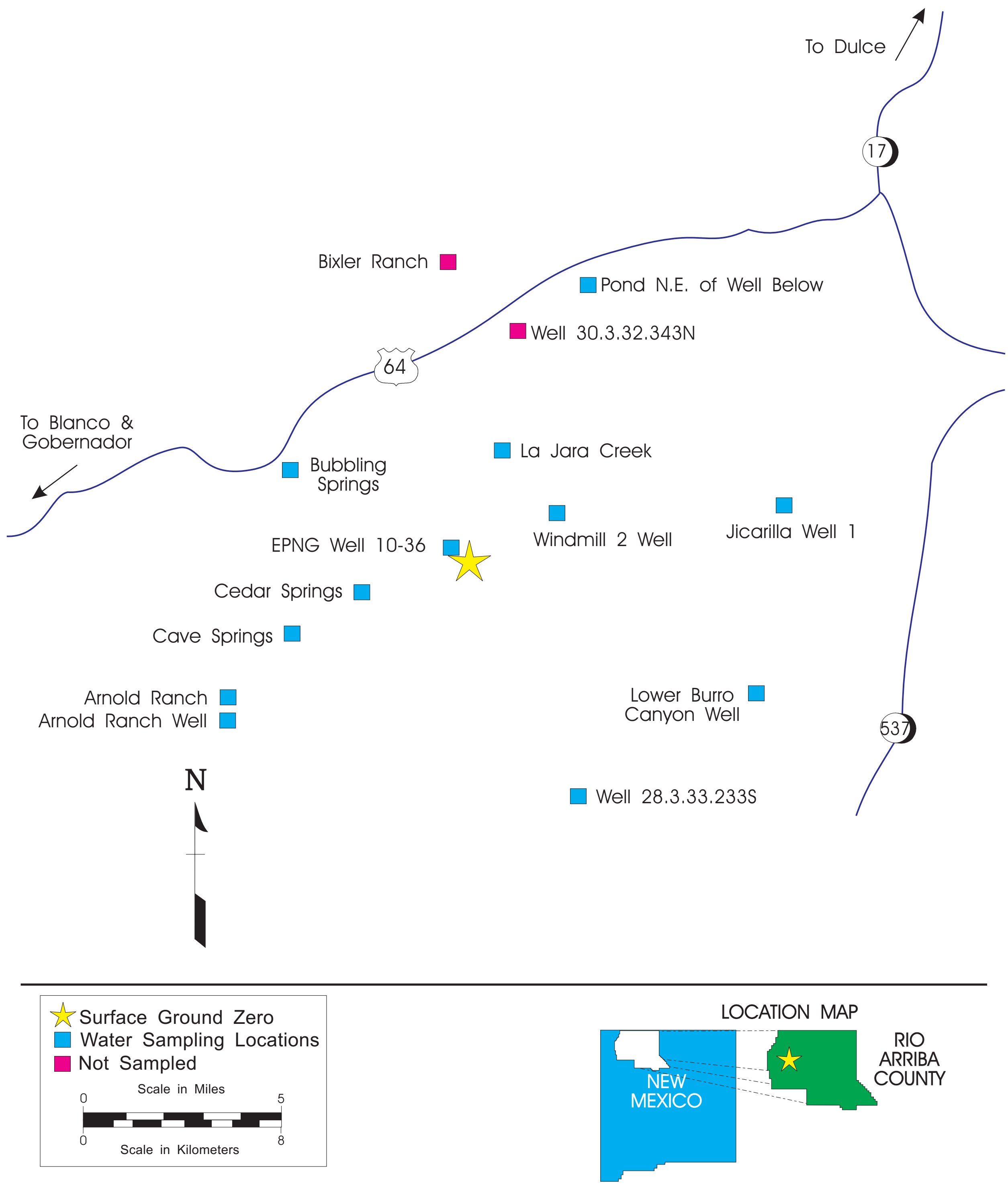


Figure 5.12 Sampling Locations at the GASBUGGY Site - 1998

Figure 5.13, have been added to the area near SGZ to monitor this contamination. Fifteen new wells were completed in 1996 and first sampled by the EPA LTHMP Program in 1998. These wells are shallow, between 9 m and 12 m (30 ft to 40 ft) in depth. In addition to the monitoring of wells near SGZ, extensive sampling of water wells is conducted in the nearby offsite area as shown in Figure 5.14.

Because of the variability noted in past years in samples from the shallow monitoring wells near SGZ, the sampling procedure was modified; a second sample is taken after pumping for a specified period of time or after the well has been pumped dry and permitted to recharge. These second samples may be representative of formation water, whereas the first samples may be more indicative of recent rainfall.

Sampling at the SALMON site was conducted from April 19 to April 23, 1998.

Long-term decreasing trends in tritium concentrations are evident for those locations that had detectable tritium activity at the beginning of the LTHMP, such as in the samples from the Baxterville City Well depicted in Figure 5.15 and Well HM-S shown in Figure 5.16. Due to the high rainfall in the area, the normal sampling procedure is modified for the shallow onsite wells as described above. Of the 55 locations sampled onsite, 34 sites were sampled twice (pre-and post-pumping), and 25 yielded tritium activities greater than the MDC in either the first or second sample. Of these, 16 yielded results higher than normal background (about 60 pCi/L [2.2 Bq/L]) as shown in Table 5.20. The locations where the highest tritium activities were measured generally correspond to areas of known contamination. No tritium concentrations above normal background were detected in any offsite samples. Man-made gamma-ray emitting radionuclides were not detected in any sample collected in this study.

In 1998, an additional 14 shallow wells were added to the annual sampling, increasing the total wells sampled onsite to 55, as noted above. In the samples from the 14 new wells, tritium values were all below the MDC. In the samples collected from the offsite sampling locations, only samples from five wells were above the tritium MDC. This activity ranged from less than the MDC to a maximum of 24 ± 3.4 pCi/L (0.89 ± 0.13 Bq/L) at the Ascot Well in Baxterville, 0.14 percent of the DCG. These results do not exceed the natural tritium activity expected in rain water in this area.

Results of sampling related to Project DRIBBLE are discussed in more detail in the onsite and offsite environmental monitoring report, "Radiation Monitoring around SALMON test site," Lamar County, Mississippi, April 1998 (Davis 1998, available from R&IE-LV).

AMCHITKA ISLAND, ALASKA

Sampling is conducted biennially in odd numbered years. The last sampling was in 1977 (Faller 1977) as mentioned above and the next sampling will be in 1999.

TRITIUM TRENDS NEAR TEST CAVITIES

Sampling groundwaters at locations where underground nuclear explosive devices have been tested reveals a consistent pattern if contamination occurs. Some time after the detonation of the device, assuming there is leakage from the cavity, the contamination will rise to some maximum value and then begin to decrease. Figure 5.17 shows the results obtained in the LTHMP for measuring tritium concentration in groundwater. Although a few other radionuclides are sometimes detected, they occur at much lower concentrations than does tritium and soon become undetectable. Note the following as depicted in Figure 5.17.

- Well EPNG 10-36 is located near the GASBUGGY test in northern New Mexico. This well was completed in sandstone. The test occurred in December 1967, and the leakage began in 1984. The tritium concentration peaked in 1988 and is now decreasing.

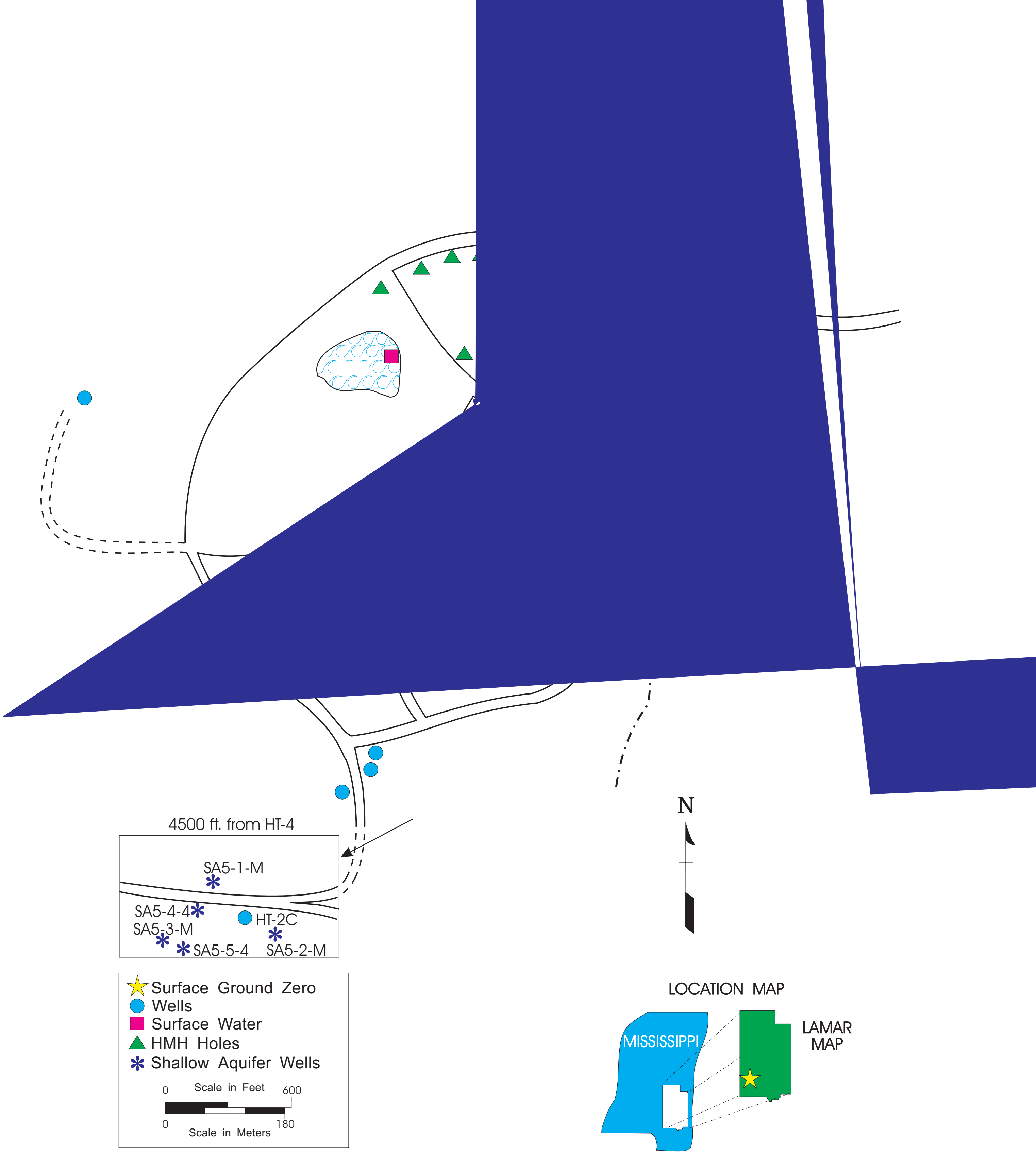


Figure 5.13 Sampling Locations Near SGZ, SALMON Site - 1998

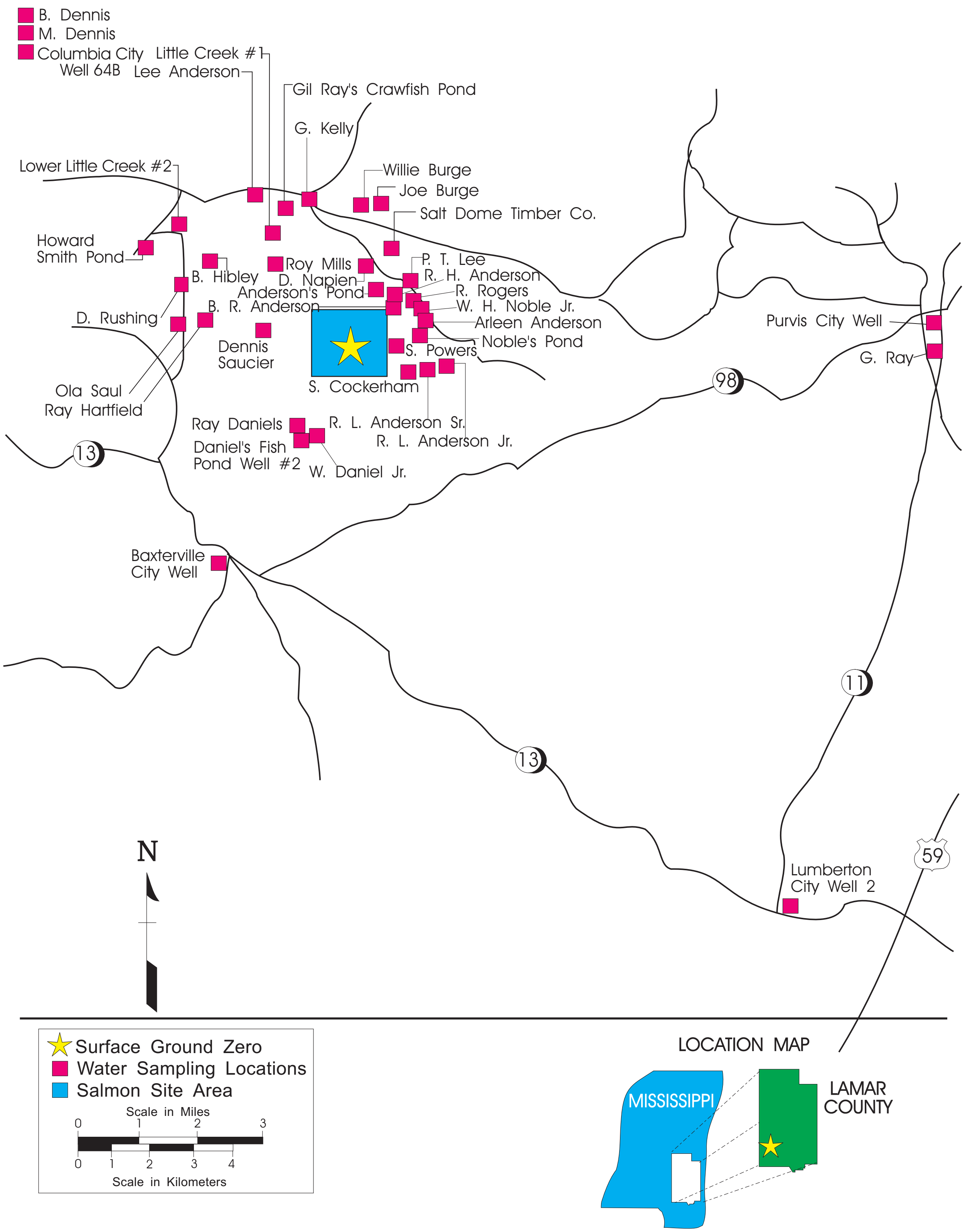


Figure 5.14 Sampling Locations Offsite at the SALMON Site - 1998

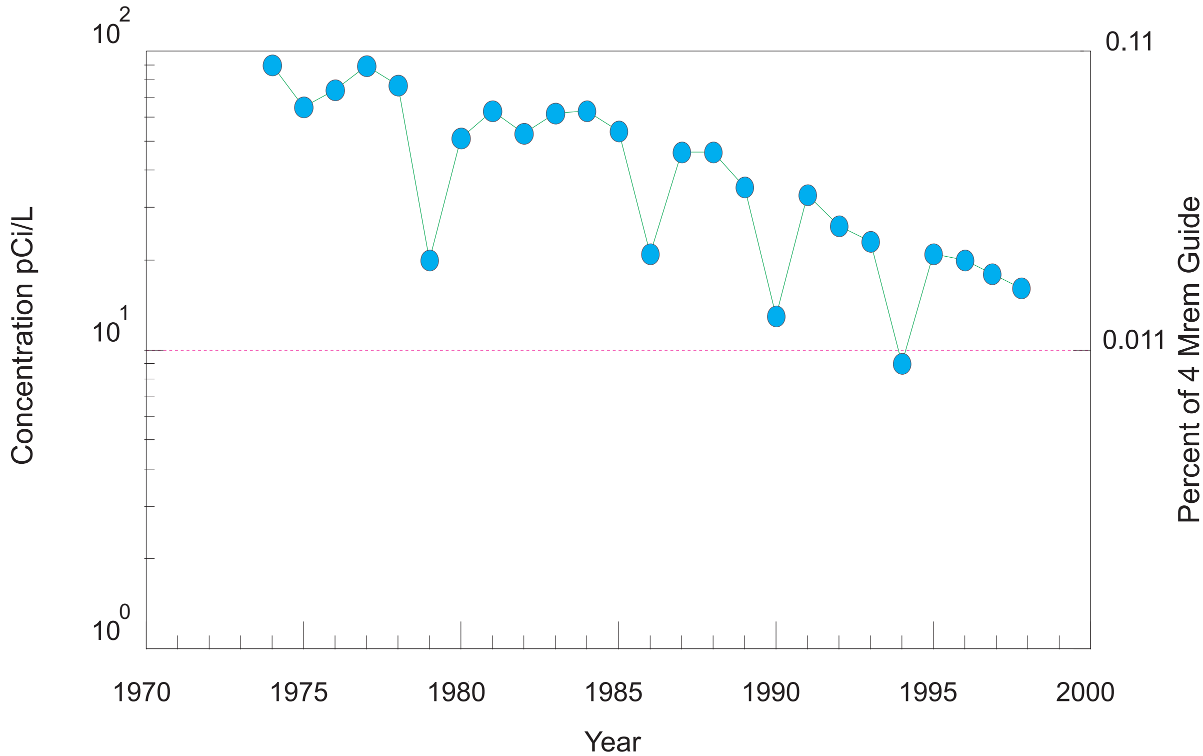


Figure 5.15 Tritium Trends in Baxterville, Public Drinking Water Supply

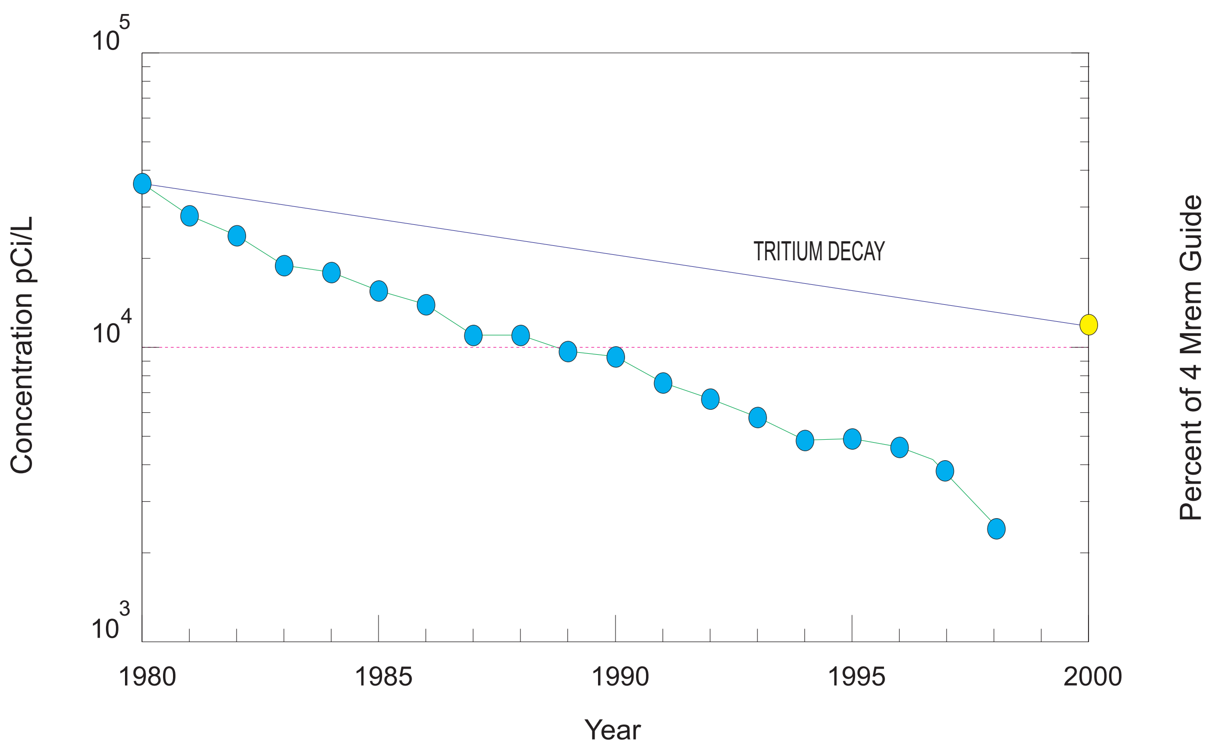


Figure 5.16 Tritium Trend in Well HM-S, SALMON Site in Mississippi

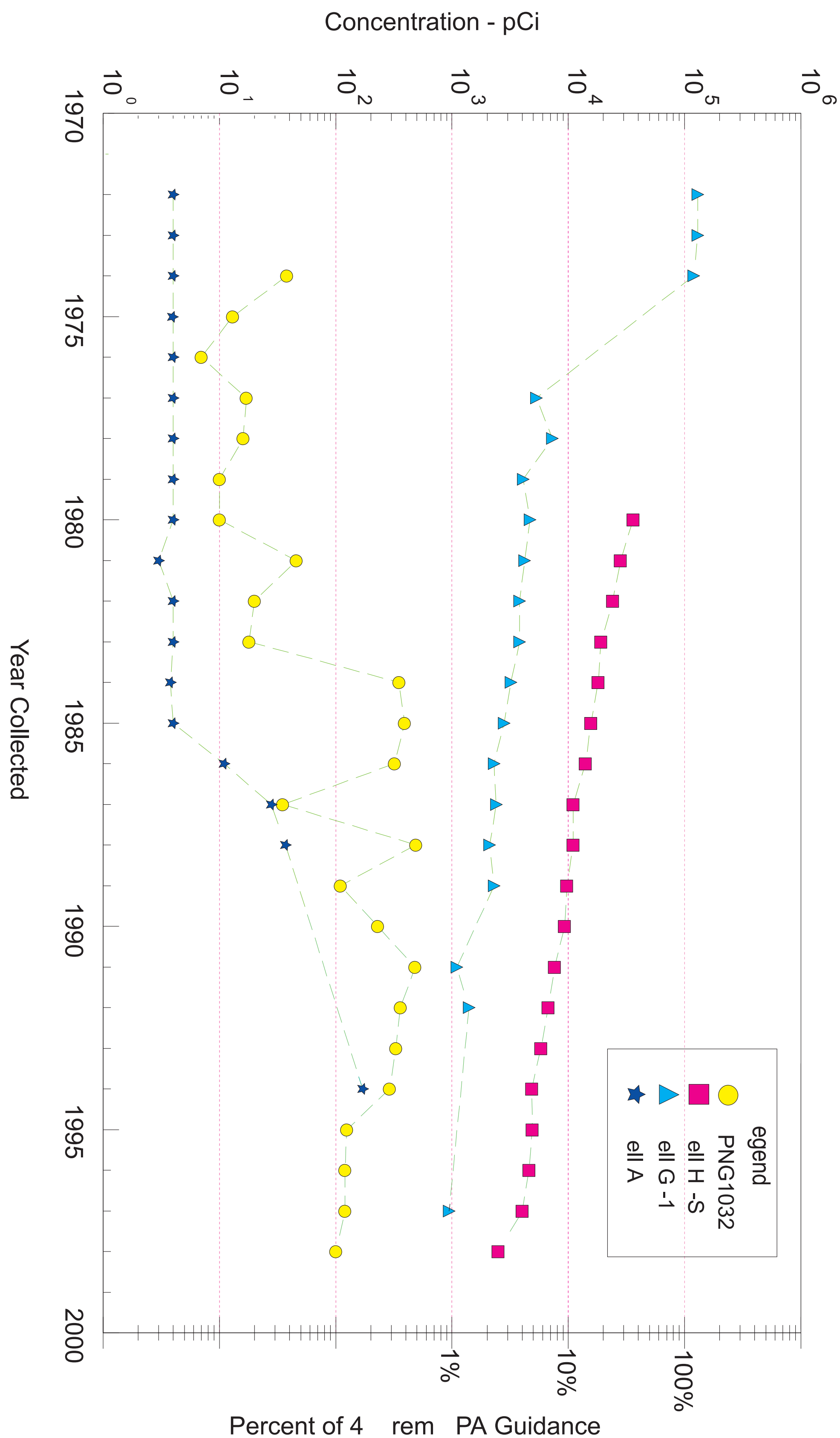


Figure 5.17 Tritium Trends in Ground ater Near nderground Tests

- Well HM-S is a surficial aquifer monitoring well near the salt dome at the site of the DRIBBLE Project in Mississippi. The STERLING test of that project occurred in December 1966. The first samples from this well, in 1980, had a moderate tritium concentration, and it has been decreasing since then.

- Well GZ-1 is near the LONG SHOT emplacement hole and was completed in a freshwater lens in volcanic rock on Amchitka Island, Alaska. This test occurred in October 1965, and the tritium concentration in surface waters began to increase about a year later. Samples from this well, first sampled in 1972, contained a high concentration of tritium that has been decreasing steadily.

- Well A was completed in 1960 in a valley-fill aquifer in an area on the NTS that has been subjected to a multitude of underground nuclear explosive tests. Samples from this well had background concentrations of tritium until 1986 when the concentrations began increasing. The well supplied drinking water so it was shut down in 1988 as the tritium concentration continued to increase. Obtaining samples is very difficult so whether the concentration is decreasing or not is unknown.

This pattern of tritium concentration in groundwater that follows leakage from underground nuclear device testing suggests that such contamination may not be a serious problem, assuming it is representative of leakage from all underground tests that may leak. The precise cause of this pattern is unknown at present. The fact that the pattern is consistent even though the geologic parameters vary is notable.

GROUNDWATER MONITORING

GROUNDWATER QUANTITY

Water levels are monitored annually by the USGS on and around the NTS at approximately 149 measurement locations. Results are used in regional and local groundwater models, but are not routinely analyzed for water level trends. However, no significant water level impacts associated with groundwater usage were detected in 1998. Data for the 1998 water year will be reported in the "USGS Water Data Report," NV-98-1.

Water usage on the NTS is also monitored by the both the USGS and BN. Data for the 1998 water year will also be reported in NV-98-1. Water use at the NTS continues to decline, due to the moratorium on nuclear testing instituted in 1992, and was about 9.16×10^5 m^3 (242×10^6 gal) in 1998.

GROUNDWATER QUALITY

Regional-scale groundwater investigations concentrated on determining recharge locations and flow paths for the groundwater flow systems in southern Nevada. This included several studies and field sampling activities. Geochemical and isotopic measurements included cation and anion chemistry, oxygen, hydrogen and carbon stable isotopes, and radiocarbon.

HRMP supported a regional-scale study of groundwater recharge sources and processes in Nevada. Approximately 125 spring and snow samples were collected from the NTS and areas north of the NTS. Samples were analyzed for hydrogen and oxygen isotopes at LLNL. For results, see Rose et al., 1999.

The multi-agency geochemical study of groundwater transport between Pahute Mesa and Oasis Valley continued through 1998. This study includes geochemists from the USGS, DRI, LLNL, HSI-GeoTrans, and the Harry Reid Center at UNLV. Preliminary results and interpretations from this study will be delivered to DOE/NV in April 1999.

Groundwater quality was determined by monitoring wells and springs, both onsite and offsite, for radioactive constituents as discussed above. The remainder of this chapter summarizes analyses of water for chemical constituents, radioisotopes, and stable isotopes in order to comply with environmental permits, better characterize NTS groundwater quality, and support regional groundwater flow and transport models.

5.6 NONRADIOLOGICAL MONITORING

The 1998 nonradiological monitoring program for the NTS included onsite sampling of various environmental media and substances for compliance with federal and state regulations or permits and for ecological studies.

MONITORING WATER SOURCES

Monitoring of natural and man-made water sources for use by wild horses continued in 1998. Two newly found wetlands in Area 30, Wild Horse and Little Wild Horse springs, are located within the annual horse range on the NTS and were used by horses in spring and summer. Only two other natural water sources (Captain Jack and Gold Meadows Springs in Area 12) and one man-made pond (Camp 17 Pond in Area 18) were used by horses this summer, as in past years. There are eight man-made water sources within or on the edge of the annual horse range that were not used by horses.

Biologists discovered five new water sources in 1998 during habitat mapping of the northern NTS and during monitoring of natural water sources on the NTS. Four of the water sources appear to be springs and may dry up during drought years or late summer. The fifth water source appears to be a historic borrow pit which catches surface runoff in large enough quantities and for long enough periods to sustain wetland vegetation. Two of the four springs were found in Area 30 on the southwest bajadas of the Eleana Range. They were named Wild Horse Spring and Little Wild Horse Spring because abundant signs of horse use.

Nonradiological monitoring of non-NTS DOE/NV facilities was conducted at three offsite facilities. This monitoring was limited to wastewater discharges to publicly owned treatment works.

Routine nonradiological environmental monitoring on the NTS in 1998 was limited to:

- Sampling of drinking water distribution systems and water haulage trucks for SDWA and state of Nevada compliance.
- Sewage lagoon influent and E Tunnel discharge sampling for compliance with state of Nevada operating permit requirements.

CLEAN WATER ACT RESULTS

NTS OPERATIONS

The NTS General Permit requires quarterly reporting for biochemical oxygen demand (BOD) and specific conductance, organic loading rates, and water depths in infiltration basins. It also requires reporting of second quarter influent toxics sampling. The results of this sampling are shown in Tables 5.21, 5.22, 5.23, and 5.24, respectively. All values in these tables are in compliance with the permit requirements.

The permit also requires monitoring of the infiltration basins, which attain a depth of 30 cm or more in January and June for parameters listed in Appendix II of the permit. Sampling is required as soon as any other system exceeds the 30 cm. Three secondary ponds at the Area 23 facility usually contain the required depth, but are excluded as needing the sampling in Part III.C.4 of the permit. During 1998, the Area 25 Central Support (Base Camp) system exceeded the 30 cm in the second quarter, and these sampling results are given in Table 5.25. All values in this table are in compliance with the permit requirements.

NON-NTS OPERATIONS

The North Las Vegas Facility (NLVF) is required by permit to sample and analyze wastewater effluent and submit self-monitoring reports. The NLVF self-monitoring report consists of monitoring results for two outfalls and the burn pit batch discharge. All sampling results for 1998 were within permit limits. The RSL facility now discharges into the Nellis Air Force Base system and no longer requires a permit. Nellis Air Force Base does, however, require a self-monitoring report, which was submitted in 1998.

SAFE DRINKING WATER ACT RESULTS

Water sampling was conducted for analysis of bacteria, volatile organic compounds (VOCs), inorganic constituents, and water quality as required by the SDWA and state of Nevada regulations. Samples were taken at various locations throughout all drinking water distribution systems on the NTS. Common sampling points were restroom and cafeteria sinks. All samples were collected according to accepted practices, and the analyses were performed by state approved laboratories. Analyses were performed in accordance with Nevada Administrative Code (NAC) 445A (NAC 1996) and Title 40 CFR 141.

BACTERIOLOGICAL SAMPLING

Samples were submitted to the state-approved Associated Pathologists Laboratories in Las Vegas, Nevada, for coliform analyses. All water distribution systems were tested once a month, with the number of people being served determining the number of samples collected. If coliform bacteria are present, the system must be shut down and chlorinated. In order to reopen the system, three or four consecutive samples must meet state requirements, depending again on the number of people served. There were no incidents of positive coliform results during 1998.

Residual chlorine and pH levels were determined at the collection point by using colorimetric methods approved by the state. The results were recorded in BN's drinking water sample logbook, and the chlorine residual level was recorded on an analysis form.

Samples from trucks, which hauled potable water from NTS wells to work areas, were also analyzed for coliform bacteria. During 1996, the state relaxed the requirement to test every truck load of water, to testing each of the three trucks weekly. There were no positive coliform sample results in 1998 that required superchlorination and resampling.

CHEMICAL ANALYSIS

Chemical analyses in 1998 were performed for VOCs, metals, and inorganics.

ORGANIC COMPOUND ANALYSIS

Samples for VOCs were collected during the second quarter of 1998 from all potable water wells except Well 5B. Four quarters of VOCs sampling from Well 5B ended December 1997, and DOE/NV requested a waiver from further sampling on January 6, 1998. All samples were analyzed by a state-approved laboratory, and none of the results were above quantitation limits.

METAL ANALYSIS

In compliance with a state agreement, samples were collected in the third quarter and analyzed for lead and copper. These samples were taken from faucets from all four potable water distribution systems. All results were below the method detection limits of 0.5 mg/L for copper and three of the systems were below 0.015 mg/L for lead. However, lead results in Area 1 were 0.06 mg/L. Subsequent investigations and sampling have narrowed the problem down to two underground copper lines. At the end of 1998 these lines were being excavated to look for brass fittings or lead solder.

INORGANIC COMPOUND ANALYSIS AND WATER QUALITY

To comply with a 1991 variance to the Area 25 water system permit, fluoride samples need to be taken annually 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 1998 confirmed that the fluoride concentration was acceptable.

During the first and second quarters of 1998, all systems (ten water wells) were sampled and analyzed for nitrates. The results of these analyses are shown in Table 5.26. Samples from wells J-12 and J-13 collected in the first quarter had nitrate concentrations below one half the maximum contaminant level of 10 mg/L, so that completes the required sampling for the last four consecutive quarters. Samples were collected from the rest of the wells in the second quarter, and all results were satisfactory, at less than half of the maximum contaminant level.

5.7 WATER QUALITY PERMITS

Water quality permits were required by the state for onsite drinking water systems. Other types of water permits were required for onsite and offsite sewage-related activities.

ONSITE WATER PERMITS

DRINKING WATER SYSTEM PERMITS

Four NTS drinking water system permits issued by the state of Nevada, as shown in Table 5.27 were renewed with new expiration dates. During 1994, the state of Nevada determined that the trucks used for hauling potable water should also have permits, so three additional permits were obtained. These permits were also renewed. No drinking water systems were maintained by non-NTS facilities.

SEWAGE DISCHARGE PERMITS

Sewage discharge permits from the state of Nevada, Division of Environmental Protection are listed in Table 5.28 and require submission of quarterly discharge monitoring reports.

NTS SEWAGE HAULING PERMITS

Permits issued by the state of Nevada Division of Health for six sewage hauling trucks for the NTS were renewed in November 1998 and are listed in Table 5.29.

NON-NTS SEWAGE PERMITS

One sewage permit was required at the NLVF and two at the Special Technologies Laboratory (STL) as shown in Table 5.28. Each was issued by the county or local municipality in which the facility was located as follows:

- NLVF - The NLVF self-monitoring report was submitted in October 1998. Two outfalls and the burn pit batch discharge are monitored.
- STL - The STL holds wastewater permits for the Botello Road and Ekwill Street locations. There is no required self-monitoring.

Table 5.1 Summary of Analytical Procedures for Water Samples - 1998

Type of Analysis	Analytical Equipment	Count Time-min	Analytical Procedure	Sample Size-mL	Approximate MDC
		BN	Procedures		
Gross α	Gas-flow Proportional Counter	100	Boil down. Place on planchet and heat to dryness	800	2 pCi/L
Gross β	Gas-flow Proportional Counter	100	Boil down. Place on planchet and heat to dryness	800	2 pCi/L
Gamma	HpGe detector calibrated at 1 keV/channel	100	Online computer analysis	500	10 pCi/L for ^{137}Cs
Tritium Convent.	Liquid scintil-lation counter	70	Distillation of 100 mL	2.5	300-700 pCi/L
Tritium Enrichment	Liquid scintil-lation counter	300	Electrolysis of 250 mL basic solution	5	20 pCi/L
Plutonium	Alpha Spectrometer	1000	Tracer, ion exchange, collect ppt on filter	900	0.02 pCi/L
Radium	Gamma Spectrometer	1000	Tracer, ppt as sulfate, collect on filter	900	1 pCi/L for ^{228}Ra 3 pCi/L for ^{226}Ra
Strontium	Gas-flow Proportional Counter	100	ppt as carbonate, count yttrium in-growth	900	0.3 pCi/L
		R&IE-LV	Procedures		
Gamma	HpGe detector calibrate at 0.5 keV/channel	100	Online computer analysis	3500	Varies with nuclide/detector ^{137}Cs: 7 pCi/L
Tritium Convent.	Liquid scintil-lation counter	300	Distillation of sample	5-10	300-700 pCi/L
Tritium Enrichment	Liquid scintil-lation counter	300	250 mL concentrate by electrolysis, distill	5	5 pCi/L

Table 5.2 Summary of the Onsite Water Surveillance Program - 1998

Sample Type	Description	Collection Frequency	Number of Sampling Locations[a]	Type of Analysis
Tap Water	Grab sample	Quarterly	7	Gamma spectroscopy, gross α & ß, ^{3}H, $^{238,239+240}$Pu, ^{90}Sr annually).
Potable Supply Wells	Grab sample	Quarterly	11	Gamma spectroscopy, gross α & ß, $^{226\ \&\ 228}$Ra, $^{238,239+240}$Pu, ^{3}H enrich, ^{90}Sr.
Nonpotable Supply Wells	Grab sample	Quarterly	2	Gamma spectroscopy, gross α & ß, ^{3}H, (^{90}Sr annually) $^{238,239+240}$Pu.
Containment Ponds	Grab sample	Quarterly	1	Gamma spectroscopy, gross ß, ^{3}H, $^{238,239+240}$Pu (^{90}Sr annually).
Sewage Lagoons	Grab sample	Quarterly	9	Gamma spectroscopy, gross α, ^{3}H, $^{238,239+240}$Pu (^{90}Sr annually).

(a) All locations were not sampled for various reasons.

Table 5.3 Groundwater Monitoring Parameters at the RWMS-5

Parameters Establishing Water Quality

Elements: Ca, Cl, F, Fe, K, Si, and Na.
Compounds and Ions: HCO_3, H_2CO_3, $SO_4^{=}$, $CO_3^{=}$, NO_2^{-}, and NO_2^{-}

Indicators of Contamination

pH
Conductivity
Total Organic Halogen
Total Organic Carbon
Tritium

Table 5.4 NTS Facilities with RCRA Closure Plans

Location	Designation
Area 2	Bitcutter Shop & LLNL Post-Shot Shop (closed)
Area 2	U-2bu Subsidence Crater

Table 5.4 (NTS Facilities with RCRA Closure Plans, cont.)

Location	Designation
Area 3	U-3fi Injection Well (closed)
Area 6	Decontamination Facility Evaporation Pond
Area 6	Steam Cleaning Effluent Pond (closed)
Area 23	Building 650 Leachfield (closed)
Area 23	Hazardous Waste Trenches (closed)
Area 27	Explosive Ordnance Disposal Facility (closed)

Table 5.5 Locations with Detectable Man-Made Radioactivity - 1998[(a)]

Location	Radionuclide	Concentration $\times 10^{-9}$ µCi/mL
NTS Onsite Network		
Well PM-1	^{3}H	180
Well UE-5n	^{3}H	78,000
Well UE-6d	^{3}H	650
Well UE-7ns	^{3}H	300
Project SHOAL, Nevada		
Well HC-4	^{3}H	680
Project DRIBBLE, Mississippi		
Well HMH-1	^{3}H	890
Well HMH-2	^{3}H	420
Well HMH-5	^{3}H	1,700
Well HMH-10	^{3}H	650
Well HMH-13	^{3}H	2,500
Well HM-L	^{3}H	870
Well HM-S	^{3}H	2,500
Well SA1-1-H	^{3}H	30,000
Well SA1-2-H	^{3}H	4,000
Well SA1-3-H	^{3}H	940
Well SA1-5-H	^{3}H	710
Project GNOME, New Mexico		
Well DD-1	^{3}H	5.8×10^{7}
	^{90}Sr	10,000
	^{137}Cs	7.1×10^{5}
Well LRL-7	^{3}H	1,800
	^{137}Cs	40
Well USGS-4	^{3}H	1.0×10^{5}
	^{90}Sr	3,700
Well USGS-8	^{3}H	62,000
	^{90}Sr	4,200
	^{137}Cs	59

(a) Only ^{3}H concentrations greater than 0.2 percent of the 4 mrem DCG are shown (i.e., greater than 1.6×10^{-7} µCi/mL [160 pCi/L {6 Bq/L}]). Detectable levels of other man-made radioisotopes are also shown.

Table 5.6 Radioactivity in NTS Surface Waters - 1998

Source of Water	No. of Sites	Gross Alpha	Gross Beta	Tritium	^{238}Pu	$^{239+240}Pu$	^{90}Sr
		Annual Average Concentrations (10^{-9} µCi/mL)					
Containment Ponds							
E Tunnel[a]	2[b]	19	56	8.4×10^4	0.2	1.6	0.2
A-19, U-19q PS#1	1			1.5×10^7			
A-20, ER-20-5 #1	1			6.4×10^7			
A-20, ER-20-6 #1, #3	2			2.2×10^3			
A-20, U-20n PS#1	1			6.3×10^7			
Sewage Lagoons[a]	8	26 - 140		-0.0003	0.0018	0.008	
Mean MDC		-1.8	1.2	750	0.018	0.019	0.45

(a) Not a potable water source.
(b) A pond and an effluent.

Table 5.7 NTS Well Cross-Check Results - 1998

Location	Tritium Concentration (10^{-9} µCi/mL)[a] BN	EPA
Area 2, Water Well 2	-260	-56
Area 3, Well U-3cn#5	28	38
Area 4, Test Well D	290	28
Area 6, Test Well B	44	46
Area 16, UE-16f	-290	-5
Area 17, Well HTH-1	-100	-62
Area 18, Well UE-18t	96	100
Area 20, Well PM-1	180	180
Area 27, Well HTH-F	28	33

(a) Underlined results are for enrichment analysis (MDC of 10 x 10^{-9} µCi/mL); otherwise indicates conventional tritium analysis (MDC of 750 x 10^{-9} µCi/mL).

Table 5.8 NTS Drinking Water Sources - 1998

System	Supply Wells	End-Point
No. 1	Wells C1, 4, 4A	Area 6, Cafeteria
	Wells 5B, 5C	Area 6, Building 6-900
	Army No. 1	Area 23, Cafeteria
No. 2	Well 8	Area 2, Restroom
		Area 12, Building 12-23
No. 3	Well UE-16d	Area 1, Building 101
No. 4	Wells J-12, J-13	Area 25, Building 4221

Table 5.9 NTS Supply Well Radioactivity Averages - 1998

	Annual Average Concentrations - 10^{-9} µCi/mL					
Description	Gross Beta	^{3}H	$^{239+240}Pu$	^{238}Pu	Gross Alpha	^{90}Sr (b)
Potable Water Supply Wells						
Area 5, Well 5C	8.3	-4.1	-0.00007	0.0003	14	0.11
Area 5, Well 5B	11	-4.8	-0.0027	-0.0018	6.8	0.085
Area 6, Well 4	6.4	-1.9	-0.0018	-0.0016	9.6	0.16
Area 6, Well 4A	6.4	-0.90	-0.0014	-0.0017	11	0.11
Area 6, Well C1	14	3.6	0.0034	-0.0027	12	0.22
Area 6, Well C(a)	-	-	-	-	-	-
Area 16, Well UE-16d	7.0	-4.3	-0.0030	-0.0014	5.9	0.078
Area 18, Well 8	3.5	-1.9	-0.0028	0.00007	0.82	0.085
Area 22, Army Well No.1	5.6	1.1	-0.0027	-0.00023	3.9	0.10
Area 25, Well J-12	4.9	-3.7	0.00097	-0.00063	1.7	0.15
Area 25, Well J-13	5.0	-5.5	-0.0019	-0.0018	2.4	0.13
Non-Potable Water Supply Wells						
Area 5, Well UE-5c	12	3.6	0.00009	-0.0014	11	0.082
Area 20, Well U-20	3.9	1.8	-0.0019	-0.0013	9.2	0.066
Median MDC	1.2	14	0.017	0.020	1.7	0.28

(a) Pump not operable.
(b) Only one sample collected during the year.

Table 5.10 Radioactivity Averages for NTS Tap Water Samples - 1998

	Annual Average Concentrations - 10^{-9} µCi/mL					
Description	Gross Beta	^{3}H	$^{239+240}Pu$	^{238}Pu	Gross Alpha	^{90}Sr (a)
Area 1, Bldg. 101(b)	-	-	-	-	-	-
Area 2, Restroom(c)	3.9	530	-0.0013	-0.0012	0.64	-
Area 6, Cafeteria	7.4	300	0.0020	0.0011	11	0.14
Area 6, Bldg. 6-900	7.3	140	0.0011	-0.0004	10	0.15
Area 12, Ice House	3.4	160	0.0010	-0.0011	0.69	0.067
Area 23, Cafeteria	9.9	120	0.0000	-0.0001	8.8	0.13
Area 25, Bldg. 4221	5.1	100	-0.0017	-0.0005	1.4	-0.008
Median MDC	1.2	730	0.014	0.014	1.6	0.28

(a) ^{90}Sr values are for one sample.
(b) Water was shut off at all buildings in Area 1 Complex.
(c) Building was not accessible; only one sample collected at outside water tap.

Table 5.11 Radium Analysis Results for NTS Potable Water Supply Wells - 1998

		Concentrations (10^{-9} µCi/mL)			
Location	Number of Samples	^{226}Ra Arithmetic Mean	Standard Deviation	^{228}Ra Arithmetic Mean	Standard Deviation
Area 5, Well 5B	4	0.42	0.56	0.25	0.24
Area 5, Well 5C	4	0.45	0.63	0.051	0.098
Area 6, Well 4	7	0.69	0.71	0.32	0.16
Area 6, Well 4A	3	1.1	0.47	0.026	0.19
Area 6, Well C-1	2	-0.54	0.66	0.78	0.015
Area 16, Well UE-16d	4	1.4	0.88	0.17	0.28
Area 18, Well 8	4	0.067	0.88	0.30	0.20
Area 23, Army Well No. 1	4	0.096	0.25	0.054	0.32
Area 25, Well J-12	4	0.11	0.38	0.0088	0.10
Area 25, Well J-13	4	-0.31	1.3	0.29	0.21
Median MDC		3.4		1.1	

Table 5.12 Summary of Tritium Results for NTS Wells Sampled by R&IE-LV - 1998

			Tritium Concentration (pCi/L)				
Location	Number of Samples	Maximum	Minimum	Arithmetic Mean	1 Sigma	Mean as %DCG(a)	Mean MDC
Test Well B	1	---	---	46	1.8	0.05	4.7
Test Well D	1	---	---	28	65	(b)	220
Well HTH-F	1	---	---	33	1.8	0.03	4.7
Well C-1	1	---	---	9.3	1.6	0.01	5.0
Well HTH-1	1	---	---	-62	65	(b)	220
Well PM-1	1	---	---	180	2.9	0.20	5.0
Well U-3cn5	1	---	---	38	65	(b)	220
Other Analyses	^{234}U	---	---	1.5	0.12	7.1	0.24
	^{235}U	---	---	0.02	0.008	0.09	0.017
	^{238}U	---	---	0.39	0.04	1.6	0.017
	^{238}Pu	---	---	0.003	0.005	(b)	0.019
	$^{239+240}$Pu	---	---	0.013	0.005	1.0	0.012
	^{90}Sr	---	---	0.54	0.38	(b)	1.5
Well UE-1c	1	---	---	-18	62	(b)	200
Well UE-5n	2	84,000	72,000	78,000	430	87	240
Well UE-6d	2	650	500	580	110	0.64	240
Well UE-6e	2	34	14	24	100	(b)	240
Well UE-7ns	2	340	270	300	110	0.33	240
Well UE-16f	1	---	---	-5	65	(b)	220
Well UE-18r	2	50	-38	6	110	(b)	*240*
Well UE-18t	1	---	---	100	62	(b)	200

(a) DCG - Derived Concentration Guide; established by DOE Order as 90,000 pCi/L for water.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Tritium by conventional analysis unless underlined to indicate enrichment analysis.

Table 5.12 (Summary of Tritium Results for NTS Wells Sampled by R&IE-LV - 1998, cont.)

Location	Number of Samples	Maximum	Minimum	Arithmetic Mean	1 Sigma	Mean as %DCG[(a)]	Mean MDC
		Tritium Concentration (pCi/L)					
Well 1 Army	1	---	---	210	85	(b)	280
Well 2	1	---	---	-56	60	(b)	200
Well 4	1	---	---	120	70	(b)	220
Well 5B	1	---	---	120	70	(b)	220
Well 5C	1	---	---	83	85	(b)	280
Well 6A Army	2	2.6	0.48	1.5	2.1	(b)	5.0
Well 8	1	---	---	8	60	(b)	200

(a) DCG - Derived Concentration Guide; established by DOE Order as 90,000 pCi/L for water.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis of ^{3}H, regular font indicates conventional analysis.

Table 5.13 LTHMP Summary of Tritium Results for Wells Near the NTS - 1998

Location	Number of Samples	Max	Min	Mean	1 Standard Deviation	% of DCG[(a)]	Mean MDC
		Tritium Concentration (pCi/L)					
Adaven							
Adaven Spring	4	98	39	68	160	(b)	260
Alamo							
Well 4 City	2	42	0	21	110	(b)	250
Amargosa Valley							
Bar-B-Q Ranch	3	-0.37	-2.6	-1.8	2.7	(b)	5.1
	1	--	--	-10	60	(b)	200
Ponderosa Dairy Well 2	4	77	-55	-7	160	(b)	260
Ash Meadows							
Big Spring	2	0.33	-0.34	0	2.5	(b)	*5.2*
Crystal Pool	3	2.5	-3.7	0.37	2.7	(b)	5.0
	1	--	--	-34	60	(b)	200
Fairbanks Spring	2	0.91	0.61	0.76	2.3	(b)	5.1
Longstreet Spring	2	1.1	-0.41	0.34	2.2	(b)	5.0
17S-50E-14cac	2	44	39	42	110	(b)	250
Well 18S-51E-7db	1	--	--	-15	65	(b)	220
Beatty							
Low Level Waste Site	Pump Out						
Tolicha Peak	4	77	-250	-110	160	(b)	260
11S-48E-1dd Coffer's	3	2.3	-3.7	-1.7	2.8	(b)	5.3
	1	--	--	-10	60	(b)	200

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis of ^{3}H, regular font indicates conventional analysis.

Table 5.13 (LTHMP Summary of Tritium Results for Wells Near the NTS - 1998, cont.)

Location	Number of Samples	Max	Min	Mean	1 Standard Deviation	% of DCG[a]	Mean MDC
		Tritium Concentration (pCi/L)					
Beatty							
12S-47E-7dbd City	2	39	-89	-25	110	[b]	250
Boulder City							
Welcome	1	--	--	-72	64	[b]	220
Caliente	1	--	--	-18	65	[b]	220
Clark Station							
TTR Well 6	2	39	-61	-11	110	[b]	250
Goldfield							
Klondike #2 Well	3	18	-67	-16	130	[b]	220
Henderson							
Community College	1	--	--	58	65	[b]	220
Hiko							
Crystal Springs	2	22	-39	-8	110	[b]	250
Indian Springs							
Sewer Co. Well 1	2	42	39	40	110	[b]	250
Air Force Well 2	2	87	39	53	110	[b]	250
Lathrop Wells							
15S-50E-18cdc City	2	22	0	11	110	[b]	250
Nyala							
Sharp's Ranch	2	-75	-79	-77	110	[b]	250
Oasis Valley							
Goss Springs	Dry						
Pahrump							
Calvada City Well	4	120	-150	-8	160	[b]	260
Passafora Residence	1	--	--	-0.21	1.6	[b]	5.5
Other Analyses	^{90}Sr			-0.41	0.30	[b]	1.4
	^{234}U	--	--	1.5	0.12	7.1	0.0054
	^{235}U	--	--	0.044	0.011	0.2	0.0067
	^{238}U	--	--	0.64	0.06	2.7	0.0054
	^{238}Pu	--	--	2.0×10^{-7}	0.0038	[b]	0.018
	^{239}Pu	--	--	0.0059	0.0034	0.45	0.0053
Rachel							
Penoyer Culinary	4	190	-170	-22	160	[b]	260
Tonopah							
City Well	2	3	-79	-38	110	[b]	250
Warm Springs							
Twin Springs Ranch	4	77	-140	-30	160	[b]	260

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis ^{3}H, regular font indicates conventional analysis.

Table 5.14 LTHMP Summary of Tritium Results for Project FAULTLESS - 1998

Location	Number of Samples	Tritium Concentration (pCi/L) Result	1 Standard Deviation	% of DCG[a]	Mean MDC
Hot Creek Ranch	1	0	85	(b)	280
Blue Jay Maintenance	1	94	85	(b)	280
Site C Compels	1	-58	85	(b)	280
Well HTH-1	1	-1.2	2.0	(b)	6.5
Well HTH-2	1	2.2	1.5	(b)	4.8
Well Six Mile	1	-28	85	(b)	280

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis of ^{3}H, regular font indicates conventional analysis.

Table 5.15 LTHMP Summary of Tritium Results for Project SHOAL - 1998

Location	Number of Samples	Tritium Concentration (pCi/L) Result	1 Standard Deviation	% of DCG[a]	Mean MDC
Hunts' Station	1	-72	85	(b)	230
Well Flowing	1	-41	85	(b)	280
Well HC-1	1	-26	65	(b)	220
Well HC-2	1	2.1	1.5	(b)	4.8
Well HC-3	Well Dry				
Well HC-4	1	680	71	0.76	220
Well H-2	1	50	85	(b)	280
Well H-3	1	14	85	(b)	280
Well HS-1	1	-1.3	1.7	(b)	5.6

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis of ^{3}H, regular font indicates conventional analysis.

Table 5.16 LTHMP Summary of Tritium Results for Project RULISON - 1998

Location	Number of Samples	Tritium Concentration (pCi/L) Result	1 Sigma	% of DCG[a]	Mean MDC
Battlement Creek	1	90	95	(b)	310
City Springs	1	-24	95	(b)	310
Gardner Ranch	1	180	96	(b)	310
Well CER Test	1	0	95	(b)	310

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis of ^{3}H, regular font indicates conventional analysis.

Table 5.16 (LTHMP Summary of Tritium Results for Project RULISON - 1998, cont.)

Location	Number of Samples	Tritium Concentration (pCi/L) Result	1 Sigma	% of DCG(a)	Mean MDC
Hayward Ranch	1	80	2.4	0.09	5.5
Potter Ranch	1	140	96	(b)	310
Jacobs Ranch	1	290	96	(b)	310
Rothgery Ranch	1	73	95	(b)	310
Spring 300 Yards N	1	-55	968	(b)	320
Well RU-1	1	42	2.5	0.05	6.9
Well RU-2	1	33	2.0	0.03	5.3

Special Samples

	Tritium (^3H)	Total Uranium[3]	Plutonium	Cesium-137
Koch Ranch Well	38 ± 5	11 ± ~2	<MDC	<MDC
Goad Ranch Well (filtered)[1]	32 ± 5	4.2 ± ~1	<MDC	<MDC
Goad Ranch Well (unfiltered)[2]	32 ± 5	6.0 ± ~1	<MDC	<MDC
Arnold Machley Well	35 ± 5	7.9 ± ~1.5	<MDC	<MDC

[1] Sample collected with wellhead filter in line (EPA sample, May 12, 1998).
[2] Sample collected with wellhead filter removed (Maxim Environmental sample, May 21, 1998).
[3] Total uranium error estimated to be <20%.

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis of ^3H, regular font indicates conventional analysis.

Table 5.17 LTHMP Summary of Tritium Results for Project RIO BLANCO - 1998

Location	Number of Samples	Tritium Concentration (pCi/L) Result	1 Sigma	% of DCG(a)	Mean MDC
B-1 Equity Camp	1	30	95	(b)	310
Brennan Windmill	1	-54	60	(b)	200
CER 1 Black Sulphur	1	81	95	(b)	310
CER 4 Black Sulphur	1	30	95	(b)	310
Fawn Creek 1	1	32	95	(b)	310
Fawn Creek 500' Up	1	-54	94	(b)	310
Fawn Creek 500' Down	1	135	95	(b)	310
Fawn Creek 6800' Up	1	35	95	(b)	310
Fawn Creek 8400' Down	1	-11	95	(b)	310
Fawn Creek 3	1	170	95	(b)	310
Johnson Artesian	1	70	60	(b)	200
Well RB-D-01	1	2.7	16	(b)	5.3
Well RB-D-03	1	1.3	1.4	(b)	4.6
Well RB-S-03	1	1.4	1.5	(b)	4.8

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis of ^3H, regular font indicates conventional analysis.

Table 5.18 LTHMP Summary of Tritium and Cesium Results for Project GNOME - 1998

Location	Number of Samples	Concentration (pCi/L) Result	1 Sigma	% of DCG[a]	Mean MDC
Carlsbad City Well	1	0.8	1.5	(b)	4.9
Loving City Well 2	1	-72	64	(b)	220
Well DD-1	1	5.8×10^7	5.2×10^4	(b)	220
^{137}Cs	1	7.1×10^5	4.6×10^3	(b)	6.5
^{90}Sr	1	1.0×10^4		(b)	
Well LRL-7	1	1.8×10^3	160	(b)	220
^{137}Cs	1	40	3.8	(b)	4.5
Well PHS 6	1	-20	65	(b)	220
Well PHS 8	1	49	66	(b)	220
Well PHS 9	1	-36	65	(b)	220
Well PHS 10	1	56	66	(b)	220
Well USGS 1	1	1.6	1.4	(b)	4.7
Well USGS 4	1	1.0×10^5	340	(b)	220
^{90}Sr	1	3.7×10^3		(b)	
Well USGS 8	1	6.2×10^4	270	(b)	220
^{137}Cs	1	59	3.8	(b)	3.2
^{90}Sr	1	4.2×10^3		(b)	
J. Mobley Ranch	1	3.6	1.6	(b)	4.9

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis of ^3H, regular font indicates conventional analysis.

Table 5.19 LTHMP Summary of Tritium Results for Project GASBUGGY - 1998

Location	Number of Samples	Tritium Concentration (pCi/L) Result	1 Sigma	% of DCG[a]	Mean MDC
La Jara Creek	1	-4	60	(b)	200
Lower Burro Canyon	1	90	61	(b)	200
Pond N of Well 30.3.32.3	1	98	61	(b)	200
Arnold Ranch Spring	1	-24	60	(b)	200
Arnold Ranch Well	1	84	62	(b)	200
Bubbling Springs	1	-4	60	(b)	200
Cave Springs	1	36	1.8	0.04	4.6
Cedar Springs	1	36	2.0	0.04	5.6
Jicarilla Well 1	1	78	60	(b)	200
Well 28.3.33.233	1	150	62	(b)	200
Well 30.3.32.343	Windmill Removed				
Windmill 2	1	52	61	(b)	200
Well EPNG 10-36	1	100	2.2	0.11	4.6

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis of ^3H, regular font indicates conventional analysis.

Table 5.20 LTHMP Summary of Tritium Results for the SALMON Site - April 1998

Location		Collected Date -1998	Tritium Concentration (pCi/L) Result	1 Sigma	% of DCG[a]	Mean MDC
Baxterville, MS						
Anderson, Billy Ray		4/22	11	1.6	0.01	4.9
Anderson Pond		4/20	12	1.6	0.01	5.1
Anderson, Robert Harvey		4/22	-38	68	(b)	230
Anderson, Robert Lowell, Jr.		4/22	-76	68	(b)	230
Anderson, Robert Lee		4/22	-76	68	(b)	230
Anderson, Tony		4/21	191	70	(b)	230
Burge, Joe		4/22	-76	68	(b)	230
Daniels, Webster, Jr.		HUB water, no sample				
Daniels - Well No. 2 Fish Pond		Pump out, no sample				
Hibley, Billy		4/20	-76	68	(b)	230
Thompson, Mike		4/21	-76	68	(b)	230
O'Quinn, Jim		4/20	-76	68	(b)	230
Salt Dome Hunting Club		Moved, no sample				
Salt Dome Timber Co.		Business closed, no sample				
Saucier, Dennis		4/20	0	69	(b)	230
Well Ascot 2		4/21	24	1.7	0.03	4.9
Baxterville Well City		4/21	16	1.8	0.02	5.5
Well E-7		4/21	-1.2	1.4	(b)	4.7
Well HM-1	Pre pump	4/20	-1	83	(b)	280
	½ hr pump	4/20	-65	84	(b)	280
	1 hr pump	4/20	-76	83	(b)	280
	Post	4/20	57	84	(b)	280
Well HM-2A	Pre pump	4/20	-1	83	(b)	280
	½ hr pump	4/20	-46	84	(b)	280
	1 hr pump	4/20	16	84	(b)	280
	Post pump	4/20	-22	84	(b)	280
Well HM-2B	Pre pump	4/20	35	84	(b)	280
	½ hr pump	4/20	-27	84	(b)	280
	Post pump	4/20	-65	84	(b)	280
Well HM-3	Pre pump	4/20	1.2	1.4	(b)	4.7
	½ hr pump	4/20	-1	70	(b)	280
	1 hr pump	4/20	-183	82	(b)	280
	1½ hr pump	4/20	-65	84	(b)	280
	Post pump	4/20	-85	83	(b)	280
Half Moon Creek	Pre	4/20	14	1.8	0.01	5.4
	Post	4/21	15	1.6	0.01	4.7
Half Moon Creek	Pre[d]	4/20	120	84	(b)	280
Overflow	Post	4/21	87	84		280
Lee, P. T.		4/20	-76	68	(b)	230
Little Creek No. 1		4/20	-38	68	(b)	230
Lower Little Creek No. 2		4/20	38	69	(b)	230
Mills, Roy		4/20	-150	68	(b)	230
Napier, Denice		4/20	38	70	(b)	230
Noble's Pond		4/20	38	70	(b)	230
Noble, Evelyn.		4/22	-38	69	(b)	230

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
(c) Underline indicates enrichment analysis.
(d) Pre indicates sampling prior to pumping the well, Post indicates sampling after pumping the well.

Table 5.20 (LTHMP Summary of Tritium Results for the SALMON Site - April 1998, cont.)

Location		Collected Date -1998	Tritium Concentration (pCi/L) Result	1 Sigma	% of DCG[a]	Mean MDC
(Baxterville, MS, cont.)						
Pond West of SGZ	Pre	4/20	13	1.7	0.01	5.4
	Post	4/21	12	2.0	0.01	6.2
Well HM-L	Pre pump	4/20	970	88	1.0	280
	½ hr pump	4/20	620	87	0.7	280
	1 hr pump	4/20	620	87	0.7	280
	1½ hr pump	4/20	770	88	0.9	280
	2 hr pump	4/20	650	87	0.7	280
	Post pump	4/20	740	88	(b)	280
REECo Pit Drainage-A		4/21	11	1.7	0.01	5.3
REECo Pit Drainage-B		4/21	72	2.0	0.08	4.8
REECo Pit Drainage-C		4/21	70	2.1	0.08	4.9
Well HM-L2	Pre[d]	4/21	-134	83	(b)	280
	Post	4/21	-98	83	(b)	280
Well HM-S	Pre	4/19	2400	96	2.7	280
	Post	4/20	2500	110	2.8	320
Well HMH-1	Pre	4/19	22	1.9	0.02	5.5
	Post	4/20	890	88	0.99	280
Well HMH-2	Pre	4/19	-38	68	(b)	280
	Post	4/20	420	86	0.05	280
Well HMH-3	Pre	4/19	-38	68	(b)	280
	Post	4/20	22	1.9	0.02	5.5
Well HMH-4	Pre	4/19	9.8	1.5	0.01	4.7
	Post	4/20	Well dry, no sample			
Well HMH-5	Pre	4/19	130	80	(b)	230
	Post	4/20	1700	92	1.9	280
Well HMH-6	Pre	4/19	59	2.2	0.06	5.3
	Post	4/20				
Well HMH-7			No Sample, well under water			
Well HMH-8			No Sample, well under water			
Well HMH-9	Pre	4/20	27	2.2	0.03	6.1
	Post	4/21	57	84	(b)	280
Well HMH-10	Pre	4/19	650	74	0.72	230
	Post	4/20	350	85	0.39	280
Well HMH-11	Pre	4/19	76	70	(b)	230
	Post	4/20	-71	83	(b)	280
Well HMH-12	Pre	4/19	-153	67	(b)	230
	Post	4/20	-41	84	(b)	280
Well HMH-13	Pre	4/19	2500	89	2.8	230
	Post	4/20	-19	84	(b)	280
Well HMH-14	Pre	Well dry, no sample				
Well HMH-15	Pre	4/19	-76	68	(b)	230
	Post	4/20	-153	83	(b)	280

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
(c) Underline indicates enrichment analysis.
(d) Pre indicates sampling prior to pumping the well, Post indicates sampling after pumping the well.

Table 5.20 (LTHMP Summary of Tritium Results for the SALMON Site - April 1998, cont.)

Location		Collected Date -1998	Tritium Concentration (pCi/L) Result	1 Sigma	% of DCG[(a)]	Mean MDC
(Baxterville, MS cont.)						
Well HMH-16	Pre	4/19	57	2.2	0.06	5.3
	Post	4/20	67	2.2	0.07	5.1
Well HT-2C		4/21	2.2	1.4	(b)	4.6
Well HT-4		4/21	-0.8	1.6	(b)	5.3
Well HT-5		4/24	-41	84	(b)	280
SA1-1-H	Pre	4/19	30,000	220	33	280
	Post	4/20	28,000	200	31	230
SA1-2-H	Pre	4/19	3,800	100	0.42	280
	Post	4/20	4,000	100	0.44	280
SA1-3-H	Pre	4/19	1,200	90	0.13	280
	Post	4/20	940	88	1.0	280
SA1-4-H	Pre	4/19	270	85	(b)	280
	Post	4/20	200	84	(b)	280
SA1-5-H	Pre	4/19	700	88	0.78	280
	Post	4/20	710	88	0.79	280
SA1-6-H	Pre	4/19	41	84	(b)	280
	Post	4/20	-68	83	(b)	280
SA1-7-H	Pre	4/19	33	1.9	0.04	5.4
	Post	4/20	30	1.8	0.03	4.8
SA1-8-L		4/22	1.6	1.4	(b)	4.8
SA1-9-2A		4/23	0.09	1.4	(b)	4.7
SA1-10-2B		4/22	-2.4	1.6	(b)	5.4
SA1-11-3		4/22	-1.8	1.5	(b)	5.0
SA2-1-L		4/22	1.4	1.5	(b)	4.9
SA2-2-L		4/22	1.7	1.6	(b)	5.1
SA2-3-L		4/22	0.38	1.5	(b)	4.9
SA2-4-L		4/22	0.09	1.6	(b)	5.1
SA2-5-L		4/23	-1.3	2.9	(b)	5.3
SA3-4-H	Pre	4/19	20	1.6	0.02	4.9
	Post	4/20	21	1.7	0.02	4.9
SA3-1-M	Pre	4/19	10	1.6	0.01	5.2
	Post	4/20	7.4	1.6	<0.01	4.7
SA3-3-M	Pre	4/19	11	1.5	0.01	4.7
	Post	4/20	16	1.6	0.02	4.7
SA3-8-1		4/23	0	1.6	(b)	5.3
SA3-10-2B		4/22	-1.2	1.8	(b)	5.9

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
(c) Underline indicates enrichment analysis.
(d) Pre indicates sampling prior to pumping the well, Post indicates sampling after pumping the well.

Table 5.20 (LTHMP Summary of Tritium Results for the SALMON Site - April 1998, cont.)

Location		Collected Date - 1998	Tritium Concentration (pCi/L) Result	1 Sigma	% of DCG(a)	Mean MDC
(Baxterville, MS, cont.)						
SA3-11-3		4/23	0.43	1.7	(b)	5.6
SA4-1-M	Pre	4/19	1.7	1.5	(b)	4.9
	Post	4/20	1.7	1.5	(b)	4.9
SA5-1-M	Pre	4/19	12	1.6	0.01	4.6
	Post	4/20	9.9	1.5	0.01	4.7
SA5-2-M	Pre	4/19	14	1.6	0.01	5.3
	Post	4/20	19	1.6	0.02	4.9
SA5-3-M	Pre	4/19	7.2	1.5	0.01	4.7
	Post	4/20	65	84	(b)	280
SA5-4-4		4/22	-0.54	1.4	(b)	4.7
SA5-5-4		4/22	2.3	1.4	(b)	4.7
Columbia, MS						
Dennis, Buddy		HUB water, no sample				
Dennis, Marvin		Doesn't want to participate				
Well 64B City		4/21	-38	68	0.01	230
Lumberton, MS						
.						
Anderson, Arleene		4/22	0	69	(b)	230
Anderson, Lee L		4/20	110	70	(b)	230
Boren, Ron		4/20	-38	70	(b)	230
Boren Crawfish Pond		4/20	38	70	(b)	230
Hartfield, Ray		4/20	-38	70	(b)	230
Ladner, Rushing, Debra		HUB water, no sample				
Powell, Shannon		4/20	0	61	(b)	200
Saul, O/A		HUB water, no sample				
Smith, Howard - Pond		4/20	38	70	(b)	230
Thompson, Roswell		4/20	76	70	(b)	230
Well 2 City		4/21	38	70	(b)	230
Purvis, MS						
Burge, Willie Ray & Grace		4/22	38	70	(b)	230
City Supply Purvis		4/21	-0.72	1.4	(b)	4.7

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
(c) Underline indicates enrichment analysis.
(d) Pre indicates sampling prior to pumping the well, Post indicates sampling after pumping the well.

Table 5.21 Influent Quality - 1998

Facility	1st Quarter S.C.[b] (mg/L)	1st Quarter BOD5[a] (µmhos/cm)	2nd Quarter S.C.[b] (mg/L)	2nd Quarter BOD5[a] (µmhos/cm)	3rd Quarter S.C.[b] (mg/L)	3rd Quarter BOD5[a] (µmhos/cm)	4th Quarter S.C.[b] (mg/L)	4th Quarter BOD5[a] (µmhos/cm)
Gate 100	306	1.08	167	1.34	121	1.27	41	1.21
Mercury	362	0.76	93	0.69	51	0.60	188	0.96
Yucca Lake	143	1.91	129	0.73	144	1.17	144	0.95
Tweezer	229	1.22	222	1.10	77	0.81	176	1.18
DAF	38	1.18	19	1.38	<60	1.18	5	1.07
Reactor Control	0	0	0	0	0	0	0	0
Test Stand 1	0	0	0	0	0	0	0	0
Base Camp 25	60	1.24	99	1.00	115	0.86	283	0.67
Base Camp 12	<6	0.26	10	0.30	<60	0.40	3	0.21
Test Cell C	0	0	0	0	0	0	0	0
RWMS Site 5	272	1.21	350	1.90	264	2.40	431	1.74

(a) Biochemical Oxygen Demand - 5-day Incubation.
(b) Specific Conductance.

Table 5.22 Organic Loading Rates - 1998

Facility	Limit (Kg/day)	(Jan-Mar) Mean Daily Load	(Apr-June) Mean Daily Load	(Jul-Sept) Mean Daily Load	(Oct-Dec) Mean Daily Load
Metered Rates					
Mercury	172	51.34	17.12	22.02	65.78
LANL on Tweezer	5.0	1.17	4.64	0.37	0.55
Yucca Lake	8.6	6.16	4.47	3.79	2.97
Base Camp 12	54	0.02	0.13	0.74	0.01
RWMS Site 5	0.995	0.18	0.71	0.33	0.55
Calculated Rates					
DAF	7.6	0.4	0.49	1.23	0.12
Reactor Control	4.2	0	0	0	0
Eng Test Stand	2.3	0	0	0	0
Test Cell C	1.3	0	0	0	0
Base Camp 25	7.4	0.4	1.71	2.35	4.48
Gate 100	2.4	1.4	0.53	0.46	0.09

Table 5.23 Pond Water Depths in Infiltration Basins - 1998

Impound	Maximum Operating Depth, cm	Average Depth, cm (1st Quarter)	Average Depth, cm (2nd Quarter)	Average Depth, cm (3rd Quarter)	Average Depth, cm (4th Quarter)
Gate 100, Basin	90	36	13	0	0
Mercury, Basin	180	0	0	0	0
Yucca Lake					
North Basin	140	127	127	104	0
South Basin	140	18	18	0	0
Tweezer					
East Basin	244	0	0	0	0
West Basin	244	0	0	0	0
DAF					
Basin 1	150	0	55	0	0
Basin 2	150	0	0	30	0
Reactor Control, Basin	130	0	0	0	0
Reactor Control, Primary	130	-	-	-	35
Test Stand 1, Basin	90	0	0	0	0
Test Cell C, Basin	90	0	0	0	0
Base Camp 25, Basin	100	0	0	0	0
Base Camp 25, Primary	100	-	-	74	86
Base Camp 12, Basin 1	120	0	0	0	0
Base Camp 12, Basin 2	120	0	0	0	0
Base Camp 12, Basin 3	120	0	0	0	0
Base Camp 12, Basin 4	120	0	0	0	0
Base Camp 12, Basin 5	120	0	0	0	0

Note: Primary lagoons at Reactor Control and Base Camp 25 also began to be considered infiltration basins in 1998.

Table 5.24 Influent Toxics for Facilities that Received Industrial Wastewater - 1998

Parameter	Compliance Limit (mg/L)	Mercury Measurement (mg/L)	Area 25 Base Camp Measurement (mg/L)	Area 6 DAF Measurement (mg/L)	Area 5 RWMS Measurement (mg/L)	Area 6 LANL Measurement (mg/L)	Area 6 Yucca Lake Measurement (mg/L)
Arsenic	5.0	0.013	0.008	0.013	0.005	0.008	0.006
Barium	100	0.020	0.019	0.020	0.030	0.054	0.023
Cadmium	1.0	(a)	(a)	(a)	(a)	(a)	(a)
Chromium	5.0	(a)	(a)	(a)	(a)	0.006	(a)
Lead	5.0	0.007	0.002	0.009	0.005	0.001	0.003
Mercury	0.2	(a)	(a)	(a)	(a)	(a)	(a)
Selenium	1.0	(a)	(a)	(a)	(a)	(a)	(a)
Silver	5.0	(a)	(a)	(a)	(a)	(a)	(a)
Benzene	0.5	(a)	(a)	(a)	(a)	(a)	(a)
Carbon Tertachloride	0.5	(a)	(a)	(a)	(a)	(a)	(a)
Chlorobenzene	100	(a)	(a)	(a)	(a)	(a)	(a)
Chloroform	6.0	(a)	(a)	(a)	(a)	(a)	(a)
1,4-dichlorobenzene	7.5	(a)	(a)	(a)	(a)	(a)	(a)
1,2-dichlorobenzene	0.5	(a)	(a)	(a)	(a)	(a)	(a)
1,1-dichloroethylene	0.7	(a)	(a)	(a)	(a)	(a)	(a)
Methylethyl Ketone	200	(a)	(a)	(a)	(a)	(a)	(a)

(a) Not Detected.

Table 5.24 (Influent Toxics for Facilities that Received Industrial Wastewater - 1998, cont.)

Parameter	Compliance Limit (mg/L)	Mercury Measurement (mg/L)	Area 25 Base Camp Measurement (mg/L)	Area 6 DAF Measurement (mg/L)	Area 5 RWMS Measurement (mg/L)	Area 6 LANL Measurement (mg/L)	Area 6 Yucca Lake Measurement (mg/L)
Pyridine	5.0	(a)	(a)	(a)	(a)	(a)	(a)
Tetrachloroethylene	0.7	(a)	(a)	(a)	(a)	(a)	(a)
Trichloroethylene	0.5	(a)	(a)	(a)	(a)	(a)	(a)
Vinyl Chloride	0.2	(a)	(a)	(a)	(a)	(a)	(a)
Cresol, total	200	(a)	(a)	(a)	(a)	(a)	(a)
2,4-dinitrotoluene	0.13	(a)	(a)	(a)	(a)	(a)	(a)
Hexachlorobenzene	0.13	(a)	(a)	(a)	(a)	(a)	(a)
Hexachlorobutadiene	0.5	(a)	(a)	(a)	(a)	(a)	(a)
Nitrobenzene	2.0	(a)	(a)	(a)	(a)	(a)	(a)
Pentachlorophenol	100	(a)	(a)	(a)	(a)	(a)	(a)
2,4,5-trichlorophenol	400	(a)	(a)	(a)	(a)	(a)	(a)
2,4,6-trichlorophenol	2.0	(a)	(a)	(a)	(a)	(a)	(a)
Chlorodane	0.03	(a)	(a)	(a)	(a)	(a)	(a)
Endrin	0.02	(a)	(a)	(a)	(a)	(a)	(a)
Heptachlor	0.008	(a)	(a)	(a)	(a)	(a)	(a)
Lindane	0.4	(a)	(a)	(a)	(a)	(a)	(a)
Methoxychlor	10.0	(a)	(a)	(a)	(a)	(a)	(a)
Toxaphene	0.5	(a)	(a)	(a)	(a)	(a)	(a)
2,4-D	10.0	(a)	(a)	(a)	(a)	(a)	(a)
2,4,5-TP (Silvex)	1.0	(a)	(a)	(a)	(a)	(a)	(a)

(a)   Not Detected.

Table 5.25 Sampling Data for Infiltration Ponds Containing 30 cm or More - 1998

Parameter	Action Level mg/L	A-6 Yucca Lake Q2 Result mg/L
Arsenic	0.5	(a)
Cadmium	0.1	(a)
Chromium	0.5	(a)
Lead	0.5	(a)
Selenium	0.1	(a)
Silver	0.5	(a)
Nitrate Nitrogen	100	(a)
Sulfate	5000	87.2
Chloride	1000	74.1
Fluoride	40	1.6
Tritium	Monitor Only	(a)

(a) Not Detected.
Note: Most sewage ponds on the NTS are exempt from this requirement.

Table 5.26 Nitrate Analyses of Well Water Samples (mg/L), First Quarter - 1998

Well Name	Limit	Result	Well Name	Limit	Result
Well 5C	10	1.5	Well J-12	10	2.2
Well 5B	10	2.9	Well J-13	10	2.5
Well 4	10	3.2	Well 8	10	1.4
Well C-1	10	<1	Well UE-16d	10	0.5
Well 4-A	10	3.6	Well Army 1	10	2

Table 5.27 NTS Drinking Water System Permits - 1998

Permit No.	Area(s)	Expiration Date	Reporting Required
NY-5024-12CNT	Area 1	09/30/1999	None
NY-4099-12C	Area 2 & 12	09/30/1999	None
NY-360-12C	Area 23	09/30/1999	None
NY-4098-12CNT	Area 25	09/30/1999	None
NY-835-12H	Sitewide Truck	09/30/1999	None
NY-836-12H	Sitewide Truck	09/30/1999	None
NY-841-12H	Sitewide Truck	09/30/1999	None

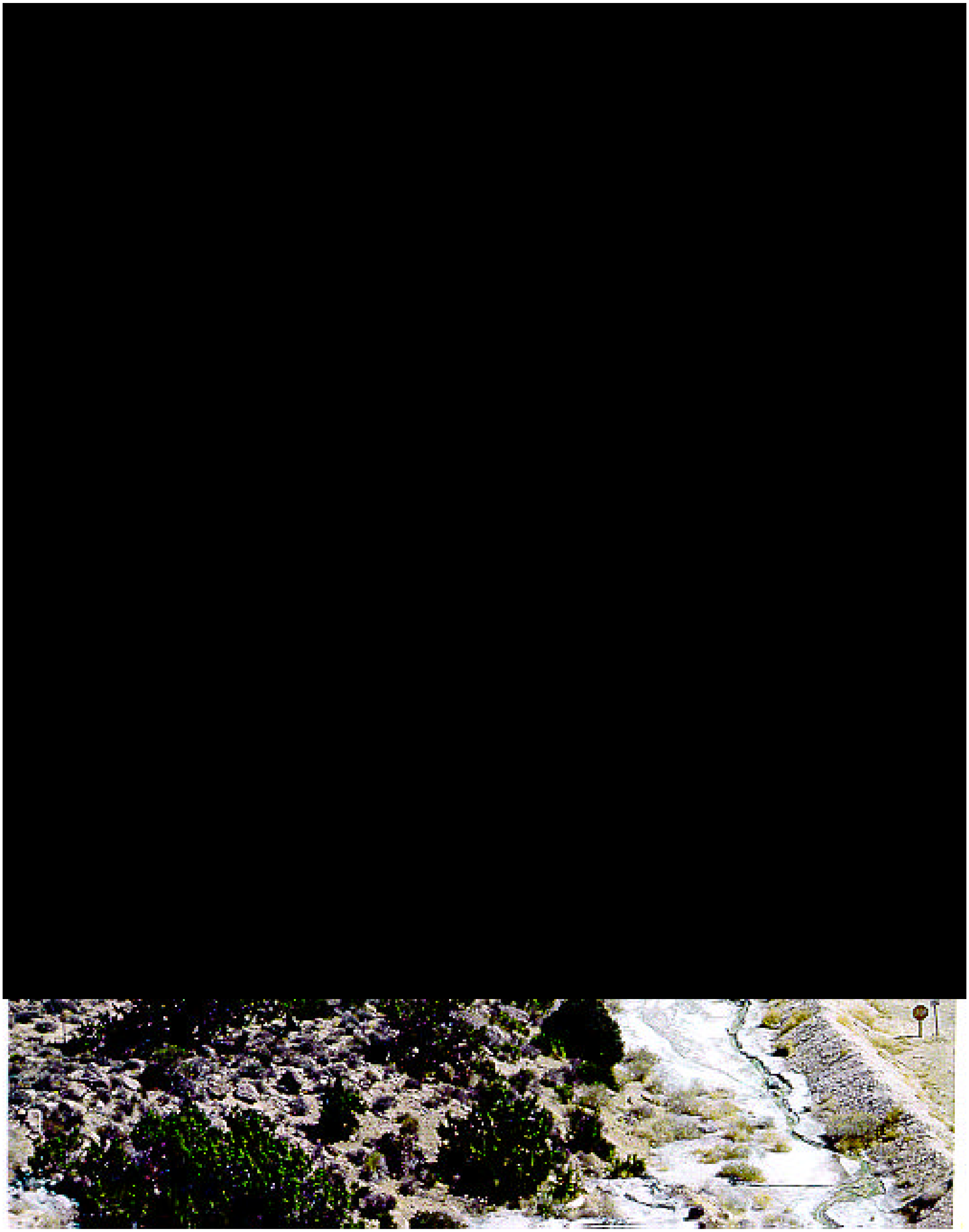
Table 5.28 Sewage Discharge Permits - 1998

Permit No./Location	Areas	Expiration Date	Reporting Required
NTS Permits			
GNEV93001[a]	NTS General Permit	01/31/1999	Quarterly
NY-17-05704	X Tunnel Collection System	09/01/1999	Quarterly
Off-NTS Permits			
North Las Vegas Facility			
VEH-112	NLVF (Sewage Contribution)[a]	12/31/1999	Annually
Special Technologies Laboratory			
AII-204/ Santa Barbara, California		12/31/1998	
III-331/ Santa Barbara, California		12/31/1998	

(a) Owner/Operator effluent monitoring required by permit.

Table 5.29 Permits for NTS Septic Waste Hauling Trucks - 1998

Permit Number	Vehicle Identification Number	Expiration Date
NY-17-03311	Septic Tank Pumper E-104573	11/30/1999
NY-17-03313	Septic Tank Pumper E-105293	11/30/1999
NY-17-03314	Septic Tank Pumper E-105299	11/30/1999
NY-17-03315	Septic Tank Pumper E-105919	11/30/1999
NY-17-03317	Septic Tank Pumper E-105918	11/30/1999
NY-17-03318	Septic Tank Pumping Subcontractor Vehicle	11/30/1999



U12N Overview of All Ponds from the Top of Muck Pile (March 13, 1989)

6.0 OTHER REPORTABLE ACTIVITIES

Reported in this section are environmental surveillance activities other than those in air and water. Activities reported are those related to the Nevada Test Site (NTS) missions and special studies under the purview of the Environment, Safety and Health Division (ESHD) of the U.S. Department of Energy Nevada Operations Office (DOE/NV). Included herein are milk surveillance, ecological monitoring, historic preservation, pollution prevention, Hazardous Materials Spill Center (HSC) operations, and waste management activities. Ecological monitoring encompasses assessment of vegetation associations, wild horse surveys, natural and man-made water sources used by wildlife and related studies.

6.1 STOCKPILE STEWARDSHIP RELATED ACTIVITIES

Under the terms of an Interagency Agreement between the DOE and the U.S. Environmental Protection Agency (EPA), the EPA's Office of Radiation and Indoor Environments National Laboratory-Las Vegas (R&IE-LV) conducts the Offsite Radiation Safety Program (ORSP). The primary activity of the ORSP is routine monitoring of potential human exposure pathways. These pathways include milk (discussed below), groundwater (discussed in Chapter 5), and air and direct radiation exposure (discussed in Chapter 4). Maintaining readiness to support nuclear testing, public information, and community assistance constitute secondary activities.

Three subcritical experiments were conducted in 1998: STAGECOACH, BAGPIPE, and CIMARRON. For each of the experiments, R&IE-LV senior personnel served on the Test Controller's Scientific Advisory Panel and on the EPA's offsite radiological safety staff.

No radioactive materials were released to the ambient environment as a result of these three experiments.

6.2 RADIOLOGICAL SURVEILLANCE

OFFSITE MILK SURVEILLANCE NETWORK (MSN)

Milk is an important source for evaluating potential human exposures to radioactive material. It is one of the most universally consumed nutrients, and certain radionuclides are readily traceable through the food chain from feed or forage to the consumer. This is particularly true of radioiodine isotopes, which, when consumed in sufficient quantities, can cause impairment of thyroid function. Because dairy animals consume vegetation representing a large area and because many radionuclides are transferred to milk, analysis of milk samples yields information on the deposition of small amounts of radionuclides over a relatively large area.

The MSN includes commercial dairies and family-owned milk cows and goats representing the major milksheds within 300 km (186 miles) of the NTS. This network was designed to monitor areas adjacent to the NTS, which could be affected by a release of activity, as well as from areas unlikely to be affected. There were ten locations comprising the MSN during 1998. Samples were collected from these locations, shown in Figure 6.1, in July 1998.

Raw milk was collected in 3.8-L (1-gal) Cubitainers from each MSN location and preserved with formaldehyde. The samples were analyzed by high-resolution gamma spectrometry for gamma emitters and for ^{90}Sr by radiochemical separation and beta counting.

The average total potassium concentration, derived from naturally occurring ^{40}K activity, was 1.5 g/L for samples analyzed by gamma spectrometry. No other gamma-ray emitters were detected. Selected MSN milk samples were analyzed for ^{89}Sr and ^{90}Sr, and the results are similar to those obtained in previous years with no obvious trends. The MSN network average ^{90}Sr values are shown in Table 6.1.

6.3 NONRADIOLOGICAL MONITORING

The 1998 nonradiological monitoring program for the 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 habitat mapping in northern NTS areas, characterized springs, monitored man-made water sources, conducted wild horse surveys, and prepared a biological monitoring plan for the HSC. In 1998, nonradiological monitoring was performed for six series of tests involving 23 chemicals that were conducted at the HSC.

ENVIRONMENTAL SURVEILLANCE

Routine nonradiological monitoring on the NTS in 1998 was limited to:

- Nevada operating permit requirements.
- Sampling of electrical equipment oil, soil, water, surfaces, and waste oil for the presence of polychlorinated biphenyls (PCBs) as part of Toxic Substance Control Act compliance.
- Sampling of soil, water, sediment, waste oil, and other media for Resource Conservation and Recovery Act (RCRA) constituents.

Two facilities at the NTS that are listed in the NTS Hazardous Waste Management Permit have undergone RCRA Closure and require post-closure monitoring.

- Post-closure monitoring of the Mercury Landfill Hazardous Waste Trenches RCRA Closure Unit was conducted on a monthly basis for soil moisture in 1998 because of much heavier than normal rainfall. The covers continue to perform as designed, with no releases occurring.
- Post Closure monitoring of the U-3fi Injection Well RCRA Closure Unit was conducted on a quarterly basis. Downward movement of moisture was not detected during the calendar year (CY); therefore, the conditions of the permit have not been exceeded.

In support of these NTS facility operations, samples are collected and analyzed from various waste streams in order to show compliance with operational requirements, or to properly dispose of the wastes generated. Most of the nonradiological analyses are performed at approved offsite laboratories. During 1998, 157 bulk or air samples were collected for asbestos determination, 70 oil samples collected for PCBs determination, and 1,627 samples of various kinds collected for chemical characterization.

ECOLOGICAL MONITORING

The ecological monitoring tasks conducted under the EMAC program in 1998 included habitat mapping of the northern two thirds of the NTS, characterizing and monitoring

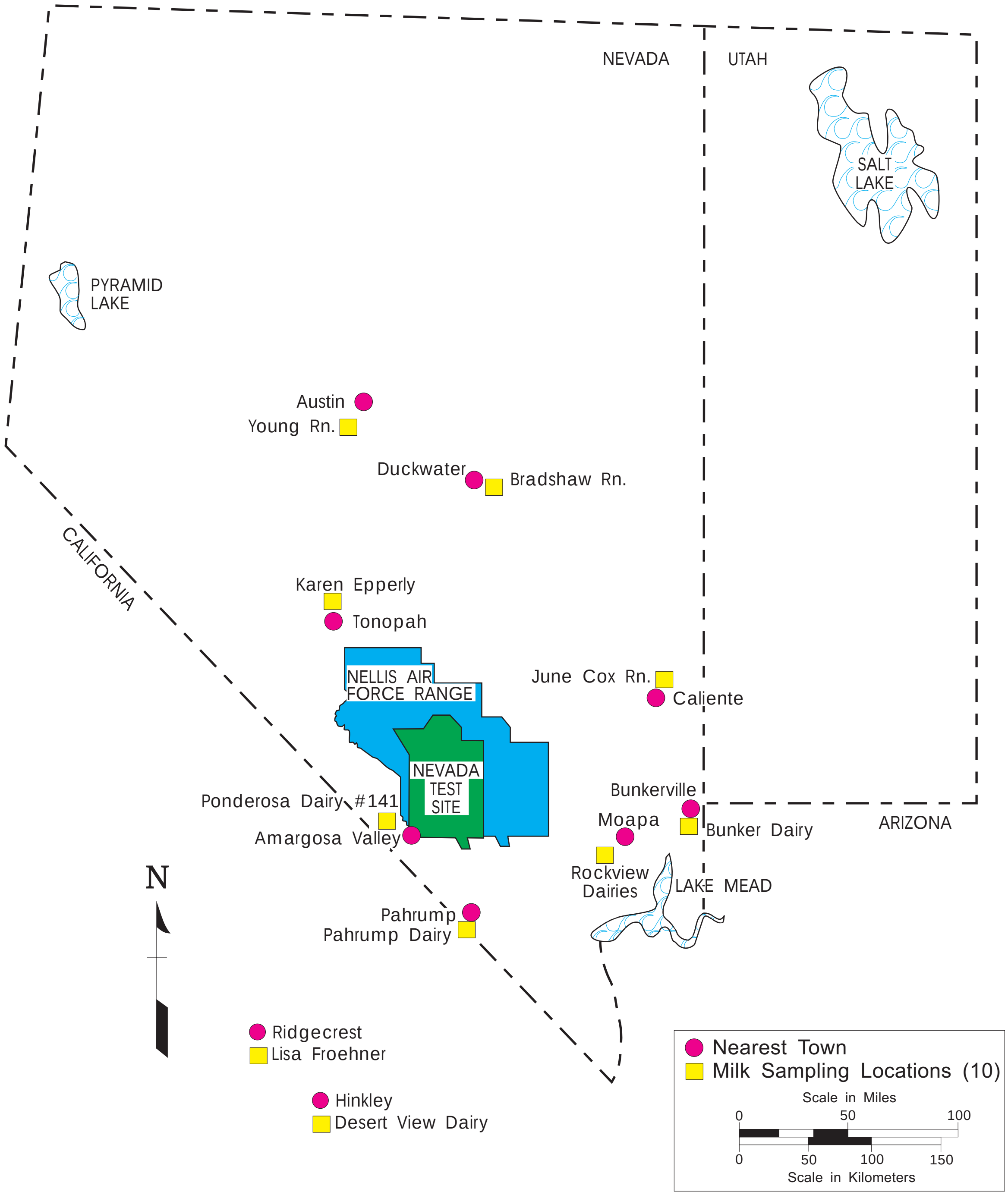


Figure 6.1 MSN Stations - 1998

hydrologic and biotic parameters of the natural springs on the NTS, conducting a census of the NTS horse population, monitoring man-made water sources to assess their affects on wildlife, monitoring spill tests at the HSC in Area 5 if they are determined to be necessary, and surveying control plots at the HSC annually.

HABITAT MAPPING

In CY 1996, efforts began to map the wildlife and plant habitat of the NTS. Selected biotic and abiotic habitat features are collected within field mapping units called Ecological Landform Units (ELUs). ELUs are landforms with visually similar vegetation, soils, slope, and hydrology. Boundaries of the ELUs are defined using aerial photographs, satellite imagery, and field confirmation. ELUs are considered to be the most feasible mapping unit by which sensitive plant and animal habitats on the NTS can be described. From March through August 1998, approximately 550 ELUs on the northern portion of the NTS were defined and sampled, completing the field component of this habitat mapping task. The majority of the ELUs sampled were within the mountains and mesas of the northwestern portion of the NTS. A total of 1,510 ELUs have been sampled on the NTS since CY 1996. All field data collected in CY 1997 and CY 1998 (approximately 980 records) were entered into a relational database and then linked to the ELU spatial data (location, shape, and size of each ELU polygon). Shrub/tree abundance within ELUs was analyzed statistically by cluster analysis to establish groups of ELUs with similar abundances. Cluster groups were then given vegetation association names according to the two or three most-abundant shrub species found in the cluster groups. Vegetation associations were then color-coded to produce a draft vegetation map of the NTS. This map will be included in the Resource Management Plan (RMP) being prepared by DOE/NV for release in CY 1999. In CY 1999, ELU field data will be linked to other spatial data within Bechtel Nevada's (BN's) Ecosystem Geographic Information System (EGIS). Examples of databases which will be linked to ELUs include lists of animal species likely to inhabit an ELU based on its vegetation association and lists of NTS herbarium plant specimens that have been collected from habitats similar to that of a particular ELU. Completion of this task will allow the integrated presentation, archiving, and analysis of NTS species distribution and abundance data with other geospatial habitat data from the NTS. The GIS-based map products and database produced will facilitate ecosystem monitoring and management of the NTS, preparation of future environmental assessments and impact statements, and siting of new NTS projects and facilities.

HORSE SURVEYS

A mark-recapture survey technique was used in CY 1998 to estimate horse abundance on the NTS. The survey was conducted over non-consecutive days between March and July 1998. A standard road course on the NTS was driven. Horses were not marked but were identified by their unique physical features. Horses observed more than once during the sampling period were considered recaptures. All observations were used to compute a population size estimate using the computer program CAPTURE (White et al., 1982). The population estimate based on the survey was 33 horses with a 95 percent confidence interval of 33 to 36 animals. Four adult males observed in 1997 were not seen. Since 1995, the feral horse population, as estimated with this technique, has declined 36 percent, from 52 to 33 individuals. A cumulative total of 21 adults (> 1 year old), 9 males and 12 females, have been classified as missing since 1995. Natural processes (e.g., predation, emigration) are the likely causes of the observed population decline, but data to verify this have not been collected.

The annual population census of horses has routinely been conducted in the summer when horses are nearer to water sources and thus easier to find. These census surveys provide an adequate estimate of the summer range of horses on the NTS but are not useful for estimating their annual range.

Therefore, efforts continued this year to record horse sign and horse sightings within ELUs to better estimate their annual range. Horse sign (e.g., scat, tracks) were recorded in each ELU sampled as part of the habitat mapping task and during surveys for sensitive plant species. All horse sign data collected this year were entered into the EGIS database. The 1998 NTS horse range includes Kawich Canyon, Gold Meadows, northwest Yucca Flat, southwest foothills of the Eleana Range, the Eleana Range, Redrock Valley, Big Burn Valley, and southeast Pahute Mesa. The annual horse range appears not to have changed in areal extent or shape from the previous year.

Monitoring of natural and man-made water sources for use by wild horses continued in 1998. Two newly found wetlands in Area 30 are located within the annual horse range on the NTS and were used by horses in spring and summer. Only two other natural water sources (Captain Jack and Gold Meadows Springs in Area 12) and one man-made pond (Camp 17 Pond in Area 18) were used by horses this summer, as in past years. There are eight man-made water sources within or on the edge of the annual horse range that were not used by horses.

MONITORING NATURAL WATER SOURCES

Five new water sources were discovered in 1998 during habitat mapping of the northern NTS and monitoring of natural water sources on the NTS. Four of these appear to be springs and may dry up during drought years or late summer. The fifth water source appears to be a historic borrow pit which catches surface runoff and retains it long enough to sustain wetland vegetation. Two of the four springs were found in Area 30 on the southwest bajadas of the Eleana Range. They were named Wild Horse Spring and Little Wild Horse Spring because abundant signs of horse use were found at both springs. The third spring was named Rattlesnake Seep. It is located in a canyon on the southern edge of Pahute Mesa in Area 19. The fourth spring was found in Area 26 during monitoring the existing Wahmonie Seeps 1, 2, and 3 northeast of Skull Mountain. The new spring, named Wahmonie Seep 4, is in a wash between Wahmonie Seeps 2 and 3. The fifth new water source, an ephemeral pond which biologists named Pahute Mesa Pond, is on Pahute Mesa adjacent to Dead Horse Flats Road in Area 19. The pond is a depression approximately 30 x 80 m (100 x 260 ft) in area and 3 m (10 ft) deep on the average. The depression catches and holds precipitation and surface runoff. It appears to have been formed many years ago during excavation of fill material for use in constructing the roadbed for Dead Horse Flats Road. The depression contained water for much of the year in 1998. Although this pond is not a natural seep, spring, or pond, it does support wetland vegetation and may, along with the newly discovered seeps, possess field indicators of a jurisdictional wetland. An updated map of the natural water sources on the NTS, including the five new sources, was produced and included in the "Ecological Monitoring and Compliance Program Fiscal Year (FY) 1998 Report" (BN 1998). Periodic monitoring of selected NTS natural water sources was continued in 1998. Several water sources were visited between January and August 1998. They included Cane, Captain Jack, Gold Meadows, Tippipah, Topopah, Tub, and Whiterock springs; Reitmann Seep and the four Wahmonie Seeps; and Yucca Playa Pond. Selected hydrology, water quality, and wildlife usage data were collected. These data were summarized and also presented in the report cited above (BN 1998).

Samples of aquatic invertebrates were collected at eight springs during 1998; Cane, Captain Jack, Gold Meadow, Tippipah, Topopah, and Whiterock springs, Reitmann Seep, and Yucca Playa Pond. The samples were fixed and preserved for later processing and identification. They are collected to develop an inventory of the invertebrate species living in the NTS's natural water sources.

Five species of mammals and 17 species of birds were detected at 11 water sources. The most abundant and widely distributed species was the mourning dove, observed at nine sites. Seasonal use of water sources is dominated by mourning doves during the summer; the largest groups were observed at Cane Spring and Yucca Playa Pond. Chukar were most abundant at Topopah Spring.

MONITORING MAN-MADE WATER SOURCES

Quarterly monitoring of man-made water sources was conducted in 1998. These sources, located throughout the NTS, include 35 plastic-lined sumps, 46 sewage treatment ponds, 13 unlined well ponds, 2 cement-lined ponds, and 4 radioactive containment ponds. Several ponds or sumps are located next to each other at the same project site. They are monitored to assess their use by wildlife and to develop and implement mitigation measures to make them safer for use by wildlife. Many NTS animals rely on these man-made structures as sources of 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. Mitigation measures, required under the Mitigation Action Plan for the Final EIS (DOE 1996c), include placing flag lines over contaminated water sources to repel birds, or fencing or covering them. Quarterly monitoring ensures that all flag lines, fencing, or covers are checked for their integrity and repaired when needed.

Man-made water sources were visited during four quarterly sampling periods; November, February-April, May-June, and September 1998. Use of unlined sumps and ponds by migratory birds and mammals such as coyotes and deer was common. The fences installed around the plastic-lined sumps do not exclude coyotes or deer, as their tracks were observed commonly inside many of the fences. Birds were observed much less at the plastic-lined sumps compared to the unlined ponds.

No animal mortalities from drowning or entrapment were observed during the surveys at any of the water sources. However, during the May-June sampling, 12 dead doves were observed at the Device Assembly Facility sewage ponds. It was determined through subsequent field observations that the doves were being killed by a pair of nesting red-tailed hawks.

HSC MONITORING

Biological monitoring at 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, DOE 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) has been prepared that 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. In CY 1998, seasonal sampling of the control and treatment transects was conducted in March and September of 1998. Treatment transects are each 1,000 m (3,280 ft) long and at 1, 3, and 5 km (0.6, 1.9, and 3.1 mi) downwind from the spill site. Control transects are similar lengths and at similar distances upwind. Data collected included the presence of any dead animals, observations of wildlife or their sign (i.e., scat, burrows, nests, tracks), and any damage to vegetation.

The chemical spill test plans were reviewed for five experiments: (1) Mountain Lion Test Series conducted by the Remote Sensor Test Range Program for 20 materials, (2) DuPont Specialty Chemicals' Fuming

Acids Mitigation Workshop using five chemicals, (3) Compressed Gas Mitigation Workshop using ammonia of varying spill volumes, (4) Effluent Tracking Experiment using ten chemicals, and (5) CADDIE tests on the release of three chemicals. Not all of these tests were performed in 1998. Letters documenting these reviews were submitted to DOE ESHD. It was determined that no biological monitoring of treatment transects was necessary for any of the experiments, except for the DuPont Specialty Chemicals' Fuming Acids Mitigation Workshop. Concentrations of chemicals tested for this workshop were expected to be close to their short-term exposure limits (STELs) at 3 km (1.9 mi) downwind of the release point, which is the edge of the playa where some vegetation and wildlife on the NTS may be impacted. Concentration levels of these same chemicals, however, would be well below their STELs at 5 km (3.1 mi) downwind on the Desert National Wildlife Range. Although recommended, based on the biological monitoring plan for HSC, monitoring of the treatment transects was not conducted for this DuPont experiment.

HISTORIC PRESERVATION

Historic preservation studies and surveys are conducted by the Desert Research Institute (DRI), University and Community College System of Nevada. In 1998, 16 surveys were conducted for historic properties on the NTS, and reports on the findings were prepared. These surveys identified 19 prehistoric and historic archaeological sites. Through consultation with the Nevada State Historic Preservation Office, one of these sites was determined eligible for the National Register of Historic Places (NRHP). Work continued on historic structures associated with early NTS activities. Demolition of the EPA Farm in Area 15 required the preparation of Historic American Building Survey documentation for the facility. This documentation will reside in the Library of Congress.

Other efforts on the NTS in 1998, included administration of the cultural resources program, preparing management objectives and plans and promoting public relations and communications concerning the NTS archaeology and cultural resources program. The Secretary of the Interior's Report to Congress on Federal Archaeological Activities Questionnaire for FY 1997 was completed. Also the plan for the Cultural Resources Monitoring Program was finalized and implemented. NRHP archaeological sites located during the past year were monitored during construction activities and two reports were prepared. In addition, as part of the Environmental Assessment (EA) for the Intermodal Transportation Facility, cultural resources research and fieldwork resulted in the preparation of sections for the EA. Cultural Resources maps and text were prepared for the RMP. Also written was a draft Cultural RMP which will be finalized in 1999.

Cultural resource surveys and other studies are conducted to assess any impacts NTS operations may have on such resources. When cultural resources eligible for the NRHP are found in a project area, and they cannot be avoided, plans are written for programs to recover data to mitigate the effects of the projects on these sites. One draft technical report was submitted for a field data recovery program conducted in 1997. A technical report was completed that summarizes hunter-gatherer adaptations on Pahute and Rainier Mesas. For those historic properties which can be avoided by NTS activities, a monitoring program has been developed to field verify the condition of these sites through time (Beck 1997).

Two reports were prepared on consultations conducted with American Indian tribes. The first was a Rapid Cultural Assessment Report on an archaeological site and the second was a technical report on American Indian interpretations and views of rock art.

To comply with federal regulations in Title 36 CFR 79 (CFR 1966), DRI continues to curate the more than 500,000 artifacts in the DOE/NV collection. DRI produced an annual report summarizing curation compliance activities.

6.4 Pollution Prevention and Waste Minimization Program

When economically practicable, source reduction is the preferred method of handling waste, followed by reuse and recycling, treatment, and, as a last resort, land disposal. BN's systematic approach to source reduction is achieved by performing pollution prevention opportunity assessments (PPOAs). A PPOA is a planned and documented procedure with the objective of identifying methods that reduce energy consumption or eliminate waste streams. The technical and economical feasible options are evaluated, and the most promising options are selected for implementation. Options include product substitution, process change (i.e., use of alternate equipment or procedure), and onsite and offsite recycling. When selecting which PPOA to perform, the goal is to reduce or eliminate the volume and toxicity of waste.

Two PPOAs were performed during CY 1998. The first consisted of the team evaluating the Boiler Room Operation at the NTS with the goal of reducing air emissions. The conclusion of the assessment was to convert the existing boiler fuel from diesel burn natural gas. If funding becomes available, the PPOA recommendation will be reevaluated for implementation.

The second PPOA was conducted on evaluating the disposal of obsolete software. There was a potential to recycle paper from software manuals; cardboard from software cases; and plastic from the diskettes. As a result, the paper and cardboard are being recycled onsite and the Pollution Prevention Project Office is evaluating sending diskettes offsite to be recycled and reused.

At the Explosive Ordinance Disposal Unit, approximately 100 kilograms (kg) (220 pounds) of reactive hazardous waste (waste explosives) from devices destined for disposal were evaluated and determined to be useful products, thereby eliminating the need for treatment and disposal.

Coordinating chemical and material exchange projects between DOE/NV, BN, and other governing agencies (i.e., Nevada Division of Environmental Protection) is another pollution prevention activity. These are chemicals and materials destined for disposal, either as solid or hazardous waste, as a result of process modification, discontinued use, or shelf life expiration. Instead, they are transferred and utilized for their intended use or return to the vendor to be recycled or reused. This is a substantial cost savings for all parties.

AFFIRMATIVE PROCUREMENT

Affirmative Procurement Program has been established to comply with the requirements of Executive Order (EO) 13101. This EO will drive site goals and performance to close the loop between recycling and buying products containing recovered/recycled materials. This program focuses on seven major categories including construction materials, landscape, non-paper, paper, park and recreation, transportation, and vehicular products, and under each of these categories is a number of specific products. The following numbers are based on Fiscal Year 1998 totals. They are as followed: 100 percent of construction materials; 98 percent of paper office products. For non-paper office products, excluding toner cartridges, BN procured 93 percent of binders, office recycling containers, waste receptacles, plastic desktop accessories, and trash bags. Toner cartridges purchases amounted to $108,819.

EMPLOYEE AND PUBLIC AWARENESS

Employee awareness of pollution prevention, waste minimization, and recycling throughout the DOE/NV complexes is accomplished by dissemination of articles through electronic mailing and publishing in the company newspaper, and sponsoring employee and community events with the intent of increasing awareness of environmental issues and the importance of individual participation to improve environmental conditions in the workplace and community. A home page was developed on the BN Intranet that includes point of contacts, material exchange projects, information on community and public outreach projects, current pollution prevention events and activities, etc.

The Community and Public Outreach activities included presentations at:

- University of Nevada, Las Vegas Earth Day.
- Bring Your Kids to Work Day.
- Local schools about pollution prevention and recycling projects at the DOE Nevada Operations Office.
- A Girl Scout Community and Public Outreach Project.
- DOE/NV, BN, Wackenhut Services Incorporated, and International Technology Corporation.

ADDITIONAL 1998 ACCOMPLISHMENTS

An estimated 190.47 metric tons of large concrete slabs were scheduled for excess from a project; however, they were used for the base of a drainage berm in place of the standard compacted-earth design. There were estimated cost savings of $20,000; this included cost avoidance of importing and placing 200 cubic meters of gravel and disposal cost of 200 metric tons of concrete blocks.

Miscellaneous equipment was donated through the School Gift and Energy-Related Laboratory Equipment Programs in the amount of $2,330,315. Equipment such as computers, oscilloscopes, amplifiers, etc., is being reused. This is an on going recycling/reuse activity. Also, BN and Amador Valley Operations donated office and computer supplies, equipment, furniture, and appliances to a school district. The estimated amount of items recycled/reused is 0.59 metric tons and the estimated donation was $5,925.

Term sales of scrap metal during 1998 (amount listed in Table 6.3) produced a profit of $138,308. This is an ongoing recycling/reuse activity.

The Pollution Prevention Project Office traveled to two offsite locations (Santa Barbara and Pleasantan, California) to promote pollution prevention, waste minimization, and recycling awareness. In addition, pollution prevention reporting requirements for the sites were established.

DOE/NV received the 1998 United States Department of Energy Pollution Prevention Award for Recycling Radioactive/Hazardous Waste which occurred during the Cotter Concentrate Project at the NTS (reported in the NTS Annual Site Environmental Report 1997).

VOLUME AND TOXICITY REDUCTION

Table 6.2 is an overview of the estimated Resource and Conservation Recovery Act (RCRA) hazardous and sanitary waste and toxicity reduction through implementation of pollution prevention, waste minimization, and activities during CY 1998 (Attachment 1). The 13 hazardous waste activities eliminated over 158 metric tons of RCRA hazardous waste.

COMPARISON OF RCRA HAZARDOUS WASTE GENERATION IN CALENDAR YEAR 1997 AND 1998

In 1998, an estimated 55.27 metric tons of RCRA hazardous waste was generated. The increase from 1997 to 1998 is attributed to the following activities:

- An estimated 2,000 gallons of routinely used oil at NTS was disposed of as hazardous waste due to inconclusive total halogen contamination tests.
- Aggressive environmental restoration projects contributed to significant increase of RCRA hazardous waste generation during 1998.

RECYCLING ACTIVITIES FOR CALENDAR 1998

By recycling, the amount of hazardous and sanitary waste disposed of can be reduced or eliminated and there are cost savings on disposal, shipping, and labor. Table 6.3 lists the recycling activities that occurred at the DOE/NV locations on- and offsite.

6.5 HAZARDOUS MATERIALS SPILL CENTER (HSC)

The HSC was established in the Frenchman Basin 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. The HSC was designed and equipped to (1) discharge a measured volume of a hazardous fluid at a controlled rate on a specially prepared surface; (2) monitor and record downwind gaseous concentrations, operating data, and close-in/downwind meteorological data; and (3) provide a means to control and monitor these functions from a remote location.

The HSC has the capability of releasing large volumes of cryogenic and non-cryogenic liquids at rapid rates through a 152 m (500-ft) spill line to the experimental area supporting the tank farm. Spill rates for the cryogenic system range from 1,000 to 26,000 gallons per minute (gpm) with the capability to release the entire contents of both tanks in two minutes. The non-cryogenic system can release fluids at rates of 500 to 5,000 gpm (1.9 to 19 m^3/min), with the capability of releasing the entire 90.8 m^3 (24,000 gallons) in five minutes.

Test sponsors can vary intake air temperature, humidity, release rate, and release volume in a 2.4 x 4.8 x 25.3 m (8 x 16 x 96 ft) wind tunnel. There are two spill pads available for use in contained open air releases of volumes of 0.19 to 3.8 m^3 (50 to 1,000 gallons). Test Area 4 has been added primarily to provide the testing capability for determining the efficacy of totally encapsulated chemical protective suiting materials when exposed to high concentrations of toxic and hazardous gaseous materials.

DOE/NV provides the facilities, security, and technical support, but all costs are borne by the organization conducting the tests. The plans for each test series were examined by an Advisory Panel that consisted of DOE/NV and EPA’s R&IE-LV professional personnel augmented by personnel from the organization performing the tests.

For each test, the R&IE-LV provides an advisor on offsite public health and safety for the Operations Controller's Test Safety Review Panel. At the beginning of each test series and, at other tests depending on projected need, a field monitoring technician from the EPA with appropriate air sampling equipment is deployed downwind of the test at the NTS boundary to measure chemical concentrations that may have reached the offsite area. Samples are collected with a hand-operated Dräger pump and sampling tube appropriate for the chemical being tested. Not all tests are monitored by R&IE-LV, if professional judgement indicates that, based on previous experience with the chemical and the proposed test parameters, NTS boundary monitoring is unnecessary. The EPA monitors at the NTS boundary, in contact by two-way radio, are always placed at the projected cloud center line.

During 1998, there were six projects conducted at HSC: (1) the Diamondback Weapons of Mass Destruction Exercise, which included the release of methyl salicylate as a stimulant; (2) the DuPont Fuming Acids Workshop, which included the release of oleum and chlorosulfonic acid for emergency response training; (3) Remote Sensor Test Range-Mountain Lion Episode using 20 materials; (4) Effluent Tracking Experiment using 10 materials; (5) the Barrier Crash Test, which did not involve any hazardous material releases; and (6) the BN-sponsored First Responder Training Class field exercises, which also did not include any hazardous chemical releases. No offsite air monitoring was performed by R&IE-LV personnel in 1998.

6.6 WASTE MANAGEMENT ACTIVITIES

RADIOACTIVE WASTE

Low-level radioactive waste (LLW) from the DOE-approved generators is disposed of at two locations on the NTS. Packaged LLW is disposed of at the Area 5 Radioactive Waste Management Site (RWMS-5) in shallow pits and trenches. LLW in large containers and unpackaged bulk waste from environmental restoration projects are buried in selected subsidence craters at the Area 3 RWMS (RWMS-3). Hazardous, transuranic (TRU), and mixed TRU wastes are stored aboveground pending shipment to offsite permitted disposal facilities.

RWMS-5 WASTE MANAGEMENT OPERATIONS

The RWMS-5 is used for the disposal of radioactive waste generated at the NTS and at offsite DOE and U.S. Department of Defense facilities. LLW is accepted for disposal from generators that have received approval from DOE Headquarters and DOE/NV (NTS 1996). Disposal of mixed waste is still restricted to waste generated on the NTS.

LLW, mixed waste, and small quantities of TRU waste have been disposed of in 22 shallow pits and trenches since disposal operations began in 1961. The shallow pits and trenches range in depth from 4.6 to 14.6 m (15 to 48 ft). Filled pits and trenches are covered by a 2.4 m (8 ft) alluvium cap pending final closure of the site.

LLW disposed of prior to implementation of RCRA (CFR 1984) by DOE in 1986 may contain low levels of hazardous constituents. A single disposal unit, Pit 3, has interim status as a mixed waste disposal unit for NTS generated wastes that meet the RCRA Land Disposal Restrictions (LDR) requirements. Low-level mixed waste generated on the NTS is stored on the TRU waste storage pad until characterization is complete. If the waste meets or has been treated to meet LDR requirements, it may be disposed of in Pit 3.

TRU mixed waste is stored in a covered building on a specially constructed RCRA-designed pad. In 1998, the Waste Examination Facility (WEF) began operations to certify this stored TRU mixed waste for disposal at the Waste Isolation Pilot Plant in New Mexico. Low-level radioactive mixed waste is also currently stored on the TRU waste storage pad.

In 1998, the RWMS-5 received 6.59×10^3 m^3 (2.33×10^5 ft^3) of waste containing a total of 3.6×10^4 Ci (1.3×10^3 TBq) of reportable radionuclides. This represents a decrease in volume and activity from the previous year because of fewer shipments from Fernald (see Table 6.6). The trend in bulk disposal at each RWMS is shown in Figures 6.2 and 6.3. Tritium accounted for more than 99.9 percent of the total radioactivity disposed of in 1998 (see Table 6.7). Uranium was the next most important radionuclide in the 1998 inventory.

Radioactivity in air, groundwater, gamma and neutron radiation fields, and soil moisture content were monitored at the RWMS-5 in 1998. Air samples were analyzed for gross alpha and gross beta radiation, photon-emitting radionuclides, plutonium, and tritium. Tritium and $^{239+240}$Pu were the only man-made airborne radionuclides detected at the RWMS-5. All airborne radionuclide concentrations were a small fraction of DOE allowable limits. Airborne tritium at the RWMS-5 probably originates from disposed LLW. The highest tritium concentration detected in 1998, 8.4×10^{-11} µCi/mL, was 0.08 percent of the Derived Concentration Guide (DCG). Low levels of $^{239+240}$Pu were detected near the WEF and inside the TRU storage building. The highest outdoor $^{239+240}$Pu concentration,

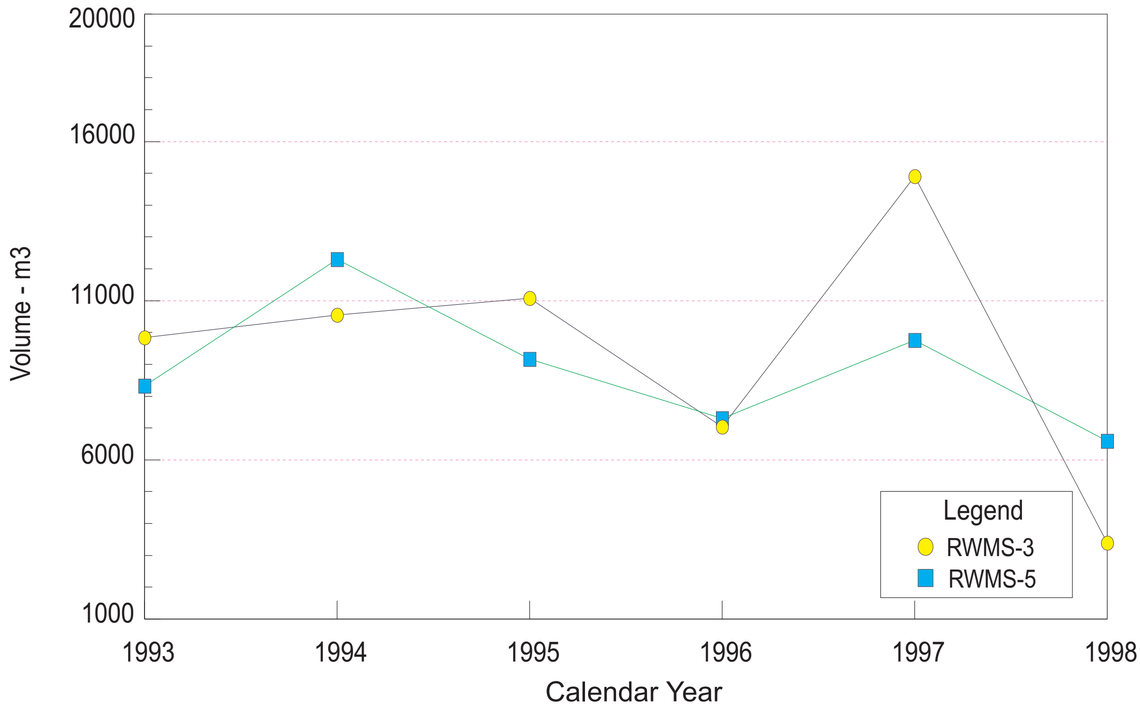


Figure 6.2 Total Volume of Waste Disposed of at RWMS-3 and RWMS-5

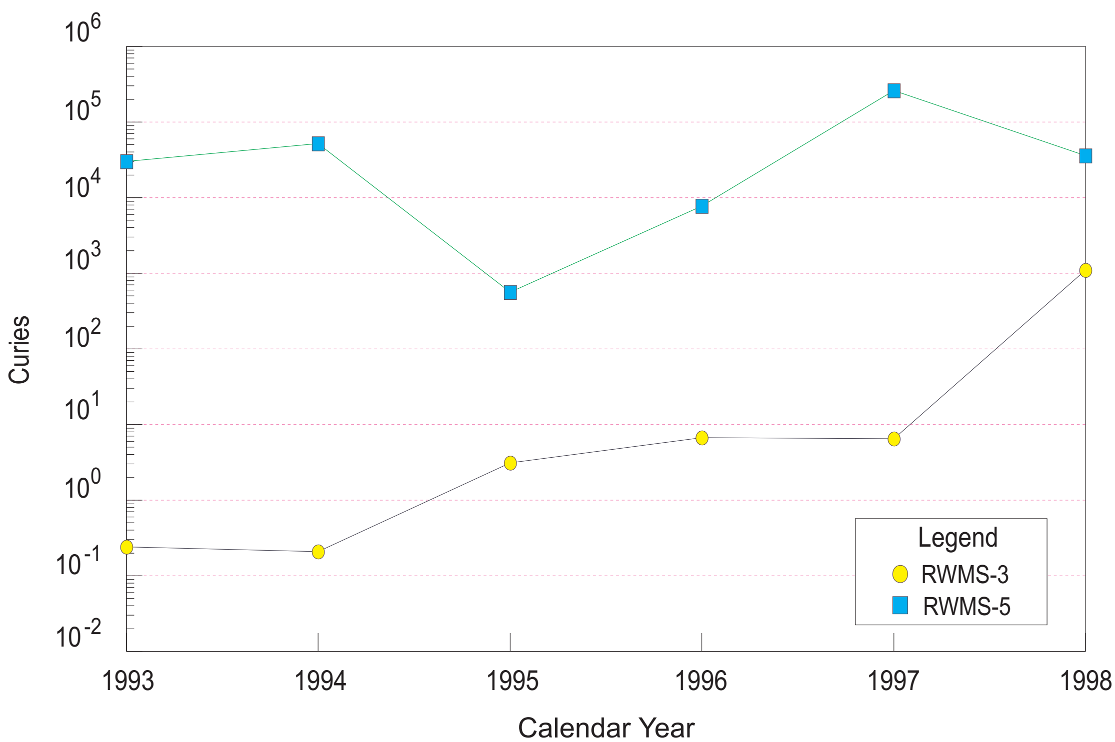


Figure 6.3 Total Curies Disposed of at RWMS-3 and RWMS-5

1.5 x 10^{-16} µCi/mL, was 0.7 percent of the most restrictive DCG. All $^{239+240}Pu$ results for the perimeter of the RWMS-5 were less than the MDC. Groundwater samples were analyzed for RCRA parameters, gross alpha, gross beta, tritium, and photon emitting radionuclides. No man-made radionuclides or hazardous chemicals were detected in groundwater. Gamma radiation fields were monitored by TLDs. Neutron radiation fields at the perimeter of the TRU waste storage pad were monitored by proton recoil dosimeters. Radiation exposures above background were measured at RWMS-5, but only at locations where radioactive waste is stored or remained exposed in active disposal units. Infiltration of wetting fronts below the depth of waste disposal units was not detected by soil moisture monitoring.

The results of air monitoring are described further in Chapter 4 and the results of water monitoring are described in Chapter 5.

RWMS-5 PERFORMANCE ASSESSMENT (PA)

The DOE assesses the long-term performance of LLW disposal sites by conducting a PA. A PA is a systematic analysis of the potential risks posed by a waste disposal site to the public and to the environment and a comparison of those risks to established performance objectives. A PA has been completed, reviewed, and approved for the RWMS-5 (Shott et al., 1997a). The PA helps to identify the processes that could cause detectable releases of radioactive materials to the accessible environment during operation of the site. The only release pathway expected at the RWMS-5 in the near term is diffusion of volatile radionuclides through the operational cap to the atmosphere. Tritium is the most abundant volatile radionuclide disposed of at the RWMS-5. PA models indicate that nonvolatile radionuclides may eventually be detected in soil excavated by burrowing animals and in the tissues of deep-rooted vegetation growing on disposal unit covers. Site characterization data and modeling studies indicate that transport of nonvolatile radionuclides from the waste to the uppermost aquifer is extremely unlikely because of the thick dry vadose zone, low precipitation, and high potential evapotranspiration at the site.

RWMS-5 monitoring results are generally consistent with PA results. Tritium, the volatile radionuclide with the largest inventory, is routinely detected in air samples at the RWMS-5 at levels that are a small fraction of DOE allowable limits. Since maintenance operations keep operational covers vegetation free, deep-rooted vegetation samples are not routinely available for analysis. Tritium is the only radionuclide that has been detected in previous analyses of cap vegetation. Groundwater monitoring results confirm that groundwater beneath the RWMS-5 remains uncontaminated. Monitoring of soil moisture content confirms that infiltrating precipitation does not percolate through the disposal unit operational caps because it evaporates and returns to the atmosphere.

RWMS-3 WASTE MANAGEMENT OPERATIONS

The RWMS-3 is used for the disposal of bulk waste. Packaged bulk LLW is accepted from approved onsite and offsite generators. Unpackaged bulk LLW from NTS environmental restoration projects also has been accepted and disposed of. Disposal is in subsidence craters formed by underground nuclear tests. The subsidence craters range in depth from 15 to 24 m (49 to 78 ft) and are filled by alternating layers of stacked waste packages and 1 m (3 ft) of clean alluvium. Waste disposed of at the RWMS-3 tends to have a lower activity concentration than waste disposed of at the RWMS-5 because bulk waste tends to be generated by environmental restoration projects.

Waste disposal operations at the RWMS-3 began in the U-3ax crater in 1968. The U-3ax crater was eventually joined with U-3bl to form the U-3ax/bl disposal unit. This unit received mostly unpackaged LLW from NTS nuclear testing operations. The U-3ax/bl disposal unit was filled in 1987 and covered with a 2.4-m (8-ft) thick temporary closure cap. This disposal unit is a mixed waste management unit as mixed waste is known to have been disposed of. Waste disposal operations moved to the U-3at crater in 1988 and was joined with the U-3ah crater to form the U-3ah/at disposal unit. This disposal unit remained open in 1998 and contains LLW only. During 1997, disposal of unpackaged plutonium contaminated soil, from sites on the Nellis Air Force Range, about 14 mi (22 km) east of Goldfield, Nevada began in the U-3bh crater. Radioactivity in air, gamma radiation fields, and soil moisture content were monitored at the RWMS-3. Plutonium was the only man-made airborne radionuclide detected at the RWMS-3. The airborne plutonium likely originates from the resuspension of soils contaminated by atmospheric nuclear weapons tests. Gamma radiation fields were monitored by thermoluminescent dosimeters (TLDs). Dose equivalents greater than background were measured at the RWMS-3. Contamination from atmospheric nuclear weapons tests contributes to the dose equivalent measured at the RWMS-3. Soil moisture monitoring did not detect the infiltration of wetting fronts below the depth of waste disposal units.

During 1998, the RWMS-3 received 3.39 x 10^3 m^3 (1.20 x 10^5 ft^3) of waste containing 1.1 x 10^3 Ci (41 TBq) of activity (see Table 6.4). This represents a decrease in volume and an increase in the activity disposed of, compared to the previous year (see Table 6.5). The increase in activity disposed of is largely attributable to tritium. The remainder of the activity was predominately ^{90}Sr, ^{137}Cs, and various isotopes of plutonium.

RWMS-3 PERFORMANCE ASSESSMENT (PA)

A PA has been conducted for the RWMS-3 (Shott et al., 1997b). Release pathways at the RWMS-3 are expected to be the same as at the RWMS-5 because of the similar site conditions and disposal operations. However, the inventory of radioactive materials disposed of at the RMWS-3 is much less than that disposed of at the RWMS-5. The RWMS-3 inventory of ^3H, which is the most likely radionuclide to be released, is significantly less than at the RWMS-5, so the potential for detecting releases of radioactivity is also significantly less. Moreover, the interpretation of environmental monitoring results at the RWMS-3 is confounded by the presence of significant soil contamination from aboveground nuclear tests. Airborne tritium monitoring at the RWMS-3 was discontinued in 1997 because all results were less than the minimum detectable concentration (MDC). Interpretation of environmental monitoring data from the RWMS-3 and comparison of environmental monitoring results with PA results is difficult because of the small RWMS-3 radionuclide inventory and the presence of contamination from nuclear testing.

HAZARDOUS WASTES

NTS OPERATIONS

Hazardous wastes generated on the NTS are accumulated at a location east of the RWMS-5, the Hazardous Waste Accumulation Site, before shipment to an offsite treatment, storage, and disposal facility. Hazardous waste generation activities at the NTS are performed under EPA Identification (ID) Number NV3890090001. The NTS continues to be regulated by the 1995 NTS RCRA Hazardous Waste Operating Permit Number NEV HW009 for the general operation of the facility and the specific operation of the Hazardous Waste Storage Unit (HWSU) and the Explosive Ordnance Disposal Unit.

Three permit modifications have occurred since October 1, 1996. These modification include changes in the NTS training program and personnel changes in the Area 5 and Area 11 Emergency Management Plans.

The Pit 3 Mixed Waste Disposal Unit located in the RWMS-5 continues to operate under RCRA Interim Status.

The NTS also has a Nevada Hazardous Materials Storage Permit Number 13-94-0034-X, issued by the state Fire Marshall. This permit is renewed annually when a report required by the state's Chemical Catastrophe Prevention Act is submitted.

CHEMICAL ANALYSES

Chemical analyses performed in support of operations conducted on the NTS are described in Section 6.3 above.

NON-NTS OPERATIONS

Four EPA Generator ID numbers have been issued to five non-NTS operations. In addition, three local ID numbers were required at one operation. Hazardous waste is managed at all locations, by using satellite accumulation areas. Three operations have centralized accumulation areas. All hazardous and industrial wastes are transported offsite to RCRA-permitted facilities for approved treatment and/or disposal.

SANITARY WASTE

At the NTS there are three nonhazardous waste landfills that have state of Nevada Operating Permits, i.e., the Area 6 Hydrocarbon Disposal Site, the Area 9 U-10c Solid Waste Disposal Site, and the Area 23 Solid Waste Disposal Site. There are no monitoring requirements for non-hazardous solid waste disposed of at the NTS in the three landfills; however, before the waste is disposed of, it is weighed.

During 1998, there were approximately 7,430 tons of waste disposed of at the NTS, as shown in Table 6.8. The permitting process considers groundwater protection at these locations.

At the Area 23 Class II Municipal and Industrial Solid Waste Disposal Site, a groundwater monitoring well has been installed. This well also serves to satisfy monitoring requirements for the Mercury sewage lagoon system. An initial baseline water sample was collected in August 1997, and compliance monitoring continued in 1998.

The RCRA-permitted Area 5 HWSU also had groundwater protection considered in the permitting process. The facility has impervious cement floor compartments with adequate spill containment capacity to store containers of hazardous waste. In the event there was a release to the soil during container handling, there is spill containment present to control the release.

6.7 PERMITS FOR NTS OPERATIONS

Federal and state permits have been issued to DOE/NV and to BN (Table 6.9). These permits are required for the conduct of such DOE/NV activities as hazardous and sanitary waste storage and disposal for certain ecological studies and for operations involving endangered species. All BN non-NTS facilities are located in existing metropolitan areas and are not subject to the Endangered Species Act. 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 HWSU for up to one year. It is then shipped offsite for treatment and/or disposal. During 1998, the total amount of hazardous waste shipped offsite was 13,422 gallons. The pernit also allows for the thermal treatment (disposal) of explosives at the Area 11 Explosive Ordnance Disposal Unit. During 1998, 207 pounds of explosives were treated at this facility.

The North Las Vegas Facility (NLVF) has a Waste Generator number of NVD09786831 that covers generation and a 90-day accumulation of hazardous waste. The waste is shipped offsite for final treatment and/or disposal. During 1998, there were 2,122 gallons of hazardous waste shipped offsite from the NLVF.

DOE/NV 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 United States Fish and Wildlife Service.

The Nevada Division of Wildlife issued a scientific collection permit, S15842, to BN that allows collection of wildlife samples.

Table 6.1 Radionuclides Detected in Milk Samples - 1998

^{90}Sr Concentration (10^{-10} µCi/mL)

Sampling Location	Number	Result
Hinkley, CA - Desert View Dairy	1	0.23
Ridgecrest, CA - Lisa Froehner	1	0.18
Amargosa Valley, NV - Ponderosa Dairy #141	1	0.43
Austin, NV - Young's Ranch	1	2.6
Caliente, NV - June Cox Ranch	1	1.1
Duckwater, NV - Bradshaw's Ranch	1	0.95
Moapa, NV - Rockview Dairies	1	0.21
Pahrump, NV - Pahrump Dairy	1	0.53
Tonopah, NV - Karen Epperly	1	0.64
Bunkerville, NV - Bunker Dairy	1	-0.31

Summary of Radionuclides Detected in Milk Samples
No. of samples with results > MDC (Network average concentration in pCi/L)

	1998	1997	1996	1995
^{89}Sr	N/A	N/A	0(0.01)	0(0.03)
^{90}Sr	0(0.72)	1(0.70)	0(0.63)	0(0.61)

N/A = Not Analyzed

Table 6.2 Pollution Prevention Results, Volume and Toxicity Waste Reduction - 1998

Activity	Accomplishment	Waste and Toxicity Waste Type	Reduction
Recycle/Reuse	Batteries shipped offsite to be recycled.	Hazardous	18.62 Mg[(a)]
Recycle/Reuse	Scrap metal term sale of lead.	Hazardous	8.26 Mg
Recycle/Reuse	Sent spent intact fluorescent light bulbs offsite to be recycled (result of a PPOA).	Hazardous	3.41 Mg
Material Exchange	Kerosene, destined for disposal, was transferred to another department at the NTS for use.	Hazardous	3.02 Mg
Material Exchange	Two 55-gallon drums of Solvent 724, destined for disposal, were returned to the vendor (buy back).	Hazardous	0.42 Mg
Material Exchange	Nine 55-gallon drums of Isopropyl Alcohol, destined for disposal, transferred to the Spill Test Facility to be used for it's intended purpose.	Hazardous	1.89 Mg

Table 6.2 (Pollution Prevention Results, Volume and Toxicity Waste Reduction - 1998, cont.)

Activity	Accomplishment	Waste Type	Waste/Toxicity Reduction (Mg)[a]
Material Exchange	Miscellaneous products (lubricants/oils, solvents, adhesives, janitor and soldering supplies, etc.) collected during closure of buildings at the NTS; these items were transferred and used for their intended purpose.	Hazardous	1.88 Mg
Material Exchange	One 55-gallon drum of Voltz Solvent destined for disposal, was transferred to security for use to clean security guard armor.	Hazardous	0.21 Mg
Material Exchange	Potassium hydroxide, destined for disposal was transferred to the Analytical Laboratory to be used for neutralizing acid waste.	Hazardous	0.49 Mg
Material Exchange	Miscellaneous copy machine supplies destined for disposal were transferred within DOE/NV and Nevada EPA for their intended use.	Sanitary	0.588 Mg
Material Exchange	Refrigeration coil cleaner destined for disposal was transferred to the Refrigeration Shop for its intended use.	Sanitary	0.08 Mg
Onsite Recycling	Gasoline from the Area 6 Gas Station, destined for disposal, was transferred and used by the Area 23 Gas Station.	Hazardous	5.05 Mg
Onsite Recycling	Gasoline was removed from underground storage tanks at NTS; destined for disposal, was transferred for use as its intended purpose.	Hazardous	6.80 Mg
Onsite Recycling	Gasoline, removed from underground storage tanks at NTS, destined for disposal, was transferred and used for it's intended purpose.	Hazardous	15.12
Offsite Recycling	Used oil from routine maintenance of vehicles and heavy equipment was shipped offsite to be recycled.	Hazardous	55.02
Onsite Recycling	Diesel fuel from Area 1 Drilling activities, destined for disposal, was transferred for use by the Area 23 Gas Station.	Sanitary	15.12
Onsite Recycling	Reusable clean bath and hand towels and wash clothes were destined for disposal due to decrease in housing were transferred to Fleet Operations to be utilized for their intended use.	Sanitary	2.72
TOTALS: Number of Projects completed - 17. Estimated Waste and Toxicity Reduction:			176.89

(a) Mg = megagram = metric ton = 2205 lb.

Table 6.3 Ongoing Recycling Activities - 1998

Activity	Waste Type	Quantity (Mg)[(a)]
Paper		
Mixed paper, cardboard, newspaper, and magazines	Sanitary	241.39
Junk Mail (mixed paper)	Sanitary	13.86
Aluminum Cans	Sanitary	1.15
Styrofoam	Sanitary	0.24
Scrap Metals includes:		
Ferrous, non-ferrous, and light Steel	Sanitary	1329.50
Scrap Metal, lead	Hazardous	5.28
Precious Metal, Silver	Sanitary	0.02
Toner Cartridges	Sanitary	1.42
Batteries	Hazardous	18.62
Fluorescent Light Bulbs	Hazardous	3.41
Automotive Cores/Parts	Sanitary	1.67
Used Oils includes: oils, diesel fuel, and gasoline	Sanitary	96.14
Tires	Sanitary	16.17
Wood includes:		
Scrap wood, pallets, chips, and compost	Sanitary	14.51
Total		1743.38

(a) Mg = megagram = metric ton = 2205 lb.

Table 6.4 Low-Level Waste Disposed of at the RWMS-3, 1993 - 1998

Calendar Year	Volume of LLW Disposed of (m^3)	Activity of LLW Disposed of (Ci)
1993	9,848	2.4×10^{-1}
1994	10,550	2.1×10^{-1}
1995	11,073	3.1×10^{0}
1996	7,033	5.7×10^{0}
1997	14,910	6.5×10^{0}
1998	3,392	1.1×10^{3}

Table 6.5 Inventory of Radionuclides (>0.1 Ci) Disposed of at the RWMS-3 in 1998

Radionuclide	Activity (Ci)	Percent of Total Activity
^{3}H	1.1×10^{3}	9.7×10^{1}
^{137}Cs	1.8×10^{1}	1.6×10^{0}
^{90}Sr	1.7×10^{1}	1.5×10^{0}
^{239}Pu	2.4×10^{-1}	2.2×10^{-2}
^{238}Pu	9.6×10^{-2}	8.7×10^{-3}

Table 6.5 (Inventory of Radionuclides (>0.1 Ci) Disposed of at the RWMS-3 in 1998, cont.)

Radionuclide	Activity (Ci)	Percent of Total Activity
^{241}Pu	8.9×10^{-2}	8.1×10^{-3}
^{238}U	4.4×10^{-2}	4.0×10^{-3}
^{241}Am	3.2×10^{-2}	2.9×10^{-3}
^{240}Pu	1.8×10^{-2}	1.6×10^{-3}
^{234}U	1.1×10^{-2}	9.7×10^{-4}
^{232}Th	3.5×10^{-3}	3.2×10^{-4}
^{228}Th	3.5×10^{-3}	3.1×10^{-4}
^{228}Ra	2.5×10^{-3}	2.2×10^{-4}
^{230}Th	1.7×10^{-3}	1.6×10^{-4}
^{235}U	1.3×10^{-3}	1.2×10^{-4}
^{210}Pb	1.3×10^{-3}	1.2×10^{-4}
Total	1.1×10^{3}	1.0×10^{2}

Table 6.6 Low-Level Waste Disposed of at the RWMS-5, 1993 - 1998

Calendar Year	Volume of LLW Disposed (m^3)	Activity of LLW Disposed (Ci)
1993	8,327	3.0×10^{4}
1994	12,300	5.2×10^{4}
1995	9,171	5.6×10^{2}
1996	7,293	7.7×10^{3}
1997	9,762	2.6×10^{5}
1998	6,590	3.6×10^{4}

Table 6.7 Inventory of Radionuclides (>1 mCi) Disposed of at the RWMS-5 in 1998

Radionuclide	Activity (Ci)	Percent of Total Activity
^{3}H	3.6×10^{4}	1.0×10^{2}
^{238}U	9.8×10^{0}	2.7×10^{-2}
^{234}U	3.7×10^{0}	1.0×10^{-2}
^{241}Pu	1.4×10^{0}	4.0×10^{-3}
^{137}Cs	1.4×10^{0}	3.8×10^{-3}
^{239}Pu	8.4×10^{-1}	2.4×10^{-3}
^{90}Sr	7.3×10^{-1}	2.1×10^{-3}
^{238}Pu	5.2×10^{-1}	1.4×10^{-3}
^{235}U	2.4×10^{-1}	6.7×10^{-4}
^{232}Th	2.4×10^{-1}	6.7×10^{-4}
^{240}Pu	1.8×10^{-1}	5.0×10^{-4}
^{241}Am	1.3×10^{-1}	3.8×10^{-4}
^{99}Tc	7.5×10^{-2}	2.1×10^{-4}
^{147}Pm	5.4×10^{-2}	1.5×10^{-4}

Table 6.7 (Inventory of Radionuclides (>1 mCi) Disposed of at the RWMS-5 in 1998, cont.)

Radionuclide	Activity (Ci)	Percent of Total Activity
^{226}Ra	2.1×10^{-2}	6.0×10^{-5}
^{60}Co	1.4×10^{-2}	3.8×10^{-5}
^{14}C	9.8×10^{-3}	2.7×10^{-5}
^{230}Th	8.8×10^{-3}	2.5×10^{-5}
^{32}P	6.9×10^{-3}	1.9×10^{-5}
^{228}Th	3.7×10^{-3}	1.0×10^{-5}
^{160}Tb	3.0×10^{-3}	8.4×10^{-6}
^{106}Ru	2.6×10^{-3}	7.4×10^{-6}
^{144}Ce	1.3×10^{-3}	3.7×10^{-6}
^{63}Ni	1.1×10^{-3}	3.0×10^{-6}
Total	3.6×10^{4}	1.0×10^{2}

Table 6.8 Quantity of Wastes Disposed of in Sanitary Landfills - 1998

	Quantity (in tons)		
Month	Area 9	Area 23	Area 6
January -March	834	293	611
April - June	792	318	103
July - September	1849	340	851
October - December	594	598	446
Totals	4,069	1,549	2,011

Table 6.9 Permits Required for NTS Operations - 1998

EPA Generator ID

NV3890090001 NTS Activities

NTS Permits

Permit No.	Areas	Expiration Date
NEV HW009	NTS Hazardous Waste Management (RCRA)	05/01/2000
SW 13 097 02	Area 6 Hydrocarbon Disposal Site	On Closure
SW 13 097 03	Area 9 U-10c Solid Waste Disposal Site	On Closure
SW 13 097 04	Area 23 Solid Waste Disposal Site	On Closure
13-98-0034-X	NTS Hazardous Materials	12/31/1998
13-98-0037-X	HSC Hazardous Materials	12/31/1998

Table 6.9 (Permits Required for NTS Operations - 1998, cont.)

NTS Permits, cont.

Permit No.	Areas	Expiration date
S15482	Scientific Collection of Wildlife Samples	12/31/1998
File 1-5-96-F-33	USFWS -- Desert Tortoise Incidental Take Authorization	08/00/2006
Interim Status	RCRA Part B -- Pit 3 Mixed Waste Disposal Operation	On Permit Approval
13-94-0034-X	State Chemical Catastrophe Prevention Act Compliance	Renewal on report submission

Off-NTS Permits

03-98-0265-X	North Las Vegas Facility Hazardous Materials	12/31/1998
03-98-0266-X	Remote Sensing Laboratory Hazardous Materials	12/31/1998

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

7.0 DOSE ASSESSMENT

The offsite environmental surveillance system, operated around the Nevada Test Site (NTS) by the U.S. Environmental Protection Agency's (EPA's) Radiation and Indoor Environments National Laboratory in Las Vegas (R&IE-LV), measured no radiation exposures attributable to recent NTS operations. However, using onsite emission measurements and calculated resuspension data as input to the EPA's Clean Air Package 1988 (CAP88-PC) model, a potential effective dose equivalent (EDE) to the maximally exposed individual (MEI) was calculated to be 0.092 mrem (9.2 x 10^{-4} mSv) to a hypothetical resident of Springdale, Nevada, located 58 km (36 mi) west-northwest of Control Point 1 (CP-1) on the NTS. The calculated population dose (collective EDE) to the approximately 32,000 residents living within 80 km (50 mi) from each of the NTS airborne emission sources was 0.27 person-rem (2.7 x 10^{-3} person-Sv). Monitoring network data indicated an exposure to the MEI of 141 mrem (1.41 mSv) from normal background radiation. The calculated dose to this individual from worldwide distributions of radioactivity as measured from surveillance networks was 0.017 mrem (1.7 x 10^{-4} mSv). These maximum dose estimates, excluding background, are less than 1 percent of the most restrictive standard.

7.1 ESTIMATED DOSE FROM NTS ACTIVITIES

The potential EDE to the offsite population due to NTS activities is estimated annually. Two methods are used to estimate the EDE to residents in the offsite area in order to determine the community potentially most impacted by airborne releases of radioactivity from the NTS. In the first method, effluent release estimates, based on monitoring data or calculated resuspension of deposited radioactivity, and meteorological data are used as inputs to EPA's CAP88-PC model, which then produces estimated EDEs. The second method entails using data from the Offsite Radiological Safety Program (ORSP) monitoring networks with documented assumptions and conversion factors to calculate the committed EDE (CEDE). The latter method provides an estimate of the EDE to a hypothetical individual continuously present outdoors at the location of interest that includes both NTS emissions and worldwide fallout. In addition, a collective EDE is calculated by the first method for the total offsite population residing within 80 km (50 mi) of each of the NTS emission sources. Background radiation measurements are used to provide a comparison with the calculated EDEs. In the absence of detectable releases of radiation from the NTS, the Pressurized Ion Chamber (PIC) network provides a measurement of background gamma radiation in the offsite area.

There are five sources of possible radiation exposure to the population of Nevada, some of which were monitored by EPA's offsite monitoring networks during 1998. These were:

- Background radiation due to natural sources such as cosmic radiation, radioactivity in soil, and ^{7}Be in air.
- Worldwide distributions of man-made radioactivity, such as ^{90}Sr in milk and plutonium in soil.
- Operational releases of radioactivity from the NTS, including those from drill-back and purging activities when they occur.

- Radioactivity that was accumulated in migratory game animals during their residence on the NTS.

- Airborne releases from the NTS due to resuspension of radionuclides from contaminated soils onsite, evaporation of tritiated water (HTO) from ponds, and diffusion of HTO from cratering tests.

Operational releases and calculated sources of radioactive emissions from the NTS are used as input data for CAP88-PC to provide estimates of exposures to offsite populations. The other three sources of exposure listed above are discussed below.

ESTIMATED DOSE USING REPORTED NTS EMISSIONS

Onsite source emission measurements, as provided by the U. S. Department of Energy Nevada Operations Office, are listed in Chapter 4, Table 4.5, and include tritium and plutonium. These are estimates of releases made at the point of origin. Meteorological data collected by the Air Resources Laboratory, Special Operations and Research Division (ARL/SORD) were used to construct wind roses and stability arrays for the following areas: Mercury, Area 12, Area 20, Yucca Flat, and the Radioactive Waste Management Site in Area 5. A calculation of estimated dose from NTS effluents was performed using EPA's CAP88-PC model (EPA 1992). The results of the model indicated that the hypothetical individual with the maximum calculated dose from airborne NTS radioactivity would reside at Springdale, Nevada, 58 km (36 mi) west-northwest of CP-1. The maximum dose to that individual could have been 0.092 mrem (9.2×10^{-4} mSv). For comparison, data from the PIC monitoring network indicated an exposure of 141 mrem (1.41 mSv) from background gamma radiation occurring in that area. The population living within a radius of 80 km (50 mi) from the airborne sources on the NTS was estimated to be 31,750 individuals, based on estimated population data. The collective population dose within 80 km (50 mi) from each of these sources was calculated to be 0.27 person-rem (2.7×10^{-3} person-Sv). Activity concentrations in air that would cause these calculated doses are much higher than actually detected by the offsite monitoring network. For example, 0.09 mrem of the calculated EDE to the MEI is due to plutonium. The annual average plutonium concentration in air that would cause this EDE is 3.4×10^{-17} µCi/mL. This is about 18 times the annual average plutonium in air measured in Amargosa Valley, Nevada, (nearest community) of 0.19×10^{-17} µCi/mL (Chapter 4, Table 4.15). Table 7.1 summarizes the annual contributions to the EDEs due to 1998 NTS operations as calculated by use of CAP88-PC and the radionuclides listed in Chapter 4, Table 4.5.

Input data for the CAP88-PC model included meteorological data from ARL/SORD and effluent release data calculated from monitoring results and from resuspension estimates. These release data are known to be estimates, and the meteorological data are mesoscale, e.g., representative of an area approximately 40 km (25 mi) or less around the point of collection. However, these data are considered sufficient for model input, primarily because the model itself is not designed for complex terrain such as that on and around the NTS. Errors introduced by the use of the effluent and meteorological data are small compared to the errors inherent in the model. The model results are considered over-estimates of the dose to offsite residents. This has been confirmed by comparison with the offsite monitoring results.

ESTIMATED DOSE USING MONITORING NETWORK DATA

Potential CEDEs to individuals may be estimated from the concentrations of radioactivity, as measured by the EPA monitoring networks during 1998. Actual results obtained in analysis are used; the majority of which are less than the reported minimum detectable concentration (MDC).

No krypton or tritium in air data were collected offsite, so the onsite krypton for 1997 and an average value for previous year's offsite tritium were used. No vegetable or animal samples were collected in 1998, so calculations for these intakes are not done.

Data quality objectives (DQOs) for precision and accuracy are, by necessity, less stringent for values near the MDC, so confidence intervals around the input data are broad. The concentrations of radioactivity detected by the monitoring networks and used in the calculation of potential CEDEs are shown in Table 7.2.

The concentrations given in Table 7.2 are expressed in terms of activity per unit volume. These concentrations are converted to a dose by using the assumptions and dose conversion factors described below. The dose conversion factors assume continuous presence at a fixed location and no loss of radioactivity in storage or handling prior to ingestion of materials.

- Adult respiration rate = 8400 m^3/yr from International Commission on Radiological Protection Publication (ICRP) 21 (ICRP 1975).
- Milk intake (average for 20 and 40 yr old) = 110 L/yr (ICRP 1975).
- Water consumption = 2 L/day (ICRP 1975).

The EDE conversion factors are derived from Federal Guidance Report No. 11 (EPA 1988). Those used here are:

- ^{3}H: 6.4 x 10^{-8} mrem/pCi (ingestion or inhalation).
- ^{7}Be: 2.6 x 10^{-7} mrem/pCi (inhalation).
- ^{90}Sr: 1.4 x 10^{-4} mrem/pCi (ingestion).
- ^{85}Kr: 1.5 x 10^{-5} mrem/yr per pCi/m^3 (submersion).
- $^{238,239+240}$Pu: 3.7 x 10^{-4} mrem/pCi (ingestion, f_1=10^{-4}); 3.1 x 10^{-1} mrem/pCi (inhalation, Class Y).

The algorithm for the internal dose calculation is:

- (concentration) x (intake in volume [mass]/unit time) x (CEDE conversion factors) = CEDE.

As an example calculation, the following is the result of breathing a concentration of tritium in air of 0.2 pCi/m^3:

- (2 x 10^{-1} pCi/m^3) x (8400 m^3/yr) x (6.4 x 10^{-8} mrem/pCi) = 1.1 x 10^{-4} mrem/yr.

However, in calculating the inhalation CEDE from ^{3}H, the value must be increased by 50 percent to account for skin absorption (ICRP 1979). The total dose in one year, therefore, is 1.1 x 10^{-4} x 1.5 = 1.6 x 10^{-4} mrem/yr. Dose calculations from ORSP data are summarized in Table 7.2.

The individual CEDEs, from the various pathways, added together give a total of 0.017 mrem/yr (1.7 x 10^{-4} mSv/yr). Total EDEs can be calculated based on different combinations of data. If the interest was in just one area, for example, the concentration from those stations closest to that area could be substituted into the equations used herein.

In 1998, because of budget cuts and the standby status of nuclear device testing, samples of game animals and garden vegetables were not collected. Also, the noble gas and tritium sampling network was discontinued in the offsite locations, and the air sampling network was reduced. In order to calculate an EDE for a resident of Springdale, Nevada, to compare with the EDE from the CAP88-PC operation, it is necessary to make some assumptions as shown in the next section.

7.2 DOSE (EDE) FROM OFFSITE EXPOSURES

The NTS average ^{85}Kr concentration is representative of statewide levels, so it can be used in this calculation. Also, tritium in air does not change much from year to year, so previous data for that can be used. Finally, Amargosa Valley, Nevada, has the nearest air sampler to Springdale, Nevada, so its plutonium concentration is used to calculate the EDE. In addition, there is a contribution from ^{7}Be that is formed in the atmosphere by cosmic ray interactions with oxygen and nitrogen. The annual average ^{7}Be concentration measured by the NTS surveillance network was 0.18 pCi/m^3. A dose conversion factor of 2.6 x 10^{-7} mrem/pCi for inhalation and a breathing volume of 8,400 m^3/yr, equates to a dose of 3.9 x 10^{-4} mrem. Also, assume the network average of ^{90}Sr in milk and the tritium in water for sources near Springdale apply. All of the calculations that use these assumptions are shown in Table 7.2 and lead to an EDE at that location of 0.017 mrem, which is about 18 percent of the EDE calculated by use of CAP88-PC. Both of these calculated EDEs are negligible, compared to the PIC measurement of 141 mR at Beatty in 1998.

The maximum offsite EDE would have been at Rachel, Nevada, because the network's highest annual average $^{239+240}$Pu concentration of 4.9 x 10^{-18} µCi/mL (0.18 µBq/m^3) occurred there. A resident of Rachel would thus receive an inhalation exposure leading to 0.013 mrem (1.3 x 10^{-4} mSv) EDE for 1998. When exposure to the other radionuclides listed in Table 7.2 is added, the total becomes 0.025 mrem.

Therefore, based on offsite monitoring data, the MEI would live in Rachel, Nevada, and the EDE would be 0.025 mrem as contrasted with the CAP88-PC result that the MEI would live in Springdale, Nevada, and the EDE would be 0.092 mrem.

7.3 SUMMARY

The offsite environmental surveillance system operated around the NTS by EPA's R&IE-LV detected no radiological exposures that could be attributed to recent NTS operations, but a calculated EDE of 0.025 mrem can be obtained, if certain assumptions are made, as shown in Table 7.2. Calculation with the CAP88-PC model, using estimated or calculated effluents from the NTS during 1998, resulted in a maximum dose of 0.092 mrem (9.2 x 10^{-4} mSv) to a hypothetical resident of Springdale, Nevada, 14 km (9 mi) west of the NTS boundary. Based on monitoring network data, this dose is calculated to be 0.017 mrem. This latter EDE is about 18 percent of the dose obtained from CAP88-PC calculation. This maximum dose estimate is less than 1 percent of the ICRP recommendation that an annual EDE for the general public not exceed 100 mrem/yr (ICRP 1985). The calculated population dose (collective EDE) to the approximately 31,750 residents living within 80 km (50 mi) of each of the NTS airborne emission sources was 0.27 person-rem (2.7 x 10^{-3} person-Sv). Average background radiation yielded an EDE of 3,064 person-rem (30.6 person-Sv).

Data from the PIC gamma monitoring indicated a dose of 141 mrem from background gamma radiation measured in the Springdale, Nevada, area. The CEDE calculated from the monitoring networks or the model, as discussed above, is a negligible amount by comparison. The uncertainty (2σ) for the PIC measurement at the 141 mrem exposure level is approximately 5 percent. Extrapolating to the calculated annual exposure at Springdale, Nevada, yields a total uncertainty of approximately 7 mrem which is greater than either of the calculated EDEs. Because the estimated dose from NTS activities is less than 1 mrem (the lowest level for which DQOs are defined, as given in Chapter 8), no conclusions can be made regarding the achieved data quality as compared to the DQOs for this insignificant dose.

Table 7.1 Summary of Effective Dose Equivalents from NTS Operations - 1998

	Maximum EDE at NTS Boundary[(a)]	Maximum EDE to an Individual[(b)]	Collective EDE to Population within 80 km of the NTS Sources
Dose	0.13 mrem (1.3×10^{-3} mSv)	0.092 mrem (9.2×10^{-4} mSv)	0.27 person-rem (2.7×10^{-3} person-Sv)
Location	Site boundary 40 km WNW of NTS CP-1	Springdale, NV 58 km WNW of NTS CP-1	31,750 people within 80 km of NTS Sources
NESHAP[(c)] Standard	10 mrem per yr (0.1 mSv per yr)	10 mrem per yr (0.1 mSv per yr)	-----
Percentage of NESHAP	1.3	0.92	-----
Background	141 mrem (1.41 mSv)	141 mrem (1.41 mSv)	3064 person-rem (30.6 person-Sv)
Percentage of Background	0.09	0.06	0.009

(a) The maximum boundary dose is to a hypothetical individual who remains in the open continuously during the year at the NTS boundary located 40 km (25 mi) west-northwest from CP-1.

(b) The maximum individual dose is to a person outside the NTS boundary at a residence where the highest dose-rate occurs as calculated by CAP88-PC (Version 1.0) using NTS effluents listed in Table 4.5 and assuming all tritiated water input to the Area 12 containment ponds was evaporated.

(c) National Emission Standards for Hazardous Air Pollutants.

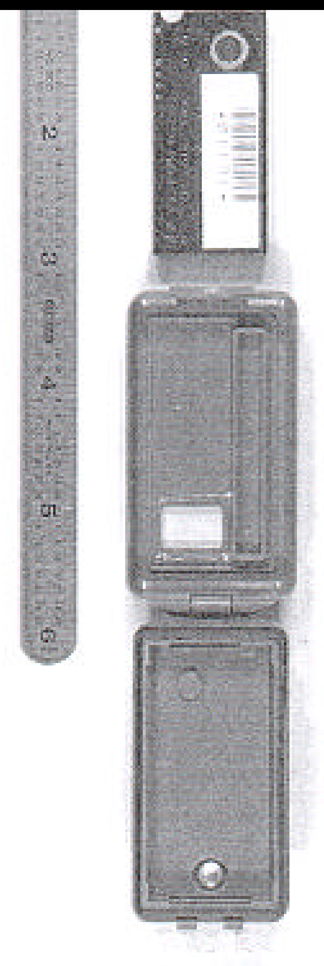
Table 7.2 Monitoring Networks Data Used in Dose Calculations - 1998

Medium	Radionuclide	Concentration	Mrem\Year	Comment
Meat				Not collected this year
Milk	^{90}Sr	0.72 [(a)] (0.027)	1.11×10^{-2}	Concentration is the average of all network results
	^{3}H	0	0	Not Analyzed
Drinking Water	^{3}H	2.3 [(a)] (0.085)	1.1×10^{-4}	Concentration is average from 4 wells in the area
Vegetables				Not collected this year
Air	^{3}H	0.2 [(b)] (0.007)	1.6×10^{-4}	Concentration is average network result (1994 data)
	^{7}Be	0.18 [(b)] (0.0067)	3.9×10^{-4}	Annual average for the NTS
	^{85}Kr	27.[(b)] (0.93)	4.1×10^{-4}	NTS network average 1997
	$^{239+240}Pu$	1.9×10^{-6} [(b)] (7.0×10^{-8})	4.9×10^{-3}	Maximum value at nearest site, Amargosa Valley, Nevada

TOTAL (Air = 5.86×10^{-3}, Liquids = 1.11×10^{-2}) = 1.7×10^{-2} mrem/yr

(a) Units are pCi/L and Bq/L.
(b) Units are pCi/m^3 and Bq/m^3.

[redacted]



TLD Components (No DateProvided)

8.0 LABORATORY QUALITY ASSURANCE

It is the policy of U.S. Department of Energy Nevada Operations Office (DOE/NV) 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 and nonradiological parameters to ensure that data produced by the laboratory meets customer-and regulatory-defined requirements. Data quality is assured through process-based QA, procedure-specific QA, data quality objectives (DQOs), and performance evaluation programs. The external QA program for radiological data consists of participation in the DOE Quality Assessment Program (QAP) administered by the DOE Environmental Measurements Laboratory (EML) and the Performance Evaluation Study (PES) conducted by the U.S. Environmental Protection Agency (EPA) National Exposure Research Laboratory in Las Vegas. The radiological external QA program also consists of participation in the Oak Ridge National Laboratories (ORNL) radiobioassay study conducted by ORNL in Oak Ridge, Tennessee. External radiation measurement QA for the onsite program is assessed by participation in the DOE's Laboratory Accreditation Program (DOELAP). EPA's Radiation and Indoor Environments National Laboratory-Las Vegas (R&IE-LV) offsite thermoluminescent dosimeter (TLD) programs consists of participation in the National Voluntary Laboratory Accreditation Program (NVLAP) operated by the National Institute of Standards and Technology (NIST). The nonradiological data QA program was accomplished by using commercial laboratories with appropriate certification or accreditation by state or government agencies.

The environmental surveillance program off the Nevada Test Site (NTS) was performed by R&IE-LV. The QA program developed by R&IE-LV for the Offsite Radiological Safety Program (ORSP) meets all requirements of EPA policy, and also includes applicable elements of the requirements and regulations of DOE/NV QA. The ORSP QA program defines DQOs, which are statements of the quality of data a decision maker needs to ensure that a decision based on that data is defensible.

8.1 POLICY

Environmental surveillance, conducted onsite by Bechtel Nevada (BN) and offsite by EPA's R&IE-LV, is governed by the DOE QA policy as set forth in DOE Order 5700.6C (DOE 1991a). The Order outlines ten specific elements that must be considered for compliance with the QA policy. These elements are:

1. Program
2. Personnel Training & Qualification
3. Quality Improvement
4. Documents and Records
5. Work Processes
6. Design
7. Procurement
8. Inspection and Acceptance Testing
9. Management Assessment
10. Independent Assessment

In addition, R&IE-LV meets the EPA policy which states that all decisions which are dependent on environmental data must be supported by data of known quality. The EPA's policy requires participation in a centrally managed QA Program by all EPA elements as well as those monitoring and measurement efforts supported or mandated through contracts, regulations, or other formalized agreements. Further, the EPA's policy requires participation in a QA Program by all EPA organizational units involved in environmental data collection. The QA policies and requirements of R&IE-LV are summarized in the "Quality Management Plan" (EPA/Office of Radiation and Indoor Air [ORIA] 1996). The QA policies and requirements specific to the ORSP are documented in the "Quality Assurance Program Plan for the Center for Environmental Restoration, Monitoring, and Emergency Response and the Center for Radioanalysis and Quality Assurance for the Offsite Environmental Monitoring Program," (EPA/ORIA, 1998). The requirements of these documents establish a framework for consistency in the continuing application of QA standards and implementing procedures in support of the ORSP. Administrative and technical implementing procedures based on these QA requirements are maintained in appropriate manuals or are described in standard operating procedures of the R&IE-LV.

8.2 OVERVIEW OF THE LABORATORY QA PROGRAM

The BN Analytical Services Laboratory (ASL) implements the requirements of the DOE Order 5700.6C through integrated quality procedures. The quality of data and results is ensured through both process-based and procedure-specific QA.

Procedure-specific QA begins with the development and implementation of work instructions (WIs) which contain the analytical methodologies and required quality control samples for a given analysis. Personnel performing a given analysis are trained and qualified for that analysis, including the successful analysis of a quality control sample. Analysis-specific operational checks and calibration standards traceable to either the NIST or the EPA are required. Quality control samples, e.g., spikes, blanks, and replicates, are included for each analytical procedure.

Compliance with analytical procedures is measured through procedure-specific assessments or surveillances.

An essential component of process-based QA is data review and verification to assess data usability. Data review requires a systematic, independent review against pre-established criteria to verify that the data are valid for their intended use. Initial data processing is performed by the analyst or health physicist generating the data. An independent review is then performed by another analyst or health physicist to ensure that data processing has been correctly performed and that the reported analytical results correspond to the data acquired and processed. Supervisory review of data is required prior to release of the data to sample management personnel for data verification. Data verification ensures that the reported results correctly represent the sampling and/or analyses performed, and includes assessment of quality control sample results. Data processing by sample management personnel ensures that analytical results meet project requirements. Data discrepancies identified during the data review and verification processes are documented on data discrepancy reports (DDRs). DDRs are reviewed and compiled quarterly to discern systematic problems. Data checks are made by Environmental Surveillance of BN for internal consistency, proper identification, transmittal errors, calculation errors, and transcription errors.

Process-based QA programs also include periodic operational checks of analytical parameters such as reagent water quality and storage temperatures. Periodic calibration is required for all measuring equipment such as analytical balances, analytical weights, and thermometers. The overall effectiveness of the QA program is determined through systematic assessments of analytical activities. Systematic problems are documented and corrective actions tracked through System Deficiency Reports.

Similar procedures and methodologies are used by R&IE-LV to ensure the quality of environmental radiological data collected off the NTS.

8.3 DATA AND MEASUREMENT QUALITY OBJECTIVES

DATA QUALITY OBJECTIVES

DQOs delineate the circumstances under which measurements are made and define the acceptable variability in the measured data. DQOs are based on the decision(s) to be made, the range of sampling possibilities, what measurements will be made, where the samples will be taken, how the measurements will be used, and what calculations will be performed on the measurement data to arrive at the desired result(s). Associated measurement quality objectives (MQOs), which define acceptable variability in the measured data, are established to ensure the quality of the measurements.

DECISIONS TO BE MADE

The primary decisions to be made, based on radiological environmental surveillance measurements, are whether, due to NTS activities (1) any member of the general public, outside the site boundaries, receives an effective dose equivalent (EDE) that exceeds regulatory limits; (2) there is detectable contamination of the environment; or (3) there is a biological effect. A potential EDE to a member of the public from NTS activities is much more likely to be due to inhalation or ingestion of radionuclides which have reached the person through one or more pathways, such as transport through the air (inhalation exposure), or through water and/or foodstuffs (ingestion exposure), than to be due to external exposure. A pathway may be quite complex; e.g., the food pathway could include airborne radioactivity falling on soil and plants, also being absorbed by plants, which are eaten by an animal, which is then eaten by a member of the public. At the NTS, because of the depth of aquifers, negligible horizontal or vertical transport, lack of surface water flows and little rain, very sparse vegetation and animal populations, lack of food grown for human consumption, and large distances to the nearest member of the public, the airborne pathway is by far the most important for a possible EDE to a member of the public.

Decisions made based on nonradiological data are related to waste characterization, extent and characterization of spills, compliance with regulatory limits for environmental contaminants, and possible worker exposure(s).

RANGE OF SAMPLING POSSIBILITIES

Determination of the numbers, types, and locations of radiological sampling stations is based on factors such as the location of possible sources, isotopes of concern, wind and weather patterns, the geographical distribution of human populations, the levels of risk involved, the desired sensitivity of the measurements, physical accessibility to sampling locations, and financial constraints. The numbers, types, and location of nonradiological samples are typically defined by regulatory actions on the NTS and are determined by environmental compliance or waste operations activities. Workplace and personnel monitoring to determine possible worker exposures is conducted by Industrial Hygienists and Health Physicists from the Environment, Safety and Health Division (ESHD) of BN.

MEASUREMENTS TO BE MADE

Radioanalyses are made of air, water, or other media samples to determine the types and amounts of radioactivity in them. These measurements are then converted to radioactivity concentrations by dividing by the sample volume or weight, which is measured separately. Nonradiological inorganic or organic constituents in air, water, soil, and sludge samples are analyzed and reported by commercial laboratories under contract to BN. Methods and procedures used to measure possible worker exposures to nonradiological hazards are defined by Occupational Safety and Health Administration or National Institute of Occupational Safety and Health protocols.

Typical contaminants for which BN ESHD personnel collect samples and request analyses are asbestos, solvents, and welding metals. Sample media, which are analyzed, include urine, blood, air filters, charcoal tubes, and bulk asbestos.

SAMPLING LOCATIONS

The locations of routine radiological environmental surveillance sampling both on and off the NTS are described in Chapters 4 and 5 of this report. Onsite sampling methodologies are described in BN's Environmental Management Procedures, and offsite methodologies by similar R&IE-LV procedures. The locations of nonradiological environmental sampling and monitoring are determined through site remediation and characterization activities and by permit requirements.

USE OF THE MEASUREMENTS

There are several techniques to estimate the EDE to a member of the public. One technique is to measure the radionuclide concentrations at the location(s) of interest and use established methodologies to estimate the EDE a person at that location could receive. Another technique is to measure radionuclide concentrations at specific points within the site and to use established models to calculate concentrations at other, offsite locations of interest. The potential EDE to a person at such a location could then be estimated. This second technique is the one used for most of the environmental surveillance data measured at the NTS.

CALCULATIONS TO BE PERFORMED

The EDE of greatest interest is the EDE to the maximally exposed individual (MEI). The MEI is located where, based on measured radioactivity concentrations and distances from all contributing NTS sources, the calculational model gives the greatest potential EDE for any member of the public. The assumptions used in the calculational model are conservative; i.e., the calculated EDE to the MEI most certainly exceeds the EDE any member of the public would actually receive. The model used at the NTS is EPA's CAP88-PC, a wind dispersion model approved for this purpose.

MEASUREMENT QUALITY OBJECTIVES (MQOs)

MQOs are commonly described in terms of representativeness, comparability, completeness, precision, and accuracy. Although the assessment of the first two characteristics must be essentially qualitative, definite numerical goals may be set and quantitative assessments performed for the latter three.

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 also refers to whether the locations and frequency of sampling are such that calculational models will lead to a correct estimate of potential EDE to a member of the public when measured radioactivity concentrations are put into the model. An environmental monitoring plan for the NTS, "Nevada Test Site Routine Radiological Environmental Monitoring Plan" (DOE 1998a) has been established to achieve representativeness for environmental data. Factors which were considered in designing this monitoring plan include locations of known and potential sources, historical and operational knowledge of isotopes and pathways of concern, hydrological, and topographical data, and locations of human populations.

COMPARABILITY

Comparability refers to the degree of confidence and consistency we have in our analytical results, or defined as "the confidence with which one data set can be compared to another" (Stanley and Verner 1985). To achieve comparability in measurement data, sample collection and handling, laboratory analyses, and data analysis and validation are performed in accordance with established WIs. Standard reporting units and a consistent number of significant digits are used. Instruments are calibrated using NIST-traceable sources. Each batch of field samples is accompanied by a spiked sample with a known quantity of the compound(s) of interest. Extensive QA measures are used for all analytical processes. In addition, comparability is attained through comparison of external performance audit results to those achieved by other laboratories participating in the EPA PES.

COMPLETENESS

Completeness is defined as the percentage of samples collected versus those which had been scheduled to be collected, or the percentage of valid analysis results versus the results which would have been obtained if all samples had been obtained and correctly analyzed. Realistically, samples can be lost during shipping, handling, preparation, and analysis, or not collected as scheduled. Also data entry or transcription errors can be made. The BN completeness objectives for all radiological samples and analyses have been set at 90 percent for sample collection and 85 percent for analyses, or 75 percent overall. R&IE-LV's completeness objective for the Long-Term Hydrological Monitoring Program is 80 percent and for the other networks it is 90 percent.

Completeness for inorganic and organic analyses is based on the number of valid results received versus the number requested.

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 same 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 for samples is determined by comparing results for duplicate samples of particulates in air, tritiated water vapor, noble gases, and some types of water samples. For TLDs, precision is assessed from variations in the three $CaSO_4$ elements of each environmental TLD. Precision is expressed quantitatively as the percent relative standard deviation (%RSD), i.e., the ratio of the standard deviation of the measurements being compared to their mean converted to percent. The smaller the value of the %RSD, the greater is the precision of the measurement. The precision objectives are shown in Table 8.1. They are a function of the concentration of radioactivity in the samples; i.e., the analysis of samples with concentrations near zero will have low precision, while samples with higher concentrations will have proportionately higher precision.

ACCURACY

Accuracy refers to how well we can measure the true value of a given quantity and can be defined as "the degree of agreement of a measured value with the true or expected value of the quantity of concern" (Taylor 1987). For practical purposes, assessments of accuracy for the ASL are done by performing measurements on special QA samples prepared, using stringent quality control, by laboratories which specialize in preparing such samples. The values of the activities of these samples are not known by the staff of the ASL until several months after the measurements are made and the results sent back to the QA laboratory. These sample values are unknown to the analysts and serve to measure the accuracy of the analytical procedures. The accuracy of these measurements, which is assumed to extend to other similar measurements performed by the laboratory, may be defined as the ratio of the measured value divided by the true value, expressed as a percent. Percent bias is the complement of percent accuracy; i.e., percent bias = 100 percent accuracy. The smaller the percent bias, the more accurate are the measurements. Table 8.2 shows the accuracy objectives of the ASL and of the R&IE-LV.

Measurements of sample volumes should be accurate to ± 5 percent for aqueous samples (water and milk) and to ± 10 percent for air and soil samples. The sensitivity of radiochemical and gamma spectrometric analyses must allow no more than a 5 percent risk of either a false negative or false positive value. Control limits for accuracy, monitored with matrix spike samples, are required to be no greater than ± 20 percent for all gross alpha and gross beta analyses and for gamma spectrometric analyses.

Both the R&IE-LV and ASL participate in several interlaboratory performance evaluation (PE) programs such as EPA's PES and EML's QAP and the DOELAP for TLDs. The ASL also participates in two bioassay programs, DOELAP and ORNL.

The accuracy of the TLDs is tested every two or three years by DOELAP or biennially by NVLAP. This involves a three-part, single blind performance testing program followed by an independent onsite assessment of the overall program. Both BN and R&IE-LV participate in this program.

Once the data have been finalized, they are compared to the MQOs. Completeness, accuracy, and precision statistics are calculated. If data fail to meet one or more of the established MQOs, they may still be used in data analysis; however, the data and any interpretive results must be qualified. Current and historical data are maintained in an access-controlled database.

All sample results exceeding the traditional natural background activity range are investigated. If data are found to be associated with a non-environmental condition, e.g., a check of the instrument using a calibration source, the data are flagged and are not included in calculations of averages, etc. Only data verified to be associated with a non-environmental condition are flagged; all other data are used in calculation of averages and other statistics, even if the condition is traced to a source other than the NTS.

8.4 RESULTS FOR COMPLETENESS, PRECISION, AND ACCURACY

Summary data for completeness, precision, and accuracy are provided in Tables 8.3 to 8.6, respectively. Complete data used in these MQO’s for 1998 are from unpublished PES reports by the EPA and from reports by EML’s QAP (DOE 1998b and 1998c).

COMPLETENESS

The analysis completeness data for calendar year 1998 are shown in Table 8.3. These percentages represent all analyses which were carried to completion, and include some analyses for which the results were found to be invalid for other reasons. Had objectives not been met for some analyses, other factors would be used to assess acceptability, e.g., fit of the data to a trend or consistency with results from samples collected before and after.

The completeness MQOs for the onsite networks were met or exceeded in all cases. For the offsite networks, the MQOs were met or exceeded except for the pressurized ion chamber (PIC) network. Failure of the PIC network was due to the loss of telemetry systems for the majority of 1998 due to budget restrictions. Secondary data collection systems were used for this period and were not effective due to reduced maintenance support of aging equipment. The telemetry system was reactivated during August 1998 which resulted in average data completeness of greater than 95 percent through the end of the year.

PRECISION

From replicate samples collected and analyzed throughout the year, the %RSD was calculated for various types of analyses and sampling media. The results of these calculations are shown in Table 8.4 for both the onsite and offsite networks. In addition to examination of %RSDs for individual duplicate pairs, an overall precision estimate was determined by calculating the pooled standard deviation, based on the algorithm given in Taylor (1987). To convert to a unitless value, the pooled standard deviation was divided by the grand mean and multiplied by 100 to yield a %RSD. The table presents the pooled data and estimates of overall precision. The pooled standard deviations and %RSD indicate the estimated achieved precision for sample results.

For the R&IE-LV, precision data for all analyses were well within their respective MQOs, except for plutonium. Plutonium results were rechecked, including selective recounting, and are believed to be valid. The high %RSD in those duplicates that exceeded the MDC suggests that there is variability of particulate distribution in the environment. Since this is the first year in which duplicate high volume samplers were employed, there are no trending data available. The R&IE-LV data presented in Table 8.4 include only laboratory and field duplicate pairs that exceeded the MDC.

For the ASL, the reason for the low precision in some of the analyses was the low activity in these environmental samples. The few that were useful for calculation of precision barely exceeded the MDC.

ACCURACY

The ASL and R&IE-LV accuracy objectives were measured through participation in the interlaboratory comparison and QAPs discussed below.

RADIOLOGICAL PERFORMANCE EVALUATION RESULTS

The external radiological PEs consisted of participation in the QAP conducted by DOE/EML and the PES conducted by EPA. These programs serve to evaluate the performance of the radiological laboratory and to identify problems requiring corrective actions.

Summaries of the 1998 results of the interlaboratory PE and QAPs conducted by the EPA and DOE/EML are provided in Tables 8.5 and 8.6. The column or section in each table labeled percent bias is the accuracy of analysis and may be compared to the objectives listed in Table 8.2. The individual radionuclide recoveries are listed in tables which may be found in the DOELAP and PES reports.

Accuracy, as percent difference or percent bias is calculated by:

$$\%BIAS = \left(\frac{C_m - C_a}{C_a}\right) 100$$

where:

$\%BIAS$ = *percent bias*
C_m = *measured sample activity*
C_a = *known sample activity*

The R&IE-LV failed the accuracy MQO in 3 of the 43 analyses attempted in the EPA PE study. The three analyses were outside of the bias MQO but were within three normalized deviation limits for each study. In the EML QAP, all of the 44 analyses performed were within the DQO of ± 20 percent. In 1998, R&IE-LV discontinued accreditation by DOELAP for the personnel TLD program and enrolled in and achieved accreditation by NVLAP. QA checks are routinely performed to ensure compliance with applicable performance standards.

BN's ASL results exceeded the 3 normalized deviation limits in 3 of the 41 analyses attempted; however, only 2 were identified by the PEs as being beyond control limits. The MQOs for accuracy in analysis of DOE/EML samples were not met in only 2 of the 78 analyses attempted.

CORRECTIVE ACTIONS IMPLEMENTED IN RESPONSE TO PERFORMANCE EVALUATION PROGRAMS

BN results were generally within the control limits determined by the program sponsors. Results which were not within acceptable performance limits were investigated and corrective actions taken to prevent reoccurrence.

In the R&IE-LV, the 1998 results that did not meet analysis criteria were investigated to determine the cause of the reported error. Corrective actions were implemented.

COMPARABILITY

The EPA PEs and the EML/QAP provide results to each laboratory participating in each study that include a grand average for all values, excluding outliers. A normalized deviation statistic compares each laboratory's result (mean of three replicates) to the known value and to the grand average. If the value of this statistic (in multiples of standard normal deviate, unitless) lies between control limits of -3 and +3, the accuracy (deviation from known value) or comparability (deviation from grand average) is within normal statistical variation.

Data from the 1998 intercomparison studies for all variables measured were compared with the grand average to calculate a normalized deviation for the R&IE-LV results. All analyses were within three standard normal deviate units of the grand average, and most were within one normalized deviate unit. This indicates acceptable comparability of the R&IE-LV results with the laboratories participating in the QAP.

One of the two EML studies for 1998 was reported outside of acceptable limits for gamma spectroscopy in both air and water matrices. The problem with the air filters was traced to incorrect spiking (that is preparation) of the air filters.

The onsite ASL results in the EML QAP were acceptable. There were only two instances in which the ASL results were greater than the MQO. Corrective actions were made and the results from the next semi-annual PE sample were acceptable. The EPA PES includes a grand average (average result from all participating laboratories, less outliers) in its report to participants. Using the formula for percent bias described above, the percent bias of the ASL results as compared to the grand average was calculated for each analysis. The outcome for this calculation did not differ from the accuracy results reported above.

Table 8.1 Precision Objectives Expressed as Percents

Analysis	ASL Conc. > 10 MDC	ASL 4 MDC ≤ Conc. ≤ 10 MDC
Gross Alpha	±30	±60
Gross Beta	±30	±60
Gamma Spectrometry	±30	±60
Scintillation Counting	±30	±60
Alpha Spectrometry	±20	±50

Note: The precision objective for TLDs at environmental levels is 10 percent.

Analysis	R&IE-LV Conc. > 10 MDC	R&IE-LV 4 MDC ≤ Conc. ≤ 10 MDC
Conventional Tritium	±10	±30
Strontium (in milk)	±10	±30
Thorium	±10	±30
Uranium	±10	±30
Enriched Tritium	±20	±30
Strontium (in other media)	±20	±30
Plutonium	±20	±30

Table 8.2 Accuracy Objectives Expressed as Percent Bias

Analysis	ASL Conc. > 10 MDC	ASL 4 MDC ≤ Conc. ≤ 10 MDC
Gross Alpha	±20	±50
Gross Beta	±20	±50
Gamma Spectrometry	±20	±50
Scintillation Counting	±20	±50
Alpha-Spectrometry	±20	±50
TLDs	Meet DOELAP Criteria	

Analysis	R&IE-LV Conc. > 10 MDC	R&IE-LV 4 MDC ≤ Conc. ≤ 10 MDC
Tritium, Conventional	±10	±30%
Strontium (Milk)	±10	±30%
Thorium	±10	±30%
Uranium	±10	±30%
Tritium, Enriched	±20	±30%
Strontium (other media)	±20	±30%
Plutonium	±20	±30%
TLDs	Meet NVLAP Criteria	

Table 8.3 Analysis Completeness Data for Calendar Year - 1998

Analysis	Medium	Completeness Percent BN	Completeness Percent R&IE-LV
Gross Alpha/Beta	Low Volume Particulate Air Filter	98.5	97.0
Plutonium	High Volume Particulate Air Filter	(a)	82.7
Plutonium	Low Volume Particulate Air Filter	98.5	(a)
Gamma Spectrometry	Low Volume Particulate Air Filter	98.5	97.0
Gamma Spectrometry	Low Volume Charcoal Air Filter	(a)	97.0
Gamma Spectrometry	High Volume Particulate Air Filter	(a)	82.7
Tritiated Water	Air	96.2	(a)
Gross Alpha	Potable Water Taps	61.5	(a)
Gross Beta	Potable Water Taps	61.5	(a)
Gamma Spectrometry	Potable Water Taps	61.5	(a)
Tritiated Water	Potable Water Taps	61.5	(a)
Plutonium	Potable Water Taps	61.5	(a)
Gross Beta	Wells, Ponds	85.4	(a)
Plutonium	Wells, Ponds	85.4	(a)
Gamma Spectrometry	Wells, Ponds	85.4	94.9
Tritiated Water	Wells, Ponds	85.4	94.9
Strontium-90	Wells, Ponds	85.4	(a)
Tritium	Milk	(a)	100
Strontium	Milk	(a)	100
Pressurized Ion Chamber	Ambient Radiation	(a)	52.5
TLDs, Environmental	Ambient Radiation	99.7	98.7
TLDs, Personnel	Ambient Radiation	(a)	93.1

(a) Analyses not performed.

Table 8.4 Precision Estimates from Replicate Sampling - 1998

Analysis	Number of Replicate Analyses	Precision Estimate %RSD
	ASL	
Gross Alpha in Air	100	33.5
Gross Beta in Air	100	13.6
Gamma in Air	22	7.96
Pu in Air	22	73.4
Tritium in Air	47	59.6
Gross Alpha in Potable Water	15	20.1
Gross Beta in Potable Water	15	6.86
HTO in Tunnel Effluent	6	2.89
Pu in Tunnel Effluent	6	20.3
	R&IE-LV	
Gross Alpha in Air	134	25.6
Gross Beta in Air	173	18.0
Gamma Spectrometry (Low-Vol ^{7}Be)	18	24.4
Gamma Spectrometry (Hi-Vol ^{7}Be)	8	30.1
Plutonium in Air (Hi-Vol)	8	59.1
Tritium in Water (enriched)	6	10.8
Tritium in Water (unenriched)	7	9.7

Table 8.5 Accuracy of R&IE-LV Radioanalyses (EML QAP and PES) - 1998

Water Samples Range of Results - pCi/L

Analysis	No.	PES	R&IE-LV	Percent Bias
Gross Alpha	5	7.2 - 54	9.7 - 64	-21 - 35
Gross Beta	5	3.5 - 95	8.7 - 102	-3.7 - 206
Gamma Spec.[(a)]	18	6.1 - 131	6.0 - 138	-12 - 10
Strontium	8	6.0 - 32	7.0 - 31	-11 - 79
Alpha Spec.	5	3.0 - 32	3.0 - 32	-1.3 - 6.1
Tritium	2	2155 - 17996	2137 - 17357	3.6 - -0.8

(a) Three analyses exceeding bias MQO were all within 3 normalized deviations for the analysis group.

Percent Bias Range for Analysis of EML QAP Samples

Analysis	No.	Air	Soil	Vegetation	Water
Plutonium	12	2.9 - 11	-0.7 - 3.9	-11 - 10	-0.6 - 4.3
Americium	8	2.9 - 7.3	1.6 - 2.0	3.2 - 13	-2.9 - 5.6
Curium	2	(a)	(a)	-8.9 - 6.8	(a)
Strontium	2	(a)	(a)	(a)	-2.8 - 10
Tritium	2	(a)	(a)	(a)	-2.0 - 7.4
Gamma Spec.	18	10 - 9.4	(a)	(a)	-2.0 - 13

(a) No sample.

Percent Bias Range for Analysis of MAPEP QAP Samples

Plutonium	3	(a)	1.6	(a)	-1.7 - -0.7
Americium	1	(a)	-4.6	(a)	(a)
Uranium	1	(a)	(a)	(a)	-1.1
Strontium	1	(a)	(a)	(a)	-6.3
Gamma Spec.	5	(a)	(a)	(a)	-4.6 - 2.5

(a) No sample.

Table 8.6 Accuracy of ASL Radioanalyses (EPA PES and EML QAP) - 1998

Analysis of Water Samples	No.	BN/ASL Average pCi/L	EPA QA Known	Normalized Deviation[(a)] Grand Avg.
Gross Alpha	3	9.1 - 25	7.2 - 54.4	0.16 - 0.97
Gross Beta	3	9.2 - 91	3.9 - 94.7	-1.25 - 0.61
Tritium	2	2,190 - 17,500	2,155 - 17,996	-0.33 - 0.15

Table 8.6 (Accuracy of ASL Radioanalyses [EPA PES and EML QAP] - 1998, cont.)

Analysis of Water Samples	No.	BN/ASL Average pCi/L	EPA QA Known	Normalized Deviation[a] Grand Avg.
^{60}Co	3	12.7 - 51.0	12.0 - 50.0	-0.03 - 0.52
^{65}Zn	2	120 - 149	104.0 - 131	1.57 - 1.94
^{90}Sr	3	6.3 - 24.7	7.0 - 32.0	-0.64 - -0.14
^{144}Ba	2	40.7 - 56.0	40.0 - 56.0	0.0 - 0.89
^{134}Cs	3	19.0 - 91.7	22.0 - 105.0	-1.88 - 0.60
^{137}Cs	3	10.3 - 116	10.0 - 111.0	-0.17 - 0.53
^{226}Ra	4	1.29 - 19.2	1.7 - 16.0	-3.57 - 6.77[a]
^{228}Ra	4	3.07 - 43.1	2.1 - 33.3	-0.20 - 2.99
^{234}U	2	10.7 - 13.1	10.7 - 13.8	-0.767 - 0.0
^{238}U	2	11.4 - 13.7	10.7 - 14.0	-0.240 - 0.757
U-(natural)	4	3.03 - 32.1	3.0 - 32.0	-0.28 - 0.46

(a) Three of four results exceeded three Normalized Deviations; however, PES failed only two.

Percent Bias Range for Analysis of EML QAP Samples

Analysis	No.	Air	Soil	Vegetation	Water
Americium	2	1.0 - 7.7	-12.6 - -10.3	9.9 - 13.1	0.4 - 5.6
Plutonium	2	-7.0 - 9.0	-3.5 - 7.7	-3.4 - 3.2	[c]-24.9 - 0.0
Strontium	2	-2.2 - 17.9	-5.3 - 19.4	9.50 - 3.1	-1.3 - 7.1
Tritium	2	(a)	(a)	(a)	8.1 - 9.8
Gamma Spec.	(b)	[d]-26.2 - 5.6	-5.3 - 9.2	0.3 - 30.0	3.6 - 15.1
Gross Alpha	2	- 10.0	(a)	(a)	-1.9 - 2.0
Gross Beta	2	14.8	(a)	(a)	-5.5 - 12.0

(a) No sample.
(b) Number of Isotopes was 11 (air), 5 (soil), 7 (vegetation), and 6 (water).
(c) One result with bias > 20 percent.
(d) One result had bias > 20 percent; however it was below the EML upper limit of 30 percent and was for ^{144}Ce, a radionuclide no longer detected in the NTS environment.

9.0 DATA QUALITY ASSESSMENT AND ANALYSIS

Several levels of data review and screening are used to characterize the quality of the data. The data are received from the laboratory as an American Standard Code for Information Interchange (ASCII) file containing 33 fields of data variables that describe a sample and the analysis performed on that sample. There is one line of data for each sample submitted to the laboratory and one file for each type of sample and analysis; for example, there is a file for gross alpha in air. These files are received monthly or quarterly depending upon the frequency of sample collection.

The files received from the laboratory are screened by a data validation computer program that runs on a personal computer. This program has 15 modules, one for each type of sample and analysis. The modules subject each line of data to between 6 and 14 checks of data values. A line of data that fails a check is copied to an output file with a notation identifying the check that failed. All modules check for valid sampling location names and identification numbers. Result values, error values, minimum detectable concentrations (MDC), and sample volumes or weights are checked to determine if they fall within expected ranges of values. The modules also count the number of samples in the file for each sampling location and compare this count to the number of sample records that should be in the file. The output files are reviewed by the sampling manager and appropriate actions are taken. The actions taken include correcting the data entries and calculations, submitting samples for reanalysis, collecting additional samples to verify unexpected conditions, and inspection and repair of sampling apparatus.

The data are then copied to a spreadsheet, combined into monthly, quarterly, or annual files, and submitted for statistical review. Most data files are reviewed statistically when the data for a full quarter of a year are available. The statistical review looks for trends in the data, outliers, clustering of data values, and consistency with historical levels. Descriptive statistics and plots of the data are provided for management review.

All data for a year are available at about the end of the first quarter of the next year. The data are archived in a data base management system and preparation of the data dependent sections of the annual report commences. An extensive statistical analysis of each data set is performed and this analysis is described in a separate data report. The following sections summarize the results of those analyses.

9.1 AIR SAMPLE DATA

GROSS ALPHA IN AIR

In 1998, 1839 weekly gross alpha in air samples and duplicates from 37 locations on the Nevada Test Site (NTS) and Nellis Air Force Range were collected and analyzed. Descriptive statistics for the results and duplicates from individual sampling locations are given in Table 9.1. The median MDC for 1998 was 1.78×10^{-15} µCi/mL and 52 percent of the results and duplicates were less than their individual MDCs. A time series plot of all data values was examined for trend. This plot indicated a slight trend of increasing values until the end of summer, then decreasing values. This plot also showed that most of the data values were between 0 and 3×10^{-15} µCi/mL, with a few higher values. A one-way analysis of variance (ANOVA) on the square root of the data (the square root of the gross alpha in air data has a normal statistical distribution) versus sampling location found a significant difference among sampling locations. An examination of location mean values did not find any clustering of means, rather the means gradually increased from a low at Area 2 Camp to a high at CLEAN SLATE II. The highest mean was only 68 percent above the lowest mean; thus, the statistical significance may be due more to the very large degrees of freedom rather than a practical significance.

Gross alpha in air data have been collected since the middle of 1996. Two and one-half years of data are insufficient for an analysis of historical trends.

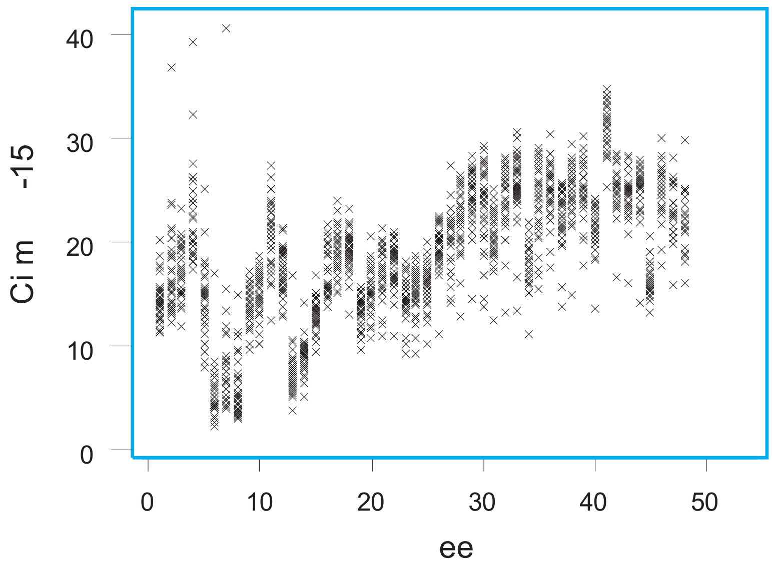
GROSS BETA IN AIR

Gross beta is analyzed on the same glass-fiber filters that are used for gross alpha analysis. In 1998, 1,810 gross beta samples and duplicates were analyzed. Descriptive statistics for each sampling location are given in Table 9.2. The median MDC for 1998 is 4.08×10^{-15} µCi/mL, and only 1 percent of the results and duplicates were less than their individual MDCs. The sampling dates were grouped by the month that sampling began, and then an ANOVA was performed to test for significant differences among months. This statistical test found significant differences; thus, there was a statistically significant trend within 1998. Figure 9.1 is a time series plot of all the gross beta results by sample week. The solid line in this figure is a "locally weighted scatterplot smoother line," which is a statistical tool for visualizing any trend that may be in the data. This line seems to show a seasonal trend with increasing gross beta levels during the hot summer months. Most of the weekly data that clusters substantially below the line in Figure 9.1 can be associated with weeks of heavy rain, which would reduce air particulates. An ANOVA was also performed to test for significant differences between sampling locations. This analysis also found statistically significant differences. The sampling location means were examined for any clustering of values, and no clusters were found. There is a pattern of gradually increasing mean values from the lowest mean at Project 57 to the highest mean at U-3bh north.

For the analysis of historical gross beta trends, the three sampling locations that have been in continuous use since 1966, when individual station data became available, are used and also the two locations that have been in use since 1967. These five locations are the Area 2 Complex, Well 5B in Area 5, CP-6 in Area 6, Gate 700 south in Area 10, and Gate 293 in Area 11. Figure 9.2 is a time series plot of the annual averages from these five locations. The line in Figure 9.2 suggests a trend peaking in 1971, then a steady decrease in annual averages until 1975. The downward trend resumes in 1978 and continues until about 1983 when a level of about 20×10^{-15} µCi/mL was reached. Since 1982, the annual averages have remained at or slightly less than the 20×10^{-15} µCi/mL level, except for the peak in 1986. Three additional peaks are seen in Figure 9.2 that occur before 1982. A significant peak occurred in 1971 which was probably due to the BANEBERRY test that accidently vented following detonation on December 18, 1970. This test was located in the southwest section of Area 8. Peaks occurred in 1977 and 1981, which are probably due to foreign nuclear testing. The peak in 1986 is attributed to the accident at Chernoble.

Since about 1982, gross beta in air levels have been uniformly low and essentially at world-wide background, except for the 1986 peak. Almost all values are above analytic MDCs; thus, the data values are valid measures of environmental conditions.

Statistically significant differences are found between locations, operational areas, and sample collection dates. The analysis of duplicate samples was used to assess sources of error and variability in the data.



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PLUTONIUM IN AIR

The glass-fiber filters that were used for weekly gross alpha and beta analysis and gamma spectroscopy were composited on a monthly basis and then analyzed for ^{238}Pu and $^{239+240}$Pu. Descriptive statistics for the results and duplicates from individual sampling locations are given in Table 9.3 for ^{238}Pu and in Table 9.4 for $^{239+240}$Pu. The median MDC for ^{238}Pu in 1998 was 9.85×10^{18} µCi/mL. Ninety-nine percent of the results were less than the MDC, and 66 percent were negative. The median MDC for $^{239+240}$Pu was 10.6×10^{-18} µCI/mL. Twenty-eight percent of the results were negative, and 68 percent were less than the MDC.

Probability plotting of the ^{238}Pu data indicated that the negative data are from a different statistical distribution than the positive data, and the positive data have a lognormal statistical distribution. Because of this, and that almost all results are less than the MDC, only a few summary statistics were done for this isotope.

Those sampling locations that have ^{238}Pu concentrations above the MDC are typically locations that have historically shown relatively high concentrations. Bunker T-4 in Area 4 had above MDC results in May and June 1998. This bunker is about 200 feet southwest of the T-4 tower location. Four atmospheric tests were conducted at this tower location in the 1950's: FOX on May 25, 1952, NANCY on March 24, 1953, APPLE-1 on March 29, 1955, and KEPLER on July 24, 1957. The 9-300 Bunker in Area 9 had above MDC results in October. This bunker is surrounded by 15 atmospheric nuclear test locations. The closest two are approximately 500 feet northwest of the bunker and were atmospheric tests: MANATEE on December 14, 1962, and APSHAPA on June 6, 1963. The other sample, with above MDC results, was collected at the Yucca Flat sampling location in Area 6 in June 1998. This location has no history of high values.

Descriptive statistics for $^{239+240}$Pu by sampling location are given in Table 9.4. The most striking features of this table are the great differences between the means and corresponding medians, large standard deviations, and relatively high maximum values. This pattern of statistics is characteristic of extremely skewed data. Probability plots of these data indicated a mixture of two statistical distributions. The data above approximately 2×10^{-18} µCi/mL have nearly a lognormal distribution and the distribution of the data below this value has an undetermined distribution. The probability plots also showed a cluster of seven higher values. An examination of the data showed that these higher values were from samples collected at the 9-300 Bunker, the SEDAN crater, CLEAN SLATE I, the Transuranic Pad Building, and BJY.

The significance of the differences in $^{239+240}$Pu concentrations among NTS operational areas can be assessed using ANOVA procedures. A one-way ANOVA was performed on the logarithms of the data; logarithms delete the negative data values. This analysis showed very significant differences among areas. The $^{239+240}$Pu concentrations in Area 9 are significantly higher than all other areas.

Plutonium in air data were first reported in the 1971 Annual Report. From 1971 to 1989 no distinction was made between ^{238}Pu and $^{239+240}$Pu, but it is known from the analytical method used that $^{239+240}$Pu was being measured. In 1989 ^{238}Pu analyses began. Figures 9.3 and 9.4 plot historical annual averages from the ten sampling locations that have data available from the last ten years. Figure 9.3 containing ^{238}Pu annual averages shows an exponential shaped decline from a level of about 4×10^{-18} µCi/mL in 1989 to almost zero in 1998. Figure 9.4 containing $^{239+240}$Pu annual averages indicates a linear and declining trend over the entire time period of the figure. The highest value in Figure 9.4 is 150×10^{-18} µCi/mL and the public derived concentration guide (DCG) is over 13 times higher at 2×10^{-15} µCi/mL.

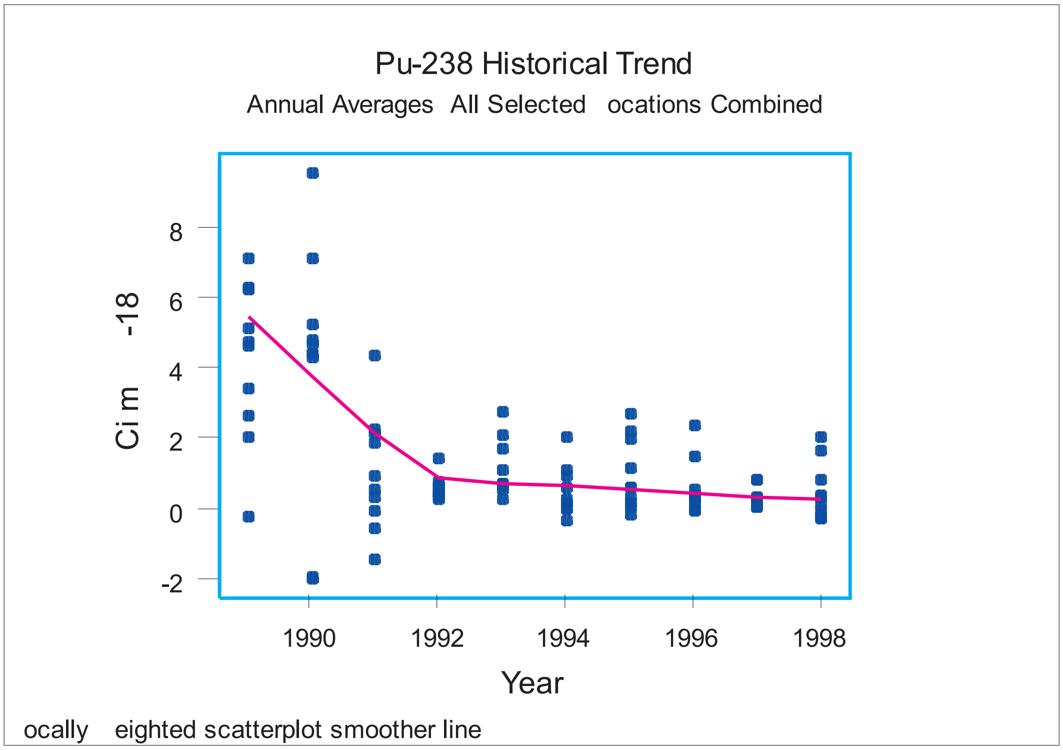


Figure 9.3 Time Series Plot of ^{238}Pu Annual Averages

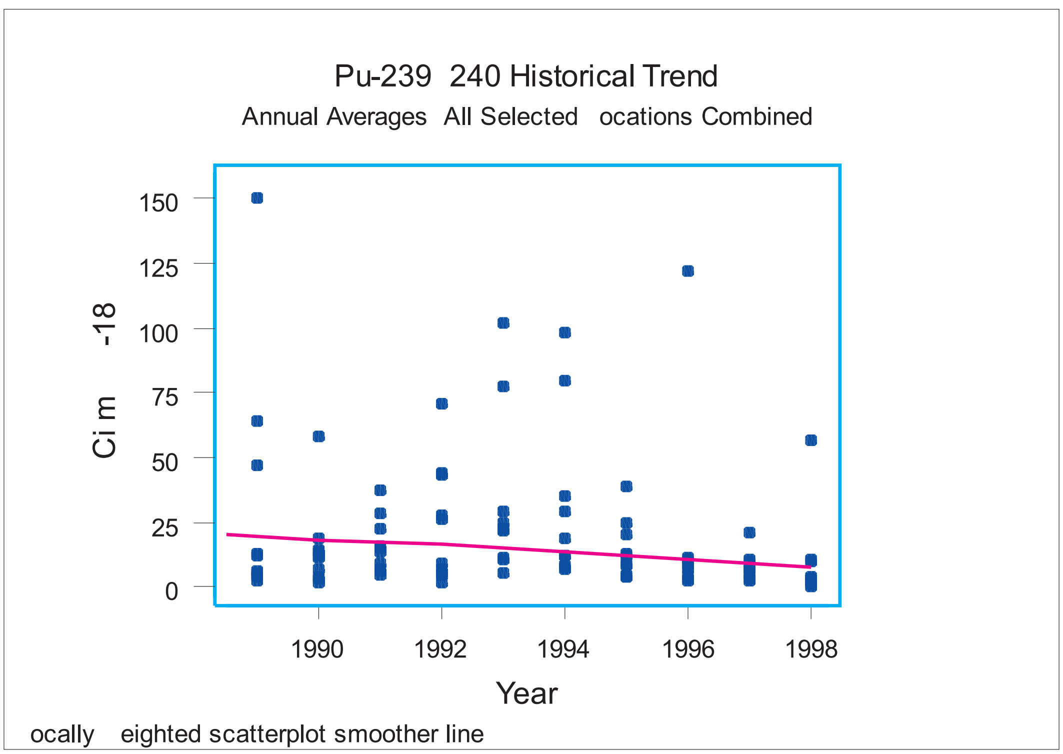


Figure 9.4 Time Series Plot of $^{239\ 240}$Pu Annual Averages

TRITIUM IN AIR

Thirteen samplers for airborne tritiated water vapor were placed at locations on the NTS during 1998. Samples were typically collected over a two week period. Figure 4.1 shows the locations of the 1998 tritium in air sampling locations on a map of the NTS. Table 9.5 gives descriptive statistics for the results and duplicates from the individual sampling locations. Note that the units used in this table differ from those used in all previous tables. Forty percent of the data values are below the individual MDCs, and 7 percent are negative. Most of the above MDC results are from the northeast corner of the radioactive waste management site (RWMS), decontamination facility, EPA Farm, SEDAN crater, E Tunnel, and SCHOONER locations. The RWMS has storage for tritiated waste as well as other radiological waste materials. The EPA Farm is close to the SEDAN crater, which is a known source of low levels of tritium. The decontamination facility has a storage area in which tritiated materials have been located within cargo containers.

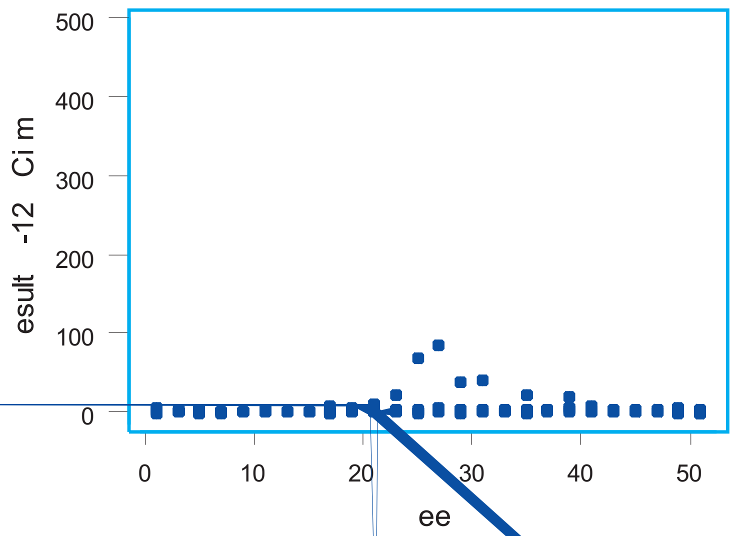
Figure 9.5 is a time series plot of all the tritium in air data for 1998. The high values seen during the summer months are mostly from the SCHOONER sampling location. Historically, most tritium in air sampling locations have shown increased tritium levels during the hot summer months.

Probability plots of the tritium in air data indicated that these data have a lognormal statistical distribution. A logarithmic data transformation will cause the higher values in Figure 9.5 to appear less remarkable. This transformation will also discard all negative data values; however, only 7 percent of these data are negative, and this is not a serious loss of information. A one-way ANOVA on the logarithms of these data indicated a significant difference among sampling locations. This analysis identified four groupings of sampling locations based on 1998 tritium in air levels. The group with the lowest tritium levels has data values that were usually less than the MDC. This group includes Stake T-18, Well 5B, BJY, the Waste Examination Facility (WEF) southwest, WEF northeast, RWMS west, and RWMS south. The second group contains four sampling locations: RWMS northeast, SEDAN crater, E Tunnel pond, and the EPA Farm. This group contains tritium levels that are well above MDC during the summer months. The final two groups each contain a single location and is significantly different from all other groups. The last groups are the decontamination facility and the SCHOONER location.

There are five locations that have been in continuous use since 1982 when tritium in atmospheric moisture data first appeared in NTS annual reports. Figure 9.6 is a historical time series plot of the median of the annual averages of these five locations. The median was used in this plot because for small sample sizes the median is a more robust estimator of central tendency than is the mean. Note that this plot has a logarithmic ordinate and that, using this scale, the data have approximately a linear decreasing trend. A linear regression on these data found a very good fit and also found that the medians for 1995 and 1996 were lower than expected. From this regression one can compute the time for tritium in air levels at the NTS to be reduced to one-half; this is four years. Since four years is about a third of the half-life of tritium, the tritium levels at the NTS are decreasing much faster than can be accounted for by radioactive decay alone.

GAMMA EMITTING RADIONUCLIDES IN AIR

Naturally occurring radionuclides not in equilibrium at the time of counting, such as ^{208}Tl, ^{212}Pb, ^{214}Pb, ^{212}Bi, and ^{214}Bi, were not included in this report. This leaves no gamma emitting radioisotopes other than those listed in Table 9.8. Of the isotopes listed in this table, ^{137}Cs is man-made; the



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remaining are naturally occurring and in equilibrium. Descriptive statistics, in units of µCi/mL, for these radionuclides appear in Table 9.8.

9.2 THERMOLUMINESCENT DOSIMETER DATA

Thermoluminescent dosimeters (TLDs) were placed at 103 monitoring locations on the NTS during 1998. The dosimeters are exchanged quarterly and processed at the Bechtel Nevada Dosimetry Laboratory in Mercury, Nevada. Table 9.6 list the annual total mR/yr for each location. Typically TLDs are exchanged during the first week of each calendar quarter. It takes several work days to exchange all the TLDs, so the exposure duration for each location varies from one quarter to the next. The median days of exposure in 1998 was 90 days. Significant exceptions to this schedule for individual locations can be caused by such things as restricted access due to snow blocked roads (a typical condition in the winter at higher elevations of the NTS). TLD results reported in 1998 include a TLD posted at Gold Meadows on October 8, 1997, and collected on April 29, 1998, resulting in a 203 day exposure. The road to Gold Meadows is usually closed by snow during the winter. This TLD was also collected late in April for the second quarter, rather than during the first week, in order to avoid a very short second quarter. This resulted in a 63 day second quarter exposure.

For convenience, TLD locations are divided into four classes. Boundary locations are close to the perimeter of the NTS. Background locations are known to have no man-made radionuclide inventory. Operational locations are adjacent to stored radioactive materials. In 1998, the operational locations included the Areas 3 and 5 RWMS locations, and the Decontamination Facility locations. The remaining TLDs are in the environmental monitoring class. Since the boundary locations were established in 1990, there have been no statistically significant differences in annual TLD exposure rates between the boundary locations and the background locations. Thus, the boundary locations are now included within the background class of locations.

Atypical values or outliers were identified, from probability plots and histograms of the data and subsets of the data, as data points plotting at some distance from most of the other data points in that subset. This process identified two distinct groups of TLD data values that have different statistical distributions. The group of environmental and background TLD sampling locations has data values with a normal statistical distribution and a mean value of 117 mR/yr, an upper limit of about 180 mR/yr. The second group contains the data values from the operational locations and the atypical values from the environmental locations and has approximately a lognormal statistical distribution with a median value of 211 mR/yr.

A formal statistical analysis of the distribution of the operational and atypical data, using the Box-Cox method, determined that the inverse of the data values, that is 1/(mR/yr), had a normal statistical distribution. Since the inverse power transformation has no practical interpretation, it is more convenient to assume these data approximate a lognormal distribution.

The six data values that were judged to be atypical and not from operational locations are listed in Table 9.7. The last column of this table, the “Area Mean”, gives the average annual exposure for the NTS area with the atypical values deleted. The 1998 atypical values had exposure rates above 200 mR/yr. The list in Table 9.7 is about the same as in previous years, except that U-3co was not in the 1997 list. The locations in Table 9.7 are mostly in Yucca Flat in places known to be contaminated by early atmospheric testing of nuclear devices. The SEDAN west location is in the throwout from the crater. The tunnel ponds contain products from the nuclear tests performed within the tunnels.

The average 1998 exposure from the environmental, background and boundary locations was 117 mR/yr. From 1994 to 1997 the NTS average exposures ranged from 120 to 128 mR/yr. The generally accepted value for worldwide background is 120 mR/yr.

A two-way ANOVA was performed on the environmental, boundary, and background locations data to test for differences among NTS areas and quarters of the year. This analysis found very significant differences among the areas and no differences among quarters. This is the same pattern as has been found in the past several years. A one-way ANOVA was then used to identify the pattern of differences among areas. This analysis found no grouping or clustering of area mean values. When the area means were sorted by magnitude, the pattern seen was a gradual and consistent increase from a low value for Area 23 to the highest value for Area 30.

Area 30 contains one TLD location. It is the boundary station located at the junction of Cat Canyon Road and the road to the BUGGY test site. This location is as close to the west boundary as can now be reached in this region due to washed out roads. This is in a geographic region with high natural radiation levels from prehistoric lava flows. Aerial surveys of this region detect higher than background levels of ^{208}Th. The highest annual exposure of all environmental locations is in Area 20 at Stake J-31. This stake is less than a mile north of two cratering tests, PALANQUIN and CABRIOLET.

Film badges were used during early activities on the NTS for ambient gamma exposure monitoring. TLDs replaced the film badges in 1977, with ten monitoring stations (locations) chosen to be near work sites. From 1977 to 1987, the TLDs used were manufactured by the Harshaw Chemical Company. In 1987, a changeover was made to TLDs manufactured by Panasonic. At the end of 1998, there were a total of 86 active TLD locations.

A three-way ANOVA was used to test for differences in mR/yr due to differences among years, differences among operational areas, and differences between location types (Background and Environmental locations with atypical values removed). The data were the annual mR/yr at each location for 1998 and the previous five years. The operational areas and types were included to remove those sources of error from the residual error and thus increase the power of the ANOVA. The results of this analysis were very significant differences for all three factors. A simultaneous inference analysis of the differences among years identified two clusters of annual averages. The first cluster is composed of only the data from 1993 and has a marginal mean value of 169 mR/yr. The second cluster contains the remaining years data, 1994 through 1998, and has a marginal mean value of 122 mR/yr. A calibration problem was discovered in the 1993 data. This problem was never resolved. This pattern of a year of higher gamma exposure levels followed by five years of lower exposure levels can be seen in Figure 9.7 which contains boxplots of the data from 1998 and the previous five years. Boxplots consist of a box, whiskers, and outliers. A line is drawn across the box at the median. The bottom of the box is at the first quartile, and the top is at the third quartile value of the data. The whiskers are lines that extend from the top and bottom of the box to adjacent values. Adjacent values are the lowest and highest data values that are less that one and one-half times the interquartile range from the ends of the box. Outliers are data values outside the adjacent values and are plotted with an asterisk.

9.3 WATER SAMPLE DATA

GAMMA EMITTING RADIONUCLIDES IN WATER

The only non naturally occurring radionuclide found by gamma spectroscopy in NTS water samples was ^{137}Cs. This isotope was found in three samples and three duplicates from

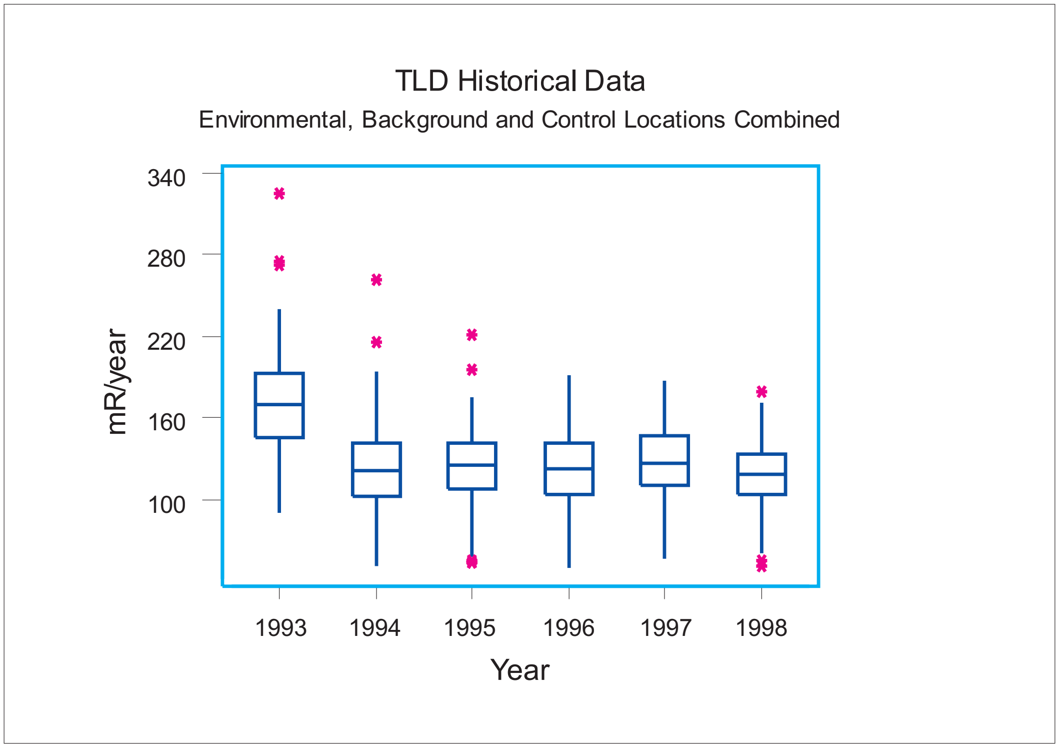


Figure 9.7 Historical Time Series of Boxplots of TLD Exposures

Area 12 E Tunnel effluent and pond. The presence of non-naturally occurring radionuclides in E Tunnel waters is not surprising, since nuclear experiments formerly occurred within this tunnel. Descriptive statistics for the E Tunnel data are presented in Table 9.9.

RADIUM IN WATER

Radium concentrations were measured quarterly at 12 supply wells in 1998. Water samples from other types of sources are not analyzed for radium. Descriptive statistics appear in Table 9.10. For ^{226}Ra all of the results were less than the MDC, and for ^{228}Ra, 93 percent of the results were less than the MDC. Since 96 percent of all radium results are less than the MDC, only the summary statistics in Table 9.10 were computed.

STRONTIUM IN WATER

In 1998, ^{90}Sr concentrations were measured in samples from 27 locations on the NTS. Samples were collected quarterly from 12 supply wells and an annual sample was collected from 5 tap waters, 2 containment pond locations, and 8 sewage ponds. A total of 57 ^{90}Sr analyses were performed. Descriptive statistics for each location are given in Table 9.11.

An examination of the data showed that all results were below the MDC except the four from the E Tunnel. Water from inside the E-Tunnel, where nuclear experiments formerly occurred, drains as an effluent and then into the pond. Thus it is not surprising to find non-naturally occurring radionuclides in these waters.

Since all of the ^{90}Sr in water results from all locations excluding the containment ponds are less than the individual MDC, and 19 percent of those results are negative, any statistical analyses or further data descriptions are unreasonable. These data simply show that, except for the containment ponds, no ^{90}Sr was detected in NTS water samples.

URANIUM IN WATER

Water samples and duplicates were collected for the second and third quarters of 1998 from the E Tunnel effluent and pond and analyzed for ^{234}U, ^{235}U, and ^{238}U. First quarter samples could not be collected because the water in the pond was frozen, and no fourth quarter samples were scheduled. The samplers logbook contains the comment that at the time of the third quarter sampling the E Tunnel pond contained rain runoff.

Uranium concentrations for all three isotopes are substantially above the corresponding MDC. There is very little variability in the effluent concentrations. The pond concentrations show some differences among sampling dates, but little variability between a sample and its duplicate. Considering this consistency and the small number of data values, eight for each isotope, no statistical analyses were done for uranium. Means for each isotope appear in Table 9.12. Each mean in this table is the average of four values.

GROSS ALPHA IN WATER

Gross alpha levels in water for 1998 were measured quarterly at 12 water supply wells, 6 tap waters, and 2 containment pond locations. Alpha analyses are not done for sewage lagoons. Descriptive statistics by location and type are given in Table 9.13. The statistics for supply wells and tap water locations combined are approximately the same as those reported for 1996 and 1997. For the entire network, all results are positive and 13 percent are less than the MDC.

Figure 9.8 plots the alpha levels by sampling week of 1998 and type of location. This time series plot shows, that in general, the containment pond concentrations are higher than the well waters and tap waters and that the well waters and tap waters have about the same concentrations. There are no interesting time dependent patterns. The well and tap water data for each quarter are uniformly spread over a range of zero to approximately 15×10^{-9} µCi/mL.

ANOVA procedures are the statistical methods of choice to analyze the gross alpha in water data for significant differences among sampling locations, types of locations, and sampling times. These procedures require that the residuals have a normal statistical distribution. The residuals from the analyses discussed in the following paragraphs were checked for normality using probability plots, and they were found to have the required normal distribution. The results from the E Tunnel sampling locations were deleted before the ANOVA because they are obviously higher than the environmental sampling locations.

The most appropriate ANOVA for the gross alpha in water data is a three-way analysis with factors of sampling location, type of location (wells or tap water end points), and quarter of the year in which the sample was collected. The locations are nested within the types, and these factors are crossed with the quarter factor. The data are rank deficient for such an analysis because of unbalanced nesting and some empty cells; thus, the results can only be considered suggestive. This analysis found a significant difference among sampling locations and no differences among types of locations and no difference due to the quarter of sample collection. These results suggest that the data can be analyzed using a one-way ANOVA testing for significant differences among sampling locations. The one-way ANOVA was performed, and, after the location means were sorted by magnitude, the mean values appeared to smoothly range from the lowest to the highest value. There was no clustering of values.

The statistically significant differences of the water sampling locations does not imply that there are health physics concerns with the levels of gross alpha in the NTS drinking waters. The EPA drinking water limit for gross alpha is 15×10^{-9} µCi/mL, and all the drinking water averages are below this limit.

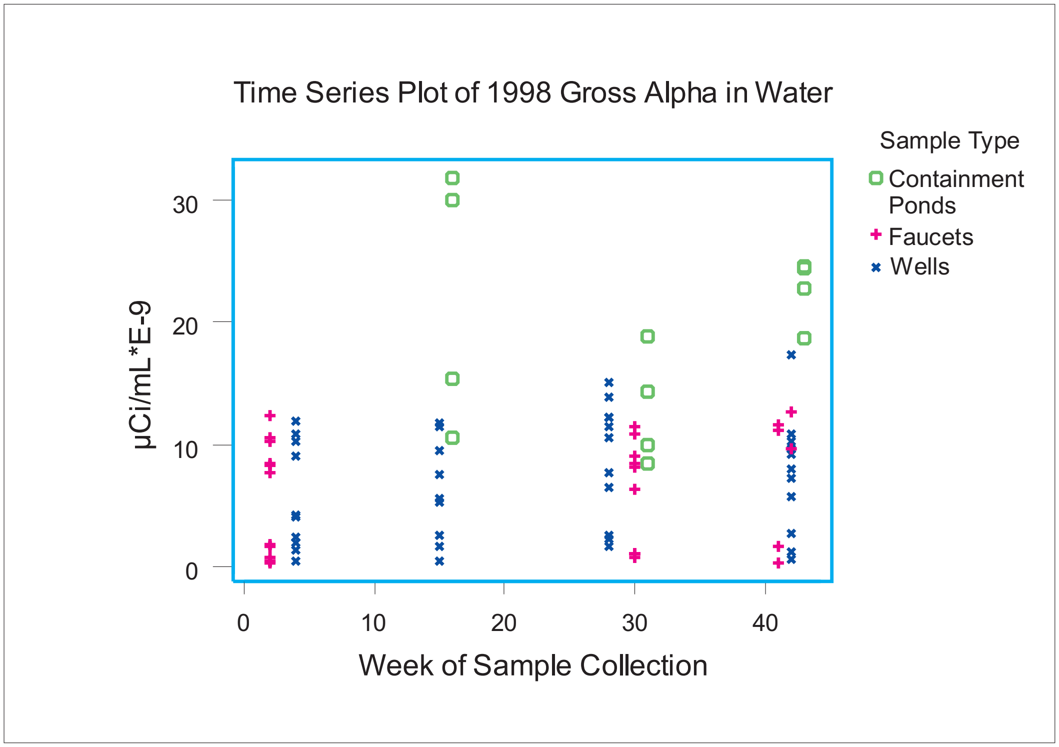


Figure 9.8 Time Series Plot of 1998 Gross Alpha in Water Results

The probable cause of the gross alpha activity in these waters is the natural radium isotopes ^{226}Ra and ^{228}Ra.

Gross alpha measurements in tap water were begun in 1984 and data exist from 1984 through 1998 for only two sampling locations: the cafeterias in Areas 6 and 23. The Area 23 Cafeteria is also called the Mercury Cafeteria. Figure 9.9 is a time series plot of the annual averages from these two locations. This figure also contains a locally weighted scatterplot smoother line which shows the overall general trend in the data. This figure shows that the Area 6 Cafeteria gross alpha levels are slightly higher than the Area 23 Cafeteria levels and that there is a slight trend of increasing levels over the past 15 years at these two locations.

GROSS BETA IN WATER

Gross beta concentrations in water were measured at 12 supply wells, 6 tap water locations, 9 sewage lagoons, and 2 containment pond locations, for a total of 29 sampling locations. Descriptive statistics are presented in Table 9.14. The values in this table for the containment pond statistics are about an order of magnitude higher than the values from the wells and tap waters. This is to be expected since the containment ponds were constructed to contain the effluents from nuclear experiments performed inside a tunnel, and thus have a more concentrated source of radioactivity than other surface waters. The E Tunnel pond contained some rain runoff from samples for weeks 16 and 31 and thus the results for these samples are atypical. The median MDC for all sampling locations and all sample collection dates is 1.23×10^{-9} µCi/mL. All sample results are positive (greater than zero) and exceeded the individual MDCs. Figure 9.10 presents a time series plot of the 1998 gross beta in water results for supply wells and tap water end points.

Probability plotting was used to determine that the 1998 gross beta in water data have a lognormal statistical distribution, as was

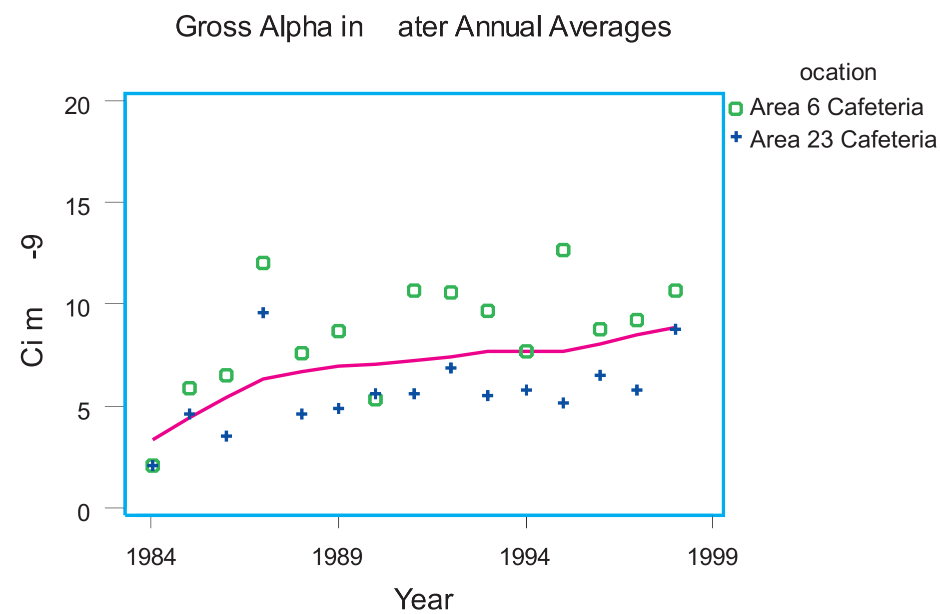


Figure 9.9 Historical Time Series Plot for Gross Alpha in ater

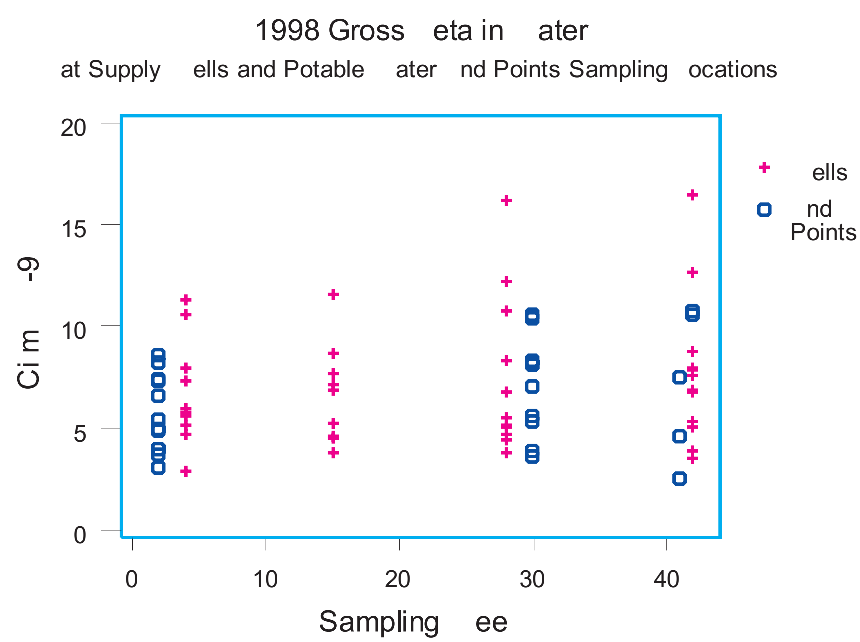


Figure 9.10 Time Series Plot of 1998 Gross eta in ater

determined for gross beta in water results in previous years. An ANOVA using the logarithms of the results found no differences among the quarter of the year that samples were collected and very significant differences among the types of sampling locations. A one-way ANOVA was then used to determine the pattern of differences among the location types. This analysis identified three groups of location types: well water and tap water end points form one group, sewage lagoons are a second group, and the containment ponds are a third group.

Gross beta in water measurements began in 1964 and data exist from 1964 through 1998 for only four sampling locations: the Area 6 Cafeteria, Area 23 Cafeteria (also called the Mercury Cafeteria), Well C-1, and Well 5C. Figures 9.11 and 9.12 present historical time series plots for these cafeterias and wells. In general, historical trends for levels of gross beta in water are not as clear as those of gross beta in air. Underground waters, such as samples from wells, would not have been affected by atmospheric nuclear testing. Gross beta in air shows declining levels since 1970, about the time atmospheric testing ended. No such trend is evident in the water data. There are obvious differences among sampling locations, but no long term trends are evident. There is a possible short term trend seen in Figure 9.11 for the tap water end points. Note that before 1996, the gross beta concentrations at the Area 6 Cafeteria were always higher than at the Area 23 Cafeteria. For 1996-1998, this pattern is reversed. Except for the E Tunnel sampling locations, the gross beta and gross alpha activity in the water is probably due to naturally occurring radionuclides, and would be expected to be relatively constant over time at any given location but vary among locations because of local geological structure. This is the situation that has been observed at the NTS.

PLUTONIUM IN WATER

Water samples for ^{238}Pu and $^{239+240}$Pu measurement were collected quarterly in 1998 from 12 supply wells, 6 tap water locations, 8 sewage lagoons, and 2 containment ponds. Descriptive statistics for each sampling location for ^{238}Pu are given in Table 9.15 and in Table 9.16 for $^{239+240}$Pu.

An examination of the ^{238}Pu data and the statistics in Table 9.15 revealed that all concentrations were below the MDC except for 10 of the 12 containment pond results. Plutonium in the E Tunnel effluent is known to result from several nuclear experiments that were preformed within that tunnel. Water that seeps into the tunnel picks up contamination within the tunnel then exits the tunnel as effluent and is collected in the containment pond. The concentrations measured from the effluent and containment pond in 1998 are consistent with historical levels at these locations. Excluding the ten ^{238}Pu E Tunnel sample values that are above their MDC, 72 percent of the values are less than zero, and all but one value were within one standard deviation of zero. This situation indicates that the measurements represent only randomness in the analytical procedures, and no plutonium was actually found in the samples. Thus, no further statistical analyses were performed.

$^{239+240}$Pu concentrations in water were measured using the same samples as were used for ^{238}Pu; thus, the same sampling pattern applies. The results were also similar. All results were below the MDC, except those from the E Tunnel containment ponds. Results for 10 of the 12 E Tunnel effluent and containment pond samples were above the MDC, while the two below the MDC results were diluted by rain runoff. $^{239+240}$Pu levels in the effluent and containment ponds are known to be elevated for the same reason ^{238}Pu levels are elevated. Fifty-one percent of the less than MDC values were less than zero, and 92 percent of these results are within one standard deviation of zero. As for ^{238}Pu, no further statistical analyses of the $^{239+240}$Pu results were performed.

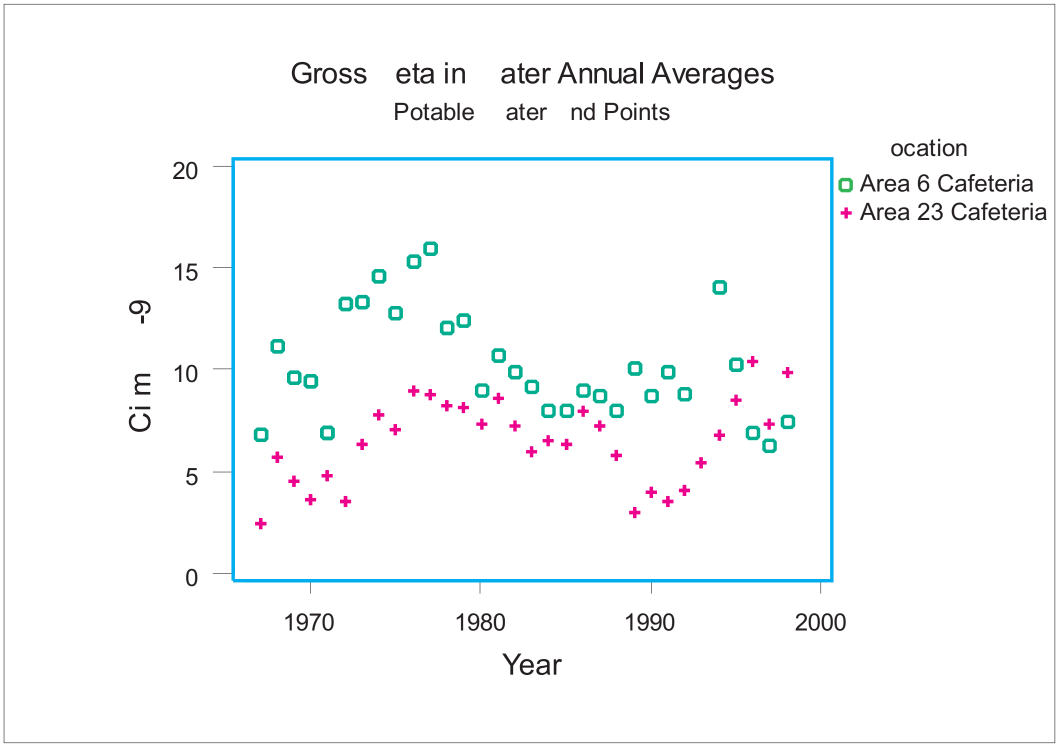


Figure 9.11 Historical Time Series Plot for Tap ater

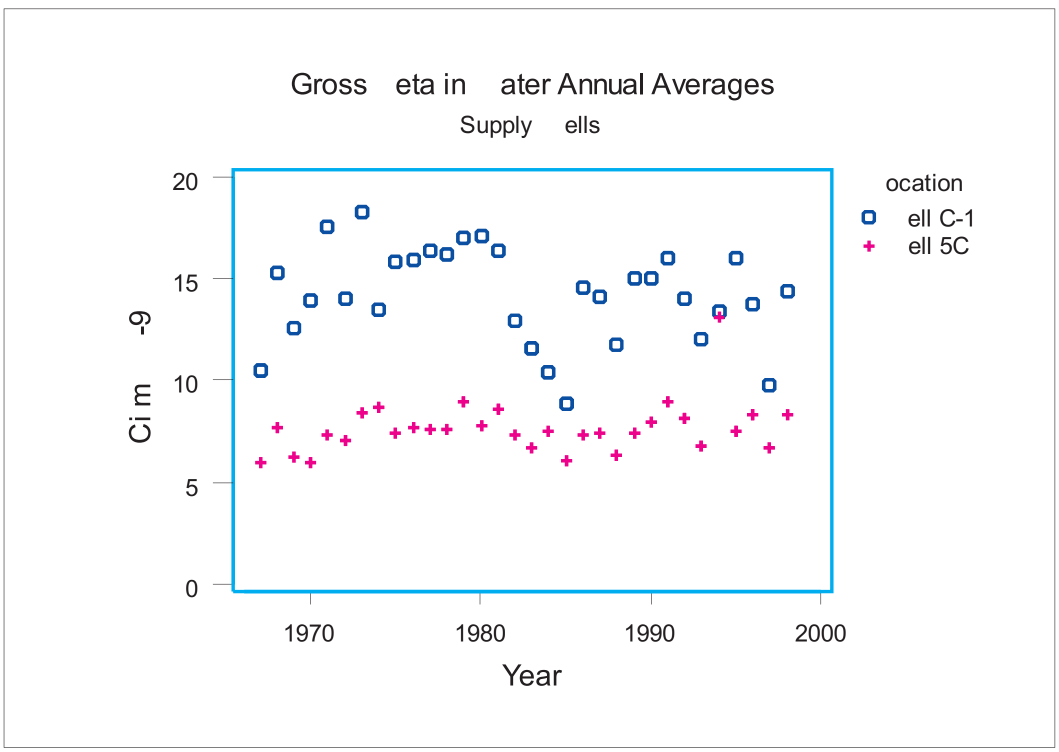


Figure 9.12 Historical Time Series Plot for Supply ells

Annual averages for the plutonium isotopes in water have been reported since 1989. Two representative locations were chosen from each type of water sampling location, except only one containment pond location was used. The chosen locations have data available for all years since plutonium concentrations were first included in annual reports, and are geographically dispersed within the NTS. The chosen locations are identified in Tables 9.17 and 9.18, which contain the historical annual averages.

Most of the annual averages in these tables are below detection limits or below the MDC, but there are a few notable exceptions. Over the years, the median detection limit for both plutonium isotopes has been approximately 20×10^{-12} µCi/mL. Prior to 1996, the sensitivity of water analyses were reported as detection limits, and in 1996 this was changed to reporting the MDC. Thus it is appropriate to use detection limits when discussing historical plutonium concentrations in water.

The E Tunnel effluents have had highest plutonium levels of both isotopes for all the tabled years. These levels are from known sources, as discussed above. Note that, for both isotopes, the concentrations show a declining trend over time and the 1989 concentrations are over ten times the 1998 concentrations.

The Area 23 sewage lagoon contained above the MDC of both plutonium isotopes in 1996, and slightly above detection limit levels of $^{239+240}Pu$ in 1989. The 1996 observations are discussed in the 1996 Data Report. The 1989 Annual Report did not comment on the finding for that year.

TRITIUM IN WATER

Two analytical procedures are used for tritium in water analyses. Most well waters are analyzed using an enriched tritium procedure. The remaining types are analyzed using a conventional tritium procedure. The enriched procedure is capable of measuring substantially lower levels of tritium and it is more accurate (smaller errors) than the conventional method; however, the enriched method is more expensive. Water samples for tritium analysis are usually collected quarterly, and some duplicate analyses were performed. Summary statistics for the samples analyzed using the enriched method are given in Table 9.19 and in Table 9.20 for samples analyzed using the conventional analytical method. In these two tables, if only one sample was analyzed in 1998 for a location, only the sample value and the MDC are listed.

Examination of Tables 9.19 and 9.20 will reveal that almost all the maximum values are much less than the median MDC. The exceptions are the samples from the E Tunnel locations and the underground test area (UGTA) and aquifer monitoring wells analyzed using the enriched method. The concentrations from E Tunnel samples are three orders of magnitude above the MDC and thus show a substantial tritium inventory. The results from the supply well samples analyzed using the enriched method are about an order of magnitude smaller than the results from samples analyzed using the conventional method. Hence, the tritium in water results can be divided into four groups of sampling locations based on tritium concentrations and analytical method: the E Tunnel sampling locations; UGTA and Aquifer monitoring wells with samples analyzed using the enriched method; supply well samples analyzed using the enriched method; and all samples analyzed using the conventional method, except the E Tunnel samples. Only the first two of these four subsets of the data have results above the corresponding MDC.

Concentrations below the MDC represent randomness in the analytical procedure rather than providing information about tritium inventories. Eighty-seven percent of the results reported in Tables 9.19 and 9.20 are less than the corresponding MDC.

Sixty-six percent of the results that are below MDC are also negative. The below MDC data will not be analyzed in this report. Also, the three results from the UGTA and aquifer monitoring wells analyzed using the enriched method will not be analyzed. Three numbers are insufficient for any meaningful statistical analysis.

Tritium in the E Tunnel effluent is known to result from the several nuclear experiments that were performed within that tunnel. Water that seeps into the tunnel picks up contamination within the tunnel then exits the tunnel as effluent and is collected in the containment ponds. The concentrations measured from the effluent and containment ponds in 1998 are consistent with historical levels at those locations. Freezing conditions in January 1998 prevented collection of first quarter samples from both the effluent and the pond. A two-way ANOVA for differences between sampling location and among sampling dates found a statistically significant difference between the sampling locations and no significant difference between the quarter in which the sample was collected. This is the opposite of the pattern of significance found in 1997. The residuals from this ANOVA are normally distributed.

Tritium in water annual averages are available starting in 1989. In general, annual averages have been below detection limits and MDCs, except for the E Tunnel locations. (Before 1996 detection limits were reported; in 1996 and later, MDCs were reported.) In the ten years from 1989 through 1998, tritium levels in the E Tunnel Effluent have ranged from 8.3×10^{-4} to 2.2×10^{-3} µCi/mL.

Table 9.1 Descriptive Statistic for 1998 Gross Alpha in Air by Sampling Location, (µCi/mL × 10^{-15})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Area 1, BJY	53	1.85	1.72	1.02	0.02	4.74	1.81
Area 2, 2-1 Substation	53	1.70	1.70	0.89	0.10	3.97	1.77
Area 2, Complex	39	1.50	1.45	0.88	0.02	3.46	1.74
Area 3, Bunker 3-300	51	1.70	1.55	0.86	-0.11	4.49	1.81
Area 3, U-3ah/at North	68	1.75	1.72	1.02	-0.65	4.23	1.84
Area 3, U-3ah/at South	52	1.78	1.77	0.76	0.02	3.69	1.83
Area 3, U-3bh North	29	2.08	1.92	0.88	-0.27	3.92	1.83
Area 3, U-3bh South	29	2.06	1.91	0.99	0.29	5.28	1.83
Area 3, Well ER-3-1	54	1.52	1.44	0.78	0.21	3.56	1.83
Area 4, Bunker T-4	52	1.54	1.66	0.78	0.02	3.54	1.80
Area 5, DOD Yard	67	1.73	1.64	0.84	0.02	3.63	1.82
Area 5, RWMS Northeast	53	1.86	1.95	0.82	-0.19	3.75	1.81
Area 5, RWMS South	52	2.00	1.93	0.96	0.21	4.49	1.83
Area 5, RWMS West	50	2.31	2.23	1.65	0.10	11.10	1.80
Area 5, Transuranic Bldg. North	53	2.37	2.19	1.41	0.77	9.58	1.79
Area 5, WEF Northeast	53	1.62	1.55	0.83	0.38	3.54	1.76
Area 5, WEF Southwest	52	1.94	1.83	0.88	0.35	3.87	1.83
Area 5, Well 5B	52	1.64	1.56	0.81	0.39	3.75	1.66
Area 6, CP-6	39	1.56	1.25	0.96	0.08	4.23	1.63
Area 6, Well 3	31	1.67	1.55	0.99	-0.10	4.85	1.77
Area 6, Yucca	53	1.96	1.91	1.03	-0.18	4.78	1.80
Area 7, UE-7ns	67	1.64	1.53	0.91	-0.55	4.09	1.72
Area 9, Area 9-300	61	1.94	1.72	1.25	-0.20	5.67	1.82
Area 10, Gate 700 South	39	1.66	1.56	0.94	-0.10	3.87	1.70
Area 10, SEDAN Crater	52	1.61	1.34	0.94	0.10	3.56	1.81
Area 11, Gate 293	38	1.55	1.50	0.70	0.08	3.65	1.70
Area 13, Project 57	51	1.64	1.54	0.82	-0.09	4.16	1.63
Area 15, EPA Farm	66	1.64	1.63	0.81	0.02	4.40	1.77
Area 18, LITTLE FELLER 2 North	45	1.81	1.72	0.80	-0.10	3.75	1.84
Area 20, CABRIOLET	49	1.69	1.55	0.99	0.10	4.38	1.84
Area 20, SCHOONER	50	1.74	1.93	0.77	0.10	3.87	1.83
Area 23, Bldg. 790 No. 2	52	1.81	1.72	0.90	-0.10	3.46	1.75
Area 25, E-MAD North	59	1.61	1.46	0.98	-0.19	4.52	1.77
Area 52, CLEAN SLATE I	22	2.18	1.81	1.52	0.10	6.72	1.70
Area 52, CLEAN SLATE II	28	2.52	2.28	1.22	0.96	6.08	1.66
Area 52, CLEAN SLATE III	49	2.38	2.19	1.09	0.55	4.70	1.64
Area 52, DOUBLE TRACKS	47	2.28	2.31	1.15	-0.22	5.00	1.64
All locations combined	1810	1.81	1.72	1.00	-0.65	11.10	1.78

Table 9.2 Descriptive Statistics for 1998 Gross Beta in Air by Sampling Location, (µCi/mL × 10^{-15})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Area 1, BJY	53	19.64	19.70	6.80	3.95	31.80	4.10
Area 2, 2-1 Substation	53	18.23	18.60	6.20	3.25	34.20	4.09
Area 2, Complex	39	15.78	15.10	5.48	2.98	26.80	4.12
Area 3, Bunker 3-300	51	18.45	18.6	5.79	5.26	39.20	4.10
Area 3, U-3ah/at North	68	19.25	19.40	6.27	4.38	33.80	4.07
Area 3, U-3ah/at South	52	18.98	18.90	5.24	3.99	31.70	4.10
Area 3, U-3bh North	29	21.74	22.30	4.25	11.80	28.00	4.07
Area 3, U-3bh South	29	21.71	21.50	4.48	12.70	32.40	4.06
Area 3, Well ER-3-1	54	18.29	18.75	5.86	4.28	31.00	4.08
Area 4, Bunker T-4	52	17.53	17.35	6.00	2.93	29.40	4.07
Area 5, DOD Pad	67	20.09	20.50	5.43	7.02	32.90	4.07
Area 5, RWMS Northeast (4)	53	20.07	20.20	6.53	4.35	34.10	4.08
Area 5, RWMS South (9)	52	20.13	19.95	5.80	7.37	31.50	4.10
Area 5, RWMS West (4)	50	20.70	21.30	6.30	5.02	34.70	4.09
Area 5, Transuranic Bldg. North	53	21.49	21.80	6.43	7.43	36.80	4.10
Area 5, WEF Northeast	53	19.20	19.10	6.63	4.18	33.10	4.08
Area 5, WEF Southwest	52	21.01	21.30	6.47	3.89	33.50	4.11
Area 5, Well 5B	52	18.32	17.85	6.08	6.63	28.10	4.09
Area 6, CP-6	39	17.90	17.40	6.42	5.86	30.00	4.05
Area 6, Well 3	31	16.90	16.50	5.63	3.45	28.70	4.13
Area 6, Yucca	53	19.50	20.70	6.60	3.83	33.00	4.07
Area 7, UE-7ns	67	18.66	18.90	6.12	2.33	29.90	4.06
Area 9, Area 9-300	61	16.80	16.70	6.41	3.20	30.30	4.10
Area 10, Gate 700 South	39	17.01	17.20	5.98	4.43	27.00	4.12
Area 10, SEDAN Crater	52	19.11	19.55	6.34	2.57	31.70	4.08
Area 11, Gate 293	38	17.67	16.70	5.79	5.18	27.30	4.10
Area 13, Project 57	51	14.54	14.00	5.18	6.49	40.50	4.01
Area 15, EPA Farm	66	17.92	18.05	5.91	4.08	30.90	4.08
Area 18, LITTLE FELLER 2 North	45	19.20	20.00	5.44	3.62	28.50	4.09
Area 20, CABRIOLET	49	17.75	19.10	5.84	5.83	28.30	4.09
Area 20, SCHOONER	50	19.29	20.30	6.23	4.23	30.90	4.07
Area 23, Bldg. 790 No. 2	52	19.01	18.60	5.52	5.63	27.60	4.12
Area 25, E-MAD North	59	18.04	17.90	6.99	3.87	30.60	4.07
Area 52, CLEAN SLATE I	22	14.68	13.85	5.47	6.84	29.90	4.09
Area 52, CLEAN SLATE II	28	19.76	19.95	4.78	7.02	32.50	4.05
Area 52, CLEAN SLATE III	49	20.11	20.40	6.75	7.17	35.60	4.01
Area 52, DOUBLE TRACKS	47	18.46	19.90	6.72	6.12	34.10	4.12
All locations combined	1810	18.77	19.00	6.19	2.33	40.50	4.08

Table 9.3 Descriptive Statistics for 1998 ^{238}Pu in Air by Sampling Location, (µCi/mL × 10^{-18})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Area 1, BJY	12	1.66	-0.21	3.81	-0.72	12.10	10.60
Area 2, 2-1 Substation	12	-0.22	-0.44	1.09	-0.91	3.13	10.93
Area 2, Complex	9	0.79	-0.22	1.80	-0.97	3.91	8.58
Area 3, Bunker 3-300	11	0.65	-0.25	1.74	-1.67	3.29	8.83
Area 3, U-3ah/at North	15	1.16	0.96	2.27	-1.43	6.91	14.60
Area 3, U-3ah/at South	12	0.55	-0.36	2.03	-1.39	5.55	11.50
Area 3, U-3bh North	6	1.41	1.82	2.03	-1.20	3.43	15.85
Area 3, U-3bh South	6	-0.32	-0.84	1.26	-1.38	1.60	22.75
Area 3, Well ER-3-1	12	0.21	-0.33	1.40	-1.13	3.07	8.87
Area 4, Bunker T-4	12	5.46	5.35	4.20	1.02	16.50	9.19
Area 5, DOD Yard	15	0.11	-0.27	1.49	-1.58	3.47	9.81
Area 5, RWMS Northeast (4)	12	-0.29	-0.35	0.68	-1.08	1.70	10.80
Area 5, RWMS South (9)	12	0.06	-0.32	1.34	-1.13	3.67	10.75
Area 5, RWMS West (7)	11	-0.66	-0.51	0.53	-1.63	-0.21	9.60
Area 5, Transuranic Bldg. North	12	1.81	-0.28	4.41	-1.28	11.80	9.60
Area 5, WEF Northeast	12	0.00	-0.28	1.44	-1.37	4.14	9.40
Area 5, WEF Southwest	12	0.62	-0.33	2.27	-1.35	5.94	11.85
Area 5, Well 5B	12	-0.08	-0.29	0.75	-0.64	1.71	9.09
Area 6, CP-6	9	-0.25	-0.28	0.66	-1.24	1.28	7.37
Area 6, Well 3	8	0.37	-0.30	1.20	-0.78	2.10	9.56
Area 6, Yucca	12	0.30	-0.29	1.53	-0.77	4.46	10.02
Area 7, UE-7ns	15	-0.22	-0.34	1.49	-1.43	4.96	10.70
Area 9, 9-300 Bunker	14	3.29	1.65	5.37	-0.69	19.10	9.71
Area 10, Gate 700 South	9	2.02	1.54	2.21	-0.35	5.40	8.36
Area 10, SEDAN Crater	12	4.41	3.03	4.86	-0.26	18.90	10.52
Area 11, Gate 293	9	0.29	-0.31	1.53	-0.66	3.91	9.57
Area 13, Project 57	12	0.41	-0.28	2.13	-1.56	6.01	8.78
Area 15, EPA Farm	15	0.25	-0.32	1.80	-0.88	6.09	9.37
Area 18, LITTLE FELLER 2 North	10	-0.36	-0.47	0.95	-1.45	2.11	12.25
Area 20, CABRIOLET	12	1.17	0.46	2.19	-0.99	5.66	10.80
Area 20, SCHOONER	12	2.66	2.44	2.87	-0.82	7.10	10.38
Area 23, Building 790 No. 2	12	-0.07	-0.37	1.47	-1.27	4.52	10.77
Area 25, E-MAD North	14	0.19	-0.26	1.95	-0.78	6.75	9.04
Area 52, CLEAN SLATE I	5	0.94	1.35	0.73	-0.30	1.46	8.01
Area 52, CLEAN SLATE II	6	0.91	0.16	2.36	-1.47	4.90	12.10
Area 52, CLEAN SLATE III	12	0.45	-0.23	1.97	-1.86	5.78	7.67
Area 52, DOUBLE TRACKS	12	0.16	-0.30	1.23	-0.84	3.09	10.81
All locations combined	415	0.82	-0.27	2.64	-1.86	19.10	9.85

Table 9.4 Descriptive Statistics for 1998 $^{239+240}$Pu in Air by Sampling Location, (µCi/mL × 10^{-18})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Area 1, BJY	12	56.79	16.35	130.98	1.07	469.00	10.85
Area 2, 2-1 Substation	12	3.14	1.91	4.48	-1.52	14.20	11.10
Area 2, Complex	9	2.84	2.83	3.39	-0.93	10.70	9.63
Area 3, Bunker 3-300	11	47.72	18.50	66.93	5.11	204.00	9.91
Area 3, U-3ah/at North	15	56.43	55.40	40.86	-0.49	148.00	16.30
Area 3, U-3ah/at South	12	46.17	35.20	41.65	7.64	164.00	12.75
Area 3, U-3bh North	6	22.25	20.45	15.11	1.67	46.30	18.05
Area 3, U-3bh South	6	22.65	18.95	13.92	2.89	39.30	23.70
Area 3, Well ER-3-1	12	1.02	0.29	2.46	-1.28	7.84	9.57
Area 4, Bunker T-4	12	23.58	24.05	14.09	-0.47	45.70	10.10
Area 5, DOD Yard	15	1.93	1.16	3.58	-2.17	9.44	10.60
Area 5, RWMS Northeast (4)	12	0.65	-0.38	1.83	-1.28	4.45	12.05
Area 5, RWMS South (9)	12	0.83	1.22	1.91	-1.89	4.21	12.40
Area 5, RWMS West (7)	11	1.14	1.26	1.85	-1.00	3.97	10.40
Area 5, Transuranic Bldg. North	12	58.47	2.00	160.11	-1.09	552.00	10.60
Area 5, WEF Northeast	12	3.21	-0.43	10.72	-2.42	36.80	10.55
Area 5, WEF Southwest	12	13.30	1.46	41.85	-1.79	146.00	13.10
Area 5, Well 5B	12	0.46	-0.48	1.56	-0.63	3.75	10.20
Area 6, CP-6	9	2.77	2.66	2.50	-0.39	6.17	7.82
Area 6, Well 3	8	1.63	1.51	2.41	-1.05	5.54	10.75
Area 6, Yucca	12	8.05	5.59	7.95	-0.56	21.20	11.05
Area 7, UE-7ns	15	10.35	8.18	9.89	-2.25	27.30	11.70
Area 9, 9-300 Bunker	14	215.86	108.50	237.73	1.31	735.00	10.11
Area 10, Gate 700 South	9	9.83	6.60	10.21	-0.42	29.10	9.36
Area 10, SEDAN Crater	12	71.29	29.30	142.60	3.40	519.00	11.30
Area 11, Gate 293	9	3.62	1.69	3.73	-0.57	9.46	10.50
Area 13, Project 57	12	14.54	4.58	27.58	-1.18	98.20	9.67
Area 15, EPA Farm	15	24.70	22.10	21.44	2.21	63.40	9.71
Area 18, LITTLE FELLER 2 North	10	4.86	2.58	9.48	-2.56	30.80	14.20
Area 20, CABRIOLET	12	0.14	-0.48	1.21	-1.12	2.28	11.85
Area 20, SCHOONER	12	9.92	2.17	20.04	-0.63	63.10	10.97
Area 23, Building 790 No. 2	12	1.32	-0.52	3.84	-1.24	11.60	12.00
Area 25, E-MAD North	14	0.56	-0.44	2.52	-3.02	6.27	9.36
Area 52, CLEAN SLATE I	5	194.42	121.00	266.50	1.31	659.00	8.36
Area 52, CLEAN SLATE II	6	144.95	160.50	90.49	22.00	269.00	13.30
Area 52, CLEAN SLATE III	12	1.89	1.10	3.54	-1.59	11.00	8.60
Area 52, DOUBLE TRACKS	12	14.29	2.23	27.53	-1.35	92.50	11.15
All locations combined	415	27.14	3.31	82.74	-3.02	735.00	10.60

Table 9.5 Descriptive Statistics for 1998 Tritium in Air by Sampling Location, (pCi/mL × 10^{-6})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Area 1, BJY	26	1.00	0.67	0.96	-0.81	3.40	2.36
Area 5, RWMS Northeast (4)	25	14.44	4.67	21.83	-0.12	83.70	3.28
Area 5, RWMS South (9)	27	2.18	2.17	1.05	0.11	4.56	3.36
Area 5, RWMS West (7)	26	1.51	1.53	0.63	-0.29	2.81	2.36
Area 5, WEF Northeast	35	1.39	1.31	1.11	-0.66	3.74	2.79
Area 5, WEF Southwest	26	1.77	1.65	1.34	0.00	5.58	3.10
Area 5, Well 5B	32	0.24	0.23	0.96	-1.71	2.46	3.04
Area 6, Decontamination Facility	26	36.68	21.45	40.75	1.82	175.00	2.53
Area 10, SEDAN Crater	35	8.53	5.09	7.66	1.33	29.20	3.10
Area 12, E Tunnel Pond	31	14.61	6.01	21.34	0.91	105.00	2.69
Area 12, Stake T-18	4	0.11	0.04	0.42	-0.32	0.69	1.97
Area 15, EPA Farm	33	8.85	8.76	3.45	1.24	14.20	3.06
Area 20, SCHOONER	24	142.46	56.75	160.93	9.44	458.00	2.95
All locations combined	350	17.15	2.50	56.17	-1.71	458.00	2.87
All locations except SCHOONER combined	326	7.93	2.27	17.63	-1.71	175.00	2.86

Table 9.6 1998 TLD Gamma Exposure Rates - mR/yr

Sampling Location	Annual Total	Sampling Location	Annual Total
Area 1, BJY	92	Area 3, U-3co South	162
Area 1, Stake TH-27	95	Area 3, Well ER-3-1	120
Area 1, Stake TH-38	104	Area 3, RWMS Center	140
Area 1, Sandbag Storage Hut	108	Area 4, Stake A-9	841
Area 1, Stake C-2	113	Area 4, Stake TH-48	115
Area 1, 1-300 Bunker	121	Area 4, Stake TH-41	105
Area 2, Stake M-140	123	Area 5, Well 5B	104
Area 2, Stake N-8	726	Area 5, RWMS East 1000'	118
Area 2, Stake L-9	171	Area 5, RWMS Northeast Corner	111
Area 2, Stake TH-58	89	Area 5, RWMS North 1000'	119
Area 3, Stake OB-20-N, End of 3B Road	85	Area 5, RWMS Northwest Corner	119
Area 3, LANL Trailers	109	Area 5, RWMS West 1000'	119
Area 3, Stake A-6.5	145	Area 5, RWMS Southwest Corner	116
Area 3, RWMS North	119	Area 5, RWMS South Gate	105
Area 3, RWMS East	148	Area 5, RWMS East Gate	134
Area 3, RWMS South	513	Area 5, RWMS Office	121
Area 3, RWMS West	121	Area 5, 3.3 Mi Southeast of Aggregate Pit	60
Area 3, U-3co North	223	Area 5, WEF West	129

Table 9.6 (1998 TLD Gamma Exposure Rates - mR/yr, cont.)

Sampling Location	Annual Total
Area 5, WEF South	161
Area 5, WEF East	121
Area 5, WEF North	116
Area 5, Trench 8 South	126
Area 5, Pit 6	502
Area 5, Building 5-31	105
Area 5, RWMS Transuranic Pad NE	176
Area 5, RWMS Transuranic Pad North	333
Area 5, RWMS Transuranic Pad SW	112
Area 5, RWMS Transuranic Pad SE	121
Area 5, RWMS Pit 5 West Side	158
Area 5, RWMS Pit 5 East Side	134
Area 6, CP-6	69
Area 6, CP-50 Calibration Door	80
Area 6, Yucca Oil Storage Area	96
Area 6, Stake OB-11.5	123
Area 6, DAF East	88
Area 6, DAF West	85
Area 6, Decon Facility Northwest	117
Area 6, Decon Facility Southeast	125
Area 7, 7-300 Bunker	282
Area 7, Stake H-8	124
Area 7, Reitman Seep	119
Area 8, Stake K-25	100
Area 8, Road 8-02	123
Area 8, Stake M-152	160
Area 9, 9-300 Bunker	122
Area 9, Papoose Lake Road	77
Area 9, V and G Road Junction	109
Area 9, Crater U-9cw	96
Area 10, SEDAN West	288
Area 10, SEDAN East Visitors Box	133
Area 10, Circle and L Road	115
Area 10, Gate 700 South	135
Area 11, Gate 293	120
Area 11, East of U-11b	115
Area 11, Stake A-221	122
Area 12, T Tunnel No. 2 Pond	234
Area 12, Upper N Pond	121
Area 12, Upper Haines Lake (E Tunnel)	117
Area 12, Gold Meadows	119
Area 15, EPA Farm	106
Area 15, Substation U15E	92
Area 18, Stake A-83	135
Area 18, Stake F-11	135
Area 19, Stake P-41	156
Area 19, Stake C-27	147
Area 19, Stake P-77	150
Area 19, Stake R-26	148
Area 19, Stake R-3	153
Area 19, Gate 19-3P, Kawich Canyon	149
Area 20, Stake J-31	180
Area 20, Stake J-41	133
Area 20, Stake LC-4	168
Area 20, Stake A-118	143
Area 22, Army Well No. 1	76
Area 23, Building 650 Dosimetry	55
Area 23, Building 650 Roof	51
Area 23, Post Office	67
Area 25, NRDS Warehouse	116
Area 25, 25-4P Gate	123
Area 25, HENRE	117
Area 25, Jackass Flats at 27 Roads	76
Area 25, Guard Station 510	119
Area 25, Yucca Mountain	128
Area 27, Cafeteria	123
Area 30, Cat. Can. Rd at Buggy Turnoff	165

Table 9.7 Listing of Atypical TLD Data Values for 1998

Sampling Location	Annual Total mR/yr	Area Mean mR/yr
Area 2, Stake N-8	726	128
Area 3, U-3co North	223	124
Area 4, Stake A-9	841	110
Area 7, 7-300 Bunker	282	121
Area 10, SEDAN Crater W	288	128
Area 12, T-Tunnel Pond	234	119

Table 9.8 Descriptive Statistics for Radionuclides Detected by Gamma Spectroscopy in Air Samples in 1998, (µCi/mL × 10^{-15})

Nuclide	Number of Samples Containing	Mean	Median	Standard Deviation	Minimum	Maximum	Percent Result > MDC
^{7}Be	415	179.0	184.0	41.7	61.0	261.0	100
^{137}Cs	49	0.900	0.873	0.229	0.389	1.53	37
^{228}Th	39	2.37	2.31	0.585	1.45	3.91	90
^{232}Th	5	3.71	3.36	1.20	2.55	5.69	80
^{238}U	6	135.0	132.0	31.2	100.0	186.0	33

Table 9.9 Descriptive Statistics for Radionuclides Detected by Gamma Spectroscopy in Water in 1998, (µCi/mL × 10^{-9}) All Samples Collected at E Tunnel

Nuclide	Number of Samples Containing	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
^{137}Cs	6	106	93	26	85	152	11

Table 9.10 Descriptive Statistics for 1998 Radium in Water, (µCi/mL × 10^{-9})

Nuclide	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
^{226}Ra	42	0.37	0.33	0.84	-1.91	2.38	3.44
^{228}Ra	42	0.22	0.18	0.24	-0.19	0.79	1.06

Table 9.11 Descriptive Statistics for 1998 ^{90}Sr in Water by Sampling Location, (µCi/mL × 10^{-12})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
SUPPLY WELLS							
Area 5, Well 5B	3	85.2	46.0	79.8	32.5	117.0	270.5
Area 5, Well 5C	4	113.4	144.5	87.3	-14.5	179.0	310.0
Area 5, Well UE-5C	3	81.7	48.3	164.2	-63.3	260.0	325.0
Area 6, Well No. 4	6	159.3	134.0	146.4	-7.7	423.0	259.0

Table 9.11 (Descriptive Statistics for 1998 ^{90}Sr in Water by Sampling Location, [µCi/mL × 10^{-12}], cont.)

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
SUPPLY WELLS							
Area 6, Well No. 4A	3	112.6	160.0	120.4	-24.3	202.0	273.0
Area 6, Well C-1	2	218.5	218.5	36.1	193.0	244.0	283.0
Area 16, Well UE-16d	4	77.6	85.2	106.5	-34.8	175.0	273.0
Area 18, Well HTH No. 8	4	84.6	89.8	72.4	0.7	158.0	295.0
Area 20, Well U-20	1	66.4				260.0	
Area 22, Army Well No. 1	2	104.3	104.3	110.0	26.5	182.0	560.5
Area 25, Well J-12	4	145.3	74.4	176.2	28.6	404.0	251.5
Area 25, Well J-13	4	127.2	77.8	150.6	8.3	345.0	251.0
TAP WATER							
Area 6, Cafeteria	1	143.0					350.0
Area 6, Building 6-900	1	151.0					275.0
Area 12, Ice House	1	66.6					270.0
Area 23, Cafeteria	1	128.0					315.0
Area 25, Building 4221	1	-8.1					249.0
SEWAGE LAGOONS							
Area 5, RWMS Sewage	1	142.0					590.0
Area 6, Yucca Sewage	1	194.0					285.0
Area 6, LANL Sewage	1	-95.0					331.0
Area 6, DAF Sewage	1	-64.1					1040.0
Area 12, Sewage Pond	1	159.0					301.0
Area 22, Sewage Pond	1	-115.0					287.0
Area 23, Sewage Pond	1	63.7					285.0
Area 25, Central Sewage	1	-222.0					489.0
CONTAINMENT PONDS							
Area 12, E Tunnel Effluent	2	1745.0	1745.0	629.3	1300.0	2190.0	651.0
Area 12, E Tunnel Pond	2	2275.0	2275.0	586.9	1860.0	2690.0	721.0

Table 9.12 Tabulated Means for 1998 Uranium in Water, (μCi/mL × 10^{-8})

	Isotope					
	234		235		238	
Location	Results	MDC	Results	MDC	Results	MDC
E Tunnel Effluent	3.62	0.04	0.062	0.02	1.30	0.03
E Tunnel Pond	1.27	0.04	0.038	0.019	0.49	0.04

Table 9.13 Descriptive Statistics for 1998 Gross Alpha in Water by Sampling Location, (μCi/mL × 10^{-9})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
SUPPLY WELLS							
Area 5, Well 5B	4	6.84	7.64	1.82	4.12	7.94	1.70
Area 5, Well 5C	4	13.75	13.40	2.95	10.90	17.30	1.84
Area 5, Well UE-5C	3	11.24	11.90	1.41	9.63	12.20	1.81
Area 6, Well No. 4	7	9.60	9.64	1.94	5.72	11.40	1.60
Area 6, Well No. 4A	3	11.43	10.30	2.05	10.20	13.80	1.66
Area 6, Well C-1	2	11.50	11.50	0.99	10.80	12.20	2.98
Area 16, Well UE-16D	4	5.91	6.06	1.33	4.21	7.32	1.88
Area 18, Well HTH No. 8	4	0.82	0.60	0.53	0.43	1.67	1.12
Area 20, Well U-20	1	9.21					1.50
Area 22, Army Well No. 1	2	3.90	3.90	2.05	2.45	5.35	1.74
Area 25, Well J-12	4	1.74	1.60	0.60	1.20	2.58	1.38
Area 25, Well J-13	4	2.40	2.44	0.31	2.04	2.69	1.55
All Supply Wells	42	7.17	7.64	4.53	0.43	17.30	1.67
TAP WATER							
Area 2, Restroom Outside Tap	2	0.64	0.64	0.16	0.52	0.75	1.06
Area 6, Cafeteria	5	10.74	10.90	1.47	8.52	12.40	1.69
Area 6, Building 6-900	5	10.08	10.50	1.31	8.41	11.40	1.70
Area 12, Ice House	5	0.69	0.51	0.35	0.39	1.10	1.03
Area 23, Mercury Cafeteria	6	8.80	8.23	2.14	6.37	12.60	1.77
Area 25, Building 4221	5	1.41	1.67	0.47	0.76	1.87	1.47
All Tap Water	28	6.02	7.91	4.66	0.39	12.60	1.61

Table 9.13 (Descriptive Statistics for 1998 Gross Alpha in Water by Sampling Location, [µCi/mL × 10^{-9}], cont.)

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
CONTAINMENT PONDS							
Area 12, E Tunnel Effluent	6	22.70	20.75	6.87	14.30	31.70	1.73
Area 12, E tunnel Pond	6	15.58	13.00	7.29	8.49	24.60	1.86
All Containment Ponds	12	19.14	18.75	7.71	8.49	31.70	1.78

Table 9.14 Descriptive Statistics for 1998 Gross Beta in Water by Sampling Location, (µCi/mL × 10^{-9})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
SUPPLY WELLS							
Area 5, Well 5B	4	11.43	11.20	0.95	10.60	12.70	1.26
Area 5, Well 5C	4	8.29	8.49	0.64	7.37	8.81	1.27
Area 5, Well UE-5C	3	11.70	11.30	4.32	7.59	16.20	1.30
Area 6, Well No. 4	7	6.39	6.86	1.09	5.08	7.92	1.22
Area 6, Well No. 4A	3	6.44	6.78	0.58	5.77	6.78	1.22
Area 6, Well C-1	2	14.35	14.35	3.04	12.20	16.50	1.89
Area 16, Well UE-16D	4	6.98	7.81	1.73	4.39	7.92	1.24
Area 18, Well HTH No. 8	4	3.51	3.64	0.41	2.94	3.81	1.25
Area 20, Well U-20	1	3.90					1.22
Area 22, Army Well No. 1	2	5.59	5.59	0.52	5.22	5.96	1.24
Area 25, Well J-12	4	4.86	4.88	0.29	4.52	5.14	1.22
Area 25, Well J-13	4	5.04	5.00	0.45	4.62	5.55	1.24
All Supply Wells	42	7.22	6.78	3.22	2.94	16.50	1.23
TAP WATER							
Area 2, Restroom Outside Tap	2	3.94	3.94	0.00	3.94	3.94	1.21
Area 6, Cafeteria	5	7.37	7.33	0.63	6.61	8.34	1.22
Area 6, Building 6-900	5	7.33	7.51	1.13	5.41	8.17	1.22
Area 12, Ice House	5	3.38	3.65	0.54	2.56	3.86	1.21
Area 23, Mercury Cafe.	6	9.88	10.50	1.13	8.28	10.80	1.22
Area 25, Building 4221	5	5.10	4.98	0.39	4.65	5.61	1.21
All Tap Water	28	6.54	6.85	2.45	2.56	10.80	1.22

Table 9.14 (Descriptive Statistics for 1998 Gross Beta in Water by Sampling Location, [µCi/mL × 10^{-9}], cont.)

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
SEWAGE LAGOONS							
Area 5, RWMS Sewage Pond	4	51.15	47.30	17.83	34.40	75.60	1.31
Area 6, DAF Sewage Pond	4	30.55	32.70	15.54	10.00	46.80	1.36
Area 6, LANL Sewage Pond	5	29.34	31.10	3.21	24.30	31.90	1.36
Area 6, Yucca Sewage Pond	4	18.85	19.80	2.63	15.00	20.80	1.31
Area 12, Sewage Pond	4	5.96	4.32	3.50	4.02	11.20	1.30
Area 22, Sewage Pond	4	35.50	39.05	10.47	20.30	43.60	1.33
Area 23, Sewage Pond	4	20.60	20.55	2.56	17.70	23.60	1.32
Area 25, Central Sewage Pond	4	26.55	25.70	5.44	21.30	33.50	1.36
Area 25, Reactor Control Pond	2	9.55	9.55	1.07	8.79	10.30	1.35
All Sewage Lagoons	35	26.36	23.60	15.06	4.02	75.60	1.32
CONTAINMENT PONDS							
Area 12, E Tunnel Effluent	6	75.23	71.55	14.54	60.60	103.00	1.23
Area 12, E Tunnel Pond	6	36.23	21.85	25.69	17.30	70.00	1.25
All Containment Ponds	12	55.73	68.80	28.48	17.30	103.00	1.23

Table 9.15 Descriptive Statistics for 1998 ^{238}Pu in Water by Sampling Location, (µCi/mL × 10^{-12})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
SUPPLY WELLS							
Area 5, Well 5B	4	-1.78	-1.83	0.30	-2.09	-1.38	21.05
Area 5, Well 5C	4	0.30	-1.67	4.01	-1.76	6.31	19.20
Area 5, Well UE-5C	3	-1.36	-2.02	1.86	-2.80	0.75	24.60
Area 6, Well No. 4	6	-1.61	-1.93	1.81	-3.74	1.68	22.80
Area 6, Well No. 4A	3	-1.71	-1.60	0.49	-2.25	-1.29	17.40
Area 6, Well C-1	2	-2.67	-2.67	1.60	-3.80	-1.54	27.45
Area 16, Well UE-16D	4	-1.44	-2.07	1.92	-2.91	1.31	21.75
Area 18, Well HTH No. 8	4	0.07	-0.19	2.21	-2.05	2.70	19.35
Area 20, Well U-20	1	-1.30					14.10
Area 22, Army Well No. 1	2	-0.23	-0.23	2.35	-1.89	1.43	21.60
Area 25, Well J-12	4	0.63	-1.14	3.96	-1.74	6.55	16.25
Area 25, Well J-13	4	-1.75	-1.73	0.28	-2.11	-1.43	19.90
All Supply Wells	41	-1.02	-1.63	2.19	-3.80	6.55	19.70
TAP WATER							
Area 2, Restroom Outside Tap	1	-1.16					13.50
Area 6, Cafeteria	3	-1.13	-1.20	0.18	-1.27	-0.93	13.80
Area 6, Building 6-900	3	-0.43	-0.91	1.15	-1.27	0.88	12.90

Table 9.15 (Descriptive Statistics for 1998 ^{238}Pu in Water by Sampling Location, [µCi/mL × 10^{-12}], cont.)

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
TAP WATER, cont.							
Area 12, Ice House	3	-1.14	-1.07	0.15	-1.31	-1.04	14.00
Area 23, Mercury Cafeteria	4	-0.10	-1.10	2.05	-1.18	2.97	13.65
Area 25, Building 4221	3	-0.48	-0.97	1.25	-1.40	0.95	13.90
All Tap Water	17	-0.65	-1.07	1.16	-1.40	2.97	13.70
SEWAGE LAGOONS							
Area 5, RWMS Sewage Pond	4	-0.69	-1.27	1.81	-2.17	1.94	19.20
Area 6, DAF Sewage Pond	4	1.28	1.31	0.25	1.00	1.49	17.40
Area 6, LANL Sewage Pond	5	-0.42	-1.22	1.40	-1.69	1.36	15.90
Area 6, Yucca Sewage Pond	4	-0.77	-1.25	1.35	-1.80	1.21	17.05
Area 12, Sewage Pond	4	-0.85	-1.36	1.38	-1.87	1.17	16.60
Area 22, Sewage Pond	4	-0.01	-0.05	1.87	-1.89	1.95	18.50
Area 23, Sewage Pond	4	-0.15	-1.10	2.48	-1.91	3.53	15.90
Area 25, Central Sewage Pond	4	-1.00	-1.52	1.39	-2.02	1.04	17.75
Area 25, Reactor Control Pond	2	0.04	0.04	2.61	-1.81	1.88	20.45
All Sewage Lagoons	35	-0.31	-1.13	1.59	-2.17	3.53	17.40
CONTAINMENT PONDS							
Area 12, E Tunnel Effluent	6	232.50	146.50	157.25	106.00	442.00	18.00
Area 12, E Tunnel Pond	6	86.10	96.30	59.00	12.10	159.00	18.40
All Containment Ponds	12	159.30	129.50	136.70	12.10	442.00	18.30

Table 9.16 Descriptive Statistics for 1998 $^{239+240}$Pu in Water by Sampling Location, (µCi/mL × 10^{-12})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
SUPPLY WELLS							
Area 5, Well 5B	4	-2.73	-2.50	0.77	-3.84	-2.08	22.95
Area 5, Well 5C	4	-0.07	0.43	1.38	-2.10	0.94	21.05
Area 5, Well UE-5C	3	0.09	0.78	1.56	-1.70	1.18	26.50
Area 6, Well No. 4	6	-1.83	-2.40	1.97	-4.45	0.80	24.35
Area 6, Well No. 4A	3	-1.44	-2.40	1.91	-2.68	0.75	19.50
Area 6, Well C-1	2	3.42	3.42	4.55	0.21	6.64	29.40
Area 16, Well UE-16D	4	-3.02	-2.41	1.56	-5.33	-1.92	22.35
Area 18, Well HTH No. 8	4	-2.77	-2.74	1.01	-4.23	-1.98	21.00
Area 20, Well U-20	1	-1.88					15.70
Area 22, Army Well No. 1	2	-2.72	-2.72	0.89	-3.35	-2.09	24.40
Area 25, Well J-12	4	0.97	-1.58	6.58	-3.20	10.80	16.95
Area 25, Well J-13	4	-1.89	-2.54	1.77	-3.19	0.73	21.60
All Supply Wells	41	-1.31	-2.10	2.84	-5.33	10.80	21.30

Table 9.16 Descriptive Statistics for 1998 $^{239+240}Pu$ in Water by Sampling Location, [µCi/mL × 10^{-12}], cont.)

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
TAP WATER							
Area 2, Restroom Outside Tap	1	-1.34					14.00
Area 6, Cafeteria	3	1.95	0.24	4.67	-1.63	7.23	14.50
Area 6, Building 6-900	3	1.11	0.39	1.39	0.24	2.71	14.30
Area 12, Ice House	3	1.00	0.25	3.28	-1.38	4.59	15.80
Area 23, Mercury Cafeteria	4	0.00	-0.56	2.02	-0.66	2.79	15.10
Area 25, Building 4221	3	-1.70	-1.71	0.32	-2.02	-1.38	15.20
All Tap Water	17	0.34	0.18	2.60	-2.02	7.23	14.50
SEWAGE LAGOONS							
Area 5, RWMS Sewage Pond	4	0.22	-0.60	3.02	-2.28	4.37	21.20
Area 6, DAF Sewage Pond	4	-0.10	0.55	1.51	-2.35	0.85	19.90
Area 6, LANL Sewage pond	5	1.23	-1.62	6.43	-3.00	12.50	18.30
Area 6, Yucca Sewage Pond	4	3.58	3.18	3.24	0.82	7.14	18.85
Area 12, Sewage Pond	4	5.80	2.20	10.20	-1.92	20.70	18.05
Area 22, Sewage Pond	4	2.84	0.58	7.49	-3.09	13.30	20.35
Area 23, Sewage Pond	4	0.68	0.65	2.20	-1.99	3.39	17.40
Area 25, Central Sewage Pond	4	1.86	1.78	1.55	0.39	3.49	19.60
Area 25, Reactor Control Pond	2	-1.07	-1.07	2.70	-2.98	0.84	22.55
All Sewage Lagoons	35	1.82	0.66	5.06	-3.09	20.70	19.30
CONTAINMENT PONDS							
Area 12, E Tunnel Effluent	6	2018.33	1475.00	1124.23	1100.00	3490.00	19.25
Area 12, E Tunnel Pond	6	676.61	828.50	566.76	9.98	1056.00	19.20
All Containment Ponds	12	1347.50	1125.00	1100.70	9.98	3490.00	19.20

Table 9.17 Historical ^{238}Pu in Water Annual Averages at Selected Locations, (µCi/mL × 10^{-12})

Location	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
WELLS										
Area 18, Well HTH No. 8	7.3	31.0	2.2	-12.0	4.8	-2.1	-1.7	-3.0	0.4	0.1
Area 25, Well J-13	-26.0	12.0	0.7	-5.0	-6.9	-0.7	-0.4	-2.9	-0.9	-1.8
TAP WATER										
Area 2, Restroom	12.0	21.0	-5.5	-13.0	0.8	1.3	4.6	-1.4	-0.7	-1.2
Area 23, Cafeteria	-8.9	12.0	18.6	5.0	0.0	1.3	1.5	-3.8	-1.1	-0.1

Table 9.17 (Historical ^{238}Pu in Water Annual Averages at Selected Locations, [µCi/mL × 10^{-12}], cont.)

Location	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
SEWAGE LAGOONS										
Area 12, Sewage Lagoon	2.7	26.7	-4.8	-9.2	1.8	-1.7	-1.3	-2.2	-1.1	-0.9
Area 23, Sewage Lagoon	26.0	-14.5	1.3	-11.4	0.0	-1.3	1.3	13.9	-1.9	-0.1
CONTAINMENT PONDS										
E Tunnel Effluent	2625.0	1616.7	732.5	660.0	450.0	687.3	323.0	355.8	388.0	232.5

Table 9.18 Historical $^{239+240}Pu$ in Water Annual Averages at Selected Locations, (µCi/mL × 10^{-12})

Location	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
WELLS										
Area 18, Well HTH No. 8	1.6	-3.0	0.6	7.2	-8.2	2.5	-1.1	-3.5	0.1	-2.8
Area 25, Well J-13	-0.3	7.8	2.6	13.2	-6.9	2.1	-1.6	-1.1	-2.1	-2.5
TAP WATER										
Area 2 Restroom	-2.4	2.7	0.5	0.1	2.3	2.2	0.0	-3.5	-2.0	-1.3
Area 23 Cafeteria	3.2	0.5	2.9	0.1	2.1	0.6	-0.1	-4.1	-2.3	0.0
SEWAGE LAGOONS										
Area 12 Sewage Lagoon	11.8	0.5	12.9	-2.0	4.3	2.2	-0.9	-2.6	1.4	5.8
Area 23 Sewage Lagoon	6.9	3.5	16.1	1.8	7.1	9.0	5.0	818.9	11.7	0.7
CONTAINMENT PONDS										
E Tunnel Effluent	21250	9223	9500	6275	4333	5343	5208	2840	3190	2018

Table 9.19 Descriptive Statistics for 1998 Tritium in Water by Sampling Location, (µCi/mL × 10^{-9}) Enriched Analytical Method

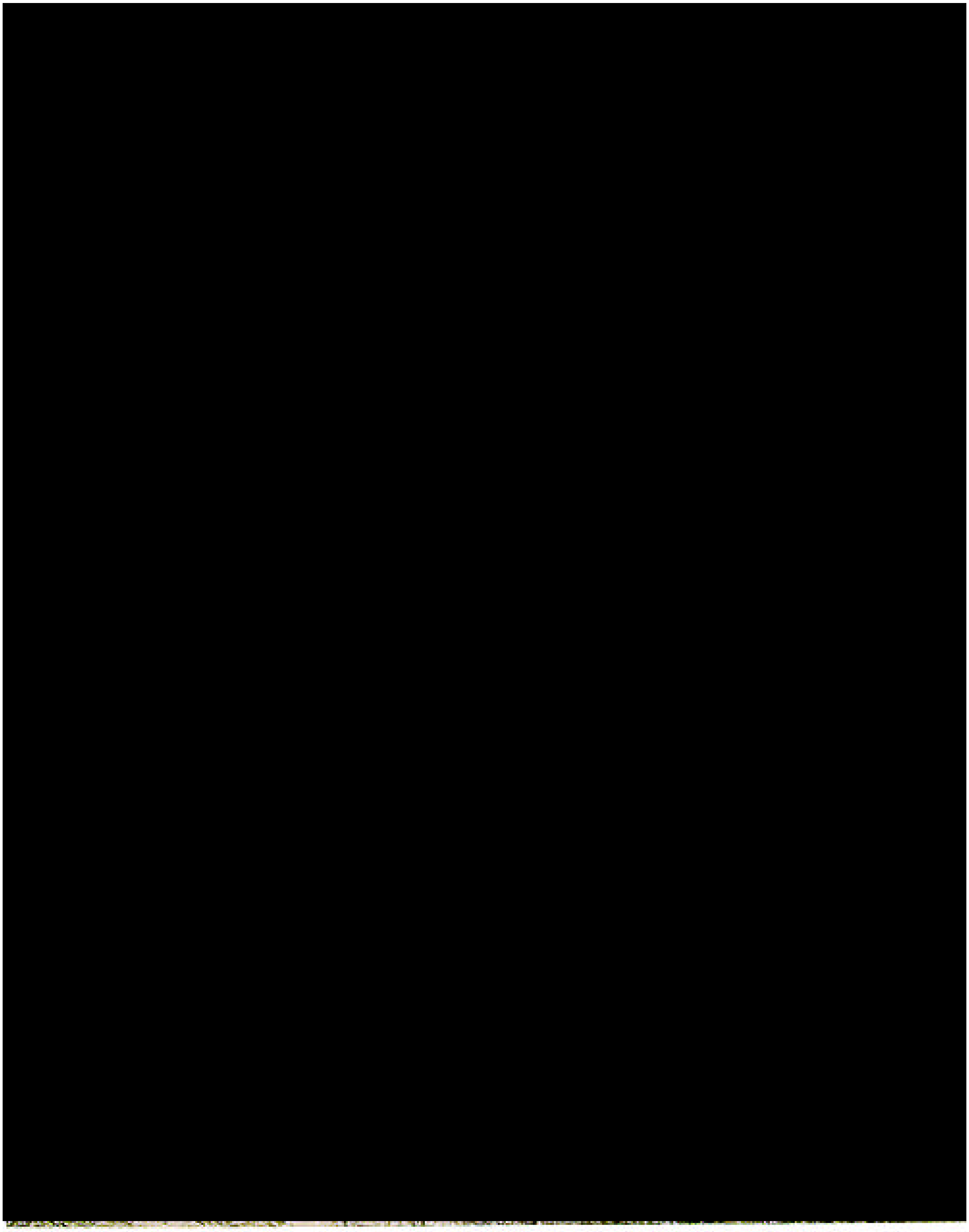
Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
SUPPLY WELLS							
Area 5, Well 5B	4	-4.83	-5.81	2.22	-6.19	-1.51	23.25
Area 5, Well 5C	3	-4.06	-3.96	0.50	-4.61	-3.62	14.10
Area 5, Well UE-5C	3	3.55	4.68	6.28	-3.21	9.19	14.00
Area 6, Well No. 4	5	-1.86	-2.14	2.34	-4.48	1.92	13.20

Table 9.19 (Descriptive Statistics for 1998 Tritium in Water by Sampling Location, [µCi/mL × 10^{-9}] Enriched Analytical Method, cont.)

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Area 6, Well No. 4A	3	-0.90	-2.68	3.76	-3.43	3.42	13.70
Area 8, Well C-1	2	3.60	3.60	8.12	-2.14	9.34	13.85

Table 9.20 (Descriptive Statistics for 1998 Tritium in Water by Sampling Location, [µCi/mL × 10^{-6}] Conventional Analytical Method, cont.)

Sampling Location	Number of	Standard	Median



Solar Air Sampler Located at Well ER-3-1 (No Date Provided)

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